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Smart Cities in the Mediterranean

Coping with Sustainability Objectives in Small and Medium-sized Cities and Island Communities

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Editorial

For several decades now, the overarching goal of sustainable urban development constitutes a core issue for planning and policy making endeavors in many city environments around the globe. Such endeavors are nowadays further intensified, mainly due to the increasing stress placed on urban constellations by the continuously escalating urbanization trend. As many researchers point out, we are currently living in a century characterized as the "Urban Age," with urbanization considered as its defining feature (Suzuki et al. 2010). Within such an Age, cities are confronted with unprecedented challenges which, coupled with the rapidly evolving economic, social, technological, and political sceneries, render sustainability a *moving target* in the policy agenda; and thus a target lying at the heart of policy makers and urban planners' work around the globe (Stratigea et al. 2015).

In such a rapidly changing environment, the concept of *smart city* arises, perceived as a promising, digitally enabled strategy and a policy path capable of supporting urban sustainability objectives. The smart city term, although not yet fully conceptualized, has rapidly gained ground; and, as various studies show, it seems to present a *new paradigm* for sustainable urban management, playing a pivotal role in coping with bewildering sustainability challenges in urban environments at a global scale (Walters 2011; Stratigea 2012; Stratigea and Panagiotopoulou 2014). Additionally, it is perceived as a *new force* in the arsenal of policy makers and urban planners, and a promising *policy option* toward setting up sustainable urban strategies for effectively managing various urban functions and promoting innovation and competitiveness of urban environments in a highly connected, knowledge- and information-intensive era (Panagiotopoulou et al. 2016); and mitigating the impacts of ascending urbanization rates and consequent stress exerted on cities by overpopulation (Chourabi et al. 2012).

In such an evolving new urban management paradigm, the challenge is to *re-define the city* as an environment of innovation, empowerment and participation of citizens, businesses and other stakeholders in shaping their future, through the choices they have and decisions they make (Stratigea 2016); or the challenge is to focus on change and transformation resulting in a smarter city, implying a change toward shaping a better and more *participative, inclusive, and empowering city*

(Schaffers et al. 2012). Smart cities, in this respect, can be grasped as places that provide qualitative and innovative services to citizens, economic activities, institutions, but also their visitors, while they focus on the production of a *safe, healthy, pleasant, and highly inclusive urban environment* (Stratigea 2012). They can also be perceived as places generating a particular form of spatial intelligence and innovation, based on sensors, embedded devices, large datasets management, and real-time information and response (Schaffers et al. 2012).

Along these lines, this book aims at shedding light on the potential of current smart city developments in pursuing a sustainable future in a specific region of the world, the Mediterranean region. Within this region, the focus is on small- and medium-sized cities and communities as well as insular territories. The particular urban settlements' network configuration of the Mediterranean region (scattered small- and medium-sized cities and communities) as well as the presence of territorial island complexes justifies such a choice; while this is further advocated by the large number but also the distinguished attributes, these cities and communities dispose. As such can be considered their highly valuable historical/cultural heritage, the coastal character of numerous Mediterranean cities involved, the globally recognized tourist attractiveness and repercussions to sustainability, the high vulnerability with respect to climate change challenges but also natural disasters (e.g., earthquakes and floods), the peripherality, and limited accessibility both within the Mediterranean area (e.g., insular regions) and at a European level (cities in the periphery of the European territory).

Apart from the above specified attributes, cities in the Mediterranean are currently confronting a severe recession state, hitting the southern part of Europe, which hampers efforts for paving sustainable urban development paths, while it is marked by high levels of unemployment, brain drain, considerable in- and out-migration movements, destabilization of production patterns and political instability. In the chapters incorporated in the current edition, smartening up that type of cities is placed at its heart, mainly based on adopting a *human-centric, place-based, and problem-solving approach* of smartening perspective, in alignment with Mediterranean cities' historical paths and distinct cultural attributes forged through the centuries. Such an approach is furthermore stressing the relevance of ICT-enabled planning efforts for improving the effectiveness of urban management and supporting creativity, inclusiveness, accessibility, and paths to sustainable urban development.

In light of the aforementioned discussion, this book attempts to gather smart city experiences around the specific study area and raise issues of concern that emanate from studies relating to Mediterranean small- and medium-sized cities and insular communities; while it also tries to gather experiences from research work that originates from relevant smart city developments at the European/global level.

This book constitutes a cooperative effort of numerous distinguished researchers and younger colleagues. It incorporates *eighteen chapters* that are classified, according to their focus and the way they approach the topics of interest, into *two parts,* namely *Part I* that is placing at its heart issues of digitally enabled planning and participation; and *Part II* presenting distinct examples of ICT-enabled applications capable of coping with a range of sectoral issues, such as energy, but also infrastructure management, spatial data management for dealing with a variety of decision-making issues, etc. that are falling into smart city concerns.

Part I consists of *twelve chapters*, which mostly elaborate on planning as well as participatory aspects and developments emerging from or driving a smart city paradigm. In this respect, works presented in these chapters range from human-centric, mature technology-oriented efforts to more technologically advanced works, while delineate experiences gained from Mediterranean and other countries of the European and the global context as well. More specifically, after the introductory section, which sets the context of the Mediterranean geographical focus of this edited volume and the type of cities concerned, follows a chapter reviewing current spatial data management and visualization tools and technologies in support of participatory e-planning, as a new digitally enabled direction that can flourish in a smart city context. This is followed by seven chapters presenting a variety of participatory planning exercises gathered from the Mediterranean but also the European and global experience. The next two chapters present the potential of ICTs for coping with two different types of problems and planning areas addressed, namely climate change and related consequences in urban areas as well as management and monitoring of protected areas (PAs) that are developed as ecotourism destinations, both considered as important contributions provided their relevance to the Mediterranean context. Finally, the last chapter of Part I elaborates on a quite promising aspect of the tourist sector in the Mediterranean, the maritime tourism, in an effort to set up certain guidelines for better linking this type of tourism to the sustainable marine and land management of related urban settlements. A short description of these twelve contributions of Part I is provided in the following.

Chapter 1 of the first part constitutes a joint effort by *Anastasia Stratigea, Akrivi Leka, and Chrysses Nicolaides* entitled "Small and Medium-Sized Cities and Insular Communities in the Mediterranean: Coping with Sustainability Challenges in the Smart City Context." As an introductory chapter, it aims at delineating the *geographical ground* of the present book by illuminating a very special region of the world, the Mediterranean region. As such, it first sheds light on the peculiar attributes of this region, which render it one of the most intriguing but also vulnerable regions of the world, and identifies the character of this region as a "hot spot" in several respects. Next comes the justification of the type of cities considered within this geographical context, i.e., small and medium-sized cities and insular communities, which are usually lagging behind in terms of smartening up efforts, and having little opportunity to join a smart journey, as the public lights and related funding opportunities are usually shared by large, very successful, powerful and market-attractive, smart cities that become examples on the global and the EU scene. The chapter elaborates on the specific attributes and distinguishable rating of these cities in: economic terms (tourism, culture, sea trade nodes etc.); geographical terms (coastal and port cities at the cross roads of Mediterranean); cultural terms; while their development potential for both the Mediterranean and the EU territory is revealed. Moreover, emerging risks in the Mediterranean are highlighted that can place at stake the sustainable future development of this type of cities;

while the importance of digitally enabled solutions, in conjunction with sustainability policies as a desirable path and an evolving policy direction for reaching inclusive, safe, resilient, and sustainable end states within such challenges in the new era is stressed. Finally, some concluding remarks are provided, sketching contemporary aspects of planning approaches that are relevant in order to cope with threats and sustainability challenges in a smart city context within this specific part of the world.

Chapter 2 entitled "Spatial Data Management and Visualization Tools and Technologies for Enhancing Participatory e-Planning in Smart Cities" is written by *Maria Panagiotopoulou and Anastasia Stratigea*. The focus of this chapter is on the issue of *participation* as an eminent feature of smart city development, as various definitions of the smart city concept and their practical applications depict. More specifically, the chapter stresses the importance of citizens and stakeholders' participation in the evolving smart city paradigm, highlighting their role in collecting empirical knowledge, identifying and prioritizing urban inefficiencies as well as selecting and deploying city- and citizen-specific smart applications, and policies capable of coping with these inefficiencies and steering sustainable, inclusive, and resilient urban environments. Furthermore, the chapter elaborates on the potential of Information and Communication Technologies (ICT) and their applications in digitally enhanced environments; and the noteworthy shift these can mark toward e-planning and e-participation, setting the ground for more knowledgeable decision making in planning and implementing smart city solutions that are mostly citizen- and city-oriented rather than purely technology-pushed. The focus of this chapter is on the delineation of participatory e-planning as a digitally enabled perspective for effectively communicating various planning problems to citizens and stakeholders and actively involving them in decision-making processes. Along these lines, the most significant tools and technologies, currently available in planners' portfolio, are reviewed in order for participatory planning exercises to be optimally implemented by successfully integrating spatial planning approaches, public participation, and visualization techniques; while the role of public participation geographic information systems (PPGIS) for citizens and stakeholders' empowerment in the spatial planning process is also discussed. Finally, some concluding remarks are drawn as to the key components and obstacles planners are confronted with, while carrying out participatory e-planning projects in a smart city context.

Chapter 3, entitled "Baakline: Towards a Smart City—Leading Change into Chouf Souayjani Region" is written by *Nouha Ghosseini*, former mayor of this area and a leader of the whole smartening up exercise. It presents a quite interesting example of the necessary steps for planning a smart city in Lebanon, considering such an effort a task implying smart governance, communities' engagement, learning and adaptation, as well as investing in the future by reshaping the entire market and ecosystem. The ground of this specific exercise is set by the argument that in a smart city context, citizens are turned from passive consumers into active and concerned citizens; producers of ideas, content, applications, and activities; as well as choosers of their society. Based on this ground, innovation and creativity are enhanced, seeking social relevance of new/unfamiliar ideas, opportunities for start-up firms, and propensity to entrepreneurial risk. The whole participatory planning exercise is taking place in the Municipality of Baakline (MBAA), setting participatory democracy at its heart as a key to both tackling the challenges faced by Baakline city and taking advantage of the evolving exciting opportunities. MBAA's approach toward a smart city offers an invitation to reflect and act through pilot projects that are expected to change the mentality of people and integrate this concept into their future plans, while public/private actors' cooperation lies at the heart of MBAA's successful projects.

Smartening up people in local communities is the focal point of *Chapter 4*, entitled "Smartening-Up Communities in Less-Privileged Urban Areas—The DemoCU Participatory Cultural Planning Experience in Korydallos—Greece Municipality" and is written by *Anastasia Stratigea, Giorgos Somarakis and Maria Panagiotopoulou*. The chapter claims that effectively coping with contemporary urban challenges and smart city developments actually implies a conscious effort to engage a range of actors of local ecosystems and transform ways of implementing things in a significant, fundamental, and structural rather than incremental manner, in alignment with the currently prevailing planning paradigm shift from a top-down to a bottom-up approach. In doing so, more qualitative outcomes and cooperative, highly inclusive, decision-making processes may emerge that affect current and future quality of local communities' living perspectives. The focus of this chapter is on *smartening up local communities*, considered as the heart of smart cities' development. Citizens and stakeholders' empowerment and engagement processes in this respect are exemplified by a specific cultural planning exercise in a less privileged suburb of Athens metropolitan area, the Municipality of Korydallos. Moreover, an innovative stepwise participatory planning framework, effectively combining classical and Web-based participatory tools for establishing face-to-face and online interaction at the different steps of the participatory process, is discussed, which is developed in order to accomplish engagement of local community and to broaden substantial participation of various citizens and stakeholders' groups in this participatory planning exercise.

In *Chapter 5*, *Efthimios Bakogiannis, Maria Siti, Charalampos Kyriakidis, and Avgi Vassi* deal with a crucial aspect of smart city development, namely *sustainable mobility*. In their work on "Using Traditional and New Digital Technology Tools to Promote Sustainable Mobility: Current Trends in the Evolving Transformation of the Smart City," they tackle one of the most emerging challenges in the contemporary car-oriented city, where congestion and lawlessness grow, while funds continue to decline. The chapter aims at showcasing a collection of practices, both ICT and non ICT-based, that focus on enabling sustainable mobility policies and measures as well as hard infrastructure projects, in order to reach the *smart city in mobility terms*. The concept of a smart city does not always require the support of Web technology tools, but rather integrates their use into a holistic approach to cope with the growing pressure of traffic and the existing travel behavior patterns. The study presents five (5) grouped sets of policy interventions and measures consisting of more than twenty-five (25) indicative actions to be applied in cities and/or regions, ranging from common traffic calming solutions to smart traffic lights, car-sharing, and innovative parking schemes. The proposed sets of actions focus on the regional level, exploring at first the case of Athens and Attica Prefecture; however, they can be applied to several other cases in urban and regional scales accordingly. Actions aim at tackling traffic safety, travel behavior dynamics and patterns, local mobility cultures and mobility and environmental awareness issues, considering the widespread use of Information and Communication Technologies.

Chapter 6, entitled "Turning Messina into a Smart City: The #SmartME Experience" is a joint effort by *Dario Bruneo, Salvatore Distefano, Francesco Longo, Giovanni Merlino, and Antonio Puliafito*. The chapter elaborates on the cloud computing technology applied to Internet of Things (IoT) as an interesting and innovative application area in the smart city context. Such a possible synergy is explored in the context of the #SmartME project, a crowd-funding project that aims at morphing Messina into a smart city. Up to now, in the process of integrating cloud computing and IoT-related technologies, a data-oriented approach has been mainly considered, employing cloud infrastructures as mere repositories for data collected by scattered devices. #SmartME project, however, follows a different approach, in which sensing and actuation resources are considered as extensions of the data center; and the cloud is adopted as a virtual infrastructure manager, providing the infrastructure administrator with a management and monitoring surface. In the present work, progress achieved during the first year of the #SmartME project is provided, placing particular emphasis on the social, bureaucratic, and technical steps that are conducted to the current deployment of tens of boards throughout Messina. In particular, the Stack4Things framework, which represents the core and soul of the #SmartME project, is presented, describing the underlying technologies and providing an overview of the Web portals that are used for administration and data retrieval.

Chapter 7 entitled "The Smart City as Shared Design Space" constitutes a joint effort by *Martin Koplin, Stephan Siegert, Aura Neuvonen, Kari Salo, Kevin Kerney, Carl Skelton, Alma Culén and Igor Nadelkovski*, who claim that there is an emergent complex of digital environments supporting virtualization of public sub-realms, neighborhood-level agoras, or places of assembly with shared information, ideas and design. These environments can be used to simplify civic engagement in urban development processes—both on- and offline. Relevant new strategies in this field are depicted by means of a range of different examples/projects, using new ICT tools and methodologies capable of enhancing participation of numerous stakeholder groups (e.g., children, migrants, older people, professionals, and non-professionals) in *urban development* and *urban re-design*. Results obtained indicate that in today's ICT-enabled public realm, public data must be offered as public information, and citizens must be enabled to get in touch with the new digital tools for strengthening participatory processes. Moreover, examples presented in this chapter delineate the need for providing access to processing tools that are user-as-producer-friendly and open to diverse groups of people, while prove artistic, playful, creative and game-based settings an ideal starting point in such a context, further opening up participatory processes by enabling social groups, previously ignored in participatory processes, to become part of them.

In *Chapter 8*, *Adnane Jadid, Martin Koplin, Stephan Siegert, Martin Hering-Bertram, Volker Paelke, Thorsten Teschke and Helmut Eirund*, in their joint effort under the work "Express Yourself/City—Smart Participation Culture Technologies," highlight the motivation for new participatory tools and methods in urban planning, and propose optical tracking as a solution to improve *Augmented Reality* (AR) features in participatory urban planning software. They claim that software and tools for smart city planning are mostly addressing the needs and capabilities of relevant administration staff, architects, and other professionals, who are used to work with highly abstract data, while creating significant barriers to citizens' participation in the planning process, who require much more direct visualization. What are needed are smart, interactive, and visual tools like in-situ-mixed reality, combining the real location with planning data. The *Betaville system*, a participatory platform for urban re-design, combines all such features and allows a wider engagement of local population in urban planning exercises. The project "Express Yourself/city," a sub-project of "The People's Smart Sculpture PS2," works as a discussion forum, combining social and cultural demands for participation in urban development with new technical approaches. One goal of "Express Yourself/city" is to improve the usability of Betaville, a target that can be achieved through a certain redefinition of augmented reality feature. The project "Markerless Adaptive Mobile Augmented Reality in Games MadMAGs" is dedicated to the provision of a solution based on optical tracking.

Chapter 9 draws upon the international experience by elaborating on a quite successful example of sustainable island development, based on visionary planning and citizens and local stakeholders' engagement. *Mark Wilson*, the author of this work, entitled "Smart and Sustainable: Lessons from Fogo Island," claims that globalization and centralization of economic activity are increasingly challenging the viability of many communities distant from the world's economic centers, with islands being a prominent example of such communities. In his work, he presents a promising example of an insular area—Fogo island—namely a small island located off the coast of Newfoundland. In this example, community and nonprofit action are successfully used for instigating social and economic change, with a unique approach to local development led by the Shorefast Foundation. Fogo Island is an excellent case combining innovative policy, community action, and sustainable practice that can inform planning for islands in general. Using a tourism and culture-based model that features sustainability and heritage preservation, Fogo Island serves as a valuable example of ways to harness community assets and motivation for regional development.

Attila Buzási and Mária Szalmáné Csete in *Chapter 10* present their work on "Adaptive Planning for Reducing Negative Impacts of Climate Change in Case of Hungarian Cities." They consider the application of smart solutions as means for planning urban development and tackling the emerging climate change challenges, confronted by Hungarian cities nowadays. Indeed, Hungarian cities, as various studies related to future weather events in the Carpathian basin delineate, will likely face similar climate-related challenges as Mediterranean cities nowadays, despite their different geographical location. Based on these forecasts, adaptive planning through indicator-based systems play a crucial role in the abatement of climate change's negative impacts; therefore, smart principles combined with an effective monitoring phase can contribute to a vital future of Hungarian cities. The present paper elaborates on climate-related interpretation of smart city sub-systems (people, environment, governance, mobility, economy, and living) by providing sets of indicators for making comprehensive, sustainable, and smart decisions. The selection of indicators is based on two main aspects: firstly, consideration of data availability for effectively using existing indicators' sets; secondly, adaptation for anticipated negative effects of climate change in urban areas in light of smart cities' potential. Interconnections between climate-related challenges and urban development can be revealed by creating climate-oriented smart city concepts and indicators to improve cities' adaptation capacity. The main aim of the present study is twofold, namely to contribute to the better understanding of complex interrelations between climate-related challenges and the role of smart cities as well as to develop specific concepts and set of indicators for improving decision-making and urban planning processes; and to reveal smart cities' potential in the abatement of negative effects of climate change through effective monitoring and project supporting systems.

As the overall goal of the present book is to elaborate on small- and medium-sized cities and communities as well as insular territories in the Mediterranean region in light of "smart" developments, in *Chapter 11*, entitled "ICT Applications in Smart Ecotourism Environments" and co-written by *Vicky Katsoni and Natali Dologlou*, the contribution of ICT to a specific type of peripheral region, i.e., Protected Areas (PAs) is explored. This is a quite crucial issue for the Mediterranean territory, characterized by the abundance of such types of areas. The authors point out that despite the quite promising potential of ICTs in rural areas and communities, their implications toward this direction are less explored. In this respect, the focus of this work is on that type of environments, and more specifically on the role ICT can play for the protection of valuable ecosystems that are setting the ground for ecotourism development. Ecotourism embraces the principles of sustainable tourism (ST), as an alternative tourism form that is largely concerned with the economic, social and, most importantly, environmental impacts of this sector. Preserving ecosystems' values in ecotourism destinations imply the need for steadily monitoring ecotourism developments and associated impacts in such destinations, with ICT offering important tools for accomplishing such a task. In this respect, the paper, by reviewing a range of academic reports and literature, aims at extracting crucial aspects that need to be dealt with in a variety of ecotourism dimensions and matching them with a range of relevant ICT-enabled tools and applications. The results of this conceptual paper reveal the key ICT-enabled tools/applications for managing ecotourism destinations, thus setting the ground for case-specific policy directions toward an environmentally responsible ecotourism development.

Given that a large number of Mediterranean small- and medium-sized cities are coastal cities, exhibiting a large potential for maritime activities, *Chapter 12*, last chapter of Part I, co-written by *Maria Nodaraki, Evangelia Ntafa, Eleni Tseva and Antigoni Valanidou*, is focusing on "Maritime Tourism Development and Prospects in Coastal Cities: The Case of Heraklion, Chania and Limassol." More specifically, this work elaborates on maritime tourism, i.e., cruising and yachting in the Mediterranean Basin, a dynamic sector gaining ground in many Mediterranean cities. The chapter addresses the subject of maritime tourism by reviewing and analyzing the current or future implications that this sector has or may bring upon Mediterranean cities through three relevant examples, two from the island of Crete, Greece (Heraklion and Chania), and one from the island of Cyprus (Limassol). More specifically, through case study work, existing links of maritime tourism to the reality of the city, the benefits and drawbacks that the sector can have on the local economy and its potential for future development, are explored. The three case studies indicate that in order to maximize the benefits reaped from maritime tourism by local societies and economies, a certain strategic planning framework should be established, broadening the interaction of maritime and land activities. Such a framework should be enriched by marine spatial planning (MSP) principles as well as ICT potential, steering "smart" tourism development (STD) and fulfilling sustainability objectives, i.e., marine and land environmental protection, spatial and social cohesion, as well as economic development and competitiveness of coastal Mediterranean cities.

Part II incorporates *six chapters* that are more application- and data management-oriented, touching upon various problems or challenges of the Mediterranean cities and insular territories. The first three chapters deal with the use of GIS technology for more effectively managing spatial decision problems in urban or insular environments. These are followed by an example drawn from the *energy sector*, namely a chapter that deals with energy demand data management in order for a systematic development of a business model concept of an aggregator company to be achieved. Data management sets the ground for the next chapter, dealing with a quite crucial issue in a smart city context, namely the one modeling and analyzing critical city infrastructures, while last but not least lies the final chapter of the second part that deals with the currently evolving unmanned aerial systems (UAS) as the means for disaster prevention and emergency response, both crucial aspects in managing urban and insular environments' aspects in the Mediterranean context.

More specifically, *Chapter 13* entitled "Business Route Planning Using GIS Technology: The Case of Footwear and Leather Retail Stores in Central Athens" is written by *Kleopatra Tzima, Iris Polyzou, Yiota Spastra, Thomas Hatzichristos, John Sayas, and Valia Aranitou*. It aims at highlighting and connecting retail trade related businesses located in close proximity to each other in central Athens area, through the design and mapping of *shopping routes*. In an economic stagnated neighborhood as the Mediterranean, its purpose is to stimulate consumption in small and medium-sized retail stores by integrating shopping with other elements of the city space. The methodological approach adopted draws upon the use of spatial analysis methods by means of Geographical Information Systems (GIS) for accurately delineating routes by combining both quantitative and qualitative criteria such as thematic identity of route, retail shops involved, stores' location and spatial concentration, proximity of retail shops with complementary economic activities, availability of public space, public transport network, and proximity to cultural activities. These criteria were taken into account for defining a final composite index that highlights areas with high suitability for various kinds of shopping routes, while such an approach is depicted to identify a "Retail of footwear and leather goods" route presented in this chapter.

Chapter 14 on "Spatial Micro Level Analysis of Building Structures in Samos Island" is co-written by *Dimitris Kavroudakis, Fotini Skalidi, and Dimitra Tsakou*. The chapter aims at presenting advanced tools for coping with dynamic environments and processes as well as thoroughly analyzing spatial entities in finer scale, in support of the better understanding of the microlevel dynamics and underlying processes of complex phenomena and the more knowledgeable decision-making at the regional level. More specifically, the focus of this chapter is on the contribution of fine-scale datasets management to policy making by use of *Spatial Micro Level Analysis* of building structures data. The proposed approach was applied on an insular area—Samos, Greece—in an effort to study two defining issues of islands' territory development in the Aegean Sea nowadays, namely informal settlements' expansion and spatial distribution of fire events, which are closely linked to pressures exerted on such areas by current development patterns as well as climate change impacts. The scope of this work is to illuminate underlying mechanisms of attraction/repulsion of informal housing and to identify the relationship between points of fire ignition and populated areas. Output of such an approach can feed decision-making processes and support more *"smart" policy directions* for coping with challenges of both island territory development and fire-related risks.

In *Chapter 15*, *Dimitris Kavroudakis and Zinovia-Maria Penteridou* elaborate on "Geographical Analysis of Emergency Evacuations in the Aegean Sea: Towards the Utilization of Big Data Analytics." *Health service provision* in isolated and fragmented insular areas, such as Mediterranean islands, is a crucial policy issue for assuring the quality of life and safety of local population. Such policy decisions need to cope with annual seasonality of tourist flows and the spatial fragmentation of activities in insular areas and call for a dynamic approach in decision-making as to the provision of such services that needs to be based on relevant spatially related data analysis in order to effectively manage availability of health services as well as specialized medical personnel. Moreover, emergency health evacuation from islands to specialized hospitals in the mainland needs to be properly planned, a service that in Greece is offered by the National Center of Emergency Evacuations (EKAB). The focus of this chapter is on improving emergency evacuation service provision of EKAB in Greek islands by properly managing population and transportation data for providing input to more *"smart" health provision decision-making processes*. By examining current and potential future demand for health services through population data, the effectiveness of big data (BD) analytics utilization is explored in support of optimal allocation of EKAB resources, maximization of supply, and minimization of possible evacuation time. The introduction of BD analytics in regional decision-making processes may enhance the potential for tailor-made planning, faster, and informed decision-making as well as scenarios' testing, service monitoring, and more effective forecasting.

Chapter 16 is a joint effort by *Ioannis Lampropoulos, Machteld van den Broek, Wilfried van Sark, Erik van der Hoofd, and Klaas Hommes* on "Enabling Flexibility from Demand-Side Resources Through Aggregator Companies." The focus of this chapter is on the emerging *aggregator company* and related business models, in response to a general quest for flexibility in *power system operations*. This work tries to fill the gap by systematically approaching and analyzing the organizational arrangements underlying a business model. It aims at contributing to the systematic development of the *business model concept* of an aggregator company and providing insight into its economic potential. A set of elements is identified that can be used for analyzing the various applications of a business model. A revenue analysis is performed based on historical data from the day-ahead market and the imbalance settlement system in the Netherlands. The case study is about a hypothetical implementation of the aggregator company with focus on residential demand-side resources. The results show a significant theoretical potential and suggest an interesting business case.

Chapter 17 on "Test System for Mapping Interdependencies of Critical Infrastructures for Intelligent Management in Smart Cities" is an effort by *Irina Ciornei, Constantinos Heracleous, Marios Kyriakou, Demetrios Eliades, Costas K. Constantinou, and Elias Kyriakides*. It deals with a critical issue in a smart city context, namely *large data management of critical city infrastructures*, such as power distribution networks (PDN), water networks, transportation, and telecommunication networks, produced from applications such as AMI, SCADA, renewable energy management systems, asset management systems, and weather data. In shifting these data into useful information for decision-making, i.e., converting the flow of continuous coming data into information, visualization is an effective solution, while visualizing large data of critical infrastructures in a holistic view at a city level is a missing link. Authors propose a technique to visualize critical infrastructure data by using a system that consists of Geographical Information Systems (GIS) for buffer spatial analysis and Google Earth in sync with realistic planning and operation methodologies specific for each infrastructure modeled. The major goal of this work is to design, model, and validate a *benchmark system* that is capable of visualizing and mapping as well as of preparing the next interlinking phase of modeling and analysis of interdependencies of several critical infrastructures. Furthermore, the aim is to provide the ground for a theoretical framework that can capture the interdependencies between critical infrastructures using techniques from graph theory, machine learning, econometric science, and operation research. The proposed framework for modeling the interdependencies between several infrastructures within a city territory is based on hybrid system automata, and it is among the first steps needed in developing fundamental mechanisms for *resilient management* of critical infrastructures and the safe operation of smart cities.

Last, but not least, comes *Chapter 18* in which *Petros Petrides, Panayiotis Kolios, Christos Kyrkou, Theocharis Theocharides, and Christos Panayiotou* present their work on "Disaster Prevention and Emergency Response Using Unmanned Aerial Systems," a quite important technology and extremely beneficial for coping with prevention activities, including assessment and mapping, as well as demanding field missions such as search and rescue, disaster monitoring and control, issues that are of high relevance to the peculiarities of the Mediterranean territory and the insular and sea environment of a large part of this area. This work highlights the significant and advantageous use of a rapidly evolving technology, Unmanned Aircraft Systems (UAS), in emergency response operations, and focuses on the importance of matching end-user needs with existing UAS technical capabilities, specifications, and payloads characteristics to achieve best results. Firstly, a detailed procedure is derived for matching end-user needs to technological requirements. Thereafter, the methodology to accurately estimate the overall mission time is derived based on the aforementioned needs and requirements. Finally, detailed evaluation of the proposed procedure and methodology is carried out through realistic examples, extracted from missions set out by civil protection organizations. It is shown that properly configuring and operating UAS technology can significantly improve utilization both in preparedness and response to emergencies in a highly vulnerable region of the world as Mediterranean.

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Part I
Aspects of Planning and Participation in Smart Cities' Environment

Small and Medium-Sized Cities and Insular Communities in the Mediterranean: Coping with Sustainability Challenges in the Smart City Context

Anastasia Stratigea, Akrivi Leka and Chrysses Nicolaides

Abstract As an introductory chapter, the present paper aims to set the geographical ground of this book by shedding light on a very special region of the world, the Mediterranean region. The scope of the chapter is, firstly, to illuminate the specific attributes of this region, which render it one of the most intriguing but also vulnerable regions of the world; and identify the character of the region as a 'hot spot' in several respects. Secondly, it aims to justify the type of cities considered within this geographical context, i.e. small and medium-sized cities and insular communities, usually lagging behind in terms of smartening up efforts; and having little opportunity to join a smart journey, as the public lights and related funding opportunities are usually shared by large, very successful, powerful and market attractive, smart cities that become examples on the global and the EU scene. Thirdly, the paper elaborates on the specific attributes and distinguishable rating of these cities in: economic terms (tourism, culture, sea trade nodes etc.); geographical terms (coastal and port cities at the cross roads of Mediterranean); cultural terms; etc. It reveals their development potential for both the Mediterranean and the EU context. A discussion follows on the emerging risks in the Mediterranean, which place at stake the sustainable future development of this type of cities and communities. Digitally enabled solutions, in conjunction with

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sustainability policies, appear as a full of promises path and an evolving policy direction for reaching inclusive, safe, resilient and sustainable end states within such a full of challenges new era. Finally, some concluding remarks are discussed as to the planning approaches that need to be in place for coping with threats and sustainability challenges in this specific part of the world.

Keywords Mediterranean region · Sustainability · Small and medium-sized cities and communities · Insular communities · Smart Sustainable Cities (SSC)

1 The Current Mediterranean Profile—Potential, Challenges and Risks

> For the three quarters of the globe, the Mediterranean Sea is similarly the uniting element and the centre of world's history.
>
> Friedrich Hegel

At the crossroads of three continents, Europe, Africa, and Asia, the *Mediterranean Basin* refers to the sea and lands around the Mediterranean Sea. Mediterranean Basin is surrounded by *21 countries—Albania, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syria, Tunisia and Turkey—*, which share a coastline of 46,000 km. It constitutes a very special region of the world from a *nature's point of view*, with huge topographic, climatic and geographical variability. More specifically, it is characterized by: a highly contrasting topography, exhibiting a remarkable topographic diversity and altitudinal differences, coupled with spectacular scenery; and a combination of land and island complexes, together with a quite large number of islands of different shapes and sizes, nicely placed in the Mediterranean Sea. Moreover, the unique mild and temperate climate; the beautiful landscapes; the rich marine environment; and the abundant but also unique biodiversity, have each played their role so as the Mediterranean Basin to be considered as one of the biological wonders and the third richest biodiversity landspot of the world (Mittermeier et al. 2005).

Rivaling the natural diversity of the region, its cultural, linguistic and socioeconomic diversity is also spectacular. The *cultural wealth* has largely been attributed to the mutual influence of its surrounding eastern and western civilizations through historically deployed important commercial routes, but also travelers of ancient times that allowed for trade and cultural exchange between the emerging societies in the region. Dense human populations have been scattered across the area for several millennia. The region has given rise to some of the world's first and greatest civilizations, while it has been considered as the *cradle of Europe's civilization* as well as the place that fuelled the Renaissance Era. It has given birth and became home to great thinkers and artists, such as Aristotle, Plato, Cicero, Socrates, Leonardo da Vinci, Michelangelo, Galileo etc. It is also the home of all Seven Wonders of the World.

The *economic wealth* of Mediterranean societies has been mainly determined by the sea, which has affected the development of economic and trade relationships, but also of societal ties with other Mediterranean communities. Trade and economic transactions were largely concentrated in the coastal areas, with Mediterranean coastal communities being rendered very prosperous and flourishing ones thus rising to power. The sea provided a means for trading, but also for colonization and wars, thus becoming the core of life for numerous communities throughout the ages; and a valuable resource for economic activity (commerce, fishing, tourism, etc.).

The *north-south fracture* is also evident in regions of the Mediterranean Basin, sketched by an economically rich and ageing northern Mediterranean rim (mostly EU member states); and the younger and poorer southern and eastern rims (Arab states).

The *northern developed rim* is mainly characterized by urban and industrialized societies with high to medium income levels, low population growth, a steadily increasing and intensifying agricultural production pattern, combined with a decreased rural population. Existing there is a highly developing urbanization trend, with evident consequences on urban density and quality of life; as well as an increasing tourism trend in rural areas.

The *southern and eastern less developed Mediterranean rim* has low-medium income levels, high population growth rates, some of the globe's highest urbanization pace, relatively high population density in rural areas, while local economic sectors are highly dependent on natural resources for their livelihoods.

As the Mediterranean region is a top tourist destination on a global scale, with tourism being considered as a *major pillar for the local economies* especially in coastal zones, an increasing *pressure* is exerted on local natural resources, which results in their rapid degradation due to uncontrolled construction interventions (transport infrastructure, hotel complexes, holiday homes or expanding cities sprawled out in all directions), water stress, waste production etc., through serving the needs of the quite large, and steadily increasing on a yearly basis, number of visitors.

The north-south fracture, combined with the recently evolved political instability and tensions in the southern part, have stirred up a significant *migration flow*, a *migration tide* as many claim, from the poorer south to the richer north, which at the end of the day has taken the form of an *evolving migration crisis* with considerable, not yet fully grasped, implications on the social and economic structure and stability of both origin and destination regions.

The study of the *key socioeconomic features* of the Mediterranean region reveals that (CEPF 2010):

- The region hosts 6.5% of the world's *population* (480 million inhabitants) (EEA and UNEP/MAP 2014). Increasing population rates are much higher in the southern and eastern part, where population has doubled over 30 years, reaching

234 million inhabitants, a number that is expected to further increase by additional 70–120 million by 2030, placing a certain population increase pressure. On the other side of the coin, population increase in the northern part reached 14% over the same period, while it is expected to increase by only a mere 5 million by 2030. Almost one third of the Mediterranean population lives on the shore, a fact that significantly impacts the marine ecosystems and the health of the surrounding coastal areas.
- Based on the mild climate as well as the natural and cultural heritage, the Mediterranean region attracts a huge number of tourists. Almost one third of international tourism (32%) flows through Mediterranean; and this flow has seen a four-fold increase in the time span from 1970 to 2000, further expanding to today. The assumption for 2025 is a continuation of the strong growth of tourist flows, with another 178 million additional arrivals (Plan Bleu 2006).
- It produces 13% of world's GDP, a picture that seems to recently follow a declining trajectory due to the economic recession, affecting Mediterranean countries.
- It follows a *development pattern* that is still highly dependent on environmental resources, consuming them in an unsustainable way (demand for natural products and services is much larger than the local ecosystems' ability to renew them). Unsustainable paths of tourist development, with emphasis on mass coastal tourism, further deteriorate sustainability performance, with severe impacts on water (in quantitative and qualitative terms) and energy over demand.

Future conservation efforts need to address *population pressures* on the land, especially in the coastal zones, where coastal overdevelopment results in a concentration of pressures on coastal areas, giving rise to issues that impact continuously evolving infrastructure deployment (e.g. erosion), and above all, issues on how to maintain traditional rural livelihoods in a way that benefits biodiversity, particularly where urbanization is high.

The Mediterranean basin has nowadays been considered as a *hotspot in multiple perspectives*. More specifically it has been perceived as:

- An *environmental hotspot*: this is due to the overexploitation of local resources especially in the marine part.
- A *climate change hotspot* (EEA 2015): this is based on estimations depicting a general future trend of warming and drying for the Mediterranean Basin, with multiple socioeconomic implications and stresses (health, energy, water, food safety and security, further habitat and biodiversity loss, fire risk, lower rates of annual precipitation, etc.) (Giannakopoulos et al. 2005; Lionello et al. 2008).
- A *biodiversity hotspot*: Mediterranean exhibits nowadays the lowest percentage of remaining natural vegetation compared with any other hotspot. Many forests have been converted to agricultural land, while urban space is rapidly expanding to the detriment of rural land (CEPF 2010).

- A *water hotspot*: Mediterranean is an area facing a constantly increasing rate of water stress (ARLEM 2011), while if no action is undertaken, predictions show that by 2025 half of Mediterranean countries will use more water than the one naturally regenerated (Sundseth 2009). Water footprint per person shows that five Mediterranean Basin countries (Cyprus, Greece, Italy, Portugal and Spain) are rated among the top 10 worst progressing nations worldwide in this respect. Tourism seasonality and its massive mass model contribute to the further worsening of water stresses.
- A *natural risk hotspot*: Mediterranean cities are historically exhibiting high vulnerability regarding disastrous natural events, such as floods and earthquakes. Floods are expected to further increase in the MED region, as a result of climate change. As far as earthquakes are concerned, MED is a high seismic area, with a high density of seismic events being located in the southern part of EU countries and the Aegean Sea.
- An *urbanization hotspot*: Mediterranean region is one of the world's most populated areas, showing an intensive and steadily increasing urbanization pattern. Such a trend results in a range of severe impacts relating to energy consumption, water resources, air pollution, traffic, soil sealing and respective loss of arable land, etc.
- A *solid waste generation hotspot*: in the MED region is generated *almost half* of EU waste, which shows a further increasing trend (15% growth of waste generation in the southern Mediterranean over the last decade) as a result of the escalating population and the increasing consumption pattern. With EU targeting a 70% recycling rate of household waste by 2030, less than 10% of the Mediterranean household waste collected is currently being recycled (EEA 2015). Waste management needs significant improvement, but a new culture is also required through educating local population towards a more rational behaviour in this specific issue.
- An *economic recession hotspot*: debt crisis of European countries has led to a deep recession, affecting in a more severe way the Mediterranean countries. Austerity measures, declining earnings, but also high rates of unemployment have burdened households' incomes and have led, among others, to: the collapse of aggregate demand; the intensively increasing bankruptcy rate of small and medium sized enterprises, further worsening an already preexisting high unemployment rate; and the increase of the number of people living below poverty level.
- A *brain drain hotspot*: poor economic performance, combined with the economic recession affecting Mediterranean countries has had, and continues to have, severe social consequences. Youth unemployment reached 'record' levels on both rims, with many countries recording unemployment rates between 20 and 30% (Plan Bleu 2006). As a result, a considerable number of young, highly qualified scientists are migrating in search of a more promising professional life and future, marking thus the currently evolving brain drain phenomenon.

Based on the above discussion, it seems that cities and communities throughout the whole Mediterranean region have been trapped into a resource-intensive model of development that renders them quite fragile in front of the current global challenges. This statement can be sustained by relative studies, proving the fact that the ecological footprint of each country in the Mediterranean Basin exceeds nowadays ecosystems' resource renewal potential (CEPF 2010). Not having so many options to revert the whole undesirable situation, it seems that the necessary *trend-breaking* efforts towards decreasing communities' ecological footprint can be supported by recent ICT developments and the emerging *smart city paradigm*. Incorporating this into integrated mitigation and adaptation urban but also rural strategies, urban and rural regions can cope with resource constraints and succeed to pave the way towards a more promising and qualitative life for both local population and visitors. And this has to be carried out in a rather hard period in terms of economic recession and scarcity of financial resources, factors that place at stake efforts of small and medium-sized Mediterranean cities and island communities to go smart.

2 Why Mediterranean? Why Small and Medium-Sized Cities and Island Communities?

The effort undertaken in this book has a specific *geographical focus* in the Mediterranean area. The reason for this lies on the value all contributors place on this region, and the previously presented—social, economic and environmental—peculiarities this area exhibits; as well as the largely looming future perspectives of the specific area in the light of current global challenges, as these are predicted by various studies around the Mediterranean future state.

Moreover, the book has a specific *focus on small and medium-sized cities and island communities* in a smart city perspective. This is largely justified by the:

- Large *number* of these type of cities spread around the Mediterranean Sea;
- *Island configuration* of the area and the need to cope with additional *barriers* (e.g. natural isolation), hampering equal access to services, opportunities, etc.
- Role as globally appreciated *natural and cultural heritage nodes*, developed by close interaction and historical/cultural bonds shared by the Mediterranean cities through centuries, rendering them, among others, attractive tourist destinations on a global scale.
- Role as nodes of interaction in the context of *sea routes—the MED port cities*—crossing the Mediterranean Sea, thus gaining importance as commercially attractive spots; while placing also additional problems and sustainability challenges that such a role entails.
- *Commonalities* of the general features of MED cities and communities, particularly their human scale, livability and social cohesion, conviviality of their neighborhoods, and their geographical cohesion and historical character, factors that constitute an ideal of sustainable urbanism in many ways.

- *Shared destiny* in respect of a number of challenges related to climate change, migration, deterioration of sea environment, austerity, water scarcity etc., which underline the necessity of cooperating and implementing "smart" solutions tailored to their attributes in order to jointly create conditions for a more sustainable and smart resource management pattern.
- Role that small and medium-sized city environments can play in the well-being of their own inhabitants but also the surrounding rural populations.

Grounded on current studies and literature around the Mediterranean area, mostly the EU part, this section attempts to briefly illuminate a few quite important issues that advocate the choice *of small and medium-sized cities in the Mediterranean territory*, mainly addressing their *particularities*, which are setting the framework of Mediterranean cities as a whole. These are shortly presented in the following and relate to the:

- Small and medium-sized cities
- Island complexes in the MED Sea
- Port cities
- Coastal cities
- MED cities as Cultural/Tourist nodes

Small and Medium-sized Cities Small and medium-sized cities represent nowadays a distinct attribute of the European settlements' network with the majority of cities falling into this category. Indeed, a recent study by Dijkstra and Poelman (2012), exploring the European network of cities, reveals that from a total of 828 cities of the European territory (cities in EU-27 plus Iceland, Norway, Croatia and Switzerland), *688* (almost 83%) *fall into small* (50,000–100,000 inhabitants—420 cities) and *medium-sized cities* (100,000–250,000 inhabitants—268 cities) (Fig. 1a); while *305* (almost 37%) of those small and medium-sized cities *lay in the EU Mediterranean region* (Fig. 1b).

Small and medium-sized cities and especially island communities in the Mediterranean, but also in Europe, are somehow *lagging behind* in terms of "*going smart*" *initiatives*, when compared to respective smart developments of larger European cities. They are in most of the cases the "*late comers*" in terms of adoption of innovative technologies, governance and financing models, which could enhance their potential for grasping smart cities' opportunities for sustainable urban management. Building momentum for those cities in the specific area seems nowadays to be of crucial importance for their survival and flourishing, as well as for enhancing their potential to cope with the impacts of economic recession, by establishing new opportunities for innovation, job creation and reversal of the brain drain trend. Furthermore, experience gained from this effort can, in perspective, uncover hidden potential of small and medium-sized cities in EU as a whole, a fact that can positively affect prosperity of regions and population of the European territory.

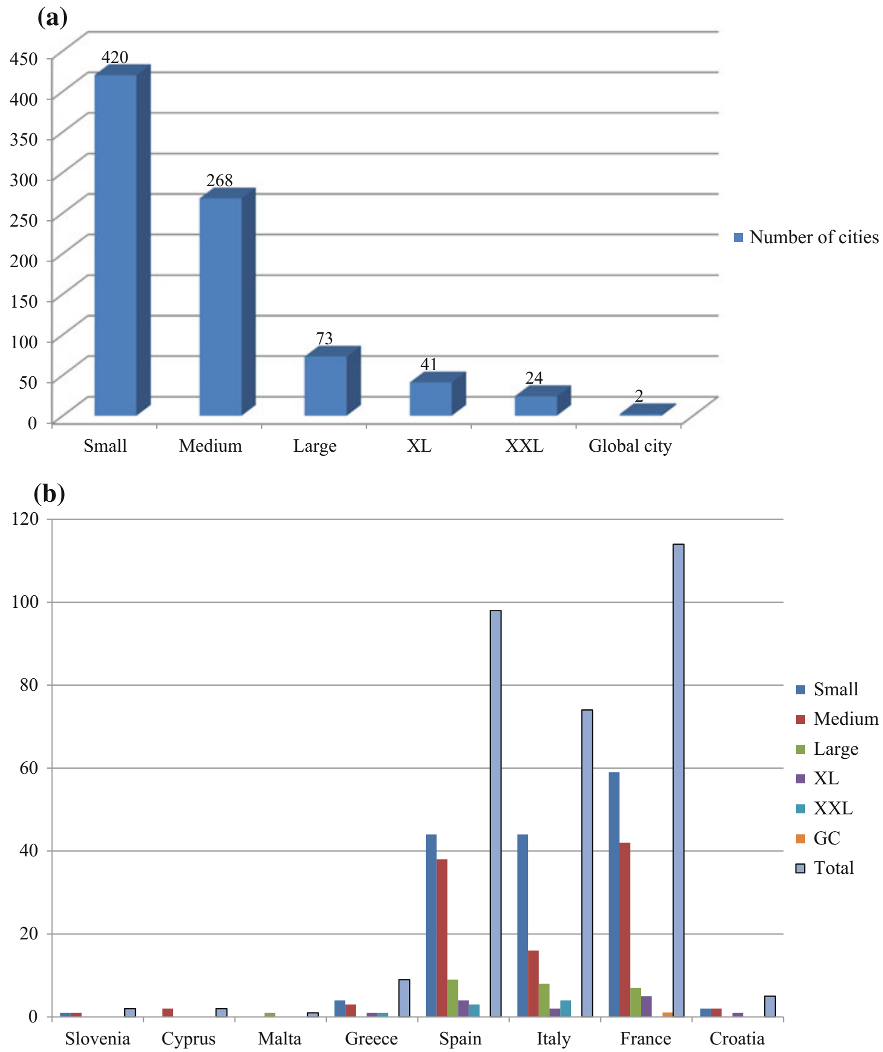

Fig. 1 EU Cities. **a** EU cities per size (EU-27 plus Iceland, Norway, Croatia and Switzerland) (Total: 828 cities). **b** EU MED-cities per size and country (Total: 305 cities)

Island complexes in the MED Sea A *second very distinct attribute* of the Mediterranean territory is the *large complex of island communities*, present in the MED Sea (199 islands with surface larger that 5 km^2) (Fig. 2). The majority of them are spread in the Aegean and the Adriatic Sea; while almost half (50.7%) belong to the Greek state.

Islands in the Mediterranean are considered as pieces of land disposing quite valuable natural and cultural characteristics, which have rendered them important

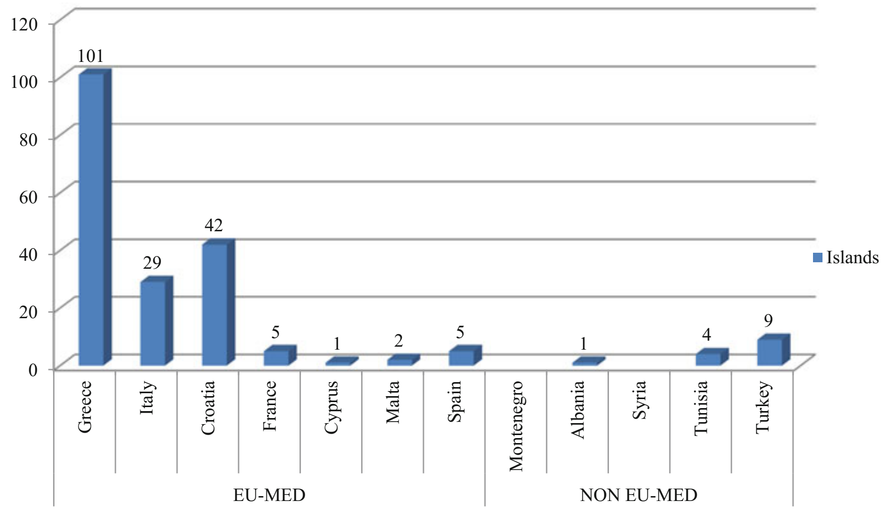

Fig. 2 Number of MED-islands per EU and non-EU country (islands with surface > 5 km^2)

nodes for tourist development. Indeed tourism constitutes nowadays a significant pillar of the island economies, but also a sector that is the cause of stress in social and environmental terms (Taberner and Manera 2006). At the same time, they are marked by limited size and lack of economies of scale; various types of bottlenecks due to their geographical peculiarity, poorly developed infrastructure and low accessibility to services (transport, health, education, etc.); limited natural, human, economic resources; digitally-illiterate and of low educational level population, etc.

Port cities A *third critical attribute* distinguishing Mediterranean Sea from other parts of the world is the dense ports' network expanding along the coastal part of the area. Throughout its history, the Mediterranean Sea was a heavily used and highly valued transport waterway, with maritime activity being a distinct element of its identity and human presence for centuries. Nowadays, is one of the world's busiest shipping routes, accounting for 15% of global shipping activity; while almost one third of international sea-borne volume originates from or is directed towards the approximately *300 ports* located in the Mediterranean Sea (UNEP/MAP 2012). Between 1985 and 2001, a tremendous increase of 77% was recorded in the volume of ship cargo loaded and unloaded in Mediterranean ports (Abdulla and Linden 2008), a trend that is expected to grow three or four-fold in the next 20 years, with such a growth being mainly marked by increasing ships' size and traffic.

Moreover, ports in the EU-28 handled 400 million *maritime passengers* in 2013. Greek and Italian ports handled roughly twice as many maritime passengers in 2014 as in any other EU Member State, with their 75 million and 72 million passengers respectively accounting for just less than one fifth of the EU-28 total. Denmark (41 million passengers) had the next highest number of maritime passengers, followed by Germany, Sweden, the United Kingdom, France (2013 data), Croatia and Spain, with each handling between 23 and 31 million passengers in 2014 (Eurostat 2016).

Port cities in the Mediterranean are of crucial importance in respect of sustainability objectives. As nodes of local and global importance, they are sources of *economic and social gains* at both the:

- *Local level*, constituting engines of economic growth and development and thus important sources of employment and income; while new opportunities are opening up, emanating from the rising of blue growth strategy and the expected benefits to be reaped by its proper implementation in each specific MED city port.
- *Global level*, giving rise in a competitive edge in international trade due to their attraction as: economic and commercial nodes; global transport hubs and gateways in international transport routes; and homes of powerful industrial clusters, located in port cities and their surrounding areas.

In total, the Mediterranean Sea hosts *99 main ports* with population larger than 50,000 inhabitants, out of which 75 ports are falling into EU countries and 24 in non-EU (data on different ports' population range between 2011 and 2014) (Wikipedia data on MED-ports 2016 and data on EU (MED-)ports from EC 2013) (Fig. 3).

The importance of port cities from the *economic and social perspective* can be grasped by their role as job creation hubs. According to OECD estimations for European port cities, each additional million tons of port cargo creates 300 new jobs in the port region in the near term; while on a global average, one million tons of port cargo in port cities is associated with 800 jobs (OECD 2013), rendering port cities sources of economic gains and jobs' creation in the short and long term.

From an *environmental point of view*, maritime traffic and port installations as well as the whole industrial complex usually built around the maritime sector in port cities has a range of negative impacts, affecting quality of marine and land environment of port cities concerned. These can relate to sea water pollution and underwater noise disturbance, hazardous waste production, air pollution due to maritime traffic as well as the functioning of port-related establishments necessary for serving their needs, traffic congestion around the port area with certain consequences in terms of air pollution and energy consumption, etc. Land use impacts are also an important variable in port development, affecting the functioning and spatial structure of port cities.

Coastal Cities Nested along the lengthy coastal part of the Mediterranean region (46,000 km length), lies a large number of cities, of varying size and peculiarities. Increasing importance is attached to these cities, attributed to their advantageous geographical location and the multiple roles/functions/perspectives that can be attached to them due to this location. This importance is largely justified by their potential to act as developmental poles in both a *green* and a *blue*, currently on-going, growth policy direction.

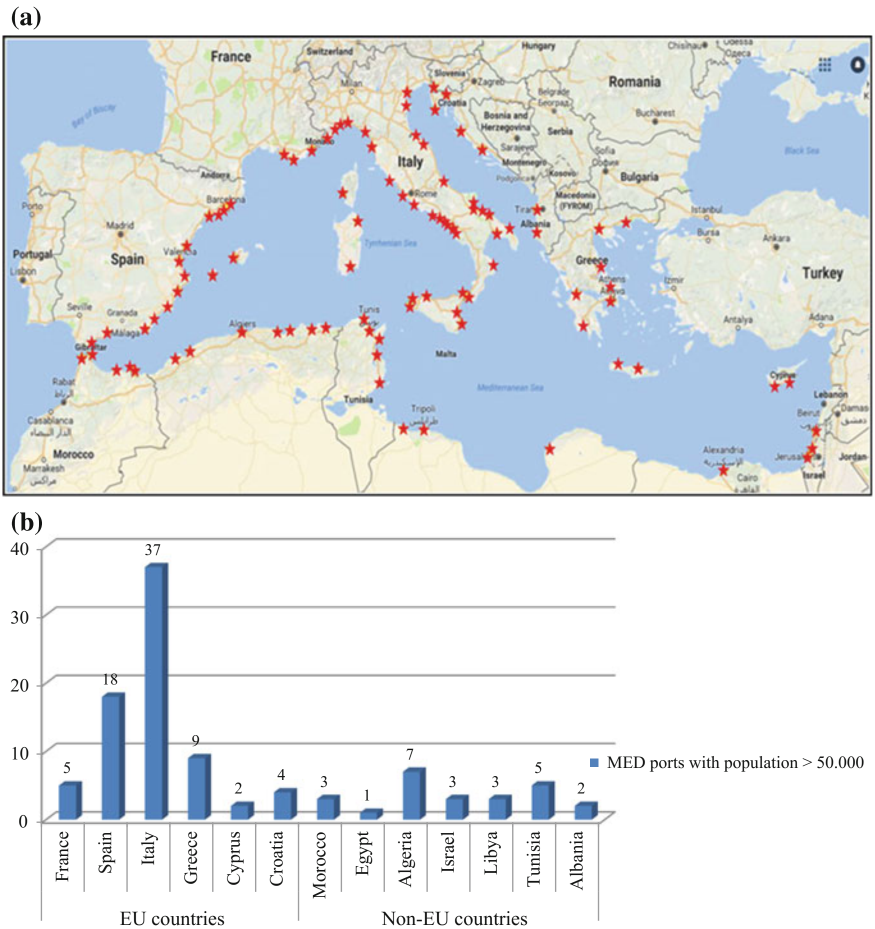

Fig. 3 Mediterranean ports. **a** Spatial distribution of main ports in the Mediterranean region. **b** Number of main ports per country in the Mediterranean region (ports with population larger than 50,000 inhabitants)

More specifically, coastal Mediterranean cities can act as *integrated multi-sectoral economic development hubs*, following: *green development paths* in sectors such as residence, industry, tourism and recreation; and *blue development paths*, hosting a variety of blue growth activities, such renewable energy production, fishing and agriculture activities, activities based on the exploitation of abundant mineral resources, sea transport as well as sea recreation and tourism activities.

Towards this end, a number of issues has been raised as to how sustainability objectives can be ensured and how to cope with land use conflicts emerging from high demand for land from these activities; while new challenges are also emerging in respect of the co-existence potential of various activities, so that a more effective land and resource use can be achieved. Quite important in this respect is spatial planning, incorporating both the land and marine dimension; and engaging a wide variety of stakeholders for a more successful and inclusive decision-making process.

MED region (cities) as cultural/tourist hub(s) The Mediterranean region in general (both northern and southern shores), but also Mediterranean cities in particular, hold a major appeal for the *tourism/leisure* market, rendering them by far the most attractive and highly appreciated tourist destinations at a global level; and the world's most visited regions. The Mediterranean area, mostly in its coastal part (seaside summer holidays), attracts almost one third of the world's international tourist flows (300 million in 2008 and predicted 368 million by 2020); and generates more than a quarter of international tourism receipts. This picture is expected to follow an ascending trend, whereas tourist flows are predicted to reach 500 million international tourist arrivals by 2030 (UNWTO 2013). Current but also future predicted developments in the tourism sector play a vital role in local economies, rendering tourism a pillar of local economic growth and employment; and a major player in a country's external balance of payments (ACE 2012).

Mediterranean's coastal areas are mostly visited for holiday and leisure purposes, with cultural urban tourism, coastal and maritime as well as cruise tourism being the prevailing tourism forms appearing in the region. Recently, other tourism forms are gradually gaining ground, such as health or professional/business tourism and alternative tourism forms such as ecotourism, religious tourism, business tourism, conference tourism, etc., contributing to the diversification of the tourism package and the gradual removal of seasonality, being a dominant attribute/problem of the tourism sector in this specific region.

3 Great Challenges Ahead—Vulnerabilities of the MED-Region

The Mediterranean Region is in the present millennium in front of a number of great challenges. Grounded on current more specialized studies, this section makes an effort to summarize and roughly sketch the '*hot*' *issues* that are nowadays considered as the challenges ahead in this specific area, with cities playing an important role for both the creation of relative problems but also their solutions in the light of both behavioural as well as technologically-enabled policy directions regarding these solutions.

A *first critical challenge* refers to the rapidly growing *urbanization pattern* in the Mediterranean area that proceeds with a rather faster pace compared to the rest of the world. This pattern has actually shown a tremendous increase during the last half of the past century. An indicative picture of this phenomenon is provided by Plan Bleu (2006), showing that the number of cities with 10,000 or more inhabitants has exhibited a dramatic increase from 1950 to 1995 (from 1923 to 3392

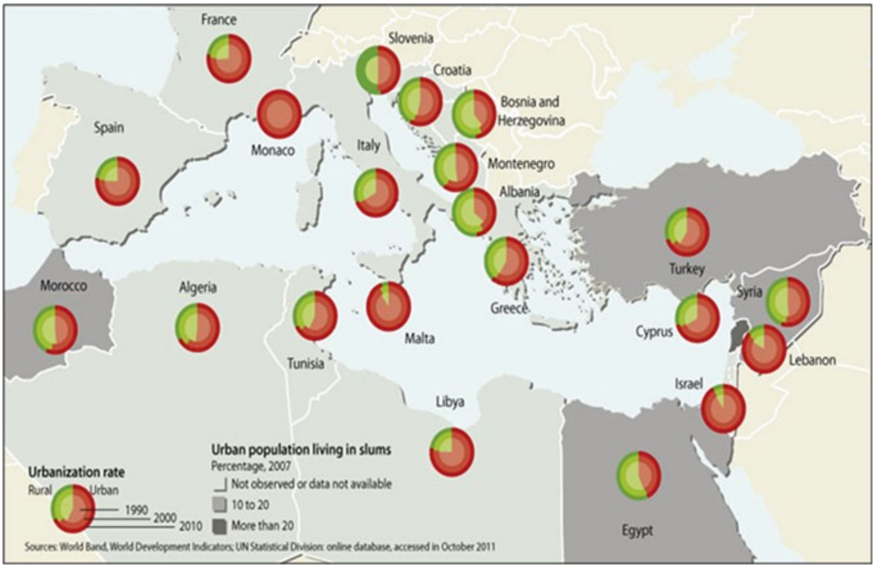

Fig. 4 Evolving urbanization pattern 1990–2010. Reproduced from GRID-Arendal (2013)

cities, an increase of 76%). Same picture is provided by ARLEM (2015), where it is depicted that in the time span 1970 and 2010, the urbanization rate around the Mediterranean increased from 54 to 66%, with the southern and eastern Mediterranean part being urbanized more rapidly than the rest of the world. The above evidence in fact reflects the spectacular rise of urban population and a steadily increasing urbanization pattern in the Mediterranean area, further continuing in the third millennium (Fig. 4).

Nowadays the Mediterranean region hosts a population of approximately 480 million people, who live across the three continents surrounding the Mediterranean Sea. This population has exhibited *fast increasing rates*, mostly noticed in the European Neighborhood Policy (ENP) South Group countries, i.e. Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria and Tunisia (Fig. 5). Projections of population trends until 2050 (United Nations 2009) show a certain population stabilization in the northern (EU) rim of the Mediterranean, while population increase in the southern and eastern part is expected to follow a rapidly ascending order.

Almost one-third of the Mediterranean population is concentrated along its coastal regions. Moreover, more than half of this population (250 million people or 55% of total population) resides in coastal hydrological basins, with this share escalating to 65% in the southern region of Mediterranean (around 120 million inhabitants). Population increase results in an uncontrolled urban sprawl, partly taking the form of informal settlements, which are mostly associated with a variety of environmental, social and economic problems and degrading environment as

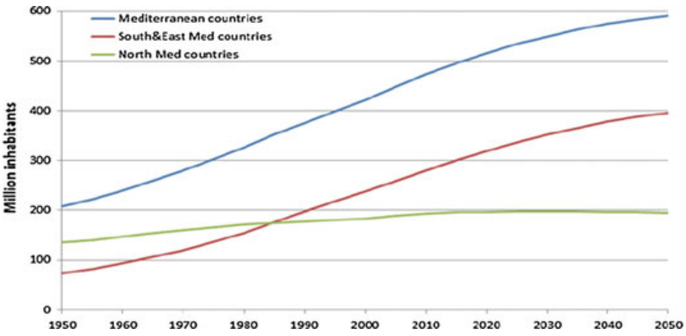

Fig. 5 Growth of population in the Mediterranean—Time span 1950–2050. Reproduced from United Nations (2009)

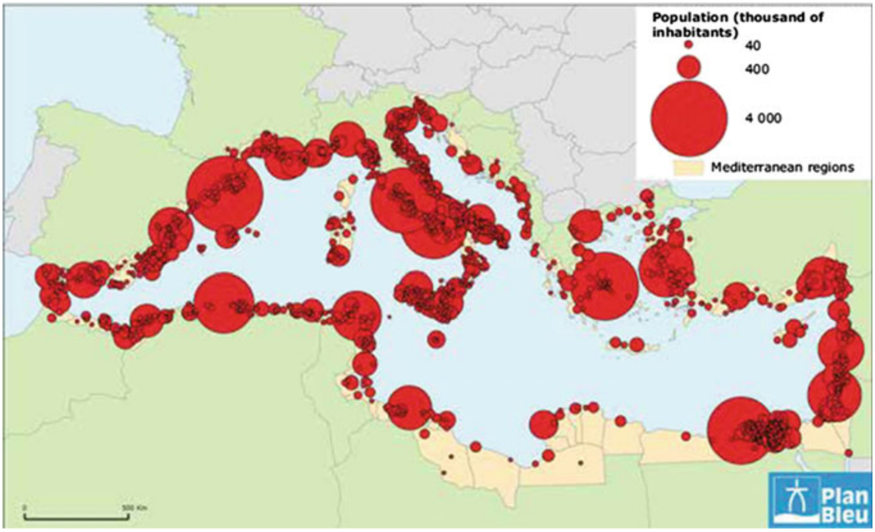

Fig. 6 Population of coastal Mediterranean cities in 2013. Reproduced from EEA and UNEP/MAP (2014)

well as lack of sufficient service and infrastructures; while at the same time, such settlements become the usual "victims" of various climate change impacts e.g. floods, resulting to acute devastations and even life loss.

Of importance is also the fact that a large part of the coastal area of Mediterranean is urbanized (25,000 km out of the total of 46,000 km of coastline), with *coastline urbanization* having already exceeded a *critical limit* (ACE 2012). Evidence shows that the urban population in all riparian Mediterranean countries grew from 94 million in 1950 (44% of total population) to 274 million in 2000 (64% of total population), an increase that challenges stability of the local resource balance (Fig. 6).

Quite distinguishable urbanization patterns are exhibited in the southern and eastern part of the Mediterranean—*the most rapidly urbanized part of the world*–, where 74% of population is expected to become urban by 2025 (Plan Bleu 2006). Lanquar (2013) links high urbanization rates of this part to coastline urbanization, associated with rapid tourism development, which evolves quite larger in annual rates than the northern Mediterranean rim [growth rates of international tourist arrivals in the northern Mediterranean rim (Southern European countries) in the time span 1995–2020 (observed and projected) is 3.8%; while in Eastern Mediterranean climbed to 6.9%] (UNWTO 2000: 54). This holds true for example for Tunisia, which has urbanized large parts of its coastline; Morocco that has opened up new beach resorts—the Mediterranean Pearl—, Turkey and other Eastern Mediterranean countries as well. Such a development of *mega-destinations* in the coastal part largely contributes to rapid urbanization and land use conflicts along the coastline, while it certainly places a huge burden threatening also the marine ecosystem.

Rapidly growing urbanization seems to be nowadays a *major risk* in the Mediterranean coastal part, leading to an *ecological overshoot*, with demand for products and services exceeding ability of local ecosystems to renew them; rapid expansion of urban land use and soil sealing through the replacement of arable-pastoral land by urban development and infrastructures; but also considerably spoiling of the social and cultural environment. At the same time, emerging economic development patterns that are largely designed for mass tourism put in question the stability of the economic profile of the region by exposing it to risks inherent to high vulnerability of this sector with respect to a wide variety of external to the area factors; and placing a remarkable stress on local resources (e.g. water, energy) but also infrastructures (transport, waste management, etc.) that is, furthermore, highly defined by tourism seasonality.

Another quite crucial challenge for the Mediterranean, as various studies reveal, is *climate change*. Extreme weather episodes are increasing in frequency and intensity worldwide; while the impacts of climate change affect all three pillars of sustainability, i.e. environmental, social and economic pillar, with Mediterranean region being one of the most vulnerable regions to global warming (ARLEM 2011). Indeed in IPCC (2007) it is stated that the rise in average temperatures in Europe will be greater than in the rest of the world, affecting winter period in northern Europe and *summer period in southern parts of the European continent*. In agreement to this statement is UNWTO and UNEP study stating that "*… the largest warming is likely to be in northern Europe in winter and the Mediterranean area in summer*" (UNWTO and UNEP 2008: 68).

As a result, the Mediterranean part will be affected also in respect of precipitation patterns, experiencing a significant drop in the number of rainy days in most of the Mediterranean regions, thus resulting in increased *risk of drought*. Although uncertainty and difficulty in getting reliable climate models at the regional level is inherent, it is clear that *water scarcity*, already experienced in the Mediterranean, will worsen, followed by extensive land *desertification*. Such a prospect is nowadays considered as one of the greatest challenges in the Mediterranean region, with

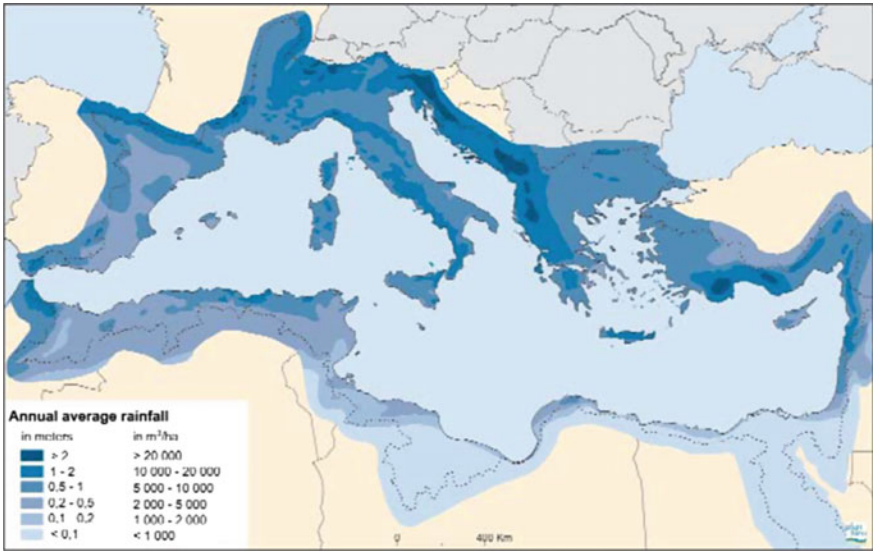

Fig. 7 Annual rainfall distribution in the Mediterranean. Reproduced from Margat (2008)

undoubtedly serious environmental, social, economic and political repercussions (IPCC 2007).

Due to climate change, the Mediterranean is already facing the reality of a water crisis in many of its areas, challenging sustainability objectives of these regions and livelihoods of their people, but also stability of their ecosystems. Considerable driving forces of this crisis are mainly: the increase in population and the accelerating urbanization rates; the heavy reliance on tourism but also on a water-intensive agricultural sector; and the climate variability and change, which have considerable impacts on precipitation levels and increasing drought frequency.

Scarcity of water resources is gradually gaining a dramatic importance, rendering the Mediterranean home of the 60% of the world's population that is classified as living in '*water poverty*' (less than 1000 m^3 of water available per capita per year) (GWP 2012). Since renewable freshwater resources (both surface and groundwater) are not uniformly spread over the Mediterranean region (see Fig. 7), with their current distribution favoring northern rim's countries, a large number of Mediterranean population (almost 20 million people), mostly inhabitants of rural areas in the southern and eastern part, have even no direct access to drinking water.

As noticed in GWP (2012), the most *water poor* Med-countries are Cyprus, Israel, Libya, Malta, the Palestinian Territories, and Tunisia, receiving all together less than 1% of the total freshwater resource of the Mediterranean region. Annual precipitation for example ranges from 1500 to 2000 mm in certain northern Mediterranean areas, such as the Alpine and Pyrenean regions, while in some southern Mediterranean countries these barely reach 100 mm, approximately 10% of the total precipitation (EEA and UNEP/MAP 2014). Calculation of

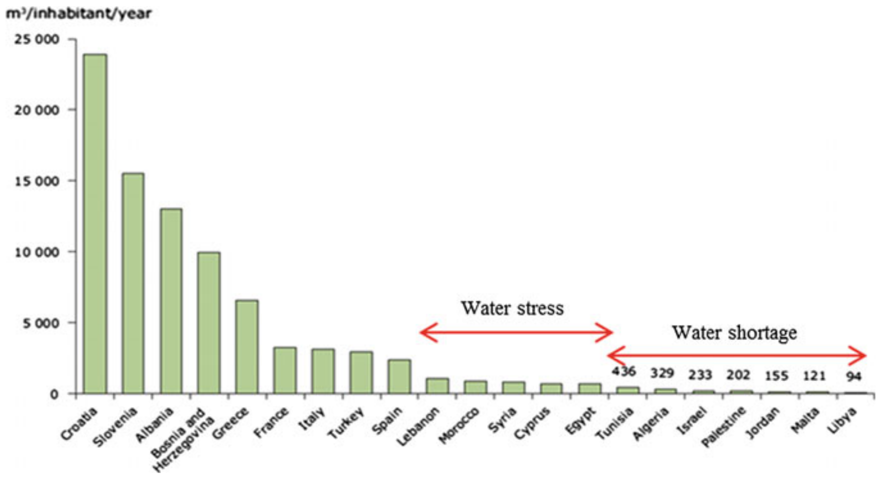

Fig. 8 Water resource availability (m^3) per inhabitant per year in Mediterranean countries. Reproduced from EEA and UNEP/MAP (2014)

Falkenmark 's (1989) *water stress indicator*, a measure for available water resources per capita per year, reveals that the majority of the southern and eastern coastal parts of the Mediterranean countries are in "*water stress*", with less than 1000 m^3/capita/year. Also in Mediterranean states like Algeria, Israel, Libya, Malta, Tunisia and the Gaza Strip, water stress indicator plummets to half—500 m^3/capita/year—a critical state that is characterized as "structural shortage" (GWP 2012), implying a severe *water shortage* situation (Fig. 8).

It should also be stressed the distortion of normal yearly precipitation patterns both intra- and inter-annually, as an outcome of climate change impacts that result to periods of severe drought, followed by episodes of torrential rain in the specific area (EEA and UNEP/MAP 2014), both with catastrophic results in all sustainability respects.

Low precipitation levels combined with high temperatures and respective high water evaporation rates, as consequences of climate change, lead to *water shortage* in the Mediterranean region, which is dramatically felt particularly in the southern MED-countries. The situation is exacerbated by the lack of a balanced water demand and supply regime, as a result of the development pattern followed (mass tourist development, agricultural development heavily relied on irrigation, etc.), where a high pressure is exerted on available water resources. Taking into consideration the climatic conditions and the duration of dry season, especially in southern MED-countries, as opposed to the seasonal shortages in northern Mediterranean countries, "annual drought" conditions are created in these areas (EMWIS 2007).

Water scarcity is further exacerbated by the rapidly evolving urbanization pattern, the specific policy choices as to mass tourist development in such regions (e.g. the 'mega-destinations' pattern) as well as the still highly dependent on irrigation agricultural cultivation pattern. Coping with that vital for quality of life, health of ecosystems and biodiversity as well as economic development challenge implies an indispensable need for a more informed, sustainable and integrated management of water resources. This has to set up a *sustainable and smart water management system* that combines both *sustainable* (water policies, land use policies, sectoral policies, increasing awareness policies, education policies etc.) as well as *smart water management policies*, using smart technologies for a more effective and efficient water management and monitoring, ensuring that people's needs today, tomorrow and beyond are met.

Various studies on climate change impacts and vulnerability of regions as to this respect classify the Mediterranean region as one of the main climate change *hot-spots* (Giorgi 2006; ARLEM 2011). As such, it has already faced problems of water stress and extreme climate events, such as higher flood levels and more prolonged droughts, higher temperatures, rising sea level, more frequent storms, more frequent river floods, etc. As such studies claim, climate change will most probably exacerbate these problems, resulting in significant human and economic losses (EEA and UNEP/MAP 2014). More specifically, according to the International Panel on Climate Change—IPCC (2013), a temperature rise of 2–3 °C is expected in the Mediterranean region by 2050; and of 3–5 °C by 2100. Increasing temperature is likely to be accompanied by a further decrease in the level of precipitation, thus worsening water stress situation in this area.

Climate change impacts seem to be more pervasive in *coastal and island tourist destinations*, i.e. the majority of regions in the Mediterranean areas, taking the form of storms and extreme climatic events, coastal erosion, physical damage to infrastructures, sea level rise, flooding, water shortage and water contamination (UNWTO and UNEP 2008); while high *vulnerability* of these regions is often coupled with a low *adaptive capacity*, especially in developing countries (Stratigea and Katsoni 2015). The high vulnerability of *island regions* has also to be taken into consideration in the light of tourism's strong *seasonality* (mainly mass coastal tourism in peak summer periods), as in many island and coastal destinations the peak tourist season coincides with low water regimes in dry periods, aggravating thus water management and environmental issues (UNWTO and UNEP 2008). Indeed island regions, despite their low contribution to the greenhouse effect, they are exposed to high climate change risk. High climate change vulnerability coupled with low adaptive capacity seen in Mediterranean islands makes them one of the most susceptible to climate change areas of the world (Sauter et al. 2013). Main risks relate to higher temperatures, changed rainfall regimes, weather extremes, and sea level rise (Fig. 9), with evident impacts on their social, economic and environmental status.

As most of the coastal part of the Mediterranean is heavily depended on tourism, i.e. a highly *climate-sensitive* economic sector, climate change impacts are expected to largely influence this region. Indeed, climate change can affect all types of tourist activities and destinations, i.e. summer or winter tourist activities and respective coastal, small islands or mountainous tourist regions in the area, placing their position in the tourism market questionable. Changing climate and weather patterns

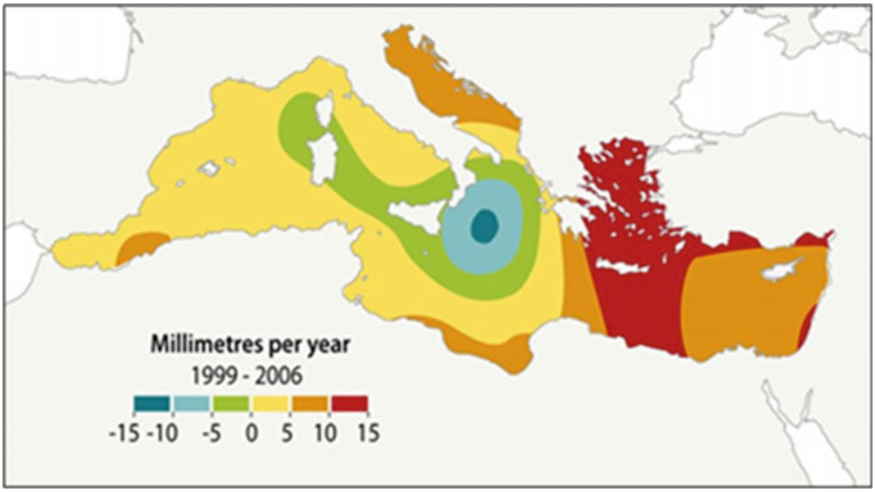

Fig. 9 Vulnerability of MED-islands due to sea level rise - Sea level variations 1999–2006. Reproduced from UNEP/MAP (2012)

in the Mediterranean will in the future be of decisive importance for the development of the tourist sector (UNWTO and UNEP 2008), as these may considerably affect tourists' comfort and thus travel decisions while, in extreme cases, they can even threaten travelers' safety, as past experience has shown (tsunami, floods, excessive heat, etc.) (Stratigea and Katsoni 2015).

As various researchers also notice, *migration due to climate change* will in the future largely affect migration movements from the southern to the northern parts of the Mediterranean area. Middle East and Africa climate change impacts, according to climatologists at the Strauss Center project on Climate Change and African Political Stability (Strauss Center 2016), Texas, have already affected weather patterns; and have contributed to an increased frequency of natural disasters (e.g. flooding, drought), placing survival of local population at risk due to the desertification of agricultural land and the severe impacts of heat waves on crops and animal grazing. Changing weather patterns favor migration to less climate change affected areas and urban centers, changing thus the geography of population distribution within countries and continents and favouring urbanization. A new class of migrants, the "*climate refugees*", is going to affect less exposed to climate extremes areas; and it seems that it will be a challenge for Europe of today and tomorrow, with yet unknown consequences.

A crucial issue for coping with challenges emerging in the Mediterranean has to do also with capabilities of *human resources*. In this respect, every single effort has to take into consideration the current *population mobility* in this region; and the quantitative and qualitative changes in population structure this entails. The Mediterranean area is on a great move in this respect, which may imply a transition to a more critical, from the point of view of human resource potential and capabilities, state for dealing with MED hot spot issues. This is the outcome of two, of different in origin, very important in- and out-migration movements that are expected to affect Mediterranean regions in the years to come. The *out-migration movement* is related to the current severe economic crisis beating the northern rim of the Mediterranean (EU Mediterranean countries) that has allowed for pretty high unemployment rates and decrease of job opportunities; and the dramatic loss of valuable highly-qualified young people in these countries, known as the *brain drain* phenomenon. The *in-migration movement* on the other hand or better known as a *migrant tide or crisis* witnessed during the last years, which is actually testing the political and social structure and stability of Europe in many respects, is associated with the on-going political crisis in countries of the southern Mediterranean rim that causes mass movements to the northern MED-part with dramatic social, economic, political and environmental consequences. Strong migration patterns from south and eastern to northern Mediterranean regions, but also the resistance of many EU countries to serve as hosts counties of those migrants, leaves northern Mediterranean countries with severe multiple problems, but also a changing population structure that, apart from tensions, can eventually lead to a certain deficit in human resources capable of handling, in an effective and scientifically sound way, the future challenges and hot issues of the area. Destabilization of population pattern, taking place in both origin and destination Mediterranean countries, is a big issue for all MED states involved, the extent, the final outcome and the impacts of which are yet unknown.

4 Discussion

Intensively evolving urbanization trend in the global and European environment in general and the Mediterranean region in particular results in the overpopulation of urban environments. Such a trend is nowadays considered the "… *defining feature of the 21st century*" (Suzuki et al. 2010: xv); but also a great challenge ahead, questioning achievement of sustainability objectives of cities. The outcome of urbanization can be perceived both: *positively*, with urban areas being considered as the backbone of the European and Mediterranean economy and development, and places that can provide *solutions* to current environmental, social and economic challenges by boosting creativity and innovation; and *negatively*, with overcrowded urban areas being conceived as the *source* of contemporary challenges and risks, due to the excessive use of resources (e.g. energy, water, land), pollution, congestion, irrational consumption patterns, overproduction of waste, unemployment, segregation and poverty, migration, etc. (Stratigea et al. 2017).

In the shared vision of the European city of tomorrow, future cities are considered as (EU 2011: VI):

- places of advanced social progress, with a high degree of social cohesion, socially-balanced housing as well as social, health and education "for all" services;
- platforms for democracy, cultural dialogue and diversity;
- places of green, ecological or environmental regeneration; and
- places of attraction and an engine of economic growth;

or stated otherwise, cities represent a "*promise for the future*", built upon concepts such as freedom, innovation, creativity, opportunity and prosperity (Schaffers et al. 2012), seeking to fulfill sustainability objectives for future urban development.

The above vision is far from the present reality as well as the probable future, as this is predicted by past and current developments and trends in Europe but also in the Mediterranean area. Actually previously described aspects of this vision constitute "*targets*" to be reached within the general planning goal of *sustainable urban development* which, under the present circumstances, is acquiring an exceptional importance; and lies at the heart of policy makers at various decision-making levels.

Main issues raised for policy making in the Mediterranean context are (Stratigea 2012; Tao 2013; Stratigea and Panagiotopoulou 2015):

- The pace of *urbanization*, especially in the coastal parts that are highly threatened by climate change impacts and mono-sectoral (mass tourism) patterns of development in many coastal cities of the region;
- *Climate change* challenges that are highly threatening sustainability of Mediterranean urban and island ecosystems;
- *Demographic aspects* (growing and ageing population) and an evolving population *in-migration* (spatial concentration in urban environments, abandonment of rural land);
- Irrational *consumption patterns* and high rates of consumption of non-renewable resources (land, energy resources, etc.);
- Increasing *social cohesion problems*, which are expected to further deteriorate by an evolving migration crisis that is triggered by political instability, economic recession, wars, climate change impacts, etc. in many neighborhoods of the Mediterranean region (and not only in that).

The "*smart, sustainable and inclusive growth*" direction, lying at the core of Europe 2020 agenda, delineates distinct lines of policy action in pursuing urban socio-economic development in the third millennium. Such a direction places *sustainability* as the flagship or the ultimate goal to be reached by urban policy endeavors. Moreover it shows the "*means*" i.e. the radical technologies and their applications as the tools currently available in the hands of policy makers and planners in pursuing sustainability objectives; and the need to reassess sustainability strategies and render them more "smart" and thus more efficient and effective in the effort to plan, implement, manage and monitor sustainable urban futures. Finally, it delineates the "*approach*", i.e. the necessity for a more inclusive, cooperative and participatory perspective in decision making-processes in the urban context, taking into consideration all actors incorporated in each specific local ecosystem.

Added to the above directions is the one of *resilience*, i.e. the capability of Mediterranean cities to absorb *future shocks* to their social, economic, and technical systems and infrastructures, which are already visible in many parts of this valuable region.

At the heart of the Europe 2020 agenda lies, among others, the concept of *Smart Cities and Communities (SCC)* (EC 2012) that is recently evolving as a result of the radical technological advances and their applications; and constitutes a *new force* for effectively managing various urban functions in a highly connected, knowledge- and information-intensive era. Promoting smartness seems nowadays to be an effective and favorable, to many cities, strategy for steering economic competitiveness, environmental sustainability, and livability (Stratigea 2012; Lövehagen and Bondesson 2013; Stratigea and Panagiotopoulou 2014, 2015; Stratigea et al. 2017); and mitigating the impacts of urbanization trends and the consequent overpopulation of cities (Chourabi et al. 2012).

Further elaboration on the smart city (SC) concept brings to the fore its different interpretations, falling into two main streams namely: the *instrumental*, considering smart city as a set of ICT-enabled products, services and systems mostly pushed by technological advances and the market; and the *normative one*, visioning smart city as a strategy towards a desired outcome, where technology is used to further enhance sustainable policies by properly integrating city attributes/functions, and increasing their efficiency in the effort to pursue smart and sustainable development end states (Stratigea et al. 2017). To stress the importance of sustainability in the smart city context, the term *Smart Sustainable Cities (SSC)* has been conceptualized by the ITU-T Focus Group (ITU-T 2014), considered as a variant of SC, *a concept having at its core the goal of sustainability*, which additionally attempts to build upon the synergies created between the instrumental and the normative view.

Different city contexts have different sustainability target sets and related policy paths to fulfill them, largely dependent on their current achievements of sustainability objectives and strategic priorities, vision for the future and selection of relevant—socially and culturally driven—smart and sustainable policies, possible (based on available resources) pace of change, level of ICT infrastructure and readiness, etc. (Stratigea et al. 2017). Seeking to reach smart and sustainable cities' futures in the Mediterranean implies different policy paths for different types of cities. In this respect, there is a need to take advantage of new planning approaches and their implementation in decision-making processes for ending up with distinct policy decisions, relevant to those different Mediterranean city contexts. Such approaches should be (Stratigea 2015; Stratigea and Panagiotopoulou 2015; Stratigea et al. 2017):

- *Holistic and integrated*: taking into consideration functional and sectoral, but also different neighborhood realities of each Mediterranean city context and their interrelationships, thus moving away from *silos planning work*, being till recently a common planning practice.
- *City- and citizens-specific*: technology is not a panacea. The different attributes, problems, identities/cultures, priorities of sustainability objectives, technological

readiness, etc. have to be explored in order to identify the most relevant smart applications that will really add value to the cities' efforts to coping with great challenges ahead.

- *Vision-driven*: a certain vision should be there, as a desired—and inspiring—end state that will motivate cities' actors towards more responsible behavior and commitment; and will ensure successful implementation of plans developed.
- *Inclusive*: it is important to bring on board all relevant actors that can affect, be affected of or contribute to a certain decision; and create new forms of social learning, participation, responsibility and commitment. Multi-stakeholders' engagement is nowadays a prerequisite for increasing awareness, opening up a dialogue among all interested parties, and ending up with more elaborated decisions that are grounded on new values and consensus-building participatory processes.
- *Multi-level governance*: decisions at the city level are made within a certain decision environment that is most of the times framed by higher hierarchically decision-making bodies. In this respect, it is nowadays necessary to establish new models of governance that will assure: interaction and mutual understanding of different decision-making hierarchical structures; and flexible responses to complex problems through inter- and cross-disciplinary approaches, leading to more cohesive and well grounded decisions at each of these specific levels.
- *Foresight*: gathering intelligence as to the potential future developments in a variety of topics/sectors/trends is considered as an important step for identifying and getting prepared as to future discontinuities and challenges, which in turn can support more informed and knowledgeable decisions of today. In coping with complexity and uncertainty of Mediterranean territories' smart and sustainable development, but also developments in the global scenery that affect the future of Mediterranean cities and populations, foresight exercises could provide valuable information and knowledge by engaging different actors, associations, decision-making bodies, lay people etc.

Smart and sustainable city development does not follow a certain pattern and as Bhattacharya and Rathi (2015: 17) state, there is not only "*one size that fits all smart city models*". In fact, current smart city examples exhibit substantial variations in terms of technological maturity, level of ICT infrastructures and type of smart applications; that additionally are deployed for serving the needs of cities of varying spatial scales, sustainability objectives and current state of achievements; geographical and geo-political context in which smart applications are developed, etc. (Stratigea et al. 2017). This holds true for cities in the Mediterranean, where cities belonging to the northern or the southern-eastern rim are confronted with different, even contrasting sometimes, types of problems that need to be treated at the same time but in different ways. Strategies towards SSC need to be devised according to historical heritage, culture, local peculiarities as well as policy structures and practices; while committed, consistent and punctually planned implementation needs to be in place for a "*success story*" to be reached.

Smart Sustainable City (SSC) concept appears nowadays as a promising option and a strategy for coping with challenges ahead for cities in the Mediterranean region. It can also present a *win-win opportunity* for both: *the cities*, in paving smart and sustainable (SSC) city- and citizen-specific development paths; and the *ICT industry players* in grasping a really large market potential in the Mediterranean. Such a strategy, in order to fulfill its goal should:

- Place at its heart a range of smart applications that can effectively cope with main *challenges* faced by Mediterranean small and medium-sized cities and island communities as previously presented.
- Steer *green and blue* development perspectives by adding value or acting complementary to sustainability policies promoted at each specific urban environment.
- Support territorial, social and economic *cohesion* as key development pillars for a smart, sustainable and resilient future of Mediterranean cities.

Needless to say, effective deployment of relevant smart technologies and applications goes hand in hand with a *human-centric approach*, *reflecting and respecting cultural and historical paths* that have been sculpted out by Mediterraneans through the centuries in this exceptional part of the world, our "oikos[1]".

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[1]"Oikos" = Home.

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Spatial Data Management and Visualization Tools and Technologies for Enhancing Participatory e-Planning in Smart Cities

Maria Panagiotopoulou and Anastasia Stratigea

Abstract In recent years the concept of "smart cities" has emerged as a new promising paradigm for urban management, capable of attaining sustainability objectives. The issue of citizens and stakeholders' participation, whose contribution to the collection of empirical knowledge, identification and prioritization of urban inefficiencies as well as selection and deployment of city- and citizen-specific smart applications and policies for coping with these inefficiencies and steering sustainable, inclusive and resilient urban environments, is of critical importance and lies at the heart of this new paradigm. Digitally enhanced environments, supported by Information and Communication Technologies (ICTs) and their applications have marked a noteworthy shift towards e-Planning and e-Participation, setting the ground for more knowledgeable policy-making towards the planning/implementation of smart city solutions that are mostly citizens- and city-oriented rather than purely technology-pushed. The focus of the present paper is on the delineation of participatory e-Planning as a digitally enabled perspective for effectively communicating various planning problems to citizens and stakeholders and actively involving them in decision-making. Along these lines, the most significant tools and technologies are described, which are currently available in planners' portfolio in order for participatory planning exercises to be optimally implemented by successfully integrating spatial planning approaches, public participation and visualization techniques; while the role of Public Participation Geographic Information Systems (PPGIS) in spatial planning is also discussed. Finally, some concluding remarks are drawn as to the key components and obstacles planners are confronted with, while carrying out participatory e-Planning projects in a smart city context.

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1 Introduction

Urbanization constitutes nowadays a rapidly expanding global phenomenon, which, according to United Nations' estimations, is expected to be further intensified by 2050 (Oracle 2011). The impacts of this escalatory urbanization trend are already evident in numerous sectors and urban functions, e.g. intensity of water and energy consumption, increasing volumes of urban waste, traffic congestion, inadequate infrastructures, insufficient energy for satisfying the constantly raising demand, ascending pollution levels, lack of social cohesion, etc. What is fully realized as to the future development of urban environments is that cities are already or will soon be confronted with great challenges, threatening their future sustainability. Policy makers and planners, in this respect, are those in charge of elaborating on these impacts so as to come up with effective and sustainable solutions that can successfully address them. Additionally, the rapidly changing global environment, marked by *key drivers of change* such as overpopulation, climate change and its impacts, water scarcity, poverty, migration waves, etc., renders the overarching challenge of *sustainable urban development* a key planning goal and a moving target in the policy agenda (European Union 2011).

Within such an environment, the radical developments regarding ICTs and their applications that can support a plethora of urban functions and provide upgraded services to citizens, businesses, public and private agencies, have significantly altered a number of scientific fields and relating processes, among which is also *spatial planning*, by providing new approaches, tools and technologies for pursuing sustainability objectives; and broadening the perspective of citizens and stakeholders' engagement in such an effort. The latter is considered by many researchers quite critical for the efficient management of current urban problems (Duany et al. 2010; Bizjak 2012; Seltzer and Mahmoudi 2013; De Pascali 2014; Steiniger et al. 2016).

Intensive and wide ICTs' exploitation in the urban context brings to the forefront the concept of *smart cities*, as innovative urban environments which, through the adoption/use of technology, seek to achieve sustainability objectives and encourage engagement of citizens, businesses and other stakeholders of local ecosystems in decision-making processes. According to the literature review, although numerous "smart city" definitions have been proposed from time to time, a clear and commonly accepted one does not still exist. Some of them are totally technology-oriented, considering ICTs as the dominant developmental lever for urban environments, while others adopt a broader and more integrated approach, incorporating aspects of society, economy, and governance as well as participatory approaches in attaining sustainable urban development objectives (Manville et al. 2014). Despite the aforementioned differences, it is largely recognized that a smart city is a city that uses ICTs in an innovative and efficient way so as to manage urban problems and infrastructures; support competitiveness and local prosperity; and create knowledgeable, aware, creative and active citizens as *carriers of urban change*, an issue that is significantly enhanced through their participation in decision-making procedures.

Within the ICT-enabled environment that a smart city represents, the concept of *participatory e-Planning* is gaining great importance. Participatory e-Planning implies a digitally-enabled planning process which effectively integrates spatial planning approaches, public participation and visualization techniques in an effort to support the cities' "going smart" journey and develop or follow city- and citizens-specific planning solutions fulfilling at the same time needs, expectations and visions, but also sustainability objectives of local urban environments.

Towards this end, the *focus* of the present paper is on sketching the *main portfolio* of digitally-enabled tools and technologies that are available nowadays for implementing e-Planning exercises. In such a context, the next section is briefly describing the rise of participatory planning as a new paradigm, followed by a general discussion on the digitally-enabled planning process known as participatory e-Planning. Next, the delineation of the most important tools and technologies that are at the service of contemporary e-participatory spatial planning is presented. The paper proceeds with the description of the role of Public Participation Geographical Information Systems (PPGIS) in the spatial planning process, while finally some comments on the key components and obstacles hampering the implementation of participatory e-Planning in the context of smart cities are made.

2 The Participatory Planning Paradigm

Planners and decision makers are nowadays confronted with *wicked problems*, i.e. problems that are quite difficult to be solved due to mainly the: incomplete or contradictory knowledge; number of people and opinions involved; large economic burdens these bear; and the strong interconnected nature of these problems with other problems. For example, poverty is linked with education, while nutrition is linked with poverty, and economy is considered a defining factor for nutrition, and so on. According to Balint et al. (2011), confrontation of wicked spatial planning problems is fraught with many difficulties, mainly emerging from two types of uncertainty: the first relates to scientific uncertainty of solutions these problems entail; while the second to the uncertainty as to the way these solutions will be grasped and accepted by the recipients i.e. the various societal and stakeholders' groups, driven by different perceptions, motives, behaviors, etc. (De Roo and Porter 2007).

Coping with wicked planning problems that are common in evolving urban environments has brought to the forefront the need for policy makers and planners to develop or adopt *new ways of thinking*. Such ways is necessary to be grounded on a deeper and multidimensional exploration of current and possible or desired future states of cities and their interrelations, as well as the potential paths linking, in a sustainable way, current state and desired future ends. Moreover, they should be grounded on the exploration of the potential perception of the various planning interventions by different social groups which, taking also into account power relationships within urban environments, can dramatically affect implementation of planning solutions, by either supporting or opposing to planning propositions. Finally, effective management of urban wicked problems in rapidly changing urban environments needs to be based on *new methodological approaches*, which are far away from rational planning thinking of the past; and are capable of exploring *new opportunities* and support *innovative and inclusive solutions* that can efficiently confront wicked problems and ensure wide consensus and commitment to planning outcomes.

Additionally, urban problems need to be solved within a volatile external environment, mainly characterized by *complexity* and *uncertainty* as well as rapid pace of mostly unpredicted changes in all respects, where solutions identified should be implemented quickly, before becoming obsolete. As Friend and Hickling (2011) claim, planners, while seeking solutions to wicked problems, are confronted with *three types of uncertainty*, namely:

- uncertainty related to the *value system* of planning efforts' recipients (values, priorities, visions, etc.), which constitutes the "lens" through which planning interventions are grasped and understood;
- uncertainties as to the developments of the *external environment*—the decision environment—which are framing the context where planning decisions will be made; and
- uncertainty as to the *decisions made*, where the planning problem at hand is largely interconnected with other problems, while a variety of decision-making bodies, at different hierarchical decision levels, are activating and their decisions can affect the effectiveness of planning exercise on a certain problem.

Facing the above uncertainties has pushed forward, among others, the current direction of *participatory planning*, aiming at exploring underlying principles of spatial entities' value systems that constitute the core of planning exercises and will largely affect decision-making processes and outcomes that best fit to these entities (Hennen 1999; Kanji and Greenwood 2001; Pereira and Quintana 2002; Puglisi and Marvin 2002; Mostert 2003; Innes and Booher 2004; Hines and Bishop 2006; Stratigea 2015). Indeed, planning and managing the city in an uncertain and rapidly evolving world and dealing with wicked problems implies gathering of *collective intelligence* (Conklin 2005). This, in turn, entails collection of *distributed knowledge*, representing perspectives, understandings and intentions of various diversified actors that activate and operate within cities. This is largely justified by the diversified perceptions different actors have on what the planning problem is or what constitutes an acceptable solution to this problem. A deep insight into these perceptions as well as an effort to achieve a certain compromise out of them and end up with a *shared view* of planning problems and related solutions, coupled with *commitment* to their implementation is a prerequisite for effective planning nowadays. In order for this goal to be fulfilled, there is a need to address and understand *social complexity*, i.e. the number and diversity of actors (citizens and stakeholders) who are directly or indirectly affected by or can contribute to the solution of a problem and related value systems; and effectively embed this knowledge into the planning process (Conklin 2005).

In recent years, *participatory planning* is considered as one of the leading approaches or a *new paradigm* in planning, fulfilling the goal of peoples' engagement in decision-making and policy formulation in various problems and spatial scales. It actually represents a transition from a *top-down*, largely hierarchical, control- and command-based planning model, to a *bottom-up*, more "*human centric*" structure of decision-making processes, aiming at co-identifying problems and jointly setting up priorities; and cooperating in the elaboration of solutions and implementation of sustainable development strategies and related policy frameworks in order to realize them (Kanji and Greenwood 2001; McGinn 2001; Innes and Booher 2004; Stratigea 2015; Stratigea et al. 2015; Panagiotopoulou et al. 2016). It can also contribute to the collection of remarkable and multidimensional information, which emerges from the cooperation among a variety of actors within highly interactive environments; and can reveal different views, visions, desires, fears, etc. Such interaction, according to numerous researchers (Pereira and Quintana 2002; Puglisi and Marvin 2002; Mostert 2003; etc.), constitutes a major step for the *integration* of different opinions; increases awareness as to shared great challenges ahead; promotes mutual understanding and networking within societies; while it can result in new innovative knowledge production and synergies' creation, capable of coping with wicked problems.

The integration of spatial planning and decision-making processes with participatory approaches is perceived as an important step forward, so as views and expectations of various societal groups to be effectively embedded in the final planning outcome; and uncertainties relating to value systems' exploration and validity of decisions made to be overcome. Furthermore, it marks a transition from traditional consultation of planners with experts to consultation with a wide range of local actors (experts, citizens, local stakeholders, associations, institutions, etc.) that reflects the particular focus of participatory planning on "... *planning with the community rather than for the community*" (Pettit et al. 2007: 22.4).

The above described new ICT-enabled perspectives have pushed forward the growth of *participatory democracy* in urban planning, a transition that implies a more intense use of Web-based interaction among decision makers, planners and local communities. Strengthening participatory context in decision-making at the urban level has led to the current evolution of *spatial governance models*, applied to both urban and regional planning studies (Pereira and Quintana 2002; Zwirner and Berger 2008). Based on these models, new urban and regional planning processes are developed, which are characterized by the wide variety of ICT-enabled local stakeholders' engagement; and are serving different objectives and related outputs, in an effort to deal with *resource scarcity and sustainability goals* in largely wired environments.

3 Evolution of ICT-Enabled Participatory Planning—e-Planning and e-Participation

Rapid technological developments of recent years have driven remarkable changes that have had, and continue to have, broad ramifications from an economic, social, environmental and political point of view (Hackler 2006). More specifically, quickly evolving digitally-enabled environments have initiated *innovations* and *altered processes* in the political, technological, economic, environmental, cultural and social sceneries (Panagiotopoulou et al. 2016). Within these environments, new challenges have come to the forefront for decision makers and planners, a fact that was prophetically questioned early enough by Castells (1992) in his article "The World has Changed: Can Planning Change?"

In coping with wicked planning problems in highly complex and uncertain urban environments, the role of ICTs and their applications is nowadays highly appreciated mostly due to the effective *digital interaction* "*bridges*" these build among decision makers, planners and local societies; and the new potential for managing and visualizing *large spatial data sets*.

Spatial planning processes are particularly complex, combining information and data from different knowledge domains, which furthermore lack homogeneity (e.g. statistical data and spatial data); they are dynamic in nature; and, in general, it is hard enough to communicate these processes to less skilled stakeholders (Hansen and Prosperi 2005). Moreover, participation in spatial planning requires access to information that is strongly dominated by visual media in the form of *maps and images*, with textual description being an important subcomponent of such information (Hudson-Smith et al. 2002). Of great help in this respect is the maturity of GIS that allowed their extensive use beyond very technical environments. This has enhanced the potential for spatial data management and visualization in a GIS environment. Furthermore, Web developments have allowed *interactive Web-based GIS* exploitation as a bidirectional interactive approach (Hansen and Prosperi 2005) that can ensure equal access to information; render participation wider and more substantial due to the better grasping of spatial data and problems; create new perspectives for social inclusion; and strengthen democratic procedures that support efficiency of spatial decision-making (Stratigea 2015; Panagiotopoulou et al. 2016). Interactive visualization and (Web-)GIS applications can be adopted/used in order for various pieces of information to be presented in an understandable way; and the investigation of spatial relationships and problems to be enabled. This way, users' apprehension of a spatial planning problem can be increased, and thus opportunities for essential and value-adding *public participation* can be broadened (Panagiotopoulou et al. 2016).

Current developments towards a *smart city context* are expected to further strengthen *data-intensive* urban planning and policy, mainly emanating from the huge potential offered by the implantation of a "digital skin", i.e. sensors into urban environments (Rabari and Storper 2014) that facilitates *quantitative data collection* on a variety of urban dimensions through networks of sensors. Such a wired environment will also enable the collection of an unprecedented amount of *qualitative data*, a fact that will be supported by the evolving new spirit of participation and the modern forms of digital interaction and crowdsourcing by a variety of actors, such as residents, governments, professionals and businesses, civil society organizations, etc. (Panagiotopoulou et al. 2016). This leads to a remarkable change in planning practice due to also the pervasive role of ICT-enabled e-Planning potential; and relates to the blurring of the discrete roles of planners and urban actors in respect of *information production and consumption* (Hudson and Smith 2002; Roch et al. 2012; Stratigea 2015; Panagiotopoulou et al. 2016), with the traditional role of planners as information producers to be gradually scaling back; while reinforcing the role of various actors in local communities as both producers and consumers—*prosumers*—of information (Wallin et al. 2010; Stratigea 2015; Stratigea et al. 2015).

Qualitative data collection, as many researchers claim will, in the near future, be further enhanced as a result of the currently experienced *participatory revolution* (Davidoff 1996; Fung and Wright 2001; Duxbury et al. 2015). This brings to the forefront the issue of *crowdsourcing* as "*…an online, distributed problem-solving and production model*" (Brabham 2008: 75); or a specific form of public (e-) participation in urban projects (Brabham 2009), serving a *twofold goal* namely to: acquire non-expert data and knowledge for feeding and therefore enriching the spatial planning process; and explore solutions to spatial planning problems and challenges, originating from the public's proposals. In the one or the other form, crowdsourcing can be used for conveying, from local communities to decision makers and planners, empirical knowledge and views on planning problems; identifying positive and negative dimensions of these problems regarding the way they are perceived by communities; rating these dimensions, etc., thus contributing to the *integration* of institutional (decision makers), scientific (planners) and empirical (communities) knowledge; but also *integration* of qualitative and quantitative data, shedding light on tangible and intangible (e.g. cultural) aspects of planning problems (Stratigea 2015; Panagiotopoulou et al. 2016).

The evolving ICT-enabled *interaction patterns* among decision makers, planners and local communities steer changes in the ways political voice and debate as well as decision-making processes for managing urban issues occur, with the ultimate goal of local communities' participation being the: empowerment and engagement of local actors; promotion of collaboration and conflicts' resolution; enhancement of accountability and transparency in governmental procedures; and support of more knowledgeable decision-making, governance and service delivery processes; while at the same time they play an important role in the achievement of resource optimization, sustainability and quality of life (Stratigea 2015; Panagiotopoulou et al. 2016). This interaction pattern seems to largely affect planning and governance aspects, whose effectiveness will be assessed on the basis of the strong and qualitative participation in decision-making they can promote.

The evolution of spatial planning nowadays demonstrates its adaptation to various broad developments as regards its theoretical basis, the tools and approaches adopted/utilized, but also its practice per se (Silva 2010), positively answering thus to the concern of Castells (1992). Today spatial planning, implemented in a globalized environment mainly characterized by uncertainty, complexity and, most importantly, the massive explosion of ICTs, has been pushed forward by effectively reading the new "signs" and taking a further step ahead towards the migration of participatory planning processes to the Web, setting the ground for the emerging *e-Planning* and *e-Participation* paradigms as valuable complements to classical face-to-face participatory approaches (Papadopoulou and Stratigea 2014; Panagiotopoulou et al. 2016). The recently evolving *e-Planning paradigm*, i.e. online spatial planning, focused on: the successful combination of participatory approaches and ICTs; and their incorporation in the (urban) planning discipline. This of course presupposes the existence of adequate technological and organizational infrastructures, in order for unhindered access of social groups to information and related planning services to be ensured, therefore highlighting the vital role of ICTs and their applications as well as the readiness of relating decision-making structures to follow such developments.

E-Planning constitutes a new challenge in the scientific field of spatial planning and "*… an instrument for collective action in the urban arena*" (Silva 2010:4). It can be perceived as an *interaction* but also a *social learning platform*, fulfilling two distinct purposes, namely (Silva 2010):

- facilitate all the work carried out during the various stages of the planning process, marking thus the transition towards *e-Planning*, which is assisted by GIS technologies for managing spatial data (Quan et al. 2001); and the Web for interaction and communication; and
- encourage and broaden public participation during the different steps of the planning process, contributing to the shaping of *participatory e-Planning*. Tools and technologies deployed at this stage offer public the possibility of e-Participation, while interactive Web maps are available so as to both improve information provision to the public and collect information or spatial data by the public (Craig et al. 2002; Goodchild 2007).

In such a context, use of the Web enables online communication among all parties involved, while GIS provide the spatial delineation of planning problems, their possible solutions as well as their impacts, enabling thus the better apprehension of problems at hand and their potential solutions. The above imply the broadening of e-Planning and e-Participation potential regarding all the three discrete planning stages, namely (Khakee 1998; Giaoutzi and Stratigea 2011):

- The *learning stage*: incorporating an in-depth analysis and understanding of the socio-economic and physical context—various layers in urban environments—within which the planning process is taking place; the identification and prioritization of problems inherent in this context; the delineation of respective goal and objectives; etc.

- The *evaluation stage*: structuring and evaluating alternative solutions so as the goal and objectives set to be achieved; assessing alternative solutions and their prioritization as to the goal and targets' fulfillment, together with the assessment of the policy framework which implements the dominant solution.
- The *implementation stage*: implementing the selected planning solution through specific policy options of the previous stage.

ICT-enabled tools and technologies that can be applied to e-Participation in the context of implementing the above planning stages are (Stratigea 2015):

- Tools and technologies for engaging citizens via the Web—e-Participation (applies to learning, evaluation and implementation planning stages).
- Tools and technologies for collecting and managing information, such as crowdsourcing, Web-GIS, etc. (learning stage).
- Tools and visualization technologies for presenting planning solutions and relating impacts, such as geo-visualization tools, Web-GIS, etc., setting the ground for collecting stakeholders' views (evaluation stage).
- Evaluation tools, such as multicriteria analysis for the online assessment and rating of the proposed alternatives by participants (evaluation stage).
- Tools and technologies for disseminating and communicating planning interventions and policies to citizens (implementation stage).

According to the aforementioned arguments, the implementation of e-Planning is closely related to the adoption and exploitation of ICTs in the various planning steps, from the information collection and elaboration stage to that of alternative solutions' building and evaluation, in order to come up with the optimal solution. At the same time, it is also closely related to the use of geospatial databases, which allow the spatial representation of the planning problems (Kubicek et al. 2007), in order for every participant to be fully aware of the problem under study. Finally, it requires an online service delivery system, a quite crucial issue for the successful implementation of e-Planning. Additionally participants, via an e-Planning platform, are given the chance to continuously monitor the progress of various planning steps, but also to be actively engaged in the planning process by expressing their opinions, expectations, aspirations etc.; and elaborating and/or approving planning decisions and relative policies (Shiode 2000; McGinn 2001).

Numerous researchers hold the opinion that the integration of Web and GIS technologies may significantly benefit spatial planning (Shiffer 1995; Kingston et al. 2000; etc.), since the participation of different societal groups is greatly broadened through e-Participation; and relative procedures are rendered "open", supporting this way transparency and liability of decision-making processes. Nevertheless, it should be noted that the use of tools and technologies for e-Participation and e-Planning does not relieve designers of a series of decisions and steps to be followed for the implementation of a participatory process. Such decisions relate to the planning of the participatory process per se, and are associated with a series of questions raised, such as "who benefits from the spatial planning process?", "what is the citizens' role in this process?" or "how communication and interaction among different groups of participants can be enhanced?", "in which stage of the planning process should stakeholders be engaged", "what is the scope of participation", etc. (Stratigea 2015). According to Ferraz de Abreu (2002), for e-Participation and e-Planning, planners must make choices regarding:

- The participatory process per se, focusing on issues such as timing of communication with the public; engagement of the public before, during or after the planning process; delineation of the planning stages in which the public will be involved; type of information planners seek to collect; format of this information (e.g. textual or visual information, comments or sketches on a map, etc.); type of participation they pursue (passive or active), etc. Key questions in this context are: why public should be involved; who should be involved in order for the objectives set to be achieved; how will participants be engaged (choice of classical or online participation tools or combination of both); and when will the public be engaged.
- The type of technologies that will enable e-Participation and e-Planning on the basis of the objectives set and the special characteristics of these particular technologies; the technological and organizational infrastructures that support the entire process; but also the current communication pattern and standards of the specific society, within which e-Planning is implemented.

The tools and technologies that can be used for the implementation of e-Participation and e-Planning are briefly delineated in the following section.

4 Tools and Technologies in Support of e-Participatory Spatial Planning in a Smart City Context

In recent years, the radical technological advances, the plethora of emerging applications as well as the new potential deriving from them for economic growth, environmental protection, social inclusion and quality of life, have broadly supported planners and policy makers in shaping a "smart" sustainable future for urban environments. Moreover, the advent of Web 2.0, which is described by Fuchs et al. (2010: 43) as "*… a medium for human communication…*", has offered users the opportunity to interact, communicate and collaborate with each other; and has rendered them creators of *user-generated content* in a *digital community*, broadening thus engagement and e-Participation. Additionally, planning "smart" entails the efficient management of *big data* (extreme volumes of various and complex data), as well as the incorporation of public involvement at the various stages of the spatial planning process, two pretty intriguing issues arising in modern planning exercises.

Taking the above into consideration, an imperative need for a wide variety of tools and technologies, capable of enhancing *data management* (collection, elaboration, analysis, visualization, etc.) and strengthening citizens and stakeholders' engagement, to be at the service of planners and decision makers is coming to the forefront. These can be adopted/used for supporting planners in (Stratigea et al. 2015):

- perceiving cities' particular economic, societal and environmental attributes (urban context), but also their interrelationships;
- exploring, identifying and visualizing various (spatial) urban problems;
- communicating problems and disseminating potential solutions and policies to the recipients of the spatial planning effort (citizens, stakeholders, etc.), seeking at the same time building *consensus* and thus achieving a more effective and broadly accepted implementation of the planning outcome; and
- identifying policy priorities in each different urban environment in alignment with the prevailing value systems.

In this respect, this particular section focuses on the delineation of the *most significant ICT-enabled tools and technologies*, which are nowadays serving spatial planners' needs and aim at attaining sustainability objectives in urban contexts. These are divided into *two main categories* namely: data management and visualization tools and technologies; and e-participatory tools. A brief description of the main tools and technologies available as well as a number of respective smart city applications are presented in the following (Figs. 1 and 2).

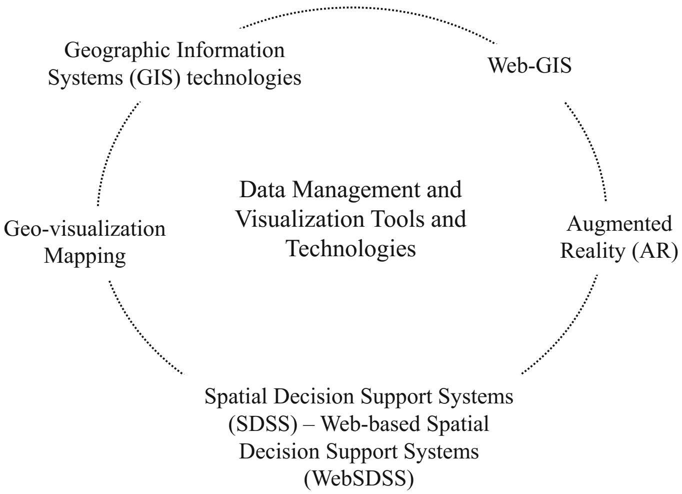

Fig. 1 Main data management and visualization tools and technologies

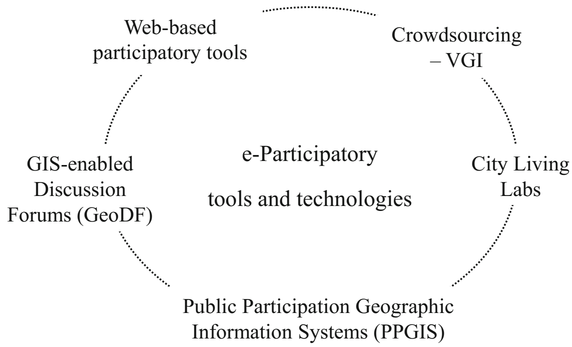

Fig. 2 Main tools and technologies supporting e-participation

4.1 *Data Management and Visualization Tools and Technologies*

Data management and visualization tools and technologies that are mostly adopted/used are:

- *GIS technologies*: for surveying, visualizing, analyzing and communicating local problems and inefficiencies. A GIS integrates hardware, software and data for capturing, storing, elaborating, analyzing, managing and displaying all forms of geographically referenced information (Folger 2009). "*… GIS allows us to view, understand, question, interpret and visualize our world in ways that reveal relationships, patterns and trends in the form of maps, globes, reports, and charts*" (http://www.esri.com/). A GIS can also help planners to answer questions and solve problems by looking at the data in a way that is quickly understood and easily shared (http://www.esri.com/).
- *Web-GIS*: refers to the integration of the Web with GIS, an important development which enhances user interactivity with maps and spatial analysis, expanding thus their potential for participating in decision-making processes. This integration is expected to rapidly escalate in the future, as highlighted by several researchers (Silva 2010; Craig et al. 2002); and has triggered further developments in the field of participatory planning.
- *Geo-visualization—Mapping*: mapping generally refers to the representation of data (e.g. spatial data) and information through the exploitation of their characteristics, their interrelations, and their relations with the geographical space and entities existing and taking action into this space. Specifically, in the case of spatial data and geographical information "*…a spatial data modeling process is adopted as a process of representing geographical reality*" (Goodchild 1992: 401). Geo-visualization regards the visualization of geospatial as well as non-geographic information, while it also "*…serves two important functions,*

namely communication and analysis… It augments human visual ability in perceiving high complex structures, detecting, exploring and exploiting salient patterns" (Jiang and Li 2005: 3). In recent years, numerous *smart city applications*, adopting contemporary mapping and geo-visualization techniques, have been developed such as:

- *SmartMap Berlin*: fully mapping of the city of Berlin in a textured photo-realistic 3D format. The 3D model allows viewers to look at the city as it is now, as it once was, and as it might turn into in the future. Using 2D and 3D geodata, recent historical changes as well as future urban development projects can also be visualized (http://www.businesslocationcenter.de/smartmap-berlin).
- *Trento i-Scope Project*: concentrates on how cities can be reproduced using 3D Urban Information Models (UIM) in support of urban planning, city management and environmental protection. It is based on an open platform, enabling citizens to participate in data collection and enhancing Web-based services (http://crowdcity.com/).

• *Spatial Decision Support Systems (SDSS)—Web-based Spatial Decision Support Systems (WebSDSS)*: Spatial Decision Support Systems are interactive computer-based systems designed to support decision makers in solving complex spatial problems, such as site selection, urban planning, and routing (Sugumaran and Sugumaran 2007). SDSS incorporate Geographical Information Systems (GIS) functionalities (spatial data management, cartographic display, etc.), analytical modeling capabilities, flexible user interfaces, and complex spatial data structures (Goodchild 2000). A WebSDSS includes a Web-based GIS as a problem solver; and facilitates geographic data retrieval, display, and analysis (Sugumaran and Sugumaran 2007).

• *Augmented Reality (AR) Technology:* view of a physical, real-world environment, whose elements are supplemented by computer generated input (sound, video, graphics or GPS data). Stated otherwise, AR interfaces allow users to experience the real world; while at the same time virtual displays can be overlaid upon or composited with real locations and objects (Azuma 1997). *IssySpots* is a mobile augmented reality application that was developed in Issy-les-Moulineaux—France, which contains a directory of more than 500 places of interest (public transport, tourist attractions, companies, administrations, schools, parks, etc.) that are displayed in real time on the user's mobile according to his/her location, enabling that way inhabitants and visitors to *navigate* in the city. With this particular technology, inlays and juxtapositions of virtual objects and information in a sequence of images are made possible. Users have also the opportunity to switch from the 2D plan to a 3D visualization (http://www.issy.com/).

4.2 (e-)Participatory Tools and Technologies

When planning in complex and highly uncertain urban environments, the role of the public as a valuable and essential source of multidimensional information for developing successful alternative plans is greatly acknowledged. As participants can and should become contributors to plans affecting their lives and surroundings, it is important that the right framework as well as the necessary tools and technologies are put in place in order for a more effective and pervasive participation context to be supported, in alignment with the multi-agent and multi-perspective nature of planning and the need for broadening its scope.

Towards this end, information on a range of *tools and technologies* that can be used for strengthening public engagement in planning the future of smart cities is systematically presented in the following. The scope of this step is to support planners and decision makers in implementing participatory planning exercises, by providing a range of available options (tools and technologies), together with explanatory information and examples that will facilitate their choice. The options available, in this respect, have as follows:

- *Web-based participatory tools*: such tools can range from preference functions, wikis, chat rooms, blogs, mailing lists, and rating systems to voting mechanisms and online surveys. They offer various e-participation potentials, while they enhance interaction among different societal groups regarding the outcomes of the planning process. Emerging Web-based participatory tools can potentially be used in urban planning in order for the context to be enriched and better results of public participation exercises to be achieved (Kingston et al. 2000; Wilson 2008).
- *Crowdsourcing—VGI*: The term 'crowdsourcing' was coined by Jeff Howe in his article "The Rise of Crowdsourcing", appeared in *Wired* magazine (2006), and is described as "… *a new Web-based business model that harnesses the creative solutions of a distributed network of individuals through what amounts to an open call for proposals*". Later on, Brabham (2008:75) argued that "… *crowdsourcing is an online, distributed problem-solving and production model*". Despite the fact that a commonly accepted definition of the term does not yet exist, crowdsourcing reflects a problem-solving approach, which presupposes the involvement of the crowd and results in the selection or shaping of the optimal solution, through the collection of distributed knowledge (Surowiecki 2004). In this sense, crowdsourcing can be considered as a form of participatory process in order for solutions to specific problems to be developed, involving at the same time various participants with different expertise, knowledge backgrounds, opinions, ideas, etc. It should be noted that, despite the fact that crowdsourcing was introduced and developed in the business sector, it can be adopted/used as a specific form of public participation (e-participation) as

well, for the implementation of urban projects (Brabham 2009) in the sense that it takes advantage of "*non-expert*" *knowledge* so as to find solutions to spatial planning problems and challenges or to acquire data and knowledge that can feed and enrich the spatial planning process. Moreover, the so called *Volunteered Geographic Information (VGI)* constitutes a particular form of crowdsourcing and refers to the volunteered production and provision of geographic information by individuals. Goodchild (2007: 212) defines VGI as a "... *special case of the more general Web phenomenon of user-generated content*". The "*IJburg YOU decide!*" project, which was developed in IJburg neighborhood—Amsterdam, constitutes a distinguished example of the use of a crowdsourcing Web tool, which enables citizens of IJburg area to share a future vision of their neighborhood, with emphasis on energy and mobility aspects. To do so, inhabitants were asked to fill a brief questionnaire, regarding what they think of their neighborhood, how they would describe it and what are their ideas for making that more sustainable. Based on the feedback gained from citizens, an action plan for Amsterdam Smart City Project was created and implemented in IJburg area (http://amsterdamsmartcity.com/).

- *Public Participation Geographic Information Systems (PPGIS)*: refer to the involvement of non-expert stakeholders in the spatial planning process (Ghose 2007; Ramasubramanian 2010), by combining community participation and geographic information on various city aspects (Steinmann et al. 2004). In other words, they attempt to bring the academic practice of GIS and mapping to the local community, enabling that way citizens' participation in the planning process and effective management of their living environment. In a nutshell, the scope of PPGIS is the *empowerment and inclusion* of local and marginalized population in spatial planning and decision-making processes (see further details in the next chapter). PPGIS activity usually involves either community mapping and database development, outside the formal government processes; or seeks expansion and enhancement of public participation and community collaboration in governmental processes for e.g. environmental planning and management (Brown 2012). Such an indicative initiative was successfully launched in Barcelona via *Repara Ciudad* application, an Open Data Cities (ODC) PPGIS platform, mainly addressing environmental issues. The application allows citizens to report damages and incidents of the urban environment to the local administration. The initiative's aim is twofold: on the one hand it attempts to bring inhabitants and public authorities close together so as to strengthen their environmental co-responsibility; and on the other hand it contributes to the shaping of a more participatory, transparent and efficient public administration (Turiera and Cros 2013).
- *GIS enabled Discussion Forums (GeoDF)*: constitute a significant tool for conducting discussions among participants, who are involved in the spatial planning process. In this context, they enable citizens to express their opinions

on a range of spatial problems, by utilizing user-friendly Web mapping and analysis tools. In order communication, better understanding but also interaction among participants to be facilitated, GeoDF offer them the opportunity to express (submit) and share their views, as well as to raise issues, relevant to the particular spatial planning problem that concerns them; and thus initiate new discussions with the other parties involved. The dominant feature of GeoDF is the *geographical reference* of participants' comments, through the expression of their views with text messages, notes, but also sketches, annotations, etc. on a map. Additionally, in order dissemination of users' views to be more effective, the system offers the potential for storing and sharing, among other participants, the different map layers in which they intervene. Views and interventions of each single user (comments, sketches, annotations, etc.) are organized and presented in a way that facilitates their incorporation in the participatory process (Zhao and Coleman 2006). The *argumentation map prototype*, introduced by Rinner (2001) in Germany, constitutes an object-based model for geographically referenced discussions; and is built upon discussion contributions (argumentation elements) and geographic reference objects, which are independent from each other (Keßler et al. 2005). Discussion contributions are also classified by issues in chronological order, while their distribution is shown on a map (Tang et al. 2005).

- *City Living Labs*: user-centered, open-innovation ecosystems, operating in the city context, which integrate concurrent research and innovation processes within a *Public-Private-People Partnership* (Von Hippel 1986; Chesbrough 2003; Komninos 2006, 2009). Living labs, in this respect, can be considered as *experiential environments*, where users are immersed in a creative social space for exploring, designing, evaluating and refining their own future as well as the policies driving from the current state to the desired futures. An interesting example of City Living Labs is presented by the *Territorial Living Lab (TLL) Sicily* that aims at exploiting ICTs in order innovative means of participatory strategic co-planning and territorial self-governance to be developed, under the assumption that citizen co-responsibility and ownership, awareness of context and implications of choices and monitoring of the impacts of decisions taken, can together finally generate models for sustainable spatial development (http://www.openlivinglabs.eu/livinglab/tll-territorial-living-lab-sicilian-region).

Finally, it should be noted that, in most cases, a combination of tools and technologies can be exploited so as to achieve more efficient utilization of available resources and existing ICT infrastructures; and offer a wide range of access options regarding online participatory processes to the public, according to its communication standards. For example, voluntary provision of digital spatial information from citizens (VGI) may be embedded in a PPGIS system, where citizens participate in the production of the required information, possibly under experts' guidance (Tulloch 2008).

5 PPGIS for Community Empowerment in Spatial Planning

Participation in spatial planning demands information that is strongly dominated by visual media (3D representations, maps, images, etc.), since they provide a close representation of reality, with textual description being an important subcomponent (Hudson-Smith et al. 2002). Taking also into consideration that people perceive and understand the information they receive according to their own cultural and social experiences (Lewis and Sheppard 2006), the adoption of visual media is required, since they entail limited linguistic and cultural barriers compared to written or verbal messages (Steinitz 2010). In this respect, geographical visualization of space (urban, rural, regional areas, insular, etc.) is perceived as a significant means of communicating the different steps of the spatial planning process to the public and stakeholders, while it is also a powerful technique for engaging them in decision-making processes (Pettit et al. 2007; Warren-Kretzschmar and Von Haaren 2014). It should also be stressed that visualization techniques offer powerful enabling tools supporting different tasks in the various stages of a participatory spatial planning exercise. For example, it can be used during the in-depth analysis of the current state of the area under study, so as to trigger public's interest in the spatial planning problem concerned and/or provide a common basis for the exchange of indigenous information and knowledge. It can also be deployed during the alternative solutions' building process, since participants can use visualizations to illustrate planning solutions and collaboratively develop a *shared vision* for the future (Warren-Kretzschmar and Von Haaren 2014).

Despite the fact that traditional communication tools in spatial planning, such as static maps, diagrams and texts still constitute the most common media for diffusing and communicating information, these exhibit great limitations regarding their ability to convey a deeper spatial understanding to lay audiences (Tress and Tress 2003; Lewis and Sheppard 2006), mainly due to lack of interactivity with users. In this respect, interactive visualization techniques and Web-GIS applications can be adopted/used in order for various pieces of (spatial) information to be presented in a more understandable way; and the investigation of spatial relationships to be enabled. Consequently, users' awareness and apprehension of a spatial planning problem can be increased, and thus the opportunities for essential public participation can be broadened. Users may also contribute by providing additional data through crowdsourcing.

According to the aforementioned, the concept of *Public Participation GIS* has come to the forefront and focuses on (Rambaldi et al. 2006: 2):

> Community empowerment through measured, demand-drive, user-friendly and integrated applications of geospatial technologies…. It promotes interactive participation of stakeholders in generating and managing spatial information and it uses information about specific landscapes to facilitate broadly-based decision-making processes that support effective communication and community advocacy.

The development of such systems originates in the 90s (the term PPGIS was conceived in 1996 at the meeting of the National Center for Geographic Information and Analysis—NCGIA); and focuses on *bridging the gap* between public participation and technology, as well as integrating GIS technologies into participatory spatial planning (use of Web-GIS by lay people). Atzmanstorfer and Blaschke (2013) highlight that PPGIS, as an approach which strengthens citizens' empowerment and participation in spatial planning and decision-making in general, may become a substantial tool in support of Spatial Decision Support Systems (SDSS).

PPGIS constitute a Web-GIS platform used by citizens in the context of various participatory spatial planning exercises. They support online data collection and processing in order for new (spatial) knowledge, relevant to a specific planning problem, to be produced (Craig et al. 2002; Brown 2012). In a nutshell, they can be perceived as a set of methods, techniques and technologies that contribute to the integration and inclusion of indigenous knowledge and different views expressed by participants; and to their mapping on the spatial context to which these refer. In this sense, the enabling and promotion of online interaction and communication with citizens, incorporated in GIS technologies, constitutes a crucial step towards significantly broadening the e-Planning perspective in the context of participatory spatial planning; and supports the effective use by the public in contrast to the traditional use by the experts (Talen 2000; Ghose and Elwood 2003).

The generic methodology adopted and followed for carrying out a PPGIS exercise comprises three discrete stages (Mare Nostrum Project 2015) which are illustrated in Fig. 3. More specifically:

Stage 1: Identification of Participants - PPGIS Community The role of participants is of catalytic importance for both the planning process and its outcome. Thus, proper selection of participants is considered a critical factor. PPGIS community refers to the identification of the group of citizens and stakeholders who can participate in PPGIS exercises. A manifest answer to the question "Who should be involved in a participatory spatial planning project?" implies the need for a certain stakeholders' analysis, taking into consideration the goal and objectives of the planning problem at hand, its controversial nature, the spatial scale concerned etc. Various approaches for stakeholders' analysis can be encountered in the literature. What is important in this respect is that identification of relevant stakeholders has to take into consideration the basic principles of participation and more particularly (Bousset et al. 2005):

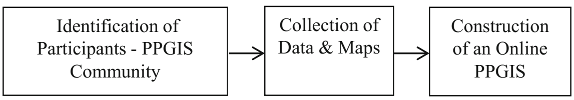

Fig. 3 Methodological steps for the implementation of a PPGIS project (*Source* Mare Nostrum Project 2015)

- *Inclusion*: Everyone should have equal opportunity to express his/her views and contribute to the formulation of solutions.
- *Relevance*: Anyone who is affected or can affect or can contribute to the planning process must be able to participate.

Moreover, since participants possess different levels of GIS and cartographic literacy, their appropriate training constitutes an integral part of this step.

Stage 2: Collection of Data and Maps During the preparation phase of PPGIS practice, maps or other visual media are assembled, while data need to be collected, elaborated, analyzed and visualized, in order participants to better understand and discuss the spatial problem under study. Apart from existing maps, it may be necessary to produce new ones, GIS layers or linked attribute data (Mare Nostrum Project 2015).

Stage 3: Construction of an Online PPGIS In order to enable and strengthen PPGIS community's interaction with spatial information, a Web-GIS platform is developed. Through the deployment of this platform, existing maps, GIS layers and attribute data are published online, and a user-friendly interface, where people can draw their own maps, is created. Participants are working on maps and data provided; and build further upon them, by adding their perspectives and local knowledge (Mare Nostrum Project 2015).

Deployment and use of PPGIS give citizens the opportunity to interact with the planning proposals via a visualized (maps) and interactive (online communication) way, which is not possible when following traditional participatory methods. At the same time, citizens' involvement can potentially result in the enrichment of spatial data managed by a GIS, which can introduce data and information related to the value system, local culture, history and tradition, etc., emanating from participants' views. Consequently, the final product is not just a spatial representation of the proposals and interventions derived from spatial planning per se, but a holistic proposal that embeds citizens' value system and principles in this spatial representation, thus serving the objectives of participatory planning (Stratigea 2015).

PPGIS applications may focus on:

- collecting data from various societal groups in order spatial planning ground to be enriched; and producing new maps that relate to the planning problem under study;
- broadening of citizens' empowerment and involvement in the spatial planning process, thus assigning them a more meaningful and active role.

A peculiar attribute of PPGIS practice is associated with the rendering of GIS technologies and systems available to the public (local and less privileged societal groups) for empowerment purposes. In this respect, their capacity to communicate, disseminate, generate, manage and use indigenous knowledge is enhanced; while also citizens' engagement/involvement in spatial planning decision-making is respectively broadened. Finally, PPGIS and can be adopted/used for various purposes such as (Rambaldi et al. 2006):

- conflict management among various local groups and between communities and local authorities regarding access, exploitation, control and allocation of resources;
- collaborative research;
- collaborative resource use planning and management;
- preservation of intangible cultural heritage;
- identity and vision building by local groups;
- transparent and consensual governance in spatial decision-making;
- awareness, education and social learning for new generations; and
- promotion of equity with regards to ethnicity, culture, gender, environmental justice and hazard mitigation, etc.

It is worth noting that apart from the typical PPGIS Web applications, these can be implemented in a conventional way also, through interpersonal communication with users—groups (Craig et al. 2002); while PPGIS may also constitute a complement to traditional participation methods (Steinmann et al. 2004).

6 Discussion

The evolution of Web and "cyber space" has set the ground for the illimitable knowledge diffusion, the promotion of innovation, the online problem solving and the dynamic interaction among people. ICTs have penetrated almost all aspects of modern globalized world, acting as integrating and enabling technologies (Caperna 2010) and establishing a new digital era, where "*…individuals are required to use a growing variety of technical, cognitive and sociological skills in order to perform tasks and solve problems in digital environments*" (Eshet-Alkai 2004: 93).

The incorporation of technological developments and their applications in spatial planning has brought to the forefront the concepts of *e-Planning* and *e-Participation*. These concepts are constantly gaining ground, since they are perceived as approaches that can fully convey the whole spatial planning process to the Web, thus facilitating public participation and attracting the interest of a wide range of participants. In this respect, they are considered as means to the expansion of the planning knowledge base, but also to the exploration of the range of different views expressed by various societal groups in order these views to be embedded into the final planning outcome. As such, they contribute to the upgrading of the planning process per se, via the broadening of participatory dimension and thus the bettering of the final planning product (Papadopoulou and Stratigea 2014).

Literature review shows that a significant range of mature tools and technologies is already available for fulfilling the objectives of participatory e-Planning and e-Participation. However, an important and noteworthy disproportion between theoretical contributions to the fields of e-Planning and e-Participation and maturity relating to tools and technologies on the one hand, and number of empirical applications on the other is observed (Geertman 2002; Campagna and

Deplano 2004), which constitutes a major issue for discussion and debate; while the impacts on broadening public e-Participation still remain a matter of sociological investigation.

Some initial attempts to interpret the above disproportion concluded that the technological evolution is a necessary but not sufficient condition for the implementation of online *participatory and geospatial technologies*; while experience shows that their adoption/use still requires the tackling of numerous intriguing issues arising, which are associated with technical, political, cultural and social aspects. As such can be mentioned (Kubicek and Westholm 2005; Macintosh 2006):

- The need for expanding ICT applications in spatial planning, so as transition from mostly pilot applications currently implemented to their widespread use to be achieved, emphasizing thus their adding value in planning.
- The technological dimension for public participation purposes should be further emphasized, in order for participatory e-Planning to be facilitated and spread; and user-friendly interfaces, for interaction and collaboration, to be developed.
- The requirement for reliable, discrete and easily communicated information representation and effective management of participants' contribution.
- The necessity for integrating the technological potentials and their applications in political processes and decision makers' organizational structures.
- The assessment of e-participatory processes' outcomes, which can significantly contribute to the improvement of their technological, organizational, political, social, etc. dimension.

Finally, an important disadvantage observed, regards the assessment of the results of e-Participation and e-Planning, in the sense that evaluation criteria and relevant indicators, on the basis of which the *effectiveness* of their implementation can be assessed, should be defined; and through them the *value added* by that type of planning exercises should be delineated.

Effectively dealing with the above aspects is quite important in an information-intensive era, as the concept of smart cities, apart from a new digitally-enabled urban management paradigm for reaching a competitive and sustainable urban edge, is mainly an evolving *collaborative paradigm*, where sophisticated ICT infrastructures and respective applications can considerably broaden communities' engagement; strengthen interaction and synergies' creation among various actors (policy and decision makers, planners, stakeholders, citizens, scientists, etc.); and promote a cooperative approach, necessary for coping with great challenges ahead in a contemporary city contexts. Such a paradigm can support a user-driven and human-centric tackling of smart cities' planning in the evolving "Urban Age", rendering thus planning a powerful discipline for increasing awareness, building of consensus and responsibility. Public Participation as "*…the involvement in knowledge production and/or decision-making of those involved in, affected by, knowledgeable of, or having relevant expertise or experience on the issue at stake*" (Van Asselt and Rijkens-Klomp 2002: 168), as well as digitally-enabled tools and technologies that can broaden potential of communities to actively engage in coping with new challenges is of crucial importance in this respect. This holds true for the Mediterranean people and small and medium-sized cities in this area as well; and represents a turn back (or a path forward) to participatory democracy, exercised in this region for centuries; but also a promising option for finding ways to deal with Mediterranean hot spot dimensions.

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Baakline: Towards a Smart City—Leading Change into Chouf Souayjani Region

Nouha Ghosseini

> It is also the title of MBAA project funded by the European Commission program: SUDEP—"Supporting the Southern Neighbourhood Partnership cities in the implementation of Sustainable Urban Demonstration Energy Projects" (European Commission 2014).

Abstract In the concept of a smart city, citizens are turned from passive consumers into active and concerned citizens, producers of ideas, content, applications, activities; and choosers of their society. This concept enhances innovation and creativity, seeking social relevance of new/unfamiliar ideas, opportunities for start-up firms, and propensity to entrepreneurial risk. Municipality of Baakline (MBAA) knows that participatory democracy is a key to both tackling the challenges faced by Baakline city and taking advantage of the evolving exciting opportunities. The "smart city" task is about smart governance, communities' engagement, learning and adaptation, and investing in the future by reshaping an entire market and ecosystem. MBAA's approach towards a smart city offers an invitation to reflect and act through pilot projects that are expected to change the mentality of people and integrate this concept in their future plans. The public/private actors are at the heart of MBAA's successful projects.

Keywords Participation · Democracy · Residential neighbourhood committee · Mentality · Local authority · Local community · New generation

1 Introduction

Baakline, a medium-sized city in the scale of Lebanon, is located in the heart of Chouf Central in the Mount Lebanon, at an altitude of 850–920 m, and 45 km away from Beirut. It is spread over seven hills, covering a naturally linked surface of 1350 ha. The estimated number of Baakline population is about 16,000 inhabitants.

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Being the centre of the rural territory, Baakline serves not only its habitants but also a large part of the population of Chouf. It daily hosts a large number of employees, students and clients of its various sectors and services. Shared facilities from different sectors are present in Baakline, rendering this city a tertiary centre of paramount importance in the Chouf region. As such can be referred:

- *Medical sector*: 1 hospital (Baakline Medical Centre), 1 laboratory, 1 dental laboratory, 7 pharmacies, more than 20 specialist's clinics.
- *Educational sector*: presence of 14 educative establishments: 8 Schools with 3338 students (2 public and 6 private), 3 technical schools, 1 language institute, 1 free primary school, and a rehabilitation centre for children with learning difficulties.
- *Cultural sector*: distinguished by the presence of a Baakline National Library, a place of cultural exchange and meeting space, including library for adults rich in books and documents of various subjects, another library for children, a microfilm archive room, and a computer room (with internet access).
- *Social sector*: Ministry of Social Affairs Centre with 46 associations.
- *Tertiary activities and services*: Baakline comprises four branches of different private banks, 75 professional offices in addition of 600 commercial establishments and services.

According to the National Physical Master Plan for Lebanon (SDATL), approved on 2009, Baakline City is considered as a "*local pole*" for its surrounding rural areas, having multiple assets and opportunities. It must remain up to its role, in facing the competition from large cities; and remaining credible at all levels to avoid centralization of the capital and limit rural exodus.

Taking into account the prospects of demographic changes, and the need to ensure a conscious urban development of environmental, economic and social balance, the MBAA, as part of the Federation of Municipalities of Chouf Souayjani (FMCS), is being forced to *re-think its strategies* and to *innovate*, without dissociating it from its surrounding. It is being pushed to look for novel solutions under times of restricted budgets and resources. However, the complexity and the pace of change, combined with the need for integrated and systemic solutions, are presenting a major challenge to MBAA, which is looking to transform the way it has traditionally operated. The socio-political situation of Lebanon makes societal challenges even more complex to solve. It is time to pay more attention to sustainable innovation and growth with *active public participation*.

A new vision must be developed to bring together good practices in responding to this challenge in an integrated way. The methodological approach is based on a *model of smart city approach for developing countries*, based on three complementary and interrelated levels: (a) the physical architecture, (b) the platform of urban services, and (c) applications, including the final uses.

Baakline unfolds being increasingly perceived as an open innovation territory. Under the theme “*Invent together and experience the city of tomorrow*”, MBAA has undertaken actions, aiming at examining and illustrating certain fundamental aspects of the “smart city” concept, namely:

- Individual and social well-being;
- Spatial planning;
- Social, economic, cultural and ecological approaches;
- Local policies and programs;
- Innovative tools;
- Identification, assessment and quality objectives;
- Awareness-raising, training and education;
- Public participation.

The high ambition of MBAA does not ignore the fact that the rationale of smart cities differs between developed countries and those which are still developing, but it is appropriate to say that the state in Baakline leads to the qualification of the smart city in a country like Lebanon. Nevertheless, common components can be identified in both cases, which are: education, employment development, rural migration, youth inclusion, social networks, transportation and energy. For example Europe is more concerned about the ageing population, while Lebanon is more concerned about youth inclusion.

In Lebanon the municipality is the only form of a decentralized local authority. The idea of decentralization was introduced in the 1989 by the “Taëf” National Accord, but it was not applied till now. In 10/7/2012, the Lebanese Prime Minister assigned a National Committee of ten experts to set up a draft Law of decentralization in Lebanon, upon the request of the ex-president Michel Sleiman, led by the minister of Interior and Municipalities. The author of this paper was honored to become a member of this national committee, as Mayor of MBAA and President of the FMCS. This draft law awaits its presentation to the parliament and its ratification.

Smart cities used to be the privilege of the developed West. No longer, since by 2025, up to half of the world’s smart cities could be outside America and Europe, according to recent studies from research firms IHS and Frost and Sullivan. With the Middle East expected to achieve the world’s highest growth rates in both mobile and cloud traffic data by 2018, cities in the region could be well-positioned to join the club. For Middle Eastern cities, therefore, becoming smart is not just an option; it is a necessary shift, one that needs to happen fast, even for the cities with limited financial resources. In such a context, MBAA tends to compile an operational definition of “smart city in developing countries”. Longer-term issue that MBAA will have to grapple with is who will be developing the smart-city solutions. In the early stages of its transformation, close partnerships with European programs like CES-MED and SUDEP, increasingly present good opportunities for Baakline to lean towards the “smart city” concept; and can be enough for it to access the necessary level of services needed.

MBAA is committed to intervene in all public matters affecting the life of its inhabitants and its local community. It is working hard to find smart and effective ways to deal with potential raising issues, such as climate change, through combining an *integrated planning process* with low rates of energy consumption and high supply of renewable and decentralized energy. The main concern remains at how local officials and population can remedy the delicate situation of the country that suffers from many political and socio-economical problems. Indeed, Lebanon is a parliamentary republic, characterized by the logic of confessional power-sharing in the state administrations. Marked by 15 years of civil war, it struggles to find an internal balance between its people components. There is a general lack of law and order, not to mention the presidential vacuum since May 2014, leading to the paralysis in state institutions (especially the National Government and the Parliament renewed beyond its rightful lifetime), not to forget the worries sparked by the arrival of Syrians refugees, undermining its fragile political system and rendering economical and social pressures on them and the Lebanese citizens as well, preventing thus Lebanon to meet its development goals. Moreover, in Lebanon where the municipality is the only form of a decentralized authority, it very often seems that the democratic deficit at the municipal councils is the result of *ill-informed citizens* about the complexity of public issues. Also the municipal council members are not fully cultured about the needs and values of democracy, to incorporate the principles of participatory governance in their practices. The Municipal Law and the dominant mentality and traditional norms prevent women, youths under the age of 21, disabled people and minorities from fully participating in the local authority, and expressing their opinion. This was really slowing down this work at the beginning, making it difficult to implant the democratic engagement and civic participation in people's minds. All these challenges require immediate measures at the policy level as well as adequate resource allocations. However, the country is not able to address these challenges properly due to the deep political division, which renders Lebanon a frail state under tremendous threat.

Baakline challenges are more often a topic of discussion and an incentive to take action. These are the problems of access to water, the energy and the sanitation, which further motivate Baakline municipality to persist on its willingness to become a "smart city". However, Baakline has a unique wealth; the qualities of its own offer it favorable opportunities to an organic development process (even if it has not appeared by decrees).

Over time, it will also be important for MBAA to adopt *open data policies* and leverage its local innovation ecosystem. Actually the assumption now is that, by default, all data should be opened. This may be easier said than done in a region where security remains a major preoccupation; and where national government is not necessarily accountable to its populations. However, how to promote the development of a smart suburban area (into rural countryside), while respecting the local culture? To be qualified as "smart city", Baakline should not simply multiply the technological tools, but also its development must be designed to interact with citizens.

MBAA aims at turning Baakline City into a *democratic society* through striving to involve its members in the process of local development and good governance with transparency and accountability, enlightening them to be conscious, responsible, and aware of the sustainable development issues based on preserving human rights, and participating in the decision-making process that concerns their city life matters, regardless of their gender, age, origin and political, social or economic background. MBAA work to implement this approach at all stages of a human rights city, when possible, including budgeting, planning, implementation, monitoring and evaluation, *can and must* be a key to successful innovation towards making Baakline a common space for solidarity.

2 Baakline Vision

Through the participation of residential neighborhood committees (RNC) and agencies [non-governmental organizations (NGO), firms or others], Baakline had established a clear, compelling and inclusive *vision* for the city, articulated as follows:

> Our city is resilient, inclusive and a pleasant place to live and trigger investments that positioned it as a business pole and pillar of sustainable development in its surroundings.

The innovation of this vision for Baakline, today and in the future, is that:

- It is developed in an interactive and collaborative manner that is inclusive for all city stakeholders' groups; and is informed by user research and engagement, with social media and other technologies used to enable public participation in the process.
- It embraces the opportunities opened up by smart technologies, smart data and smart collaboration.
- It does so in a way that integrates these into the core socio-economic, political and environmental vision and purpose for the city's future, rather than seeing them as somehow separate from the city's core strategic objectives.
- It is measurable.

MBAA tries to embed the Smart City concept into Baakline Vision by elaborating on four main themes (see Table 1).

3 Baakline Mission

The strategic guidelines for Baakline's future have been looked at from the following dimensions: *economy, mobility, environment, people, living and governance*. Baakline stands to become a smart city that could then crystallize a lot of

Table 1 The four main themes of Baakline vision

Themes		Aspects involved
Sustainable development	Sustainable and innovative city	– Controlled urbanization – Innovative vision of human-centered local development – Promotion of growth, employment and economical knowledge – Investing in heritage and natural sites – Developing a dynamic and integrated economy with innovative industrial and commercial areas – Promoting business competitiveness through innovation – Creative and cultural industries – Tourism and attractiveness of destinations – Mainstreaming of the culture: cultural resources as driver for growth and employment opportunities
Social inclusion and democratic participation	Comprehensive and inclusive city	– Good governance – Adoption of open-data policies – Promotion of a new interaction pattern between the city and its citizens for the comprehensive development – Enhancement of the decision-making process – Alleviation of social exclusion – Improvement of services and technology access to knowledge at a reasonable cost – Enhancing understanding and capacity for action – Creating and retaining identity – Modifying values and preferences for collective choice – Building social cohesion – Contributing to community development – Fostering civic participation – Capacity and knowledge building – Social cohesion and integration of disabled persons
Integrated environmental and sustainability	Green and eco-city	– Focus on the protection of the environment and natural resources – The usage of sustainable energy to be competitive and safe – Improve the energy performance in public and private buildings – Intelligent mobility – Effectiveness of wastewater refining and solid waste treatment – Socio-environmental responsibility – Willingness to pay for greener economies and societies

(continued)

Table 1 (continued)

Themes		Aspects involved
Climate change adaptation	Resilient and enabling city	– Focus on adaptation and risk management – Propensity for entrepreneurial risk – Opportunity for start-up firms – Social relevance of new, unfamiliar ideas – Definition of the obligations and rights of the citizen with its city and realization of the social and environmental security – Promotion of developmental and economic policies in support of the overall environmentally and friendly growth of the society – Population sustainability: In- and out-migration effects/change in social and cultural mark up of affected target groups

energy, physical, natural, human and societal capacities in realizing this vision in which:

- Baakline ensures a *high quality of life* that returns to the urban challenges on the basis of a multi-party partnership—municipality-citizen-society—based on *participatory democracy*.
- Its *economy* generates a dynamic change to establish an effective ecosystem for nurturing entrepreneurship, innovation and, in general, creating an environment that would enable sustainability and long-term investments with new technology trends into growth and jobs.
- Baakline is concerned about *climate change*, it is very efficient in its use of energy and natural resources; it is increasingly powered by renewable energies and has been paying much more attention to sustainability in innovation activities.
- Based on a flexible system, an innovative approach of integrated human, societal and natural resources, must be undertaken since the planning phase in order to:

  – Increase the comfort of citizens.
  – Strengthen public services (particularly energy and water), with the gradual disappearance of the shortage of these services to reduce the double bills that are currently paid by citizens.
  – Stimulate local production, such as agriculture and sustainable tourism.
  – Attract private sector investments and create new jobs.
  – Improve the environment and conservation of natural resources.
  – Use and promote information and communication technology (ICT).

All these strategic directions are inherent characteristics of urban dynamics and constitute the attractiveness and smartness of Baakline city referred on several pillars including: (a) technology use when possible, (b) innovation, (c) integration, (d) participation.

Based on *participatory democracy* approaches, the active participation of stakeholders in the design, approval and future implementation of the strategy is the *main challenge*. This is the way to reach a broad *strategic consensus*; and to create an effective lobby of social, economic and environmental agents, to provide the driving force behind the future of the strategy.

4 Towards the Development of Innovative Tools

The development of innovative tools, notably in Baakline city and its rural surrounding area, where the experiences are still scarce, is encouraged by creating working groups and involving academic circles to work in multi-disciplinary ways and to pursue in depth new areas of research, education and professional activity. The innovative instruments are summarized as follows:

- Participatory instruments
  - To facilitate community input to and participation in any municipal decision.
  - To work at the local level, helping communities to identify and understand the characteristics, value and vulnerability of the city they live in, and express their aspirations.
- Cross-sectional instruments
  - To integrate the concept of smart cities into the various spheres of MBAA administrative activities.
  - To take this concept into account as a factor that cuts across various public policies for land use.
  - To develop holistic approaches to sustainable development.
  - To integrate the cultural and natural heritage.
  - To take account of smartness in biodiversity conservation areas.
- Instruments for awareness raising and training
  - To inform and train the various groups and agencies concerned with sustainable development about the interdisciplinary and specific nature of the problems associated with it.
  - To inform and train municipal council members and employees of MBAA.
  - To offer a sense of belonging and educate people of all ages, especially young people and children.

- Incentive-based instruments
  - To put emphasis on incentives and restrict prohibitions.
  - To develop contractual instruments, trying to coordinate the activities of different actors.
  - To develop agreement-based tools.
  - To encourage traditional types of people belonging and integration.
- Statutory and regulatory instruments
  - To integrate the smart city concept into local spatial development planning efforts.
  - To amend legislation towards improving the quality of life for dwellers.
- Technical instruments
  - To assess and demonstrate the economic importance of the smart city concept.
  - To update periodically the open data of the urban observatory of Baakline, in order to monitor changes and evaluate interventions in the city.
  - To improve the quality of land use in industrial and commercial areas.
  - To develop techniques for rehabilitating degraded areas.
  - To stimulate the exchange of experiences between all stakeholders.

5 Identifying and Assessing the State of the Art of the City—Formulating Smart City Quality Objectives: Efficient and Innovative Methods

The exercise of democracy integrates both smart city identification and assessment methods, and the formulation of quality objectives, in so far as it is now an established fact that the smart city concept does not encompass the same significance for one and all; and that each component has different values attributed to it by groups of people who do not have the same aspirations. Involved here is a crucial challenge, which presupposes both the acceptance of differences and the fact of lending a ready ear to others with regard to what is special and what is common place (Monzón 2015).

The shift from knowledge to action assumes that any action, whether it has to do with planning, management or implementation, is coherent with the values attributed by local people to their city, with the aim of foreseeing and anticipating the long-term future; but it must also encompass systems of economic and social logic at work, and the bio-physical functioning of the natural environment and that modified by man. The formulation of smart city quality objectives is thus an essential task in the decision-making process, which must incorporate these various areas of knowledge—a task, it goes without saying, which is both complex and difficult.

Nevertheless, the formulation of *smart city quality objectives* is a complicated task, which represents a decisive moment in the shift from mobilizing knowledge to acting upon it. Its purpose is both to foresee and anticipate the future in the long term by consulting the local people concerned. It then seems that this formulation:

- Has to be seen in a context of knowledge of the facts, in other words of the dynamics underway that transform the city.
- Can only be achieved with a determination and concern to plan for coherence between what the future city will be and a system of values attributed to this city. Also that this coherence must nevertheless embrace the development this value system will certainly undergo.
- Can be implemented by actions that must be incorporated within the principle of social equity, implying that there must be access to, and a socially shared use of natural and cultural resources.

Consequently, the formulation of smart city quality objectives is confronted with many different challenges focusing on the interaction of different dimensions, which has made it possible to update the distribution of data gathered during the identification and assessment phases into various fields of significance and activity. The *main challenges* have as follows:

- The *first challenge* concerns the question of development trends under way and the ability of our society to control them, and even shape them in order to steer them towards a desired end. Any objective that has to do with collective action is subject to the many different decisions taken by the individual people involved, overriding the mistaken tendency to think that the smart city evolves as a result of major decisions and major projects decided upon by territorial authorities and major operators. Actually the city, also and above all, evolves as a result of a host of individual decisions. The fact is that in the great majority of cases, these are part and parcel of major development trends. Hence the importance of identifying them and taking informed decisions in order to better formulate the actions/objectives towards the smart city. However, all these objectives must be formulated in relation to these dynamics either by accompanying them with measures making them possible to guarantee coherence between them and the previously identified city values, or by trying to steer them in a direction permitting such coherence.
- The *second challenge* involves the sharing of decisions among concerned persons. All objectives must thus be part of the principle of social equity, which means acting in such a way that the planned smart city is defined by those politically involved, so that this smart city, as planned for the future, corresponds to the vision these different people have of it. However, these decisions stem from the task of those who have been entrusted with making them, in other words, elected officials, who must act properly, in such a way that they take into account the aspirations of ordinary people.
- A *third challenge* concerns sustainable development. All smart city quality objectives must in effect guarantee the reproduction of the natural environment

and its resources in the long term. They must therefore take into account the biophysical processes at work and become a part of them, or attempt to steer them along a path guaranteeing this long-term reproduction of the environment and its resources.

6 Integration of Smart City Policies and Actions—A New Political Framework

Many methodological proposals can be put forward to do with the theme of smart city identification and assessment and the formulation of its quality objectives. The idea of integrating smart city considerations into MBAA policies and actions that directly or indirectly affect Baakline city is innovative in itself. This integration demands a multidisciplinary or/and a holistic approach to smart city, taking into account three aspects:

- The *horizontal aspect*: methods of achieving integration involving all sectional policies that have a direct or indirect impact on the smart city context. This aspect is more ambitious and consequently its implementation is much more complicated. Consideration needs to be given successively to when integration needs to take place and according to which mechanisms.
- The *vertical aspect*: deriving from the principle of subsidiarity. It incorporates and combines the smart city policies of all tiers of government in a genuine policy strategy, stretching from central government through any constituent states to local authorities.
- The *cross-sectional aspect*: by maintaining the principles of coherence and consistency, reflecting the reality that the problems of an increasingly complex world involve new players such as private, non-governmental or semi-governmental organizations and bodies as well as more spontaneous groupings. The fact that the number and range of players is growing has begun to have an increasing impact on the development of modern civil society. At the same time, the ideas and activities of these new groups offer huge innovative and creative potential.

7 MBAA Planning and Actions' Implementation: Transforming the City's Operating Model

Baakline city *vision* incorporates the need to develop an *integrated city operating model*, which is focused around citizen and business needs, not just the city's organizational structure. In order to achieve the vision objectives, MBAA has established the *steps* described in the following sub-sections.

7.1 Create an Urban Observatory: On the Way to Smart City

A key element of the methodological approach followed by MBAA since 2006 is the foundation of an *urban observatory* that helps understand both the needs and challenges of the city in all its dimensions. The open data help to evaluate the impacts that development has on community social and economic well-being. Its analysis relies on both quantitative and qualitative measures of impacts. Development impacts are generally evaluated in terms of changes in community demographics, housing, employment and income, market effects, public services, and aesthetic qualities of the community. Qualitative assessment of community perceptions about development is an equally important measure of development impacts. Assessing proposed developments in a socio-economic context will help community leaders and residents to identify potential social equity issues; evaluate the adequacy of social services; and determine whether the project may adversely affect overall social well-being. Its *objectives* are as follows:

- Identify *needs and challenges* in the context of the city vision: it is important that this work is accomplished with the cooperation of different actors, whether elected, scientists, technicians and inhabitants.
- Promote *quantitative and qualitative knowledge*: methods should not only raise quantifiable data, but also provide an equivalent way to the knowledge of value systems that the population attributes to sustainable development.
- Promote *parity* between the public and experts: the knowledge produced is not just scientific. It also cuts across traditional or empirical knowledge.
- Promote *access to open data*: this access should enable a shared understanding not only by the scientific world (that is to say by all the disciplines), but also by the less informed public. This means that a special effort needs to be made by MBAA to facilitate the comprehension of these data by all users.
- Promote *cooperation* on projects: it is important that MBAA explicates multi-scale systems of values, assigned by the local society.
- Enable a *ubiquitous, integrative and inclusive digitization* of city spaces and systems.
- Embed *openness and sharing* in the way the city works.

With important studies and links to research, the Urban Observatory information can assist MBAA, researchers, NGO and other organizations in their efforts to set up indicators and monitor results to track progress and to compare policies and related measures that aim at enhancing different socio-economic impacts of Baakline population. Also, reflection processes are supported in order to determine, in what way certain socio-economic impacts play an essential role in achieving democratic governance as well as a sustainable democratic society.

7.2 Establish Neighbourhood Committees Based on the Concept of Participatory Democracy: Inclusive City

MBAA and FMCS had the opportunity to work on EU projects (like "ARAL" Programme—LOGO I & II—2002–2012) and the United Nation's program on "Strengthening the capacity of the Arab countries to achieve the Millennium Development Goals by 2015". Chouf Souayjani region was selected as a *leading model in Lebanon*, and as the second Region in the Arab world, after the Aqaba Region in Jordan (UNDP 2015). These programs lead us to reach a degree of institutionalization of civic engagement in terms of reliance on the participation of citizens and civil society, the private sector and all stakeholders in determining developmental issues, priorities and decision-making processes at the local level. This helps us build a *strategic vision*, focusing on priority issues, taking into account the resources, opportunities and the potential constraints. FMCS (including Baakline city) has developed a strategic plan addressing the social, economic and environmental issues in terms of complementarities with different levels of management plans and structural/physical planning for the sake of sustainable development. The planning and execution of development activities, defined by the strategic plan, were implemented by the local authorities of FMCS.

To better achieve the grassroots of participative democracy, MBAA established five RNC throughout its territory. These play a major role in the municipal life and participatory planning, in a consultative, decisive, and sometimes, executive way. They also contribute in building the standards and positive values, based on solidarity and concerted caring efforts to achieve sustainable development delivered from the real needs of the people, building thus a fruitful cooperation and trust among all segments of society and the municipality.

7.3 Revise Spatial Planning: Innovative City

Following the results collected from the Urban Observatory, a revision of Baakline Master Plan was undertaken between 2007 and 2010 (date of approval of the scheme by the Lebanese State) in order to be more productive and flexible. The participation of the city residents and other key stakeholders in the decision-making processes through community consultations and meetings was essential to develop a long-term (2006–2020) development vision and a strategic direction of Baakline land use.

Using GIS technology (data and mapping), MBAA adopts an *urban management action plan* that intends to:

- Improve the *performance* of the urban development department to more effectively perform its urban planning functions.

- Institutionalize a *quality management program* (QMP).
- Strengthen *capacity* of the municipality's human resources.
- Establish a *strategy* to improve transactions, financial management and collection of local revenues, including public awareness to increase the level of citizen satisfaction.

7.4 Preserve Baakline Culture and Heritage: Eco-City

Culture is a way of living, thinking, and behaving. It plays an important role and in fact causes impacts on development in several different fields of our daily life. It is linked to well-being and health; and is used to address social cohesion and inclusion. It has also become a mean of provoking urban revitalization and the development process of Baakline.

All MBAA's work concerning culture and heritage springs from the main theme that the person's culture is his identity, and that every person has the right to freely express this identity through accessing, practicing and introducing his own culture, especially when we talk about the rights of minorities, and related approaches. Aiming to overcome the *human rights discrimination* into the Lebanese municipal law, this new process of participatory democracy addresses the needs and constraints of the following key stakeholders:

- The *young people*: in electoral law, people below the age of twenty-one are deprived of the right to vote and run for the elections on municipal and national levels.
- The *women*: The proportion of women's participation in the political decision in Lebanon is still very weak (4.7% parliament members and 0.06% as mayors).
- The *minorities*: Usually the municipal elections show that important sections of the population (especially the members of small families) see themselves as outsiders.
- The *residents* who have an origin different from the area where they live: they are deprived to elect their municipal representatives, and barred from taking part in the decision-making process in their residency location, thus leaving their needs unheard by the elected municipal body.
- People with *special needs*.

Concerning Baakline heritage, the land use Master Plan deals with the old town of Baakline through several functions (residential, craftsmanship, heritage, tourism etc.), in order to achieve three objectives: (a) reconfigure the historical picture of the old town, and revitalize it in an urban and functional way; (b) find the diversity and complementarity between the old city and the surrounding neighbourhoods; and (c) enhance the role of cultural heritage tourism to stimulate the local economy.

7.5 Develop an Industrial Area: Sustainable City

In an attempt to assemble all existing industrial factories that had been established into the residential areas with all the expected new ones, MBAA has developed an industrial zone in the outskirts of the town with related guidelines to minimize the negative impact of the industrial sector on the environment: green border of 10 m around this zone, special conditions of facades and architectural blocks are planned.

7.6 Provide Smart Mobility: Green City

In order to reduce non-renewable energy consumption and carbon dioxide emissions, the municipality plays an essential role in facilitating street traffic and securing public transportation

Through the establishment of 10 km additional roads, linking the seven hills of Baakline without passing on the main road or the town centre, a good and safe vehicular mobility plan was built up, relieving also traffic on the main road.

MBAA also enhances the soft mobility through a network of tourist pathways and eco-tourism crosswalks inside Baakline, linking it to all Chouf Souayjani towns.

7.7 Enhancing Eco-Tourism and Green Environment: Eco-City

Baakline owns a forest extending over an area of 12 ha that has been exposed to many environmental violations during the war years: littering, embankments, and cutting down trees to name a few. This site has been renovated by MBAA and turned into three parts

- *Forest reserve*: that is well-protected in order to maintain biodiversity and keep on its natural appearance. The reception of eco-tourists stays limited.
- *Hiking Forest*: this area is well equipped by specific tracks, including break and light equipment areas.
- *Public Park*: located on the outskirts of the forest, the park meets the priority needs of the community and visitors. It includes playgrounds, driveways green health, green space, etc., suitable for children and mothers who can enjoy the safe and beautiful atmosphere.

In order to further enhance the tourism in Baakline, a *network of tourist routes* and pedestrian crossings was established within the framework of a European funded project “ARAL-Logo II”, starting from Baakline forest, leading to other sections of the city, and eventually to the other FMCS towns. These paths are essential to relieve traffic caused by tourists and motivate them to explore new trails and tourist sites on foot.

7.8 Strengthening Public Services and Enhancing Local Policies and Programs About Water and Energy: Green City

One of the advantages of this type of projects is to strengthen the public infrastructures that are already in place, improving their situation and the services they offer. It would combine what is already available and invest in new ones to improve public services relating to energy, solid waste, water supply and waste water management in Baakline.

MBAA is among the few Lebanese municipalities that hold a decentralized service in directing the supply and distribution of water to subscribers. This responsibility requires to smartly managing its water resources. An ambitious work is still needed to be done. The key lies in finding the adequate devices and facilities to optimize water supply and electricity in Baakline public buildings. This includes the installation of solar water heaters, photovoltaic panels or wind and the establishment of rainwater tanks and even the installation of devices that collect drinking water from the moisture in the air.

In addition to the above MBAA, affiliated to the European CES-MED program "Cleaner Energy Saving—Mediterranean Cities", has signed the *Covenant of Mayors* (CoM) in 2014. This program helped MBAA to prepare its Sustainable Energy Action Plan (SEAP) that develops the capabilities of the municipality to form and apply domestic policies in the renewable energy and energy efficiency fields for reducing CO_2 emissions; and managing water and waste, transportation systems, public mobility as well as urban sustainable planning, with the exchange of best practices for the preparation of comprehension plans and solution of pressing problems.

Baakline Municipality works on developing new *policies* and finding *innovative solutions* to increase the welfare of the population through:

- Preparing a scoping study to assess the current situation and determine the preliminary data available, which helps diagnose and analyse these data to accomplish "Reference emissions inventory CO_2" as a measurement for all greenhouse gases.
- Assessing the needs of the municipality and the city in the field of energy, in addition to preparing the list of priorities.
- Adapting the SEAP to suit the city's economy and respond more effectively to the challenges of sustainable policy for the municipality, while assessing, monitoring, tracking and measuring results.

- Preparing a roadmap to implement the SEAP at the municipal level. This strategic plan is translated into concrete measures that could reduce CO_2 emissions in 2020 by 20%, compared with the initial level of the inventory emissions.
- Preparing awareness plans for citizens that is considered an important part of the overall sustainable energy plan.
- Raising awareness for the local population on the local sustainable policies and exchange of knowledge and experience, within the framework of an overview to help everyone respond more effectively to the challenges of sustainable policies.
- Organizing dialogue and partnerships with the public and private sector and the civil society.

In this field, the municipal council has set energy policies aimed at minimizing the traditional energy consumption in buildings and services as well as public lighting.

Moreover, under the SUDEP European program, MBAA gained in 2013 a grant to execute a project aiming to improve energy services in Baakline. The main objective of this project is to transform Baakline into a smart city and achieve the EU's objectives through adopting renewable energy and energy efficiency to lower CO_2 emissions by 2020, thus resulting into a change in its surroundings, encouraging the other Chouf Souayjani towns to sign the CoM and join this program as well, a new momentum to continue in the path of sustainable development in the Chouf Souayjani area.

The *main activities* of this project are:

- *Activity 1*: Developing and implementing sustainable policies and legislations, in moving towards and adhering to the CoM and "Green Buildings". MBAA tends to set a policy to increase the interests of residents in the municipal sector with innovative solutions, such as energy efficiency and renewable energy in buildings (for new buildings: near neutral energy and for existing buildings: optimal cost approach).
- *Activity 2*: Establishing a cooperative of renewable energy, under the theme "Sustainable Energy for All".
- *Activity 3*: Make "Pilot/Demonstration projects" showing energy efficiency and renewable energy in renovated public buildings, which can be replicated in the region and Lebanon. These address the: (a) conversion of Baakline municipal and Chouf Souayjani Federation of municipalities' buildings to sustainable buildings; (b) sustainable street lighting; (c) renewable lighting for the Chouf Stadium; (d) drinking water pump on solar energy; (e) supply of the forest facilities with renewable energy.
- *Activity 4*: capacity development for the eight other FMCS Local Authorities, using media to change people's energy use behaviour, information and awareness raising for all citizens and private/public sectors through awareness campaigns, training sessions, brochures, social media, press conferences, field visits, artistic performances and various activities.

7.9 Solving the Problem of Solid Waste Through Sorting from the Source: Flexible City

The operation of solid waste collection, transportation and treatment falls under the national government responsibility. After the crisis that has erupted on 07/17/2015, MBAA, in coordination with FMCS and the help of their RNC, have succeeded to find a solution (while the country hasn't done it yet) to pave the way for waste sorting from the source; and operating a waste sorting plant, which is an important component of an integrated waste management system. The waste sorting components of this plant are to be processed later, or disposed in an economic and environmentally sound manner. In this context, it can play the role of a screening plant for the collection of special waste (exhausts, batteries, oils, electrical home appliances, etc.) to be later disposed in a special place.

Intelligent assets are under negotiation to augment capabilities in waste management and recycling, using technology to achieve higher recycling yields through more precise sorting activities, as well as allowing the operator to optimize waste collection routes and incentivize citizens and businesses' waste disposal activities.

MBAA believes that it will be able to experiment a more *circular economy* in the future, to design value chains with regenerative products, materials and energy reaching zero waste. MBAA have to rely on enablers such as the IT, a global political framework with the right incentives and circular logistics with return solutions.

7.10 Raising Awareness, Learning and Training: Towards a Learning City

Cities can learn from each other, increase knowledge stock in respect of the best policies and latest practices, and foster exchange of good ideas. Baakline is not only playing the role of training and educating its citizens, but its good relation with other cities world-wide has enabled it to learn from their experiences and exchange best practices.

On one hand, knowing that learning cities are leading the way for the development of truly smart cities targeting employment, innovation, climate change, energy and poverty, progress in smart cities would be very desirable. MBAA has the chance to conduct many key projects with the invaluable assistance from the EU and other international partners. In its conviction, MBAA is associated with the actions that pose the need for a shared future of our planet as well as the sustainable development and solidarity of people, where exchanges are increasing on a basis of equality and a culture of peace. Local authorities can play a greater role in conflict prevention, respect for human rights, equality between men and women, solidarity, social cohesion and sustainable development.

On the other hand, *collective learning* must be a part of MBAA's mission, by choosing its own learning style, putting in place agencies and practices, and investing in knowledge acquisition. Helping institutions, including NGO, stakeholders and corporate partners, can support the hardware and software needs of the city, especially in facilitating a strategy and practice of learning, including knowledge acquisition and processing, in a learning environment of trust and open exchange for local partners to discover, process, and absorb knowledge together. It is creating sort of a collective thought process.

MBAA has prepared the *awareness strategy* for citizens as a major part of the comprehensive plan to disseminate the smart city concept through main themes like: participatory approaches, participative democracy, sustainable energy, etc. This strategy includes:

- Educating and training the members of the municipal council and MBAA employees.
- Raising awareness and educating people of all ages, especially young people and children.
- Promoting the concept of sustainable energy and energy efficiency through awareness campaign, training courses, booklets, leaflets, posters, social media, press conferences, field visits and various other activities.
- Ensuring that all stakeholders have a clear, consistent and common understanding of the key concepts involved in smart city development; how these concepts relate to each other; how they can be formally modelled; and how such models can be leveraged and integrated into new and existing information architectures.
- Empowering stakeholders to create new sorts of services and value, by opening up city data via open platforms; and driving forward the internal culture changes and the external market enablers that are needed to create a flourishing city information marketplace.

For example, under SUDEP project, MBAA conducted scientific sessions carried out by experts from the Lebanese University, targeting engineers, architects and renewable energy investors to become ASSESSORS in green buildings.

Such training sessions shall allow the trainees to establish healthy communication, in which human uniqueness and human dignity are respected, and the autonomy and maturity of concerned persons are encouraged. In other words, the participants shall acquire active communication and listening skills, allowing them to contain intra and/or inter-party conflicts, and to transform them into useful change tools. Therefore, the participants shall know how to be responsible citizens, and how to fully practice democracy and leadership, and respect human rights in their day-to-day life.

8 Expected Results

MBAA knows that *collaboration is a key* to both tackling the challenges faced by Baakline and taking advantage of the evolving exciting opportunities. The smart city task is about smart governance, engaging communities, learning and adaptation, and investing in the future by reshaping an entire market and ecosystem, driven by the requirements allowing Baakline to work well for its residents and businesses. It will take determination and persistence in order to assure the following expected results.

Individual and Social Well-Being: Towards a Comprehensive City Based on the Open Data observatory, MBAA has undertaken systematic analysis to identify and evaluate the potential socio-economic impacts of development on the lives and circumstances of its population, their families and communities. If such potential impacts are significant and adverse, MBAA will provide a forum, with the neighbourhood committees, for planning how to maximize the beneficial impacts of a proposed development. Beneficial impacts can include:

- better standard of living due to increased access to employment;
- more business opportunities, training and education;
- greater access to and from a community;
- increased funding to improve social infrastructure and cultural maintenance programs; and
- adoption of a citizen-centric approach in all aspects of service design and delivery.

MBAA aims to enhance the better inclusion and participation of its local population, including young people involvement, better targeting of aid, economic efficiency, risk management, cost reduction (intelligent lighting, oriented approach, necessary e-services, and renewable energy), generating additional revenue.

However, MBAA's approach towards a smart city offers above all an invitation to reflect and act through pilot projects that are expected to change the mentality of people and integrate this concept in their future plans. The public/private actors are the heart MBAA's successful projects.

MBAA and the Local community have been accompanied to identify their own problems and priorities, while "vertical" applications have emerged to meet these needs and simplify citizens' lives.

Smart Citizens: Towards an Innovative City In the concept of a smart city, citizens are turned from passive consumers into *active and concerned citizens*; producers of ideas, content, applications, activities; and choosers of society. The concept of smart city enhances *innovation and creativity*, seeking to social relevance of new/unfamiliar ideas, opportunities for start-up firms, and propensity to entrepreneurial risk. Also the access to the city data (open data) increases the emergence of new applications and the involvement of citizens in the decision-making through direct democracy, for validation of the service concept. For example, we can actually find: access to high speed internet; computers, smart phones/tablets, free courses in all areas for self-study; social networks, forums, participatory sites.

Smart Governance: Towards a Comprehensive City MBAA is being challenged to surrender its legislative power in order to facilitate real partnerships with the local community and embrace notions of participatory governance, where principles of democracy, subsidiarity, citizens' empowerment and community engagement are more established features of its political landscape.

Given the growth of the local population and concern about issues such as job creation, Baakline has the opportunity to stand positively at the developing map of the region, and attract the private sector investments, which opens the way for many jobs' creation.

The best balance among MBAA's social spending and citizens in need, protects them through providing solutions to strengthen territorial integrity, reduce crime and quickly react in case of disasters (like the latest national solid waste crisis).

Smarter Energy Infrastructure: Towards a Green City Looking forward, a surge of innovative and disruptive business models in the energy sector is currently under way. Through the European SUDEP project, MBAA targets to establish a specialized cooperative *"Energy for All"*, which will be seeing a proliferation of intelligent assets to optimize energy use in many settings, from homes to street lighting. In addition, new businesses will be emerging that enable off-grid renewable energy as a service at affordable prices. Such new business models could be crucial in giving a broader access to renewable energy sources to many more end users. Moreover, these models could make it increasingly viable for developing markets to build entirely distributed energy systems and avoid the significant resource and capital costs tied up in it. The cooperative will disseminate the usage of intelligent assets to improve efficiency in energy consumption as a recognized and growing practice.

MBAA has so far issued some legislation to motivate local population to adopt the concept of energy efficiency and renewable energy; and to improve insulation of buildings. More specifically, the municipality has officially issued legislations concerning photovoltaic installations in citizen's homes. They are as follows:

- An official Municipal Council Decree, stating that every household that installs the solar water heater will be exempted from the municipal water charges for one year.
- An official Municipal Council Decree, stating that every household that installs a full processing solar lighting system will be exempted from the municipal water charges for five years.

Concerning street lighting, MBAA changes light intensity remotely, depending on natural light and street conditions, replacing individual components based on actual burning hours rather than on assumptions, and reconfiguring installations to adapt to changing environmental factors.

The future is likely to entail a built environment that is flexible and modifiable which, through its interconnectivity, can feed the wider system (the city or the traffic grid), using information that enhances potential of both traffic management and urban planning.

Setting the Right Enabling Conditions: Towards a Resilient City Public participation enriches the power of citizens to transform their city with small actions around resiliency, poverty, community-building, governance, resource use and quality of life. MBAA aims at enhancing the context notion that we are more than consumers,—we are participants, makers, re-thinkers and co-designers of our city-; and that Baakline, as common, is a fertile ground for creative innovation.

A converging theme in this respect is the challenge of enabling open, yet secure, data sharing that fosters innovation and generates trust between stakeholders. The most significant challenge for businesses is to successfully move towards more open innovation, gradually shifting from the traditionally protective approaches, focused on centralizing data to maintain control; and ensuring adequate trust and security. The greatest policy challenge is to create an environment where businesses are able to innovate openly; while at the same time ensures organizations' and individuals' integrity with a strong legal framework.

MBAA faces on the one hand the challenge of creating an appropriate regulatory environment around technological innovations that effectively ensures stakeholder trust and security, while encouraging innovation. On the other hand, sensitive issues like data privacy and security require a robust legal framework, with adequate enforcement mechanisms.

Public Participation and Civic Engagement towards Financial Viability and Sustainability: An Inclusive City This MBAA procedure to enhance the participatory democracy at the local level is a trendsetter in the municipal life at the national level. MBAA is being challenged to improve its regulatory frameworks in order to facilitate real partnerships with local community and embrace notions of participatory governance, where principles of democracy, subsidiarity, citizens' empowerment and community engagement are more established features of its political landscape.

Drafting and ratifying an internal RNC regulation guaranteed the sustainability of this approach. This has drawn the attention of EU Delegation in Lebanon, providing MBAA (as project leader) and FMCS (partner) with a grant under the European Project "Support to Democratic Reform in Lebanon" (European Commission 2013) for the assistance in further developing this approach through creating new tools in order to expand this innovative experience to all FMCS local authorities. This grant well motivates all FMCS municipalities and their citizens. It aims to fulfill the following objectives: increase the local government performance; involve citizens in policy-making; enhance the role of the RNC and spread openness, transparency and democracy at the local level. This is carried out by disseminating the good practices with the appropriate institutions and mechanisms in place to ensure more effective participative democracy. It helps to emerge a new local leadership culture and increase the youth and women's political participation.

The RNC elections were held in the FMCS cities. Their results show the increase of women participation in RNC (35% of these committees' members are women), and youths who are below the age of 21 were given the right to run for the RNC elections and vote through the process as well. Also the rights of minority groups are preserved by allowing those who live in the city to have the right to run the RNC elections and vote in the process, even if they were of different origins or belonged to the minority families. Not to forget that during all the RNC election processes that has so far occurred in our region, the simplest rights of handicapped people were completely respected.

MBAA strives to operate and manage its affairs transparently and with fairness, through proper utilization of the city's technical, human and financial resources. This happens with a great deal of transparency and accountability from the elected RNC to hold senior position in the follow-up and evaluation of the desired objectives' achievement. This process guarantees efficiency of local management and provides services to citizens in response to their expressed needs. It also reflects the importance of amending the social behaviour of citizens; and builds standards and positive values based on social solidarity and citizens' engagement to create a sense of ownership and commitment, stemming from their real expectations.

MBAA is targeting to share its best practices, spread information on this democratic experience and proven results from this successful initiative, in order to motivate other Lebanese municipalities to follow it as well (Ghosseini 2016).

9 Identification of Barriers that Handicap Objectives' Implementation

A smart city concept in countries like Lebanon often encounters brakes that could jeopardize its realization. The main *obstacles* are:

- The multitude of actors and decision makers of the city at the national and local level.
- The low adoption of new digital solutions. Several digital technologies are quickly becoming outdated and require replacement. Cost of equipment and user training.
- The cost of IT implementation.
- The low involvement of older citizens.

However, not all participants have shared this beautiful enthusiasm about the concept "Baakline towards Smart City". Many consider it as simple techno-utopias reserved for those who can afford to live in such environments. As some participants objected, a smart city needs more educated citizens without worsening the rural-urban division. Moreover, even if a smart city couldn't pass through investments in technology, how will MBAA and other Lebanese local authorities avoid widening the digital crack, which already tends to favour more the urban environments? A smart city needs broadband, an educated workforce collaborating with universities, innovation and digital inclusion.

10 Delivering the City Transformation Concept in Practice—Concluding Remarks

MBAA's experience towards a smart city can enrich the power of dreams, the imagination and the importance of idealism and nostalgia, as well as the benefits of looking at the world in different ways. The Future Baakline, as an idea that often relies upon utopian thinking to sustain itself, can be as cruel as it is consoling. Even as it makes possible investment into its urban space as a site of future fulfillment, MBAA may fail to deliver upon this promise. The challenge asks what future such utopian thinking makes available for the city and what present realities it denies; also, what futures can be imagined by the citizens themselves?

Major evidence is that a smart Lebanese city does not look like a smart European or American city! Many of our main urban problems are not technological, but social, like poverty and inequality, and have been exacerbated, not solved, by corporate privatization and city branding strategies. Therefore, a lot of attention is being given to Lebanese cities these days, for a good reason: while the Lebanese State falters, cities are uniquely positioned to effect positive change on a broad scale. Lebanese Municipalities are the middle actor: they are not the top down and they are not the bottom up. Since sectarian divisions and civil wars are tearing apart Lebanon (and most of the Arab countries), Lebanese people (notably the youth) suffer from stress, and from intra and interpersonal conflicts (at work, at home, at the street, etc.). Not to mention the political and economic crises prevailing in Lebanon, the presence of 2 million of Syrian and Palestinian refugees on Lebanese territory, the atmosphere of insecurity, the lack of communication skills; etc. Conflicts are thus increasing, consuming our vital energies and affecting our productivity at all levels. Additionally, there has been little room for people power, democratic debate and citizens' rights in many discussions of the city future. Unless every citizen assumes his/her responsibility in any conflict, there would be no peace in any family, community or country.

For these reasons, MBAA needs to initiate new smart initiatives and case studies about the commons, community, civic engagement and more, looking critically and carefully at the policy process, driving forces, power and sociological context, in order to develop a smart mentality to cope with urban and political changes. This is the paradox faced by any smart initiative, corporate or otherwise. Participation-based and citizen-run interventions into the smart city can give us glimpses of what might be possible if the IT was used progressively in the service of urban dwellers, rather than simply in efficient high-tech and corporate profit-making activities.

Despite the disparity in contexts and needs, the transition to smarter cities can be a leading solution for enabling cities in developing countries, like Lebanon, to meet the challenges resulting from growth in their urban populations. Taking into account financial constraints and involving the people in decision-making will be key factors to achieve this development and make it a success.

Looking Ahead: the smart city concept, is it a paradox?

The smart city concept seems to be characterized by the inherent paradox of providing common guidelines for a diversified management of the cities. It is a challenge for the municipalities to bypass this paradox by strongly encouraging facilitation from above and by enhancing involvement from the bottom, which should be crucial elements in public awareness-raising, training and education.

Despite the entire disadvantages and problems at the national level, Baakline city tries to establish its *smart city roadmap* through:

- Working with stakeholders to identify a set of services and initial smart city deliverables that represent quick wins for the city.
- Giving priority to changes that can be delivered quickly, at low cost and low risk.
- Establishing systems to learn from early customer experience, to improve services in the light of this, and then to drive higher levels of take-up.
- Working with early adopters within the city authority and partner organizations in order to create exemplars and internal champions, and thus learn from experience and drive longer-term transformation.
- Establishing processes to ensure that critical success factors are identified, measured and managed.

The integration of the smart city concept into the MBAA's Roadmap is a huge and highly ambitious plan, but still feasible. It requires a lot of effort, both in the field and behind the scenes of our institutions. The smart city task is about smart governance, engaging communities, learning and adaptation, and investing in the future by reshaping an entire market and ecosystem, driven by the requirements allowing Baakline to work well for its residents and businesses. It will take determination and persistence in order to assure the expected results. However, the benefit it can bring to Baakline will set an example for other Lebanese municipalities. Through this roadmap, Baakline has the opportunity to position itself favorably in Chouf Souayjani region and remain up to its role as a "local pole for its surrounding rural areas"; to enhance its financial viability and its sustainability; and to attract private investments with a purpose of a multitude of job creation. We must become smarter together.

After all these initiatives[1] can we talk about the smart city in Lebanon????

[1]*Scalability of the participatory approach*: Through all my 18 years of municipal experience, I have realized that the pace of change in the Lebanese society mentality is slow, although convertible with time. This urged me as a Lebanese woman to promote this idea of participatory democracy and fight for the rights of women, youth minorities and handicapped people. Inclusive and democratic approach along with electing RNCs is surely scalable and applicable in every society, whose people are mature and well aware that such a movement will lead them towards new ways of addressing problems, and developing the perspective towards sustainable development. Through this, a win-win situation can be achieved. I hope the RNCs experience still applicable with the new municipal council.

The smart city roadmap is considered as a tremendous effect on the results being done. Since June 2016, it is in the hands of the new municipal council. Citizen participation and participatory instruments do not change in any way the fact that it is the elected representatives who adopt laws and make collective decisions: the future of our experience is now challenging… This demonstrates the importance of political will and, at the same time, the fragility of the process in developing countries like Lebanon.

Critical for securing the input of citizens is transparency in the process and offering citizens follow-up to their recommendations, for citizens want to know what will happen to the input they have given. Exclusive reliance on new technologies may not completely address the problem.

In Lebanon, at the local level, decentralization can allow greater self-determination for local authorities, at the same time that it demands more responsibility from local politicians in terms of enhancing the participatory democracy. A municipality's important role in local interest politics can create a favorable atmosphere for supporting laws and negotiations with a view to a public administration shared among the public and private sector and the communities.

Acknowledgements The author would like to acknowledge the European Union for its great help to Lebanon. MBAA has been involved in a number of EU-funded projects that contribute to strengthening its capacity and to improving the quality of life of its citizens with broad democratic participation and with plenty of opportunities. It is a vivid demonstration of why the EU places such great importance in supporting the development of Lebanese local authorities.

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Smartening-Up Communities in Less-Privileged Urban Areas—The DemoCU Participatory Cultural Planning Experience in Korydallos—Greece Municipality

Anastasia Stratigea, Giorgos Somarakis and Maria Panagiotopoulou

Abstract Coping with contemporary urban challenges and smart city developments actually implies a conscious effort to engage a range of actors of local ecosystems and transform ways of implementing things in a significant, fundamental and structural rather than incremental manner, which results in more qualitative outcomes and cooperative, highly inclusive, decision-making processes that affect current and future quality of local communities' living perspectives. Citizens and stakeholders' participation in such an effort is growing in importance, in alignment with the currently prevailing shift from a top-down to a bottom-up planning paradigm. Along these lines, the focus of this paper is on smartening up local communities, considered as the heart of smart cities' development. More specifically, the paper targets citizens and stakeholders' empowerment and engagement in a specific cultural planning exercise in a less privileged suburb of Athens metropolitan area, the Municipality of Korydallos. This is accomplished by the development of an innovative stepwise participatory planning framework, effectively combining classical and Web-based participatory tools for establishing face-to-face and online interaction at the different steps of the participatory process; and broadening substantial participation of various citizens and stakeholders' groups in this exercise.

Keywords Cultural planning and policy · Participation · Participatory planning · Citizens' engagement/empowerment · Classical and Web-based participatory tools

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1 Introduction

> Smart cities are first and foremost a cultural and organizational transition (Brynskov 2013).

Coping with contemporary planning problems implies the need to gather local knowledge from various stakeholders' groups that are affected by or can influence or contribute to the formulation of knowledgeable policy decisions, in an effort to successfully integrate scientific and empirical knowledge into decision-making processes, taking also into consideration policy constraints. Fulfilling this need is grounded on a variety of participatory tools, both classical and information and communication technology (ICT)-enabled, capable of fostering collaborative, consensus-building planning solutions (Healey 2006). Citizens and stakeholders' participation in spatial planning exercises is growing in importance, since it is further facilitated by a variety of ICT-enabled technologies and their applications that have rendered possible the bidirectional (e-)interaction between planners and decision makers on the one hand and local communities on the other. Such technologies have pushed forward the issue of *participation* in planning, which is gaining interest in alignment with the currently evolving transition from a top-down, hierarchical and command-oriented to a *bottom-up and community-empowering decision-making paradigm* (Zwirner and Berger 2008; Stratigea 2015), an issue that, in practice, also entails a shift from an *outcome*- to a *process-oriented* planning context.

The *value added* by participation in planning exercises is today widely appreciated, a fact that has led to a boost of participatory (spatial) planning exercises, steering a *participatory revolution*, as it is characterized by various researchers in the field (Blühdorn 2009; Stratigea 2015). The concept of participation is not new of course. However, it is considered nowadays pretty significant, mainly due to the prevalence of bottom-up planning approaches, widely engaging citizens and local stakeholders; but also the maturity and widespread use of relevant ICT applications (Klein 1999; Stratigea 2012) that allow the establishment of proper mechanisms for effectively bridging policy makers and planners with the recipients of their work, i.e. different stakeholders' groups. Both have largely affected the number of empirical applications and their practicality.

ICT-enabled participation (e-participation) in spatial planning has enlarged planning and decision-making essence by broadening: the variety of relevant data sources; the nature of planning per se (from an outcome- to a process-oriented exercise, operating at the same time as a community learning platform); the potential for rendering planning a largely *cooperative effort*, targeting consensus-building objectives; the commitment to planning outcomes and thus successful implementation of plans; and the sharing of benefits reaped within local societies (Healey 2006; Stratigea 2015). Moreover, it has offered the possibility for transferring various steps of the planning process to the Web (e-planning), enhancing this way interaction and cooperative planning perspectives

(Hudson-Smith et al. 2002; Macintosh and Whyte 2008; Stratigea et al. 2015a; Stratigea 2015).

Participatory planning approaches, in this respect, are gaining ground based on their potential to cope with contemporary planning problems in a more effective and efficient way, reflecting the need for a more *realistic* and *normative* approach to planning problems' treatment, aiming basically to deal with *complexity* of these problems—*wicked problems*—and provide *equal access* to engagement in decision-making processes and therefore a *shared power* of the various societal groups in decisions made (Healey 2006).

From a *realistic point* of view, participatory planning processes are considered as procedures for improving both the decision-making processes per se, as well as the quality of decisions deriving from them. Both are mainly based on the engagement of various stakeholders' groups and the enrichment of ground knowledge emerging from participation in the planning process that can lead to better management of relevant problems. Gathering this knowledge implies removal of *barriers* of various groups to engaging in decision-making processes, thus changing traditionally formed power structures in communities and opening up new chances for participation to broader, less privileged, but equally important in decision-making processes, parts of society.

From a *normative point of view*, participatory approaches broaden the democratic nature of decision-making processes; and deepen understanding among societal groups of mutual interdependencies and common destinies, a fact that is nowadays considered crucial for coping with current challenges and complex planning problems, confronted by communities. Solving these problems implies new decision-making patterns and rules, capable of embedding *value systems* of various societal groups in a vision building process. Participatory approaches are empowering democratic processes, through which planners and decision makers can better grasp the social context and its values and incorporate them into the political negotiation that a participatory process entails (Stratigea 2015).

Furthermore, participatory processes, through the establishment of *effective face-to-face and ICT-enabled communication channels* between decision makers and planners on the one hand and citizens/stakeholders on the other are considered as mechanisms for improving *trust*, *legitimacy* of decisions and *commitment* to their implementation. Nowadays, they constitute a *"measure" of good governance*; while they contribute to *mature and active* citizens' creation, by empowering and training them in new forms of *social learning and action*, as well as broadening networking potential and interaction at the community level.

Engaging citizens and stakeholders in *participatory planning processes* can result in the (Stratigea 2015):

- establishment of highly qualitative *democratic governance* models;
- *empowerment* of social groups by engaging them in socially innovative learning processes;
- planning of more effective and widely acceptable, vision-driven, solutions guaranteeing *commitment* and *successful implementation*;

- development of mutual *trust and respect*;
- better understanding of current *challenges* and *priorities set* that increases potential for more effective consideration of their solutions;
- motivation of new *social learning processes and cooperation* through exchange of empirical knowledge, experiences, views, expectations and visions;
- more effective management of *conflicts* among different groups and establishment of *peace building mechanisms*;
- building of *consensus* in coping with common problems; and
- *training* in Web-based interaction as a new communication model among all parties involved.

The aforementioned are considered as *milestones* for pushing forward smart city initiatives, taking into consideration that *active, engaging and "smart" people*—smart community, i.e. social development and citizens' empowerment as stated by Shah (2015) or the component of "people" as defined by Giffinger et al. (2007) in their study on the components of a smart city—constitute the *blood* and give *essence* to any ICT infrastructures, forming the backbone of smart city development endeavors. It is grounded on the statement that smartening up a community implies a conscious effort to engage and transform ways of doing things in a significant and fundamental rather than incremental manner, shifting to more qualitative ways of living and engaging in decision-making processes that affect current and future living perspectives; while smarter and more informed citizens can lead to knowledgeable choices that can in turn result in smarter cities too.

Along these lines, the *focus* of the present paper is twofold namely to: develop an *innovative participatory framework* for taking advantage of participatory planning processes towards the development of an *integrated strategic cultural plan* for more effectively managing cultural structures and infrastructures in a less-privileged urban area (the Korydallos—Athens Municipality) and, by that, fuelling local development perspectives of this city; and deploy and test the effectiveness in the participatory planning process of the *DemoCU cultural platform* as a smart Web-based infrastructure for establishing online interaction and broadening participation of a variety of citizens and stakeholders' groups in the cultural planning exercise that is coupled with classical participatory tools. Towards this end, a multi-layered participatory approach, based on *classical and Web-based participatory tools* is designed, which seeks to broaden citizens and stakeholders' engagement in a strategic cultural planning exercise for the region at hand, taking into consideration the peculiarity of the planning problem—*cultural development*—namely development of a sector that embraces all social groups. This, in turn, implies that the relevant planning exercise has to take for granted that all different views, expectations and visions of these groups, need to be embedded in the outcome of the planning process, namely the final cultural development plan.

The *structure* of the paper has as follows: the first two sections shed light on the type of participants engaged, as well as the participatory tools used in the DemoCU cultural planning process; next, the multiple stages of the participatory planning framework, developed in this work, are analyzed; then, their implementation in the study area and results obtained are discussed; finally, some conclusions are drawn based on the experience gained from this empirical exercise for *smartening-up people*—both producers and consumers of cultural products-as well as *administrative bodies*, as a prerequisite and a milestone in the current smart city discourse for sustainable local development.

2 Who to Engage? the DemoCU Approach

Selection of stakeholders for engagement in a participatory planning process varies according to the goal and objectives to be achieved; the interest of the topic explored for the different social groups; and their ability to contribute to this topic (Stratigea 2015). Main groups of potential stakeholders are:

- citizens as individuals;
- groups of citizens, representing numerous associations;
- institutions of the public sector;
- institutions of the private sector;
- experts on topics explored;
- decision-making bodies that are entitled to be the recipients of the outcome of the whole participatory exercise for its further implementation, e.g. municipal authorities.

In DemoCU, participants engaged along the participatory process are presented in Fig. 1. More specifically, groups involved are described below.

The *Cultural Consultation Committee* (*CCC*), which was formed for the purpose of DemoCU project and consists of cultural associations' representatives, selected by specific evaluation criteria from a pool of potential candidates from the local

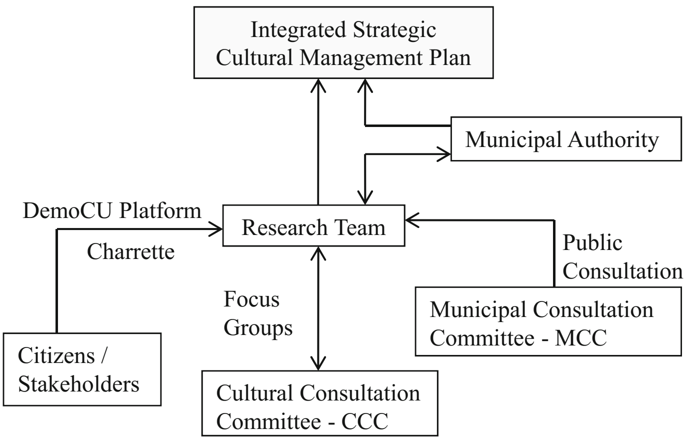

Fig. 1 Participation in DemoCU—groups involved and participatory tools applied

community. The role of this Committee is to support the research team and contribute to the development of the draft and the final cultural management plan. Moreover, it cooperates with the research team for elaborating data, collected from participatory processes (consultations with citizens, cultural associations and other stakeholders' groups), and gradually incorporating them into the final proposal of the civil society towards the local administration for further implementation.

The *Municipal Consultation Committee* (*MCC*) of Korydallos Municipality, which cooperates with the research team along two phases: first, at the phase of articulating the draft plan; and second, at the phase of finalizing it. This Committee holds an institutional role in the whole process, as this is defined by legislation related to local administration (Hellenic Republic 2010). The goal of consultations with this particular Committee is the modulation of the specific plan according to the choices and priorities of the various social groups that it represents.

Citizens and stakeholders of Korydallos Municipality, who are engaged by means of *face-to-face* and *Web-based communication*, aiming at gathering information in respect of their views and expectations that can broaden the knowledge of the research group, regarding the attributes and content of the Strategic Cultural Management Plan in order to be in alignment with local desires; while also satisfying the views of cultural associations and smoothly integrating them into the general planning of the study region.

The *Municipal Authority*, which is in very close cooperation with the research team during the planning process of DemoCU, serving the goals of: spreading information of DemoCU efforts to relevant recipients; identifying political priorities; and introducing them into the Strategic Cultural Management Plan. As a consequence, the final planning outcome can serve as a pillar for the development perspective of the study region, properly incorporated into the strategic directions of Korydallos Municipality.

The research team is in close cooperation with all the above groups in the context of formal and informal interaction, taking place in separate (each single group) or joint participatory sessions (all groups in common sessions), aiming at creating a fertile ground for mutual understanding and reaching consensus on the decisions made for the finally proposed Strategic Cultural Management Plan.

3 How to Engage?—DemoCU Participatory Tools

In the current section, the participatory tools used in DemoCU methodological framework, are presented. The specific participatory planning exercise makes use of both *classical and Web-based participatory tools* in order to take advantage of both streams of available options, address capabilities of these options, as well as capabilities of various stakeholders' groups engaged. More specifically, Focus Groups (FG) and Charrette classical face-to-face participatory methods as well as public consultations are implemented, combined with Web-based participation through the project's platform. In the following, the key aspects of these participatory tools are shortly provided.

3.1 Focus Groups Method

FG participatory method constitutes a qualitative research method, useful for the exploration of specific questions or dimensions of a planning problem, which are not possible to be grasped by means of quantitative methods. Some indicative definitions of the method are presented in Table 1.

FG method is a promising scientific tool and a suitable social setting for organizing a social debate (Kasemir et al. 1996). It may serve as a platform for *social learning* that brings together scientific knowledge and behavioral patterns of participants; while it also may be seen as an instrument for strengthening *participatory democracy*, by systematically engaging citizens in decision-making processes. FG methodology can be defined as a structured process for dealing with complex issues, using knowledge from various scientific disciplines and/or stakeholders, so that integrated insights are made available to decision makers (Rotmans 1998). Within this process, a guided group discussion is carried out, focusing on a specific topic. In contrast to an ordinary group discussion, purposive information about the focal issue is given as *input and/or stimulus* to the FG. The key attribute of FG, as a research method, is the *interaction* among the group's members. The whole process is characterized by its *dynamic nature* and *synergetic effects*; while it results in the production of far richer information than any other research method (Berg 1989; Stewart and Shamdasani 1990; Stratigea 2013; Stratigea et al. 2016).

FG can be applied for (Bar-Din Kimel 2003):

- collection of qualitative data from the group of participants;
- diagnosis of problems as to the planning issue at hand;
- identification of relationships among the different dimensions of a problem and/or production of new ideas;
- setting of hypotheses relative to the studied issue;

Table 1 FG definitions

Source	Definition
Dawson et al. (1993)	Groups of properly selected persons with similar background and experiences, gathered in order to discuss on a predefined topic, in a certain time span and under concrete rules. Participants share some common characteristics relevant to the problem at hand
Powell et al. (1996)	Groups of people selected for discussing and commenting on a specific issue, on the basis of their personal experience. It ends up with the collection of empirical information and knowledge which, when combined with scientific knowledge, can contribute to the amelioration of problem's solution
Morgan (1988)	A method for collecting qualitative information from participants with the support of a carefully structured group discussion, aiming at the articulation of their views in a friendly environment

- assessment of plans, projects and policies;
- increasing awareness of participants as to planning issues or challenges ahead;
- promotion of a more pluralistic decision-making model;
- exploration of the issue under study, new knowledge production; etc.

3.2 Charrette Method

Charrette method establishes a *face-to-face intensive negotiation process* among the various social groups engaged in the participatory process, serving the goal of reaching consensus on a specific plan (Bouzit and Loubier 2004a, b). The method has mostly been applied for resolving planning issues at the local level. Its *main attributes* are:

- *Equity of participation*, implying representation of all social groups in order to resolve conflicts and reach consensus.
- Each participating group takes for granted the *creative negotiation* on a specific plan in order to end up with an outcome that will best satisfy the needs of all different groups engaged.
- Wide *publicity* of Charrette workshops is predicted, so that information is properly spread to a large part of the society for strengthening awareness, empowering those involved and increasing participation potential, mutually benefiting all societal parts involved.

The issue under study is analyzed into several *dimensions*, while each one of them is subjected to elaboration by a specific sub-group of participants. Every sub-group is then **exhaustively** working on the assumed dimension in charge, while all sub-groups are periodically cooperating in order for interaction to be created both among groups and different dimensions elaborated (feedback loops). In each cross-cutting session, views on each specific dimension are presented, different opinions or objections are expressed, and synergies are created; concluding to a cohesive outcome. Based on the results of this interaction, sub-groups continue separately their work, taking into consideration aspects and views articulated by members of the rest sub-groups. Sub-group and collective work continues, until consensus is built and a final proposition regarding the studied issue is prepared (Bouzit and Loubier 2004a, b). The method can engage from a small to a very large number of people (50–1000 persons respectively), while its duration can range from a few days to a couple of weeks, depending on how much controversial the study issue is and how fast consensus can be achieved.

Charrette is usually applied, when there is a need for (Karner et al. 2011; Stratigea 2015):

- gathering of useful ideas and views at the early stages of a planning process;
- encouragement of interaction and cooperation among a large number of participants for reaching consensus;

- supporting of decision-making in difficult and complex problems at the local level;
- confrontation of sticky situations and conflicts' resolution, mainly emanating from persistence of various groups in their positions; and
- development of plans and blueprints that are based on citizens and stakeholders' views, thus facilitating successful implementation of planning outcomes.

Moreover, the method is useful in cases that decision-making is relevant to a large part of the society (e.g. culture, health), where broadening perspectives of planning through successfully embedding stakeholders' views guarantees the successful implementation of related plans and the minimization of potential conflicts (Stratigea 2015).

3.3 Web-Based Participation

The radical technological developments and the intense use of Internet and its applications for a more effective communication and spread of information have largely facilitated citizens' engagement in the planning process. Relevant empirical studies are growing in number and are revealing the significant contribution of contemporary information and communication tools in the planning discipline.

At the same time, high consideration is shown as to the new types of *barriers* that can be introduced in respect of the equal access of various social groups to these means (Carver et al. 2001; Brabham 2009; Stratigea 2011; Papadopoulou and Stratigea 2014). Such barriers are mostly related to: the access to Internet and broadband infrastructures; the skills required for its successful use; the lack of face-to-face interaction that may impede lay people to unfold their thoughts and feelings; the lack of interaction and synergies' creation out of it, which are considered the bedrocks of face-to-face interaction (Carver et al. 2001; Papadopoulou and Stratigea 2014); etc. These barriers can undermine the basic principles of participation and therefore the outcome of relating participatory processes.

Despite the above weaknesses, the power of Internet and its applications towards opening up participatory processes to a wide range of societal groups, removing obstacles of cost, time, etc., remains nowadays indisputable. Their intensive use, especially from distinct societal groups (e.g. youth) as well as skilled people, renders that type of interaction quite useful for engaging them in a participatory planning process. As many researchers claim (Conroy and Gordon 2004; Button and Ryfe 2005; Mandarano et al. 2010), a combination of face-to-face and Web-based participatory processes seems to be a rather effective approach, offering more satisfying and qualitative planning outcomes and effectively dealing with tradeoffs of different processes. Thus, Web-based participation should be treated as complementing rather than competing to traditional participatory approaches (Seltzer and Mahmoudi 2012).

Adoption of Web-based participatory approaches in DemoCU was evaluated by the research team as a quite useful approach and was implemented through the project's Web platform. The latter was deployed for spreading information about the project and the planned participatory steps, undertaken in order to promote citizens and local associations' (e-)engagement and their contribution to the structuring of an Integrated Strategic Cultural Management Plan for the study area. The DemoCU platform is used for diffusing information about the draft plan and gathering citizens and local stakeholders' opinions for improving it and adjusting it to the local preferences and expectations. At the same time, the platform serves as a *source of information* about every step of the participatory effort and the trajectory towards the finalization of the Cultural Management Plan; and as a *digital cultural node*, highlighting the cultural profile of the city and relating stakeholders activating in the area (information about location, field of expertise, schedule, events organized, etc.) and disseminating this information to the public.

4 The Methodological Framework of DemoCU

The innovative participatory framework developed in DemoCU is discussed in the following. The stages involved, serve the goal of engaging multiple citizens and stakeholders' groups in gathering knowledge on the specific cultural planning issue at hand. Interaction between decision makers (municipal authority) and the research team on the one hand and the local community on the other, was decided to be accomplished by both *classical* and *Web-based participatory approaches* for balancing strengths and weaknesses of these two streams (Button and Ryfe 2005).

A *multilevel participatory process* was designed, targeting a step-wise work progress towards the final plan. The participatory framework, developed in this respect, is illustrated in Fig. 2. It actually consists of *three distinct stages*:

- *Stage 1*: explores the current state of the study region (Municipality of Korydallos), placing emphasis on the socio-economic state; and the type/spatial distribution and mapping/visualization of cultural structures and infrastructures.
- *Stage 2*: constitutes the heart of the participatory framework, used in DemoCU for the development of an Integrated Strategic Cultural Management Plan for further implementation by the local administration.
- *Stage 3*: contributes to the articulation of the final plan as a proposition of civil society to the local administration, embedding opinions and expectations of citizens and stakeholders' groups concerning the cultural sector.

A short description of the three stages follows, placing emphasis on the main part of the framework, where the whole participatory exercise is taking place.

Stage 1 aims at getting good insight into the study area. The geographical position of the Municipality is explored, as well as population developments and social attributes. Moreover, the economic structure and current infrastructures are studied; while a thorough analysis of the cultural sector and related infrastructures was carried out, aiming at their mapping and exploring patterns of their spatial distribution. Finally, all relevant to cultural sector actors, both from the public and the private

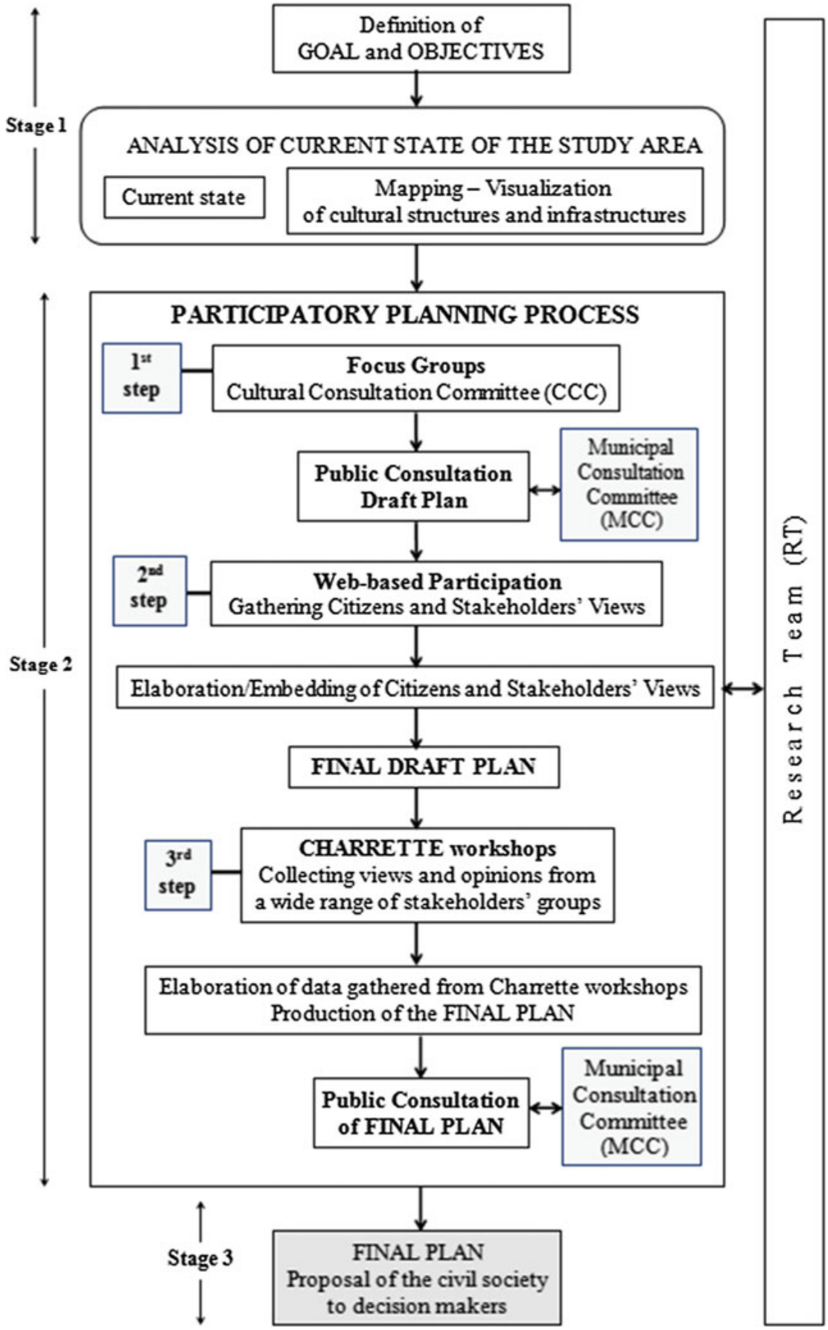

Fig. 2 DemoCU participatory methodological framework

domain were identified and mapped, while information regarding their activities, role, position in the cultural sector's power structure, etc. was also collected and elaborated. At this stage, the DemoCU platform was also designed and information about cultural structures and infrastructures was gathered and presented on a Web-based Geographic Information System (GIS) map, embedded in the platform.

The core of the participatory framework constitutes *Stage 2*. After having explored the key attributes of the area at hand and the status of the cultural sector, the research team has made certain decisions as to the *context of participation*, the *participatory methods* to be used in this exercise, the *civil groups* and other *stakeholders* that should take part, the *sequence* of the various steps of the participatory process, etc.; so that the final Strategic Integrated Cultural Management Plan, based on wide communication with local community, to be gradually built and the highest possible consensus on this plan to be reached.

The participatory process in Stage 2 incorporates a number of steps, which have as follows (Stratigea et al. 2015b, 2016) (Fig. 2):

- *First step*: the scope of this step was to build up a *Draft Cultural Management Plan* as a starting point for the participatory planning process. The draft plan, created by the research team, is further elaborated in cooperation first with the CCC, the informal committee established for the DemoCU project's purposes, acting as a consultant of the research team. High experience and involvement of members of CCC in local cultural affairs was valuable in order to improve this draft plan. Next, consultation of the improved plan with MCC, a formal consultation committee according to the national law, was carried out, seeking a further improvement of the draft plan by using the different standpoints of this committee, representing different parts of the local society. Consultation with CCC used the *FG* participatory method, engaging into the participatory process members of CCC in a number of FG sessions; while interaction with MCC took the form of a public consultation, bringing on board cultural stakeholders' groups from the local society as well. The outcome of these participatory sessions was the *finalization* of the draft plan, "filtered" by experts of the sector—members of CCC—but also different viewpoints—as expressed by members of MCC and other groups involved; and its opening up to the community.
- *Second step*: the improved draft plan emerging from the previous step is subjected to consultation with citizens and local stakeholders. A Web-based consultation through the DemoCU platform is established in this respect, where local views and empirical evidence on a number of issues raised in a structured questionnaire are gathered, feeding further improvements of this plan that reflect local knowledge and expectations. Feedback from Web-participants was requested through a Web-questionnaire that was focusing on *goals and objectives* of the proposed plan, and the *policy framework* (policy directions, policy measures and actions) designed for attaining them. Participants were asked to rate them according to their preference, while commenting on the whole or a part of the plan was also possible. Comments gathered through the Web were collected and co-elaborated-evaluated with the support of the CCC, leading to the *final draft plan* of cultural management.

- *Third step*: the final draft plan is opened up to the local society. Face-to-face interaction is used in this respect by means of *Charrette* participatory workshops. Different societal groups were engaged, such as youth, elderly, disadvantaged people, cultural associations, representatives from the public authorities, etc. After the elaboration of information gathered and incorporation of relative propositions into the final plan with the collaboration of CCC, the final plan was furthermore negotiated with MCC, as a final step of the whole DemoCU participatory process.

Stage 3 refers to the finalization of the Strategic Cultural Management Plan. In this stage, final comments of the MCC members were worked out and the *final proposition* was produced and was forwarded to the Municipality, for incorporating this into its strategic plan and implementing it.

Furthermore, wide communication of the final plan was achieved through the organization of a dedicated conference, where commitment of local authorities and cultural stakeholders' group towards the implementation of the final plan was pronounced.

5 Implementation of the DemoCU Cultural Planning Participatory Framework

The role of *culture* as a vehicle in pursuing local development objectives is nowadays highly acknowledged. Indeed culture is considered as an overarching as well as an underpinning aspect, a catalyst for durable economic and social development; but also an aspect that incorporates *intrinsic spiritual and unique values* of *societal knowledge* and *identity,* that need to be protected and handed over to future generations (Hawkes 2001; INHERIT Project 2007). Along these lines, in the present section the implementation of the DemoCU innovative participatory framework and results obtained are presented, seeking to: *smarten-up local community* and *broaden participation* in a cultural planning exercise in order to end up with a final planning outcome that brings on board and embeds different expectations and visions of local society—*a short term expected result*; and promote cultural development of the region at hand as the cornerstone of a more creative and long lasting future development and identity—*a longer term outcome*.

5.1 Stage I—Analysis of Current State

A thorough analysis of the *study area*—Korydallos Municipality—was carried out at this stage. The study area lays on the northern-western, less privileged suburbs of Athens metropolitan area (Fig. 3), in a privileged position as regards transport accessibility. The Municipality has rapidly grown in terms of population during the

Fig. 3 The study region (in *red*)—Korydallos municipality in Athens metropolitan area

last decades as a result of urbanization trend favoring the city of Athens and its suburbs. The outcome of this process was a rapid economic development, where commerce and entertainment were the prevailing sectors. The image of the Municipality has also, for decades now, been "sealed" by the semiotics of a prison complex, located in a central place of the city; and partly restraining its socioeconomic development and affecting its image. During the last few years, the economic recession has also negatively influenced the study region, largely impacting local economic potential and diminishing employment opportunities. Cultural development and support of creative industry is considered as a way out of this unpleasant situation, but also as an opportunity for improving the image of the city and shifting from a "prison city" to a *vibrant cultural node* in its neighborhood.

Korydallos Municipality is characterized by a vibrant *cultural profile*, marked by actions of both the public sector (cultural initiatives undertaken by the Municipality's legally established cultural association); and the private sector (a plethora of cultural associations is activated in the study area, addressing the needs of men, women, children but also third age citizen groups). At this stage, the current state of the cultural structures and infrastructures of Korydallos Municipality are studied and evaluated, aiming at identifying needs, strengths, weaknesses, but also challenges faced by the cultural sector in the specific socio-economic environment. Mapping of cultural structures and Web-GIS visualization of the cultural sector, carried out at this stage, have revealed both the spatial distribution of the cultural resources, but also qualitative information about each cultural structure or infrastructure, which can be valuable for the planning goal at hand as well as the stakeholders' analysis, necessary for detecting important stakeholders' groups of the area.

5.2 Stage II—Participatory Planning Process

The structuring of a draft cultural management plan was the starting point for the multidimensional participatory process of DemoCU. This process aimed at engaging multiple stakeholders and citizens' groups in order to gather empirical knowledge and use it towards the improvement of the final planning outcome.

First Step—CCC Consultation The first step of the participatory approach developed and implemented in DemoCU is focusing on the consultation of a draft cultural management plan, created by the research team with the two advisory committees, namely the informal CCC and the formal MCC. CCC consists of numerous persons with great experience in cultural issues regarding the study area; while MCC consists of a number of persons representing various local interest groups. The outcome of these consultations is the finalization of the draft cultural management plan for further negotiating it with citizens and local stakeholders' groups in the study area.

Consultation with CCC was carried out by use of the *FG participatory method*, comprising sixteen members of CCC, properly selected from a pool of potential candidates, identified at the first stages of the DemoCU project. The participatory process was conducted by members of the research team. A *structured discussion* was planned for this purpose, aiming at:

- Elaborating on certain *critical issues*, which were previously explored by the research team; and were expected to affect cultural developments of the study area.
- Contributing to the articulation or improvement of *goals and objectives* of the cultural management plan, as expressed by the research team and delineated by the study of the critical issues.
- Supporting the identification of a locally adjusted *policy framework* (policy guidelines and measures) for pursuing goals and objectives set, but also relevant actions for implementing this framework.

More specifically, the key lines of the draft plan were presented by the research team in the FG discussions, while a *dialogue guide*, forming the basis of interaction among CCC members, was also prepared. Issues raised in this purposefully driven interaction were concentrating on gathering empirical evidence and knowledge on:

- The *external environment*: elaborating on *trends and critical issues* of the external environment and their prioritization, potential impacts of these trends and critical issues on the topic explored—cultural sector, exploration of options available for the maintenance of cultural infrastructures in an economic recession environment, etc.

- The *internal environment*: exploring critical issues of the cultural sector in the study region and their rating as regards their importance and impact on the sector's future development.
- The *goals and objectives* that should be set in the cultural planning exercise according to the developments of both the external and internal environment.
- The *policy guidelines* for reaching goals and objectives that would be affordable, adjustable to local peculiarities and thus acceptable by the local community.
- The *policy measures* realizing the aforementioned defined guidelines as well as relevant *policy actions*.

The interaction, although tense certain times, has managed to reach *consensus* on a range of issues, which have led to further improvements and articulation of statements as to the originally proposed draft plan as follows:

- There is a need to upgrade *quality of life*, an effort that should start with the removal of prisons' complex from the city, which has marked its image and identity for decades now.
- Based on the current state of the cultural sector in the study area, but also the availability and quality of cultural infrastructures, the city can be developed as a *cultural node* both at the local and supra-local level. This element should be embedded in the local strategic plan and should also be part of the DemoCU planned cultural identity of the city concerned.
- *Ageing of population* brings to the forefront new needs/products that should feed the strategy of cultural associations in order for them to be properly met. Culture could become the vehicle for a healthy and creative ageing through the development of relevant cultural and sports products.
- There is a need for a new strategy by local cultural associations in order to reflect new needs and demand of the various local social groups.
- *Financial crisis* has marked local social developments, with society exhibiting a healthy reaction by placing emphasis on self-organization, volunteerism, cooperative action, etc. There is a need for a more close cooperation of local government with private cultural associations activating in the area.
- Economic recession and long term unemployment are testing social cohesion. Solidarity actions as well as the adoption of relevant policies in support of vulnerable groups and their active engagement in cultural actions are crucial.
- Certain new problems arise, mostly due to Municipal *budget constraints*. These relate to the cost of cultural infrastructure maintenance, the need for a certain compensatory functioning of these infrastructures or even functioning under private public management schemes, etc.
- Roma social group in the region, although a small group, should be taken into consideration when planning cultural development, as a means for removing marginalization and ghettos phenomena.
- There is a need for promoting *volunteer action* as a vehicle for cultural and social development.

- *Cooperation* is a critical aspect, where joint cultural actions should be undertaken for value-adding and synergies' creation as well as exploration of new funding sources, since public investments are nowadays really scarce.

The whole participatory process has revealed that although all CCC members realize the challenges of the external environment and the need for reconsidering their strategies as to the cultural sector, most of its members seem to be rather attached to old fashion strategies and ways of managing cultural activities.

First Step—MCC Consultation This part of the participatory process serves the goal of filtering the critical issues, the goals and objectives as well as the policy framework previously elaborated by the formal MCC members, whose structure reflects the peculiarity of the different social groups that build up the social structure of the specific Municipality. This would result in a certain improvement of the above issues based on the perceptions of MCC members, which will steer their felicitous and locally adjusted articulation.

The participatory process was based on the *public consultation* with MCC members. A free dialogue was promoted in this respect, after the presentation of work carried out so far on the specific, under discussion, issues. Members of MCC have generally welcomed the whole effort and the progress reached so far. MCC members had kept track with previous work, while key conclusions had as follows:

- New ways of facing things should come out of the DemoCU effort. *Consensus* was reached on the fact that within a rapidly changing environment, dealing with old fashioned ways cannot lead to fruitful results. New specialized, adding-value cultural activities should be planned for targeting further development of the sector; and rendering it a vehicle for local development.
- Some consider the exploration of *funding options* for deploying new modern and more qualitative cultural infrastructures of great importance; while others believe that, in a recession period, emphasis should be placed on new ways of more efficient management of existing ones. As such, a *multifunctional*, seven days, round the clock exploitation of these infrastructures for serving citizens' needs was proposed.
- Of importance is also considered *voluntarism* as a potential option for solving problems that are currently not easy to be solved.
- The *impacts of economic recession* were also discussed mainly from the point of view of the limited municipal budget, with the share of funding for cultural development being one of the main victims regarding local priorities. Within such a reality, ways out should be explored, with the private sector and sponsorships considered as main sources for cultural flourishing and survival.
- Further development of the Municipal Library and computerization of functions and processes as well as linkages to local school communities would be an interesting proposition for upgrading and adding value to cultural development of youth.

- Finally, the need for cooperation and joining efforts of all actors involved, a more knowledgeable cultural management as well as the exploitation of current financial opportunities, were recognized.

The outcome of this first step of the DemoCU participatory framework was a more elaborated version of the originally introduced, by the research team, cultural management plan, based on the improvements proposed in the context of the consultation process with CCC and MCC groups. This is then opened up to the local community, by use of a combination of a Web-based and a face-to-face interaction, presented in the following.

Second Step—Web-Based Participation Web-based participation took place through the properly designed DemoCU platform. The whole process lasted almost four months and aimed at gathering local knowledge on the key elements of the draft plan. Wide publicity was given to the process so as to motivate citizens and local stakeholders to engage and thus increase participation potential. The process was based on a Web questionnaire, in which goals and objectives as well policy framework proposed for reaching them were presented in a question form. Participants were invited to rate their choices according to their preferences.

Web-questionnaire was filled by *140 citizens*, of whom 64% were residents of Korydallos Municipality and 36% were residents of neighboring Municipalities, enjoying cultural services of the study area. Women participation rated higher than men (60% vs. 40% respectively), mainly due to the active role played by women cultural associations in the area.

Youth groups were highly presented in participation, as compared with other age groups, reaching almost 50% of participants (Fig. 4). This is mainly based on the fact that younger age groups are much more accustomed to ICT-enabled interaction and have the necessary skills for such type of communication.

Third Age, as ICT-illiterate generation is rating very low at this step (Fig. 4). Indeed they do not dispose the skills required to carry out this type of participation,

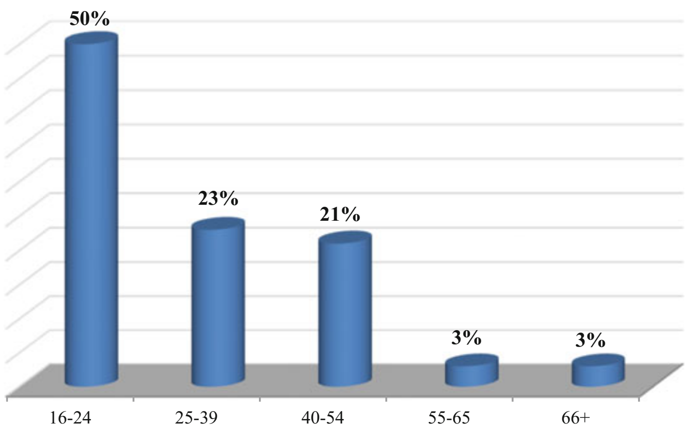

Fig. 4 Age distribution of web participants (Reproduced from Stratigea et al. 2016)

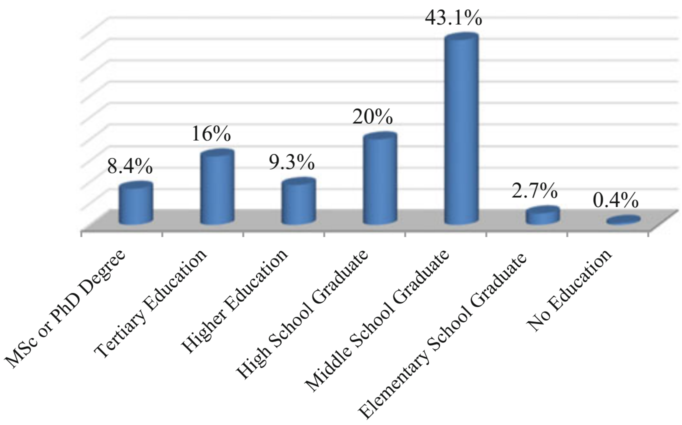

Fig. 5 Educational level and web-based participation (Reproduced from Stratigea et al. 2016)

while at the same time they are not used in such type of participation. For these types of groups, face-to-face interaction seems to be the prevailing mode of communication.

The level of *education* seems to be a decisive factor for Web-based interaction, showing a positive correlation with propensity to participate. From Web-based participants, 24.4% disposes a higher educational level, while 8.4% holds M.Sc. or Ph.D. degree (Fig. 5). On the contrary, population with elementary education exhibits limited Web-based participation.

In Fig. 6 the positions of Web-participants as to the strategic goal of the cultural plan are depicted, being the (Stratigea et al. 2016: 53):

> Development of Korydallos Municipality as a cultural node at the local level, placing emphasis on the creation of innovative and alternative cultural products and services, which will contribute to the establishment of multiplier effects for the local socio-economic environment.

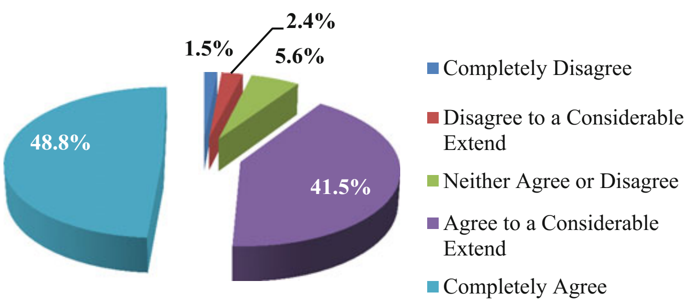

Fig. 6 Position as to the strategic goal of the proposed cultural plan for the Municipality of Korydallos (Reproduced from Stratigea et al. 2016)

According to this figure, it is evident that almost 90% of Web-participants are sharing this view.

As to the objectives set in the Cultural Management Plan, Web-based participation has revealed the following results:

- *Objective 1—"culture as a central element of Korydallos Municipality identity"*, stressing the importance of the cultural sector for building up the city's future image, meets expectations of 85.6% of Web-participants.
- *Objective 2—"culture for all"* implying equal access of all social groups to cultural products gathers positive reaction of 89.8% of Web participants.
- *Objective 3—"upgrading of Municipality cultural structures"* also reaches a high level of consensus (80.7%).
- *Objective 4—"cooperation of local cultural associations"* concentrates 77.4% of views, reflecting the participants' realization of the need to fill the cooperation gap among cultural associations for developing economies of scale.
- *Objective 5—"development/management of cultural infrastructures"* reaches also consensus in the study area, with 86.0% realizing the need of a multi-functional use of existing cultural infrastructures instead of deploying new ones for serving existing needs.
- *Objective 6—"establishment of linkages of culture with local society and economy"* seems to gather the agreement of almost 80.0% of views expressed, revealing the understanding by Web-participants of the role of culture in economic and social development.
- *Objective 7—"development of creative industry"* is considered as a very important option in a recession period, where consensus reached among Web-participants is up to 78.0%.
- *Objective 8—"promotion of participatory democracy"* seems to also gain ground among Web-participants, gathering almost 85.0% of positive views.

Of value is also the information gathered through the DemoCU platform as to the prioritization of policy directions by participants, which provides information about which policy directions are acceptable or which will be opposed by the local community's interests. This information can support a more adjustable to the local community policy framework, thus increasing successful implementation potential and related outcomes.

For example, the policy directions that seem to exhibit the highest level of acceptance regarding objective 1 are presented in Fig. 7. According to this, the importance attached by participants to the integrated management of cultural infrastructures as well as the structuring of a discrete cultural identity for their region, is quite evident. Relevant pieces of information are provided for each objective considered.

DemoCU Web-based participatory process, although not completely fulfilling research team's expectations, can be *positively assessed*, taking into consideration the level of Web-based participation practice in Greece and the lack of citizens' relative experience in such processes. Distribution of participants per age group

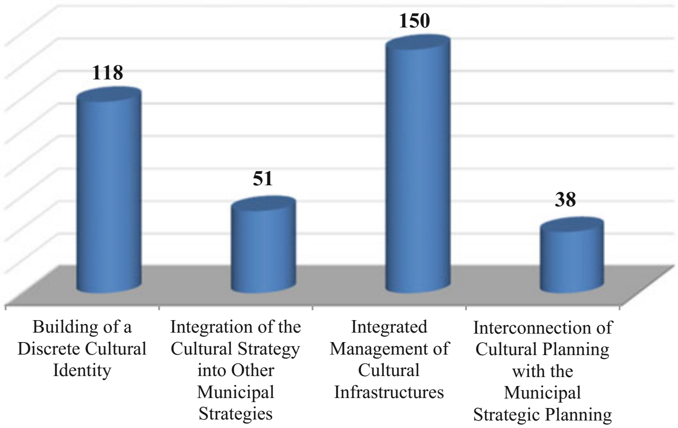

Fig. 7 Rating of policy directions in DemoCU—number of participants for each direction (Reproduced from Stratigea et al. 2016)

proves the potential of Web-based participation in youngest groups' interaction pattern, whose engagement was a main reason for adopting Internet-based participation in DemoCU.

Results obtained from this exercise are useful for verifying specific choices made by the DemoCU as to the goal and objectives as well as the design of relative policy framework. Along these choices, consensus was reached by the majority of participants. The prioritization of policy measures and related actions in respect of policy directions serving each objective set is also of great importance. This can be proved valuable to the local administration for setting priorities and managing relative resources (both material and human). Moreover, it has revealed a range of important topics that need to be handled, such as citizens' training in ICT, specialization of Municipality's staff in cultural issues, promotion of intercultural and intergenerational cultural approaches, etc., perceived as a *meaningful message from civil society* to the Municipality for relevant action undertaking.

Third Step—Charrette Workshops The outcome of the Web-based participatory process has pushed one more step forward the progress of structuring the Integrated Participatory Strategic Cultural Management Plan, with the next step being the further opening up of the process to a variety of citizens and stakeholders' groups of the local society through a face-to-face interaction, following the step of Web-based consultation. In this respect, at this final step of the participatory process the focus is on consultation with groups that are considered vulnerable or can have certain specific requests or needs as regards the cultural products or are producers of culture in the study region. As such are considered:

- *youth*, with culture being a "weapon" for reactivating youth community in local cultural affairs and combating the NEET ("Not in Education, Employment, or Training") phenomenon that is already visible in Korydallos Municipality;

- *third age people* with culture being a sector that can keep them active parts of the local society and ensure intergenerational cultural communication;
- people with *special needs*, who have certain cultural products' requests in order their unimpeded access to cultural affairs to be assured;
- *Roma community*, where culture is considered as the glue for establishing solid relationships of these groups with the local community and removing isolation and marginalization phenomena; and
- *producers of culture* such as theater and movie groups, cultural associations, ethnic groups, etc. that are vividly activating in the area.

Engagement of the above groups took place by use of the *Charrette participatory method*. The whole process was implemented in a time span of two months (February–March 2016). Consultation with the above presented target groups was focusing on the same topics as previous consultations, i.e. validation of goal and objectives as well as the proposed by the DemoCU research team policy framework.

Implementation of Charrette method was properly adjusted to the peculiarities of the study area and the groups involved. More specifically, the inability of bringing together all different groups in a series of sessions has led to the decision of organizing a distinct series of sessions, dedicated to each specific group. Sessions' work has mostly taken place in the premises of Korydallos Municipality, but also in school complexes for meeting young people from the student population, special places where elderly are socializing, etc. Coordination of each session series was carried out by the research team. In each session, depending on the number of participants, single groups and plenary sessions were organized, following a structured pre-planned discussion on the topics of interest. In single groups' discussion specific dimensions of the issues at hand were discussed, while in plenary discussions interaction among different groups and specific dimensions of interest topics was taking place.

Out of these Charrette participatory workshops, certain interesting propositions came to the forefront, which have partly improved goal and objectives, but mostly they have enriched policy measures and relating actions and have added value to the policy framework with fresh and fruitful ideas.

Assessing the choice of Charrette participatory method it can be said that this was not so effective, mainly due to peculiarities, different interests and daily schedule of the different target groups. These have impeded a joint session of all different groups as well as cross-fertilization of ideas and views shared by each group. Research team has flexibly reacted by organizing smaller sessions adjusted to group schedule and interests, so that at the end of the day fruitful, both from a quantitative and a qualitative point of view, results to be derived from the whole participatory process. Despite the adjustments and simplifications in the application of Charrette method, results are considered as quite useful for the goals of DemoCU.

It should be noted here the interest of the *young groups* entered the Charrette participatory process and the specific needs that this participation has revealed in terms of new products desires. Moreover it was stressed the necessity for a certain refreshing of traditional approaches through which cultural issues are dealt with in the region up to now. Of importance is the clear message of this group for being active part of cultural affairs in the study region, and channel its creativity and energy towards this direction, a way out that is valuable in the middle of a severe economic recession that affects negatively, in a direct or indirect manner and in multiple ways, this target group. Culture in this respect can constitute a great landmark for removing isolation and disappointment and a platform for interaction, co-creation, solidarity and future hope creation.

Of importance are also the messages gathered by the *third age* target group. Beyond the self-evident such as healthy and creative ageing, culture can be used as a vehicle for social activation of older people and social offering, while their contribution to social affairs and the transfer of cultural wealth and related values they owe to the next generation is critical. Inter-generational dialogue can bring multiplier effects for all parties involved, spreading inter-temporal values from older to younger generations. Interaction of these groups with *producers of culture* in the study area, both from the public and the private sector, was quite useful, with the latter realizing the environment, within which they are going to activate in the future and the need to reposition their strategy, readdress cultural needs and related products offered as well as reconsider costs of cultural provision and coalitions' establishment with cultural and other actors present in the specific local ecosystem.

Third Step—Public Consultation with Citizens, Stakeholders' Groups and the MCC Elaboration of information gathered through the Charrette workshops, being the outcome of the cooperation of the research team and the CCC, has led to the articulation of the *draft final plan*, in order for this to be further elaborated, at a final step, through the public consultation of the plan with the local community and the MCC. In this public consultation event, thorough presentations of the final draft plan took place by the research team, while fruitful discussions and cross-fertilization of views and ideas were promoted, aiming at validating the final planning outcome by the various community groups and the MCC.

Discussion was also furthermore focusing on the ways the proposed plan can be implemented, how proposed actions fulfill real needs of local population as to the cultural sector, etc. Useful propositions were gathered in this session for further elaboration and incorporation into the final plan. Collection of thoughts as to the introduction of the proposed outcome in the strategic plan of the Municipality, in order this outcome to establish the ground upon which all policies will be built, was also equally important. Such a perspective could be further expanded by the extensive use of the DemoCU platform, where constantly updated information about the status of the cultural sector in Korydallos Municipality as well as day by day information about cultural events and actions in the city will be provided.

5.3 Stage III—Final Outcome/Cultural Plan

This constitutes the final stage of the multilevel participatory process of DemoCU, where comments and propositions of the previous stage are incorporated and the structuring of the *final plan* is accomplished. The whole process aimed at *smartening up the Korydallos local community* by actively engaging a variety of community groups, representing different interests and views, in a *negotiation process* in order to end up, through mutual understanding of others' positions, in an outcome that reaches the highest possible consensus and is thus widely acceptable. This constitutes the final proposition of civil community to the Korydallos Municipality.

6 Conclusions

DemoCU was a useful experience for all actors involved in the participatory process. As an effort to *smartening up local community groups* through their empowerment and engagement in decision-making processes at the local level, it faced all kind of difficulties such an experiment entails. Lack of trust, for example, to decision-making processes as a result of the current political fluidity, instability and lack of credibility was a major barrier in gaining confidence and motivating stakeholders' groups and citizens to participate. Face-to-face contacts and personal communication, at least in primary stages, were useful strategies towards the establishment of proper communication bridges.

Outcomes reaped by this effort were encouraging from a qualitative point of view, although not fulfilling expectations in quantitative terms. As to the latter, it has to be noted that in total 372 citizens and stakeholders have expressed their views as regards the main pillars of the cultural plan, being engaged in 16 workshops during the one year duration of the project; while Web-based participation engaged in total 140 citizens. One main factor, justifying the less than expected quantitative participation, remains the developments of the wider environment, within which the exercise was carried out, characterized by uncertainty, as well as political instability, two national elections and one referendum, economic recession and social degradation of the last few years, which have changed citizens' focus of concern and priorities. This environment has had a catalytic role against willingness of local societies to engage in the common and be part of decision-making processes; while has largely constrained their expectations. Of importance is also the fact that those who are willing to participate they do not always know how to do it, what their chances are or their rights in that kind of processes. These inefficiencies as well as experience gained from the participatory processes carried out revealed that local communities need to be trained to new social learning and (e-)participation processes in order more fruitful and creative results to be reached; and a more fertile ground for smartening up citizens and communities to be established. Same holds true for local authority staff, as knowledge available and expertise of administrative human resources in effectively handling (e-)participatory exercises seem to be critical issues for successfully carrying out such exercises at the local level. Of importance is also the scarcity of resources, rendering participatory processes the luxury of the few.

The multilevel participatory context of DemoCU and the contact with citizens and local cultural stakeholders through various communication/interaction channels (both of classical and Web-based nature) have become the stimulus for an upgrading of the social and political discourse established through the planning process, leading to the smartening up all parts involved. The outcomes of this approach have fed the structuring of a final participatory cultural plan for a more efficient and integrated management of cultural resources and assets, building this through a step by step approach in order consensus-building and commitment on specific policy options and choices to be ensured; and be properly integrated in the specific socio-economic and political context.

The feeling of belonging, cultivated through DemoCU, as well as the promotion of the concept of active and knowledgeable citizens, who participate in decision-making processes and co-design/co-decide future outcomes are quite important not only for the specific sector studied—the cultural sector—but also for building other future perspectives as well, seeking to promote more democratic governance for the sake of prosperous, flourishing, cohesive and smart local communities. The DemoCU project aimed at becoming a "seed" towards: the smartening up of the specific community; and the promotion of face-to-face and digitally-enabled participatory decision-making processes, as new ways of *social learning*, *social networking* and *consensus-building mechanisms*, applied in a sector—the cultural one—that can be used as a vehicle for local development. Experience gained can be further exploited for a creative and smart management of urban affairs in an environment of multilevel crisis, where ways out have and need to be based on *smart and creative PEOPLE*.

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Using Traditional and New Digital Technology Tools to Promote Sustainable Mobility: Current Trends in the Evolving Transformation of the Smart City

Efthimios Bakogiannis, Maria Siti, Charalampos Kyriakidis and Avgi Vassi

Abstract Sustainable mobility is one of the most emerging challenges in the contemporary car-oriented city, where congestion and lawlessness grow, while funds continue to decline. Greece, so far, remains far behind the European and international innovative channels for transportation and mobility technology-assisted applications, having indeed a considerable increase in recent research and business projects. This paper aims at showcasing a collection of practices that focuses on enabling sustainable mobility policies and measures as well as hard infrastructure projects, both ICT and non ICT-enabled, in order to reach the smart city in mobility terms. The concept of a smart city does not always require the support of web technology tools, but rather integrates their use in a holistic approach to cope with the growing pressure of traffic situation and the existing travel behavior patterns. The study presents five (5) grouped sets of policy interventions and measures consisting of more than twenty five (25) indicative actions to be applied in cities and/or regions, ranging from common traffic calming solutions to smart traffic lights, car-sharing, and innovative parking schemes. The suggested sets of actions focus at the regional level, exploring at first the case of Athens and Attica Prefecture, however they can be applied in several other cases in urban and regional scale accordingly. Actions aim to tackle traffic safety, travel behavior dynamics and patterns, local mobility cultures and mobility and environmental awareness issues, considering the widespread use of information and communication technologies.

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1 Introducing Smart City in Mobility Terms

A smart city is defined by its efficiency and livability as well as by the use of innovative operational and information technology. One of the key issues determining the new era of cities, is the ability of gathering, using and leveraging a meaningful amount of data (stored or real-time) in order to improve services directed to their citizens, decrease costs in energy consumption etc. According to the European Commission, a Smart City is a city that is well performing in six (6) key fields of urban development, built on the "smart" combination of endowments and activities of self-decisive, independent and aware citizens. These fields are smart economy, smart governance, smart living, smart people, smart environment and smart mobility. There are plenty of ranking systems, such as the Smart City ranking by Boyd Cohen, the European Smart Cities, the Juniper's Smart City Rankings, the Intelligent Community Forum assessment as well as panels including global and European stakeholders (i.e. the World Bank, universities, United Nations Habitat representatives etc.), listing cities that perform well in one or more of the afore-mentioned sectors. These rankings can directly assist cities in global and regional recognition as they draw public attention as well as attract several investment and development funding. More and more projects are being implemented within the concept of smart cities with the formulation of partnerships and other entities participating in programs such as Interreg, URBACT, Horizon 2020, Civitas, etc.

Traditional urban and transport planning have dealt so far with practices that tend to meet demands by improving capacity through car-centric approaches, especially in cities where urbanization is rapidly growing. Typical solutions have led to car-oriented development patterns, which also drive the land use patterns in unsustainable city forms. Numerous researchers and studies consider transport to be among the three most energy consuming activities, with the other two being the sectors of housing and food production.

Recent transportation research and studies regarding the sustainable and compact city form have highlighted the importance of altering daily commuting habits and introducing sustainable urban mobility practices along with the redesign of streetscape. Sustainable urban mobility is an emerging field in transportation and environmental studies—especially in the European transport Agenda—introducing policies and practices to face problems such as road safety, air and noise pollution, congestion etc. The need for sustainable urban mobility has been distinctly described only after 2001, with a Green Paper from the European Commission being finalized and issued in mid-2007 entitled "Green Paper—Towards a new culture for urban mobility". 2006 and 2007 were the years that the Commission had largely discussed the issue, launching the debate on mobility through several conferences, workshops, internet consultations and meetings. Later on, in 2011 the European Commission, via the White Paper "Roadmap to a Single European Transport Area—Towards a competitive and resource efficient transport system" adopted a roadmap of 40 concrete initiatives for the next decade to build a competitive transport system that will increase mobility, remove major barriers in key areas and fuel growth and employment. At the same time, according to the European Commission (2011), the proposals will dramatically reduce Europe's dependence on imported oil and cut carbon emissions in transport by 60% by 2050. This comprehensive strategy (called Transport 2050) puts innovation and smart solutions at the core of future development and recognizes the importance of technology-assisted mobility applications towards the success of a new sustainable transportation environment.

Greek cities, being formally obliged to follow European strategies, have implemented several, however abstract, practices related to transportation. European Funds (Horizon 2020, Interreg etc.) have allowed the development of a number of strategies, projects, mobility practices and services related to the smart city concept in cities such as Athens, Piraeus, Thessaloniki, Thermi, Trikala, Heraklion and others. Innovations in smart mobility are more profound in Thessaloniki (project Intelligent Thessaloniki) as well as in the city of Trikala (project CityMobil2), where the first autonomous bus has completed its pilot application and was tested in real traffic conditions; in Piraeus (project Cyclecities and Smile), which has participated in innovative mobility projects etc. Although several projects regarding mobility have been implemented, development has mostly focused on pilot services and the output data are not integrated in the future strategic municipal or regional planning. Similarly, the tools and innovative services developed by these projects do not seem to be upgraded in following schemes or applied in future technologies. Moreover, public-private partnerships in Greece do not follow the European norms, and thus it is difficult to promote the concept of sustainable competitiveness as a driver of prosperity and long-term growth in terms of sustainable mobility. Initiatives are driven either by public entities (universities and research centers) or by business and project consultants, whose interests are limited to the end of each program.

2 The Transition to a Holistic Approach: Introducing a Methodology on Smart Mobility

2.1 Transition to a Smart Mobility Context

It is profound that the city layout determines the way people move, which if combined with each country's transportation culture, shapes the daily mobility environment. Smart or so called "intelligent" transportation services are changing the way cities move (Arup 2016); while at the same time "smart infrastructure" projects are becoming commonplace (Fishman 2012). More and more cities are implementing practices and policies related to intelligent transport systems (ITS) and many of them are investing in infrastructure that can assist in the transition to an up-to-dated 21st century urban mobility agenda. Common problems include travel delays, congestion, increased travel costs, environmental degradation and the need for public spaces' regeneration. Smart solutions in mobility terms consist of systems, applications, implementation of policies, designs and plans, indicator systems for assessing performance and many more. Addressing issues in different environments with various implications in culture and planning sets requires an overall approach with a set of tools and a robust methodology to explore, analyze, select, and combine the suitable methods and practices to "tackle" the identified issues, while keeping intact any particular place identities. This is to avoid homogenization that calls cities to only adopt central European-like public space and road designs; and suggests that proper integrated solutions are driven by people-centered and participatory procedures. Understanding the attitudes and behavior of urban residents in relation to their daily travel needs and using this knowledge to assess the potential for behavioral change is at the core of current urban mobility studies, as it was recently supported by the London School of Economics and Political Science (LSE) Cities Report (Rode et al. 2015). Some solutions can only be adopted by cities that have already implemented progressive transport planning embedding walking, cycling and public transport parameters; while other solutions can support cities that are at a critical point in terms of tech industry revolution. The overall approach however targets cities that deal with socio-economic pressure, congested public spaces and downgraded urban environment.

Changing travel patterns implies a critical intervention in the culture of daily commuting that aims at sustaining a transition from traditional car users to green travelers and/or technology focused individualists and innovative access-oriented users (groups user identification from Rode et al. 2015); while it requires integrated approaches in both planning and policy implementation.

The smart mobility agenda should include different technology-assisted services, alternative use of vehicles, introduction of the "sharing" culture, innovative integration of traditional traffic calming tools, implementation of customized solutions and a communicative participatory approach for information and awareness raising. This report collects the basic concepts of smart mobility as implemented in numerous cities around the world and groups the key categories of traditional and innovative approaches to assist in the development of an integrated *smart and sustainable approach*. The conceptual diagram presented in Fig. 1 depicts the summary of available services and new developments on smart mobility patterns.

Data collected from smartphones, sensors and other communicative channels (see graphic in Fig. 2) can form new type of services and mainly introduce smart solutions to the current transit users, drivers, walkers and cyclists. Real time traffic management; real-time traveler information; route planning; car, ride and bike sharing systems; multi-modal transportation management; etc. can be some of the

Fig. 1 Overall diagram of smart mobility tools, policies and services

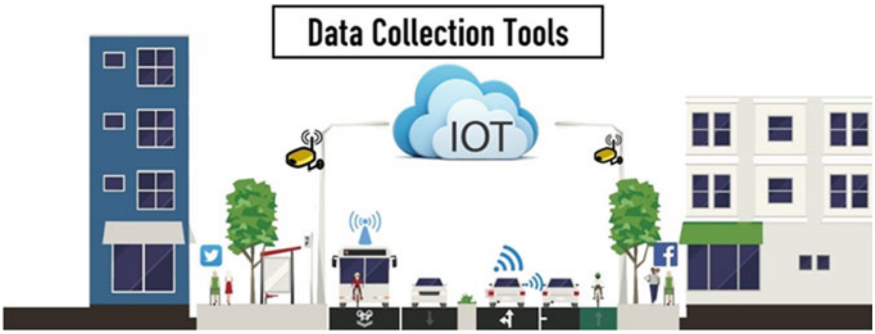

Fig. 2 Data collection tools including sensors, social networks, connected and autonomous vehicles

many services that highly rely on data gathering, crowdsourcing and technology to assist urban mobility alternatives. If the transportation related professions take full advantage of the technological and operational cutting-edge advances, traffic management can gain critical new tools to measure and understand commuting behavior and habits, leaving behind the traditional origin-destination and traffic volume studies. This can imply a highly promising professional revolution, embedding numerous changes in both the analysis and the policy formulation of sustainable mobility studies. The data can be gathered and provided either real-time or on demand according to the overall planning; and this can allow the flourishing of new types of services, letting the user of the transportation network become both the provider and the consumer of mobility information.

Fig. 3 Mobility services including ridesharing and multimodal management systems

Services generated in this new era of data acquisition and processing can significantly alter the way people choose to interact with their daily travels. Based on the new data availability and management, cities can develop dynamic tools to support reduction of traffic and carbon emissions; improve daily commuting pattern; decrease travel and maintenance costs; organize and sustain a viable on and off street parking system; impose fair congestion charging; and, most importantly, engage residents in urban and transportation management issues. Services may include congestion schemes, car sharing schemes, on demand car services, smart parking systems, real-time traffic control (see Fig. 3). Technologies allowing data collection from the wider environment (e.g. sensors or smartphones) can be used by local authorities to detect and solve problems, while complementary services can provide incentives to smart-users that decrease their environmental footprint and go multimodal. More common services deal with integrated public transport fare management or journey planning and travel assisting applications for improving individual travelers.

Automobile applications are on the rise and the rapid electrification of vehicles rushes to keep up with smart solutions. *Connected vehicles* can access, consume and produce information and share it with drivers, passengers, public infrastructure and machines, including other cars (Koslowski 2012). These next-generation vehicles can integrate a huge amount of the new services, such as ridesharing; while they can largely support smart parking services and assist in the development of new forms of private-public transportation. Connected vehicles can support integrated safety systems, evaluate weather and traffic conditions as well as act as sensors themselves and redistribute the data they gather in real time. The automotive industry is evolving in a rapid pace, presenting cooperative systems that deliver almost any kind of road data requested. Moreover, these vehicles can open the discussion on car ownership and help car-oriented cities to not consider abandoning their key gadget of travelling, but rather invest on it and leverage from its capabilities.

Traditional approaches in smart mobility are related to common traffic-calmed infrastructure and different planning hierarchies than previous transportation studies. Interventions should be followed by relevant policies and monitoring of their outcomes. Concise pedestrian networks, sidewalk widenings, bike lanes, road diet schemes, typical traffic calming solutions for traffic control (speed humps, speed tables, raised crosswalks, raised intersections, textured pavements, traffic circles, roundabouts, chicanes, re-aligned intersections, neckdowns, center-island narrowings and chokers), traffic calming solutions for volume control (full closures, half closures, diagonal diverters, median barriers, conversion to one-way streets) can accordingly be selected to fit in each case (see graphic representation of traffic calming techniques in Fig. 4). A crucial element in traditional approaches includes horizontal and vertical signaling that are constantly maintained, contributing to a tidy street environment.

Fig. 4 Traditional approaches in smart mobility (Reproduced from Traffic Calming 2016)

2.2 Developing a Methodological Framework for Planning Smart Mobility Solutions

The overall methodology of introducing smart mobility solutions should: consider current transport plans, existing inefficiencies, previous interventions in the smart city concept; explore willingness of citizens to support such systems; indicate priorities that need to be fixed; and conclude to potential policies, measures and tools that can contribute to street and overall transportation upgrade (see Fig. 5). Considering the potential policies and measures to be applied in each city, these should assess the technical effort needed and existing or future funding; while exploring political willingness to support small or big changes in infrastructure. Travel behavior reflects societal norms and the traditional urban culture of citizens; hence changes should be also largely supported with information and awareness

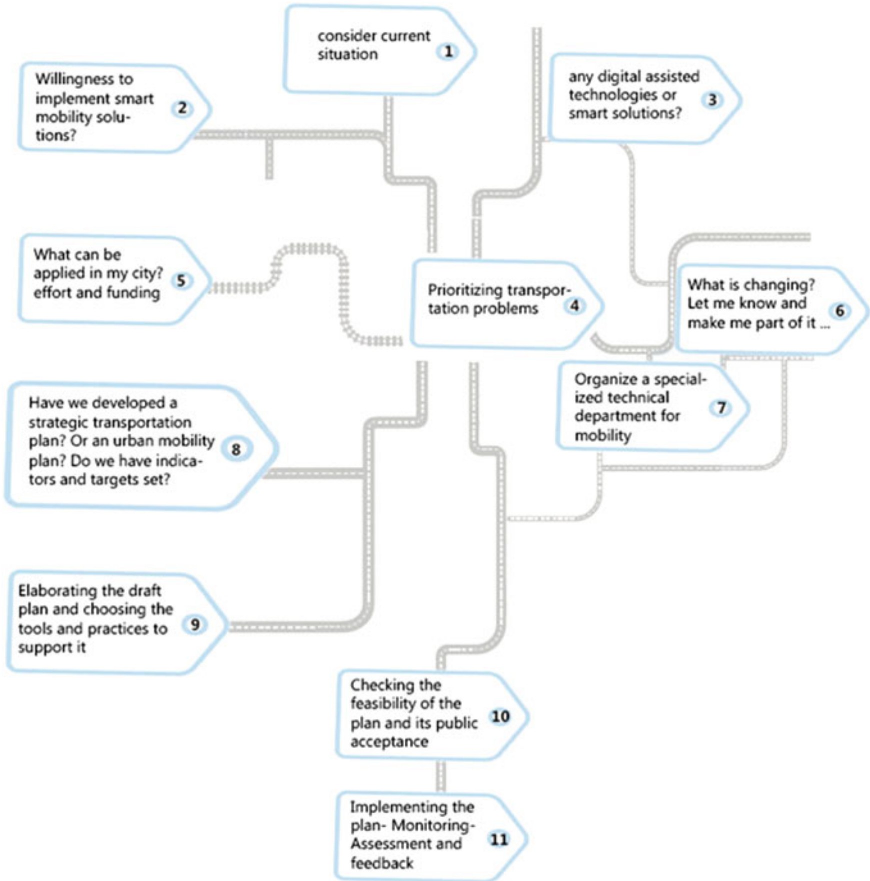

Fig. 5 Methodology on selecting city-specific smart mobility applications

raising campaigns. Adopting new policies and measures demands prior awareness raising steps in order to increase understanding of the needs and ease the acceptance and implementation of the planned interventions. Analyzing, assessing and selecting tools that best fit a specific city presupposes integrated management capabilities from specialized personnel and the development of a *strategic transportation plan*. If not existed, transport officials should elaborate a plan and choose the practices, measures and tools that can support it. Following, a technical feasibility study should check the ability of the city to implement such a plan; and ensure its public acceptance, with the last stage being the implementation. Implementation should be followed by constant monitoring and assessment based on output data, as these will be provided by the system and will refer to real-time data before and after each stage. Managing of these data will support feedback that is crucial for successful continuity. The structure of the proposed methodology has followed the standards integrated in urban and transportation planning studies (problem-solving workflow); and was based on the norms of contemporary smart city strategies and sustainable urban mobility plans (SUMP).

3 Categories and Special Policy Directions of Smart Mobility: The Case of Attica Prefecture

3.1 Introduction

Athens, being the case mostly explored in this research, has been largely affected by significant socio-economic changes in the recent decade. Urban development has been defined by sprawl and car-dependency; however the public transport system has been improved in terms of services and operational management. Although there are numerous fruitful discussions on the revitalization of the historic center, the re-development of old and upcoming inner-city neighborhoods and eventually the targeting of a transition to a compact city model, there is little progress in upgrading walking and cycling, two of the key pillars in the sustainable mobility discourse. Compact city models are discussed and legally established, but without the necessary adjustments in transportation terms. Athens has not implemented many efficient policies for road safety and sustainable mobility. Relevant policy directions as well as actions should involve a range of *traditional and innovative research tools* that would put an emphasis on participatory processes in order to raise awareness and effectively motivate citizens' engagement. Rising fuel prices along with severe income reduction can fortunately contribute to sustainable mobility promotion, since economic restraints force residents to consider transport alternatives. The particularities in the Athenian urban planning environment, such as the narrowness of the street form, the lack of an extended and organized on and off street parking spaces, the short distances and the sense of enclosure in existed inner-city neighborhoods, provide an ideal environment for combined smart mobility tools. The five (5) key elements explored in the Prefecture of Attica, regarding its inadequate transportation environment are:

- Narrow streets that present non-fixed width regarding traffic lanes and pavements, which leads to illegal parking in the remaining dead spaces. Narrow sidewalks with several obstacles, preventing walking and social interaction.
- Although public transport has been improved, car remains the main mode of transport as neither incentive for multimodality have been provided nor severe and systematic car restriction policies have been formulated.
- Athens has not invested in cycling that has proven to be the key solution in moving and parking around for short to medium distances.
- Old and poorly maintained vehicles consist of the main car and bus fleet in the city, which downgrades the environment and increases carbon emissions.
- Very few digital technologies have been applied to adopt international and European applications in the transport environment.

Having explored the Prefecture of Attica in terms of needs and inefficiencies, Sustainable Mobility Unit (SMU) at the National Technical University of Athens has proceeded to the development of a certain methodology, the steps of which are presented in Fig. 5. At first, taking for granted the authorities' willingness to adopt smart mobility solutions (step 2), the current situation was explored (step 1) in terms of urban and transportation characteristics, including their consent in smart solutions (step 3). Assessing the eagerness of municipal authorities in dealing with information and communication technology (ICT) and promoting digitally-enabled policy directions and smart solutions in general, research has focused on prioritizing transportation problems (step 4) and exploring the potential effort and funding in the various choices (step 5).

As this is an *ongoing research*, the current objectives are centered on specific proposals regarding actions and policy directions. More specifically, research in the Prefecture of Attica has categorized the smart mobility actions required in *five groups*, further analyzed in a range of specialized actions tackling the major transport issues (see concept graphic scheme in Fig. 6). These groups focus on urban design interventions, smart systems and applications assisting mobility and quality of commuting, smart transportation schemes and vehicles, innovative policies in educating and awareness raising, and lastly smart management (data collection, processing and assessment) of data relating to trip patterns and environmental conditions.

Some of the suggested actions have already been applied to different urban environments, many of them following a holistic and systematic approach; while others a rather abstract way. Good examples of urban design interventions, in terms of urban mobility, can be found in Porto (Portugal), while recent smart systems and applications can be encountered in Valencia (Spain) and Rome (Italy). Numerous small and medium-sized cities in southern France and Italy, like Casalmaggiore, have introduced innovative policies for education and awareness raising, whereas smart data processes are applied to several cities (Rome, Venice, Athens, Heraklion,

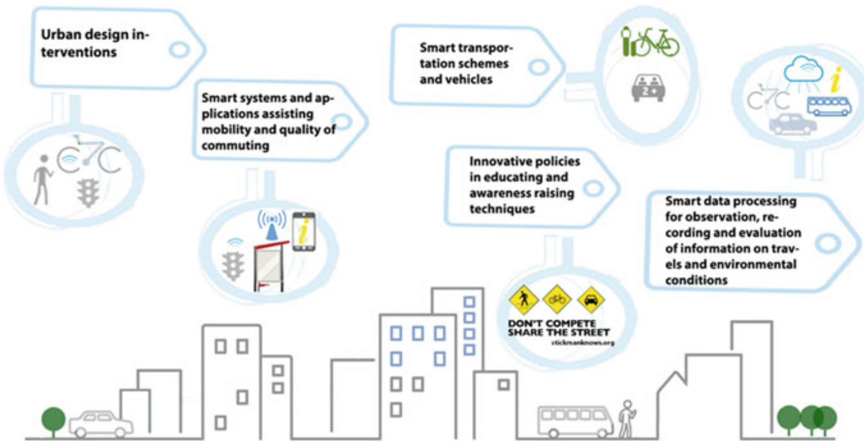

Fig. 6 The Athenian potential scheme with selected policies and tools in all five (5) categories

Thessaloniki, Madrid, Barcelona etc.), mainly due to funding opportunities provided by an increase in the relevant European funds.

3.2 Urban Design Interventions

Urban design interventions refer to hard infrastructure projects and implementation of policies and measures that do not necessarily contain digitally-enabled technologies and range from urban pilots, integrating urban and transport planning interventions to traditional traffic calming measures and speed reduction tools. Intersections, signaling, complete street design and case-specific solutions are at the core of this group of actions.

1st Policy Direction: Combined Urban and Transport Planning—Pilot Traffic Calmed Areas Inefficiencies in planning, operational issues in traffic safety and urban design cannot be addressed simultaneously throughout the overall urban area of Attica Region. Once street hierarchy is defined and parts that demand immediate intervention are identified, potential traffic calmed areas can be studied. Policies and measures will be studied for the specialized zones, prioritizing pedestrian and cyclists as well as specific areas will be converted to 30 km/h zones. 30 km/h zones have been successfully implemented in numerous cities in Germany, Belgium, and Netherlands; while recent pilot applications have shown positive results in Valencia (Spain) and Dublin (Ireland). These pilot areas in Athens will later form the norm for similar designs to be applied in the whole prefecture. The model for the pilot aims at identifying priority segments to be turned into traffic calmed, namely:

- The city center of Athens and a number of selected neighborhoods in each municipality.
- The surrounding areas of schools and other education and sports facilities, attracting young commuters.
- The surrounding areas of the main public transport stops and stations.
- The immediate surroundings of public spaces, such as squares, parks and community gathering places.
- The surrounding areas of shopping centers.
- Areas aiming to become living labs, experimental and gentrified neighborhoods that attract people for a specialized activity.

These pilot traffic calmed areas will become the start for a viable and socially comfortable new urban model that presents low cost traffic organization and its rules are in compliance to the European mobility agenda.

2nd Policy Direction: Speed Restrictions in Accordance to the Environmental Capacity of Street Sections and Downgrade of Studied Segments in the Street Hierarchy Plan This action applies to streets or street segments, which due to the existing land use pattern seem downgraded (i.e. extended asphalt paving) or have to accommodate dense pedestrian activity. These can be transformed to more active and complete streets, in accordance to NACTO guidelines (2013) and current European trends. Speed restrictions are justified and applied either for simple traffic safety reasons, or for holistic plans that add on the street bicycle lanes, prioritize pedestrians etc. The traditional Greek city has a unified speed limit in its overall surface, however sustainable policies ask for specialized limits according to the use and character of the street and the activities it accommodates.

Reducing the speed limit is also necessary in road sections that are designed to become the future “green routes”, linking the regional municipalities with the center of Athens.

3rd Policy Direction: A System of One-Way Streets The one-way system is in favor of road safety and can restore human scale public spaces for several reasons:

- Avoidance of common frontal collisions.
- The number of movements at intersections is limited (at an intersection of a two-way street, the number of straight and turning movements is 12, which is limited to 4 in an one-way intersection).
- The one-way system allows the reduction of the street width and hence provides space for sidewalk widening, parking spaces and speed reduction.
- Converting two-way streets into one-way, while introducing bike lanes, encourages the overall sustainable mobility promotion policies:

– One-way street systems force cars to follow a specific path, complicating their move hence discouraging unnecessary trips and passing by local neighborhoods to shorten external journeys (through traffic).
– One way streets with clear signs and horizontal signaling eliminate on street parking in both sides, thus reducing accidents with low to medium severity.
– Crossing pedestrians have to check one side coming traffic.

An integrated one-way street system should be accompanied by a strong vertical and horizontal signaling system, which can also be assisted by digital services.

4th Policy Direction: Replacing Common Intersections with Traffic Lights with Small and Operational Roundabouts Traffic lights are a safe solution when respected, which has been proven to add delays and risk with Greek drivers that accelerate in the orange and many times in the redesign. Roundabout forces all vehicles to reduce their speed, and small roundabouts have been found as a very flexible solution in local street systems and congested arteries. Some roundabouts are assisted by digital technology to inform drivers approaching them to reduce speeds and help on free-flowing traffic.

5th Policy Direction: Smart and Case Specific Policies in the Road Network. Temporary Pedestrianization and Special Occasion Configuration This is an action that is largely applied in many European cities as well as in several tourist places in Greece. A temporary pedestrianization demonstrates that when removing car traffic, street environment stops to be hostile and attracts pedestrians and cyclists. This can also demonstrate that the road network is flexible and can still operate when segments or whole streets are removed from its service for a specific time period, provided that the necessary information to drivers is in place. Street safety issues in tourist areas and metropolises in Europe are very important, and common solutions such as the temporary pedestrianization are absolutely feasible. Attica Prefecture can try similar practices and extend urban tourism potential in the city center and other chosen places. Case specific policies require flexibility and a strong campaign for supporting and informing residents and visitors.

6th Policy Direction: Smart Enhancement of Pedestrian Movements|Elevated Crossings and Plateau The elevation of pedestrian crossings is the crucial infrastructure that promotes walking and recognizes pedestrian priority at intersections. Conventional intersection allows the car to pass uninterrupted, as nothing is used to physically reduce speed, and hence the pedestrian is forced to step down the road and up again to the opposite sidewalk. Elevated crossings can provide consistency in pedestrians and act as alternative speed bumps and obstacles to the car.

Raised junction areas (plateau) alter significantly the image of transition areas from car-oriented to people centric, since whole surface of the crossing is elevated between the curbs, contributing thus to a more visible pedestrian priority from drivers and a more readable street environment.

7th Policy Direction: Introduction of Special Chicane Islands Chicanes are curb extensions that alternate from one side of the street to the other, forming S-shaped curves. Chicanes can also be created by alternating on-street parking, either diagonal or parallel, between one side of the street and the other. Each parking bay can be created either by restriping the roadway or by installing raised, landscaping islands at the ends of each parking bay (Traffic Calming 2016).

These curb extensions can improve traffic safety in places like the front of public transport stops, close to intersections for speed reduction, which can also add to the social cohesion of neighborhoods, when proper urban furniture is installed on them. These surfaces can accommodate sensors or other information equipment and invite users to use them.

8th Policy Direction: Cycling Integration to Tackle Congestion The integration of cycling in Athens will contribute to the introduction of sustainable road conditions and will ease traffic flows in the main urban thoroughfares. The implementation of the Metropolitan Cycling Network along with the completion of local cycling networks will relieve the main arteries and drivers will be introduced to the coexistence with cyclists. The implementation of "bicycle streets", where the car is required to move at 20 km/h and remain behind the bicycle can help towards the same direction. The extended use of social networking and smartphone applications can boost further bicycle use and the formulation of a new society of drivers that choose their route depending on its urban/suburban characteristics, aesthetics, safety etc.

9th Policy Direction: Integrating Greek Particularities in the Traffic Environment: Motorcycles and Scooters Motorcycles and scooters are commonly used in Greece, due to the lack of parking but also good weather conditions. Motorists are in danger as they rush through car traffic, while at traffic lights they tend to stand on the sides of the cars. Similarly to bike-boxes in the Netherlands and Denmark, Athens needs motorcycle boxes at intersections allowing them to stand, while waiting for the traffic lights in front of cars in a dedicated surface where they will be protected and prioritized.

3.3 Smart Systems and Applications Assisting Mobility and Quality of Commuting

These systems refer to those promoted and accommodated by local authorities or private entities to detect and solve problems, as they use largely breakthrough or conventional technology to support a certain mobility aspect.

10th Policy Direction: Smart Parking System An important part of traffic congestion is created by drivers looking for a parking space. Information on empty spaces and the transmission of this knowledge through a platform can save unnecessary movements and inform about the real time and cost of a car journey, suggesting alternative paths to destination and ideal parking spaces nearby. Such parking systems can also boost entrepreneurship, as drivers can be informed about coupons, discounts and other incentives in using peripheral private or public parking facilities.

11th Policy Direction: Smart Public Transport Stops and Stations Public transport is one of the key pillars in sustainable mobility and studies reveal that good transit systems raise the level of economic activity and prosperity in large cities (i.e. NBCRT 2003). Smart transport management schemes and applications to ease waiting and travel times and relating costs are evolving rapidly in developed cities, like Barcelona, Amsterdam, London and many more (EY 2015). Smart stops, on the contrary to conventional ones, are using vehicle positioning technology to inform passengers on arrival times, while integrated transport systems promote multimodal choices.

12th Policy Direction: Interactive Traffic Lights Conventional traffic lights have a fixed phase rotation schedule, irrespective of the existing traffic volumes and delays, which are constantly changing. Intelligent and interactive traffic lights are connected to counters, or become counters or sensors themselves, in order to adjust their schedule so that congestion will be relieved. ITS use these data to provide the drivers, through other platforms, alternative routes or inform them about waiting times etc.

13th Policy Direction: Public Transport Management Application Public transport management applications usually provide data to users for the overall operation and fares of the public transport. GPS technology tracks the user's location and provides nearest stop for their destination along with suggested time for departure and arrival.

3.4 Smart Transportation Schemes and Vehicles

These schemes promote collective use of vehicles or other alternative ways of commuting that aim at promoting further the advantages of technology in changing the traditional transportation model.

14th Policy Direction: Car Sharing Car sharing aims to attract residents, visitors and students who do not have a car either because they cannot afford one or because they do not want, but may periodically need to use one. Car sharing schemes need companies that have a car fleet and a system to charge its use and manage the clients. This is a convenient solution for cities with extended public transport and efficient walking and cycling infrastructure that want to decrease the number of cars and provide their residents with smart and collective transportation schemes. Smart phone technology and applications are essential for its successful use.

15th Policy Direction: Carpooling Carpooling is a sort of collective private car that aims at users willing to share a ride, usually for work commuting. It is very convenient for travels between the suburbs and the city center. Passengers share fuel costs and may use in rotation different cars. Digital technology can identify common origin—destination schedules and suggest users that could share their ride.

16th Policy Direction: Bike-Sharing Bike-sharing stations are usually installed in stations with a buffer zone of 300 m to serve cities that strongly promote bicycle use. Bike-sharing systems have been implemented in more than 600 cities (Vassi and Vlastos 2014) in the world with various systems to support their use. Technology evolution has of course improved their capacity, as new systems can now simply unlock bikes via smart phones, or provide integrated systems that allow interconnection and tracking of their location, allowing them to park even outside designated bike share stations.

17th Policy Direction: Management of the Taxi Fleet Taxis in Athens are a cheap alternative to public transport, hence their use differ from other European capital cities. Smart applications have changed the way communication between the driver and clients' works, informing about the available cars and their location, easing their pick up and eliminating unnecessary travels within the city centers. Moreover, the lack of a robust regional public transport network has made taxis to conduct fixed routes between regional areas in specified timetables, which if supported through mobile application can help both passengers and drivers.

3.5 *Innovative Policies in Educating and Awareness Raising*

These policies aim to tackle the knowledge gap for sustainable transportation, addressing both local authorities and citizens. Actions should inform about alternatives in commuting and their advantages as well as educate citizens in more environmentally responsible transport patterns.

18th Policy Direction: Sustainable Mobility and Traffic Safety Observatory The observatory will be managed by a sustainable mobility department (see action 19) and should be supported by an online interactive platform that:

- Will deal with the current situation in Attica Prefecture, recording common issues on the streets (maintenance issues, damages or inconsistencies regarding infrastructure and urban furniture, signage etc.), dangerous spots, malfunctions in public transport operation, short and long term traffic arrangements, short assessment of applied solutions, etc. Relevant experience of good practices and lessons learned from unsuccessful examples will be recorded. Black spots will be identified and mapped regarding accidents involving pedestrians and cyclists.

- Will be used as part of awareness raising, consultation and public participation procedures in planning. The platform will show the completed projects, as well as the proposed or under construction projects allowing citizens to suggest for improvement. The main advantage of such an observatory platform is that all data are visualized regarding their impacts on the specific areas of intervention.
- Will showcase good practices from other European and international cities that could be transferrable in the case of Attica Prefecture.

19th Policy Direction: Sustainable Mobility Department in Local Authorities Local technical authority services should include a specified departmental office dedicated to sustainable mobility. This office deals with issues related to: walking, cycling and public transport as well as urban and transportation planning. Special platforms should promote its operation and among its duties should be traffic management, introduction of ICT technologies, observation and assessment of new planning tools as well as management of participatory events for further engagement of citizens to the goals promoted.

20th Policy Direction: Awareness Raising Campaign in Schools Awareness raising campaigns in schools demand the cooperation of regional authorities and the relevant educational directorates as well as the Ministry of Education. Traffic safety campaigns and education about sustainable mobility issues are commonly implemented in European cities like Graz and Vienna (Austria), Rome (Italy), Malmo and Lund (Sweden), while Athens has completed some abstract similar application. Introduction of students into the way public transport networks operate and serve citizens, informing them about the driving code and explaining signs as well as letting them know about dangers and risks that can have a great impact on their interaction to the city. These campaigns aim at forming future grown-ups that respect their surrounding and their fellow citizens, making them responsible for their choices in the city. Technology, due to its attractiveness to students, can further engage them in such campaigns and several applications can help them realize any impacts caused by daily habits regarding transportation.

21st Policy Direction: Planning Collectively Actions that will Engage Students in Traffic Safety and Sustainable Mobility Regional and local municipalities should cooperate with Directorates and Ministerial authorities in order to organize collective actions addressing the engagement of students to traffic safety and promotion of sustainable urban mobility. Actions can include: collective school commuting with bikes or on foot (see: cycling and walking bus actions in United States of America, SafeRoutes 2015), training programs for bike use, field trips to areas or cities that present good case studies for cycling and walking integration.

Collective school commuting is organized in several cities of the world (i.e. St. Albans and Kent—United Kingdom, Lecco—Italy, Lyon—France), where accredited parents are accompanying students who walk or cycle to and from school through a specified route, which allows more and more students to join the so-called "walking buses" (as the concept was named by David Engwicht in 1992) or cycling buses. Training programs that teach students how to walk or cycle with safety can really transform the culture of a city towards sustainable mobility and make next generation citizens more aware of the impacts of their travel behavior. Field trips to areas that promote walking and cycling (e.g. Karditsa-Greece) can show students a viable alternative to the common model of Athens and inform them about the benefits to following a viable city model.

Such actions demand careful planning regarding their technical and social parameters since they are used as the basis for increasing the interest of students in mobility behavior, and can engage a large amount of participants from local authorities and educational directorates, to students, their parents and educators.

22nd Policy Direction: Information and Awareness Raising Campaign The design and implementation of an information and awareness raising campaign regarding issues of road safety, environmental capacity and sustainable mobility should include all modern aspects of targeting controversial audiences. The minimum elements should include the development of audiovisual material, brochures, lectures and seminars. Events should be supported by Prefectures and Municipalities in any given chance and constant information must be provided to the citizens.

23rd Policy Direction: Innovative Education of New Drivers about Sustainable Mobility Traditional driver's license training is only focused on operational elements of the car, and simple driving rules regarding the interaction with other vehicles. This typical procedure presents a great opportunity for the state to educate drivers in further issues that are considered important for driving behavior, interaction with pedestrian, cyclists etc. Obtaining a driving license typically has to do with driving techniques, while driving is a rather forceful action in the city's environment, related to behavioral patterns, mobility choices, respect to vulnerable road users along with several impacts on the environment and the aesthetics of the city. Instructions on traffic safety, behavioral issues regarding vulnerable users, environmental and social impacts of a car-dependent lifestyle should be considered as equally important aspects on gaining the "ability" to drive. Education should include:

- The role of public transport, cycling and walking around the city.
- Suggestions in avoiding extended car use when not necessary.
- The need for choosing multimodal transportation i.e. car and public transport, car and bike, walking and cycling etc.
- The motion characteristics of pedestrians, disabled, children, elderly and cyclists in the street environment, so as to identify potential hazards from distraction or difficulty in moving.

A contemporary driving license should also improve the driver's ability to use digital tools for navigation, route planning, eco-driving, etc., as the driver's comfort in using them can be similarly important to the physical act of driving.

24th Policy Direction: Education on the Use of E-Bikes The electric bike market grows rapidly in Europe in recent years, due to the great improvements in battery technology and the considerable reduction of e-bike costs. The electric bike is changing significantly the cycling data and attracts more users, regardless of their age and physical condition, overcoming the barriers of inclined terrain and distance travelled. Prefecture's authorities can organize seminars on educating potential users and promoting electric bikes as a competent alternative to car and motorcycle drivers. In such attempts, technology can ease further their use regarding route planning and individual user preferences.

3.6 Smart Data Processing for Observation, Recording and Evaluation of Information on Travel and Environmental Conditions

As described earlier in the paper, there are numerous applications in cities that have already invested in urban and transportation planning and present consistent policies in improving transportation trends. Attica Prefecture can start with small paces by utilizing low cost information and investing in long-term infrastructure to assist its future transport planning.

25th Policy Direction: Smart Lighting "Smart" lights are becoming commonplace in Europe and abroad, improving energy efficiency and upgrading environmental performance. Led type technology can save money and energy, adjusting their use according to the daylight. Emerging smart lighting poles can also act as sensors to record and analyze data for air pollution, noise levels, temperature, humidity, as well as traffic, pedestrian and cyclist volumes.

26th Policy Direction: Crowdsourcing Application in Public Transport, Taxi and Car Fleet to Collect Emission and Traffic Data Crowdsourcing applications, based on the voluntary participation of interested citizens in data collection and sometimes evaluation of alternatives are highly emerging practices in the international arena and can easily be used similarly in Attica Region. Air pollution special counters (CO, NO_x, O_3, SO_x, PM, etc.) will be placed voluntarily on public transport, taxis and cars. Their participation will be preset to a specific operational framework and the data will be evaluated and feedback part of the afore-mentioned. The output of their processing will be presented in the Observatory and held in a special database.

4 Conclusions

Sustainable urban mobility is fundamental to European and Mediterranean cities' economy and social life. Safe, pleasant and affordable daily commuting is key to the everyday quality of life of citizens and can ensure equality, accessibility and increase of social cohesion. Smart city solutions in the field of urban mobility aim to address these issues, while involving citizens in action and removing barriers in their communication. The emerging trends in technology, business models and societal needs could and, in certain cases, have already affected the way current and future transport issues will be faced.

This paper has explored a collection of practices that focus on enabling sustainable mobility policy directions including traditional and innovative approaches, such as traffic calming measures, infrastructure, data collection tools and mobility services. Based on the current trends, the authors provide a first approach on their methodology of introducing and applying smart mobility solutions in cities by considering a number of facts and exploring what fits best in a city's profile depending on a number of factors that can contribute to an overall transportation upgrade. Moreover, the paper provides a short review on how some of the emerging trends could potentially be applied in the case of Attica Prefecture. Studying the experience of the Athenian city and its wider metropolitan region in terms of its technological advances, its alignment to smart solutions in administrative level and the implementation of urban mobility projects has led to the conclusions that smart mobility parameters have to be studied and applied in accordance to the city's particularities and deficiencies. The presented methodology, as applied through the case of Attica, develops a creative toolbox with actions that can lead to smart paradigms of shifts in a daily commuting base as well as in the prevailing transportation culture of car-oriented cities. The crucial element in the suggested study remains the applicability and its potential outcomes in the future modal share. Critical issues raised from the above may also include the adaptability of local authorities in such a new scientific perspective along with their eagerness to adopt strategies and tools to solve long-established traffic and transportation problems.

Finally, the discussed issues within the overall concept of the smart city are expected to raise several research questions related to travel and mobility behavior, approaches in different age groups and different mobility attitude groups and provide critical outcomes in future transportation studies.

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Turning Messina into a Smart City: The #SmartME Experience

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Abstract The Cloud computing paradigm applied to Internet of Things (IoT) has recently found an interesting and innovative application area in the Smart City context. #SmartME is a crowdfunding project that aims at exploring such a possible synergy with the intent of morphing Messina into a Smart City. However, in the process of integrating Cloud computing and IoT related technologies, a data oriented approach has been mainly considered in the past, employing Cloud infrastructures as mere repositories for data collected by scattered devices. In the #SmartME project, the University of Messina Mobile and Distributed Systems Lab (MDSLab) research group is focusing on a different approach in which sensing and actuation resources are considered as extensions of the data center and the Cloud is adopted as a virtual infrastructure manager providing the infrastructure administrator with a management and monitoring surface. In this paper, details about the first year of the #SmartME project are provided with particular emphasis to the social, bureaucratic, and technical steps that conducted to the current deployment of tens of boards throughout Messina. In particular, the Stack4Things framework, which represents the core and soul of the #SmartME project, is presented; describing the underlying technologies and providing an overview of the Web portals that are used for administration and data retrieval.

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1 Introduction

#SmartME is an ongoing project, led by the University of Messina and the Messina municipality, and involving other commercial and public administration partners, mainly aiming at designing, deploying, and implementing a smart city architecture and infrastructure in Messina. To morph Messina into a smart city, it is essential to set up an Open Data platform, empowered by the harnessing of low-cost micro-controller boards to be installed onto buses, lamp posts, and buildings of local institutions. Moreover, such a network will be enlarged with sensors and actuators scattered all over the urban area. Thanks to such an infrastructure, it will be possible to collect data and information in order to build services for citizens, who may take part in this network through the involvement of smartphones and other mobile devices by which it will be possible to interact with objects and may even themselves turn into data producers. For instance, it will be possible to monitor global indices about environmental quality, which will constitute the initial testing stages of the project. Yet, an Open Data platform will be available to be leveraged for other services too (e.g., mobility management, district area monitoring and safety, urban budget tracking, reporting of acts that may jeopardize maintenance of public facilities and citizens' safety).

Several works deal with infrastructure issues and solutions related to Smart Cities and their relationship with IoT and Cloud. Specifically, Lee et al. (2011) propose a platform for managing urban services that includes convenience, health, safety, and comfort. Cloud computing infrastructures (Bruneo et al. 2014) recently found useful applications in the context of Smart Cities (Li et al. 2011; Mitton et al. 2012). Taking into account other experiences, such as the earliest experiments around Smart City planning, e.g. projects like the renown SmartSantander (Sanchez et al. 2011) as well as those involving other global cities (Pellicer et al. 2013), typically most efforts revolve around managing heterogeneous devices, usually by resorting to legacy protocols and vertical solutions out of necessity, and integrating the whole ecosystem by means of an ad hoc solution.

In our vision the Cloud may play a role both as a paradigm and as one or more ready-made solutions for a virtual infrastructure manager, to be extended for IoT infrastructure. Even if a lot of applications in a Smart City scenario have been proposed so far, there is a lack of common initiatives and strategies to address most issues at infrastructural level in a comprehensive way, nor are any of these efforts aimed at establishing a more general framework, i.e., one which is geared toward software-defined control loops, including Mobile Crowd Sensing as a pattern to exploit and enhance. We have laid in (Merlino et al. 2014) the details of a first step in the direction of standardized, cross-domain approaches, where the focus lies in integrating an Open Source framework for Cloud management, OpenStack, with the IoT, in particular addressing the data collection and visualization stages by leveraging existing functionalities and built-in scalability of the framework.

#SmartME intends to contribute to the creation of a pervasive platform, where next generation services interact with the surrounding environment, collecting data and applying management strategies. By adding smart objects into the mix, novel opportunities arise for *contextualization* and *geo-awareness*. In this view, computing, storage, networking, and sensing become complementary aspects to be coordinated in order to provide a new category of resources according to the Sensing and Actuation as a Service paradigm (Distefano et al. 2012), in a potentially autonomic and rewireable infrastructure fashion that we called *Software Defined City* (Merlino et al. 2015). The reference scenario is highly dynamic, since it can involve both static [sensor networks, radio frequency identification (RFID), etc.] and mobile [smartphone, personal digital assistant (PDA), etc.] heterogeneous objects and nodes that can randomly join and leave the connected environment in a volunteer contributed scenario. Smart objects have to be abstracted and virtualized in order to be provided under the guise of customizable virtual devices and corresponding services. Enabling technologies towards the envisaged goals are: abstraction and virtualization of objects; volunteer techniques for enrolment and distributed coordination; Cloud-like, service-oriented interfaces, autonomic techniques and semantic enablement. It follows that several services will concur to make the city of Messina smart and help citizens to improve their daily life accordingly, as Smarter People.

In terms of benefits to the citizens, for instance, an expected outcome since the earliest stages would be at-a-glance access to statistics about key environmental indices, particularly useful for specific areas of interest (home, workplace, schools, etc.). Going forward, information and communication technology (ICT)-supported mobility, such as e.g. live timetables and real-time monitoring of buses on a map will be a key contribution of this project to urban planning and development of augmented fruition modes for users of city facilities, e.g. public transportation.

For the scientific community, #SmartME represents an interesting case study, that is going to supplement current and ongoing FIWARE-based experiments, thanks to a development, integration and testing platform that we are set to establish, integrated with networks of sensors, actuators or other smart devices already deployed to the district area, and to this day employed exclusively for specific application domains and a limited number of purposes. The project was financially supported through a crowdfunding initiative that collected the necessary funds in order for this project to actually become operational, in order to establish a virtual community in Messina, where researchers, geeks and citizens may interact, improving city services and jointly concurring to drive a steady stream of innovations. The main services being developed cover the following areas: urban mobility, e-Health, environmental monitoring, and fleet management.

In this paper, we will show details about the project, highlighting the main technologies and showcasing the web portals. In particular, Sect. 2 outlines the history of the project so far, with a specific focus on the crowd-funding initiative, whereas Sect. 3 features a high-level overview of the #SmartME platform, in particular presenting the hardware prototype in Sect. 3.1, the core software framework in Sect. 3.2 and key technologies involved in Sect. 3.3, respectively. In Sect. 4 we describe in detail the layout of the data visualization and infrastructure management portals, including examples specifically relating to the user experience, ending the paper in Sect. 5 with final considerations and plans for some forthcoming #SmartME activities.

2 The #SmartME Project

The #SmartME (2016) project was born from a wish of a team of researchers in the MDSLab (2016) at the University of Messina who, in collaboration with the Industrial Liaison Office and the Center for Information Services of the University (CIAM), are eager to encourage, in an innovative fashion, a conversation with the municipality of Messina, based upon the paradigm of the IoT, in order to spur the creation of a novel, virtual, ecosystem. The project is also going to involve the university spin-off DH Labs, active in the production of innovative solutions for advanced sensor-based systems, and it is sponsored by the Municipality of Messina.

At the foundation of #SmartME lays the belief that research can and should yield benefits for the community, and the other way around too, in a kind of symbiotic relationship based on the "*crowdsourcing*" pillar. We are therefore talking about a novel way for academia to play a role with regard to technology transfer, a more "open" grassroots one indeed, aimed as it is even at laymen; a smarter one, because it enables anyone—citizens, researchers, enterprises—to experiment and test new services for the city. Indeed, the MDSLab team has asked for support on a crowdfunding platform in order for this project to take off for real. This way, through this crowdsourced fundraising we were able to kick start the #SmartME project, meanwhile also establishing a community of potential users and/or passionate supporters at the onset.

Indeed, the crowdfunding approach has established an excellent practice to close the gap between the University and the Municipality, the latter already in the process of embracing bottom-up processes for most ICT development initiatives. In this sense a dialogue has been opened in terms of strategic, long-term planning for the metropolitan area, which is just starting to benefit from a recent EU-sponsored funding scheme for the forthcoming city *master plan*.

More specifically, the #SmartME project milestones are reported in the following timeline/roadmap:

- I Nov. 2014: Brainstorming, first idea of #SmartME.
- II Dec. 2014–Jan. 2015: Aims and goals, first draft architecture, identification of hardware and software technologies.
- III Feb–April 2015: Crowdfunding initiative.

- IV April 2015–Dec. 2015: Equipment and device design and assembly.
- V Sept. 2015–June 2016: Software platform development.
- VI March 2016–Dec. 2016: Initial infrastructure deployment and operation.
- VII June 2016–Dec. 2017: Service development and deployment.

As of now (March 2016) we have already deployed tens of fully operational smart boards and nodes within the municipality of Messina, including the software platform. We have already shared information about the #SmartME idea, main aims and goals with a number of communities, so here, following this roadmap; we describe the crowdfunding initiative of step III. Details on equipment, devices, technologies, and on the adopted software platform (Stack4Things) are provided in the following sections.

With regard to the #SmartME crowdfunding initiative, we leveraged Eppela (2016), a well-known Italian crowdfunding platform. Different types of contributions have been identified, based on the corresponding rewards, specifically 7 categories:

- *First-tier supporter*: this kind of contribution was meant for any citizen aiming to support the project without playing any otherwise active role. The name of the contributor has been included in the public list of official supporters of project.
- *Second-tier supporter*: citizens opting to support the project this way, apart from being included in the public list of supporters, received a "thank you" postcard.
- *Third-tier supporter*: citizens supporting the project this way, have been included in the public list of supporters, received a "thank you" postcard and got as a bonus a t-shirt with the #SmartME logo.
- *User*: a contributor of this kind got exclusive access to data collected by the system during the first year of operation, both in raw form per each sensor, and in aggregated form.
- *Developer*: a candidate of this kind should be an expert in the development of network-enabled applications and services, either in terms of academic research or industrial development, who got guaranteed access to the infrastructure for a timeframe proportional to the amount of contribution, to be enjoyed within a 12-month time interval, in order to run and test his/her services.
- *Adopting a sensor*: every contributor had also the faculty to ask for the deployment of a certain sensor in a given position and to get access to data there measured and collected. For instance, any citizen who would like to find out about noise levels in the residential area where he/she lives or get any info about outdoor air quality may ask the deployment of the required sensors in order to collect data as desired. Such a possibility has been made available also to organizations or even informal groups of citizens. This way a number of envisioned scenarios may be unlocked, their potential limited only by the imagination of citizens, and driven by passion for technology and their hometown.
- *Brand sponsorship*: this mode of contribution was mainly meant for enterprises. A contributor of this kind, apart from enjoying all the aforementioned rewards,

got a brand of her own advertised for a whole month, continuously, on the website of the project. The crowdfunding fundraising campaign successfully terminated after two months, collecting in total 34,132 €, more than twice the target of 15,000 €. It involved 84 backers: 16 first-tier supporters, 9 second-tier supporters, 25 third-tier ones, 14 users, 1 developer, 3 sensor adopters, and 10 contributors aiming at advertising their own brands. Therefore, support from different types of contributors, from citizens to public administrations, from researchers to companies, has been witnessed.

3 The Framework Architecture

Figure 1 depicts the overall architecture of the #SmartME framework. The Stack4Things Cloud is exploited as a mediator with respect to the #SmartME nodes. It exposes a representational state transfer (REST) application programming interface (API), which is consumed by the Administration portal. Through this user-friendly Web interface, the infrastructure administrator can act on the nodes, querying their status and enforcing system-wide actions. Stack4Things translates such commands to corresponding messages, which are delivered to the #SmartME nodes.

#SmartME nodes are programmed to periodically send samples to a set of comprehensive knowledge archive network (CKAN) data stores. The CKAN (2016) is a web-based open source data management system for the storage and distribution of datasets. Data delivery is performed trough the CKAN REST API interface. Data is consumed by the Public portal, which provides a user-friendly showcase through which citizens can browse the #SmartME nodes and have a sneak peek at collected data. Moreover, the CKAN data stores offer the possibility for both citizens and third party services to perform complex queries and retrieve historical series. In this section, we will give a few details about each of the components represented in Fig. 1, while details about the #SmartME portals are given in the following section.

3.1 #SmartME Nodes

Figure 2 reports the composition of a #SmartME node. The Arduino (2016) Yún is a Single-Board Computer powered by an Atmel ATmega32u4 micro-controller and the Atheros AR9331 System-on-a-Chip. The Atheros MIPS processor supports a Linux distribution, based on an Arduino-enabled “flavor” of OpenWrt supporting microcontroller-exposed interfaces to general purpose input output (GPIO) pins, called Linino operating system (OS). The board has built-in Ethernet and Wi-Fi support, a universal serial bus (USB)-A port, micro-SD (secure digital) card slot, 20

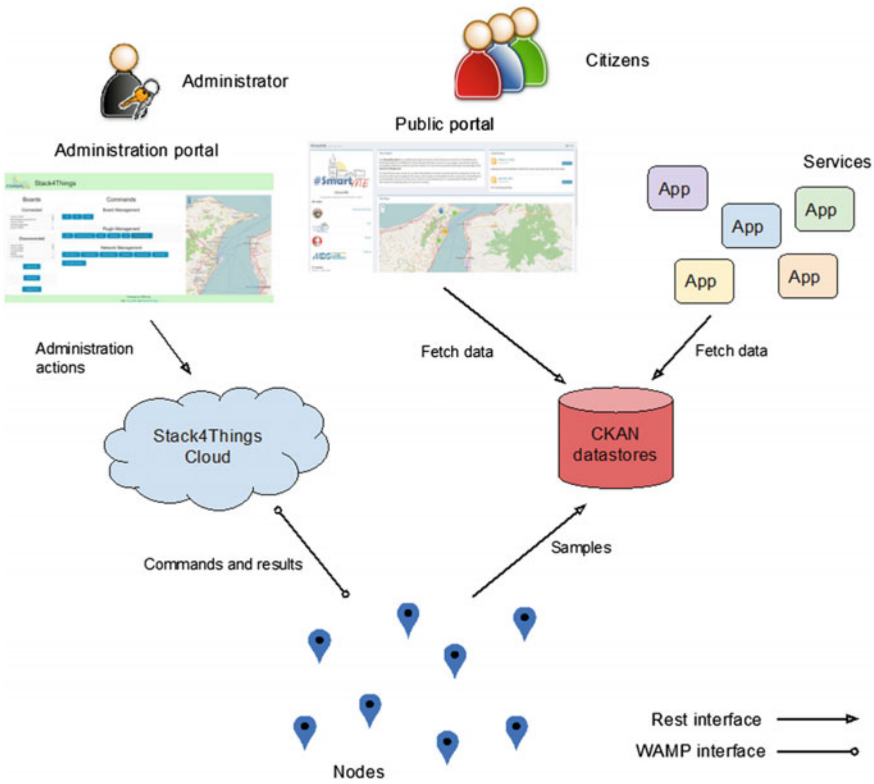


Fig. 1 Architecture of the #SmartME framework

digital input/output (I/O) pins (of which 7 can be used as pulse-width modulation outputs and 12 as analog inputs), a 16 MHz crystal oscillator, a micro USB connection, an in circuit serial programming (ICSP) header, and 3 reset buttons.

The Yún board has been equipped with a Tinkerkit Shield hosting a set of low-cost sensors. Specifically, a Tinkerkit thermistore, Ldr, and Mpl3115 have been installed as temperature, brightness, and pressure sensor, respectively. A Groove MQ9 is used as gas sensor to obtain information about air quality. In particular, *CO* levels are captured as an indication of *air pollution*. A Honeywell HIH-4030 has been chosen as *humidity sensor*; while an Arduino KY38 captures the *environmental noise* level.

3.2 *Stack4Things*

Stack4Things is an OpenStack-based IoT framework, developed by the MDSLab at the University of Messina. Stack4Things is an open source project that helps

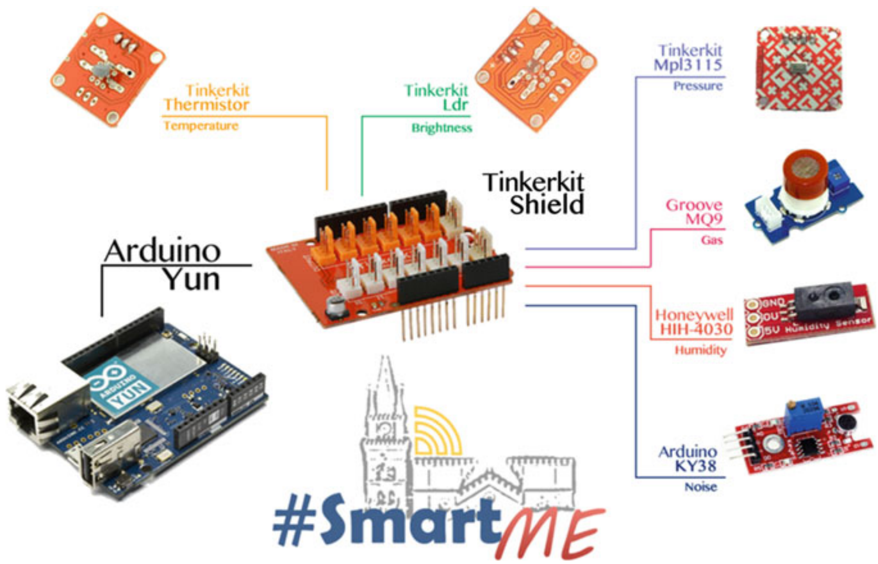


Fig. 2 A #SmartME node

administrators in managing IoT device fleets without caring about their physical location, their network configuration, their underlying hardware/software setup. It is a Cloud-oriented horizontal solution providing IoT object virtualization, customization, and orchestration. Stack4Things enables an out-of-the-box experience on several of the most popular embedded and mobile systems, e.g. Arduino, Raspberry Pi, and Android. Main features of Stack4Things are:

- *Object virtualization*: Interaction with IoT devices as entities in the Cloud is enabled, together with access to all their hardware and software properties through a uniform interface. New virtual devices can be built by mashing up multiple scattered objects.
- *Overlay networks of things*: Creation and management of Cloud-mediated or fully peer-to-peer virtual networks among remote objects are implemented. This allows the deployment of standard (i.e. not specifically ported) applications on top of the IoT devices, e.g. as they were on the same local area network (LAN) without caring about network address translation (NAT)/firewall issues.
- *Remote control and customization of devices*: From low-level firmware/operating system configuration up to business logic can be performed. The administrator can operate on nodes through the Cloud interface or remotely access them wherever they are.
- *Fleet management and delegation*: IoT objects can be organized in fleets and they can be controlled hassle-free, whichever the scale. A complex delegation model allows delegating and revoking permissions to users and groups with tunable granularity, implementing a multi-tenant Cloud of IoT objects.

- *Fog orchestration*: Objects can be orchestrated by aggregating them in IoT ensembles, allowing to building and deploying new applications without caring about object location and network configuration. This way, Stack4Things implements a Fog computing platform.

Stack4Things is a horizontal solution, an IoT operating system for the deployment of smart applications. Smart homes, smart buildings, smart cities are only some examples of Stack4Things scenarios.

3.3 Underlying Technologies

Stack4Things (Merlino et al. 2014; Stack4Things 2016) is built on top of three main technologies: OpenStack, Node.js, and the web application messaging protocol (WAMP).

OpenStack (2016) is a cloud operating system that controls large pools of compute, storage, and networking resources throughout a datacenter, all managed through a dashboard that gives administrators control, while empowering their users to provision resources through a Web interface. It represents a centerpiece of infrastructure Cloud solutions, a fully Open Source ecosystem of tools and frameworks upon which countless international projects and global enterprises are founding their Cloud strategies.

Node.js (2016) is a JavaScript runtime built on V8 JavaScript engine. It uses an event-driven, non-blocking I/O model that makes it lightweight and efficient. Node.js' package ecosystem, *npm*, is the largest ecosystem of open source libraries in the world. In fact, Node.js has become ubiquitous in almost every technology niche and especially so in IoT, where it is exploited in e.g. Node-RED, a visual tool for wiring IoT APIs; and Cylon.js, a framework for cross-platform robotics and physical computing.

WAMP (2016) is an open standard WebSocket subprotocol. It provides two application messaging patterns in one unified protocol: publish/subscribe and remote procedure calls. WebSocket is a Web protocol that overcomes limitations of hyper text transfer protocol (HTTP), when bidirectional, real-time communication is required. WebSocket is specified as an internet engineering task force (IETF) standard; and is built into modern browsers. WAMP adds the higher level messaging patterns of remote procedure call (RPC) and PubSub to WebSocket.

4 The #SmartME Portals

As anticipated, among the outcomes of the #SmartME project is the design and implementation of a public portal to get a glimpse on the collected data. In Fig. 3 we can see a screenshot of the main page of the portal where, apart from an

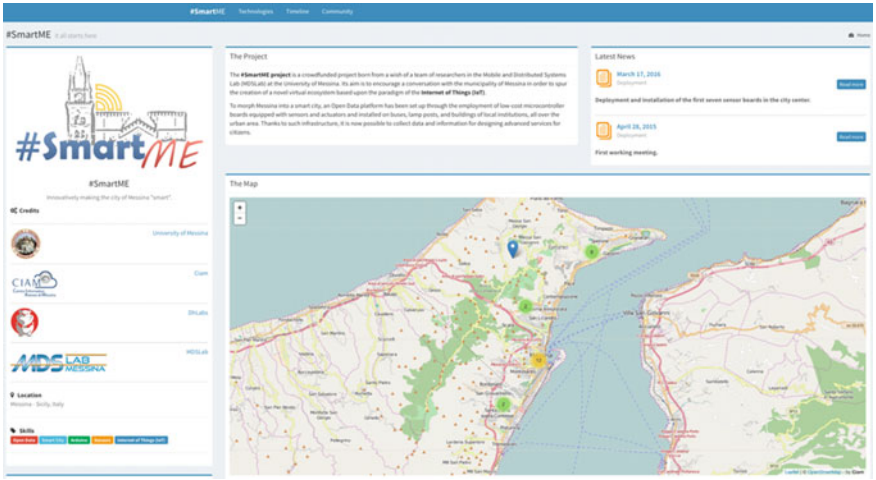


Fig. 3 Screenshot of the #SmartME portal

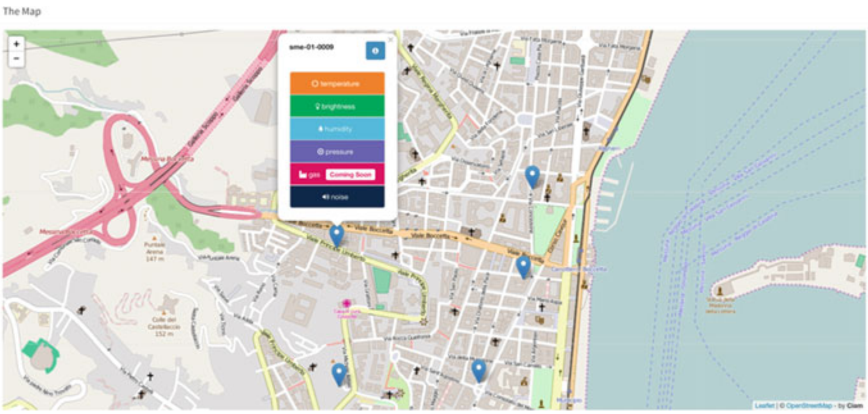
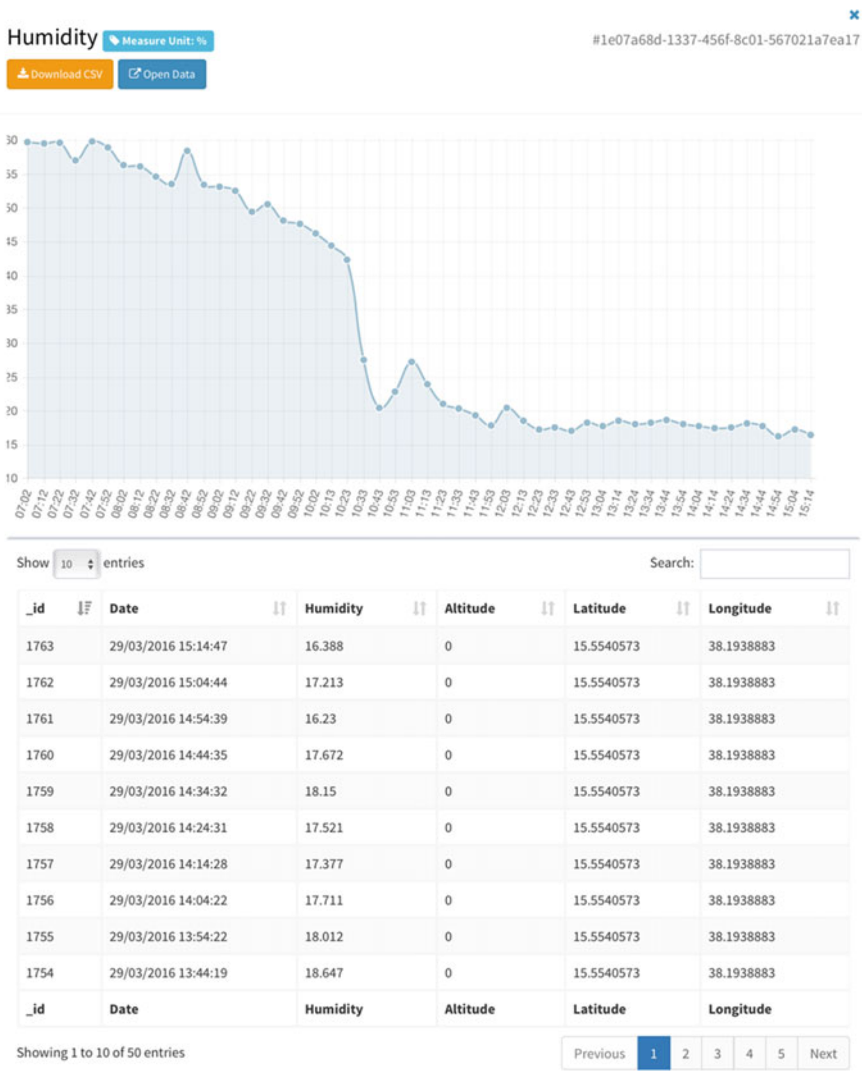


Fig. 4 Map detail

introductory section, a news log and project credits, there is a scrollable, live map with a placeholder for each of the boards deployed over the urban area or, zooming out, a visual cue about the (aggregate) number of boards under a specific marker.

When clicking on a single board placeholder, as can be seen in Fig. 4, a contextual window will pop up, enumerating available (or "coming soon") sensors/actuators wired to the board, color coded according to the category of observations being produced by each item in the list.

Then, clicking on one of the items will bring up an interactive (i.e. zoomable/scrollable) time stamped graph of the latest observations for the corresponding category (Fig. 5 provides an example with a humidity sensor), including a



_id	Date	Humidity	Altitude	Latitude	Longitude
1763	29/03/2016 15:14:47	16.388	0	15.5540573	38.1938883
1762	29/03/2016 15:04:44	17.213	0	15.5540573	38.1938883
1761	29/03/2016 14:54:39	16.23	0	15.5540573	38.1938883
1760	29/03/2016 14:44:35	17.672	0	15.5540573	38.1938883
1759	29/03/2016 14:34:32	18.15	0	15.5540573	38.1938883
1758	29/03/2016 14:24:31	17.521	0	15.5540573	38.1938883
1757	29/03/2016 14:14:28	17.377	0	15.5540573	38.1938883
1756	29/03/2016 14:04:22	17.711	0	15.5540573	38.1938883
1755	29/03/2016 13:54:22	18.012	0	15.5540573	38.1938883
1754	29/03/2016 13:44:19	18.647	0	15.5540573	38.1938883
_id	Date	Humidity	Altitude	Latitude	Longitude

Fig. 5 Real-time data

table below with a list of such observations together with the coordinates, i.e. altitude, longitude and latitude, of the sample, useful in case of mobile nodes. In the upper-left corner, a description of the system of units for the samples under consideration is depicted, together with a couple of links, to download a comma-separated value-formatted dataset, or to access it online as Open Data series on the platform.

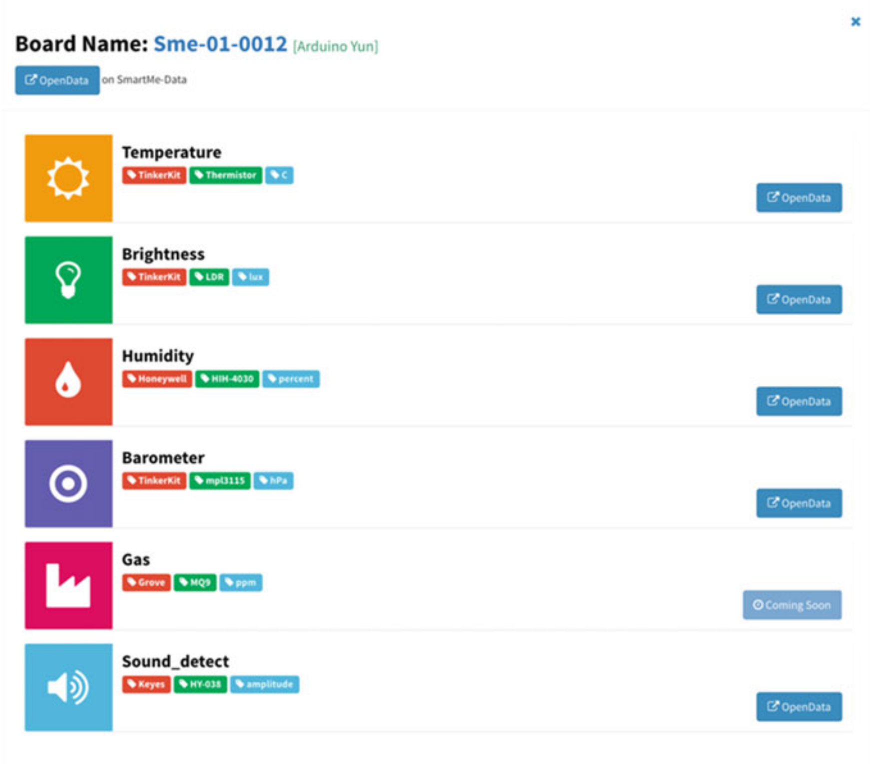


Fig. 6 Board details and datasets

In the aforementioned contextual window, clicking on the blue ***i*** (information icon), a more detailed outline of the available sensors pops up, as depicted in Fig. 6, where color codes help also in identifying either (red label) the kind of sensor-hosting expansion/daughter-board employed (e.g. Tinkerkit), or (green label) the model of the sensor. On the right, for each category of measurements a link to the aforementioned historical data can be found.

Switching to the boards' management functionality, a different website, i.e. a Management portal is available, currently only for operators and other authorized personnel, but meant to be more widely usable in the near future for running experimentations and providing sandboxing mechanisms for prospective developers of Smart City services. A screenshot of the main page is available in Fig. 7, where on the left there is a box about boards' status and operations, whilst on the right there are buttons for specific categories of commands: board-specific actions, as well as plug-in/network management.

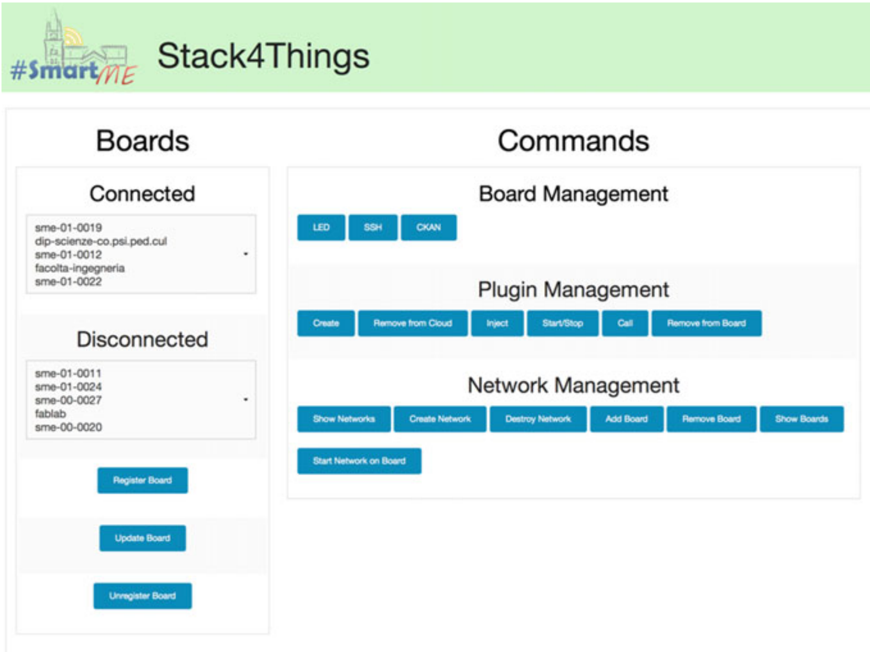


Fig. 7 Screenshot of the management portal

In particular, the status box shows which of the registered boards are connected and which are not, whereas below the two lists there are buttons to trigger board registration, metadata updates as well as deregistration, respectively. With regard to management commands, the upper box features buttons for: toggling status light emitting diodes (LEDs); opening a port on the Cloud for providing secure shell (SSH) sessions tunneled back to the board; and redirecting browsing to the CKAN platform to inspect Open Data collections for the board, respectively. The middle box displays actionable for: creating, removing (from Cloud), injecting (to a set of boards), starting/stopping plug-in, as well as invoking synchronously ("call") plug-in-provided remote procedure calls, or un-deploying ("remove from board") plug-ins, respectively. The lower box, featuring (overlay) network management operations, features buttons for: showing, creating and destroying networks, as well as adding/removing boards to a network, showing boards belonging to a certain network, and bringing (virtual) network interface up, respectively.

More in detail, in Fig. 8 we have the form for registering a new board to the Cloud, where a code (universally unique identifier) gets generated, populating the Board code field, whereas the other fields are blank and values have to be provided by the user upon registration for: the label (a user-friendly name), coordinates (latitude, longitude, altitude), a flag indicating whether the board is enabled to join

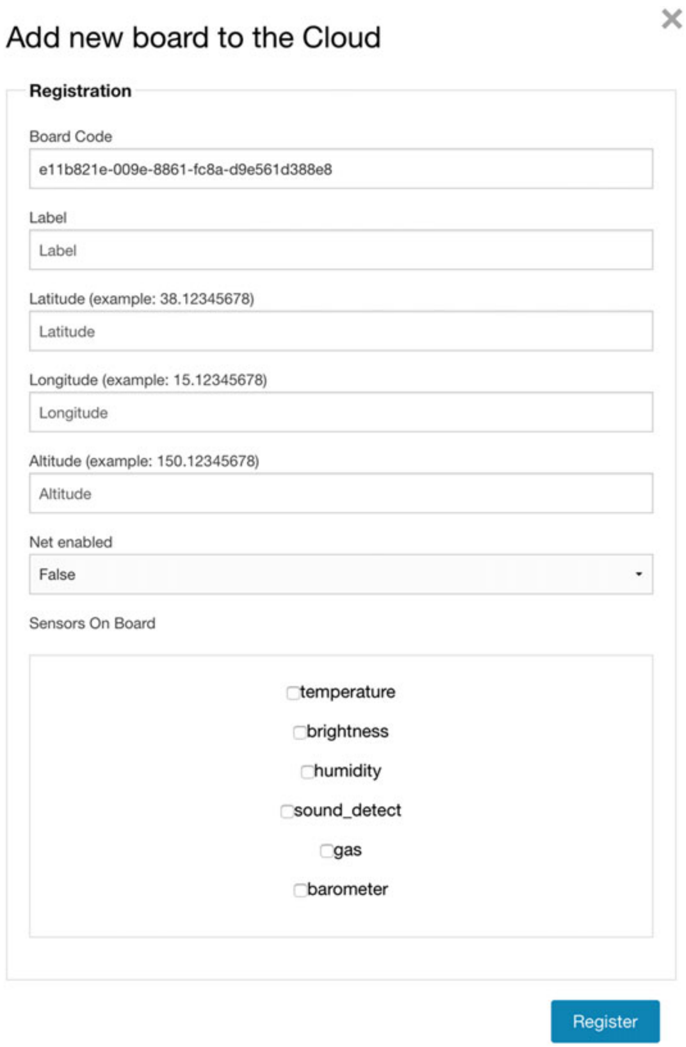


Fig. 8 New board registration

Cloud-instantiated overlay networks, and at last a list of flags to be checked, one for each sensor device actually wired to the board.

In Fig. 9 is depicted the form for creating a plug-in, i.e. uploading code to the Cloud and registering it, thus making such code ready to be deployed on boards under the guise of plug-ins. The fields include the name of the plug-in to be uploaded, the type of plug-in, i.e. either operating asynchronously (e.g. sending

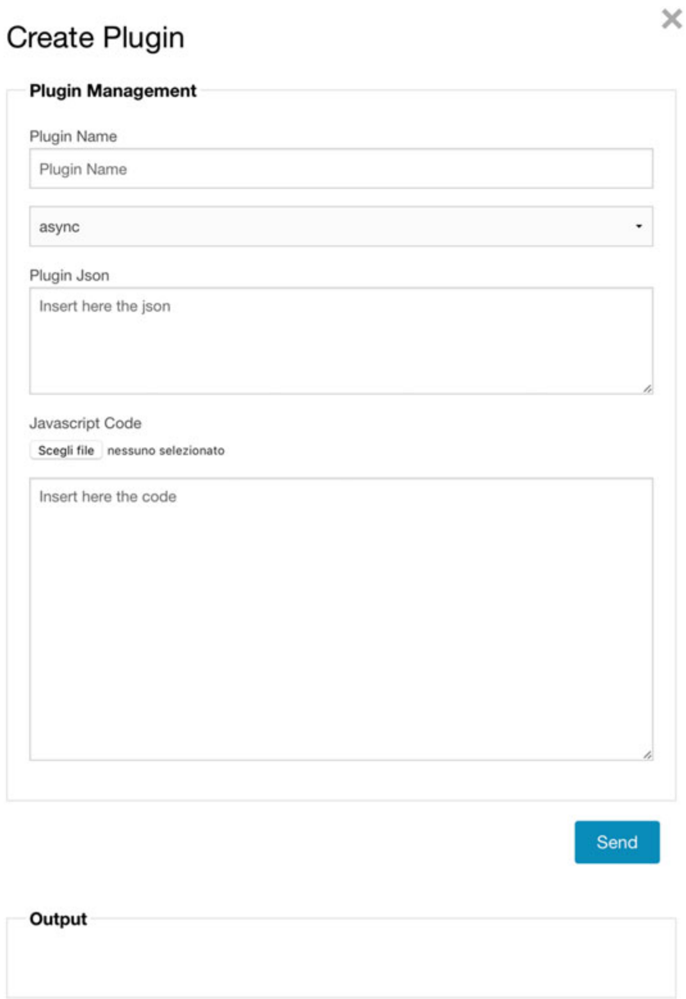


Fig. 9 Plug-in creation

samples periodically) or synchronously (exposing RPC primitives to, e.g. retrieve a sample), plug-in metadata formatted as JSON, and plug-in code. Down below is an output field, where the result of the command being executed is displayed.

In Fig. 10 the interface to create a new network is introduced, where the operator has to provide a user-friendly name for the network, and the network address in classless inter domain routing (CIDR) notation.

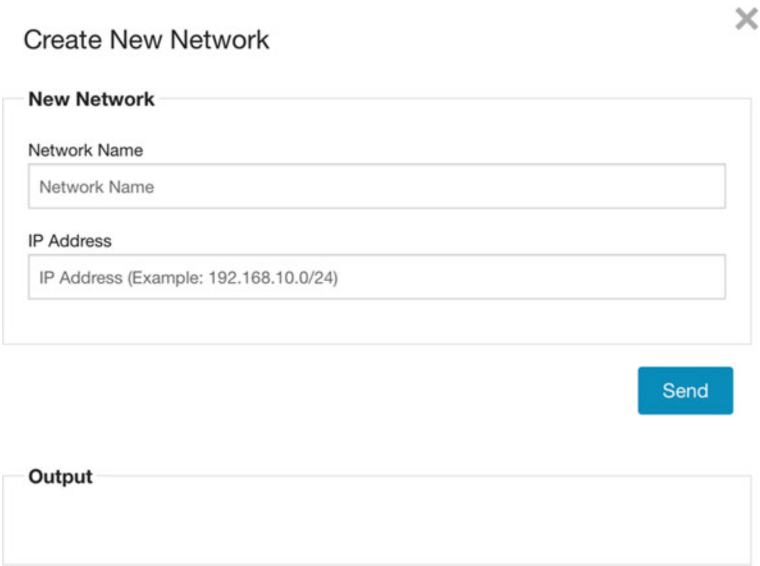


Fig. 10 Network creation

5 Conclusions

This paper reports on the *#SmartME project*, an initiative aiming at deploying and implementing the Smart City concept in the Messina municipality. Under the guidance of the University of Messina MDSLab team, in collaboration with the municipality authorities and some companies active in the Smart City and IoT areas, the first phases of this project have been implemented and documented in the paper. But the #SmartME project has been mainly supported by a *crowdfunding initiative* that raised funds for more than twice the initial target, involving almost 100 contributors and citizens. This way, for the time being and thanks to this grassroots campaign and support, an embryonic *Smarter* instance of Messina is already under construction, since some sensors, actuators and transducer-hosting Arduino-based smart boards have been implemented and deployed.

Apart from the efforts spent in enlarging the community of early adopters and makers, the rationale behind this activity lies inherently in the vision of an elastic, on-demand infrastructure underlying the Smart City, as such to be repurposed at will in a Software-Defined fashion (Merlino et al. 2015) for several, possibly concurrent applications and services.

The efforts related to the initial stages of the project, the crowdfunding initiative, the related technologies, boards and nodes design and implementation, as well as the software to manage the overall infrastructure, Stack4Things and the related, CKAN-powered, portal are described in detail in the paper.

A key outcome of these early stages lies in the actual involvement of several actors in the development of services to be deployed on our horizontal platform, exploiting service-oriented provisioning facilities, and already sharing resources where feasible.

Ongoing and future work on #SmartME is mainly focused on developing Stack4Things further to improve node customizability, optimizing node utilization through virtualization capabilities, while achieving interoperability goals through abstraction, in order to enabling an ever-growing number of mobiles and other smart objects to be involved in the #SmartME infrastructure. On the other hand, we plan to develop advanced vertical services for the citizens on top of the horizontal #SmartME infrastructure, mainly focusing on smart mobility, e.g. smart parking, traffic monitoring, intelligent route planning, but also in the environmental monitoring and emergency management contexts.

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The Smart City as Shared Design Space

Martin Koplin, Stephan Siegert, Aura Neuvonen, Kari Salo, Kevin Kerney, Carl Skelton, Alma Culén and Igor Nadelkovski

Abstract Beyond the conceptual frameworks of open data and smart cities there is an emergent complex of digital environments to virtualize public sub-realms: neighborhood-level agoras or places of assembly with shared information, ideas and design. These environments can be used to simplify civic engagement in urban development processes—both on- and off-line. This paper presents different examples towards new strategies in this field. It presents and discusses projects using new Information and Communication Technology (ICT) tools and methodologies targeting participation in urban development and urban re-design on

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numerous stakeholder groups. These include children, migrants, older people, professionals and non-professionals. The findings indicate that in today's ICT-public-realm, public data must be offered as public information and citizens must be enabled to get in touch with the new digital tools to strengthen participatory processes. The examples show that the underlying processing tools must be accessible, user-as-producer-friendly and open to diverse groups of people. They also show that artistic, playful, creative and game-based settings can be an ideal starting point for this attempt. These strengthen acceptance among administrations and integrate social groups that are not addressed by existing participatory strategies.

Keywords Participation · Media art · Labs for urban re-design · Digital tools · Smart citizenship · The People's Smart Sculpture (PS2)

1 Introduction

Participation has a long cultural tradition in Europe. Participation is based on the cooperation between different social groups, spheres of action and institutions. In most of the European and Western countries the realm of urban development has generated its own strategies on how citizens can be involved in decision-making and participation. But the rising complexity of life in so-called smart urbanity, the re-design of our cities, and the multidisciplinarity of digital approaches and the digital shift in general is challenging the traditional forms of participatory concepts in urbanity. Decision-making processes for future activities in the field of a smart and sustainable urbanity therefore require an enhanced approach to citizen participation and user-friendly articulation methodologies on the one hand; and technologies and tools for a new perception of the urban environment on the other hand (Koplin et al. 2016). It is required to access the full potential of the new capabilities of communication networks, the broad availability of microcomputers, new design and especially young people's e-skills. Increase of citizens' engagement in their urban surrounding and fostering identification with the cities they live in can lead to social development, innovation development, democratization and, in the end, also to more employment. Participation has to become part of every smart city initiative. This cannot be done just by creating new technologies. It can only be done by using intelligent methods and methodologies and by developing new tools that help to involve also groups of citizens that are mostly left out of today's urban decision-making, like children or migrants.

In the project PS2, citizens of any age and background, artists, activists, design experts, scientists work together in experimental design of tools and methodologies for the collaborative and participative smart development of their urban environment. By doing this, PS2 tries to find answers on the urgent needs of how urban participation can be adapted to future demands. The project is about the re-design and the cultural construction of future spaces by real people as performative spaces.

It fosters participative arts, urban design, and culture processes in Europe's city spaces (Koplin et al. 2016). The PS2 approach works on two levels: (i) the employment of new methodologies, software and apps for participatory urban re-design that are tested on site and in everyday life situations; and (ii) the evaluation of those activities in a comparative analysis, under the aspect of real transferability. The scope of the technological and conceptual approaches tries to integrate as many stakeholder groups as possible.

The article tries to verify that the integration of intelligent digital tools in urban decision-making processes can help to realize a new smart participation as a necessary cultural technique in Europe's city spaces as outlined above. To do this, the article features seven exemplary sub-project actions, showcasing the variety of approaches within the PS2 consortium. The first five examples are related to an activity called the *Public Urban Lab*, a temporary innovation lab, realized in Bremen in June 2016. The activity, described in Chap. 2, used the format of *open labs*. In the last few years, open labs for collaborative design and shared scientific research spaces have emerged all over the globe. They function as community centers and take the role of freely accessible, democratic educational institutions, where citizens can meet and share knowledge and technologies without social barriers like university fees or membership to a certain club. The Public Urban Lab adapted this format as this provides the possibility to assemble citizens, creatives, politicians and urban experts at the same place at the same time; and to learn more about participative art, digital media and urban development in a way that would be impossible behind the closed doors of a university conference.

"Express Yourself/city", described in Chap. 3, follows the same goal but it focuses on the topic from a slightly different angle. In workshops, the project teaches people how to build three-dimension (3D)-models by using simple open source software. This enables the participants of the workshops to visualize their wishes for the development of certain areas in the city in a gamificated way.

The fourth chapter deals with the key tool tested in the context of the Public Urban Lab, namely the urban re-design software Betaville, developed in Bremen and New York City. It is simple software that can be used by both non-professionals and professionals to discuss and reshape the structures and the surface of a city. The usage of Betaville at the Public Urban Lab has also shown which adjustments are necessary to increase usability of the system and turn it into a tool that can effectively change urban participation.

People's perception of environments, especially in the city, is closely related to the omnipresence of sound. The Neighborhood Living Room is the attempt to use *sound experiments* to raise awareness for the public spaces.

Chapter 6 describes an art-driven approach on urban development called *Shared Museum*. This describes a chain of art activities dedicated to function as a channel for the wishes local citizens have towards their city and neighborhood. The approach consists of art interventions and discussions in the format of salons, i.e. non-formal meetings of people with a shared passion for certain topic, in this case urban re-design. The goal was to find out if and how wishes and ideas of individuals or micro-groups can be made visible for a larger public by using art and by combining analogue and digital technology.

The last two sections of the article are not directly related to the Public Urban Lab Bremen. But they also tangle the question of how citizen knowledge and individual ideas can be leveraged from grassroot level to public awareness. The first one describes the concepts of Pop-In and Drop-In spaces. These are designed as new formats to integrate youth in the processes of urban discussions. Pop-In spaces try to use the element of surprise to attract citizens; whereas Drop-In spaces want to give new impulses to existing institutions. The last chapter tries to analyze how the dimension of time can be used to foster people's engagement in questions of urban design. The projects creates a 3D version of the Macedonian city of Bitola that allows people to travel back in time and observes if this leads to increased identification and activism.

2 The Public Open Lab Bremen

The Public Urban Lab in Bremen was implemented as an open discussion forum, art-, participation-, future- and reflection-forum for one week in June 2016, set up in a white overseas shipping container between Central Station and Übersee-Museum in Bremen. At the Public Urban Lab people discussed, discovered and got introduced to new digital and artistic methodologies and tools for participatory urban development of the future. The Public Urban Lab is part of the European Union (EU)-project PS2 and was realized with the support of the research cluster Mobile Life of the City University of Applied Sciences Bremen.

The idea behind this activity was to create a temporary test space for the tools developed in the PS2 sub-project "Express Yourself/city" (see Fig. 1). With the Public Urban Lab, the PS2 team based in Bremen wanted to reach as many people as possible and therefore chose the square in front of the Central Station as the ideal place for the container, since it was crossed by ten thousands citizens every day. It is also the most democratic space in Bremen, used by people of all age, status, employment at any time of the day. Outside the container, other team members were constantly interacting with the citizens passing the square, discussing the urban surrounding. In the specific case of the Bremen Central Station this is a rather delicate topic: the whole area around the station can be identified as a non-functional urban space. The interviews showed that people do not like the place. They cannot use it for anything else but for crossing it. The interviews also showed that people have concrete visions and ideas what they would change to make the place a more welcoming, functional one.

Inside the container, coaches instructed all interested pedestrians how to build 3D-models with open source software. Thereby people were shown a digital way they can express their urban wishes. Together with the coaches, the 3D-models

Fig. 1 Public Urban Lab, presentations, workshops, social art in public space

were implemented in a tool called Betaville. The software development of Betaville is a shared project of the M2C (Institute of Applied Media Technology and Culture Bremen), the University of Applied Sciences Bremen and the New York University since 2008. Betaville exists in different versions. In use at the Public Urban Lab was an online client (Eirund et al. 2013). It is a game engine, based on a 3D mirror-world that can reflect the infrastructure and buildings of any city in the world. During the 6 days of the lab activity, dozens of new buildings were added to the virtual representation of Bremen. Ideally, the alternate suggestions are taken into account by the administration of the city in the planning phase of the re-design of certain urban areas.

In general, the administration and the representatives of the federal government of Bremen showed great interest in the Public Urban Lab activities. In an open discussion they explained the strategies of urban development to an audience that usually has little contact to the topic. The program of the Public Urban Lab featured also workshops and presentations on different topics related to urban re-design. Over 300 people participated in the events, providing a large collection of information that will be used for creating future events and cooperation. The Public Urban Lab for many visitors became a spot to express their ideas about the future of the town and possible changes in its districts.

Another digital tool used during the PS2 project is the Kids-App. With this environment, its Content Management System (CMS) and mobile application, designed and programmed by computer scientists, children and adults of all age can design their own mobile tours through the urban space without the need of any technical support or intensive knowledge. The system empowers children to become an active part in urban development, exchange ideas and comment on them.

Artists, designers, planners, and representatives of organizations and institutions reflected urban and regional development prospects of Bremen as an example for a smart, artistic, participatory city of the future.

3 Express Yourself/City—Gamificated Re-design in the Public Urban Lab

Virtual urban art invites all citizens to participate in attending, responding and modifying 3D sculptures, linked to real spaces. These may be art works, fictional buildings, provoking sculptures or informative objects. Participants use their tablet device to create an augmented reality view and do modify 3D objects proposed by others. This fosters a creative process to develop virtualized objects by and for the community of interested citizens, creative industries and artists. The aim of "Express Yourself/city" is to create 3D and augmented reality views, containing image-representations of actions on and beside urban areas and places, new design and their possible changes. The use of urban space in the past and the present can be compared, as well as changes and different versions of a place. Fictional views of a possible future use of the space, future architecture, digital narratives or art works can be created (Eirund et al. 2013). The project addresses and profits from the fast growing percentage of people already making use of online tools, pads, tablets and smart phones; and invites all citizens to participate in attending, responding and modifying these sculptures, at the real spaces in the city of Bremen. Web and social media are used to communicate progress during the implementation process (new proposals and the upload of best-of examples). Users are able to upload two-dimension (2D) and 3D proposals and modify (others') proposals as well as vote for them (by comparison) (Koplin and Skelton 2012). The input is curated by local and European artists from the project partner's countries; while an overall curator coordinates the creative and technical activities and people's access and collaborative processes between citizens and artists. Local cultural projects and neighborhood organizations about urban re-design were integrated in the process. A Bremen-based public project that cares about vacant buildings and fallow areas in order to establish temporary use by artists and creatives as an innovative tool for urban development was integrated into the project for to work with the artists and creatives on ideas and the design for a future permanent use of vacant buildings for artists, culture and creativity. A shared governmental project for urban development in Bremen, Leipzig and Nürnberg was invited to exchange the results of the experimental project with policy and administration. The relevant outdoor areas had been defined by the citizens and the curator.

At the Public Urban Lab Bremen the "Express Yourself/city" project was responsible for the realization of a one week workshop on participative urban re-design. It was implemented by scientists and urban development experts from New York and Bremen. For the participants, students of media informatics, this was a new way of practical experience. Their results were directly influenced by the Central Station's square. They got into contact with other citizens. All this made the topic more relevant for the students.

The project was also the driving force behind the implementation of the Betaville system used by creatives and other visitors of the lab.

Fig. 2 Participants of the Public Urbane Lab workshop of the *ZZZ*—Zwischen Zeit Zentrale—discussing the future of active citizenship and labs for participation in urban development

The Public Urban Lab featured a number of workshops, closely related to the central ideas of this PS2 sub-project. More specifically were carried out: a workshop examining the future of participation in city development and the role of urban laboratories in general (see Fig. 2); a participatory walk to critical and highly discussed urban areas around the Bremen Central Station; how new visions of urban design could be transformed into audio-visual presentations was the topic of an urban projection workshop conducted by video artists and dj; the topic of active citizenship and new approaches on participatory engagement in city development were discussed with other activists.

4 Betaville and Its Role at the Public Open Lab Bremen

MIT (Massachusetts Institute of Technology) set the precedent of "mashing up" the functions of engineering laboratory, art/design studio, and general-purpose technical facility in 1975 with the founding of the MIT Media Lab, as an outgrowth of their school of architecture. In the years since, an enormous variety of organizations from advertising agencies (the Ogilvy Lab, the RGA Lab) to architectural design firms (the Rockwell Group Lab) and community development organizations (Living Labs around the world) have opened variants of the lab-studio-open workshop type.

Since Al-Hazen developed the foundation of the scientific method, while under house arrest in the early 11th century (Sabra 1989), it has been fundamental to the purpose and function of a laboratory to be a closed environment: in the first instance to protect the integrity of testing a very specific hypothesis, and in the second to protect laypersons and the general public from potentially harmful materials and equipment until the experimental phase of discovery is complete, at which point the laboratory work ends. Other but equally stringent modes of isolation are enforced as a matter of course in teaching and quality assurance/testing laboratories. From a traditional research perspective, a laboratory that is open and public must be either ineffectual or dangerous. From the point of view of a builder of tools for public participation in urban planning and/or design, however, there is no viable development process that conforms to academic research protocols. The standard ethical review protocols, designed primarily with medical research in mind, do not account well for the requirements (and hazards) of technology development at the intersection of geospatial information and urban design/development politics (Elwood 2006).

Since the formal launch of the Betaville project as a joint effort of the Brooklyn Experimental Media Center, of New York University and the M2C Institute at the City University of Applied Sciences Bremen, a group of researchers has effectively worked to supplement the respective Ethical Review Board protocols by allying themselves with organizations more directly engaged and experienced in community consultation processes, to provide more relevant protection, such as the Municipal Art Society and Downtown Brooklyn Partnership in New York, the Office de Consultation Publique de Montréal, and the Engineering Department of the City of Los Angeles (Skelton 2014). In practice, the development and implementation of the Betaville platform's various components, since its inception, has been driven and directed by an understanding that the logic of constraining expert knowledge and control in isolated facilities is radically and fundamentally irrelevant to Betaville's primary purpose, supporting informal collaborative participation in the preliminary stages of conceptualization of possible changes to build environments, from public art through urban design to development and re-development planning.

In the process of framing participation in the iCity Urban Informatics for Sustainable Metropolitan Growth translational research initiative, led by the University of Toronto Transportation Research Institute (Cody et al. 2016), the Betaville research group has advocated for a re-activation of the old idea of "public works" in the domain of urban infrastructure, in that case at two distinct levels: transportation infrastructure, in order to re-integrate the quantitative performance values associated with contemporary practice, with the "old school" values of distinctiveness now more commonly associated with after-the-fact "placemaking"; and a parallel integration of qualitative and quantitative dimensions in the conception and design of next-generation of information technology (IT) tools to support operation, planning, and design of urban transportation networks.

The Public Urban Lab in Bremen in June 2016 was strategically located between three apparently unrelated concepts of an urban transport "node": the train station itself, built between 1886 and 1891, simultaneously as a grand architectural work and utility; a construction site for a new shopping complex; and the "Hochstrasse", a 2 km-long elevated expressway built in 1968 to expedite cross-town traffic, and a classic demonstration of what kind of urban blight can happen when roadway design briefs are reduced to purely quantitative measures of performance: dark and unwalkable principal street below, inaccessible park beyond (the Rembertiring), worst-case residential and commercial use/values adjacent, etc. Regarding Betaville, the Public Urban Lab functioned on three strategic research approaches: firstly by conducting a daily workshop during the PS2 "Express Yourself/city"

International Week 2016 of the Media-Informatics Program of the City University of Applied Sciences Bremen (see Fig. 3); secondly by a researcher in residence action at that same university with researchers and students as software beta-tester/critics; and thirdly by assisting programmers of the M2C Institute, signing responsible for the technical development for the new Betaville web graphics library (WebGL) client prototype that is created in collaboration with usability experts at the Visual Laboratory at OCAD (Ontario College of Art and Design), University in Toronto.

All of this was undertaken among the intensity of a tightly packed program of art activities, seminars, workshops, demonstrations, expert panels, and occasional interruptions (the three thunderstorms). The format of this temporarily Public Urban Lab was a great forum for discussions, workshops, presentations and tests, but at the same time frustratingly short for to practically re-design the area. When some of the participating creatives and students were clear on their interests and requirements, were properly oriented to the adjacent urban issues and came up with their very best ideas and proposals for the future re-design of Bremen, it was time to return the container lab. In the short time of one week, the workshop group was able to make sense of the key elements and performance characteristics of the temporarily laboratory that are required for the continuum of research, new ways of public engagement that were needed for possible next steps in the development of new "informatic public works": software tools, and the attendant use and development practices that can support full integration of technical performance, quality

Fig. 3 Public Urban Lab, Carl Skelton and Betaville users at the container

of environment, and public engagement. Software development laboratories themselves may need to be "public works" in their own right, in a domain where there is no individual who can legitimately claim the prerogative of judging for all the others, and every citizen has a "duty of expertise" as he/she participates in public discourse about what should be different in the public realm at the local level.

5 Augmenting Audio Reality with Soundscapes at the Public Open Lab Bremen

The Neighborhood Living Room sub-project, which is part of PS2 Project, studies different methods to create a more dynamic, participatory audience relationship with Museum of Technology in Helsinki, Finland. Utilizing and exploring soundscapes is one of our approaches.

Soundscape is part of our environment as well as any other part of the scenery we live in. At its best, the soundscape is a living organism that includes us, people; and improves our well-being. However, the perceiving and verbalizing of our sonic environment is a rather unknown concept to us. The sonic environment receives new dimensions when it is considered from more experimental point of view. R. Murray Schafer created the term "soundscape" that refers to our acoustic environment. Acoustic ecology is the study of sounds in relationship to life and society (Schafer 1994: 205). Modern man has changed the acoustic environment radically in the past decades; and today the world suffers from overpopulation of sounds (Schafer 1994: 71). Due to this development there is a growing demand for acoustic design that would turn the tendency of growing amplification and discord towards a more harmonic and human soundscape (Schafer 1994: 207). These numerous efforts to reduce the overall noise all the way from the early ages of modernism have not been successful, and it is legitimate to say that the situation has gotten worse especially in the urban areas (Hendy 2013: 304–308). In order to create a soundscape that would please its residents it would be necessary at first to define what a pleasant soundscape means. All of us have different kinds of knowledge, different starting points and values regarding the soundscape (Puustinen 2006); and yet the very nature of sound is always to some degree common property (Hendy 2013: 322). Even though sound unites us in experiencing the world, it is lacking a common language (Takala 2014: 24). Acoustic space is something ubiquitous that disregards the particular visual and material delineations and spatial arrangements (Labelle 2010).

Participatory and communicative planning has become more common within past decades, but its implementation is suffering from scattered information and lack of appropriate practices and tools (Puustinen 2006: 258). In soundscape design, the challenge is cost by the fact that the only way that hearing exists after the actual perception of the physical sound and the sensoric reaction is in our mind and memory. Before sound reproduction and other audio technologies, hearing and listening was a private act and remains of it were accessible only to original experience him or herself. Once it was possible to record and playback the sound, it became a common, public, and shareable thing (Kahn 2001: 8). But something still remains private, un-hearable and under the control of individuals: the interpretation and the idea of the sounds heard. If we wish to have a conversation about sounds, we need to have sonic example of what we are describing, because otherwise we are talking about something that cannot be shared: the memory of a sound. The goal of the Neighborhood Living Room soundscape project is to explore methods to engage common people, especially youth to their sonic environment; and explore it in workshops that recourse communicative digital sound tools. The soundscape platform developed offers immersive tools for making sonic memories, experiences and opinions hearable. In further development, these kinds of tools could be used for participatory city planning and gathering spatial knowledge.

Our soundscape platform consists of a backend system and mobile applications (see Fig. 4). The backend system is an audio digital asset management system (ADAM) and a management application. ADAM contains functionalities to manage assets and provides interface for the management application and the mobile application over the Internet (Salo et al. 2016b). The management application is more or less an administration console to manage assets and users. The mobile application in the context of this paper is a soundscape mixer application. Actually we have developed three different Android applications for the same purpose (Salo et al. 2016a). It should be noted that ADAM is not limited only to soundscape creation. Mobile application could be anything that utilizes audio files, like interactive audio stories, audio memory sharing or audio guide applications.

In order to get feedback of our soundscape platform and test soundscape approach for engaging youth, we organized a workshop for a school class (9th grade). We gave a task to create a soundscape with the three Android applications to an image that reflected the exhibition topics of the Museum of Technology. Before the workshop, we had already assigned a team of sound design students to

Fig. 4 Overall system architecture

plan what kind of sounds would be useful in the museum context. Using open source material they collected and modified 142 audio files (59 in "wav" and 83 in "mp3" format); uploaded these files to ADAM; and defined the metadata of each individual audio file. The workshop started with a short lecture about soundscape and its basic structure, as the concept of soundscape was not expected to be common to all the young participants. For creating the soundscape, the students were provided photos of Helsinki from different eras and an adjective that exemplified an atmosphere in the selected photo. The task was to create a soundscape that would fit the photo and reflect the atmosphere. The students were provided a sound library (142 audio files) to choose sounds from; and they had three applications in their use for creating the soundscape. After the creation of the soundscape, all soundscapes were listened and discussed. The conversation offered a possibility to share and reflect each one's perspectives to sounds and auditory perception. The feedback from the workshop was positive. The test group found the tools easy to use and suitable for the task. The workshop with the soundscape tools was a fun and new experience. It should be noted that even with 142 sound files, the users wished there would have been more variety. In our opinion the soundscape platform functions as a suitable learning environment for sonic workshops.

Another soundscape workshop has been implemented as a part of Public Open Lab Bremen. In it, we wanted to test the transferability of tools, i.e. if the soundscape platform can be utilized in a communicative city planning context. The workshop was designed to offer local citizens an inside view into the theories around soundscapes and our acoustical perception in favor to raise awareness and to motivate people to take influence on their local soundscape. Since the processing of acoustical impressions is subjective, it was important to animate the participants for active discussion about their personal listening habit and the reflection of their auditory perception. Beside the theoretical discourse, the workshop therefore offered the possibility to let the participants individually explore their listening habits with the usage of the soundscape platform. The participants had to choose between three soundscapes they should imitate with the help of the application; "generate a harmonic soundscape", "generate an interesting soundscape", "generate an ordinary soundscape". In this way their perceptional association of aesthetics and sound could be regarded and taken into discussion. This enabled participants to develop their mind within the field of acoustics; and to reflect their personal feelings to certain sounds and sound constellations.

The practical part of the workshop was followed by a sound walk (Westerkamp 1974) at the train station of Bremen; and a final discussion in which participants were eager to talk about their sound perception and the perceived attributes they now are able to explain. Being able to find words for acoustic properties enables the capability of the reflection of acoustic impressions; and contributes to the critical look onto existing soundscapes, especially in urban areas.

6 The Public Space as Shared Museum

The project "The Public Space as Shared Museum" consists of a series of creative and artistic interventions as participative actions in different parts of the city of Bremen. Artists from Bremen and other European cities create social dynamics and digital art representations with new ways of participation for citizens. The goal of "The Public Space as Shared Museum" is to bring together social art and experimental, informal game-based cultural learning. It also focuses on empowerment potentials, and the practical approach of resource-oriented engagement of citizens, volunteers and experts. The result is a chain of art activities working on two levels: (i) by a series of art interventions; and (ii) by a series of salons.

Art Interventions One activity in the art chain was performed by a Swiss-American media art team in February 2016. The participatory performance post-monochrome took place in a shopping mall in Wale, a traditional worker's and migrant's district of Bremen, dealing with infrastructural problems and a population that has little contact to art exhibitions or other cultural institutions like e.g. museums. The concept of the post-monochrome event brought together the current culture of selfies and one of the oldest technologies in photography, the cyanotype.

The technique, invented in the middle of the 19th century, produces blueprint-like pictures as contact prints on paper or tissue by exposing negatives to a source of ultraviolet light. The artists, which have never been in Wale before, established a contact to visitors of the Wale Center shopping mall, stimulated them to take selfies and then produced cyanotype blueprints of these selfies in the mall (see Fig. 5).

The transformation of the digital, colored pictures into analogue, long lasting, monochrome cyanotypes triggered a reflection process about selfies and the situations in which these photos are usually generated as well as the intentions people have when they take selfies. It also revealed how the participating citizens perceive the shopping mall and their district. The cyanotypes were first exhibited at an art gallery in the mall during the day and after that for six months in the PS2 Gallery

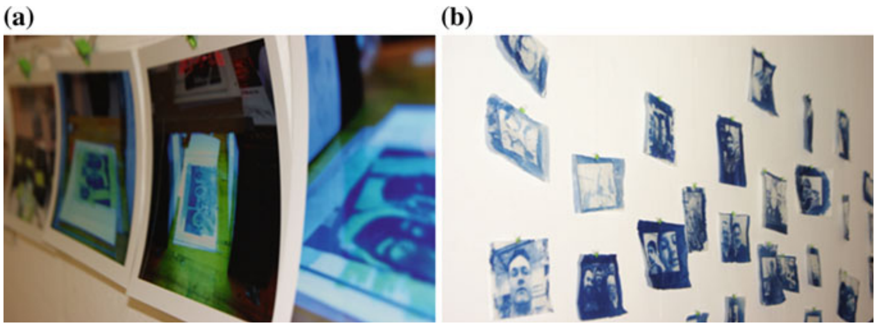

Fig. 5 Ursula Scherrer's and Flo Kaufmann's selfie-cyanotypes produced during a participative art performance in the Walle-Center and exhibited at the PS2 Gallery in Bremen

space. After that the pictures returned back to the shopping mall, where they were handed over to the local participants. By doing this, the art project created a sustainability effect for the people in Wale. The activity functioned as an interruption in the local's everyday life, motivating them to engage in public discussions on urban development—something most of the daily visitors of the mall would have never done before.

Another example of how participative art can lead to an altered perception of the own neighborhood is the *myMatrix* system. In *myMatrix* hundreds of pictures are fused to one bigger image. The pictures can be uploaded online and thereby involve citizens from all over the world. More and more different stakeholder groups in Bremen (e.g. refugees, children) will enlarge the Bremen-Matrix over the next months with pictures from urban photo tours. This game-based approach provides possibilities to discover new parts of the own city and meet new people.

The Salon Series With the Salon series "The Public Space as Shared Museum" creates temporary forums for open discussions with different expert groups, related to participation and urban development. For the first issue, the Salon A, well-respected regional artists, curators and cultural scientists came together to discuss the potential and the limitation of participative art. The Salon B focused on sound. The participants were local musicians, sound artists and sound designers. They discussed the influence of sound on our perception of the city space and the demands for smart sound design in urban development. To the third issue, the Salon C, educational experts and teachers were invited for a debate on participatory methods and techniques in schools and other learning environments. With the Salons, the project tries to install temporary think-tanks. The results of the Salons influence the design and the content of future activities in the PS2 sub-projects and in the best-practice study that will be produced at the end of the project.

7 Pop-Up and Drop-In Concepts Presented Virtually at Shared Museum

In addition to more classical urban spaces for showcasing artistic, engaging, interactive and innovative installations such as museums, science centers, hands-on museums, and new spaces are emerging. Some co-creative activities, e.g. flash mobs, can occupy any public space, from parks to shopping malls. However, designing innovative participatory and collaborative interactive spaces that enhance accessibility, inclusion and creative engagement amongst urban youth is a challenge. This is so, at least partially, because of what we call an access gap: it is difficult for researchers, designers and artists to gain access to urban youth cultures and participate on the premises of these cultures. At the same time, it is not easy to recruit youth in the framework of research projects, where participation happens under premises of the project. Thus, the design for public activities that involve youth needs to be addressed carefully, and at various levels of granularity.

This includes reflecting on what type of activities are designed for and with youth, how are the design explorations carried out, where are they carried out and which youth groups to include in ways that are relevant to them.

Two forms of such activity spaces for youth, that the Norwegian subproject of PS2, headed by Katie Coughlin, the leader of the Oslo Children's Museum, Sumit Pandey and Alma Culén, researchers from the University of Oslo have experimented with, are drop-in spaces (activity programs designed and hosted at some institution, e.g. hands-on children's museums); and pop-up spaces (workshops that simply pop-up in different neighborhoods or institutions and attract random bypassers locally). The main differentiator between the two is the element of surprise that pop-ups bring, as well as the duration of the activity, usually much shorter with pop-ups than drop-in events. In what follows, we provide some examples of both.

Pop-up Spaces Pop up spaces can be about gardens on parking lots, experiencing pop-up restaurants, singers, culture hacks and much more. Our focus is on engagement with technology. Little bits, a technological platform for aiding rapid prototyping and electronic tinkering for youth with little to no prior experience with electronics material in a workshop setting, were used to explore the construct of a "pop-up" maker-space for configuring creative participatory cultures. Pop-ups have been tried with diverse groups of youth, such as: (i) Children from the age group of 7–12 years; (ii) Children from 3 to 12 and their parents; (iii) Young professional graphic designers. The workshops also differed in terms of where they were organized.

The children pop-ups popped in libraries and culture houses, while graphic designers had the event in conjunction with a conference (Pandey and Srivastava 2016). Due to the differences in the age and nature of each group, the approach used to engage the participants in the workshop was different. However, the physical space in each case was temporarily converted into a maker space, with free and easy access to prototyping materials such as colored paper, card sheets, foam boards, paints, scissors, brushes, ice-cream sticks, rubber bands, cups, assorted Lego bricks and play-dough (see Fig. 6). Multiple littleBits workshop kits ("littleBits: electronic building blocks for creating inventions large and small") (LittleBits 2016) were used as the primary technological material for provoking electronic tinkering.

The quantity of each material differed, based on the theme of the workshop. This also helped evaluate the role and impact of supportive materials on the nature and form of engagement when used in conjunction with littleBits pop-ups. In the case of a "pop-up maker space", having a diverse set of electronic and non-electronic, reconfigurable, tangible materials is critical for engagement and involvement of participants.

The temporality (short duration) of these pop-up spaces leave little room for struggle with tools and materials—they need to be accessible and some level of creativity needs to be possible to accomplish for all participants. Typical output of these workshops for children was a sense of joy, mastery and accomplishment when they see their first remote controlled car, or some other gadget, move, vibrate or make sound (Fig. 7).

Fig. 6 The pop-up creativity workshop for children and their parents. It utilizes both electronic and non-electronic materials

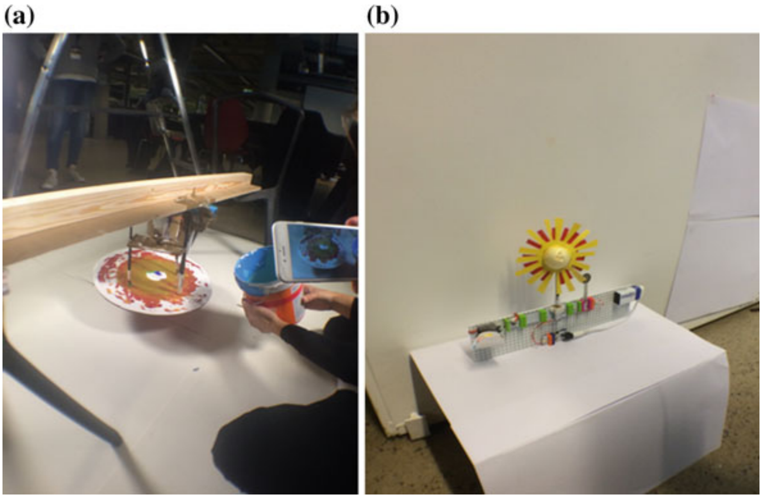

Fig. 7 The pop-up creativity workshop for graphic designers—creative out-comes is more complex and purpose-full

On the other hand, the outcomes (Fig. 7) that young creative professionals made were of more explorative nature, creative and complex, in tune with intention to explore this new digital fabrication material and its potential.

Drop-in Spaces Drop-in spaces, as we have implemented them, are a part of organized and advertised events. They are a separate entity at those events and their purpose is to motivate youth for further engagement in cultural and civic activities in their city. We have very recently designed such a space for engagement of youth and children aged 1–14 through Eco-A interactive installation that was a part of City Kids exhibit run by Oslo Children's museum (Culén et al. 2016) (Fig. 8). Eco-A consisted of three components. The first component of the installation aimed to create a shared information space (Bannon and Bødker 1997), related to diverse issues pertinent to climate changes; and presented at a level understandable for children. The second one took a critical approach, probing and questioning children's existing and future habits that impact the environment. The third component of Eco-A, inspired by design activism, aspired to engage youth and children in voicing their opinions on climate change and other environmental issues.

The shared information space (on the right in Fig. 8) was implemented as series of short, animated videos informing about climate changes and other environmental issues. A child could change the video using tangible interaction (a ball that when placed in different containers played different videos). The second part of the exhibit was designed as a series of small questions intended to trigger reflection. The questions were posed as in a quiz, a familiar format for children, but the purpose was not to test their knowledge or play. The questions were intended as an impetus to reflect over and discuss their own habits and those of their families. Example questions were: "Would you mind getting second-hand stuff as a Christmas gift?", "Would you be willing to buy less stuff in order to reduce climate changes?" or "Do you think that it is better to walk or cycle to school, rather than driving in a car?"

After watching the videos and spending time going through a sequence of speculative and critical questions, the children could sit down and write messages to policy makers, parents, or whoever they thought could be responsible for helping them to shape a better future for themselves. They could use ordinary paper and pencils, or they could talk into the bottle, recording their message (see Fig. 9). Bottles were then deposited in a deposit bin (see Fig. 9, on the right).

Drop-in spaces then have a capacity to engage in reflection and further action. They can, by design, make further connections to organizations, such as Miljøagentene (2016) in the case of Eco-A, artists or future events. As they can last longer, they also have a capacity to include and engage specific audiences.

Fig. 8 Interaction designers and artists setting up the Eco-A, before the opening of the event

Fig. 9 The "activist" part: write a bottle post, or say it into the bottle and deposit in the deposit bin!

Fig. 10 3D model of the central part of the City of Bitola

8 Four-Dimension (4D)—Virtual Urban Art

The goal of this PS2 sub-project is to create and use a system for increased citizen participation in the area of urban art, urban development and new ways of planning. Influenced by the socio-economical development, the urban centers experience constant change in their structure and often the people have minor influence in the decision-making process. People in the cities have many concerns and problems connected with their specific urban situation, but often limited opportunities to express their diversity of opinions and ideas. In the first phase of this sub-project, a group of artists and architects will be involved, and in the later stages all interested citizens will be integrated. To this purpose, the Foundation Gauss Institute from Bitola implements the technical and methodological solution and creates with artists a 3D model of the city of Bitola with input of the geo-referenced data for every object (type of object, historical background, law regulations, etc.) as well as a software platform for web-access (see Fig. 10). The users can suggest future

Fig. 11 Geo-referenced historical data

solutions for predetermined "Hot Spot" areas via the platform for collaborative arts ("Art Crowd Sourcing"), where people from different profiles can suggest innovative ideas and solutions for certain urban areas. All these solutions are open to the general public.

The 4D Virtual Urban Art is a solution based on a precise 3D model of the proposed urban environment, in which the users can explore and suggest changes of the areas they live in and upload their ideas to the online database. The decision-making process of urban art, urban development and planning is closely connected to the history of the selected areas and their cultural heritage value (see Fig. 11), but it is also influenced by plans for future development projects. The Institute and Museum Bitola will support the citizens with the historical information and the cultural value of match of the diverse interpretations and cultural expressions (see Fig. 12). Adding the dimension of time (3D + time = 4D), the users can explore their habitat and receive time-related information on certain objects or areas. For example, the user can "travel in time", and see historical data about the area of interest, which can be an inspiration plus for the suggested future solution.

In the promotional phase of the project, people are able to suggest ideas "on-site". In this way, the users can easily visualize the suggested solution with a broader view of the area concerned.

Fig. 12 Workshop with citizens explaining their visualized urban art ideas

9 Conclusions

The Public Urban Lab brought into contact with *urban re-design* people, who usually have no or only little contact with such a topic. The lab format was therefore the right choice to disseminate the goals of the PS2 sub-projects “Express Yourself/city” and “The Public Space as Shared Museum”. It proved that people desire non-formal forums to discuss and learn new ways of participation. It is easier for citizens to be creative and active when these forums are located at urban areas where change is the most necessary.

But it also showed that there are great differences in how younger and older people perceive the possibility to use digital tools as a channel to articulate their wishes towards urban development. The idea of using technology appears to be evident for older and younger people, but older people have higher burdens to actually use the digital tools whereas a majority of younger people doubt that digital tools can really influence decision makers. The future development of the tools should focus on how this age gap can be bridged.

Based on the two soundscape workshops, it can be argued that the soundscape approach is a viable participatory method both in museum and urban planning context. We have successfully designed and implemented a soundscape platform, which is transferable. With these sonic tools, we have been able to offer a digital method to bring one’s auditory experiences hearable and into common discussion. Based on the findings from the workshops with real users, we can state that the interaction with soundscape platform was well appreciated.

The Betaville system has effectively demonstrated that to mount and operate a radically open laboratory is meaningful for next steps towards the participatory designed smart city of the future, in which the full spectrum of developers, designers, stakeholders, representatives, citizens and agents can have direct access to one another *in the presence* of specific urban environment planning and design challenges. The next laboratory experiment must be to demonstrate that such an open urban lab can practically change the city by being operated for the several months it would take to fully address the re-design of the particular case of something like the Hochstrasse district, from the Rembertiring to the Bundeswehr Hochhaus in Bremen. Until then, Betaville's new generation of tools will develop as much as possible in its most appropriate test bed: the public realm itself.

The art activities conducted in "The Public Space as Shared Museum" proofed successfully that artistic interventions aiming at individual participation can be a very effective tool to increase civic engagement and identification with local urban spheres. But the efforts to really create sustainable effects are immense and depend on certain individuals. Certain cooperation will be therefore difficult to keep alive in case these people move away.

Concerning the Pop-In spaces, one can state that they are effectively lowering the threshold for participation, allowing safe, empowering experiences related to mastery and creativity. Their limitation is that they do not provide an entry point for further involvement and a handle to new events. The Drop-In spaces, on the other hand, can lead to sustainable further actions and future events. In conclusion, the Oslo sub-project will continue exploring possibilities that diverse activity spaces provide for building youth participatory cultures and deeper engagement in shaping the future of their urban environment.

The last chapter presented a time-machine. The 4D-Virtual Urban Art project showed that a digital tool can motivate people to take a deeper look in the history of their home. This form of nostalgia can be a good tool for the increase of participation and activism.

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Express Yourself/City—Smart Participation Culture Technologies

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Abstract This paper highlights the motivation for new participatory tools and methods in urban planning; and proposes optical tracking as a solution to improve Augmented Reality (AR) features in participatory urban planning software. Actual software and tools for smart-city-planning target only on the relevant administration staff, architects and other professionals. These systems create significant barriers for citizens' participation in the planning process as they were designed with the professional user in mind. Professionals are used to work with highly abstract data, while citizens and many creatives would require much more direct visualization. What are needed are smart interactive and visual tools like in-situ-mixed-reality, combining the real location with planning data. The Betaville system, a participatory platform for urban re-design, combines all these features and allows all people to engage in urban planning. The project "Express Yourself/city", a sub-project of "The People's Smart Sculpture PS2", works as a discussion forum, combining social and cultural demands for participation in urban development with new technical approaches. One goal of "Express Yourself/city" is to improve the

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usability of Betaville. To achieve that, the augmented reality feature needs to be redefined. The project "Markerless Adaptive Mobile Augmented Reality in Games MadMAGs" is dedicated to providing a solution based on optical tracking.

Keywords Participation · Smart cities urban planning · Mobile augmented reality · Optical tracking · Gamification

1 Smart Participation Culture

Today we live in a society where more and more people own a smartphone or a tablet device. According to the United States (US)-American Network Digital Trends the number of smartphone users is expected to reach over 6.1 billion by 2020 (Boxall 2015). Today's number is also impressive: as the Hamburg based company Statista has evaluated, the smartphone users worldwide will reach over 2 billion this year (Statista 2015). The predictions vary extremely but the trend is clear: smartphones will be the worldwide standard communication technology in the near future.

Alongside with the massive distribution comes a diversification of the devices. E.g. a wide variety of displays is available: these range from common off-the-shelve-devices like tablets and smartphones that can be employed in BYOD (bring your own device) fashion, over specialized devices [Samsung has the first augmented reality (AR)-glasses for smartphones on the market], head-mounted displays (HMD) to custom solutions like GeoScope and projection-systems on physical three-dimension (3D)-city-models. These options vary in their quality of visual augmentation, support for group activities in discussions of proposals and respective cost for hardware and content.

We also live in a world where networks and participation is increasing massively. Facebook alone had 1.591 billion users at the end of 2015. Other networks like snapchat are growing at high speed (over 350% in the last 8 months) (Statista 2016).

The consequence is that user culture and user habits are rapidly changing. Openness, transparency and participatory potential are key factors for today's citizens and their everyday life. That again has influence on a lot of social environments and decision-making processes that were accessible only for professionals before, but that have to open themselves for citizen-knowledge and non-professionals. One of these environments is smart city development. The success of every city development project now and in the future depends on how the changed user culture is addressed and used.

Keeping in mind that everybody has a smart device and interconnects with many things on several levels, one can state a grown interest in the topic of urban re-design. People are engaging at large numbers in urban gardening projects and other initiatives, trying to shape the urban environment. People come together in smaller and larger groups, online and offline, and talk about urban change and smart use strategies.

What happens is that with growing knowledge about city development, growing interaction and participation in urban processes, citizens develop a demand for creating knowledge and want to be asked and be part of the development of their urban surroundings.

What does that mean for the future of smart city projects? It means that these wishes and demands need to be picked up in their progression. Participation will keep growing. The number of smart devices will keep growing and people will always claim their right to be asked.

The "People's Smart Sculpture" (EU-PS2), a large scale Creative Europe co-funded project, addresses these issues. EU-PS2 raises questions about the design of smart city technologies; and creates surroundings where citizens and artists as well as professionals are enabled to create their urban visions by using these technologies. The background is that actual software and tools for smart city planning target only the relevant administration staff, architects and other professionals. These systems create significant barriers for citizens' participation in the planning process as they were designed with the professional user in mind. Professionals are used to work with highly abstract data, while citizens would require much more direct visualization. Best practices are smart in-situ Mixed Reality (MR), combining the real location with planning data.

The technologies tested and implemented in EU-PS2 show how smart participation in urban contexts is possible to be in use. Cities will become interactive corpuses through the new user culture, enabled by combining new technologies and social developments.

The remaining is organized as follows: the first two sections introduce the related work in context of urban development tools, MR and gamification. The fourth section presents the "Express Yourself/city" use case with the Betaville project at the Public Urban Lab Bremen, as part of the EU-PS2 project. In the fifth section, AR tracking will be explained and our AR framework will be introduced. The last section contains the conclusions and future steps.

2 Urban Development Tools

Urban development has been a widely discussed topic in a lot of scientific disciplines in recent years. Along with the digital revolution the field has opened up; once only a topic for architects and city planners it has become a favorite among social and cultural scientists, ecologists, computer scientists, and many more—they are all lining up together to interpret and shape the urban future. Modern approaches towards urban development bundle knowledge and know-how from different disciplines in theoretical or practical methods and technologies.

The reason for these broad, cross-disciplinary, activities in urban development is quite evident. We live in a rapidly transforming world. Urbanization is one future key challenge for humanity—quite as urgent as dealing with climatic change. According to the United Nations (UN) World Urbanization Prospects of 2014 "by 2050, 66% of the world's population is projected to be urban" (UN 2015). That creates great societal changes. A lot of theories on urban development discuss ideas on how we should adapt the design of our urban spaces to the increasing number of people living in cities.

Very often theories about urban development refer to the smart city term. Mostly smart cities are associated with smart technologies, i.e. technology developed during the digital age like social media, big data, robotics, cloud-computing, AR or of course new and more efficient mobile devices. But the large number of existing definitions involves more aspects. A simple but very powerful definition was given by Caragliu et al. (2009):

> We believe a city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.

This rough definition contains all relevant aspects discussed in current research (see Anthopoulos 2015). Although urban development should not be mixed up completely with the smart city debate, the mentioned characteristics feature certain aspects of particular interest for the conclusion of this paper:

- the human factor: smart cities cannot be realized without the smartness of humans;
- use of modern communication devices like smartphones and tablet devices;
- participatory strategies enabling to play a new role in urban development.

AR and MR applications, using novel interaction and visualization techniques, have high potential to provide attractive user experiences in smart city planning. A central challenge is the choice of an appropriate display technology. A wide variety of displays is available for the implementation of MR: tablets and smartphones, AR glasses, HMD, projection systems, or custom solutions like GeoScope. These options vary widely in the quality of the visual augmentation provided, the cost of the hardware, and their suitability for different usage settings.

While technical data such as resolution and cost are important for the selection, other aspects that are not easily established from data-sheets like ergonomics, comfort and reliability are essential for acceptance. We have gathered design experiences and user feedback from over 10 years of work with MR applications for smart city planning and public participation. Based on this, we provide a structured approach for the informed selection of MR displays that we use in our development activities.

Gamification is a fun way to engage people to solve real life problems. It picks up elements of games like goals, levels, bonuses, progression, challenges, status, statistics, rewards and many others; and applies them with a game design technique in a non-game context. Game design techniques involve the process of conceiving a game. To design a game you need to know your target group. Once you know your target group, you can design a suitable game for this, combining the elements of game. A gamer will spend time and energy in useful work and can simultaneously collaborate with other gamers to solve large-scale problems. Gamification can be applied in many domains, such as security, computer vision, adult content filtering, and Internet search. One such application is *Labelling of Random Images* on the Internet (Von Ahn 2006): On the Web, millions of images exist without any appropriate textual descriptions or classification. Describing the content of an image is quite complex, using computer vision algorithms. However, this problem can be solved using the above-mentioned game. It is played by two players at a time in which they cannot communicate with each other. The goal of this game is to guess what label the other player has given to a particular image. If the labels match, the players get points and the image can be labeled with the matching word.

3 AR for Smart Urban Development

The realization of a MR system requires some means of visually combining computer-generated graphics with the real physical environment. The three principal technologies to achieve this are: video-see-through, optical-see-through, and spatial projection. The choice of technology has important impacts on the design of the application, as some are not applicable in all application settings; and they differ significantly in the interaction modalities supported. More specifically:

- *Video-see-through systems* use a camera to capture a current live-view of the real-world environment. This video stream is then augmented with additional graphical information and displayed on a conventional display.
- *Optical-see-through systems* use an optical combiner, e.g. a semi-transparent mirror, to overlay computer graphics over the user's view of the real-world environment.
- *Spatial projection systems* use video- or laser-projectors to project the augmentation information directly onto the physical environment.

The choice of a display technology, and consequently of a specific display that implements it, influences important aspects of the resulting application. These factors include technical data like resolution, contrast and dynamic range; environmental aspects like waterproofing and ruggedness; ergonomic aspects like adjustability, balance and weight; usability and user experience aspects like utility, comfort and attractiveness. These factors must be considered early in the design process to make a suitable choice of display technology, since changing display technologies later on will require significant and costly redesign.

Over the last decade, we have developed a variety of MR systems for smart-cities, urban planning and architecture, addressing both the requirements of end-users and content creators. In this section, we present several display technologies that were used successfully in these projects; and discuss specific considerations that are relevant for designers.

Mobile Video-See-Through Devices: e.g. Smartphones and Tablets Smartphones and tablets can be used as video-see-through MR devices. Attractive properties for designers are the relatively low prices and the fact that many potential users already own a smartphone, which enables the implementation of BYOD scenarios, in which users use their own devices. Significant limitations are the small display size and frequent issues with tracking, since only the sensors already integrated into the device are available [usually global positioning system (GPS), camera and inertial sensors]. Smartphones and tablets can be used as a baseline, as they are currently the most frequently used platform.

Located Video-See-Through Devices: e.g. GeoScope Video see-through devices that are installed at a fixed location enable precise localization and the use of additional sensors. An example is the GeoScope (Paelke and Brenner 2007), a device that works similar to a telescope in a fixed location, where the user can adjust jaw and elevation angles by pointing the device at specific points of interest. The mechanical sensors that measure these angles, combined with the precisely known location, provide very precise tracking. Disadvantages are the limited flexibility caused by the fixed location; and the need for a custom designed and build device, including the need for making it robust or even vandalism proof if operated in public settings.

Mobile Optical-See-Through Devices: e.g. AR Glasses AR glasses using optical-see-through techniques like Epson's Moverio and Microsoft's HoloLens are used in a small, but increasing percentage of MR applications. A key advantage is that the user retains vision of the real environment in addition to the augmentations; and that glasses allow hands-free use. Central limitations of these devices are the relatively high costs, limited autonomy due to small batteries, and significant weight.

Projection Systems: e.g. Projection of Physical Models or Maps Projection systems can be used to provide augmentation on physical real-world environments (video mapping), on physical models (e.g. on 3D printed city models) or onto paper maps. While projections in outdoor settings are limited by the lack of mobility, the high setup cost, a small augmented area and issues caused by environmental light (e.g. video mapping on facades can usually only be used at night), indoor projections are a flexible technique that encourages collaboration as these can usually be viewed by many users at the same time. To provide a spatial reference for the viewers, white physical 3D models (which can be created by rapid prototyping techniques like 3D printing) can be used as the background, onto which the augmentation information is projected. Such setups are attractive but costly. A cheaper alternative is the use of paper maps as the projection background. However, some users are unfamiliar with relating maps to physical reality, making physical 3D models more useful for such clients.

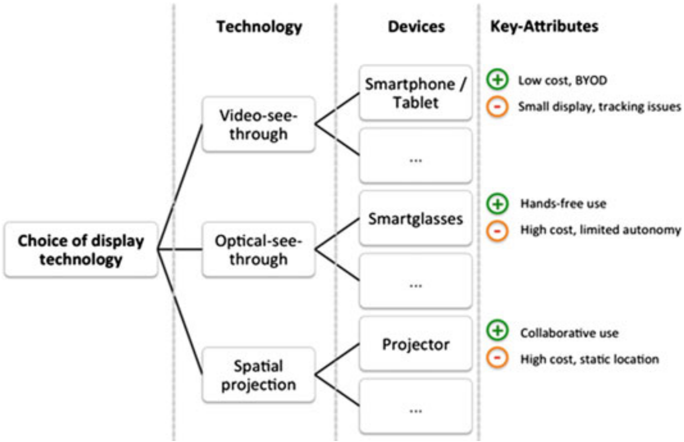

Fig. 1 Choice of appropriate display technology

The choice of a suitable display is an essential building block of a MR system. We have presented an overview of proven solutions from past projects (Fig. 1); and are continuing research and evaluation to extend our knowledge-base to optimize our selection process and provide consulting based on results. The work presented in the remainder of this paper relies on mobile video-see-through devices.

4 Express Yourself/City Use Cases

This section includes four parts. The first introduces the EU-PS2 project. Next, the Betaville system for participatory urban design is presented. The third part talks about the experimentation with the Betaville system in the Express Yourself/city context. Finally, the last subsection enumerates the Betaville outcomes and shows the measures taken in order to enhance the Betaville platform.

4.1 The EU-PS2 Project

"Express Yourself/city" is a sub-project of EU-PS2[1] that is a creative research and innovation project about the design of methodologies and tools for the participative cultural evolution of urban spaces in Europe. The approach blends different levels of access: public participation, collaborative creativity, exploratory and game-based

[1]The EU-PS2, co-funded by the Creative Europe Program of the European Commission (EU-PS2 2016).

learning. It consists of 12 project partners in 11 sub-projects in 8 European countries involving citizens, artists and creatives from 29 European countries. The approach works on two levels: the implementation of cultural participation projects by researchers, artists, creatives on the one hand; and the ongoing optimization of the participation aspects in these projects through reflection and evaluation in a series of participation workshops in the 8 countries. Thereby EU-PS2 integrates diverse groups of people into a practical dimension of re-design of the urban environment, all working together towards realizing the vision of a hybrid open environment where everybody can follow—even change—the ideas concerning collaborative re-design and development of urban art (Koplin 2014). The project is also the base for a new deal between artists, experts, citizens, learners, creators and the government. It is a performative sort of integrated art to combine social and cultural sustainability in the city (Koplin et al. 2016).

Innovative technologies and tools are key to realize the project's visions. That is why in a lot of sub-projects new technologies are developed and tested. Within the sub-project "Express Yourself/city", the aim is to use digital media and gamification experimentally in participatory urban development. In art projects, workshops and public urban labs, 3D objects are to be placed on sites that are critical for the urban development of the city of Bremen. These 3D objects illustrate new ideas and alternative suggestions for the development possibilities of places and re-design of town virtually. The activities in Bremen include a series of creative and artistic interventions as participation actions in different parts of the town and also social art and experimental, informal learning activities. "Express Yourself/city" addresses and profits from the fast growing percentage of people already making use of pads, tablets and smartphones; and invites all citizens to participate in attending, responding and modifying these sculptures at the real spaces in the city of Bremen. One of the technologies used to achieve that is the *participatory platform Betaville*.

4.2 Betaville

Every city is "in beta", every city is incomplete and under on-going development. For the development of a livable city, the citizens' demands, potential interests of authorities, and technical restrictions should be taken into consideration. This requires the active participation of different parties, such as a city's residents, experts and potential investors in the urban development and decision-making process. Starting out from this premise, the Betaville project at M2C (Institute of Applied Media Technology and Culture Bremen), the City University of Applied Sciences Bremen, the Gotham Innovation Greenhouse New York and the BXMC (Brooklyn Experimental Media Center) of New York University aim at providing online collaboration platforms in the field of urban development (Koplin and Skelton 2012).

Urban development *projects* in Betaville are represented by an *area* in the real world that is defined by a center *coordinate* and a number of GPS *coordinates*

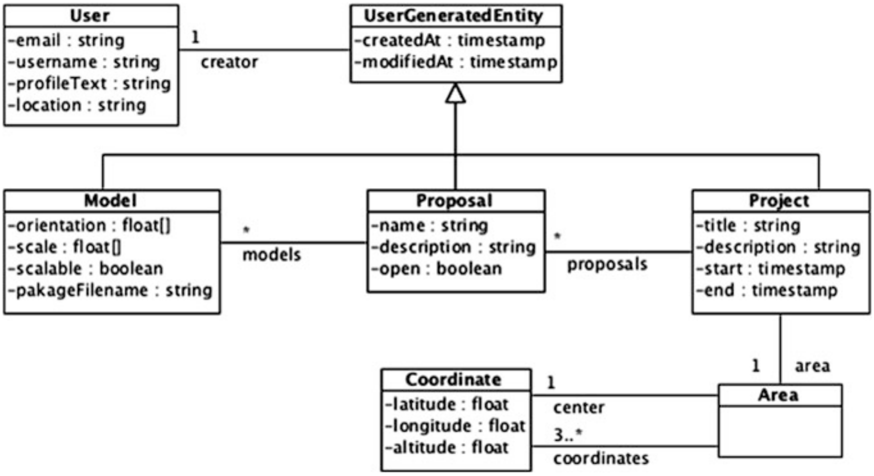

Fig. 2 Class diagram of Betaville data model

bounding this center. Each *project* can be associated with *proposals*, where a proposal constitutes a suggestion for urban development within the regarded area. Proposals form a hierarchy with the first published proposal at the root and alternative suggestions (e.g. modifications to a proposal) as its descendants. The actual urban development suggestion is expressed using a textual description and a set of 3D *models* of e.g. buildings, lakes or trees that a proposal can be associated with. Since projects, proposals, and models are user-generated entities, each of them has a *user* as its creator–a city's engaged citizen. The class diagram in Fig. 2 illustrates a simplified view of the Betaville data model.

The Betaville platform comprises two mobile clients (smartphone and tablet), a multi-touch table and a web client, which are connected to a server that serves the data storage and exchange of project and proposal data via a representational state transfer—application program interface (REST-API) (Fig. 3).

Using state-of-the-art technologies, every member of the community has the chance to participate in a city's on-going development projects online, e.g. by proposing new ideas in the shape of 3D models, by refining and extending already published proposals or by commenting on them. The process of repeatedly voting for one out of two proposals suggested by the system makes it possible to include the users' opinions in the selection process of the most popular proposal, which represents the voice of the community. This gamification feature can help to increase the participation of people by making Betaville more fun and enjoyable (ISEA 2011).

The mobile client is implemented as an Android app for smartphones and tablets. The mobile client leverages its mobility and location-awareness features: using the camera, GPS and compass that are built-in in the current generation of mobile phones and tablets, its AR mode provides the user with impressions of development

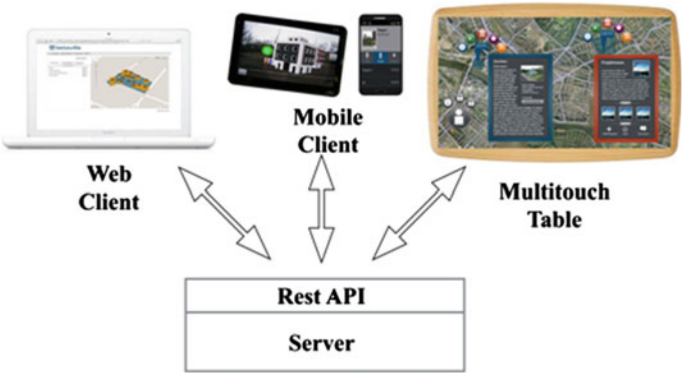

Fig. 3 Betaville platform overview

proposals right on the spot. Figure 4 presents an arts' installation, created during an event within the EU-PS2 project.

In AR mode, the mobile client shows its true potential: users may experience the different proposals of a project in the real world at their designated location. The impressions collected by the user in this situation may stimulate further user activities, such as engaging in discussions, voting for or against a proposal or designing a new proposal. The mobile client also contains a map view, enabling the user to browse through all projects in the system; and locate them on a map.

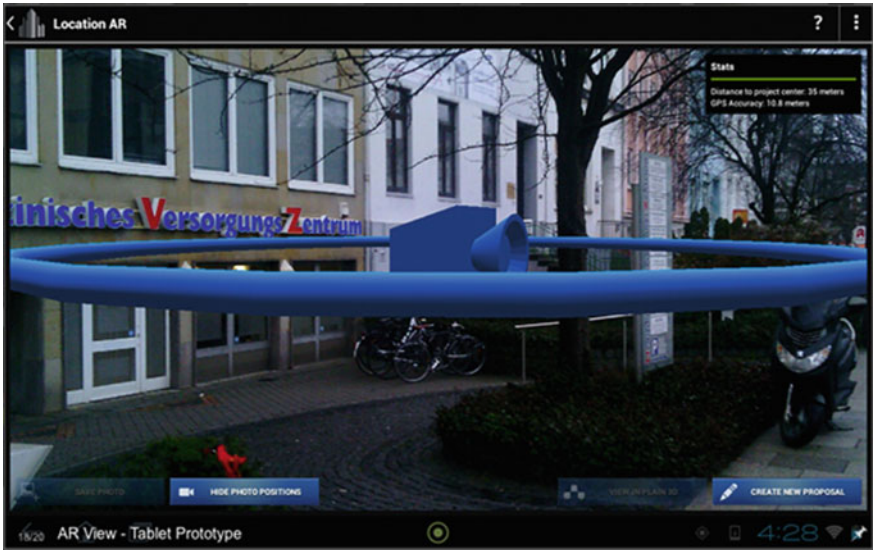

Fig. 4 Arts installation in AR view on Betaville tablet client

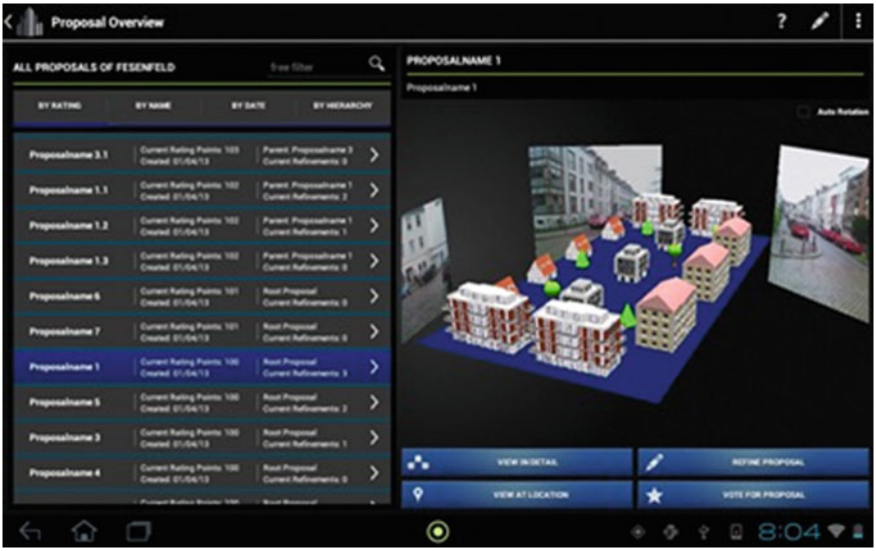

Fig. 5 Betaville tablet client of City University of Applied Sciences Bremen

In off-site mode, when the AR feature is not available, the mobile clients offer an interactive 3D view of proposals, where photographs of the surroundings are used instead of reality. As a result, users are still able to get an impression of a proposal within its designated environment. Moreover, they are able to interact with the 3D view, i.e. to apply transformations such as rotation or scaling, and hence look at a proposal from different perspectives. The right-hand side of Fig. 5 illustrates this feature, while the left-hand side shows a list of proposals in the browse view.

The main purpose of the multi-touch application in Betaville is to support the collaboration of multiple users in the urban development and decision-making process. Due to the large screen of a multi-touch table, people are able to work simultaneously on such a system (Fig. 6). Hence, the application offers a possibility to a group of people to browse, compare, discuss and vote for urban proposals together.

The web client serves as the central point for project and user management in the Betaville system. Moreover, the web client offers functionalities for more advanced tasks (than those provided on the clients), which can be performed from a desktop computer. Since the web client is available on the internet, it can be linked to activities in social networks or other public announcements, and therefore also serves as a reference point for getting new users interested into the system.

The Betaville server architecture supports reusable components and is extendable for future additions, due to the use of many features of the Spring Framework (Spring 2016). The most integrated Inversion of Control (IoC) and Dependency Injection (DI) in the Betaville server implementation, authorization is based on Uniform Resource Locators (URL); and a custom user-authentication is provided,

Fig. 6 Team work at Betaville multi-touch table

which interacts with the Spring security framework. The Betaville server provides web services, which can be consumed from the mobile and multi-touch clients through a JavaScript object notation (JSON)-based hypertext transfer protocol - application program interface (HTTP-API). In order to achieve this, the web service layer is implemented, using the Spring model-view-controller (MVC) framework. The server manages the data generated and consumed by the aforementioned clients. Further information about the Betaville project can be found on the project's website (Betaville 2016).

4.3 Betaville and Express Yourself/City

Betaville was tested and evaluated during a one-week Public Urban Lab in Bremen in June 2016. Therefore, an overseas container with a digital media lab was positioned at a prominent place in the Bremen urban space, in front of the main station. Artists, scientists, students, teachers, and professionals started a dialogue with citizens and creatives on the topic of urban participation. They presented Betaville within the public, stimulated the use of the different clients and collected valuable feedback for future working steps.

At the public urban lab, citizens, artists and professionals had been also able to learn and discuss technologies developed in other EU-PS2 sub-projects, like apps and tools that can inspire and motivate people to become active participants in the smart city shaping processes. This also can help to find new approaches to enhance Betaville and, more importantly, to define strategies towards smart participation methods and the design of participatory tools and technologies in smart city planning. The Public Urban Lab Bremen therefore works as an empowerment or at least awareness-raising machine for the topics discussed in this paper among the Bremen population.

In EU-PS2, Betaville is of significant importance in the sub-project “Express Yourself/city”. In this sub-project, the platform is used for creative design and learning experiences. Betaville supports the aim of “Express Yourself/city”, which is to create and experiment with new digital media and gamification in participatory urban development. Students, artists and other stakeholders will use Betaville in art projects, workshops and Open Labs to place 3D objects on sites that are critical for the urban development of the city of Bremen; and would strongly prefer smart tools instead of town hall meetings. 3D objects illustrate new ideas and alternative proposals for the development possibilities of places; and support re-design of the town virtually. Citizens, artists and creatives shape 3D objects, modify and comment them, and create alternative visions for the development of the critical areas. Figure 7 shows the user interaction with the tablet clients during the art event *Rememberti* on urban change in Bremen in September 2015. The event created about a dozen of new visions for an urban area that has been subject to controversial debates over the last decades.

An important reason why Betaville can serve as an ideal tool to create educational effects in the EU-PS2 project is that it allows access for everyone from everywhere, which helps to reach a huge number of participants for the events. Users can profit from Betaville because it combines several advanced mobile smart city learning concepts, including AR, integration of mobile and social media channels and mobile tagging in a single platform approach. As Buchen and Pérez-Sanagustín (2013) have pointed out, the concept of smart cities goes far beyond technologies and technological infrastructures. For them smart cities need:

> Locally and globally interconnected citizens who use smart technologies to learn by using, sharing, remixing and co-constructing learning resources, and in this way actively contribute to solving societal, environmental, political and economic challenges.

(a) (b)

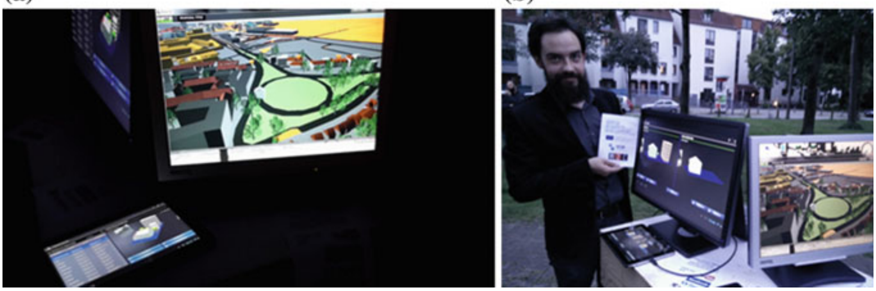

Fig. 7 Experimenting with the Betaville clients at the art event Rememberti

The design of Betaville contains all of these prepositions, especially because it puts the "*Smart Citizen*" in the central role on the way to Smart Cities. With its application in the EU-PS2 project, it perfectly serves the main characteristics of Smart City Learning scenarios as Buchen and Pérez-Sanagustín (2013) see them.

4.4 Directions

The experiences of the users in the workshops and events will directly influence the further development of the web client, which is also part of EU-PS2, and of the Betaville platform in general. Among the strengths of the Betaville system are: the in situ experience; the fact that it can activate a wide range of people usually not interested in participating in the processes of urban development; and the assembling of public opinions, prior to the actual planning action in an urban area. The Betaville web and mobile clients, however, show two major *shortcomings*:

- Users' possibilities to actually create 3D models and hence the personal design possibilities are very limited. Due to these limitations and the fact that 3D manipulation functionality might also be required on the web client, a next logical step in the development of Betaville could be the re-design of its client-technologies, based on hypertext markup language 5 (HTML5). Since HTML5 contains web graphics library (WebGL) to display real-time 3D graphics and works with different operating systems and browsers, it might be the technology of choice for client-independent 3D rendering and manipulation.
- Betaville uses location-based data, provided by a mobile device's GPS sensor to place the 3D models in the desired area. The delivered location data, however, show a tolerance of ±5 m, which is unacceptable for a convincing AR experience. To make the visualization more accurate, we propose the use of optical AR, tracking along with location-based AR tracking.

Our approach for marker-less optical tracking is described in the following section.

5 Work in Progress: A Configurable Solution for Mobile AR

In the following two sections, tracking is presented as one of the key challenges for developing an AR system (Azuma et al. 2001); and the "Marker-less Adaptive Mobile AR in Games" (MadMAGs) framework for configurable mobile AR solutions is introduced.

5.1 Tracking in AR

Tracking means to determine the pose of an object, i.e. its position and orientation with respect to some coordinate system in real time. Zhou et al. (2008) categorized the AR tracking techniques in sensor-based and hybrid tracking techniques.

As the name suggests, sensor-based tracking uses several types of sensors. Tracking can be based on a variety of sensors (Welch and Foxlin 2002; Lane et al. 2010) like camera, magnetometer for measuring the magnetic field (compass), gyroscope for measuring rotation, accelerometer for measuring translation, and finally the GPS sensor. These sensors provide us with information about reality, like position and motion. All these information can be used in a tracking method to recognize objects around us; and to estimate their position relative to us.

Vision-based tracking techniques are a part of sensor-based tracking, which use image information to track the position and orientation of a camera (Yang et al. 2008). There are two approaches for vision-based tracking: marker-based and marker-less. Marker-based tracking on the one hand uses a marker, which typically is a black and white 2-dimensional texture and has specific properties that make it easy to identify their position in the real world. Marker-less tracking, on the other hand, does not use any specific marker or references, but relies on an object's innate (visual) features; knowledge of these features can be used for tracking in an unprepared environment.

While each sensor comes with its inaccuracies, hybrid-tracking techniques combine various sensor data into a merged data stream in order to enhance the quality of tracking data (Azuma et al. 1998). However, hybrid technologies increase the complexity of the tracking process (Rolland et al. 2001).

Tracking still remains a major challenge for AR applications. It has to be as precise, accurate and robust as possible in order to create the illusion that the virtual content is a part of the real world (Azuma 1997). An accurate tracking system is required for AR systems because even a small tracking error may cause a noticeable misalignment between virtual and real objects (Wang and Dunston 2007). (Visual) tracking has been the most popular research area in AR (Zhou et al. 2008). The following section exhibits the necessity of computational framework in AR system and MadMAGs Framework will be presented.

5.2 Marker-Less Adaptive Mobile AR in Games

Besides tracking, registration, i.e. the process of aligning a virtual object in the real environment, and interaction, Höllerer and Feiner (2004) mention three more requirements for a mobile AR system:

- computational framework;
- wireless networking;
- data storage and access technology.

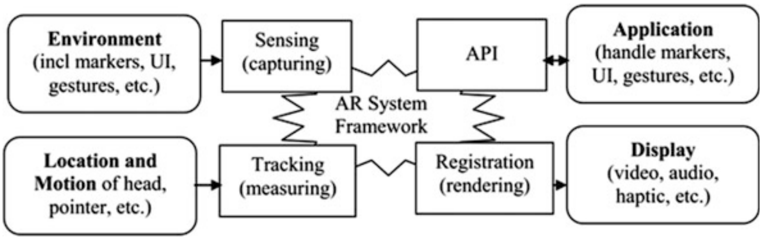

Fig. 8 Typical AR system framework tasks. Reproduced from Van Krevelen and Poelman (2010)

AR systems have to perform some typical tasks like tracking, sensing, display and interaction as shown in Fig. 8 (Van Krevelen and Poelman 2010). A computational framework can generate and manage the virtual material to be layered on top of the physical environment, process the tracker information and control the AR display (Höllerer and Feiner 2004). There are two kinds of framework architectures in AR systems: autonomous and distributed (Lopez et al. 2010). In autonomous frameworks, the components run in the same physical environment; whereas the components in distributed frameworks are located in networked computers.

A modular architecture is the way to design AR tracking algorithms in a flexible manner. Frameworks are desirable that allows to flexibly exchanging these principle steps of tracking to allow feedback loops and additional processing steps. The framework's components can be combined with each other to assemble new configurable algorithms. Different settings such as indoor or outdoor and domains from architecture visualization to mobile gaming or machines maintenance pose different requirements for mobile AR (Skelton et al. 2011).

The focus of the MadMAGs project is to design and implement a mobile, platform independent and flexible framework, promoting the development and (re-) combination of innovative algorithms in the fields of image processing and computer vision in mobile AR applications. At the core of the targeted AR framework, we identified the needs to be able to process streams of (image) data on the one hand; and to represent a tracking and registration solution as a configurable network of algorithms on the other. Such a network can be illustrated by directed graph composed of:

- exchangeable *processing nodes* implementing independent and concurrent algorithms; and
- dedicated *coordination nodes* taking care of the synchronized transmission of data between processing nodes.

On top of these fundamental requirements, we have to cover additional functional requirements, such as integrating sensor data from various sources (e.g. camera, gyroscope, GPS) as a means of enhancing (optical) tracking quality, augmenting a scene by overlaying virtual objects on the camera image, and facilitating interaction both with the virtual camera and virtual objects. Moreover, non-functional requirements like extensibility and performance are key factors to the success of the aspired solution.

The software architecture is based on the Pipes and Filters style (Buschmann et al. 1996), where processing nodes are represented as filters and coordination nodes as pipes. A network of pipes and filters is then referred to as pipeline. To prove that the proposed software architecture meets the defined requirements, a first prototype is implemented and run in a desktop environment. A pipeline configuration gives first evidence regarding the platform's flexibility and performance: the pipeline processes a camera's images, extracts features, and tracks these features in consecutive frames using the optical flow algorithm, thus generating a list of movement vectors (red arrows in Fig. 9). These movement vectors serve to update the camera's position and orientation within the 3D coordinate system, and hence the display of the scene.

6 Conclusions and Future Work

The current work shows that participation in the urban and smart city context relies on the implementation and use of new smart tools and technologies that support the interaction of people by making their visions for future city developments visible

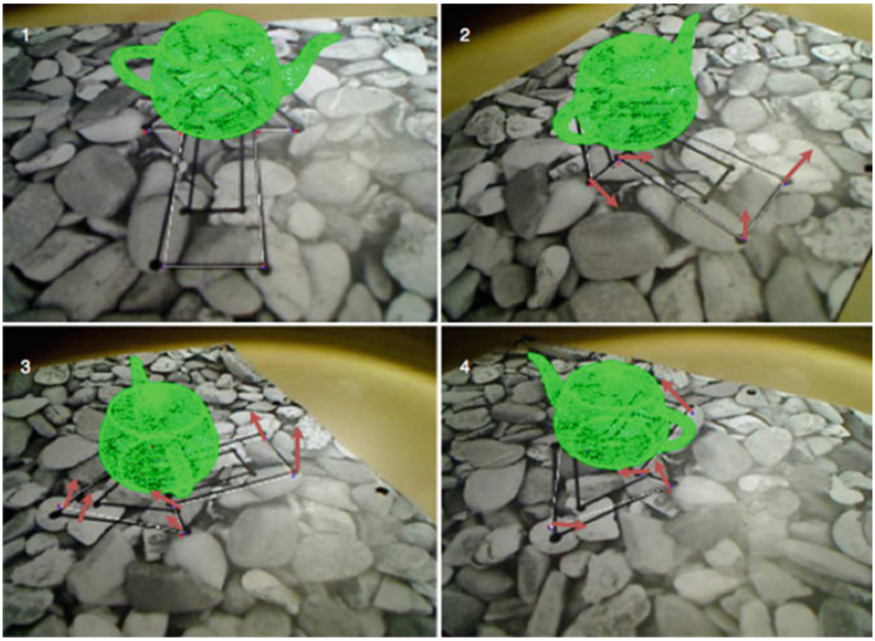

Fig. 9 3D tracking based on optical flow using the MadMAGs framework. Reproduced from Pooya (2016) (Color figure online)

e.g. with AR features and by combining it with entertaining and motivating interactive aspects of gamification.

The paper lined out that the EU-PS2 project serves as an ideal surrounding for innovation, testing and improving participative tools for urban development. The "Express Yourself/city" sub-project provides a perfect use case for the application of the Betaville system and MadMAGs technologies. Betaville enables people to step into the processes of urban planning—something non-professionals usually have no or very limited access to.

It has been shown that the Betaville feature with the biggest participatory potential is the in-situ experience achieved through AR presentation of urban development proposals. Currently, this feature is not working to its full extent due to the inherent inaccuracies of GPS-based positioning of 3D objects.

The MadMAGs project aims to provide a solution to this issue by using innovative 3D optical tracking methods. Optical tracking is often used in AR to attach virtual objects, like prospective architecture to the camera image of a site seen through a mobile device. The advantage of optical tracking is that it reacts much faster and more accurate to changes in position and orientation, compared to gyroscope and GPS sensor data.

The next step in the development process will be to integrate the optical tracking results of MadMAGs as well as further gamification features into the Betaville system and to implement the revised Betaville in future use case scenario of EU-PS2 to enhance participation of people and creatives to design and develop the citizens-friendly European city of the future.

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Smart and Sustainable: Lessons from Fogo Island

Mark I. Wilson

Abstract Globalization and centralization of economic activity are increasingly challenging the viability of many communities distant from the world's economic centers. One category of places that encounters economic challenges is islands, because they face higher costs and have long served on the periphery of the economy. One example of community and non profit action used for social and economic change is Fogo Island, a small island located off the coast of Newfoundland, with a unique approach to local development led by the Shorefast Foundation. Fogo Island is an excellent example of innovative policy, community action, and sustainable practice that informs planning for islands in general. Using a tourism and culture based model that features sustainability and heritage preservation, Fogo Island serves as a valuable example of ways to harness community assets and motivation for regional development.

Keywords Fogo Island · Island territories · Isolation · Development · Adaptation · Creativity

1 Introduction

Globalization and centralization of economic activity are increasingly challenging the viability of many communities distant from the world's economic centers. Many regions and cities face problems because of their location and proximity to the economic mainstream, and face the distress of being bypassed by globalization so that the predominant economic benefits are not captured. One category of places that encounter economic challenges is *islands*, because they face higher costs and have long served on the periphery of the economy. Islands also confront the threats to future prosperity of climate change and rising sea levels (Attzs 2009).

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In addition, changes in resource management, especially for agriculture and fishing, means that islands often lack the scale of activity needed to compete globally. In the challenges they face, however, some islands are able to maintain *identity*, sustain *heritage* and provide an economic foundation for their residents. These islands merit our attention as models of *adaptation and creativity*.

Many communities are experiencing the continued impact of their peripheral location along with declining resource economies (Stratigea and Katsoni 2015). While often disadvantaged by location and history, islands can be resourceful to overcome some of their disadvantages through innovative and creative planning and management. As Baldacchino (2006: 98) noted:

> Small islands may be looked upon as political innovators of the information age, testing out the limits of possibility which insularity, small size, location, and a measure of administrative autonomy may offer … though not without the threat that big cities may cheat them of their prized political capacities.

Islands have long faced challenges based on their location and economic foundation. Adrianto and Matsuda (2004) point to the vulnerabilities of these places affecting their well-being and quality of life.

In their study, Postira, Tonkovic and Zlatar (2014) sought to assess four elements of *sustainable islands*—economic, ecological, social and cultural—and recommend policies that are tailored to each island or location in concert with local communities. Mackelworth and Caric (2010) added elements of spiritual, political and health factors in their analysis of Croatian islands and introduced the role of *gate-keeper* to understanding how decisions were made on islands. Of note, they encourage engagement with gate-keepers early in any process of development or change as a way to leverage existing social capital to achieve community goals.

Islands can face intense competition from nearby communities offering similar services and amenities, although offering unique local experiences can provide an advantage sought by tourists eager to find new experiences (López-Guzmán et al. 2011). Tourism can also be used to help environmental problems, as shown by the Greek island of Samothraki, which considered United Nations Educational, Scientific, and Cultural Organization (UNESCO) biosphere designation as a way of remaking itself and a different tourist destination; while also solving problems of overgrazing on the island (Fischer-Kowalski et al. 2011). The tension between environment and development is often portrayed as competitive, although Teelucksingh and Watson (2013) note that often these two factors are co-dependent and that development needs to recognize this relationship, or changes to one will affect the other. Similarly, a rural region of Jamaica sought a tourism solution to its economic problems, but in so doing recognized the importance of identifying goals of any development plans (Nicely and Palakurthi 2012). Often, islands seek economic support from tourism, but development can also harm the ecological and cultural foundations of the island community (Bucar and Renko 2008).

In serving the interests of islands, it is valuable to consider successful cases of land use, technology, promotion and sustainability on islands that can inform policy elsewhere. In addressing island social and economic viability, a *social dynamics* *approach* is adopted (Xing and Dangerfield 2011: 1750) that sees island tourism "as a network of integrated systems, including demographic, cultural, economic and energy". Such an approach is a good application to Fogo Island, as it has evolved to form networks that serve a wide range of purposes. This case study of Fogo Island offers examples of the importance of an innovative mindset, the needs for a champion, and the ability to harness the advantages of new technologies and interests.

2 Background

Fogo Island is an excellent example of innovative policy, community action, and sustainable practice that informs planning for islands in general. Fogo Island is about 25 km long and 14 km wide, with a total area of 237 square km and a population of approximately 2700 people, down from 5000 residents in the 1960s. The island lies off the coast of Newfoundland, a Canadian Province in the Atlantic Ocean (Fig. 1). The island has a long history of fishing, but also one of economic distress as the fishing industry failed to thrive or support the island's residents. In the 1960s about 60% of the island's population needed government assistance. At that time, residents were encouraged to leave and resettle in larger settlements on Newfoundland, but even with financial assistance many were reluctant to leave and fought the relocation policy (Corey et al. 2014).

An early indication of the strength and community orientation of the residents was their opposition to relocation, and participation in a community development initiative around recording their experiences. The Fogo Process that emerged from the audio and film project of the National Film Board of Canada coalesced the island residents around community issues along with a desire to preserve their heritage (Williamson 1989). The project encouraged residents to record their experiences, and in the process of capturing their heritage they laid the foundation for their future. The act of capturing the Fogo communities on film and video led to interaction and organization, and reinforced community identity. This meant that a byproduct of the film initiative was the strength, identity and organization needed for the community to influence their future; the Fogo Process helped build the social capital needed for social action and regional development (Clarke 2012).

The future faced by Fogo Island continued to be challenging as fishing declined as a major source of income. The 1960s saw the development of co-operatives and a strong island identity that served the residents through difficult times, including the 1992 moratorium on cod fishing, the mainstay of the Fogo economy. Among ongoing problems is reliance on an unreliable ferry service for the 45 min trip to Newfoundland, and once there it is several hours driving for medical care and major shopping centers (Lak 2014). The aging population has roots to the island that many do not want to leave, but the lack of opportunity and work, especially for young people, means that there are strong economic incentives to leave. At the same time, declining fortunes make it difficult for residents to sell property to fund

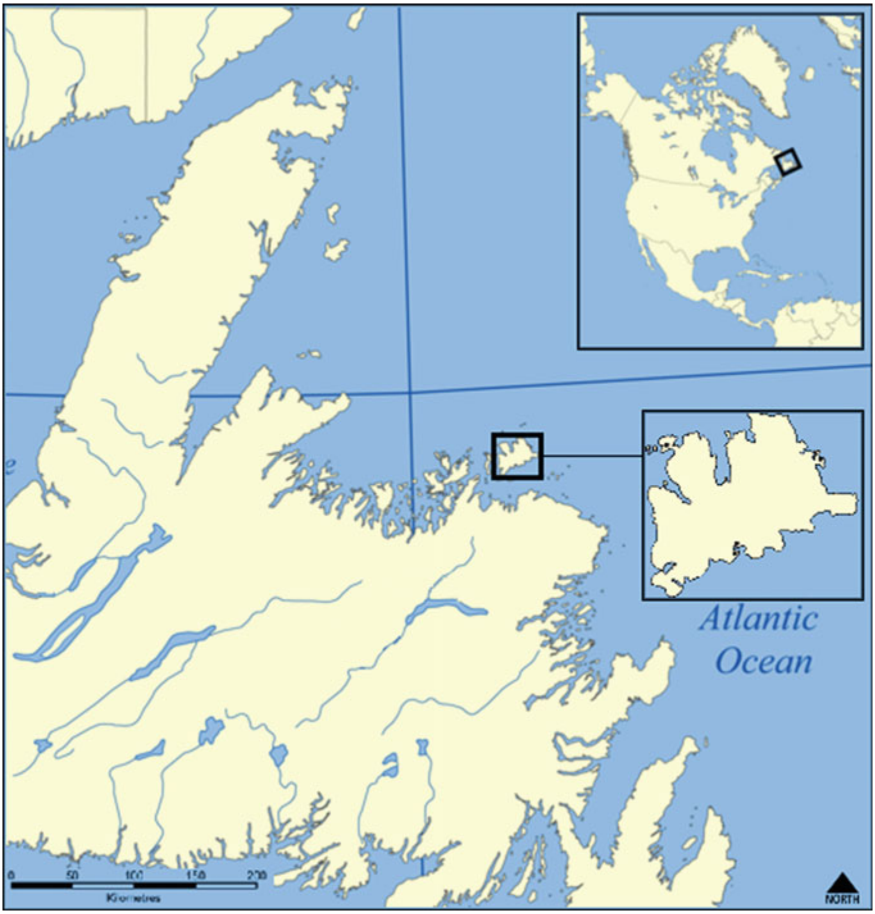

Fig. 1 Location of Fogo Island. Source: Map created by Deeyuso and published without changes under a Creatice Commons license: https://commons.wikimedia.org/wiki/File:Fogo_Island_(Canada).png

relocation, even with provincial support. From this background emerged an *innovative community* and nonprofit organization approach to island development led by the Shorefast Foundation.

3 The Shorefast Foundation

A common response to community need is the use of nonprofit action. Nonprofit organizations often allow the provision of goods and services when the private market and government are unable, or unwilling, to respond (Weisbrod 1991;

Mauldin 2013). Fogo Island faced such a problem, and used the nonprofit form as a way to establish an institution to serve as a vehicle for change. The Shorefast Foundation was founded by Zita Cobb and her brothers in 2003 to respond to the many needs of Fogo Island. Ms Cobb grew up on Fogo Island and left to find success as a technology entrepreneur, but then returned to the island to provide sustainable economic opportunities.

The name of the foundation, Shorefast, also reflects local tradition as it is the name of a cable that anchors fishing traps in the ocean to the shore, essentially a metaphor for connecting community to place (Corey et al. 2014). The mission of the organization combines business, community and sustainability forces to promote change. As the Foundation explains (Shorefast Foundation 2016):

> We use business minded ways to achieve social ends.… We use a new model for economic and cultural resilience that may hold learnings for small communities everywhere. Our model is based on social engagement, strategic investment in community capital, and inclusive local economies.

At the core of the Shorefast Foundation's work was recognition that the community needed to recognize its assets and to work with what they had. The island's assets included an attractive landscape, vernacular architecture, established traditions of culture, crafts and farming, and an interest in sustainability. The experience and legacy of the Fogo Process also meant that community collaboration and action were familiar responses to problem solving and decision-making. In addition, Fogo Island's leaders recognized the importance of technology in linking the island to the greater economy, reinforcing Baldacchino's (2006) recognition of relative location in the internet age. These assets and mindset served a growing global interest in tourism for new, sustainable and authentic places (Stratigea and Katsoni 2015). The term adopted for this concept was *geotourism*, first popularized by the National Geographic Society, and adapted by the Shorefast Foundation for their needs (Shorefast Foundation 2016):

> We believe that these geographically and culturally unique islands are extremely well suited to visitors wanting to experience this. We plan to add the necessary infrastructure to catalyze this industry on Fogo Island and Change Islands and to do so in a manner that engages the local people as masters of their own destinies.

The Shorefast Foundation bases its decisions and actions on three driving principals of social entrepreneurship (Shorefast Foundation 2016):

- There is inherent, irreplaceable value in place itself and that the key to sustainability lies in nurturing the specificity of place; in the intellectual heritage and cultural wisdom, talent, knowledge and abundance that exists naturally in each place.
- That with an initial investment, viable enterprises and businesses can be developed so that the surpluses from these businesses (social enterprises) contribute to the resilience and economic wellbeing of the community.

- That art is a way of knowing, of belonging, of questioning, of innovating. It is a way of participating in a global conversation and a way of making sense of the world. As such, it has the potential to contribute to positive social change.

These principles are derived from the unique conditions on Fogo Island, but they also apply, with some adaptation, to many islands in the world that face similar problems (isolation, declining economic opportunities, population loss) yet have similar assets (heritage and culture, artistic traditions, geotourism potential). Islands in the Mediterranean, Caribbean and Pacific and Indian Oceans *share challenges* with Fogo Island. The question is whether conditions and actors in these areas can affect change.

The Shorefast Foundation provides the institutional setting for action and development, and is also able to harness the existing capacity of island residents for change. The philosophy promoted by the Foundation was not imposed on the residents, but reflected their interests and goals. In fact, the use of surpluses generated by Foundation activities is determined by the community, which sets priorities for new investments. In this way, the essence of leadership was to recognize the assets and capacity of Fogo Island and its residents; and to channel that energy into productive strategies. It is important to note that this approach is not common to all community development organizations; and that a top-down message that ignores local capacity is likely to fail (Helmig et al. 2014).

4 Fogo Island Development Strategies

The approach of the Shorefast Foundation focuses on a number of elements firmly based in Fogo Island history and culture, with the Foundation providing finance, advice and leadership. The first element was to implement a *geotourism strategy* that included the establishment of the Fogo Island Inn, a dramatically modern hotel with 29 rooms that opened in 2013. In addition to providing a place to stay, the Inn also was built, and operates, on green design principles and ethical sourcing. As well as serving as a hotel, the Inn also exemplifies the geotourism philosophy through its operations, food sources etc.

The management of the Fogo Island Inn and the Shorefast Foundation also show the astute use of new technology as a way to promote the island, using the internet, social media as well as traditional media outlets. The dramatic architecture, unique island characteristics and features, and emphasis on arts and culture fed the highly effective marketing strategy of the island. From its launch, the Foundation and Inn have used media to promote its message, with regular mentions and features in *The New York Times*, *Boston Globe*, *Washington Post*, *Financial Times*, *Newsweek* etc. as well as the leading travel and lifestyle magazines.

The Inn attracts tourists to an area that is difficult to reach by offering pristine environments, engagement with the landscape and local culture. The Inn served local crafts production by creating a market for furniture and artwork that was then extended through online sales globally. The food served in the Inn is locally and sustainably sourced, and features traditional recipes that reflect the heritage of the island.

The Fogo Island Arts Program has several elements. It constructed four artists' studios using contemporary architecture and located across the island, which drew media attention to Fogo and its artistic heritage. The studios are for the use of visiting artists who are selected through a competitive process to receive Foundation support for their residence on the island. Local residents exchange ideas with artists-in-residence through exhibitions and discussions. The resulting artistic and cultural products reinforce the identity of Fogo Island, in much the same way as the film and video projects of fifty years ago.

A Business Assistance Fund is based on the microfinance model of the Grameen Bank and serves residents seeking to develop their ideas. Supported businesses are expected to respect the sustainability goals of the Foundation, to use local materials when possible and to promote local crafts, foods and products. In supporting local production the fund helps create new sources of economic activity as well as reduce reliance on imports from other regions.

5 Lessons from Fogo Island

Evaluating the model developed for Fogo Island is difficult because most of its work has been recent, since the opening of the Inn in 2013. Initial findings show a consistent flow of tourists to the island and the Inn, as well as sales of art and craft products from island visitors and residents. The business fund supported fifteen new businesses in its first three years, and the Foundation has been active lobbying for infrastructure improvements to serve the island. The case of Fogo Island suggests the following elements as needed for a community development strategy, based on a sustainable geotourism model:

- Island social capital among residents and their diaspora that allow discussion, decision-making and action to take place.
- A physically and culturally inviting island that offers natural and social attractions to visitors.
- Recognition of island assets and the ability to use and adapt assets for future development.
- Understanding of island ecology and sustainability practices.
- Leadership—government, business or nonprofit—that reflects the interests and needs of residents and champions a vision of the future island.

The experience of Fogo Island and its approach to *community development* fits well with the growing interest in placemaking, which recognizes the interplay of place, culture, identity and economic development. Fogo Island has suffered through negative economic change but also benefitted from the commitment of the community to stay on the island and consider innovative approaches to development, as well as the leadership of the Shorefast Foundation as a facilitator to make Fogo Island's vision real.

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Adaptive Planning for Reducing Negative Impacts of Climate Change in Case of Hungarian Cities

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Abstract As weather forecasts for Hungary show rising temperature and less precipitation in some months of a year in the near future, application of smart solutions regarding urban development and planning is a key for tackling the emerging challenges. According to studies related to future weather events in the Carpathian basin, Hungarian cities will likely face similar climate-related challenges as Mediterranean cities nowadays, despite of their different geographical locations. Based on these forecasts, adaptive planning through indicator-based systems plays a crucial role in the abatement of negative effects of climate change, therefore smart principles with an effective monitoring phase can contribute to the vital future of Hungarian cities. The present paper states climate-related interpretation of smart city sub-systems (people, environment, governance, mobility, economy and living) by providing sets of indicators for making comprehensive, sustainable and smart decisions. The selection of indicators is based on two main aspects: firstly, data availability for effectively using existing indicators' sets; secondly, adaptation for anticipated negative effects of climate change in urban areas in light of smart cities' potential. Interconnections between climate-related challenges and urban development can be revealed by creating climate-oriented smart city concepts and indicators to improve cities' adaptation capacity. The main aim of the present study is to contribute to the better understanding of complex interrelations between climate-related challenges and the role of smart cities; and develop specific concepts and set of indicators for improving decision-making and urban planning processes. The second aim is to reveal the role of smart cities in the abatement of negative effects of climate change through effective monitoring and project supporting systems.

Keywords Climate change adaptation · Smart city · Indicators · Urban planning

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1 Introduction

The changing consumption patterns occurring nowadays in cities, which are strongly related to economic growth on a global scale, have social consequences such as growing migration from rural to urban areas (UN 2014). Better quality of life and related urban-specific consumption patterns are attractive features of cities, therefore huge number of population is moving from rural to urban areas in the developing world. As our world becomes more and more urbanised, cities are facing remarkable challenges in their way to be liveable, sustainable and well planned for improving citizens' quality of life. Urban areas are responsible for a huge amount of resource and product consumption, resulting to 75% of the global greenhouse gas (GHG) emissions and approximately 80% of total energy consumption (Koop and van Leeuwen 2016; Greco and Cresta 2015).

Recent urban studies regarding sustainability are focusing on climate-related vulnerability and the interconnections and synergies between sustainable development and resilience at the local scale (Jabareen 2013; McDaniels et al. 2015). In the last decades, climate change has become one of the most important and widely studied challenges of urban areas due to the huge number of population and assets exposed to climate-related risks (IPCC 2014). According to McDonald et al. (2011), significant proportion of urban population lives in cities, where water availability and quality or water delivery is burdened; and these people do not have the chance to meet their own needs due to the long-term droughts, driven by the changing climate. Monzon (2015) summarises and specifies the main challenges of European cities, paying special attention to sustainability aspects and the negative impacts of climate change on them. The more frequent droughts affect greatly the Mediterranean cities, however according to numerous meteorological predictions, by the middle of 21st century these impacts and consequences will be common in the Central European region (Bartholy 2007; Bartholy and Pongrácz 2010; Faragó et al. 2010).

Consequently there is a need for promoting future sustainability-oriented solutions in any urban sectors, since unsustainable actions provide only short-term benefits or aggravate environmental degradation through depletion of resources. In the first step of resilience-based planning procedures, the most *vulnerable* topics of a specific city must be identified by urban planners and decision-makers. Moreover, relevant input and output flows, interdependencies and processes among urban subsystems must be further understood and analysed (Desouza and Flanery 2013). These highly evaluated and quantified urban features are the basis for pursuing urban sustainability objectives, facilitated by innovative and digitally-enabled data collection and analysis methods that are supported by smart technologies; and are aimed to define complex sustainability factors regarding consumption patterns as well as optimize production structures (Kitchin 2014).

Thus by applying the above mentioned data-intensive methodologies, innovation and urban sustainability requirements can be linked. For this purpose urban leaders and institutions have significant role, as the main actors for building sustainable, smart and resilient cities.

Urban planners and decision makers should focus on planning more sustainable and resilient cities, therefore a vast amount of quantitative and qualitative data are needed to develop effective and successful strategies. For this purpose, numerous set of indicators have been elaborated by non-governmental organizations (NGO), municipality experts, companies and academia. Kitchin (2014) emphasised the role of quality and quantity of information in urban planning and decision-making processes, stressing the importance of an innovative and adaptive urban planning approach that is based on the collection and analysis of not only historical, but also real-time data (Oliveira et al. 2015). This vast amount of data can be provided in a smart city context, where innovative Information and Communication Technologies (ICT) are used for collecting and analysing data from different (and almost every) part of cities for supporting planning and development purposes. Nowadays, many sets of indicators are used and developed for assessing cities' smartness (Caragliu et al. 2011; Walravens 2015; Garau et al. 2016), sustainability (Michael et al. 2014; Dizdaroglu 2015; Huang et al. 2015) or resilience (Angeon and Bates 2015; Bozza et al. 2015) of a certain city or a given system. However, the demand for information often exceeds the supply of it. As smart cities' ICT infrastructures can provide extended amount of data from a variety of sources, urban planners should rely on these data/sources to develop more effective strategies.

The increased amount of data emerging from smart infrastructures in a smart city context results to more effective planning and decision-making processes and a so-called information-driven decision-making approach. It shall be emphasised that the above mentioned technocratic urban planning approach must be completed with smart governance, well-equipped planners and decision makers for setting and implementing strategies to achieve sustainable, resilient and smart cities.

The present paper aims to develop climate-focused interpretation of smart cities by relying on indicator-based urban planning, so that smart cities shall be seen as a new perspective for achieving urban sustainability and resilience due to their potential to collect and elaborate on a huge amount of appropriate data. After revealing synergies between different urban interpretations and climate-oriented smart city perspective, present climate challenges of Hungarian cities and an adaptation-centred indicator-based smart planning approach is presented. The selection of indicators is firstly grounded on their availability, while it is further enriched by the extensive amount of data produced in a smart city context.

2 Sustainable, Resilient and Smart Cities

In this section, synergies and interrelations between *sustainable*, *smart* and *resilient* cities are revealed by means of a conceptual exploration. Although all of these types of urban areas are widely studied, cited and elaborated by academia, NGO and municipal experts, there are no common definitions and assessment criteria for them

(De Jong et al. 2015). The mostly diverse interpretation and explanation of these concepts can be attributed to the intriguing issue of urban sustainability. Although there is a commonly accepted definition for sustainable development, the main issue regarding urban sustainability is highly dependent on how this is grasped and realized by different urban contexts. Consequently, urban sustainability is a largely diverse, normative concept, which reflects both local specific features and global understanding of the conceptualisation process. Sustainable urban development usually strives for maintaining the quality of life of a given generation; and providing future generations the opportunity to meet their own needs, based on efficient and future-oriented resource consumption patterns (Mahon et al. 2012; Marans 2015). According to this definition, optimisation of urban systems has a crucial role in achieving sustainability and long-term well-being of residents, without excessive consumption of finite resources. All requirements need huge amount of data to optimise urban structures, therefore implementing and maintaining an extensively connected system will be required to achieve sustainable end states of urban areas.

As it was mentioned above, nowadays one of the main threats of cities is related to climate change impacts, which are witnessed through heavy rainstorms, floods, rising temperature and droughts (IPCC 2014). Tackling climate change challenges is crucial for cities in order to serve not only sustainability but also survival objectives. Therefore, climate-oriented aspects need to be embedded into decision-making processes for a sustainable future of urban environments (Voskamp and van de Ven 2015), since the resilience of a given urban area is a prerequisite in order to be also a sustainable one. This assumption can be explained by introducing sustainability pillars and vulnerability aspects of them as prerequisites for long-term maintenance and operation of cities that ensure citizens' well-being.

Social sustainability is based on a society, which can be adapted to future changes and is able to change its own structures and processes in order to cope with the adverse effects of any changes. If a given society does not have information and knowledge on the adverse effects of climate change, while it is largely exposed and vulnerable to the climate-related natural hazards, it cannot be sustainable in a long term. From a *socio-economic* point of view, a well-structured and prosperous urban economy should maintain its operations during natural disasters; and sustain its essential functions in order to cope with that kind of events and enable a certain level of safe and qualitative life for the society.

As to the *environmental sustainability*, responsible consumption of natural resources entails reduced amount of emitted GHG, which in turn ameliorates negative impacts of climate change. Last, but not least, governance sector can take many actions, capable of reducing urban vulnerability to climate change, such as improving hard and soft infrastructure elements or increasing its own flexibility to make real-time decisions during climate-induced disasters. Consequently, a future-oriented and climate-smart governance system shall contribute to urban sustainability through effectively maintaining the critical infrastructure elements. As can be seen in the previous paragraphs, urban resilience and sustainability are strongly interconnected within different aspects of urban life and operations. Basically, resilience reflects the ability of a given system to cope with negative effects, originating from its external environment. Based on the topic of present paper, urban resilience is targeting mainly climate-focused challenges in order to strengthen capacity for tackling extreme adverse impacts and maintaining operation of a city. Therefore increasing resilience contributes to enhanced sustainability in all three pillars i.e. environment, economy and society.

Concepts relating to smart cities are less heterogeneous and disputable when compared to sustainability ones. However, there is no yet a widely accepted definition for city smartness, while additionally a certain, commonly accepted, approach on how to achieve "smartness" of cities is also lacking (Anthopoulous and Vakali 2012; Albino et al. 2015; Angelidou 2015). In fact there are three main views of the concept: a strongly technocratic, a knowledge-based and an integrated approach (Greco and Cresta 2015).

Based on the *technology-centred approach*, smart cities are cities heavily, and almost exclusively, relying on innovative ICT infrastructures, where a variety of connected devices are producing extensive data and information on cities' operations (Maric et al. 2016). Based on these massive data sets, city functions can be controlled and commanded. A utopia can be drawn in this respect, where human control is almost lacking, while cities' functioning can be based on connected devices that can communicate with each other. As various researchers state (Kitchin 2014), such a future can render cities more vulnerable, based on unsecure and hackable urban systems.

Following the rationale of the *knowledge-based perspective*, a smart city can effectively collect and use citizens and stakeholders' knowledge through proper ICT-enabled interaction processes; while by supporting knowledge generation can drive continuous innovation in the cities' context (Monzon 2015). In such a city, residents are well-educated and open to new technologies, which are supplementary elements in developing efficient resource consumption in urban areas. Based on the human and social capital, smart cities are hubs of innovation and knowledge generation.

Finally, the *integrated concept* of smart city does emphasize the synergies created between the knowledge-based and the technocratic approach, referring to the treatment of the city as a whole, i.e. as a system taking into consideration the different subsystems (social, economic and physical) and sectors (transport, energy, water) as well as their interrelationships (Marsal-Llacuna and Segal 2016).

Summarising the above presented concepts and interpretation approaches regarding smart, resilient and sustainable cities, a theoretical framework can be elaborated. In this respect, a smart city can actually be perceived as a tool or a strategy for achieving sustainability objectives in urban areas, by providing the ground for digital collection and management of a huge amount of data, coupled with upgraded social and human capital and governance structures. In this sense, the main focus of smart urban planning is concerned with urban sustainability, by means of effective and information-driven planning approaches, treating real-time data for improving finite resource consumption patterns, and efficiently managing governance structures for improving the implementation of a given action or regulation. Beside the smartness of a city, as it was presented above, climate resilience is also a current requirement and a goal to be achieved by cities. From this perspective, climate-centred planning approaches may illuminate other aspects of sustainable urban development, tackling climate change challenges and risks and improving readiness of cities to cope with their impacts. Figure 1 represents the connections and synergies among the above mentioned concepts, where urban sustainability is the main aim, while smart city provides a digitally-enabled environment and respective tools for effective data gathering and management, and adoption of more inclusive planning and governance approaches that are further enriched by the aspect of resilience.

3 Smart Cities in Terms of Climate Change

In the previous section, key urban concepts were discussed and their interrelations were explored. The focus of the present section is on reducing negative impacts of climate change by taking advantage of smart urban environments. More frequent extreme weather events occurring in urban areas and constantly growing population trend feature the imperative need to plan and maintain smart and sustainable cities. Such cities can provide efficient responses not only to environmental but also to economic and social challenges through sustainable urban systems (Desouza and Flanery 2013). Moreover long-term planning approaches can contribute to planning a more resilient and less vulnerable future of our cities.

As it was stated above, high concentration of population implies increasing vulnerability of urban areas, therefore resilience-related aspects should be prioritised in urban planning processes (Sharifi and Yamagata 2014; Xu et al. 2015). It can be seen in Fig. 1 that climate resilience can contribute to the achievement of

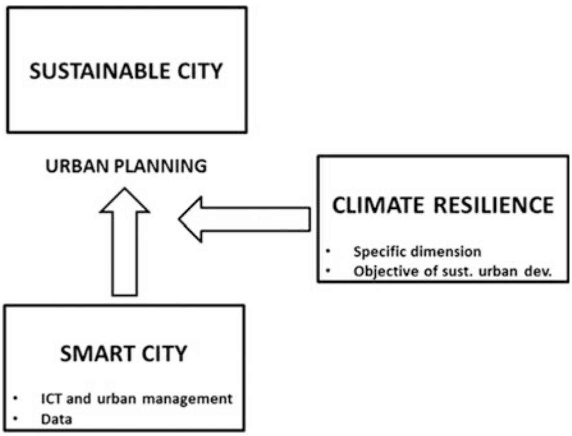

Fig. 1 Interconnections between climate resilience, smart and sustainable city

urban sustainability by shedding light on a specific dimension or one of the main objectives of sustainable urban development currently. Online and on-going data flows from smart cities' infrastructures, further enriched by extended application of ICT, can provide accurate indications as to the urban population and physical assets that are potentially vulnerable. This knowledge can support relevant decision-making on strategies to reduce vulnerability and achieve sustainability, being ultimate goal of current urban development strategies.

The potential of reliable and of multiple origin information in a smart city context is quite significant. Managing this information can result to the identification of potential climate-related risks and damages; and support more knowledgeable decisions towards the increase of urban systems' resilience. Based on the integrated concept of smart cities, ICT can effectively work within smart governance structures; and feed planning and decision-making processes towards the reduction of urban vulnerability, by efficiently managing resource consumption and distribution (Khansari et al. 2014). GHG emissions can be also reduced in this respect, leading to further value adding to mitigation policies. From an adaptation point of view, a well-planned and managed smart city with extensive application of ICT constitutes an environment, within which useful information can be collected and analysed in order to reduce exposure to climate change risks and vulnerability by:

- applying early warning systems;
- providing information to population;
- collecting data regarding ecosystem services;
- providing information to disaster management;
- analysing future climate scenarios;
- modelling emergency routes;
- diffusing knowledge for more effective education and increase of awareness, etc.

It can be realized that application of smart technologies shall contribute to better *planning and managing resilient cities*. Therefore considerations of the interconnection of the two concepts—smart city and climate change—are necessary for improving our cities' performance. In this respect, better simulated future climate change scenarios can contribute to more effective financial resource allocation and implementation of properly planned infrastructure projects. From a *social point of view*, effectively managed early warning systems can be planned, thus protecting the population and reducing mortality losses due to the impacts of heat waves or floods. Furthermore, use of digitally-enabled devices for smart metering can effectively manage water and energy consumption levels.

Climate-induced challenges require effective tools and actions for tackling them. In Table 1, a range of main mitigation and adaptation actions that can be implemented in a smart city environment are depicted, classified into the six smart city components. The further classification of climate-oriented indicators into the Giffinger's six smart city components is based on the possible application of smart technologies in mitigation and adaptation actions. It can be stated that ICT-based technologies, by providing extended amount of data that can support decision-making towards more effective cities' operation, can contribute to improvements of cities' adaptive capacity. This interconnection between smart solutions and urban climate challenges can provide a new interpretation of urban structures through the so-called *adaptive smart city*, where actions regarding both GHG reduction and adaptive capacity improvements are combined in order to maximise cities' operational efficiency. Apart from the rigorous concept of adaptive actions, in this case "adaptive" smart city means a city where resource consumption is managed and controlled in order to mitigate GHG emissions; while further actions are taken for improving resilience in the following six smart elements:

- smart economy;
- smart people;
- smart governance;
- smart mobility;
- smart environment;
- smart living.

4 Climate Challenges of Hungarian Cities

In case of Hungary and the Carpathian basin, significant change in climatic features has been predicted by numerous authors (Bartholy 2007; Bartholy and Pongrácz 2010; Probáld 2014). According to the Hungarian Meteorological Service (OMSZ), remarkable summer and winter warming and changes in precipitation patterns will likely to be (OMSZ 2015), therefore preparedness of Hungarian cities for tackling negative impacts of climate change is urgent. In the following, regional climate projections regarding anticipated weather extremes and historical data for the Carpathian basin are depicted, for determining main climatic challenges in the area. Figure 2 represents the change of the annual (left side) and summer (right side) average temperature in Hungary for the period 1981–2014. It can be seen that annual temperature has increased by more than 1.2 °C in the northern and south-western part of the country. However this rising has reached more than 2 °C in the Northeast. In case of summer heat, temperature rising has reached approximately 2 °C in most of the eastern part of Hungary and a heat wave hub can be seen between the Balaton lake and the Danube.

Completed with historical climatic anomalies in Hungary, Fig. 3 shows the number of days with heat waves from 1981 to 2014. It can be stated that every part of Hungary has been affected by increasing summertime heat waves, therefore Hungarian cities are strongly exposed to the rising temperature and related negative impacts.

Based on the results of PRUDENCE project, relevant climatic changes can be predicted for the Carpathian basin as regards temperature and precipitation aspects. As it can be seen in Fig. 4, the expected late summer precipitation change in Central

Table 1 Aspects of adaptive smart city—possible mitigation and adaptation actions in each smart city component

Adaptive smart city					
Economy	People	Governance	Mobility	Environment	Living
Improving energy efficiency Reducing GHG emissions ICT-based resource consumption Cooperation with civil sector Climate-induced patents Zero emission company vehicle	Knowledge transfer, education Innovation On-line billing systems Climate change consciousness	Early warning systems Flood protection Municipal energy consumption Climate strategies Regulatory Mainstreaming climate change Resilient infrastructure Disaster risk management	Traffic reduction Reducing energy consumption Real-time traffic controlling	Renewable energy consumption Waste water treatment Urban green spaces Climate-oriented open spaces	Controlling domestic energy and water consumption Building insulation Passive building shading Smart energy and water metering Domestic reusing and recycling

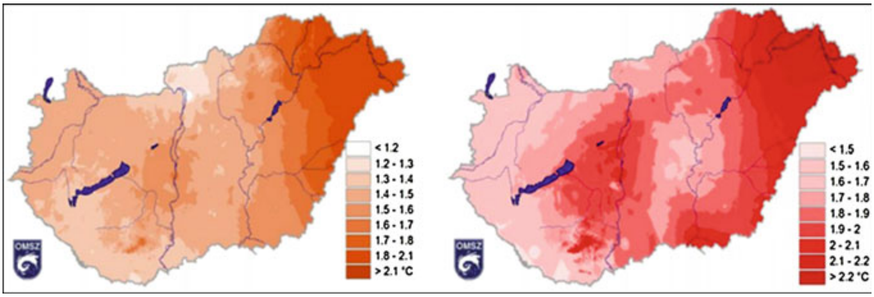

Fig. 2 The change of annual (*left*) and summertime (*right*) temperature in Hungary for the period 1981–2014 (Reproduced from OMSZ 2015)

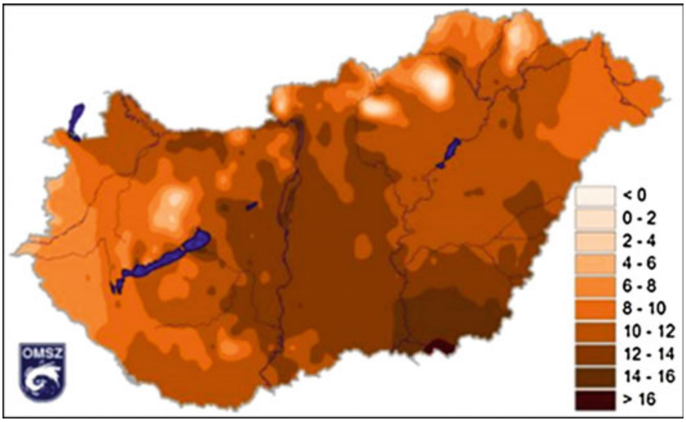

Fig. 3 The change of numbers of summertime heat waves in Hungary between 1981 and 2014 (Reproduced from OMSZ 2015)

Europe is expected to reach an approximately 30% decrease for 2071–2100, based on the reference period 1961–1990. It means that anticipated weather features of Hungary in 30–40 years time will likely be the same as in the Mediterranean countries nowadays. Therefore Hungarian cities will likely be facing heat waves, droughts and other weather extremes, which are currently attributed to the Mediterranean area and cities. Preparedness for the above mentioned impacts of climate change in Hungary has been involved into a study by Kelemen et al. (2015), in which cyclones of the Mediterranean area have been analysed. It shows that effective urban planning in Hungary can be achieved by studying the current meteorological features of Mediterranean area for supporting and improving our cities' planning capacity.

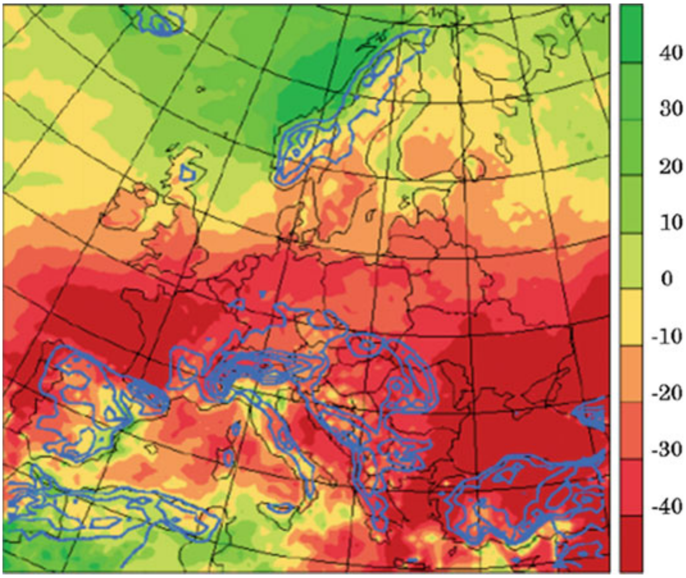

Fig. 4 Expected summer precipitation change in Europe for 2071–2100 (Reproduced from Faragó et al. 2010)

It must be emphasised that significant climatic changes in Hungary introduce negative impacts on urban areas, therefore Hungarian cities must pay more attention on these impacts, which are occurring currently. According to the OMSZ, the number of icy days will likely to be decreasing by approximately 50%, whilst the number of days with heat wave is expected to reach 7–13 by 2050 and 18–23 by the end of the century. Beside temperature anomalies, Bartholy's (2007) work summarises the expected regional climate change in Hungary by the end of the 21st century; and the significant seasonal precipitation anomalies: decreasing amount of precipitation in summer time by even 30% and the same amount of increase in wintertime. Coupled with the predicted rising temperature, it means increasing flood risk for the Hungarian municipalities. Buzási (2014) stated that, in case of Budapest, strengthening heat waves and increasing flood risk are the two main climate-related challenges in the 21st century regarding the Hungarian capital. Based on the results of the above presented regional climate models, this assumption shall be extended to all Hungarian cities. The above climate-related changing conditions of urban environments in Hungary imply the need for cities to embed climate issues into their strategic planning for achieving sustainability objectives (Brandt et al. 2015); and meeting citizens' needs for a longer term. For this purpose pervasive collection of data and information is required (Lee et al. 2014; Stratigea et al. 2015), largely facilitated by smart urban infrastructures and connected subsystems.

5 Planning for Adaptive Smart Cities in Hungary

Seeking to fulfil urban sustainability objectives, smart urban infrastructures deployment and adoption of resilient planning approaches, as noticed in previous sections, need to be applied. In Hungary the main development document on local scale is the so-called Integrated Settlement Development Strategy ("ITS" as the Hungarian abbreviation in the followings). ITSs include actions and projects regarding urban development, however there is a little attention on climate-related issues in them. In this section, a smart urban development planning approach is introduced, implying a different planning process, comparing to the mainstream one prevailing in the Hungarian urban development practice. This innovative planning approach is basically an ex-post methodology based on current ITSs of cities and is based on the following steps. *Firstly*, aims of a given ITS are explored and grouped by neighbourhood units and related sectors. *Secondly*, actions defined by ITS are grouped into the six smart components provided by Giffinger. These actions however are basically not connected to smart developments. It can be seen that they are strongly sustainability-oriented ones, but they have characteristics which can help the planners to group them into Giffinger categories. For instance one of the main aims of a Hungarian city regarding public transportation is to achieve energy-efficient and low-carbon public transport sector. This aim can be grouped into smart mobility Giffinger's component in order to be connected with a dedicated smart technology offered by a given smart city supplier. *Thirdly*, each action is assigned to a given indicator, therefore the change of the indicators give easily manageable feedbacks for decision makers and planners. This planning process is based on the demand for evaluating a given smart action in urban areas regarding its effectiveness. By applying this approach, smart city products can be grouped by smart dimensions and indicators, while they are coupled with the aims of the urban development plans. Therefore related aims of a given city from its ITS can be linked to smart products and vice versa through the monitoring of a given indicator, tracking the process of achieving a dedicated urban development goal, whilst this indicator had previously been grouped into a smart city element. Thus the impacts of a given smart and resilience-centred action can be evaluated in terms of cities' goals.

In the present section, two sets of indicators are developed based on the current availability of data. In this case, indicator-selection is strongly limited, since considerable part of data required in order to achieve comprehensive planning procedure is not available. The role of data availability regarding smart cities' development is a widely studied and analysed area, with numerous challenges and opportunities. According to Maric et al. (2016), ICT-enabled, problem identification and solving can be easier and faster, which in turn is crucial with regards to uncertainties and variability of climate-related data. Additionally, some studies have focused on the provision and value of real-time data in a smart city context (Marsal-Llacuna et al. 2015; Oliveira et al. 2015; Calvillo et al. 2016), where huge amount of devices, infrastructures and sensors' networks are connected and produce all day long real time data.

Table 2 represents a set of indicators applied to describe and analyse the *adaptive smartness* of a given *Hungarian city*. In this sense, adaptive implies the climate-oriented part of urban development policies for improving urban resilience; while smartness refers to the previously mentioned integrated approach of smart city presentation. Indicator selection is based on statistical databases of the Hungarian Central Statistical Office, municipalities own research and both on-line and offline surveys and questionnaires. Therefore it presents a *data-driven approach*, since the most relevant limitation in developing this set of indicators was *data availability*. It can be stated that a large amount of data regarding smart economy, smart governance and smart mobility elements are available; consequently these categories can be considered as data rich as regards current data availability in Hungary. However a "smarter" city should provide a more extensive database. On the other hand, smart people, smart environment and smart living categories contribute to the potential evaluation and planning approach with approximately 3–4 indicators. This amount hardly supports an effective planning procedure; therefore expansion of data supply must be achieved.

As it was stated above, smart cities through their smart technologies may contribute to the more effective and better planning processes via extended data sources. This advantage of smart urban areas has been emphasised by various authors: Calvillo et al. (2016) emphasised the role of smart grids by collecting and analysing real-time data for optimising cities' operation; Monzon (2015) stated that one of the main benefits of being smart is the potential for a more comprehensive and holistic urban management approach that is based on the large amount of information; Angelidou (2015) claimed that smart products can change current urban planning approaches toward a more effective and online ones; Anthopoulos and Vakali (2012) defined smart technologies as tools for supporting different urban planning and development aspects; Lund et al. (2015) introduced an evaluation theory and practice by collecting and analysing vast amount of data for planning a more effective urban energy system, based on renewable sources; finally Vasilakopoulou et al. (2014) underlined the role of data on micro scale for improving planning approaches.

Based on the above stated role of information for developing more effective planning processes in urban areas, a so-called *information-driven framework* was developed. In this approach, there is no need for reducing the planners' data demand, since smart cities through extensive use of ICT, knowledge transfer potential, educational level and innovation can provide as much information as urban planners and decision-makers need.

It must be emphasised the main difference between previously mentioned data-driven and information-driven indicator selection approaches. As it can be seen previously, current urban development processes apply a data-driven approach, since the main limitation factor was the availability of data. Contrary to this, information-driven approach refers to the real needs of urban planners in developing and selecting indicators to better evaluate a given aspect of their cities.

Table 2 Indicators for describing adaptive smart city in a data-driven approach

Adaptive smart city—data-driven method					
Economy	People	Governance	Mobility	Environment	Living
% of renewable energy consumption % of companies with smart metering No. of patents No. of companies with environmental management system % of environmental expenditures Share of green vehicles in companies' fleet	Graduation rate % of households with on-line billing systems No. of cooperation between business and civil sectors	No. of mobile applications regarding weather alerts % of repeatedly flooded area Total energy consumption in municipality-owned buildings No. of mitigation and adaptation actions Existence of disaster risk plan	Length of bicycle paths Share of green vehicles in the public transport fleet Annual urban transport performance (no. of passengers) Average age of passenger cars	Total renewable energy consumption % of waste water treated by tertiary stage % of green spaces No. of trees	% of domestic smart metering % of households with air conditioning (AC) % of wastes generated by households

Information-driven approach therefore is an extended version of current indicator selection processes. The outcome of this approach is presented in Table 3, incorporating indicators regarding adaptive smart cities in terms of the information-driven approach. In fact, indicators of Table 3 is an enriched version of indicators of Table 2, where Table 3 is completed with currently unavailable, but desirable types of information (in bold below) for planning purposes. The additional set of indicators needed is based on the outcome of a Hungarian smart city pilot project; and is emerging from surveys and questionnaires among experts.

Aiming at reducing vulnerability of urban environments to current global challenges, climate-centred information can contribute to effectively planning more resilient cities, while mitigating GHG emissions. In addition, widely used ICT and their applications can enrich data sources and information gathering in a currently unimaginable way. In this utopia, a so-called extended information-driven planning approach can be applied for planning and managing our smart, resilient and sustainable cities. Finally, it must be emphasised that broadening access to ICT infrastructure and upgrading of ICT skills of human capital are crucial in a smart city context, since effective urban planning and management of urban challenges cannot be achieved without strong motivation and partnership of people.

6 Conclusion

The present paper aimed firstly to reveal complex interrelations and possible synergies between different urban concepts, such as sustainable, resilient and smart cities. After the theoretical review, it can be stated that smart cities shall play a significant role in achieving urban sustainability through extensive use of ICT and collection of a vast amount of data from them. It must be emphasised that social side of smart cities are also pivotal in this respect, therefore a purely technocratic approach cannot lead to fruitful results in terms of sustainability achievements.

The second aim was related to the incorporation of climate change impacts into current urban planning approaches, thus adaptive smart city as a new and innovative concept was identified. In such a city, smart technologies and social and human capital are integrated into a planning approach that targets the decreasing of urban vulnerability as a main objective of climate-centred sustainable urban planning process.

Finally, data-driven and information-driven smart planning approaches were delineated by applying relevant sets of indicators for assessing climate-centred smartness of a given urban area. Based on the previous discussion, current climate-related smart policies and actions can be combined with policies and actions referring to a certain city level (neighbourhood level), combining thus more general with more of local nature urban development goals and strategy. Applying this methodology, urban planners and decision makers are able to pay more attention on smart projects; while, based on data and information emerging from smart urban infrastructures, they can more effectively assess and monitor results of

Table 3 Indicators for describing adaptive smart city from an information-driven approach

Adaptive smart city—information-driven method					
Economy	People	Governance	Mobility	Environment	Living
% of renewable energy consumption	Graduation rate	No. of mobile applications regarding weather alerts	Length of bicycle paths	Total renewable energy consumption	% of domestic smart metering
% of renewable energy consumption grouped by sources	**% of population with sustainability knowledge**	**No. of emergency hospital beds during heat waves**	Share of green vehicles in the public transport fleet	**Total renewable energy consumption grouped by sources**	% of households with AC
% of companies with smart metering	**% of households with more than two ICT devices per person**	**No. of doctors on duty during climate disasters**	**Length of urban roads observed and controlled by smart technologies**	% of wastewater treated by tertiary stage	% of wastes generated by households
No. of patents	**No. of people reading climate-related news on smart devices**	% of repeatedly flooded area	Annual urban public transport performance (no. of passengers)	**% of generated domestic wastewater**	**Emergency reporting application**
No. of patents for improving resilience	% of households with on-line billing systems	**Complex exposure, sensitivity and vulnerability assessment to the whole urban area**	**Annual GHG reduction from public transport**	**% of reused wastewater**	**Proportion of households equipped with home alarm**
No. of patents developed by a cooperation with civil sector	**% of population with extended knowledge about climate change**	Total energy consumption in municipality-owned buildings	Average age of passenger cars	**Annual average water consumption for irrigation**	**% of households using smart consumer website**
No. of companies with environmental management system	**% of population with knowledge about local climate plans**	**No. of municipality-owned buildings with integrated energy management system**	**% of car sharing**	**% of real-time controlled domestic irrigation systems**	**% of households equipped with CO_x and energy display**
% of environmental expenditures	**% of households using ICT to reduce expenditures**	No. of mitigation and adaptation actions	**% of vehicles equipped with CO_2 and energy display**	% of green spaces	
No. of climate-related actions financed by business sector	No. of cooperation between business and civil sectors	**% of urban area involved into climate plans by defining dedicated action**	**% of vehicles equipped with route planner**	**% of climate-resistant public spaces**	
Share of green vehicles in companies' fleet		Existence of disaster risk plan	**% of climate-resistant public transport stops**	No. of trees	
Ton of mitigated GHG by business-financed or owned green areas		**Length of dedicated emergency routes**		**No. of information platforms about local ecosystems**	

planning outcomes. As pursuing sustainable urban development goals has been coupled with the application of smart technologies, a broadening perspective for evaluating the impact of smart urban development projects is emerging, which is mainly based on data availability relative to additional indicators' sets. These indicators' sets are capable of addressing and assessing the effectiveness of climate-oriented policies targeting mitigation and adaptation patterns, whilst smart technologies can fill the gap in data requirements. According to a highly optimistic scenario, the amount of data emanating by use of smart technologies; and the potential for integration of data emerging by different smart infrastructures shall contribute to the introduction and application of an extended information-driven planning approach, in which on-line real-time data will form the ground for on-going urban management. The extended amount of information can support urban planners and decision makers in monitoring the progress of planning outcomes as to preset development goals; therefore more knowledgeable, effective and innovative interventions can be identified in pursuing urban sustainability and resilience goals. Beside the technocratic utopia a smart city may represent, it must be realized that achieving urban sustainability cannot be grasped without smart governance, based on human and social capital, which are the key drivers for achieving sustainably balanced urban welfare.

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ICT Applications in Smart Ecotourism Environments

Vicky Katsoni and Natali Dologlou

Abstract Radical technological developments and their applications can largely contribute to a more effective management of challenges currently faced by our planet. Nevertheless, the light has up to now been shed on urban environments, mainly due to the rapidly evolving urbanization trends and related consequences; while the implications of Information and Communication Technologies (ICT) in rural areas and communities, although quite promising, are less explored. In the present paper, the focus is on that type of environments, and more specifically on the role ICT can play for the protection of valuable ecosystems that are forming the ground for ecotourism development. Ecotourism embraces the principles of Sustainable Tourism (ST), as an alternative tourism form that is largely concerned for the economic, social and, most importantly, environmental impacts of this sector. Preserving ecosystems' values in ecotourism destinations imply the need for steadily monitoring ecotourism developments and associated impacts in such destinations, with ICT offering important tools for accomplishing such a task. In this respect the paper aims, by reviewing a range of the academic reports and literature, at deriving crucial aspects that need to be dealt with in a variety of ecotourism dimensions; and matching them with a range of relevant ICT-enabled tools and applications. The results of this conceptual paper reveal the key ICT-enabled tools/applications for managing ecotourism destinations, thus setting the ground for case-specific policy directions towards an environmentally-responsible ecotourism development.

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Abbreviations

CI	Community Informatics
CMC	Community Multimedia Centers
CRM	Customer Relationship Management
CS	Computer Simulation
DMS	Destination Management System
DSS	Decision Support Systems
EIAS	Economic Impact Analysis Software
EMIS	Environment Management Information System
ERP	Enterprise Resource Planning
GPS	Global Positioning System
ITS	Intelligent Transport System
LBG	Location Based Games
LBS	Location Based Services
MCT	Multipurpose Community Telecentres
SM	Social Media
TIS	Tourism Information System
VLE	Virtual Learning Environment
VT	Virtual Tourism
WCOCFS	Weather Climate and Ocean Change forecasting Software
WLAN	Wireless Local Area Networks
WOM	Electronic Word Of Mouth

1 Introduction

Ecotourism is about managing a dynamically evolving process, which interacts and interrelates with the particular environmental, social, cultural, economic, political and technological features of each single protected area. Information and Communication Technologies (ICT) can be particularly helpful in this respect, mainly due to their potential in promoting social, economic and environmental sustainability objectives (World Economic Forum 2010). The term ICT encompasses any technologically-enhanced tool, method or product for the gathering, storage, processing, retrieval, transmission/reception and visualization of information, typically in a digital form. ICT are embedded within the destinations' environment, enrich tourist experiences and strengthen destinations' competitiveness (Gretzel 2011; Buhalis and Amaranggana 2014). *Smart Tourism Destinations* evolving nowadays enhance tourists' travel experience by providing intelligent platforms for gathering and distributing information within destinations; facilitate efficient allocation of tourism resources; and integrate tourism suppliers at both the micro and the macro level in an effort to ensure that benefits from this sector are well distributed to local society.

However, the authors of this paper assert that ICT applications and tools are underrepresented in most ecotourism research studies, probably because the evolution and application of technology runs faster than the evolution of ecotourism's theoretical and practical framework. ICT and their applications have not gained an important position as key tools for achieving ecotourism goals in Protected Areas (PAs) in a smart destination framework.

Fulfillment of ecotourism principles and respective constraints these place in PAs must be continually monitored for a successful ecotourism development. In this respect, these principles should be perceived as *ecotourism goals* or as *main pillars* as Fennell (2001) states. Looking at the ecotourism context and principles, it is realized that ICT-based tools and applications with the potential to be used in PAs must mainly derive from the following *groups-tanks*:

- mainstream tourism sector; and
- sustainable management and ST.

Additionally, there should be taken into consideration tools and applications used for:

- environmental management and conservations processes;
- educational/interpretation processes; and
- participatory policy making and governance.

Of course non ecotourism-related ICT tools should also be applied in order to facilitate every day's life and local needs. These principles were then adopted by the authors to create categories for ecotourism ICT-based tools/applications.

To this end, this paper offers a systematic framework, and sets a first basis for future research work on ICT solutions for smart ecotourism development in protected areas. The *structure* of the paper has as follows: first, definitions of key terminology and review of literature related to ICT in tourism is provided, in an effort to clarify ICT concepts and principles as well as identify relevant stakeholders. Then, the approach of ecotourism in a smart tourism context is elaborated, integrating theoretical and practical aspects of ecotourism, and presenting the proposed conceptual ICT framework for ICT-enabled ecotourism development. Finally, some discussion on main findings and potential opportunities is presented.

2 ICT Tools for (Eco)Tourism in Protected Areas

Tourism is mainly a service (intangible, heterogeneous, perishable), with tangible physical elements (e.g. hotel buildings, transportation vehicles and infrastructure). As a dynamically evolving sector it can stimulate local economic development in terms of income, employment, foreign exchange earnings and taxation; while it has multiplier and spillover effects, as it consumes a wide variety of local goods and services and thereby distributes income widely. Tourism is perceived as the easiest way to increase the life standard of a region and to strengthen its economic ground. Urban and regional planners, industry and sector representatives, non-governmental organizations, and municipal corporations are responsible for providing the true development of the region and residents, taking into account resource availability and constraints.

The World Tourism Organization defines *sustainable tourism development* as (UNEP and WTO 2005: 12):

> the development that meets the needs of present tourists and host regions while protecting and enhancing opportunity for the future. It is envisaged as leading to management of all resources in such a way that economic, social, and aesthetic needs can be fulfilled while maintaining cultural integrity, essential ecological processes, biological diversity, and life support systems.

Ecotourism on the other hand, as stated in the first Ecotourism Declaration in Quebec (2002), embraces the principles of sustainable tourism, concerning the economic, social and environmental impacts of tourism. It also embraces the following specific principles, which distinguish it from the wider concept of sustainable tourism:

- contributes actively to the conservation of natural and cultural heritage;
- includes local and indigenous communities in its planning, development and operation, and contributes to their well-being;
- interprets the natural and cultural heritage of the destination to visitors;
- lends itself better to independent travelers, as well as to organized tours for small size groups.

Although there exist many definitions of ecotourism in the literature, Fennell (2001), in an analysis on 85 ecotourism definitions, supports that all these definitions have certain common main pillars: (a) reference to where ecotourism occurs, e.g. natural areas, (b) conservation, (c) culture, (d) benefits to locals, and (e) education.

Under the sustainability umbrella, there is also the concept of the *Protected Area (PAs)*. According to the International Union for Conservation of Nature [IUCN] (1994: 7):

> protected area is an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.

Ecotourism destinations and PAs are unique and vulnerable and, as all tourist destinations, possess to a greater or lesser extent a variety of capitals, such as environmental capital, human capital, socio-cultural capital, economical capital and political capital (Sharpley 2010). If PAs want to meet the need for environmental sustainability, it means that these capitals may be exploited by the destination in such a way so as to reflect local developmental objectives, and take advantage of opportunities and possibilities offered by the external market, as well as the existence of ICT.

According to the World Economic Forum in 2010, the three main principles that underline the ICT usage and lead to economic gains include:

- The role of the environment as a crucial enabler of networked readiness, innovation and ICT use. Governments and other relevant actors' policies for a supportive market and regulatory environment are considered beneficial.
- The whole effort is a collaborative process, implying multi-stakeholders engagement, namely government, businesses and civil society.
- ICT readiness facilitates ICT usage. Preparation and willingness to use ICT is a critical determinant of effective ICT usage by all parts of a society.

As the boundaries of the ICT sector are blurring, people are experiencing an increasing convergence of technologies and digital media in the last few years and a key issue is how to make the best use of access to ICT. This is partially caused by the low-cost and rapid spread of mobile telephony across the globe; and the decreasing cost of personal computers and Internet access via residential and public connections. Modern ICT are closely linked to Web 2.0, which covers a wide range of interactive, dynamic applications allowing for exchange and cooperation between users (Zew 2010; Henning et al. 2013). Such applications are used to a growing extent by society through smart phones, tablets, crowdsourcing and other digital devices. Social networking and Web 2.0 companies, such as Facebook, have emerged as major players in the technological scenery. The growing popularity of smart phones has enabled the creation of thousands of innovative applications (more than 100,000 of them on Apple's iPhone platform alone), which are changing the lives of millions of people on a daily basis. Nowadays the world is more connected than ever before. Crowdsourced applications by using tourists' input give valuable insight to destinations in capturing tourists' demand and complaints in timely manner (Haubensak 2011).

ICT is recognized as a revolutionary power; a driver of sustainable economic growth; and an enabler of establishing better living conditions for both citizens and tourists. Information Technology is increasingly becoming critical for competitive operations of tourism and hospitality organizations as well as for managing the distribution and marketing of organizations on a global scale (Law et al. 2009; Ali and Frew 2010, 2014). For example, the use of advanced video conferencing allows firms to significantly reduce the expenses and ecological footprint associated with travel. There have been three main innovation waves impacting the tourism scenario in recent decades, namely (European Commission 2013: 27 and 31):

(i) the development of the Computer Reservation System (CRS) in the 70s;
(ii) the development of the Global Distribution System (GDS) in the 80s; and
(iii) the Internet in the 90s. Due to the Internet evolution, the entire process of developing, managing and marketing tourism products and destinations is

under transformation, empowering interactivity between tourism enterprises and consumers to unprecedented levels (DANTE 2014).

ICTs have also allowed destinations to evolve into a more complex type of hub, one that spreads familiarization with new technologies and provides the opportunity to expand connectivity to surrounding areas. This connectivity, in turn, expands the array of options for both urban and non-urban inhabitants to relate with the destination (World Economic Forum 2010). The authors believe that the above mentioned principles also exist for the application of ICT in ecotourism in protected areas. Especially relevant technologies for the monitoring and management of the environment are in-situ, further enriched by remote sensors, including satellites and unmanned vehicles and robotic systems; Geographical Information Systems and spatiotemporal databases; simulation models for different physical and biological processes; high-performance data-processing systems; as well as Web-based and mobile computing.

ICT *solutions for ecotourism* can help in diffusing information and educative multidimensional content to local communities; providing access to knowledge, needed by PAs' management agencies in their daily operations; and distribute educational material, information and services to travelers in their before/during/after trip processes. In addition, general ICT solutions can improve the life of local communities in PAs, often marked by isolation. Thus it is highlighted the importance of access of stakeholders in PAs to ICT; and the need for increasing their skills in order to make effective use of relevant to their interests ICT applications. This reflects the current conviction that in order to open up new opportunities a certain path has to be followed (UN 2004), as the one depicted in Fig. 1, largely enhanced by access to and use of proper ICT to increase knowledge stock availability and related opportunities this can bring.

The ICT framework approach for ecotourism development and environmental preservation of PAs proposed in this work is quite simple and constitutes a two-step approach, namely:

- *first step*: principles that need to be regulated and their possible ICT solutions are traced;
- *second step*: appropriate ICT solutions, according to end-user(s), are selected.

First step—A Principle-Based Approach ICT solutions with the potential to be used in a PA emerge from *two ICT reservoirs*.

The *main ICT reservoir* is derived from the potential ICT solutions that could be classified according to ecotourism principles of the five of the six ecotourism tenets as proposed by Donohoe and Needham (2006) (Fig. 2). For every proposed element of the five tenets, a variety of ICT solutions exist or/and could be developed and

Accessibility → Information → Knowledge → Opportunity

Fig. 1 The process of shifting from access to opportunity. Reproduced from UN (2004: 2) exploited each time for serving a specific need of the PA at hand. Indicative tool examples of this *principle-based approach* are provided in the right column of Fig. 2. These tools can be ICT-enabled, non ICT-enabled and a combination of both.

For example, consider a PA where the biggest gap to move towards ecotourism is tourism seasonality. This issue corresponds to "benefits to locals" of Fenell's ecotourism pillars as well as to "sustainability" and "distribution of benefits" of the key tenets of Donohoe and Needham, as described in Table 1. Associated elements of ecotourism labeled as N, O, Q, R, T, U and V are mainly involved. To solve seasonality problem, tool responses can be applied as, for example, those indicated in Table 1.

The *second ICT reservoir* is in practice inseparable, as it is impossible to distinguish ecotourism from the whole development process of an area and the global reality. Besides the main principles for ecotourism, PA capitals, external forces (social, environmental, economic, technological, and political and at the same time regional, national, international and planetary capitals) and external tourism markets (globalization), must be considered. Thus, a huge reservoir of external ICT solutions—*non ecotourism-specific*—exists and is getting improved and extended every day, some of which may be useful to PAs and their development (Fig. 3).

Second step—The End-User Approach Smart Tourism Destinations focus on best serving tourists' needs by combining ICT with casual culture and tourist innovation industry in order to promote tourism service quality, improve tourism management and enlarge industry scale to a broader extent (Huang et al. 2012).

Priority and emphasis must be given to ICT solutions for the *key stakeholders* in order to apply case-specific suitable ICT solutions for their PA, so that associated ecotourism principles to be successfully implemented.

For stakeholders of secondary importance it is also requested to use adapted ICT solutions for achieving ecotourism goals, but their involvement is not as fundamental, as that of the key stakeholders. Key and secondary ecotourism stakeholders are also encouraged to use non ecotourism-specific targeted ICT solutions, in order to allow technology to penetrate in the developmental process and play its role to the ecotourism balance and future of a PA.

The authors support Grimshaw's (2011) statement that technology should be compatible with the laws of ecology, gentle in its use of scarce resources as well as designed to serve the human person. Moreover they assert that there is a strong need to revise the context of ecotourism and add technological—capital assets interactions and interrelations as part of ecotourism principles. Based on sensitivity of PAs and the need to severely follow conservation rules, there is a need for steadily keeping track of ecotourism principles and developments; and continually monitoring their successful implementation. Ecotourism goals or Fennell's main pillars (2001) and opportunities previously described can form the ground in this respect; while these principles were adopted by the authors to identify and categorize ecotourism ICT-enabled tools and applications.

Ecotourism pillars		Key normative tenets of ecotourism	Associated elements of ecotourism	Potential ICT Tools Examples
Reference to where ecotourism occurs		Nature-based	A. Activity occurs primarily in nature	Protected areas as ecotourism destinations are taken as granted, thus data for ICT tools regarding A,B,C and D associated elements are not presented
			B. Healthy ecosystems	
			C. Undeveloped / pristine areas (minimal human interference)	
			D. Provides opportunity for visit to natural areas	
Conservation		Preservation / conservation	E. Maintenance and enhancement of ecosystems	Wireless environmental monitoring
			F. Awareness of ecosystem's requirements	Participatory environmental sensing
			G. Collaborative efforts between providers and community	Distance learning programs and webinars for conservation
			H. Design, incorporation and implementation of preservation / conservation actions into management plan	In situ environmental sensing
Education		Environmental education	I. Provides bio-cultural education for all stakeholders	Online education
			J. Encourages interaction with nature	Geocatching
			K. Increases awareness and understanding of an area's natural heritage	PA website
			L. Empowers visitors and other stakeholders to effectively engage to issues affecting natural and cultural heritage	Newsletters
		Sustainability	M. Achievement of equity and social justice	Free WiFi
			N. Maintenance of ecological integrity	Trail web maps
			O. Satisfaction of human needs	Telemedicine
			P. Social self-determination and cultural diversity	e-networks
			Q. Integration of conservation and development aspects	e-evaluation
Benefits to locals		Distribution of benefits	R. Equitable local access to resources, costs, and benefits	Lifelong e-learning
			S. Benefits complement rather than replace traditional local practices and activities	e-business clusters and e-trade
			T. Maximizes short and long term benefits for visitors, providers, locals etc.	e-offers
			U. Improves the quality of life for local people	e-job training
			V. Complements existing tourism infrastructure	Smart buildings
Culture		Ethics / responsibility	W. Ethics based environmentally, socially and culturally responsible approach	Game-based learning apps targeting local environmental, social and cultural issues
			X. Ecological principles to guide decision-making	e-evaluations
			Y. Consideration of the impacts and consequences of travel in natural areas	e-guide of do's and don'ts
			Z. Lead by example - increase awareness on the value of ethics-based business and action	e- newsletters

Fig. 2 Key tenets and associated elements of ecotourism. Adapted from Stacey and Needham, as cited in Donohoe and Needham (2006: 205)

Table 1 Example of possible tools to cope with seasonality in a PA

Associated elements of ecotourism	Non ICT tools examples	ICT tools examples
M. Achievement of equity and social justice		
N. Maintenance of ecological integrity	E.g. inform about: sustainable resource use; the need to reduce resource use in high pick period of visits (if applicable); the differences of environmental requirements and restrictions in the PA throughout different seasons	Update PA webpage: distinguish seasonal activities offered in the area, distinguish seasonal environmental and cultural conditions/issues/events; trail web maps; online webcams
O. Satisfaction of human needs	Provision access to basic needs all year round	Telemedicine
P. Social self-determination and cultural diversity		
Q. Integration of conservation and development	Constant monitoring and evaluation	e-evaluation, newsletters
R. Equitable local access to resources, costs, and benefits	Participatory management, education of stakeholders, use of developmental financial tools for local entrepreneurs	Lifelong e-learning, e-governance
S. Benefits compliment rather than replace traditional local practices and activities		
T. Maximizes short and long term benefits for visitors, providers, locals etc.	Ecotourism services training, offering variety of activities to visitors through the year (depending on the season), redesign leaflets emphasizing four season tourism	E-offers in low season, e-guides, social media teaser posts, e-networking
U. Improves the quality of life for local people	Employment training	Free WiFi, webinars for improving skills on ICTs, e-job training
V. Complements existing tourism infrastructure	Consultancy on small, eco-infrastructures, or eco-services (e.g. mountaineer guides) or equipment (e.g. bikes)	e-promotion of seasonal environmental conditions (flora, fauna, landscapes), seasonal activities offered, events, cultural seasonal aspects

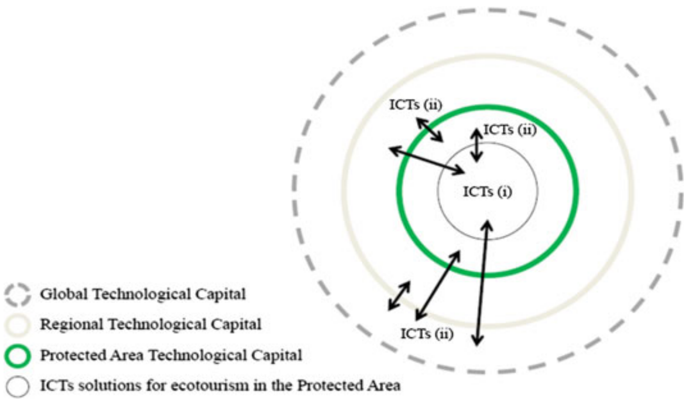

Fig. 3 Availability of ICTs tools in a protected areas

3 Building the Rationale for a "Smart" Ecotourism Destination

The authors support the view that ecotourism principles, analyzed in previous sections, can form the ground for identifying relevant ICT tools for serving PAs protection and preservation as well as ecotourism monitoring objectives. Furthermore, it is argued that even if we use these principles as factors to explore ICT-based solutions, we potentially would end up with general solutions for ST rather than ecotourism. Therefore, potential of these principles in this ICT registry is rather limited and further insight needs to be in place in order to identify ecotourism-specific ICT tools and applications, serving management and preservation objectives of PAs.

In order to overcome this difficulty and identify ICT tools and technologies that are best fitting the goal pursued, a three step *methodological approach* was developed and conducted as follows (Fig. 4):

- First a range of *academic reports* were reviewed in order to derive the crucial information needed as to the different dimensions of ecotourism, as a guide for exploring ICT-based tools and applications serving all dimensions of ecotourism. This step has led to the identification of a number of *keywords* (Fig. 4), associated with different dimensions of ecotourism activity.
- Second, based on this set of keywords, a *web search* was conducted, by means of different keywords' combinations. Searching was confined to English and Greek languages. Based on this search, a *pool of ICT tools and applications* was established. However, not all of them were explicitly reported for use in ecotourism.
- The third step refers to the further exploration of ICT applications identified in the second step, aiming at the proper *selection* of those that seemed most

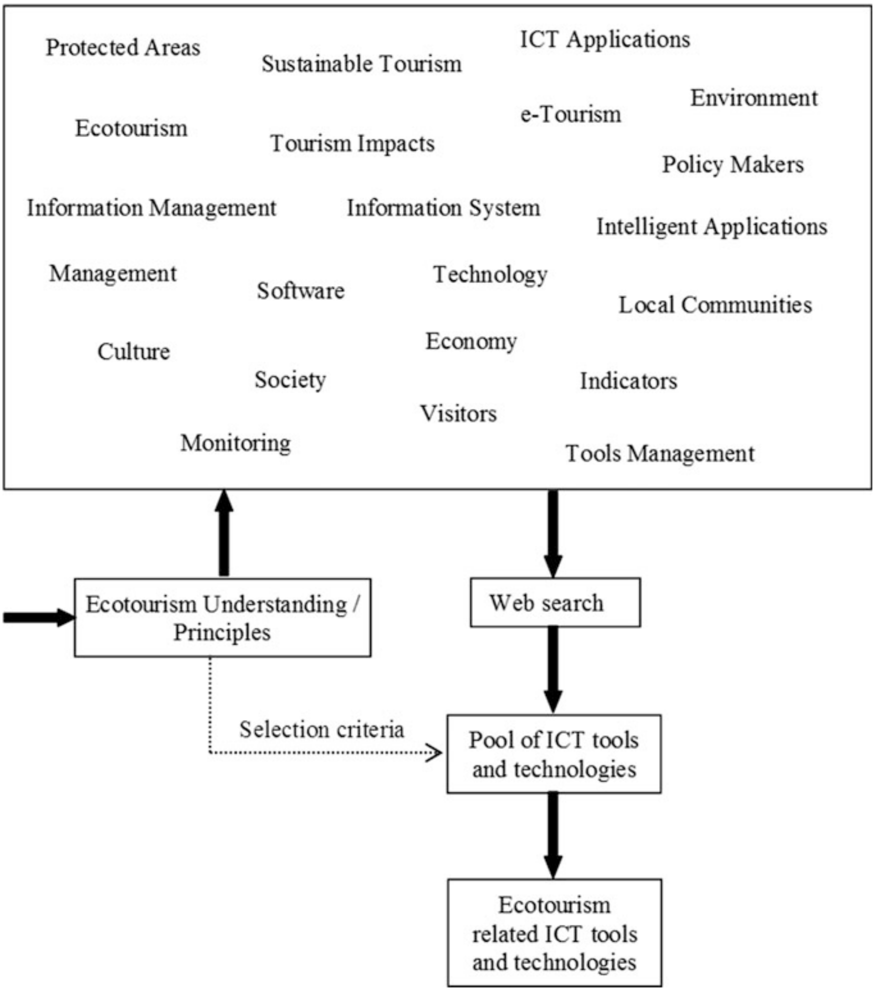

Fig. 4 Methodological approach for identifying ICT-enabled tools and technologies relevant to ecotourism

relevant to ecotourism concerns. This leads to the creation of an *ecotourism-specific pool of ICT tools and applications*.

An important aspect for ecotourism development is the *local stakeholders' engagement*. For the purpose of this study, literature research has resulted to the selection of the following *main categories* of ecotourism stakeholders' groups: local community (LOCOM), PA managers and staff (PAMAN), travelers (TRAV) and other local business stakeholders (OLST) e.g. ecolodges owners, as the main categories of ecotourism stakeholders (abbreviations in parentheses were used in the ICT-based tools/applications recorded). These groups are actually reflecting all relevant to PAs stakes, namely the stake of the: local community, the values and rights of which are served by PAs' preservation and integrity; managers of PAs as those owing specialized knowledge and/or in charge for protecting PAs through the implementation of relevant regulations; travelers, as those aiming to gather tourist experience linked to PAs in a certain destination; as well as local business stakeholders' groups that have an interest in achieving economic gains out of this natural resource. The selected groups stand from different viewpoints, being representatives of all three sustainable development pillars, i.e. society, economy and environment.

It must be recognized that the related studies of Franklin and Hosein (2009), as well as the comprehensive studies of Ali and Frew (2009, 2010, 2014) on ST ICT-based tools/applications, where the most helpful and relative to our subject works upon which we based our findings. In addition, work of Henning et al. (2013) on the use of ICT in Large Protected Areas was quite helpful to get information regarding Web 2.0 and modern ICT applications in PAs.

In Table 2 (see Appendix I), the results of our study are presented, keeping track of ecotourism themes that need to be explored for an ecotourism development fulfilling preservation of PAs; objectives falling within each theme; and ICT-enabling tools and technologies that can support achievement of ecotourism objectives. By the information contained in this table it becomes evident the wide spectrum of key ICT-based tools/applications that can be used for:

- delineating potential ecotourism destinations;
- conserving PAs' natural character;
- protecting and promoting cultural assets associated with PAs;
- educating local stakeholders and community actors for upgrading local knowledge and capacity to gently deal with peculiarities of PAs as tourist destinations; and
- enhancing benefits reaped by local business community.

The wide range of ICT tools and technologies falling into each theme and related objectives exhibit the variety of options available, which in turn can facilitate PA-specific choices that fit best to local peculiarities, current ICT-skills and readiness, visions of local communities as regards options and relating paths for sustainable exploitation of local resources, etc. Moreover, these can broaden policy choices for managing and monitoring preservation aspects and properly adjusting decision-making processes in a more flexible and effective way.

Besides the ICT tools and applications that have been developed exclusively for tourism, a multitude of ICT-based solutions exist and are constantly being enhanced for environmental management, education, citizen participation and e-governance, financial sustainability and so on. These are part of the external technological capital of PAs; and can be selectively applied to the PA area at hand. Table 2 (see Appendix I) presents examples of such ICT tools. Indicative examples of Table 2 and their value for both the PA and the destination in general are shortly discussed in the following.

Table 2 Key ICT-based applications for ecotourism in PAs

Ecotourism themes	Objectives	ICT-based tools/applications and Web 2.0 components*
Ecotourism destination	PA recognition as an ecotourism destination	**PAMAN**: GIS; GPS; CS; VT; WLAN; SM; create website; Google earth; dynamic web maps; static web maps; Open source platforms for developing LBG; photos; 3D images; video; online real time views; route mapping; geotagging; participation to newsletters; e-guides **LOCOM**: GPS; GIS; SM; Google earth; dynamic web maps; static web maps; upload photos; video; route mapping; geotagging; participation to newsletters; e-guides **TRAV**: GIS; GPS; VT; WOM; SM; websites; newsletters; e-guide; route planner; Google earth; dynamic web maps; static web maps; LBG; photos; 3D images; video; online real time views; route mapping; geotagging; trip planning process via the www; visit ecotourism networks websites; newsletters; e-guides **OLST**: GIS; GPS; CS; DMS; LBG; WLAN; GDS; SM; create websites; online destination networks; Google earth; dynamic web maps; static web maps; upload photos; video; online real time views; route mapping; geotagging; participation to newsletters; e-guides
Conservation	Sustainable use of resources Biodiversity conservation Educate all stakeholders for conservation Generate income for PA conservation Actively contribution to the conservation Lends itself better to independent travelers, as well as to organized tour for small size groups Deliver memorable interpretative experiences to visitors that help raise sensitivity to host countries' environmental climates Interpret the natural heritage of the destination to visitors	**PAMAN**: GIS; DMS; EMIS; LBS; TIS; CS; WCOCFS; VT; ITS; SM; ecotourism networks websites for parks; 3D images; video; online real time views; route mapping; geotagging; virtual tours; electronic visitor counting; camera records; create Game-based learning apps and games targeting in natural conservation; on line education; distance learning programs; webinars for conservation **LOCOM**: CI; DMS; LBS; VT; VLE; LBG; SM; GPS; Google earth; dynamic web maps; static web maps; photos; video; route mapping; geotagging; virtual tours; on line education/distance learning programs and webinars for conservation **TRAV**: CI; DMS; LBS; VT; WOM; VLE; SM; GIS; GPS; LBG; websites; newsletters; e-guide; route planner; Google earth; dynamic web maps; static web maps; photos; 3D images; video; online real time views; route mapping; geotagging; virtual tours; Game-based learning apps targeting in natural conservation **OLST**: GIS; DMS; EMIS; LBS; TIS; CS; WCOCFS; VT; ITS; CI; ERP; VLE; SM; GIS; GPS; LBG; create websites; online destination networks; Google earth; dynamic web maps; static web maps; photos; 3D images; video; online real time views; route mapping; virtual tours; geotagging; participation to newsletters; e-guides; learn and share information for do and don't in the PA; on line education/distance learning programs, webinars for conservation

(continued)

Table 2 (continued)

Ecotourism themes	Objectives	ICT-based tools/applications and Web 2.0 components*
Culture	Minimize physical, social, behavioural and psychological impacts Build cultural awareness and respect Actively contribution to the cultural heritage conservation Interpret the natural and cultural heritage of the destination to visitors Deliver memorable interpretative experiences to visitors that help raise sensitivity to host countries' political, environmental and social climates	**PAMAN**: CI; DMS; LBS; VT; VLE; SM; upload 3D images; video; online real time views; route mapping; cultural virtual tours; camera on sight records; create Game-based learning apps and games targeting in cultural conservation **LOCOM**: CI; DMS; LBS; VT; VLE; SM; GPS; Google earth; dynamic web maps; static web maps; photos; video; route mapping; geotagging; virtual tours; on line education/distance learning programs andwebinars for culture heritage conservation **TRAV**: CI; DMS; LBS; VT; WOM; VLE; SM; GIS; GPS; websites; newsletters; e-guide; route planner; Google earth; dynamic web maps; static web maps; photos; 3D images; video; online real time views; route mapping; geotagging; virtual tours; game-based learning apps targeting in cultural conservation **OLST**: CI; DMS; LBS; VT; VLE; SM; GIS; create websites; online destination networks; GPS; Google earth; dynamic web maps; static web maps; photos; 3D images; video; online real time views; route mapping; virtual tours; geotagging; participation to newsletters; e-guides; on line education/distance learning programs and webinars for cultural conservation
Education	Build environmental and cultural awareness and respect Interpret the natural and cultural heritage of the destination to visitors Educate all stakeholders about their role in conservation	**PAMAN**: CI; DMS; LBS; VT; MCT; create/use/shares educative video; audio files; create game-based learning apps and games targeting in natural and cultural heritage conservation; on line education/distance learning programs; webinars for management of PA; webinars for improving skills on ICT **LOCOM**: CI; DMS; LBS; VT; MCT; VLE; on line education/distance learning programs andwebinars for natural and cultural heritage conservation; game-based learning apps and games targeting in natural and cultural heritage conservation; webinars for improving skills on ICT **TRAV**: CI; DMS; LBS; VT; WOM; VLE; website; virtual tours; static web maps; interactive web map; GIS; educative videos; geocatching; game-based learning apps targeting in natural and cultural conservation; WOM **OLST**: CI; DMS; LBS; VT; MCT; VLE; on line education/distance learning programs and webinars for natural and cultural conservation; webinars for improving skills on ICT

(continued)

Table 2 (continued)

Ecotourism themes	Objectives	ICT-based tools/applications and Web 2.0 components*
Benefits to ecotourism stakeholders	Provide positive experience for both visitors and hosts Generate financial benefits for both local people and other stakeholders Recognize the rights and spiritual belief of the indigenous people in your community and work in partnership with them to create empowerment	**PAMAN**: EIAS; DSS; DMS; CI; CS; GIS; WLAN; SM; MCT; CMC; blog; forum; e-government; online evaluation; visual broadcasting of working conditions; internet banking; ICT for energy efficiency; eco-ICT **LOCOM**: EIAS; DSS; DMS; CI; CS; GIS; SM; MCTs; CMCs; blog; forum; e-government; online evaluation; visual broadcasting of working conditions; internet banking; Tele-health/Telemedicine **TRAV**: WOM; e-souvenirs shops; watching visual broadcasting of working conditions **OLST**: EIAS; DSS; DMS; CI; CS; GIS; WLAN; CRM; MCTs; CMC; blog; forum; SM; e-government; online evaluation; visual broadcasting of working conditions; internet banking; Tele-health/Telemedicine; virtual business clusters; ICT for energy efficiency; eco-ICT

*LOCOM, PAMAN, TRAV and OLST consist of groups of ICT-enabled tools and technologies that serve the needs of local community, PA managers and staff, travelers and local business stakeholders respectively

Wireless Environmental Monitoring This can assist to PA management, maintenance and enhancement of ecosystems, etc. by providing useful, accurate and up-dated environmental data (E). For example, a network of sensors can collect real time meteorological data and terrain information in order to assess the risk of forest fire in a certain PA and send this information for further analysis to a control center, using wireless communication. If the results indicate a critical situation, PA managers can warn visitors and increase human surveillance. In the same spirit, a sensor network can provide early fire detection.

Participatory Sensing Its use in a PA can raise the awareness of local stakeholders and/or visitors about ecosystem requirements (F). Visitors and the local community can become actively involved in the monitoring/conservation process, using special location-based applications on their mobile phones. For instance, participants can report their personal observations or measurements (e.g. digital photos and videos), which is useful for mapping and tracking flora and fauna activity and habitats. Such data can be uploaded to the Web or to special-purpose information systems, from which they can be retrieved and processed by the PA manager.

Geocatching It constitutes an activity that encourages interaction with nature (J). It is an outdoor recreational activity, in which participants use a Global Positioning System (GPS) receiver or mobile device and other navigational techniques to hide and seek containers, called “geocaches” or “caches”, anywhere in the world. By hiding geocaches in PA locations, the game participant interacts with and discovers nature in a playful way. At the end, the participant shares his experience online via the international networks and websites of this game. Geotagging (the process of adding geographical identification metadata to various media, such as a geotagged photograph or video, websites, SMS messages) should be incorporated in the smart ecotourism destination’s marketing plan.

Web Presence Awebsite containing information related to the PA can increase visitor awareness and understanding of an area’s natural heritage (K). The web-site’s content, appearance and functionality is of great importance as it can greatly promote the wider area, its unique environmental and cultural resources and its restrictions to visitors. Using the right website technology, very nice and rich web-sites can be typically maintained even on a very low budget.

Trail Web Maps These maps can be used by visitors to plan an excursion, but also during “exploration” of a PA via mobile devices, while at the same time maintaining ecological integrity (N). Information can also be provided in a dynamic way, based on the visitor’s current location, e.g. to point to paths and locations of special environmental or cultural interest.

Access to Health Services This serves one of the most important human needs and can be partly achieved in PAs by use of telemedicine services (O). It constitutes a quite important issue, as PAs are often remote areas, offering a rather limited access to more specialized health infrastructures and services. In such a context, a more safe visitors’ traffic in PAs can be assured.

E-offers Special offers addressed to visitors depending on seasonal demands can maximize short and long term benefits for visitors, providers, locals etc. (T). More specifically, one can promote a PA by targeting off-peak periods though a diversified activity offering, which in turn can reduce stress on the natural environment and local infrastructure; while achieving a more balanced inflow of visitors throughout the year. As an example, a PA that is typically visited for its beaches in summer could also be made attractive for hiking, biking, sailing and cultural events during spring and autumn.

Smart Buildings These can achieve high energy savings and efficiency; and should be considered when planning new tourism infrastructure in a PA (V). Energy efficiency is of crucial importance in an era of scarce resources, and hence every effort to reduce activities' ecological footprint is crucial. This holds even more so for PAs, which have an extra ecological dimension; and where smart buildings may reduce environmental impact as well as "educate" visitors towards a more environmentally-responsible use of resources.

E-guides They include do's and don'ts for visitors and contribute to awareness raising as regards the impacts and consequences of travelling in natural ecosystems (Y). Most tourism e-guides include some information about the area and available accommodation and service facilities. These can be augmented with rich multimedia information about the PA's environmental and cultural resources. Equally important, they should include information about do's and don'ts for visitors, so that they also become aware of the sensitivity of the PA and their "obligations" towards it.

Structured information provided by Table 2 (Appendix) can help Decision Support Systems' managers (DSS) in PAs and ecotourism destinations to identify themes, objectives and ICT-enabled tools for better management those valuable resources and grasp existing market opportunities; while also feeding other decision-making bodies' work for embedding specific needs and requirements of PAs and ecotourism destinations in the general strategy, planning and implementation of their policies. As Hall (2004: 147) states:

> Increased focus needs to be given to the formulation of the goals, institutional arrangements, instruments and evaluation of ecotourism policy, if it is to become more effective in meeting the needs and aspiration of the local communities that it is meant to assist consultants, policy makers and boosters, who are often the uncritical proponents of this policy.

4 Conclusions

The ICT framework approach for ecotourism proposed in the current work is simple: principles that need to be respected/enforced and their potential ICT-enablers are traced; and appropriate ICT solutions according to end-user(s) are selected. ICT solutions with the potential to be used in PAs can be classified along the lines of the five (out of the six) *eco-tourism tenets*, as proposed by Donohoe and Needham (2006) and according Fennell's *ecotourism pillars*, as indicated in Fig. 2. For every proposed element of the five tenets, a variety of ICT solutions can be adopted or developed for the specific needs of the PA in question. Indicative examples are given in the rightmost part of Fig. 2. While this *principle-based approach* can be used for ICT as well as non-ICT tools, in this study the focus is on ICT-based examples.

Priority and emphasis must be placed to ICT solutions addressed to the key stakeholders of PAs' management and preservation in order these to be applied to ecotourism destinations of their jurisdiction, so that relative ecotourism principles are properly respected. Secondary stakeholders may also use adapted ICT solutions for achieving ecotourism goals, but their role/involvement is (obviously) not as fundamental as that of key stakeholders.

In our attempt to categorize ICT solutions for a *smart ecotourism destination*, several issues/facts came up:

- Social capital of a PA refers to ecotourism stakeholders. They are, more or less, the end-users of potential ICT solutions for ecotourism in a PA. ICT tools can be specialized for a particular user group or be common for different groups.
- Principles must be safeguarded for ecotourism development to be successful. They are synonymous with ecotourism goals. Therefore each principle must be examined in order to adopt/develop the (ICT) tools that are most appropriate.
- Non-ICT and ICT tools for planning, implementing, managing, and monitoring ecotourism follow the same framework.
- Key ICT solutions for ecotourism could be important tools to regulate the eco-tourism development according to the current needs in a particular area.
- Key ICT solutions for ecotourism might refer to software, information systems, tools, applications, Web 2.0 components and so on; and/or a combination of them.
- Globally a huge variety of ICT solutions exists (and is constantly being improved and extended), some of which may be useful to PAs and their development.
- Technology needs to serve everyone and can be applied almost everywhere and for everything.

As already mentioned, the list of ICT tools contained in Table 2 is just indicative. The vibrant and ever ongoing developments in the area of ICT lead to the creation of numerous monitoring, computing, information management and information sharing technologies, which can be exploited for a variety of different purposes. However, there is no "silver bullet" and "no one-size-fits-all" blueprint to follow in order to properly plan, manage, promote and maintain a balanced eco-tourism development in a PA. The ultimate challenge remains open: namely, to understand the particular context of each PA system, and to carefully plan for its balanced development, as every PA is unique (Dearden et al. 2005).

Given the complexity of ecotourism activity, it is not only useful but also necessary to have a framework on which ICT solutions could be applied. This is important as (Donohoe and Needham; Dowling and Fennell; Fennell; as cited in Donohoe and Needham 2006: 193):

> Diverse interpretation of ecotourism causing a myriad of difficulties for managers and planners who are in need of operational guidance.

Introducing and/or enhancing technological involvement, especially in remote PAs and their communities is an indispensable and unavoidable task, especially when there is limited or no access to ICTs by local stakeholders. This conceptual paper sets a systematic framework and forms a basis for future research work on ICT solutions for ecotourism in PAs. Following an inclusive approach that is necessary in a PAs' management approach, the study considers all relevant actors that should be engaged in such a context, namely local community, PA managers and staff, travelers and other local stakeholders, e.g. ecolodges owners, as the main categories of ecotourism stakeholders and proposes examples of stakeholder-specific ICT-based tools/applications. In this respect, different groups of ecotourism stakeholders can be properly navigated to select the appropriate ICT tools, based not only on the particular developmental needs of their area, but also on aspects that cover their environmental, social, cultural, economic, technological, and political reality; thus broadening their perspectives towards sustainable ecotourism development paths.

Appendix I

See Table 2

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Maritime Tourism Development and Prospects in Coastal Cities: The Case of Heraklion, Chania and Limassol

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Abstract The paper elaborates on maritime tourism, i.e. cruising and yachting, in the Mediterranean Basin. Today, although maritime tourism is dynamically gaining ground in many Mediterranean cities, there is no specific regulatory framework for it yet, apart from European Union's recommendations, aiming at motivating countries to promote tourist development. The paper addresses the subject of maritime tourism by reviewing and analyzing the current or future implications that this sector has or may bring upon Mediterranean cities through three relevant examples, two from the island of Crete (Heraklion and Chania), and one from the island of Cyprus (Limassol). More specifically, through case study work, existing links of maritime tourism to the reality of the city; the benefits and drawbacks that the sector can have on the local economy; and its potential for future development are explored. The three case studies indicate that in order to maximize the benefits gained from maritime tourism by local societies and economies, a certain strategic planning framework should be established, broadening the interaction of maritime

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and land activities. Such a framework should be enriched by Marine Spatial Planning (MSP) principles as well as Information and Communication Technologies' (ICT) potential, steering "Smart" Tourism Development (STD) and fulfilling sustainability objectives i.e. marine and land environmental protection, spatial and social cohesion, as well as economic development of coastal Mediterranean cities.

Keywords Maritime tourism · Marine spatial planning · Smart cities · Smart tourism destinations · Heraklion · Chania · Limassol

1 Introduction

This research explores the maritime tourism sector in the Mediterranean Basin, representing an important "blue" growth opportunity for coastal Mediterranean areas. Maritime tourism covers predominantly water-based activities, for example sailing, boating, yachting, nautical sports and cruising in marine regions, such as the Mediterranean or Baltic Sea. This tourism segment incorporates also deployment and operation of landside facilities, manufacturing of equipment, and other relevant services (European Commission 2014).

The present paper is interested in two forms of maritime tourism in Mediterranean coastal cities: yachting and cruising. "*Yachting*" is the marine activity through which tourists use yacht boats for recreational purposes. The yacht boats provide accommodation and catering services. The advantage of this kind of leisure is that tourists have the opportunity to choose their destination according to their preferences. On the other hand, "*cruising*" is a different form of leisure. It includes special organized tours with cruise ships, which act as tourists' accommodation in the sea and provide tourists the chance to visit a range of different cities or places. Cruising allows visitors to gather experiences from a variety of places that would be hard to get to by land, especially in case of small-ship sailings that are able to maneuver through narrower waterways and dock at smaller ports.

Maritime tourism is a dynamic form of tourism in most Mediterranean cities. However, there is no specific regulatory framework for it yet, apart from European Union's (EU) recommendations aiming at motivating respective countries to promote tourist development. These recommendations underline the importance of sustainable maritime development in coastal areas, further stressed by means of the "blue growth" EU policy direction. Moreover, maritime tourism presents numerous and complex challenges related to sustainability. Tourism activities, especially when of massive forms, can set local ecosystems at risk and disrupt the pristine and fragile coastal areas, reducing thus their attractiveness and long term viable development patterns (ECORYS 2013).

The *purpose* of this research is to explore current inefficiencies but also benefits of maritime tourism as regards their role in coastal cities' development; and provide certain guidelines for better linking cruise and maritime tourism to the cities' reality. This will be accomplished by elaborating on three Mediterranean case study examples: two from the island of Crete, namely Heraklion and Chania, and one from the island of Cyprus, Limassol, in an effort to reviewing and analyzing the current or future implications that maritime tourism has or may bring upon coastal Mediterranean cities. Based on experience gathered from case study work, the scope is to identify the *building blocks* of a strategy for coping with inefficiencies and spreading benefits to coastal cities as a whole, so that a more structured and integrated maritime tourism management perspective in Mediterranean coastal cities to be achieved.

The *structure* of the paper has as follows: in the next section, Marine Spatial Planning (MSP) developments in the EU are discussed, as a ground for setting guidelines in respect of maritime development. Next the evolving concept of Smart Tourism Destination (STD) in a smart city context is shortly presented, followed by a systematic presentation of outcomes of case studies elaborated in this work. Then certain guidelines for enhancing maritime tourism development in coastal Mediterranean cities by means of strategic planning, embedding MSP and STD perspectives are put forward, while finally some conclusions are drawn.

2 Marine Spatial Planning (MSP) in Europe

Nowadays, Europe lacks of a specific regulatory framework regarding *maritime tourism*. Nevertheless, in the past years European Commission attempted to address the subject by issuing several policy texts with *guidelines* regarding sustainability of maritime tourism and cooperation between member states. In the following, it is shortly presented the effort of EU to tackle this issue through a number of initiatives and relating Communications and Directives, reflecting the large interest and the need to set up a common ground for member states' cooperation in this field.

In 2006, the Commission published the "*Maritime Policy Green Paper*", which refers to the different aspects of a future Community maritime policy. The Green Paper highlights Europe's maritime identity and aims regarding the achievement of sustainable development by reconciling the economic, social and environmental dimensions of the exploitation of the seas and oceans. Consequently, maritime policy aims at promoting a maritime industry that is innovative, competitive and environmentally friendly; and incorporates the issue of quality of life in coastal regions as well. Furthermore, the Green Paper considers what new tools and modes of maritime governance should be developed (European Commission 2006).

In 2007, the European Commission adopted the Communication "*Conclusions from the Consultation on a European Maritime Policy*", which refers to the one-year consultation that was launched with the adoption of the Green Paper on Maritime Policy (European Commission 2007c). Moreover, at the same year, the European Commission adopted the Communication "*An Integrated Maritime Policy for the European Union*", also known as the *Blue Paper* (European Commission 2007b); and a corresponding *Action Plan* (European Commission

2007a). The latter sets the ground for the clear recognition that all matters relating to Europe's oceans and seas are interlinked; and policies must develop in a joined-up way in order the desired results to be reaped.

A European Union Integrated Maritime Policy requires a governance framework that applies an integrated approach at every decision-making level, as well as horizontal and cross-cutting policy tools. Actions of such an integrated maritime policy are primarily focusing on five areas, namely: maximizing the sustainable use of oceans and seas; building a knowledge and innovation base for setting up maritime policy; delivering the highest quality of life in coastal regions; promoting Europe's leadership in international maritime affairs; and raising visibility of maritime Europe (European Commission 2007b).

The Action Plan enumerates a set of actions proposed by the European Commission as a first step towards the implementation of a *new, integrated maritime policy* in the European territory; and the means for the attainment of the key objectives of that policy. Among them are falling spatial planning, an integrated approach to data collection, processing and delivery; and the coordination of surveillance and monitoring activities and processes (European Commission 2007a).

In 2008, European Commission adopted the Communication "*Roadmap for Maritime Spatial Planning: Achieving Common Principles in the EU*", which puts forward a set of key principles for *Maritime Spatial Planning* (MSP); and seeks to encourage the development of a common approach among member states, implemented at the national and the European Union level (European Commission 2008). MSP is identified as one of the *cross-sectoral tools*, supporting the implementation of the Integrated Maritime Planning. It helps public authorities and stakeholders to coordinate their actions; and optimizes the use of marine space to the benefit of economic development as well as the marine environment protection. It provides a framework for dealing with competing human activities and managing their impact on the marine environment. Its goal is to balance sectoral interests and achieve sustainable use of marine resources, in alignment with the European Union's Sustainable Development Strategy (European Commission 2008).

In 2009, the European Commission adopted the Communication "*European maritime transport space without barriers*", which identifies all issues that European ports must resolve in order to meet the ever-growing demand for sea transport; copes with technological changes; and addresses the need to reduce emissions. The Communication sets out an action plan, while it also announces future legislative initiatives. The common aim of these initiatives is to set up a framework enabling European ports to achieve sustainable future development and attract the necessary investments that are vital for their modernization (European Commission 2009).

In 2010, the European Commission adopted the Communication "*Maritime Spatial Planning in the EU—Achievements and Future Development*", which seeks to outline the current context of MSP in the European Union from the experience gained since then (European Commission 2010). Based on that, one important conclusion is that the development of MSP processes by member states is already on the way, although different member states are following different paths and time scales. A more coherent common approach would be useful for significantly enhancing the potential value for the European Union as a whole, as well as for each specific EU sea basin context. The increased need for coordinated planning of sea basins, in the context of current economic developments and the implementation of European Union policies and legislation, would be strongly positively affected from MSP, since it would set out issues that facilitate cross-border cooperation among member states.

In 2011, the European Commission adopted the "*White Paper, Roadmap to a single European Transport Area—Towards a competitive and resource efficient transport system*", which further specifies the orientations of the Maritime Transport Strategy until 2018 (European Commission 2011). For implementing the vision of a single European Maritime Transport Area, a "Blue Belt" of free maritime movement in and around Europe should simplify the formalities for ships travelling along European Union ports. Moreover, a suitable framework capable of dealing with tasks for inland waterway transport as well as market access to ports needs to be established (European Commission 2011).

In 2012, the European Commission adopted the Communication "*Blue Growth—Opportunities for marine and maritime sustainable growth*", where the objective is to launch a joint initiative with member states, regions, and all relevant stakeholders to unlock the potential of the "*blue*" *economy*. Within this communication, the need for putting forward policy measures for the development of maritime tourism at a European Union level is considered as one of the "blue" economy priorities (European Commission 2012).

The same year, European Ministers for Maritime affairs adopted the "*Limassol Declaration; Declaration of the European Ministers responsible for the Integrated Maritime Policy and the European Commission*", namely a Maritime Agenda for growth and jobs to support Europe 2020 Strategy (Council of the EU 2012). In addition, the Commission identified that present legislative proposal is an essential part of the ambition to develop Europe's "blue" economy (European Commission 2012).

In 2013, the European Union with the Proposal for a Directive "*Establishing a framework for Maritime Spatial Planning and Integrated Coastal Management*", has set itself the goal to become a *smart, sustainable and inclusive economy* by 2020. Maritime sectors offer areas for innovation, sustainable growth and employment, which should contribute to this goal. The main purpose is to promote the sustainable growth of maritime and coastal activities; and the sustainable use of coastal and marine resources, by establishing a framework for the effective implementation of MSP in European Union waters and integrated coastal management in the coastal areas of member states (European Commission 2013).

In 2014, the Commission adopted the Communication "*A European Strategy for more Growth and Jobs in Coastal and Maritime Tourism*" (European Commission 2014), which focuses on the challenges to be addressed and proposes a strategy to enhance the sector's sustainability and competitiveness (European Commission 2014). The Commission will stimulate performance and competitiveness by improving knowledge, addressing demand volatility and overcoming sector fragmentation. Moreover, it will promote skills and innovation and strengthen sustainability by addressing environmental pressures; promoting an innovative, sustainable and of high-quality offer; and exploring opportunities in geographical constraints. At last, it will maximize available European Union funding by European Structural and Investment Funds (ESIF), and promote research, innovation and competitiveness, education, training and culture, environmental and climate change concern as well as other aspects. Furthermore, the Commission will ensure that coastal and maritime tourism is embedded in other European Union policies, like Intelligent Technologies connectivity, sustainable transport, safety issues and freedom of movement for workers. Cross-cutting policy aspects such as environmental protection, regional development, training, consumer protection and climate change mitigation and adaptation policies will also be considered.

The aforementioned Communication concludes that coastal and maritime tourism needs an *ambitious policy framework* for further reaping potential benefits. The Commission, member states, regional and local authorities, industry and other stakeholders must take targeted actions in coherence with other European Union policies that have an impact on this sector. The Commission will regularly monitor this process to ensure that actions are implemented (European Commission 2014).

Furthermore, in 2014, the European Union adopted the Directive "*Maritime Spatial Planning*", which aims to create a common framework for MSP in the European Union. The Directive focuses on the objectives of developing sustainable growth on maritime economies; promoting the coexistence of relevant activities and uses; and protecting and improving the environment, taking also into consideration resilience to climate change impacts (European Union 2014). According to this Directive, member states must adopt an *ecosystem approach*; take into account land-sea interactions, environmental, economic, social and safety aspects; promote coherence between MSP and the resulting plans and other processes; ensure an inclusive approach by involving all relevant stakeholders; organize the use of the best available data; ensure trans-boundary cooperation; and promote cooperation with third countries. EU countries are now obliged to transpose the directive into their national legislation and appoint competent authorities by September 2016. The implementation of MSP in member states' jurisdictional waters has to be achieved by March 2021 and to review these plans at least once every ten years.

Nowadays four European countries (Belgium, The Netherlands, Germany, and Norway) have implemented spatial plans for their marine jurisdictions. In two cases, Norway and The Netherlands, there are already in second or third generation. Three other countries (England, Portugal and Sweden) will implement marine spatial plans for their marine waters over the next few years. Over the next decade more than 40 countries will have produced about 60–70 marine spatial plans at the national, sub-national (territorial sea) and state or provincial levels (Ehler 2014).

In conclusion, it is a satisfactory outcome that the European Union has provided the *world's first legal requirement* for countries to create transparent planning-at-sea systems; and to cooperate with their neighbors to make that happen. This is a first step towards achieving the goal of sustainable development in coastal areas. A second crucial step is for the current policy directions to be implemented by each member state through the establishment of a MSP in alignment with the blue growth policy direction.

3 The Evolving Concept of Smart Tourism Destinations

The concept of smart cities has gained a great interest in the last few years, while it has received a variety of definitions by various researchers (Hall 2000; Giffinger et al. 2007; Hollands 2008; Washburn et al. 2010; Kourtit et al. (2012); Komninos et al. 2013). These definitions depict certain differences that reflect the way these are perceived by different researchers. However they all stress the importance of Information and Communication Technologies (ICT) as the backbone of a smart city that is used for the bettering of cities' performance in various sectors and city functions. Cities are evolving as smart when important sectors, such as the environment, energy, mobility, governance and the society can cooperate in a smart way, aiming at the sustainable development and the improvement of citizens' quality of life. The effectiveness of this cooperation is achieved through the junction of local innovative systems, networks and ICT applications.

Following developments of the smart city concept that cross-cuts all different sectors and functions within such a city; and by expanding the concept of smartness into the tourism sector, the concept of *Smart Tourism Destination* (STD) emerges nowadays (Buhalis and Amaranggana 2013). The term actually reflects the increasing reliance of tourism destinations, tourism industries and tourists on emerging forms of ICTs that allow *massive data amounts* to be collected, managed, transformed and communicated, properly forming value tourism propositions.

The aim of a STD is to support sustainable tourist development of destinations and improve the quality of experiences gained by tourists; while at the same time improve quality of life in the destination (Lopez de Avila 2015). Indeed a STD is characterized by innovative systems and modern qualitative infrastructure facilitating accessibility, interaction and integration of visitors with tourist destinations. It places emphasis on the broadening of tourists' experiences by establishing digitally-enabled communication bridges for bringing tourists closer to *residents, business community and cities' cultural and natural heritage*. This can be accomplished by means of digitally-enabled platforms; while upon such platforms information and data concerning city's assets and attractions, services, etc. can be exchanged instantly. Based on ICT-enabled innovations, destinations struggle to serve specialized tourism demand, outperform their competitors and fulfill long term prosperity.

4 Case Studies

In many coastal Mediterranean cities, maritime tourism (cruising and yachting) is the most important form of tourism. It is largely perceived as a socio-cultural activity that is closely related to the human desire for recreation, contact with the sea and acquaintance with foreign places and their cultural heritage. As such, it constitutes a major source for regional and local development too. Mediterranean coastal cities can be considered as privileged in this respect as, by properly planning this type of tourist activity, they can reap the benefits from developing as nodes of a maritime tourism network in the Mediterranean area. Nevertheless, it seems that such a perspective has not yet been fully grasped by many local decision-making bodies; while it has also not yet been fully realized the value of MSP as a significant planning tool for implementing this perspective; and deriving gains out of it for the local economy and society.

In the following, the maritime tourism activity is presented and analyzed through *three distinct case studies*; and an attempt towards its interpretation and identification of its pros and cons to both the locals and the visitors is undertaken. The selected case studies refer to three European Mediterranean cities, namely Chania and Heraklion in Crete Region, Greece; and Limassol in Cyprus, which currently host a range of cruise and yacht tourism activities. Greece and Cyprus constitute two of the most important tourist destinations in the Mediterranean Region, enjoying a global reach that is mainly emanating from the remarkable natural resources, the important historical trajectory and cultural heritage, the mild and mostly sunny weather for large time spans, the hospitality of local population, etc. Both have neither fully implemented coastal policy nor established an MSP. Apart from certain common features, the selected case studies exhibit different characteristics with regards to the spatial scale as well as the profile and attributes of the related city environments, the port and marina infrastructures established in each of them, the local economy, etc. Consequently, they provide a fertile ground for exploring aspects of maritime tourism and illuminating its potential bonds to the reality of cities in the contemporary world.

The structure of case studies' presentation has as follows: firstly an analysis of the current state of cruising and yachting industry and their links to the economic and cultural aspects of each specific area concerned is discussed, based on elaboration of data collected from multiple sources (literature, official sites, field work, etc.); then an effort to interpret findings is carried out, in order for meaningful inferences to emerge, with a specific focus on the benefits reaped but also the negative impact that maritime tourism has on the local economy as well as its potentials for coastal areas. The outcome of the field work has led to the identification of certain guidelines that could be implemented as well as a range of approaches and methods that could be developed to ensure that maritime tourism can add value and positively contribute to respective urban economies through successfully integrating maritime activity to the local urban environments addressed.

4.1 Case Study 1: Heraklion, Crete—Greece

Heraklion is the largest city and the administrative capital of Region of Crete. Located on the northern part of the island, the city constitutes a real attraction for visitors and an important, globally recognized, tourism destination, based on the harmonic combination of cultural wealth with good climatic conditions and an ever-changing landscape.

The port of Heraklion has an excellent geopolitical position in the middle of the southern eastern Mediterranean Basin. It is the main sea gate for passenger, cruise and commercial traffic in the whole Crete Region. Thus, the city of Heraklion is an attractive and welcoming Mediterranean maritime tourism destination.

Cruise ships, docking usually in the port of Heraklion, undertake mostly cruises of short duration (one week). Along these trips, cruise ships sail among ports, which are located to neighboring regions e.g. cruises around the Greek islands. Moreover, at the port of Heraklion come along cruise ships, which undertake a seven days cruise in the Mediterranean Sea, usually docking in a number of ports of South Europe, North Africa, West Asia, Cyprus and Malta (MedCruise 2016b).

As far as the current *port infrastructure* is concerned, there is a passenger terminal of 2500 m^2 in the port area. It is rather well organized and provides all services recommended by the Schengen Convention (control of visas, special controls etc.); and demanded by the cruise industry (passenger identification, control of luggage etc.). Furthermore, there is a special space for passengers, who start their cruise trip from Heraklion (home port) in which embarkation (check in) and baggage are controlled. There are also shops with local products, cafes, snack bars and souvenir shops. Services related to the rent of cars, taxis and tourist buses are provided too. In the terminal, there is a special kiosk, where passengers can be informed about the city. Tourists can find for free maps of the city, Wi-Fi internet access point, automated teller machine (ATM) services and lockers.

Public transport means are available—a bus stop inside the port area—connecting the port to the city centre. The bus station is nearby and can be reached by foot.

The marina of Heraklion is quite small and not well organized. It is located at the old part of the port in front of Koules Fortress. It hosts a small number of yachts and sailing boats; and it provides parking, electricity and water, as well as oil and gas supplies.

Socio-economic Profile of Cruise Ship Passengers In the past, cruising was considered as an activity addressing only affluent social classes. Nowadays, the growth of the cruise industry has resulted in rendering cruising a familiar and friendly way of travelling, which can be addressed not only to high income classes, but also to the ones of middle income, since it offers the opportunity to cruise at rather affordable budgets. According to the results obtained by field work about cruising in the city of Heraklion, cruise ship passengers' age groups vary from 35 to 55 years old. They were of average income and of high educational level. Moreover, it was noticed that a notable number of visitors were families.

Cruise Timetable The port of Heraklion functions mainly as a transit port. According to the results of fieldwork, the cruise ships dock at the port for a rather limited time, pre-defined by the cruise schedule. The cruise ships anchor in the mornings and passengers disembark. They are usually obliged to pass through the custom office. In the afternoon, new cruise ship passengers may join. The ship leaves the port late in the evening. So cruise ships remain at the port of Heraklion for approximately eight hours.

Cruise ships offer accommodation services, so tourists are getting all main services inside them (accommodation, dining and entertainment). When not on board, passengers are usually moving around in groups, following a pre-arranged program. They visit destinations of local importance, like well-known archaeological sites, museums, areas of natural value, religion monuments; while they do their shopping in the port neighbourhood. Ship crews spend also several hours out of the ship, a fact that implies a certain economic footprint on local community too.

Interaction of Cruising and Yachting Tourists with the City of Heraklion The field work revealed that passengers tend to gather in specific parts of the city. They often take a walk from the port to the city center and spend most of their time at the paved street of 25th August (Fig. 1). There, a lot of souvenir shops, cafes and snack bars offer services and goods to the cruise tourists. Moreover, cruise tourists visit only the nearby monuments and famous archaeological sites, strongly recommended by the travel agencies, such as the Archaeological Museum and the Palace of Knossos in order to get acquainted with important cultural heritage monuments of the city.

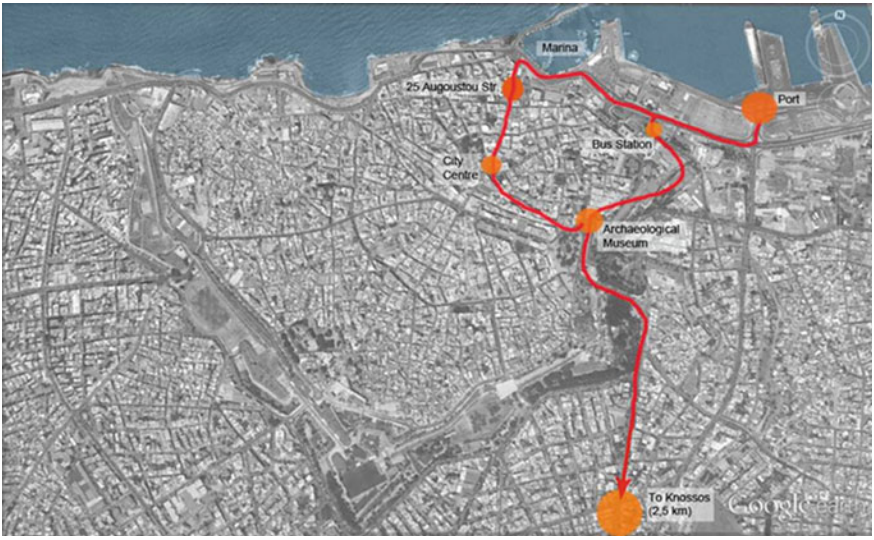

Fig. 1 Interaction of cruising and yachting tourists with the city of Heraklion, Current Situation

Benefits and Drawbacks of Cruising and Yachting Tourism in the City of Heraklion Cruising has a continuing positive growth over the past years. As can be inferred from Fig. 2 (Port Heraklion 2016), there was a notable increase of cruise ships arrivals at the port of Heraklion during the autumn period of 2013–2015 (months September to November) and the spring period of 2013–2015 (months March to June). This means that cruising tourism has contributed to the prolongation of the area's tourist period beyond the peak summer season, which is usually between June and September; and thus has positively affected local development objectives.

To the *positive impacts* of cruise ship tourism can be incorporated the *new job creation*. Shops, restaurants, bars, transport services, tour guide agencies of the city etc. have recruited additional staff in response to the rising cruise tourists' traffic. Thus, several new professions have emerged in the local labour market in support of the growing cruising tourism interest; and new business opportunities have emerged. Moreover, the strengthening of interest for maritime cruise tourism and the respected increase of the number of tourists visiting the city has positively affected the implementation of *regeneration projects* transforming city's image; as well as *restoration projects*, targeting the protection and designation of natural and cultural resources of the city, both aiming to reinforce city's attractiveness to visitors. These projects have led to the regeneration of the coastal zone and the further highlighting of the built cultural heritage. This, apart from improving the overall image and identity of the city, has furthermore improved the quality of life of residents, promoting local pride and motivating people to cooperate towards the enhancement of economic and cultural development.

However, cruising and yachting tourism in the coastal city of Heraklion has also exhibited certain *negative impacts*, which could be summarized as follows: the limited time cruising tourists have to move around the city, forcing them to remain only in its central part, results in an unbalanced sharing of gains by the local economy, gathered mainly by a small number of local stakeholders, who are located at the heart of the city. Moreover, the most attractive city pathways (e.g. 25th

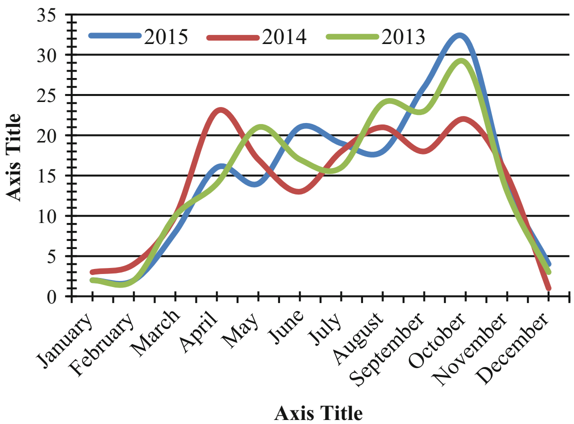

Fig. 2 Quantitative characteristics of cruising in Heraklionin the time span 2013–2015 (Port Heraklion 2016)

August Street) obtain a strong tourist character, which contradicts other city functions hosted in the surrounding area (banks, offices etc.); causes problems in the everyday life of the locals (crowding, traffic jams, noise etc.); distorts local real estate market and land uses etc. Furthermore, the strong orientation of visitors towards specific heritage sites of utmost importance (e.g. the Archaeological site of Knossos or the Archaeological Museum) impedes them from developing substantial links to local culture and identity, thus negatively affecting the quality of visitor's experience; while threatening respective sites with a possible deterioration due to overcrowding.

4.2 Case Study 2: Chania, Crete—Greece

The city of Chania is located in the western part of Crete and is the capital of the regional entity of Chania. It is the second largest city of the Crete Region. It spreads out along the northwestern coast of the island in several district areas, including Akrotiri, the large peninsula where the airport is located and Souda in the north-western coast, hosting the port of Chania city.

The port of Souda is the biggest natural port of the Mediterranean Basin and a well-protected one. The port, located at a distance of 7 km away from the city of Chania, has a perfect location, with close proximity to the most popular ports of the surrounding area such as the Aegean Sea, the Ionian Sea, Italy, Turkey, the Middle East and the North Africa (MedCruise 2016c).

The city of Chania, on the other side of this peninsula, and open to the sea, is an attractive maritime tourism destination, with marinas and beaches attracting potential visitors. The most famous marina of Chania is the Old Venetian Harbour, where are hosted the remains of several coastal buildings from the Venetian era (Chania Municipality 2016). A floated dock marina welcomes yachts and motor ships to the Chania Old Venetian Harbor. It is placed in front of the "Arsenals" old warehouses, giving the sea visitors a sense of a different era.

By assessing port and the marina infrastructures it can be inferred the following: Souda port is lacking all necessary facilities for cruising tourism, namely facilities that are mandatory by law (passport control, individual expert control, etc.) and are required by the cruise industry. Same holds for the Old Venetian Harbour, which operates as a marina for yachts and small cruise ships. However, according to the Association of Mediterranean Cruise Ports (MedCruise 2016c), a small renovation project is being undertaken in the Souda port, aiming to improve port services.

Services provided to maritime tourists are limited to information desks in the port station to guide them to the city; and transportation means nearby like bus station, taxi service and car rental for serving their transportation to the city center. The bus stop from Souda to Chania Central is about 50 meters' distance from the port, a relatively small distance. When a cruise ship arrives at the port the frequency of the public bus service is increased (buses every 5 min). In the wider port region there are few rather unorganized restaurants and cafeterias.

Socio-economic Profile of the Cruise Ship Passengers Cruises in Chania attract mainly families, although in recent years it is also an attractive option for young people of age groups between 25 and 35 years. At the same time, it attracts people with high income and often a satisfactory level of education. This kind of tourists is capable of spending decent amounts of money in order to satisfy their varied interests and get around the city to explore attractive destinations.

Cruise Timetable In Chania, cruises usually make short stops for a limited time, with passengers having actually a few hours at their disposal. The average staying time in the city of Chania is approximately eight hours. The cruise ship passengers usually arrive at the port early in the morning and leave in the afternoon. Furthermore, some cruise ships moor in the midday, disembark passengers in the port and sail late at night. The cruise ship passengers receive most of the services during cruising. Outside the cruise ships, they are acting mainly as organized groups with a specific time schedule and program.

Interaction of Cruising and Yachting Tourists with the City of Chania By visiting Chania, the cruise and yachting tourists have the possibility to undertake many activities and visit places of cultural interest. The city has a unique beauty, rich cultural heritage, and several beaches, a combination that forms city's identity and supports local economic development. The city of Chania is a crossroad of religion and civilization with a long history, offering fascinating historical and natural destinations.

Some notable sights include the remains of the Venetian "Arsenal", where ships were once being constructed and repaired; the huge municipal market; the Chania Archaeological Museum, which is considered one of the best small museums in Europe, and the Maritime Museum; the Ancient Hellenic city of Aptera and the Monastery of Ag. Triada (Fig. 3). To the western part, there are a number of attractive beaches, while at the city's outskirts is the Botanical Garden, the

Fig. 3 Interaction of cruising and yachting tourists with the city of Chania, Current Situation

impressive Samaria Gorge, and the caves at Kournas Lake (MedCruise 2016c). The old city, which is a complex of alleys and houses, and the city center expand around the Old Venetian Harbour. In particular the old city, standing for many hundred years now, has been rebuilt, ruined and built up again, a fact that has given the city a flavor and evidences from different eras. The buildings date back to the 17th century, when the Venice Republic bought the island of Crete and developed Chania as a major center for ship building and trade. Old city is full of shops selling souvenirs and local products, providing cruise ship passengers the chance to hang around and do some shopping, a fact that has a positive economic outcome for the local economy. Furthermore, cruise tourism has fuelled the creation of a range of professional activities in support of cruise and yacht tourists' needs, such as restaurants, cafe and craft shops.

In Chania there are many landmarks of supra-local importance, such as famous archaeological sites and museums, "Natura" parks, monasteries and religious monuments that can be visited by cruise ship passengers. What has been observed by field work is that tourists usually visit certain major destinations in the city, which are mainly located around the old port of Chania and receive higher rates of visitors, compared to the other city destinations.

Benefits and Drawbacks of Cruising and Yachting Tourism in the City of Chania Cruising in Chania consists of an important form of tourism and has a noticeable growth over the past years. According to CLIA (Cruise Lines International Association), the port of Souda was among the *ten first destinations* for cruising tourists for the time span 2013–2015. The Hellenic Ports Association (ELIME) notes that in the year 2013 forty seven (47) cruise ships arrived at the port of Souda, a number that decreases to only thirty eight (38) ships in 2014; while is considerably recovering by 2015, reaching the number of fifty nine (59) cruise ships. The aforementioned information implies a considerable scaling back of the number of ships arriving at Chania port in year 2014 (Fig. 4). This was mainly the outcome of a certain cruise ships companies' policy, marking a shift in cruise ships' routes from the Mediterranean Basin to the Caribbean that was due to the geopolitical tension in North Africa and Middle East countries. The scope of such a policy

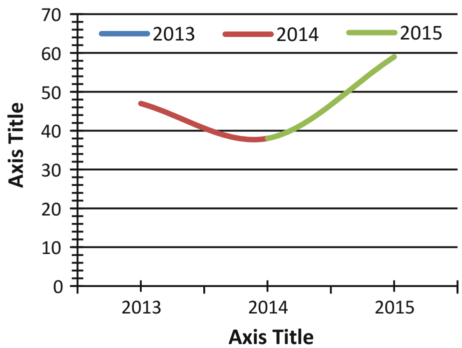

Fig. 4 Arrival of cruise ship passengers at Souda, the port of Chania (ELIME 2015)

was to avoid unpleasant situations and ensure safety of cruise travelling, a fact that has changed later on and has driven to a remarkable increase of cruise ships arrivals in 2015 (ELIME 2015).

Speaking of the *positive impacts* of the notable cruising maritime tourism on the city of Chania, it could be stated that this has added value to local economic development, while broadening the tourism portfolio of the area and supporting local income as well as reversal of tourism seasonality. Escalating number of cruise ships' arrivals provides a positive sign of the attractiveness of the city and its potential in this type of tourism; while also depicts willingness of cruise tourists to gather tourist experience exuded from the abundance of Chania local assets. The surrounding area of Souda and the city of Chania receive most of the benefits reaped from the rising of cruising and yachting tourism.

On the other hand, the way tourists experience the city results to a limited spread of related benefits, linked to the concentration of visitors in certain specific city places. Such a concentration is mainly due to both the lack of awareness on the whole spectrum of cultural and natural assets of the region; and the excessive advertising of certain famous sites, attracting tourists' interest. This however confines the effective interaction between visitors and the whole city; and limits gathering of tourists' experience that can be gained by hanging around in other, very special attributes of the city, such as specific monuments or landmarks. Additionally, the extensive port infrastructures required for serving a further escalating load of cruising ships, in combination with the infrastructures of military base in Souda bay, can potentially lead to the aesthetic deterioration and pollution of the whole area; while can place at risk the unique beauty of the natural coastal environment.

4.3 Case Study 3: Limassol—Cyprus

Limassol is situated in the southern coast of Cyprus and is the second largest city of the island, with 180,000 inhabitants (CyStat 2014). The increasing appeal of the city to a wide range of tourists has, in recent times, rendered Limassol an important destination for cruise ships heading towards Greece, the Greek islands and other Middle East countries. The port of Limassol in the southern coast of Cyprus is a deep-sea multipurpose port which, due to a variety of reasons, has throughout the years been established as the maritime capital of the Cyprus state.

At the time of writing this paper, the Cypriot Government has undertaken all actions required to proceed towards an agreement with major investors for the partly privatization of the Limassol Port. Three possible investors have been selected through a bidding process for the three areas of the port: the Port's container terminal, the marine services and the multipurpose passenger terminal (CNA 2016). The official propositions will be submitted at the House of Representatives (Savva 2016). Whatever the outcome of this process is, the fact remains that Limassol Port has gained a vital importance for Cyprus; with efforts constantly being made towards modernization and further development of the shipping industry.

Another project that officially opened in June 2014, and is expected to strengthen level of maritime tourism in the near future, is the Limassol marina. This project positions Cyprus on the nautical yachting map. The marina has a capacity of 650 berths; and constitutes the only new development in the Mediterranean Sea that offers private berths directly attached to waterfront residences. Furthermore, the master plan of this project includes a pedestrian promenade, restaurants, cafeterias and clubs, shops and boutiques, a cultural centre, a public parking facility and all-day round security services (Cyprus Profile 2012).

Adjoining in Limassol Marina is the area of the Old Harbor, where new constructions and renovation actions, carried out during the past years, have recently been accomplished. When fully opening to the public, the area will offer a variety of services, such as cafeterias and restaurants; and land uses in the form of open space squares and areas for cultural events, offices, etc. (CPA 2016b).

The aforementioned development projects that have recently opened to the public or are now being constructed will contribute to the improvement of the image of Limassol city as a tourist destination. In combination with other major projects, currently undertaken in the country, and according to Angelos Loizou (Cyprus Profile 2016), chairman of the Board of Directors of Cyprus Tourism Organization, the image of Cyprus as a tourist destination will be even more strengthened, presenting a *competitive edge* against other destinations in the Mediterranean Basin (Cyprus Profile 2016). However, if proper planning is not carried out, the expected increase in cruise ships and yachts tourist flows may cause reverse effects than those expected in the whole area.

In the port area, a new passenger terminal is already being built, with a total surface of 6800 m^2 that aims at positively affecting service provision to cruise passengers. In addition, this project can distinguish the commercial from the passenger's part of the port. The terminal will be compatible with the criteria that are set by the Schengen convention; and follow the safety and security requirements that are set by the European Union (CPA 2016a). However, controversial opinions exist regarding the magnitude of the project, taking into consideration its real application and expected use by passengers.

Socio-economic Profile of the Cruise Ship Passengers According to field work, cruises in Limassol attract mainly people around the ages of 35–55 years, well-educated and of high average household income.

Cruise Timetable The passengers of cruise ships arrive at the Limassol Port Terminal, and a bus station nearby, accessible on foot, provides easy transportation to the city. Currently existing facilities that are provided to passengers are, among others, a tourist information counter, lounge and cafeteria.

Interaction of Cruising and Yachting Tourists with the City of Limassol Taking into consideration the limited amount of time that potential visitors have at their disposal during their cruise trips, Limassol city areas rating high in their preferences are mainly located in the old town. More specifically, these areas refer to the Old Harbor and the Limassol Marina; the square of the Medieval Castle; the Saripolou Square; the Old Market Square; the Hero's Square; the pedestrian street of Ag. Antreou; the seafront linear promenade; the Garillis linear park; and the Municipal Garden. These areas offer a variety of cultural, recreational and leisure options, with restaurants, cafeterias, bars, playgrounds, theatres, museums and galleries. Furthermore, they incorporate important buildings and monuments that are associated with the historical heritage of the city. Some of them are the Medieval Castle, the Agia Napa Church, the Tzami Kepir, the Municipal Market, and public buildings like the Courthouse, the Postal Office and the Town Hall. These attraction points are easily accessible by foot, available public transportation means and bicycle.

Benefits and Drawbacks of Cruising and Yachting Tourism in the City of Limassol Port gains a relatively higher traffic in terms of cruise passengers. In particular, during the first half of 2015, Limassol port was visited by five times more passengers than the port in Larnaca (CPA 2015). Generally, this port handles approximately 80% of the country's cruise passengers (CyStat 2015). Limassol port functions as a point of embarkation, both for itineraries based in Cyprus and international cruise routes (MedCruise 2016a). Hence, Limassol city was selected among other Cypriot port cities for further review and analysis, based on the dynamic trajectory that maritime tourism has in this city.

Nowadays, the spatial concentration of, mainly mass, tourism activities in particular coastal areas of the city has caused functional and environmental problems; while the absence of a highly diversified tourism product and the lack of new alternative forms of tourism, targeting niche markets, deteriorates tourism seasonality problems. Drawbacks emerging due to the tourist model promoted so far have certain negative consequences that affect the economic and social development as well as the environmental quality of the city. In the old town center, i.e. an easily accessible area from cruise passengers, the local authorities promote development projects as regards central activities and services of the city, with the aim to upgrade the image of the urban center and improve services offered to various types of tourist categories. As maritime and yachting tourists have different attributes and needs, the challenge is to embed them in such developments; and create a positive and vivid interaction between them and the locals.

5 Experience Gained—Guidelines for Enhancing Maritime Tourism Development in Coastal Cities

Comparing the three city examples, two of medium size (Heraklion and Limassol) and a smaller one (Chania), it is noted that the cities of Crete appear to have a significant growth in cruising tourism during the last year, unlike the city of Cyprus, where a decrease is observed (Fig. 5). Nevertheless, according to the preceding

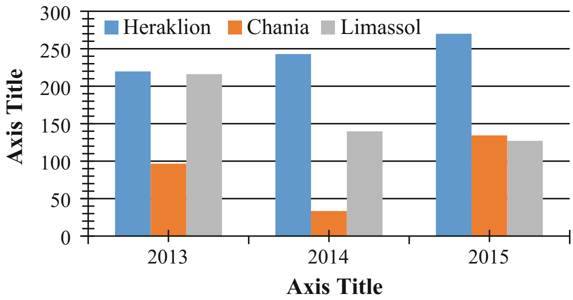

Fig. 5 Arrival of cruise ship passengers at the ports of Heraklion, Chania and Limassol—Time span 2013–2015 (CPA 2015; ELIME 2015) (*Note* for comparison reasons, 2015 arrivals in Limassol are estimated according to the first half of the same year)

qualitative analysis, all cities face numerous and similar problems as regards the way they manage to plan an attractive local tourist product for directing cruise ships itineraries to these cities and spreading the benefits to local societies.

Firstly, all three cities have *problems* in respect of land connections, which prevent cruise tourists to access more attractive and interesting points in and out of the destination cities. Due to the inefficiency of transport infrastructures, the tourists visit only specific areas in each city, attractive for shopping and sightseeing, and do not have the opportunity to experience the authenticity of the city, the origins of things and places, the native people, their culture and history. The tourist areas are not managed in a way to benefit local economy as a whole; and to ensure a balanced share of the benefits reaped from cruise tourism among different parts of the city.

Another *similarity* is that all three cities lack of efficient and qualitative marketing services for effectively promoting their cultural heritage. The cruise tourists visit only the monuments and famous archaeological sites that are best marketed and are located in or nearby the coastal zone. However, other archaeological sites or monuments or cultural resources at large, same well preserved and in close distance, are often insufficiently explained, difficult to access or there is neither information nor publicity on them. Moreover, the local production is not well highlighted. There are just a few authentic shops at the coastal zone, selling local products and providing information as to local ways of production.

As far as the *differences* are concerned, Heraklion and Limassol appear to have more effective infrastructures and better port facilities than Chania. This occurs due to the fact that these two ports play a central role in the respective islands' maritime industry.

More specifically, *Chania* has less developed infrastructure both in quantitative and qualitative terms; and therefore gets a smaller portion of maritime tourism market. However this city, due to its small and thus friendlier scale and vitality as well as the notable architecture, earns the benefits of locality and exhibits a larger potential to create an effective interaction among cruise visitors and the locals.

On the other hand, *Heraklion* has better infrastructure and the ability to serve an increased number of passengers, interconnecting surrounding areas and working as a transit station. However, this fact creates great functional problems in the city, since the diffusion of maritime visitors is rather ineffective; and negatively affecting the everyday life of locals as well as the authentic experience tasted by visitors.

Limassol has also better infrastructure, while forthcoming plans' deployment for further modernization of facilities and services are expected to diversify and increase its strength and qualities to attract cruise tourism. In addition, the city's coastal zone is more developed, better planned and offers tourists a wide variety of activities' options. However, the city needs to put forward actions targeting a planned diffusion of visitors in order to avoid problems similar to the ones faced by the city of Heraklion in the near future.

The above results outline the current state of maritime tourism activity in all three cities as well as their similarities and differences. Moreover certain inefficiencies are also revealed, with a prevailing one being the unequal share of benefits of maritime tourism activity to the local economy and community. This is largely explained by the lack of interaction of maritime tourism activity with cities' structure, culture and real identity, confining thus the grasping of authentic tourist experiences. Nevertheless, the previously described case studies have also depicted the potential of maritime tourism in Mediterranean coastal cities.

According to the results obtained, maritime tourism management seems to be confronted with certain difficulties; while it is obvious the lack of systematic planning efforts and of an integrated strategy for paving the way towards a more promising maritime tourism development to the benefit of the Mediterranean cities involved. This may occur due to the planning and decision-making constraints applying in such a topic as well as the lack of an integrated planning approach linking, in a cohesive way, land and marine resource development and potential. The aforementioned weaknesses lead to a more or less unplanned spread of cruise ship visitors in the city, usually marked by negative outcomes in the welcoming destinations due to the minimization of positive interaction among the visitors, the local society and the economy. In that way, the social and economic benefits of maritime tourism are, most of the times, unevenly shared by local societies, with gains embraced by certain particular groups. Therefore, it is imperative for coastal cities to establish a certain *strategy* that could enhance positive relationships and interactions between cruise ship visitors and local communities, for achieving sustainable and evenly distributed local development objectives; increasing visibility and attractiveness of various parts of the city according to resource availability and potential; and reinforcing the benefits that maritime tourism can bring to local societies.

In the following, certain *recommendations*, emerging from the experience gained by case study work, are presented for enhancing maritime tourism development in coastal urban environments that can be perceived at the *building blocks* for a more efficient maritime tourism management perspective.

A first recommendation refers to the development and successful implementation of a *strategic planning framework* as regards tourist development in general and maritime tourism in particular; with emphasis placed on the sustainable management of land and marine natural and cultural resources as the basis for building up attractive, authentic, experience-based and integrated tourist products.

Development of such a framework presupposes that each Mediterranean coastal city could create its own strategy, formulated in alignment with the city's vision and myths, development perspectives and paths as well as specific attributes and competitive advantages; while being in alignment with external developments in both the sector and the global scenery as well (economic recession, climate change, marine protection regimes, "smart" developments, etc.). Within such a framework, promotion of sustainable maritime tourism can be further facilitated by means of the *MSP*, as a necessary step and an obligation of each Member State by 2021 (European Union 2014). Embedding MSP into the strategic planning framework will support sustainable exploitation of marine and land resources; enhance interactions of land and sea and thus integration of respective tourism activities; and fairly distribute positive outcomes to local communities, while ensuring authentic tourism experiences for visitors of the city to be grasped.

The main goal of such a *strategic planning framework* should be the integration of marine and land tourism activities; and the spreading of marine tourism gains to the local economy and society. For this goal to be achieved, a range of planning interventions need to be in place that can relate to the: improvement of urban design in order to effectively link the land and marine part of the city; increase of urban transportation efficiency for assisting unimpeded movements of maritime tourists throughout the city; provision of easily accessible digitally-enabled information and content as to the city's landmarks and the possible transportation options to reach them etc. Internal capabilities should be realized in this respect, steering the promotion of city's strengths as well as the improvement, wherever possible, of its weaknesses.

Spreading both maritime visitors and related gains throughout the whole city is a desirable end state in coastal city environments. To achieve this, a challenging option can be the creation of a *network of routes* in the city, either alternative or thematic, incorporating important monuments, archaeological sites, areas of natural interest, religion monuments and other attraction points and landmarks of the coastal destination (see indicative proposed network of routes for the cities of Heraklion and Chania in Figs. 6 and 7 respectively). Such a network can support a more holistic and properly planned set of options to maritime tourists; while it has to be flexible in nature and reproduce the city's identity and attributes, enlarging thus the interaction among the city, the locals and the visitors. Furthermore, it can support visibility and attractiveness of local assets as a whole, enhancing thus the spreading of both visitors and benefits reaped. These networks could facilitate the integrated management of coastal cities, while enabling functional linkages between ports and marinas on the one hand and specific points of interest throughout each specific city on the other hand, to be established. Thematic routes, created in the context of inner city networks, target different maritime tourists' interests and allow intercultural communication among the locals and the visitors. Developing of such networks and respective routes needs to be a *cooperative effort*. This implies a human-centric approach, i.e. a focus on citizens and stakeholders engagement, in order conflicts emerging among different stakes to be minimized; participation in co-design of the image and identity of the city for marketing purposes to be

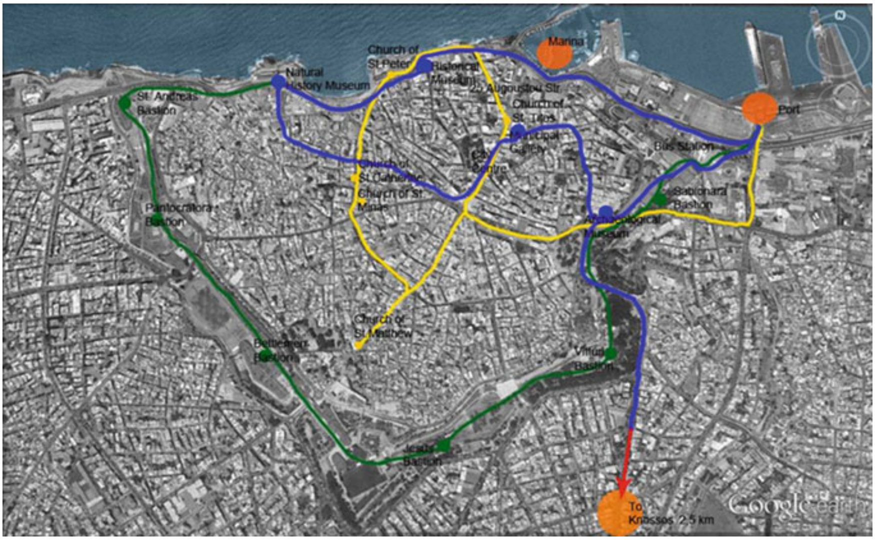

Fig. 6 Proposal for the city of Heraklion

Fig. 7 Proposal for the city of Chania

activated; and engagement of citizens and local stakeholders in the creation, maintaining and updating of *content* of the proposed city network through crowdsourcing to be broadened (Buhalis and Amaranggana 2013).

Taking a step further, quality of experience that maritime tourists can gain from coastal cities can be further enhanced by embedding the concept of *smartness* into the city itself, rendering it a *smart tourism destination*. As smartness is based on three main pillars, namely the human capital, the infrastructure and the information

(Komninos et al. 2013), this implies the need for creating the necessary ICT infrastructure—the backbone of smartness—and using this for the bettering of services provided to both locals and visitors (Net!Works 2011); and the improvement of city functions' management for enhancing potential experience. Coastal cities as STD can use technology-embedded environments, responsive processes, end-user devices and engaged citizens and stakeholders towards the enhancement of tourism experience. The latter can be accomplished through the deployment of intelligent platforms for collecting and distributing data and content regarding the destination. Use of such platforms by maritime tourists can open up the variety of options available (e.g. routes of the network, landmarks) for authentically experiencing the destination; provide further information in various forms (text, images etc.) as regards these options; and support more informed decisions and creation of personal itineraries, based on personal preferences.

6 Conclusions

Sustainable management of the maritime tourism sector is an essential prerequisite for the future development of Mediterranean coastal cities. This can be established by means of a strategic planning framework, implemented by each coastal city, as a means for further exploiting, in an environmentally responsible way, blue growth potential and opportunities and effectively linking them to local urban development perspectives. Development of such a framework can be accomplished in parallel and in alignment with the MSP that each Member State must develop and implement, while the latter facilitating development and implementation of the former. The main goal of this strategic planning framework should refer to the establishment of effective linkages between marine and land assets and activities, in support of a purposeful, planned and respectful spread of the benefits of maritime tourism in coastal urban environments. This can be pursued through the development of an inner city network, embedding local assets in a structured and integrated way in order for attractive thematic routes, fulfilling maritime tourists' expectations and strengthening authentic experiences, to be established.

Moreover, taking into consideration the current digitalization options and supporting network technologies, as well as the fact that tourists nowadays appear as 'mature consumers', i.e. more experienced, sophisticated, educated, knowledgeable and demanding, seeking information on destinations through ICTs in order to support relevant choices, emphasis should be placed on ICT-enabled visualization and marketing of those routes. This implies the need coastal regions to additionally embed *smart tourism* perspectives in their strategic planning, pushing forward the development of relevant infrastructure projects and content; and using technological advances in order to increase visibility and digitally-enabled accessibility of spatially-related urban tourism products through the Web. Hence, the concept of STD becomes a reality, in support of pursuing economic, social and spatial cohesion of the coastal city environments.

While this research outlined the selected subject and identified areas of improvement, it still has certain limitations. Since the analysis of case studies is based on empirical work, a more in-depth research should be carried out for further improving recommendations made. Moreover, it would be interesting to see the interaction among ports and coastal cities located close to each other. A future research direction could explore and compare various case studies according to their geographical position in the Mediterranean basin, for example the Aegean, Ionion, Adriatic, Ligurian, Tyrrhenian, Alboran and Balearic Seas.

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Part II
Data Management in the Context of Smart City and Insular Communities

Business Route Planning Using GIS Technology: The Case of Footwear and Leather Retail Stores in Central Athens

Kleopatra Tzima, Iris Polyzou, Yiota Spastra, Thomas Hatzichristos, John Sayas and Valia Aranitou

Abstract This chapter presents research aimed at highlighting and connecting retail trade related businesses located in close proximity to each other in central Athens, through the design and mapping of shopping routes. The purpose of this research is to stimulate consumption in small and medium-sized retail stores by integrating shopping with other elements of the city space. The methodological approach that was followed includes spatial analysis methods using Geographic Information System (GIS) for the accurate delineation of routes through the combination of quantitative and qualitative criteria such as: thematic identity of route and the participating retail shops, location and spatial concentration of stores, proximity of retail shops with complementary economic activities, availability of public space, public transport network and proximity to cultural activities. These criteria were taken into account for the definition of a final composite index that highlights areas with high suitability for the shopping routes. Indicatively, this chapter presents one such route based on the theme: "Retail of footwear and leather

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goods". In this framework, all stages of spatial analysis processes are presented, i.e. the selection of the appropriate criteria, the delineation and mapping of the shopping route.

Keywords Shopping routes · Retail trade · Urban space · Spatial analysis

1 Introduction

The present paper is based on a research program entitled "Study for the Analysis and Design of six Business Routes in the Municipality of Athens". The main aim of the project was to analyze the *commercial landscape* of the city and to propose alternative ways of reinforcing the small and medium scale enterprises of the city center. Specifically, the study focuses on *business route planning*, analyzing spatial characteristics of central commercial areas that are mostly affected by the current economic crisis. In fact, more than 26% of the stores of the city center remain currently closed (ESEE 2015).

According to the relevant literature, the high vacancy rates are related to the expansion of shopping malls in the periphery, as well as the creation of new commercial areas, located outside the traditional commercial core of the city. Since 1970 up to date the municipality of Athens is no longer the predominant retail center and has, progressively, lost its attractiveness (NTUA and ESEE 2012). Moreover, the closed stores and services in the city center reflect the impact of the recent economic crisis: on the one hand the clientele progressively diminished and, on the other hand, many entrepreneurs fail to cope with this new economic reality. As the studies conducted by the ESEE from 2010 until today show (INEMY-ESEE 2016), the retail sector is mostly affected.

The *focus* of the present work is on the design of business routes as a means towards highlighting the commercial densities of the city center by use of GIS technologies. The routes are defined according to the areas' spatial characteristics; and take into account the multifunctionality of the city. As it is often described in the literature, the small and medium-sized stores coexist within a vivid urban and social structure (Aranitou 2006; Aranitou and Sayas 2011). Thus, the business routes combine a variety of urban qualities, such as transportation facilities, green and public spaces, as well as cultural attractions. Those commercial densities are related to the city's urban history (Potamianos 2015) and at the same time reflect its recent evolutions.

While the initial research project proposed six business routes in respective distinct neighborhoods of the city center (INEMY-ESEE 2015), the present work elaborates on a specific business route, referring to the retail of footwear and leather goods expanding from Ermou Street and the Commercial Triangle of the city to Psiri area. The spatial analysis as well as the qualitative data collection and observations confirm that shoe and leather stores constitute one of the most vivid commercial concentrations in this specific part of the city.

The *structure* of the paper has as follows: first a brief presentation of the area's attributes is provided; it follows the sketching of the methodological approach, shedding light on the specific elements that need to be defined; then application of this approach in the area of concern is presented, utilizing GIS methodology; while finally certain inferences are drawn.

2 The Study Area

The study area—*Ermou Street and the Commercial Triangle*—is located between the administrative and commercial part of the city center—Syntagma Square—and its traditional and historic part—Monastiraki and Thision area (Fig. 4). Ermou Street and the Commercial Triangle are the most entrepreneurial areas of Athens, hosting a large variety of retail stores, administrative buildings and numerous services. The Central Food and Meat Market are located in proximity to the study area, attracting a vivid clientele on a daily basis. Located in the heart of Athens, the area is well connected to public transportation, namely bus lines, metro and tram. Thus it attracts visitors from the whole region of Athens municipality; as well as a tourist clientele, attracted by the centrality of the area and its proximity to remarkable archaeological sites and museums.

In the '90s, an urban regeneration project has contributed to the upgrade of the area's public spaces as well as the preservation of the building stock and its historic character. At the same time, a network of pedestrian streets was designed and implemented, further enhancing area's attractiveness and boosting visitors' traffic. In this context, Ermou Street became one of the most central shopping streets of the city, where next to the small and medium retail stores, large commercial buildings and international brands have been located.

Today, the number of restaurants and cafes along Ermou and its parallel streets are fast expanding. In fact, one of the most characteristic effects of the economic crisis in the city center of Athens is the increasing number of restaurants and cafes that tend to replace the closed retail stores. Nevertheless, the data gathered by the ESEE show that the vacancy rates in the area are lower in comparison to nearby parts of the city. Furthermore, an estimation of the rent prices of commercial spaces in the neighbourhood show that the price per square meter (average prices calculated from rent offers on relevant property rental/sale websites, rising to 24 euro per square meter) is above the average one observed in the city center. So, it can be concluded that, although the general economic environment is not favorable for the retail commercial activities, the area does preserve its strength. The design of a business route could, in a structured way, highlight less known aspects of its commercial activities.

3 Methodology

A key tool for route designing and planning is spatial analysis with GIS technology. Specifically, in order to identify the most appropriate and attractive routes, map algebra on raster data is utilized (Tomlin 1990), based on the most important criteria that determine whether a site is appropriate or not. The basic steps of the methodology are summarized in Fig. 1.

Selection of Criteria One of the most important steps of spatial analysis is the exploration and definition of the appropriate criteria. In the current study the selected criteria are summarized in Table 1 (see next section).

Estimation of Business Densities The qualitative observation of certain point locations' density on a map can be replaced by use of a more objective approach, based on the analysis of a grid's pixels. Another method that can potentially be used is the "Nearest Neighbor Point" analysis, focusing on distances between point locations. In this method, instead of focusing on points per grid pixel (surface), we focus on the surface per point. The distances of each point from its nearest one are

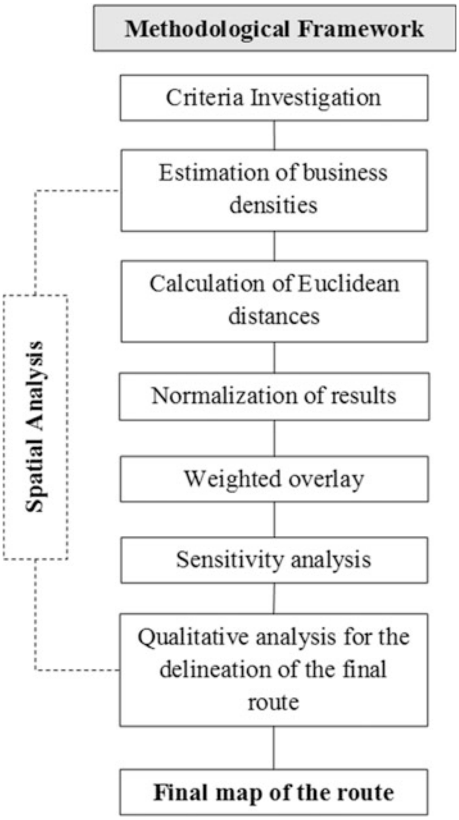


Fig. 1 Methodological framework of business route planning utilizing GIS technology

Table 1 Outcome of the criteria investigation step

Criteria	Description
Thematic determination	Thematic section of route and the participating retail shops
Geographical determination	Location and spatial concentration of participating retail shops
Related activities	Retail shops with similar commercial subject
Public space and transportation	• Green areas, parks and squares • Means of public transportation
Cultural activities	• Museums, monuments, archaeological sites • Theaters, cinemas, exhibitions

calculated, based on a random spatial process and more specifically on the Poisson distribution. The method compares the expected average distances to the corresponding real or perceived average distances, identifying deviations from the random spatial process. The business point densities in this paper are estimated by using the "Nearest Neighbor Point" method.

Calculation of Euclidean Distances In mathematics, the Euclidean distance or Euclidean metric is the "ordinary" (i.e. straight) distance between two points in space. Older literature refers to metric as Pythagorean metric.

Suppose we have two observations for which we have measurements. If we denote the two observations by $y = (y_1, y_2)$ and $x = (x_1, x_2)$, then a first approach to the calculation of a distance between the two points would be the Euclidean distance:

$$d(x, y) = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2} \tag{1}$$

For the case that we have observations on p variables, namely $y = (y_1, y_2, \ldots, y_p)$ and $x = (x_1, x_2, \ldots, x_p)$, a certain generalization is possible. Then the distance is calculated by the following formula:

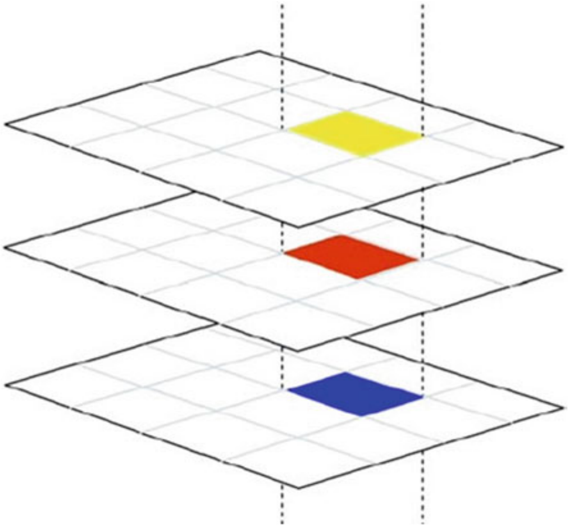
$$d(x, y) = \sqrt{\sum_{i=1}^{p} (x_i - y_i)^2} \tag{2}$$

Practically, for each point of the study area, the distance from its nearest point of interest is calculated.

Normalization of Results Each of the layers resulting from the processes described above is normalized in the range from 0 to 100, to be combined with the others.

Weighted Overlay One of the advantages of raster layers is that we can combine them by using the "overlay technique" (Longley et al. 2015) (Fig. 2). Thus, if the dimensions of the pixels in each layer are the same, it is possible to combine the values of each pixel in the same location.

Fig. 2 The overlay technique



As identified in the previous steps, the values of all variables (criteria) in all locations of the layers can be combined into a single layer (Fig. 3). The simplest way is by adding the values of the variables for each pixel, using appropriate weights and thus creating a composite index, the "suitability index". The final product of the above process, for each route, is a raster layer, in which the more suitable pixels are the ones closer to 100, in the range 0–100.

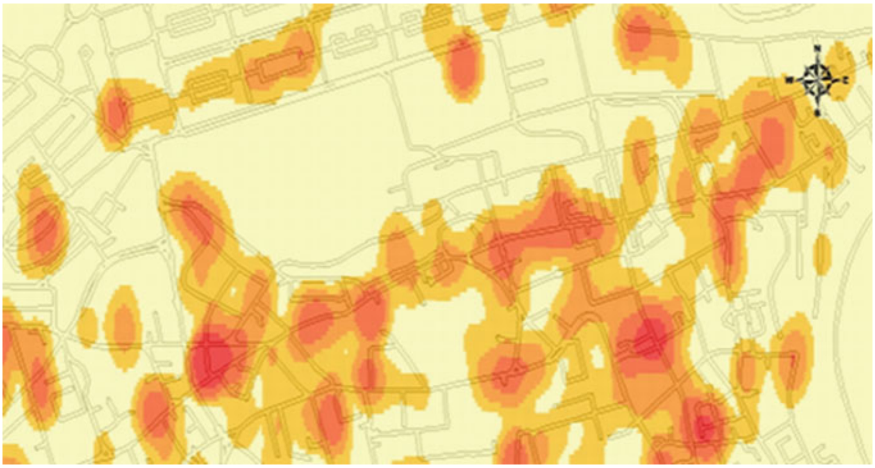


Fig. 3 Route areas with the overlay technique

Sensitivity Analysis Sensitivity analysis studies the consequences on the optimal solution of a linear model, with a possible change in its parameter values (Salteli et al. 2004). Such a process imparts a kind of stochastic nature in the modeling of a system and therefore usually accompanies any corresponding problem. In the proposed methodology, sensitivity analysis is focusing on the criterion of business density.

Qualitative Analysis for the Final Route Planning The last step of the methodological framework for the final business route planning is of qualitative nature. A threshold, in the 0–100 range of the final layer resulting from the raster analysis, is determined. The use of the threshold leads to a binary space, where from the one side areas are excluded, while from the other areas are included.

The qualitative decision of the threshold is performed by taking into account the following factors:

- the impact of the core idea of the business route on enhancing entrepreneurial activity and creating mutual benefits for participating companies and the city of Athens;
- synergy, interconnection and commitment of participating companies;
- innovative entrepreneurship that can emerge through route planning;
- the traditional occupations of the city of Athens, in conjunction with the sectoral targeting of Institute of Commerce and Services of ESEE (INEMY-ESEE).

4 Case Study: Business Route Planning in Central Athens

In the current section the application of the previously discussed steps of the methodological framework is presented, implemented in the specific study area of Ermou Street and the Commercial Triangle.

4.1 Criteria Investigation

Business route planning aims at highlighting and linking retail shops located in relative proximity to each other. The purpose of such a planning exercise is to increase the commercial traffic of small and medium-sized businesses in the city of Athens; while at the same time supporting retail trade shops to meet their customers' needs. Given the nature of the central part of the metropolitan Athens area, planning a business route needs to take into consideration the following aspects:

- The mixing of land uses in Athens downtown, such as commerce, green areas, services and housing. Business route planning will highlight this multifunctionality.

- Business route constitutes a critical pillar and an economic resource for the city; while it can also enhance tourist interest in the commercial trade sector.
- Public transport is an important factor, since it ensures unimpeded accessibility and thus increases commercial traffic in the area.
- Cultural activities in the surroundings of the study area highlight the existing qualities of the city.

The above mentioned factors are gathered in Table 1. These were taken into consideration in the context of determining criteria and planning the route.

4.2 Data Input

The data used in the spatial analysis context, serving the purpose of business route planning, are the following:

- Data on the locational aspects of retail shops emanating from the recordings of INEMY-ESEE in the Athens central area.
- Data on green areas and squares.
- Data on cultural attractions (museums, monuments, archaeological sites) as well as entertainment activities (theaters, cinemas and exhibitions).
- Data on public transport stations.

The *study* region is the area of concern of INEMY-ESEE, where retail stores, members of this institute, are located. The area of concern of the INEMY-ESEE incorporates a number of central districts of Athens, like Plaka, Monastiraki, Athens Commercial Triangle, Kolonaki, Exarcheia and the blocks on both sides of Patission Street to Ano Patisia (Fig. 4).

Based on the specific requirements of the thematic route planning exercise, the type of retail shops that was taken into account falls into the main category “Retail of footwear and leather goods” (Code: 47.72), as defined by the Statistical Classification of Economic Activities (STAKOD) (Fig. 5). Additionally, a range of other types of retail shops, with supplementary to the main one activities, were incorporated into the business route planned (Fig. 6). More specifically, the following categories were considered:

- Retail sale of clothing (STAKOD Code: 47.71).
- Retail sale of cosmetics (STAKOD Code: 47.75).
- Retail sale of watches and jewelry (STAKOD Code: 47.77).

Stores of the above supplementary categories can complement the thematic delineation of the planned business route and provide guests the chance to visit companies with similar to the main commercial activity.

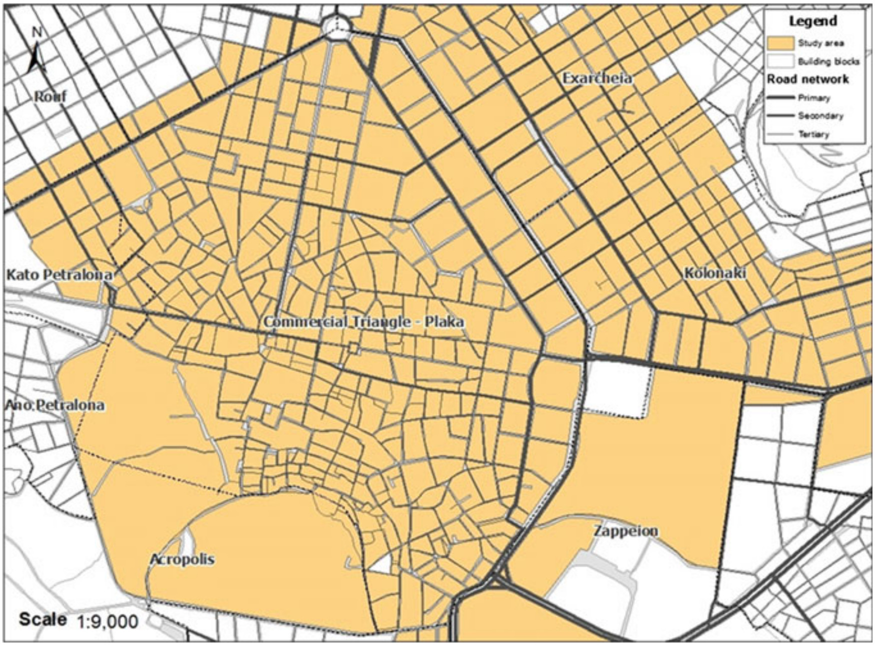


Fig. 4 Study area

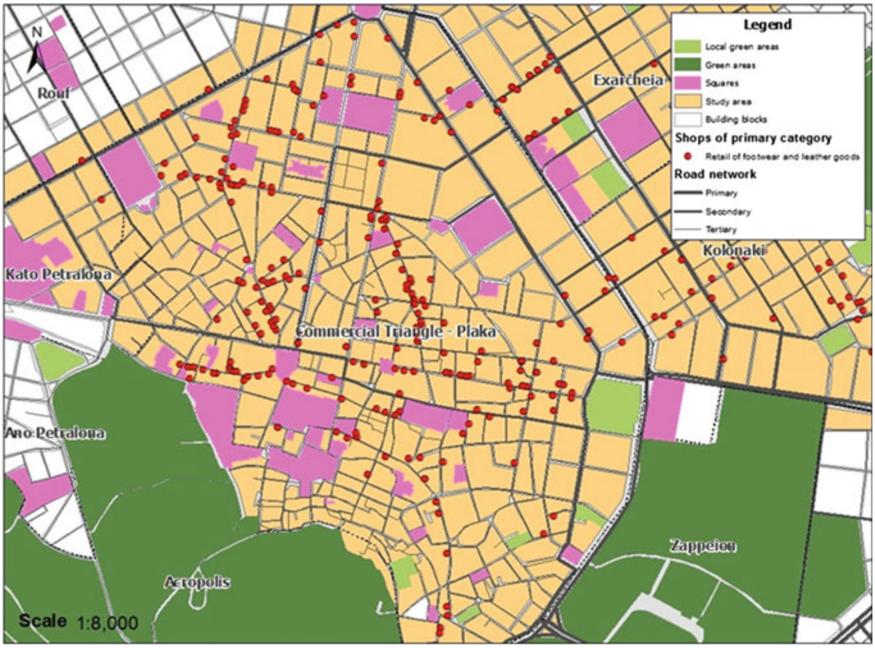


Fig. 5 Shops of primary category for the route planning

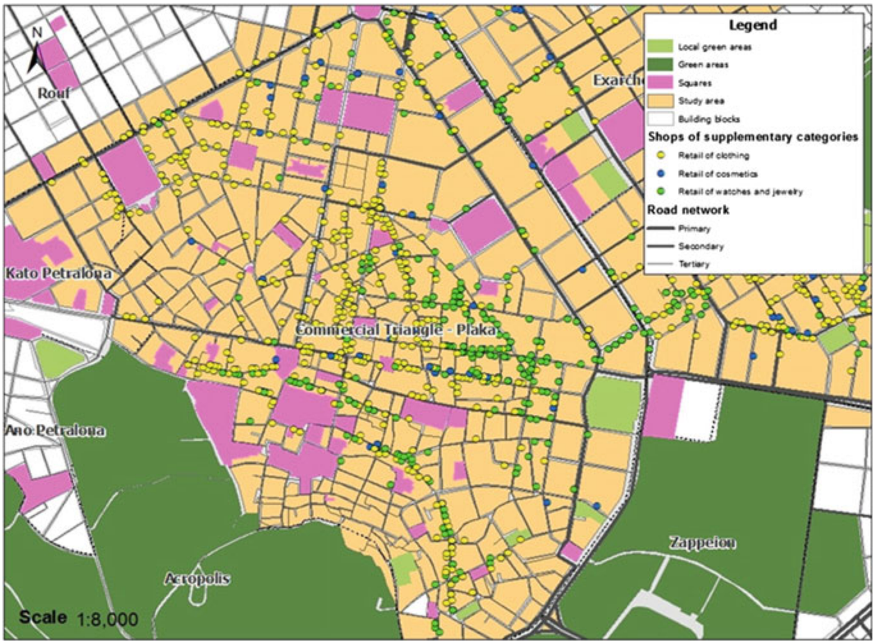


Fig. 6 Shops of supplementary categories for the route planning

4.3 Spatial Analysis

In the following is delineated the implementation of the steps incorporated in the context of spatial analysis of the proposed methodological framework (Fig. 1), on the basis of which the final map of the business route will emerge.

4.3.1 Criteria Definition

The factors presented in Table 1 above play an important role in the process of route planning and therefore are selected as criteria for spatial analysis. More specifically, these criteria correspond to the following thematic layers:

- Density of retail stores of the main category.
- Density of retail stores of supplementary categories.
- Euclidean distance from green areas and squares lying in the area of concern.
- Euclidean distance from cultural attractions (museums, monuments, archaeological sites), and entertainment activities (theaters, cinemas and exhibition).
- Euclidean distance from public transport stations.

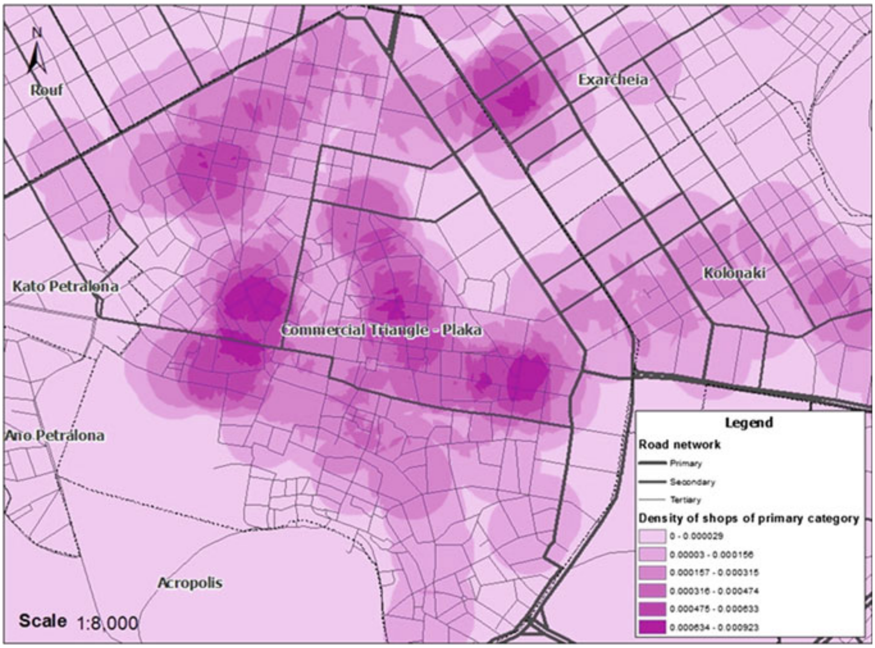


Fig. 7 Density of primary category shops

Density of Retail Stores The density of stores is an important factor for spatial analysis as well as for the accurate route zone planning. By this criterion it is assured that the business route will exhibit a high concentration of retail stores falling into the primary category concerned.

In Fig. 7 the density of retail shops in the study area is presented. The color grading distinguishes the different values of stores' density; and identifies areas of higher or lower densities respectively. Based on the results depicted in this figure, it is obvious that certain high concentrations of the primary stores' category are observed in a number of sub-areas of the central Athens district. These concentrations are mainly located in the Commercial Triangle of the city of Athens and the area of Monastiraki. Indeed, primary businesses concerned can be identified mainly in streets like Ermou, Evangelistrias, St. Markou, Themidos and Miaouli.

Alongside the concentrations of stores of the main category lay a range of retail stores, with supplementary or similar to the main one, activities, which were studied for presenting a more integrated view of the business route at hand. The spatial pattern of these secondary activities is depicted in Fig. 8, in which the high concentrations of these shops in the Commercial Triangle and especially along Ermou, Pericleus, Theseus, Fokionos, Kornarou and Diomias streets is sketched.

Euclidean Distance For the business route planning, cultural and entertainment activities; as well as opportunities for socialization and relaxation (like parks and

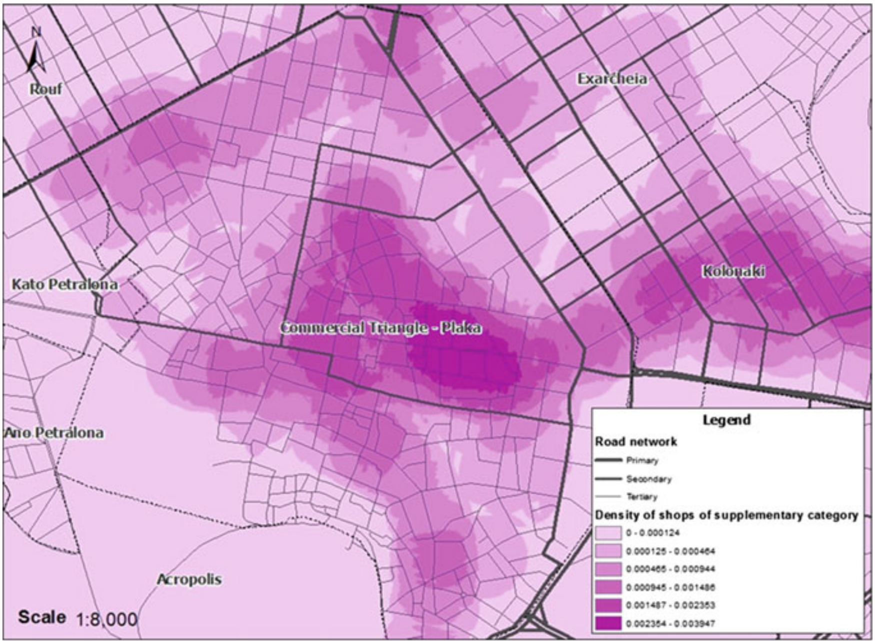


Fig. 8 Density of supplementary category shops

squares) were taken into account together with transportation options available. This implies the need of an additional set of criteria to be considered in the spatial analysis, as follows:

- Euclidean distance from green areas and squares.
- Euclidean distance from cultural attractions (museums, monuments, archaeological sites) and entertainment activities (theaters, cinemas and exhibitions).
- Euclidean distance from public transport stations.

The above criteria constitute thematic layers and are shown in Figs. 9, 10 and 11. The color grading illustrates the different values of the Euclidean distance (in meters), with these with dark green color being close to the point of interest and those with red color being perceived as more remote.

4.3.2 Reclassification of Criteria

The criteria/thematic layers presented in the above paragraphs are not of the same scale and therefore the comparison of their values is not possible. To cope with this inefficiency, the criteria were reclassified with their values being normalized by corresponding them to a single scale of 0–100, in order a direct correlation and implementation of algebraic operations between them to be feasible.

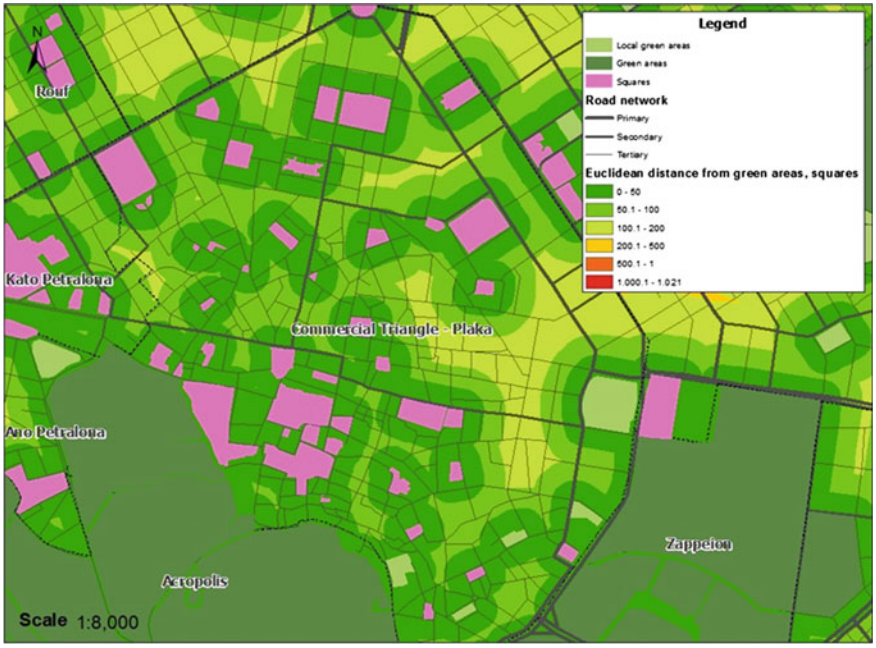


Fig. 9 Euclidean distance from *green areas* and *squares*

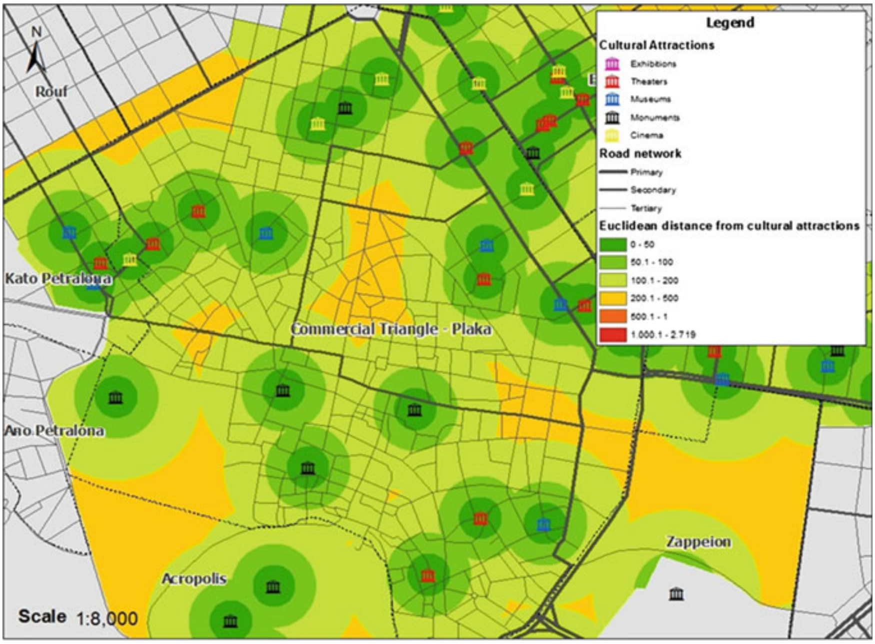


Fig. 10 Euclidean distance from cultural attractions, theaters, cinemas and exhibitions

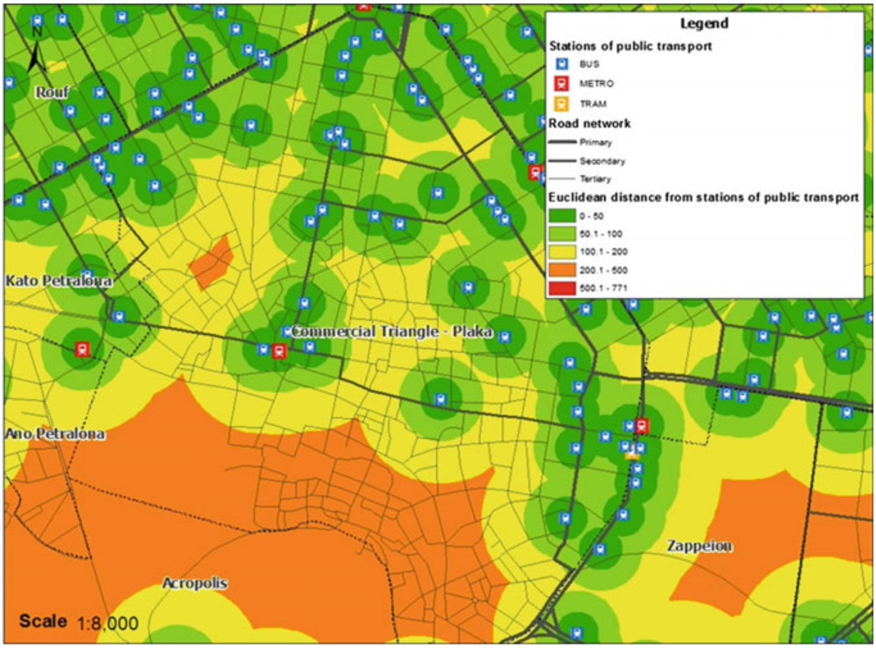


Fig. 11 Euclidean distance from stations of public transport

4.3.3 Weight Overlay

For the selection of the final route zone, addressing of proper weights to each of the normalized criteria/layers was considered as indispensable (Table 2). In particular, the criteria associated with the density of stores of the primary category were considered as the most important and received 50% weight in the rating of criteria set. Furthermore, the density of the businesses of supplementary sectors was considered to be the next most important criterion, receiving a weight of 20%. These two layers are considered the most important factors and therefore their contribution to the final result is rated high.

Table 2 Rating of criteria set

Criteria	Weights (%)
Density of retail stores of the main category	50
Density of retail stores of the supplementary category	20
Euclidean distance from green areas and squares	10
Euclidean distance from cultural attractions (museums, monuments, archaeological sites), theaters, cinemas and exhibitions	10
Euclidean distance from stations of public transport	10

Finally, the criteria of Euclidean distance from cultural attractions, green areas and public transport stations received a weight of 10% each, affecting to a lesser extent the identification of the final route zone.

4.3.4 Composite Index for the Route Planning

Having normalized the values of criteria and assigned proper weights, a *composite index* for the business route zone planning, was determined. The index takes input values from the five criteria concerned, together with their corresponding weights. On the basis of this input, a final composite index–layer–is calculated by means of the Eq. 3 below:

$$CompositeIndex = \frac{\begin{array}{r}(\text{criterion}1) * 50 + (\text{criterion}2) * 20 + (\text{criterion}3) * 10 \\ + (\text{criterion}4) * 10 + (\text{criterion}5) * 10\end{array}}{100} \quad (3)$$

The resulting layer of the composite index is shown in Fig. 12. The higher the value of this index (yellow and green colors in Fig. 12), the more relevant to the route zone the corresponding area is; or in other words, the defined criteria are met

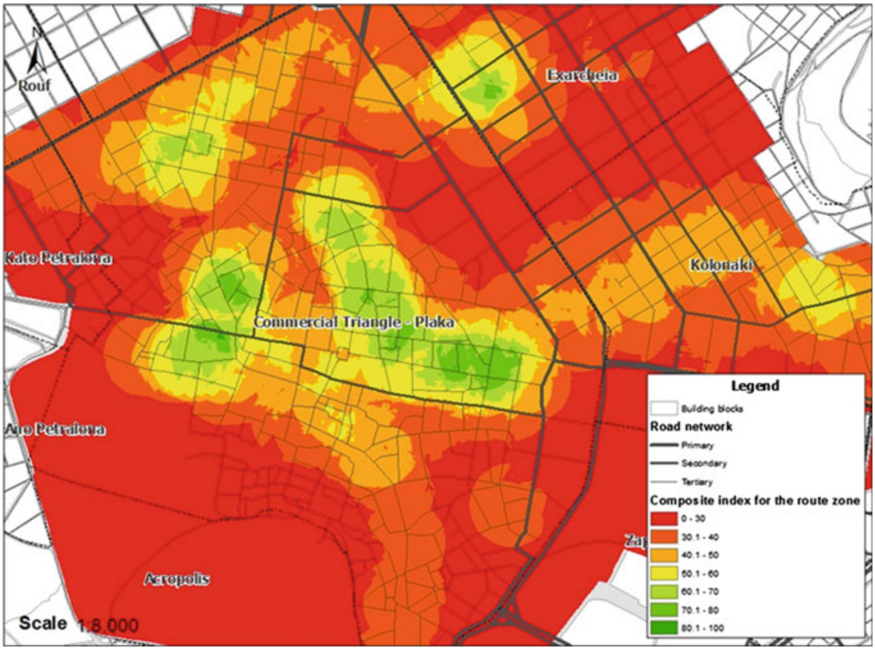


Fig. 12 Composite index for the determination of the route zone

to the greater extent. On the other hand, the red areas of Fig. 12 denote low values of the index and, consequently, they are not suitable for being incorporated into the route. By elaborating on the final results, several areas can be identified in which the composite index performs pretty well, which in turn implies that these areas are highly suitable for being part of the route zone. As such can be mainly considered both the area of the Commercial Triangle (Ermou, Pericleus, Evangelistrias, Mitropoleos, Karageorgi Servias and St. Mark streets) and the one of Monastiraki (Ifestou, Themis and Miaoulis streets).

4.3.5 Sensitivity Analysis

As part of the spatial analysis presented in Fig. 1, a sensitivity analysis of results was performed at this step. During this analysis, thematic layers and respective criteria that have led to the final result were studied, while small changes to the weights of the corresponding layers were introduced. More specifically, the values of the weights of the most significant layers, related to the retail shops, were changed and the composite index of each alternative trial was recalculated.

- *1st Trial*:

  Weight of the shops of the main category: 45%.
  Weight of the shops of supplementary categories: 25%.

- *2nd Trial*:

  Weight of the shops of the main category: 55%.
  Weight of the shops of supplementary categories: 15%.

Based on the outcomes obtained by these two trials (see Figs. 13 and 14), it turns out that the above changes of weights are slightly affecting the final result, i.e. no large differences emerge when small changes of criteria weights are considered. This entails that the initially calculated index, as the result of the primary elaboration, is exhibiting a certain stability and is perceived as being insensitive to small changes. Based on this inference, weights initially attached (of 50 and 20% respectively for primary and supplementary retail stores) are selected for the final zoning of the business route.

4.3.6 Qualitative Analysis for Final Route Delineation

Having calculated the composite index that determines the route, which takes values according to the degree of criteria satisfaction, the final stage is the definition of the value (threshold) above which an area on the map is considered appropriate

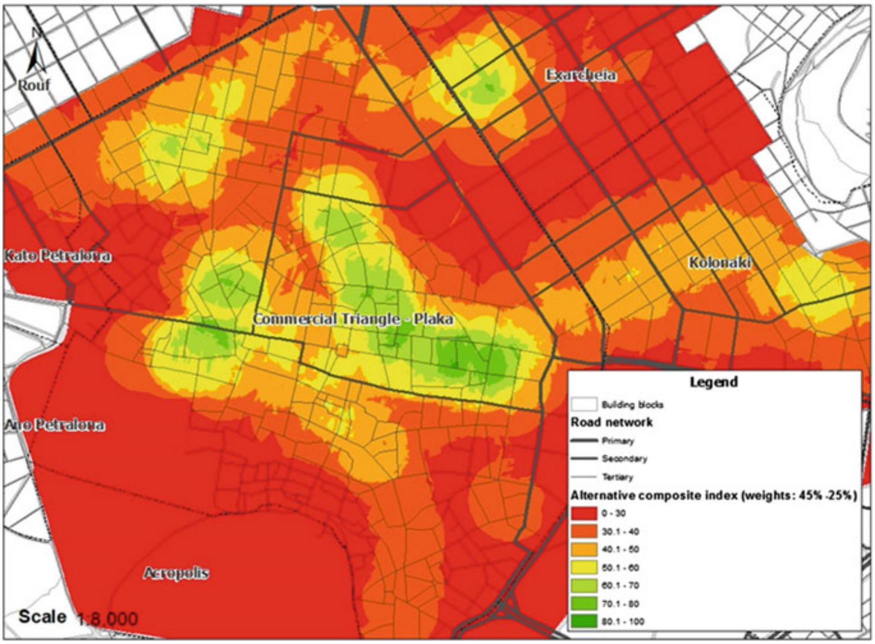


Fig. 13 Composite index for the determination of the route zones in the first scenario (weights: 45–25%)

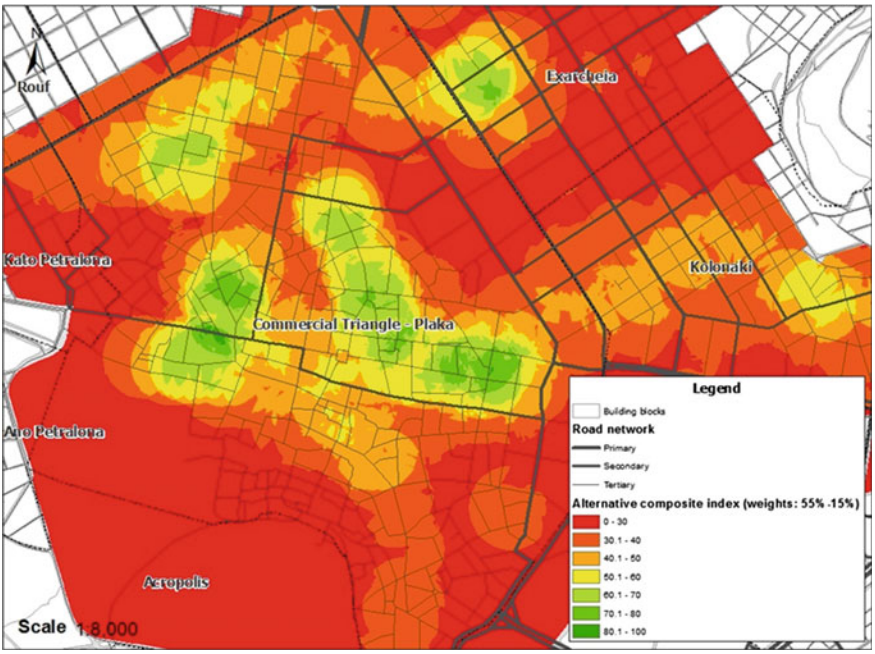


Fig. 14 Composite index for the determination of the route zones in the second scenario (weights: 55–15%)

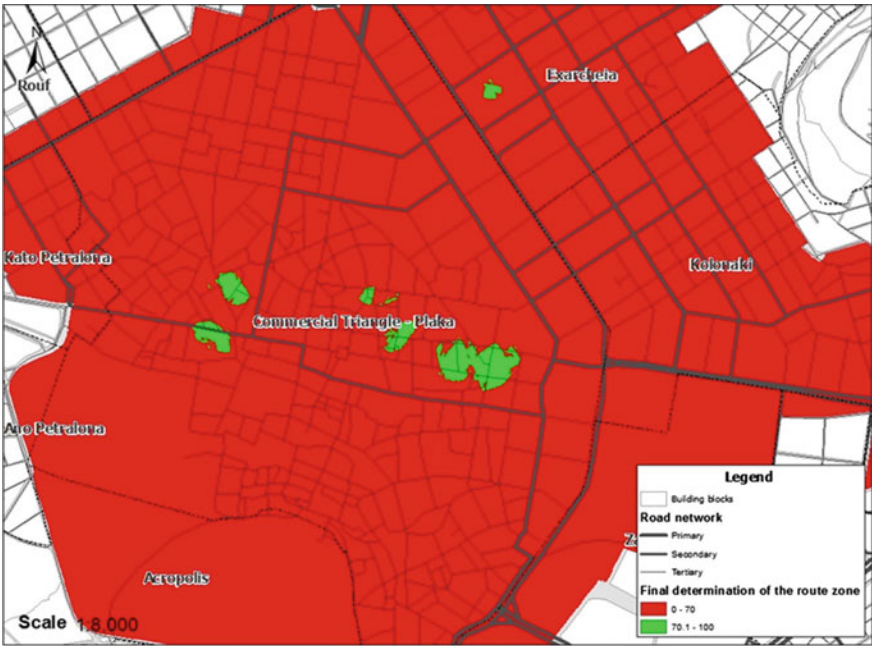


Fig. 15 Qualitative analysis for the delineation of the final route zone

to be included in the route zone. In this case and after multiple testing, the value of 70% was considered an appropriate threshold, above which the index values highlight zones that can be part of the business route; and largely satisfy the criteria set. Figure 15 shows the result of the composite index after having set the abovementioned threshold. Specifically, green areas create two different zones for the route, which are linked by Ermou Street.

Figure 16 shows the building blocks (in blue color) that define the route zone as resulted from the calculation of the composite index.

In this area the simultaneous fulfillment of all criteria set is observed. Apart from the sufficient number of main category stores located in the area (60 businesses in total), it seems that there are options for parallel activities in the route zone since several cultural attractions (e.g. culture, entertainment), squares and parks are located close to the route blocks. There are also many bus stops and three metro stations in the area, ensuring unimpeded accessibility through pubic transprot. Finally, in Fig. 17 the final map of the bussiness route is displayed, in which building blocks (in brown color) and stores of the main category are highlighted.

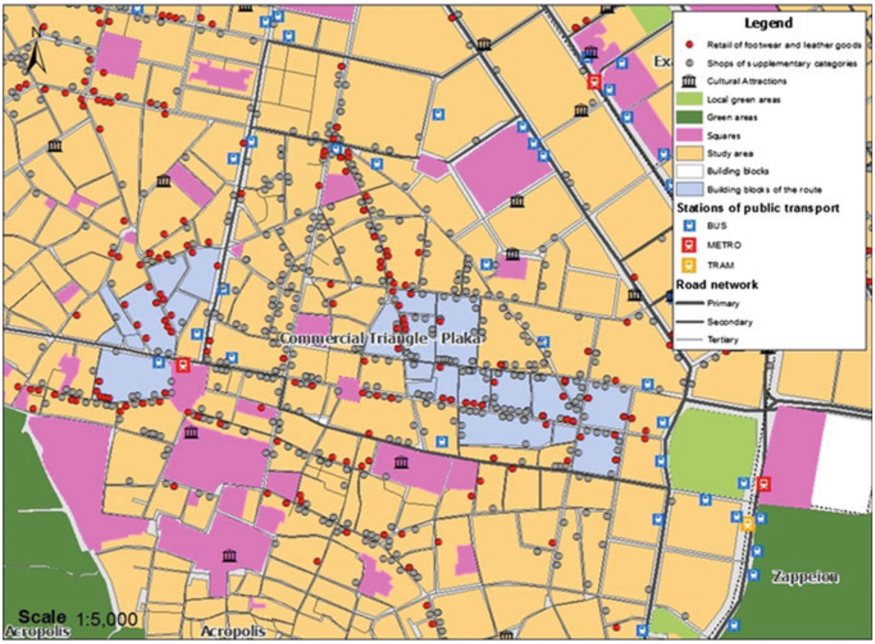


Fig. 16 Building blocks that defines the route zone

5 Conclusions

Business Route designing and planning is a key issue for urban development, exhibiting a strong spatial dimension. Therefore, spatial analysis utilizing GIS was used in this research, considering this method as the most appropriate for a quantitative approach of the problem, offering sound and reliable results. In particular, the raster overlay method with various layers of data was used for the determination of areas with high retail activity, including also other important infrastructures that are conducive to designing a suitable business route. The resulted composite spatial index is proved to be a valuable tool for cases of business route planning; while its output largely depends on the selected criteria of the study.

According to the results of the analysis, business route extends in two areas: in the Commercial Triangle—Ermou Street and in a specific part of Monastiraki—Psiri area. Indeed, Ermou and its parallel adjacent streets, i.e. Mirtropoleos and Karageorgi Servias, attract a large variety of clothing and footwear stores. The second area, incorporating Ifestou and Miaouli Streets, attracts mostly leather shops. The commercial activities of both areas are supplementary and offer a large variety of choices to eventual clients. Moreover, as defined in the methodology section above, the business route is easily accessible by public transportation and can combine cultural and entertainment activities as well, since it is located in

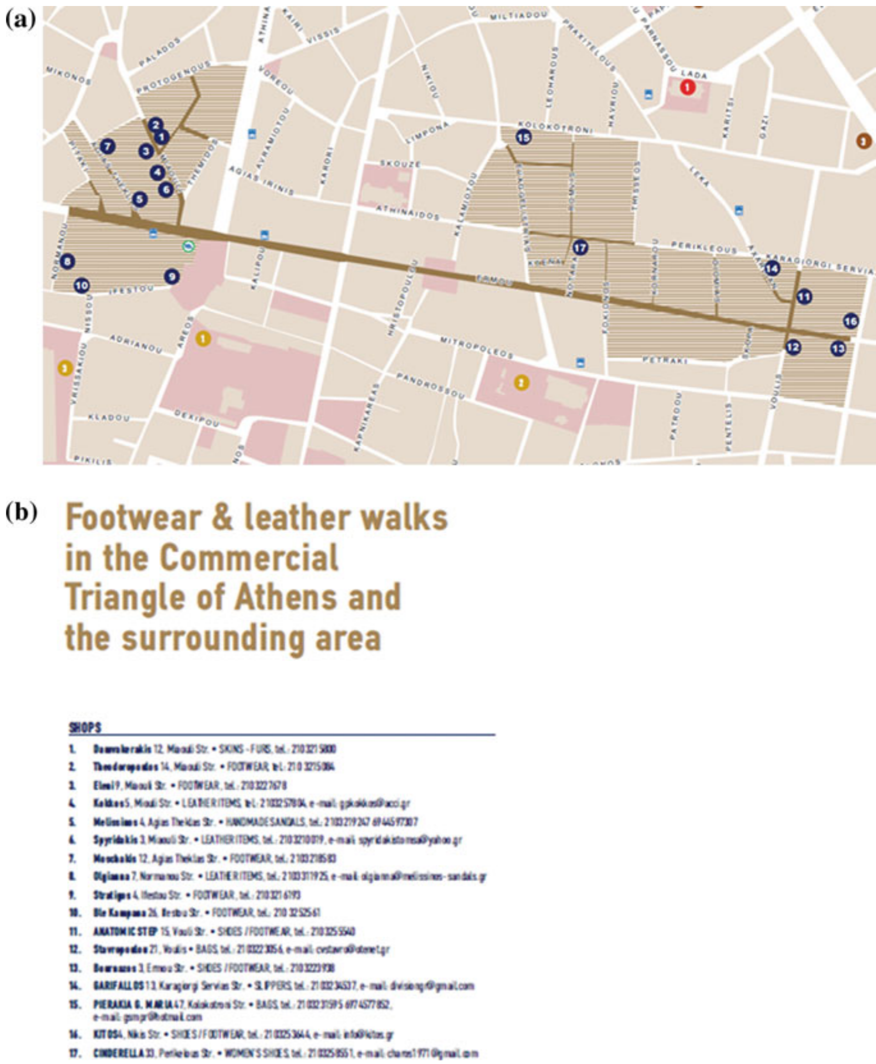


Fig. 17 Final map of the business route

proximity to important archeological sites, museums and galleries, but also theaters, cinemas and exhibitions.

The results of this research set up a series of questions associated with the socio-spatial transformations of the city and its commercial structure: which are the continuities and/or discontinuities of the commercial activities in the central neighborhoods of Athens and how the newly established entrepreneurial activities interact with the existing ones? The combination of qualitative data and GIS technology could highlight interesting aspects of those questions, by emphasizing the importance of space on the social and economic transformations of the city.

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Spatial Micro Level Analysis of Building Structures in Samos Island

Dimitris Kavroudakis, Fotini Skalidi and Dimitra Tsakou

Abstract Decision-making at the regional level has become more complex over the last years, requiring advanced tools to cope with dynamic environments and processes; and a thorough analysis of spatial entities in finer scale for better understanding of the dynamics and underlying processes. The focus of this paper is on the contribution of fine scale datasets in policy making by use of Spatial Micro Level Analysis of building-structures data. This approach enables the exploration of the spatial pattern in finer scale, setting the ground for a better insight in micro level dynamics. The proposed approach was applied in an insular area—Samos, Greece—in an effort to study two defining issues of islands' territory development in the Aegean Sea nowadays, namely informal settlements' expansion as well as spatial distribution of fire events, which are closely linked to pressures exerted on such areas by current development patterns as well as climate change impacts. The scope of this work is to illuminate underlying mechanisms of attraction/repulsion of informal housing; and identify the relationship between points of fire ignition and populated areas. Output of such an approach can feed decision-making processes and support more "smart" policy directions for coping with challenges of both island territory development and fire-related risks.

Keywords Geographical analysis · Insular areas · Spatial micro level data · Informal settlements' development · Risk of fire events

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1 Introduction

Planning and policy making are nowadays in front of great challenges. To effectively cope with these challenges, novel decision-making approaches are required, which are capable of taking into account the rapid evolution of events at the urban, regional and sub-regional level; and supporting fast and precise decisions.

Decision-making in general is a complex as well as data- and information-intensive process, implying the need to combine and elaborate on data and information, emanating from a plethora of sources in order to understand and properly react to fast evolving events.

In support of increasing *complexity of planning problems* and related decision-making processes, developments of the *smart city concept* have fuelled the deployment of, among others, a range of technologies that can be of relevance to a variety of spatial planning problems. These include data collection technologies, advanced analytics technologies and smart devices. Smart data collection technologies refer to actuators that can collect and store various types of data, which can be proved of great value for decision-making processes (Frank 2000). As such can be mentioned transportation and weather data, population mobility at the local and regional level, etc. Advanced analytics, such as Big Data Analytics, are nowadays used for the analysis of large distributed datasets, calling for extensive computation power (Russom 2011). An example of this type of data is daily traffic of cars, sea vessels and individuals in urban environments. With the expansion of technological advances and the gradually maturing of certain technologies, the development of, more complex and of a significantly decreasing cost, hardware devices is nowadays possible. This has led to the emergence of actuators and mobile devices that can capture and analyze information useful for the automation of various services in smart environments.

At the same time, the complexity of planning problems and the wide range of decision-making bodies of different hierarchical decision levels—from local to national–that needs to be engaged in order these to be solved, entails the necessity for effective coordination among these bodies, a fact that is pushing forward *new governance settings* in effectively handling contemporary spatial planning challenges. In Greece for example, this is quite evident at the regional level, where the increased number of tasks, addressed to this level and the respective government, requires cooperation of various governmental agencies. These tasks include, among others, health provision activities, litter collection and deposition, civil protection planning, water supply and various other maintenance activities (roads, beaches, ports, transportation etc.), all considered as defining features for the quality of life of local population. The resulting *complex hierarchy* of duties and jurisdictions as well as *spatial data sources* concerned, renders decision-making a fragmented process. This is due to the difficulties embedded in incorporating all necessary data and information from the various decision-making agencies in a single and coherent entity, in order accurate and efficient decisions as to rapidly evolving events to be made. In coping with this inability, *Geographical Information Systems (GIS)*

(Goodchild et al. 1992) offer a valuable tool in support of complex and data-intensive decision-making processes, by enabling the visualization and analysis of spatial distribution of events; and the better understanding of underlying processes. Moreover, spatial analysis methodologies can shed some light on the better grasping of current spatial pattern of events and its association with other variables (Bivand et al. 2008).

Based on the above discussion, the *focus* of this paper is on the contribution of *fine scale datasets* in decision-making processes by use of Spatial Micro Level Analysis of building-structures data. This approach enables the exploration of the spatial pattern in finer scale, thus enhancing decision makers' insight in micro level dynamics. This was applied in an insular area—Samos Greece–, a middle scale island in the Eastern Aegean Sea, with a number of urban and rural populated areas, considered as an ideal example for this type of analysis due to its diverse build and natural environmental entities. The empirical application concerns the study of two quite defining issues of islands' territory development in the Aegean Sea nowadays, namely informal settlements' expansion as well as spatial distribution of fire events, which are closely linked to pressures exerted on such areas by current development patterns as well as climate change impacts.

The scope of this work is to illuminate underlying mechanisms of attraction/repulsion of informal housing; and identify the relationship between points of fire ignition and populated areas. Output of such an approach can feed decision-making processes and support more "smart" policy directions for coping with challenges of both island territory development and fire-related risks. The *structure* of the paper has as follows: in the next section certain background information is provided, aiming at sketching developments in modern tools and technologies for dealing with planning problems in "smart" environments. This is followed by the adoption of such tools and approaches for coping with two very important issues in a specific case study, the Samos Island, Greece. More specifically, the application of the *spatial micro level analysis* for studying informal development of settlements and identification of fire events hot-spots, relevant to a large number of islands in the Aegean, is presented. Finally some conclusions are drawn.

2 Background

The dynamic nature of problems faced in an urban or regional setting calls for advanced methods, approaches and tools for capturing respective data; exploring potential solutions; and monitoring their progress over time. Options available for implementing such procedures, i.e. collection of data from various sources, in-time and accurate analysis of them, and monitoring have nowadays been broadened by smart systems available. Such systems can support relevant decision-making processes by enabling tailor-made decisions to be taken, thus saving time, resources or even lives in some instances.

In order to capture the evolution of problems of a dynamic nature, "smart" approaches are required that can support acquisition of a better insight and a deeper understanding of the very essence and extent of the problems at hand. Moreover, there is a need for embedding in these approaches Information Technology (IT) tools that can handle and properly visualize spatially-aware dynamic phenomena, in a way that could make them fully graspable by decision makers. This perspective is quite essential for improving decision-making processes; and it actually implies utilization of tools and technologies that can manage *digital (spatial) data*, emerging from a variety of different sources. By adopting such tools and technologies, *information fusion* will be enabled, which may reveal unknown aspects of dynamically evolving events, related to specific problems studied. For example, in order to fully understand the traffic needs of an island, data about the quality of roads, the traffic volumes as well as the size of population concerned in each island's geographical area is needed. The above data may be obtained from various sources, e.g. police, municipalities and/or travel agencies. Proper combination or integration of these data is required in order a reliable *decision-making platform* to be created, which in turn can be used for identifying inefficiencies and supporting relevant policy decisions.

In recent years, an abundance of works regarding *smart solutions* in a city context can be encountered in the literature, which elaborate on a variety of digitally-enabled solutions to city problems, infrastructures' management etc. Indicative examples are the works of Neirotti et al. (2014), focussing on the current trends in smart city initiatives; Kramers et al. (2014), exploring Information and Communication Technology (ICT) solutions for reducing energy use in cities; Al-Hader and Rodzi (2009) elaborating on the monitoring of city infrastructures; Nuaimi et al. (2015), dealing with applications of Big Data to smart cities; Batty (2013), setting the case for Big Data at the service of smart city planning; Kavroudakis (2015), describing a methodology for constructing micro-data for smart decision making; Kavroudakis and Kyriakidis (2013), working on health-related smart decision-making with the use of Artificial Intelligence approaches; Kavroudakis et al. (2012, 2013), elaborating on the use of spatial micro-simulation approaches for understanding spatial inequalities of population for smart policy evaluation by geographical area; etc.

A number of works can also be found in the literature regarding "smart" systems for coping with *fire prevention* and *fire management*. For example, Bao et al. (2015) have implemented a smart system for optimization of forest fires monitoring; while Hodgson and Newstead (1983) have also implemented a system for location-allocation of forest-fires control stations. Additionally, Alonso-Betanzos et al. (2003) describe the use of intelligent systems for forest fire risk prediction.

Of great importance in such systems is the use of *Geographical Information Systems* (GIS). Indeed, these can include modules for spatial data analysis and visualization in order the spatial context to be taken into consideration; and therefore "smarter" and more spatially-defined decision-making processes to be enabled. In this respect, GIS can be used for exploring spatial aspects of events, structures and other spatially-aware data, feeding thus more knowledgeable decision-making processes and smartening up decisions towards a viable and sustainable management of scarce resources. Within a technology-intensive decision environment, GIS are quite pertinent in making decisions touching upon issues such as: land-use planning, spatial allocation of services (e.g. transport and energy infrastructure, health services, educational services etc.); more informed spatial planning; "smart" transportation, etc. Fulfilling objectives of that type of spatial exercises presupposes transparency and openness of *public, qualitative and quantitative, spatially-defined data*.

Various decision-making processes need to rely on *finer scale spatial data* in order spatial analysis to be performed and certain conclusions, useful for policy making, to be reached. An example is the informal settlements' development, being the focus of the case study discussed in subsequent sections. Fine scale analysis of spatial datasets is a computationally intensive process and requires efficient use of modern IT solutions. Moreover, spatially aware micro-data, such as houses' boundaries, may require data evaluation approaches that are rather expensive. Nevertheless, the construction of a spatial database of buildings for a certain geographical area and at certain time spots can form the ground for the spatial analysis of informal settlements' development, and systematic provision of the information needed for improving policy making and effective planning interventions in such areas.

3 Spatial Micro Level Analysis—Application in Samos Island

Informal housing development is the process of constructing building structures in unplanned areas. This phenomenon is noticed in several Mediterranean countries, in Greece as well, where it requires the payment of some special permits as a compensation for the unplanned development. At the same time, houses outside planned areas can be connected to service networks, such as electricity grid, water provision network and transportation network.

This unplanned development process extends the boundaries of settlements beyond the official (and planned) limits, without compensating for the required expansion of the relevant services' grid. In other words, the expansion of e.g. electricity grid follows the unplanned expansion of a settlement. Such a situation is fraught with problems, mainly emanating, among others, from the lack of a centralized planned expansion process of the various infrastructure networks. It is important for regional and local authorities to use relevant tools and technologies for capturing the current spatial distribution of informal structures; and use this knowledge for setting up policies that can effectively cope with inefficiencies involved is such situations, while restraining such a dynamic expansion of settlements.

The study of dynamic events such as informal development of houses outside city's boundaries requires the utilization of spatially aware methods. By means of GIS methodologies and the use of spatial data referring to distinct time spots, changes in built environment can be identified; and capturing of informal house development is made possible. In order to handle this type of problems, spatial analysis in finer possible scale is required, which can be accomplished by use of modern geospatial technologies that can be effective in identifying and analyzing events in fine scales. Additionally, the dynamic character of such events requires the construction and analysis of a time-series of datasets, implying the need for a systematic capturing of data in specific time spots. This would illuminate a certain process of change over time, providing indications as to the underlying factors affecting the development of informal houses and the evolutionary spatial pattern of this phenomenon.

3.1 The Problem

Fragmented geographical spaces, such as *islands* of the Aegean Sea, are dynamic and complex systems, characterized by a range of peculiarities as to the human and natural resources, as well as their economic potential and structure. Their distinguished natural and cultural beauty render islands attractive tourists destinations, a fact that apart from short term positive economic gains, it also places severe risks and load in environmental and social terms. Tourism sector, as the prevailing economic activity, is largely defining the local economy, while resulting to a substantial contribution to the National Gross Domestic Product (GDP), acquiring thus a crucial importance for both the local and the national economy. Agricultural and fishing activities, although keeping lower shares in the local economy, exhibit also a certain potential, with benefits reaped from both the local population and the large number of visitors of such areas.

The high dependence of the local economy on the tourist sector is though rendering island regions fragile places, vulnerable to external developments of the sector—the tourist market—but other developments as well e.g. demographic trends, economic recession, climate change. Furthermore, it places a large burden on the build as well as the natural and cultural environment, mainly based, among others, on the tremendous demand for services during peak tourist periods, where actual population rates several times higher than population of low season tourist or winter periods. Indeed, a few hundred of actual population of certain islands in winter periods can rise up to five times greater in summer time. Seasonality of population is a challenge for meeting, in peak periods, the needs of population for public services such as: education, waste management, transportation, health, electricity, water, environmental protection, safety and civil protection.

An important problem of island territories in the Aegean Region, partly motivated by pressing tourist development and related needs for shelter, is *informal building structures*. This is due to the fact that informal development of settlements has considerable dimensions and repercussions in all three sustainability pillars (economy, society and environment). It also reflects a dynamic process of, certain times improper, settlements' development; and a defining factor for the unplanned, of eventually high economic and environmental cost, geographical expansion of infrastructure networks for service provision. As such, it needs additional attention in order to delineate and record the full extent of the problem and the underlying processes fuelling such a development. Local authorities, who are in charge for coping with this problem and related consequences, are nowadays confronted with limited resources, but also lack of the necessary skills and time series of spatial data needed to undertake such tasks; and follow a proactive planning approach for preventing unpleasant situations out of informal settlements' development. They rather "react" in a fragmentary way that does not address the real cause of the problem, but aims at arranging short term inefficiencies.

Another important topic with crucial, of long term, environmental, social and economic consequences in island regions is the *fire events*, which take place mostly during summer months. The importance of this issue is further stressed, taking into account climate change aspects in the Mediterranean territory, one of the most important climate change hot spots at the global level in terms of climate change impacts, with island and mountainous regions, as various studies show, being the most vulnerable ones. Coping with this dynamic event requires resources for prevention and repression. Same as in case of informal built development, local fire patrol services have limited resources in terms of personnel, knowhow/skills, time series of spatial data and tools and technologies needed for analysing fire incidents and determining potentially dangerous hot-spots.

As various studies, dealing with such problems, reveal, the two quite important for island regions issues previously described, can be effectively handled by use of "smart" tools and technologies emerging in a smart city context, which can prove valuable for regional island territories as well. In the context of this work, these two issues, i.e. informal development of settlements and identification of fire events hot-spots, relevant to a large number of islands in the Aegean, are selected for further elaboration. The goal is to provide the means for getting better insight by *quantifying* informal development of settlements and *identifying* fire events hot-spots, in support of more knowledgeable decision-making and designing of strategies to effectively cope with them.

The approach to be used in this respect is the *spatial micro level analysis*. Potentials of this approach will be presented by its application in the Samos Island. Samos is a Greek island located in the eastern Aegean, and it is the eighth largest Greek island with total area of 477 km^2. It belongs to the administrative region of North Aegean, along with the Fourni and Ikaria islands. According to the latest population census (2011), there is a permanent population of 32,974 inhabitants in the island. Samos has experienced catastrophic fire events, which affect the island almost every year and lead to a gradual degradation of soil resources. From 1993 until 2014, the island counts 925 fire incidents, mostly burning forest areas.

The Samos case study will illustrate the details of spatial micro level analysis and will present the results of a preliminary spatial analysis regarding informal development of buildings outside of towns' limits. Additionally, a secondary analysis of fire events in Samos Island will be discussed, by combining the spatial database of the island's buildings with the spatial database of island's fire events.

3.2 Methodological Approach

The methodological approach followed, involves a number of steps. More specifically, at a first step, raw satellite data were collected and geo-referenced with the use of GIS. This enabled, at a second step, the use of vector graphics methods for the digitization of polygon structures (buildings). The outcome of this second step is an extensive dataset of all man-made structures in the island. At a third step, R programming language for the analysis and quantification of proximity and overlay of buildings was used. The quantification of proximity of buildings incorporates the use of spatial analysis methods for the estimation of mean nearest neighbour values by settlement. These values illustrate the mean distance between structures in each settlement; and are a measure of density per area unit. The overlay methods aim at the identification of buildings that lay outside the official settlement boundaries, thus presenting informal building structures.

We used GIS technologies and more specific the QGIS (QGIS 2016; QGIS Project Team 2016) software along with R programming language (Black 2014; CRAN 2015). The QGIS software was selected as the more appropriate open source GIS software, capable of incorporating R scripts for spatial analysis. R programming language was selected due to the number of libraries for spatial analysis it offers. A *by-product* of this work is the development of a number of R programming methods and algorithms for efficiently calculating a number of spatial measures for the identification of informal building structures outside settlement boundaries.

The development of these methods could be embedded in a "smart" decision-making tool, which will automatically examine and analyse maps in order to identify man-made structures outside settlement boundaries.

3.3 Data and Analysis

The data used in this work are collected from satellite images from Google Earth service (Google 2016). We used the base layer of satellite services in order to digitize 27,124 man-made structures in the island of Samos. The secondary data produced are vector GIS layers. Additionally, the settlement boundaries were digitized from original paper designs from local Municipality of Samos Island. The digitization process transformed the data to vector formats in order to be used in R programming language for further analysis.

The administrative division of the island includes four Municipality units, which occurred after the implementation of the “Kallikratis Plan”, in 2011. The law which has led to the above reform is the 3852/2010 and it follows the “Kapodistrias Plan”, as expressed in 1997 by the law 2539. The four Municipality units of the island are: Vathi, Karlovasi, Pythagoreio and Marathokampos.

Additionally, we used digital data about land-uses in the island of Samos, which were downloaded from Greek Geodata Portal (2016). A range of different land uses can be found in Samos island such as: areas of absolute protection, areas of natural protection, areas of natural-protection formations, protected areas of agricultural support programs, protected agricultural areas, cultivation areas, protected forest areas, areas of tourism and summer houses, areas of ancient protection and areas of special use (ZEU).

In order to quantify the land-uses of the area, we calculated the area by land-use. Cultivation areas occupy a relatively larger part of the island, with a total area of 132,149 km^2, while areas belonging to ZEU occupy a smaller part of the island (1126 km^2).

The size and type of data collected is relative big and we used an advanced Spatial Data Base (PostgreSQL Global Development Group 2016) for the storage and management of the geographical data. Modern GIS offer a number of methods for such case studies.

In order to quantify the relationship between building and the population size in each Municipality of Samos island, we need to collect population data by administrative unit from the Greek Statistical Authority (ELSTAT 2016). According to the latest census of population, the highest population rates appear in the Municipality of Vathi, followed by the Municipality of Karlovasi, Pythagoreio and Marathokampos. In 2011, Vathi had the highest active population; while it had the lowest rates in children and aged population groups. The same age structure appears in all municipalities of the island. There is a relatively small number of very young and very old individuals; and, at the same time, a relative higher number of active middle age groups in the island. From 1991 to 2011, there is a certain increase in the population of Karlovasi; a gradual decrease in the population of Pythagoreio over the last 3 censuses; and a decline in the population of Marathokampos. According to the latest population census, Vathi and Karlovasi have increased their population density compared to the other municipalities, which is also in alignment with the number of man-made buildings in the area.

Another dataset used in this work is the spatial database of points, which represents the starting points of fire incidents in Samos Island (from 1993 to 2013). The data were obtained from the Natural Disasters Research Lab of the University of the Aegean (Geography of Natural Disasters Lab 2016). According to the period of the events, fire incidents can be categorized in two categories: fires during winter months, which are not so common; and fires during summer months, which tend to have relatively more fire incidents, mainly due to climatological conditions and human activity in the area. *According to the above data*, summer incidents of fires have higher frequency than the ones during winter months.

Finally, the categorization of burned areas along with their size in hectares from the year 2000 to 2014 shows that the most vulnerable type of area is Forest Type and Grass Type areas, which is also relatively analogous to the relative frequency of appearance of that type of land uses in Samos island.

Samos counts 183,407.6 ha of totally burned area, out of the 47,600,000 ha of the total area of the island. We therefore realize the importance of this problem not only for the natural environment and its protection, but also for the economy as a whole, since it affects, directly or indirectly, all economic sectors of the island (tourism, agriculture etc.). The annual number of burnt areas from the year 2000 to 2014 shows that the two most important years of catastrophic fire events were 2000 and 2010, time spots in which the highest rates of island's areas were burnt (Hellenic Fire Service 2016). More specifically, from 2000 to 2014 a total of 820 fire events took place, which mostly burnt areas of forest type (106,329.3 ha or 58% of total burned areas were forests). Second in fire damage was semi-forest areas (59,928.7 ha of burned area or 33% of total burned areas). Last were agricultural areas (16,211.1 ha of burned area or 9% of total burned areas).

3.4 Results

In order to quantify the proximity of buildings outside the official settlement boundaries to the village boundaries, we need to use proximity analysis methods. As there was limited access to data regarding type and use of buildings, we used Point Pattern Analysis approach, which quantifies the number of spatial events by Euclidean distance. We constructed sequential buffer zones from each point pastern and counted the number of events located inside each buffer zone. We used this method in order to quantify the relationship between buildings-boundaries as well as the relationship between fire starting points-buildings. The results of this analysis are potentially useful for identifying areas with relatively increased unplanned development as well as to identify areas with man-made structures close to fire starting points. The proximity analysis between buildings and the official boundaries of settlements used buffer zones of: 50, 100, 150, 200, 250 and 300 m. This analysis calculates the number of informal buildings outside the official boundaries. The number of informal buildings per buffer zone is presented below:

- buffer zone of 50 m—20,948 man-made structures;
- buffer zone of 100 m—21,114 man-made structures;
- buffer zone of 150 m—21,731 man-made structures;
- buffer zone of 200 m—22,258 man-made structures;
- buffer zone of 250 m—22,760 man-made structures;
- buffer zone of 300 m—23,296 man-made structures.

As can be seen from the above results, there is a relatively high number of man-made structures outside the official boundaries of villages in the island.

The number of buildings increases as the size of the buffer zone increases. The proximity analysis between fire starting points and man-made structures quantifies the possible relationship of the two point patterns and may help fire patrolling agencies to identify potentially vulnerable areas. This analysis calculates the number of buildings in specific buffer-distance around known *fire-starting points*. The number of buildings per buffer zone is presented in the following list:

- buffer zone of 50 m—180 man-made structures;
- buffer zone of 100 m—637 man-made structures;
- buffer zone of 150 m—1310 man-made structures;
- buffer zone of 200 m—2086 man-made structures;
- buffer zone of 250 m—3037 man-made structures;
- buffer zone of 300 m—3943 man-made structures;
- buffer zone of 350 m—4644 man-made structures;
- buffer zone of 400 m—5195 man-made structures.

From the above results, one can see a relatively high number of fire events starting very close to buildings outside official boundaries. This may be an indication of correlation between informal buildings and fire events, especially if the land-use type of the area is of forest type.

In order to quantify the average distance between fire starting points and man-made structures, we used spatial analysis methods. More specifically, the Nearest Neighbor Analysis was applied (Clark and Evans 1954; Pinder and Witherick 1972; Ramsahoye 2002) in order to conduct statistical hypothesis testing against complete spatial randomness (CSR). We compare the average expected distance that would exist if the spatial distribution of points was completely random against the observed average distance between the point and their nearest neighbor. The result of the Nearest Neighbor Analysis between fire ignition points and man-made structures shows that there is no statistically significant relationship between the fire starting points and the locations of buildings in the island. Also, as the administration area of Pythagoreio has the most fire ignition points, we conducted the same analysis just for this area. There seems to be a relatively smaller average nearest neighbor distance from the buildings in this area to the fire starting points. This indicates that maybe there is a spatial relationship between the two point patterns only in the area of Pythagoreio, which is a relatively highly visited tourist area during summer period.

According to the results of our analysis, there are 8479 buildings in the city of Vathi, 7101 buildings in the city of Karlovasi and 3371 buildings in the city of Marathokampos. There are 63 villages in the island of Samos, 18 villages in the Municipality of Vathi, 17 villages in the Municipality of Karlovasi, 16 villages in the Municipality of Pythagoreio and finally 12 villages in the Municipality of Pythagoreio. Most of the man-made structures are located inside the official boundaries of each single village. Nevertheless, according to the results of this work we can identify the spatial distribution of man-made structures located inside and outside the official boundaries of villages. As we cannot accurately associate a

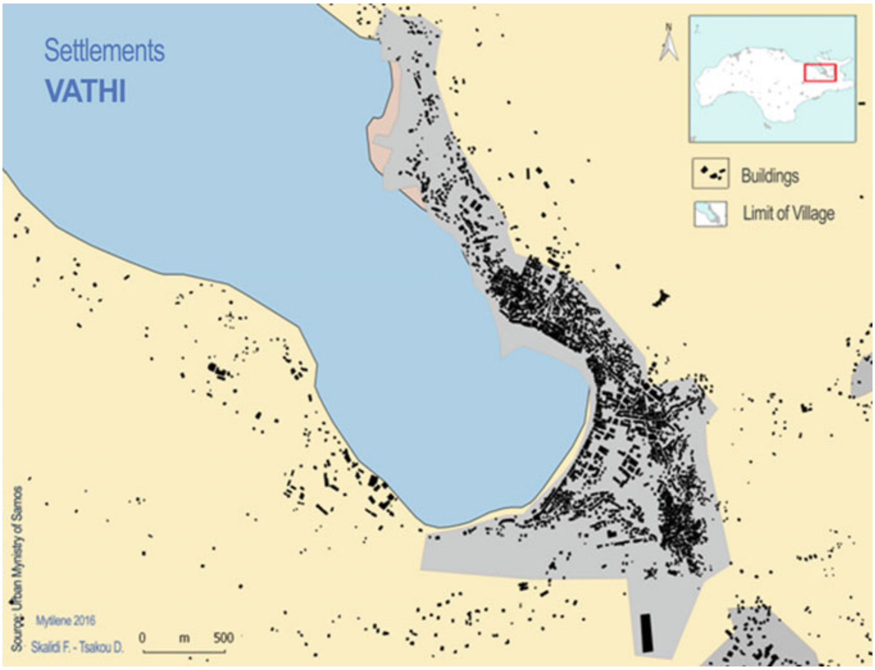

Fig. 1 Man-made structures in the Municipality of Vathi in Samos island

man-made building, which is outside the official limits of a village, with the village itself, we therefore identify only the man-made structures which are located inside the official boundaries.

There are some very distinct cases, where a considerable number of informal man-made structures lays outside the official boundaries of settlements.

As can be seen in Fig. 1, the Municipality of Vathi has a considerable number of man-made structures outside the official boundaries of the settlement. Such a visualization of the problem of informal building settlement can be used towards the design of a settlement's expansion strategy; and the expansion of new transportation services (network) for serving the needs of new areas of the settlement.

Another very interesting case is the Municipality of Pythagoreio (Fig. 2), which is a very attractive tourist area of the island. There is a number of building structures, which are outside the official boundaries (Fig. 3). Finally, a very distinctive case is the village of Mytilinioi, which has 1611 buildings outside the official settlement boundaries (Fig. 4). This is a clear case of unplanned development, which requires additional attention. Of importance is also the ascertainment that among the 27,124 buildings on the island, only 18,301 are within the official settlement boundaries.

Furthermore, by using the fires-starting-point datasets, we were able to quantify the spatial distribution of the events and identify areas which may need additional fire-services personnel. More specifically the Municipality of Vathi has the highest

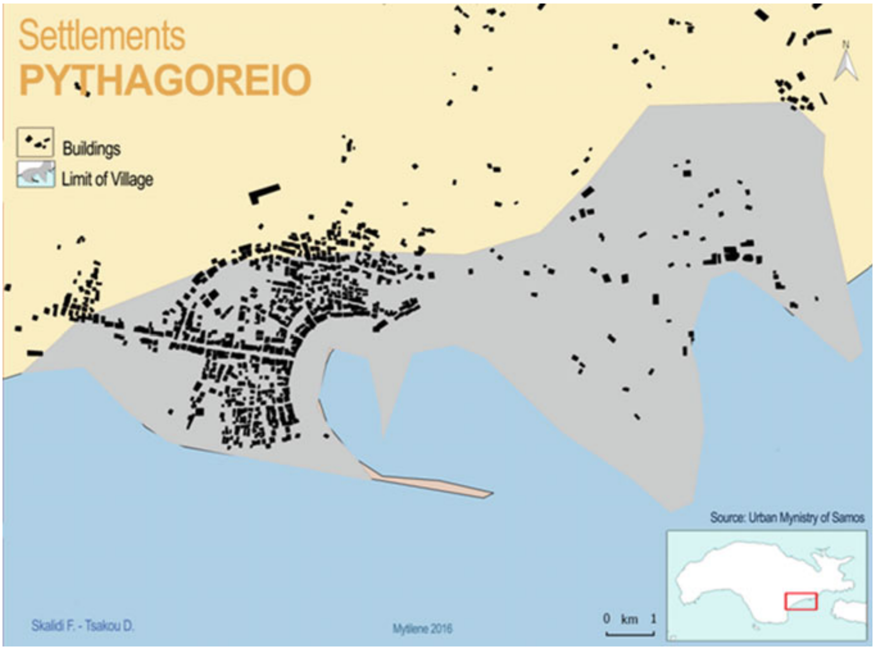

Fig. 2 Man-made structures in the Municipality of Pythagoreio in Samos island

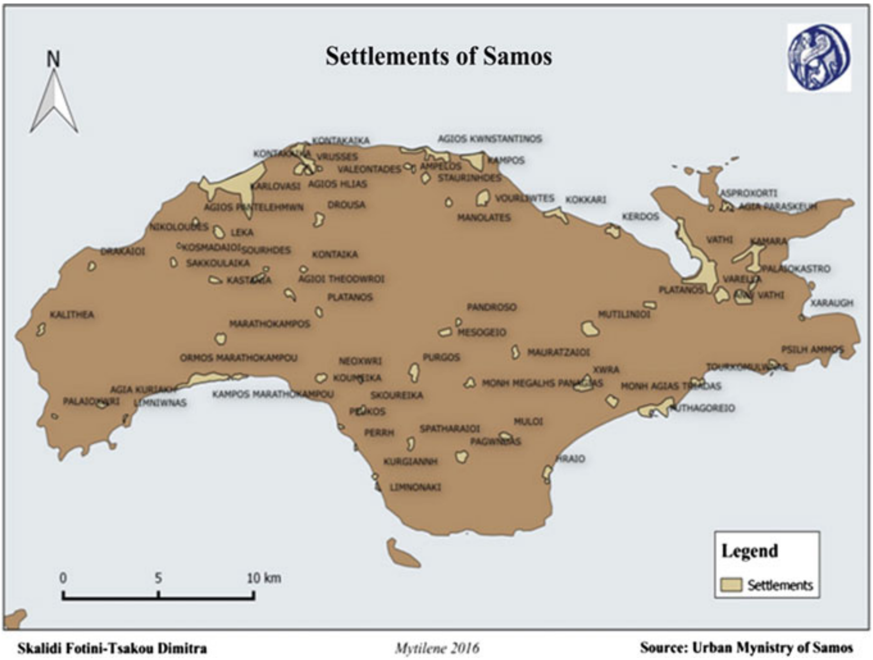

Fig. 3 Village boundaries in Samos island

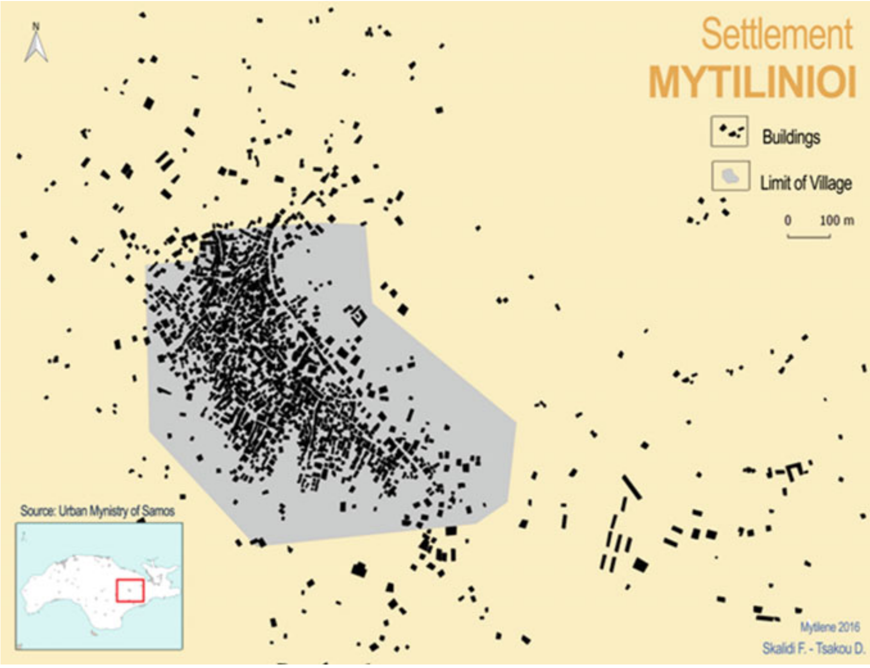

Fig. 4 Man-made structures in the village of Mutilinioi in Samos island

number of fire incidents with 121 fire incidents (35% of all incidents in Samos island); Municipality of Karlovasi has 104 fire events (30% of all incidents in Samos island); Municipality of Pythagoreio has 84 incidents (24% of all incidents in Samos island); and Municipality of Marathokampos has 37 fire events (11% of all incidents in Samos island). Most burnt areas appear in relatively lower altitudes (0–300 m above sea level), compared to higher altitudes (>900 m above sea level), where there are relatively less burnt areas. The average intensity of the fire events is 223 ha of burnt area per incident. From the total island's burnt areas, 58% were forests, 33% were semi-forest areas and 9% were agricultural areas. During the last 14 years (2000–2014), there have been recorded 183,407.6 km^2 of burnt areas during 820 fire events in the island.

It is clear that the Municipality of Vathi requires additional attention regarding fire prevention care. Also, possible extra funding may need to be invested in this area in order to upgrade fire-prevention services.

Results obtained by this study can guide policy decisions as to the priorities that need to be set, the expansion of services to specific informal built settlements, the priorities in municipality budget break down, etc. Results of informal building structures could, for example, be used in order to identify areas requiring additional transportation services or services of water provision; while results about fire events may be used from local fire prevention services for setting up additional patrolling. Both results finally can play a significant role towards setting policy priorities and increasing effectiveness of resources for upgrading service provision, an important outcome during the current recession period, characterized by limited financial and human resources.

4 Conclusions

This research illustrates the use of spatial analysis techniques for the identification of areas requiring additional attention; and the smartening up of related decision-making process. The methods discussed could be used for automating identification of hot-spots and areas of attention in vulnerable island areas. Replicability of the proposed approach is of value, since relevant problems appear in many Aegean island territories.

The results of this work have shed some light on the underlying attraction/repulsion mechanisms of informal housing in the island of Samos. It has also contributed to the exploration of the relationship between fire starting points and man-made structures in the island. The above results may help local authorities to identify areas of increased informal development and areas with increased spatial concentration (clustering) of fire incidents. The spatial distribution of informal man-made structures may be critical information for a range of authorities such as: municipalities, police, fire authorities, health authorities, water authorities, waste management authorities etc. Fire protection authorities may use the outcomes of this work in order to identify vulnerable areas and explore the possible contribution of informal development of settlements to fire incidents in the island, thus setting up proper fire repulsion strategies.

The outcome of this work can be extremely useful to local decision makers as it offers practical tools for problems' identification, potential for better management of the built space according to current regulations; proper distribution of resources; and proactive planning approaches in order to cope with potential impacts of these problems. The tools and technologies adopted are based on open source licenses, which decrease the cost of use and thus usefulness and potential application in times of budgets' cut down.

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Geographical Analysis of Emergency Evacuations in the Aegean Sea: Towards the Utilization of Big Data Analytics

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Abstract Island areas in the Mediterranean constitute an important cultural and natural resource as well as spatial entities upon which dynamic activities, such as tourism, take place. The annual seasonality of tourist flows and the spatial fragmentation of activities in island areas place certain burdens that call for a dynamic approach in decision-making as to the provision of various services, e.g. health services, based on relevant spatially-related data analysis. The availability of health services as well as the specialized medical personnel determines in a certain extent the quality of health provision in island areas. The National Center of Emergency Evacuations in Greece (EKAB) provides the means for emergency health evacuation from the Greek islands to specialized hospitals in the mainland whenever necessary, playing thus a crucial role for the improvement of quality of life in the Aegean archipelago. The focus of this work is on improving emergency evacuation service provision of EKAB in Greek islands by analyzing population and transportation data for providing input to more "smart" health provision decision-making processes. After examining the current and potential future demand for health services through population data, the effectiveness of Big Data (BD) analytics utilization is explored in support of optimal allocation of EKAB resources, maximization of supply and minimization of possible evacuation time. The introduction of BD analytics in regional decision-making processes may enhance potential for tailored-made planning, faster and informed decision-making as well as scenarios' testing, service monitoring and more effective forecasting.

Keywords Geographical analysis · Big data · Islands · Health services · Emergency evacuations

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1 Introduction

An important characteristic of the Mediterranean area is the large number of islands that are spread in the Mediterranean Sea. Island areas, although exhibit a substantial heterogeneity in terms of size, level of development, morphological attributes etc., they share certain distinct geographical, environmental, social and developmental *features*. These features form island's discrete identity and refer to the following peculiarities (Hotchkiss 1994; Cross and Nutley 1999; Moraitaki-Tsami and Vasilakis 2007): islands are isolated geographical areas, with surrounding aquatic environment forming a physical barrier that conditions transportation options as well as access to various services, and leads to a certain degree of isolation; the size of islands is often very limited, with such areas being inhabited by a small number of population; island areas are perceived as fragmented spatial entities in terms of both service provision and resource utilization; additionally they constitute fragile ecosystems, particularly exposed to natural phenomena and uncontrolled environmental events.

At the same time, island areas in the Mediterranean are perceived as hubs of important cultural and natural resources upon which dynamic economic sectors, such as tourism, are flourishing, steering thus local development and employment opportunities. In supporting economic prosperity and social cohesion in an environmentally sound way in island areas, certain quite important inefficiencies as to the efficient service provision to local population and visitors need to be effectively dealt with. These inefficiencies are mainly emanating from the annual seasonality of population due to tourist activity and the spatial fragmentation of activities in island areas.

Coping with such inefficiencies calls for a dynamic approach in decision-making processes that is largely based on relevant (spatial) data analysis. This effort needs to take into consideration the seasonality of population in island areas, which varies mainly over winter-summer months; and is a defining factor for effectively planning the provision of a variety of services, such as water, waste, security and transportation. In Greek islands of the Aegean Sea, for example, the permanent population shows a considerable variability that is both island- and season-specific. As islands are among the popular tourist destinations, there are cases where the population during the summer period is three times greater than the population during winter months. The seasonality of island's population (Kizos 2007) challenges local decision-making as regards service provision. Indeed, planning the provision of transportation services, waste collection and management, water provision, health provision and electricity as well as security services is fraught with difficulties in respect of allocating resources and personnel; while the importance of the islands' tourist activity in the Gross Domestic Product (GDP) of Greece makes this effort a crucial one, since this fragile economic activity is very sensitive in unsatisfied service provision.

The dynamic problem of allocating resources in a fragmented geographical space is quite complex, considering the number of factors affecting decisions at a regional and sub-regional scale. This implies the need to elaborate on information emanating from various services, sources and administrative levels in order a more knowledgeable decision-making at all governance levels to be achieved; and an effective balance of resources and human power, capable of responding to cases of uneven provision of services, to be reached.

Health provision is among the factors influencing quality of life in fragmented geographic areas, such as the islands in the Aegean Sea. The availability of health services as well as the specialized medical personnel determines, in a certain extent, the quality of health provision in island areas. Furthermore, as critical health incidents in such areas need to be treated in larger hospitals of the mainland, regional scale decisions, such as the placement of *emergency evacuation services*, are of crucial importance. Coping with this problem calls for the utilization of relevant tools and methods that can enable fast, reliable and pinpoint decision-making; and can manage speed of change, complexity and diversity of available geographical data. Towards this end, "smart" technologies and approaches can be applied, which enable the interconnection of various data sources into a coherent "data ecosystem", forming the ground for effectively data analysis and management; and relevant decision-making.

The latter is the *focus* of the present work. More specifically the paper concentrates on data management technologies and tools for supporting decision-making as to the provision of emergency evacuation services provided by EKAB. This is accomplished by the construction of a single integrated measure of emergency evacuation for the islands in the Aegean Sea, Greece. This measure categorizes islands of the study area according to probabilistic rules based on data management as to: population size, population age structure, transport links and current heath provision. After examining current state of health services in the islands of the study area and quantifying the transportation options per island, population data for the categorization of islands according to potential need for emergency evacuations is used. Finally, it is argued that this type of analysis could be expanded by use of BD from transportation authorities.

2 The Riddle of Health Provision in Island Communities

Establishing a safe and secure landscape for economic and social activities in, less accessible, insular regions preserves population stability and supports local development perspectives, with tourism activities constituting the main pillar of these perspectives. An important part of this landscape is the *health sector*, where the provision of a stable and reliable health system affects prosperity and quality of life of both population and visitors; and constitutes a defining element as well as an enabler for the development of insular economies. As Moncada et al. (2010) state, the establishment of appropriate health services is vital for the socio-economic development of island areas.

Locating a health service in a remote geographical area is an *intriguing issue*. Such a location decision is not only *financially unprofitable*, but also needs additional resources for keeping track of reliable services and maintenance. Moreover, staffing a health service, such as a regional health center, requires additional funds as the availability of specialized personnel, willing to relocate, requires relocation grants. Additionally, the burden of running such a service in remote areas is relatively increased due to additional transportation costs of goods and specialized materials. The aforementioned issues are fueling decisions as to the type and size of health infrastructure that will be located to island regions, following the rules of a certain hierarchical structure of the national health system. This in turn implies that certain critical incidents need to be handled in hierarchically higher components of the Greek health system, i.e. large hospitals in the mainland.

Such a handling is confronted with the physically restrained *accessibility* of islands, largely affecting health provision, mainly due to the limited transportation options. In such a context, a certain *evacuation* system for transporting patients from lower to higher level health establishments has to be defined; and certain locational decisions as to its spatial structure have to be made. That is locations, means of transportation as well as human support have to be properly organized in order to serve an unstable and normally unable to predict evacuation demand. The medical transportation of patients requires not only specialized medical transportation means, but specialized personnel as well. This increases the cost of local health establishments, since it presupposes disposition of additional health personnel that will be used for joining evacuation procedures.

In conclusion, the overall cost of running a health establishment or supporting evacuation procedures in remote areas such as islands is relatively increased, comparing to other health establishments in the mainland, while riddle decisions have to be made.

Another factor, which also affects recourse allocation in the health service sector in fragmented geographical areas such as the island ones, is the *seasonal population variation*. Many islands, as popular tourist destinations, are confronted with seasonal population rise that is following tourist flows' ups and downs pattern, with their population rating much higher during the high tourist season; while being much smaller during the low tourist season. This *seasonal variation* is an important factor in the design and evaluation of health service provision in the islands, as demand for services is much higher during summer period, while scales back in winter time. This variability implies also considerations in terms of higher needs for transportation means, personnel and health material during peak population periods.

Furthermore, the population variation does not follow a *regular pattern* on a yearly basis; on the contrary it exhibits different patterns from year to year, depending on a variety of external to islands factors that affect tourist preferences and related flows. Indeed tourist flows may periodically shift from one island to another, influenced by tourist market developments e.g. touristic packages, availability of touristic events, changing price policies, new tourist destinations; while flows are also affected by political instability or tense, environmental hazards, natural disasters and other unpredictable trends.

Effectively coping with that type of uncertainties implies the need to get access and manage accurate and near real time population data, in order to flexibly respond to changing demand pattern for health services; and reconsider location of both service infrastructure and personnel accordingly.

One of the *main debates* with respect to the establishment of health-related infrastructure and services in fragmented areas, such as islands, relates to the *equal provision* of services to all islands against *proportional provision* according to their population size.

Equal provision may be a socially desirable notion and a considerable objective to pursue when planning the distribution of health services. Public policy makers should ensure equal access to health services and promote health policies that cope with geographic inequalities in this respect (Gravelle and Sutton 2001). But at the same time, it should not be ignored the fact that running a number of health-provision establishments in all islands in order to meet possible demand in a socially fair way, increases the *direct and indirect costs*; and this is a problem that needs to be properly handled, especially in a recession time where scarce resources need to be carefully managed.

Proportional provision of health services, on the other hand, is a somehow more cost-effective approach, taking into account that service provision is adjusted to islands' population. Of course a minimum provision of basic and life critical services needs to be installed in most of the areas where permanent population exists, but on the other hand the installation of fully staffed emergency services in all islands is not a rational and cost-effective approach. Does this mean that one should accept regional inequalities as a de facto or an impossible to handle peculiarity of island spatial systems? The answer is of course no, in terms of a fair regional policy treating with justice all land parts of a state. What is necessary is to find a way to cope with this inefficiency, to make more "smart" decisions, to use digital technologies and related tools and applications for data management as enablers for more accurate and efficient assessment of current and possible future health service demand in the remote and fragmented island configurations of the Mediterranean Sea. The above will inform decision-making processes towards an adequate service provision at the first level; and an *evacuation policy* that best assesses fluctuating islands' demand and supports this kind of locational decisions that enable timely response to this demand for dealing with further needs for more specialized health care provision or handling of critical health events. The latter is the focus of the present work, coping with "smart" decision-making as to evacuation policy locational decisions for serving relevant demand in insular areas of the Aegean Sea.

3 Big Data Approaches in Support of Decision-Making in Fragmented Insular Areas

The currently evolving concept of smart cities has brought to the forefront a variety of tools, technologies and relating applications for coping with contemporary cities' challenges. Along this line, a number of works are encountered in literature in the later years, regarding the context of smart cities. Neirotti et al. (2014), discuss current *trends* in smart city initiatives. Kramers et al. (2014) explore information and communication technology (ICT) solutions for *reduced energy use* in cities. Al-Hader and Rodzi (2009) discuss about development and monitoring of *smart-city infrastructure*. Nuaimi et al. (2015) discuss about applications of BD to smart cities; while Batty (2013) sets the case for BD in smart cities and *city planning*. Kavroudakis (2015) describes a methodology for constructing micro-data for *smart decision-making*.

Relevant efforts have been undertaken regarding smart systems for *fire prevention and management*. Bao et al. (2015) have implemented a smart system for optimization of forest fires monitoring. Hodgson and Newstead (1983) have also implemented a smart system for location-allocation for control of forest fires by air tankers. Additionally, Alonso-Betanzos et al. (2003) describe the use of intelligent systems for forest fire risk prediction.

The issue of *health-related smart decision-making* has also come to the forefront, by means of relevant works, based on the use of Artificial Intelligence approaches (Kavroudakis and Kyriakidis 2013). Moreover, there has been a number of works by Kavroudakis et al. (2012, 2013), depicting the use of spatial micro-simulation approaches for understanding spatial inequalities of population distribution; and using that knowledge for smart policy decisions by geographical area.

What is evident from various smart city literature sources is the need for *data fusion* from different sources in order to enable smart decision-making. The volume, speed of change and complexity of data in urban environments may categorize them as BD, i.e. large amount of data which imply the need for different data management and analysis approaches. BD is actually an umbrella term related to *large scale complex unconventional datasets* that are difficult to analyze using established methods (Lovelace et al. 2016). This emerging new approach in Information Technology (IT)-related sciences is closely related to the notion of identifying trends and hidden processes from large scale data; and analyzing them by use of advanced analytics for the extraction of knowledge. Scientific fields such as marketing, economics as well as regional sciences have been experimenting with the use of BD. On the other hand, as discussed in the work of Crampton et al. (2013), there are some cases where BD is inappropriate for extracting scientific knowledge. The use of BD in business environment has already been implemented by using large scale customer datasets, which enable deeper understanding of current and potential clientele. Retail companies use DB approaches to monitor sales; and social media to get deeper insight into customer preferences and perceptions. Financial services are using data mining methods in BD for user groupings and preparation of relevant tailored offers and products. In medical sector, organizations are analyzing health related BD sources to predict admissions by associating patient records and diseases spreads. Also, there are some examples where health-care organizations use BD approaches for predictive modeling to detect health-care fraud, waste and abuse (Zimmerman 2013). Similar approaches could also be used in *geographical studies* so as to check the geodemographics of areas against potential policy reforms and changes. From the *policy point of view*, the use of databases (DB) could enable the calibration of strategies and policies for meeting the needs of area geo-demographics. Also, such a system could help towards the delineation of services that need to be rendered, based on local trends such as: the location of new health service sites or the relocation of existing ones.

In order to transform BD into meaningful information for decision-making a number of *techniques* need to be applied. Initially one needs to use data science approaches for storage and retrieval of data. Also, quantitative methods are required in order to combine and associate information among data sources. Finally, some technical skills are required in order to handle complexity and volume of data as well as distribution of information among many servers.

Applied geographical and regional sciences can benefit from the use of BD analytics by taking advantage of data from a variety of sources. More specifically, *potential data sources* for a BD system include social media, web services, public records and private sector data. Over the later years, there have been a number of works regarding BD and social media, such as Twitter (Wang et al. 2012; Wu et al. 2014), Facebook (Menon 2012) and LinkedIn (Sumbaly et al. 2013). There is a number of geolocated web-based services that connect supply with demand such as AirBnB, which provides a platform for house renting across the globe. Another service is FourSquare which is a "check-in" platform for almost any place around the world where with users can rate and discuss about venues, businesses and other geographical spots. Both web services deal with *geographical big-datasets*, which are a valuable resource for research and business intelligence. There is a number of works showing the use of BD approaches in AirBnB operations (Van Rijmenam 2016) and FourSquare (Noulas et al. 2011; Zadrozny and Kodali 2013). Mobile telephony Antenna logs keep track of service information that can also be used as a part of a BD system, which can feed usage information about a geographical area for the understanding of *seasonal population movements and residence*. The work of Laurila et al. (2012) explores the usage of such datasets with privacy-respecting approaches.

Transport data logs from public and private organizations, offer a unique source of information about the *movement of population and goods across geographical areas*. Such datasets can help towards the understanding of *seasonal movements* of population as well as *accessibility* of areas and *proximity* to amenities. The work of Lv et al. (2015) examines traffic flows prediction based on BD approaches. Transportation sciences show particular interest in BD Analytics as transportation data volumes are increasing; and the extraction of relevant knowledge becomes even more difficult. Possible sources of traffic data include not only public transportation sources, such as bus and metro, but also taxi companies and private car hiring companies. Taxi companies could also provide *geolocated taxi-calls* (origin/destination). These data could enable a more detailed geographical analysis of an area by examining the variations of transportation over the time.

When the area of interest is related to *island areas*, *marine traffic information* can also be obtained, which may shed some light on the understanding of *population inflows and outflows* to islands. This is potentially useful to regional studies as it may be used for grasping *accessibility patterns* (Spilanis et al. 2005, 2012; Karampela et al. 2014) and *attractiveness* of island areas (Kizos et al. 2005; Spilanis et al. 2006; Kizos et al. 2014).

Public services such as water providers, electricity providers and health services (both primary and secondary level) may also contribute with the provision of *anonymous geolocated data* that will help understand *local population trends*. More specific, consumption of water and electricity could be used for *seasonal adjustment of supply* over island areas. Energy providers in island areas may also utilize BD to capture current supply and demand of energy in order to align with strategic objectives (resource optimization) through specific pricing plans consistent with supply and demand (Nuaimi et al. 2015).

Another application of BD may be the use of *sensors' information* for water management and smart waste management by applying IT innovations and intelligent sensors to effectively manage water consumption and garbage collection services (Neirotti et al. 2014). BD applications can also support efficient transport planning by providing easy ways to more effectively handle their services from different fields/locations and reduce transportation costs (Kramers et al. 2014).

Finally, a very interesting application of *BD in island economies* could be the incorporation of *hotel bookings* to a universal system, which could extract useful tourist information for policy making. An almost real-time informative data feed about hotel bookings could enable better public policy regarding tourism, health services, environmental protection and transportation provision by geographical area.

While BD applications have up to now mostly focused on serving various sectors in a smart city (Fan and Bifet 2013) and help create a knowledge-based society, the previous discussion shows their potential, yet not fully explored or exploited, in *fragmented island regions*. For example BD applications for islands may provide the necessary platform for sending feedback to specific entities in order to take action and alleviate or resolve transportation problems.

BD analytics provide a novel approach in examining dynamic processes that can be of value for *decision-making in insular territories* by providing new, more sophisticated approaches for understanding supply/demand of services offered and establishing a platform for policy evaluation and possible scenarios' building and assessment. Such a platform should integrate solutions in order to end up with better and more controlled utilization of information sources, such as Enterprise Resource Planning (ERP) (Ragowsky and Somers 2002) and Geographic Information System (GIS) (Al-Hader and Rodzi 2009). In a smart city environment, but also in island environments, there are components that can be connected with

BD such as mobility, governance, environment, and people as well as their applications in service sectors such as healthcare, transportation, smart education, and energy (Khan et al. 2013).

On the other hand, there are a number of challenges preventing local authorities from capitalizing on BD. These include cultural and technological type of challenges. The data management of BD is a challenging task, as it requires the storage, retrieval and analysis of large volume of *spatially-aware datasets*. More specifically, it requires sufficient storage space in multiple computers, inter-linking of spatial data with economic activities, efficient data retrieval and advanced statistical analytics. Getting authorities to share and make information transparent is a difficult task as this requires sufficient effort to preserve confidentiality of information and prevent population tracking (individual or group of individuals). There is also the need to set up policies to ensure data accuracy, high quality, high security, privacy, and control as well as to use data documentation standards that provide guidance on the content and use of the datasets (Bertot and Choi 2013).

Local and regional authorities keep records in unsuitable format, such as paper and inaccessible digital records. There is still a significant amount of information that is not yet in digital form and in most of the cases is stored in very unsuitable locations. There is still much work to be made before transforming the flow and format of information of local authorities into usable and transparent format, ready for a BD ecosystem. The collection and storing of data in digital form may help local authorities save resources, funds and time. Around 90 percent of the world's digitized data was captured over just the past two years (Nuaimi et al. 2015). Another important challenge is the transformation of raw data to information useful for further processing. This transformation requires good understanding of the data sources and the problem which needs to be solved. The data should be transformed in such a way that can provide meaningful and scientifically accurate information, required by the decision makers. Furthermore, information should then be transformed to knowledge with the use of advanced analytics in order to provide useful arguments and insights for decision-making. The two steps approach of transforming raw data to information and then to useful knowledge is crucial for enabling a deeper understanding of dynamic phenomena; and illuminating trends that are not yet captured by conventional approaches. Finally, most available data mining algorithms are not very suitable for BD mining applications as their design is based on limited and well defined data sets (Wu et al. 2014). A near real time application for islands analytics should also include advanced data-mining tools that would enable the fast exploration of information in order to provide sophisticated results for decision making.

The volume, speed of change and complexity of *regional data* may also categorize them as BD. For example, BD for island regions in the Aegean Sea may include information about transportation, health services' provision and tourist activities, etc., entailing the need for a combination of data sources in order to identify solutions and evaluate alternative "*what-if*" scenarios.

A *"smart"* decision-making approach for *emergency evacuation analysis*, being the subject of the present paper, can support the coordination of relevant services in the Aegean Sea. This implies the need for a centralized Decision Support System, which will be based on *Big Data* (BD) analytics approaches for the assessment of current and near future supply-demand conditions in the islands of the Aegean Sea. Such a system may help identification of areas than need additional heath services according to current population needs; while can, at the same time, be used for informed decisions regarding re-location of human and related financial resources.

A “smart” Decision Support System, based on BD analytics, could collect data from transportation authorities through which, as previously discussed, seasonal movements of population can be assessed and possible system changes can be identified, based on predictive statistical models. This means that sophisticated BD analytics, by elaborating transportation data, can substantially improve decision-making; while minimizing risks and unearth valuable insights into the population size that would otherwise remain hidden. The quantity of data and the use of advanced analytics may reveal possible *surplus or deficit* of health services in a certain island. This means islands where the current health services exceeds population needs—*surplus*—and islands where the provision of health services falls short—*deficit*—in respect of needs of population that is currently in the area.

4 Emergency Evacuation Services in the Aegean Sea—A Case Study

In order to examine the potential use of BD in a geographically fragmented area, we focus on the potential use of BD for the prediction of possible *emergency evacuation services* in the islands of the Aegean Sea, Greece. The study area includes the islands of the northern Aegean Sea, the islands of the Dodecanese and the Cyclades islands. The Aegean Sea includes a large number of Greek islands, which form a unique geographical space in terms of both natural and socioeconomic variations. The islands of the Aegean Sea form two administrative regional units (Region of North Aegean and Region of South Aegean). Each island has one municipality unit. There is a remarkable variation of permanent population by island in the Aegean Sea, which entails the need for setting up distinct strategies regarding service provision relevant to each single island. For example the provision of health services is related to the number of permanent population of each island. This is coupled with the fact that considerable population seasonality can be noticed in each island, which is related to tourist activities taking place mainly during the summer months.

Emergency evacuation services in islands of the Aegean Sea play a very important role as they add value to the current health services by transferring critical cases from the island to mainland Greece. For “smartening up” planning of emergency evacuation services and taking advantage of smart decision support approaches, there is a need for data fusion i.e. integration of data emanating from various data sources and relevant stakeholders. The problem of balancing demand and supply of such services implies the identification of islands that require additional health services for both local population and visitors by use of smart technologies and approaches in decision-making processes.

4.1 Current Transportation Options in the Aegean Sea

Transportation is among the factors affecting *physical isolation* of islands. When evaluating *emergency evacuation means* in the Aegean Sea, one should also take into consideration the mainstream transportation option available (airplanes and ferries) operating in the area, before addressing specialized means such as evacuation helicopters. This is because some less critical medical evacuations can also use mainstream transportation means without violating health-treatment protocols and procedures. A relatively increased number of Greek islands in the Aegean Sea are served by air transport activities under the supervision of Greek Aviation Authority. From the total 26 airfields in Greece, 21 of them (80.8%) are located in the islands of the Aegean Sea: Kasos, Astupalaia, Suros, Skiros, Kalumnos, Kithira, Naxos, Karpathos, Leros, Skiathos, Paros, Milos, Ikaria, Limnos, Samos, Xios, Kos, Mitilini, Mukonos, Santorini and Rhodos. Air transportation is important for Greek islands, providing the fastest transportation option for some islands; and is used as a secondary option for non-critical medical evacuations.

Maritime transportation is also present in the Aegean Sea. Most of the islands are served by relatively regular sea ferry-routes. Transportation of non-critical patients by sea-ferries is not very popular. Nevertheless, it is still a viable transportation option in cases that air-transportation is not possible. Islands with more intense sea-ferry schedules have relatively increased accessibility with respect to medical evacuations; and population has better access to tertiary health services in mainland Greece. The ferry routes in most of the islands of the Aegean Sea appear to be analogous to island's size of population, with regular connections to Piraeus main-harbor. On the other hand, islands with relatively lower population appear to have smaller number of sea-ferry links.

The morphological attributes of the Aegean islands and the characteristics of the ferry transport network have promoted the use of helicopters as the main transportation mean for directly accessing otherwise inaccessible areas. The capabilities of this transportation mean as well as the relatively fast deployment of heliports facilities have motivated the use of helicopters as the *main emergency evacuation mean*. Currently 38 heliports are in operation in the Aegean Islands' area (HCAA 2016).

4.2 Towards an Integrated Measure of Emergency Evacuation

The Greek health system uses emergency evacuation procedures when necessary in order to support transportation of life-critical medical cases. The EKAB is providing the means for emergency health evacuation wherever necessary (EKAB 2016). Its role is crucial for improving quality of life conditions in remote and peripheral islands of the Aegean Sea providing, in case of emergency, a fast transportation option to specialized hospitals in the mainland of Greece. One of the main evacuation means of EKAB is the helicopter service, which has sufficient service range and all-weather capabilities. Examination of *optimal sitting* of heliports may reduce costs and improve quality of service by enabling short time response and reduction of total travel time of evacuations. Faster response may also be critical in medical terms, as in some cases the time spent until treatment, may be crucial. The EKAB was established as a legal entity in 1985; and is under the supervision of the Greek Ministry of Health. Its purpose is to provide and coordinate emergency evacuations services. Evacuation is defined as the supervised transportation of a patient to a health service facility. The Greek Health System (Ministry of Health 2016) categorizes evacuation procedures into the following *four distinct types*:

- *Evacuation type 1*: Evacuation of patients with critical conditions from the scene of the incident to the nearest appropriate health formation for treatment purposes.
- *Evacuation type 2*: Evacuation of patients from a doctor's office to a more suitable health service for treatment purposes.
- *Evacuation type 3*: Transportation of patients from a secondary or a tertiary health formation to an intensive care unit or to a specialized center for treatment or rehabilitation.
- *Evacuation type 4*: Repatriation or transportation of patients for transplantation or transfer grafts.

This work focuses on the Evacuation type 3, which is the most frequent type of evacuation in the Aegean islands. During the last ten years of EKAB operation 15,531 *evacuations* took place, of which 9530 were men and 6001 women, from ages 0 up to 93 years old. In the study area of this work, 14,794 came from the Cyclades islands (35.22%), 3509 patients from the Dodecanese islands (24.4%), and 3254 individuals from other islands of the Aegean Sea (22.5%). The 53% of the total patients were of critical conditions, 42% were in moderate conditions, while the remaining 5% in a more stable state.

In order to evaluate the overall accessibility of the islands as well as to quantify medical evacuations, we need to develop a *single integrated measure* that will take into consideration both the supply and the demand of the specific insular geographical area. This is to combine the current availability of transportation means along with the potential medical demand of the population. In this context we calculated quantile values for 6 variables for the islands falling into the study area. We used quantile values in order to enable the comparison and integration of values between different variables. The 6 variables forming the integrated measure are:

- *Population 0–19*: Number of individuals below 19 years, living permanently in an island according to the Greek Census of Population 2011 (Hellenic Statistical Authority 2011).
- *Population 20–59*: Number of individuals between the ages 20 and 59 years, living permanently in an island according to the Greek Census of Population 2011 (Hellenic Statistical Authority 2011).
- *Population 60–80+*: Number of individuals above 60 years, living permanently in an island according to the Greek Census of Population 2011 (Hellenic Statistical Authority 2011).
- *Annual flights to Athens*: Number of annual flights from an island to Athens main airport (HCAA 2016).
- *Weekly sea-ferry routes to Athens*: Number of weekly sea-ferry routes from an island to Athens main port (Ministry of Transport 2016).
- *Current health provision*: Number of health services in an island (Ministry of Health 2016).

For every single island we calculated the quantile value for each of the above 6 variables. This enabled us to get a better understanding of supply-demand relationship in terms of health provision in the area; and evaluate this relationship against accessibility data, such as annual air-flights and weekly sea-ferry routes to/from the islands of the Aegean Sea. We ranked islands by transportation options, population size and health service availability separately. This produced quantile rankings (1st class, 2nd class, 3rd class and 4th class). Then, for better comparison purposes, we composed all rankings into a single ranking by island. For the combination of the 6 rankings into a single ranking, we assumed that population of age groups 0–19 and 60–80+ years is more vulnerable and should have relatively increased accessibility to medical supervision. Finally, we came up with a 3 class ranking for all islands in the Aegean Sea ("*Good conditions", "Average Conditions", "Need Attention"*).

4.3 Results

The results show that islands with hospitals and under-populated islands with health centers have relatively good conditions regarding emergency evacuation. These are islands with secondary heath services (hospitals) and under-populated islands with access to primary health services (health centers), which appear to be in the upper quantile of the integrated measure of emergency evacuation. On the other hand, islands with relatively increased population but with relatively limited number of health services as well as relatively less connected islands tend to appear in the lower quantile of the integrated measure.

Figure 1 depicts the results of the integrated measure of health provision in the islands of the Aegean Sea with respect to population groups, accessibility and health provision. According to the results, 34.6% of the islands in the case study have overall good conditions regarding availability of health services and access to mainland hospitals. On the other hand, 44.2% of the islands have relatively bad conditions regarding accessibility to mainland hospitals and health service provision.

The results of the integrated measure of emergency evacuation were mapped (Fig. 1) in order to examine the spatial distribution of the overall measure and check against possible spatial dependency. The map depicts the three categories of the overall measure of emergency evacuation. The upper category includes islands with relatively good conditions, such as sufficient health services or/and transportation options with regards to population structure. The middle category includes islands with relatively moderate conditions; while the last category includes islands with relatively bad conditions. From a policy making point of view, one should focus on islands laying in the lower category, in an effort to identify possible system upgrades or evaluate the efficiency of transportation options with respect to population size.

The results indicate that there are some islands requiring additional attention regarding health services. The population structure of some islands, combined with their current transportation options, reveal the necessity for establishing better transportation connections between these islands and the mainland. Also, the health service availability in these islands is relatively limited, a fact that increases the probability of future emergency evacuations. The islands requiring additional attention are: Alonisos, Skopelos, Oinousses, Psaron, Folegandros, Agathonisi, Astypalaia, Leipsi, Karpathos, Kasos, Kea, Kythnos, Nisiros and Kimolos. On the other hand, the results of this work indicate that there are some islands with relatively good overall conditions regarding emergency evacuations. These islands appear to have relatively more health services than population size and structure (age groups) would justify. Also, these islands have relatively more frequent transportation connections with the mainland, a fact that reduces the overall probability of emergency evacuations. The islands with relatively good conditions include: Skyros, Lesvos, Limnos, Samos, Chios, Syros, Santorini, Leros, Patmos, Mykonos, Naxos, Paros and Rodos.

In a "smart" region context, the above results could be used in a Decision Support System that may incorporate transportation and population BD for the evaluation of overall conditions for each island, regarding emergency evacuation demand. This will enable better allocation of resources and support better planning of services.

The quality of results is related to the quality of data used. The input data are aggregations of tabular data by island; and reflect the current available transportation options and population structure. In a "smart" region context, such kind of data should be provided directly from local authorities in a time-series format,

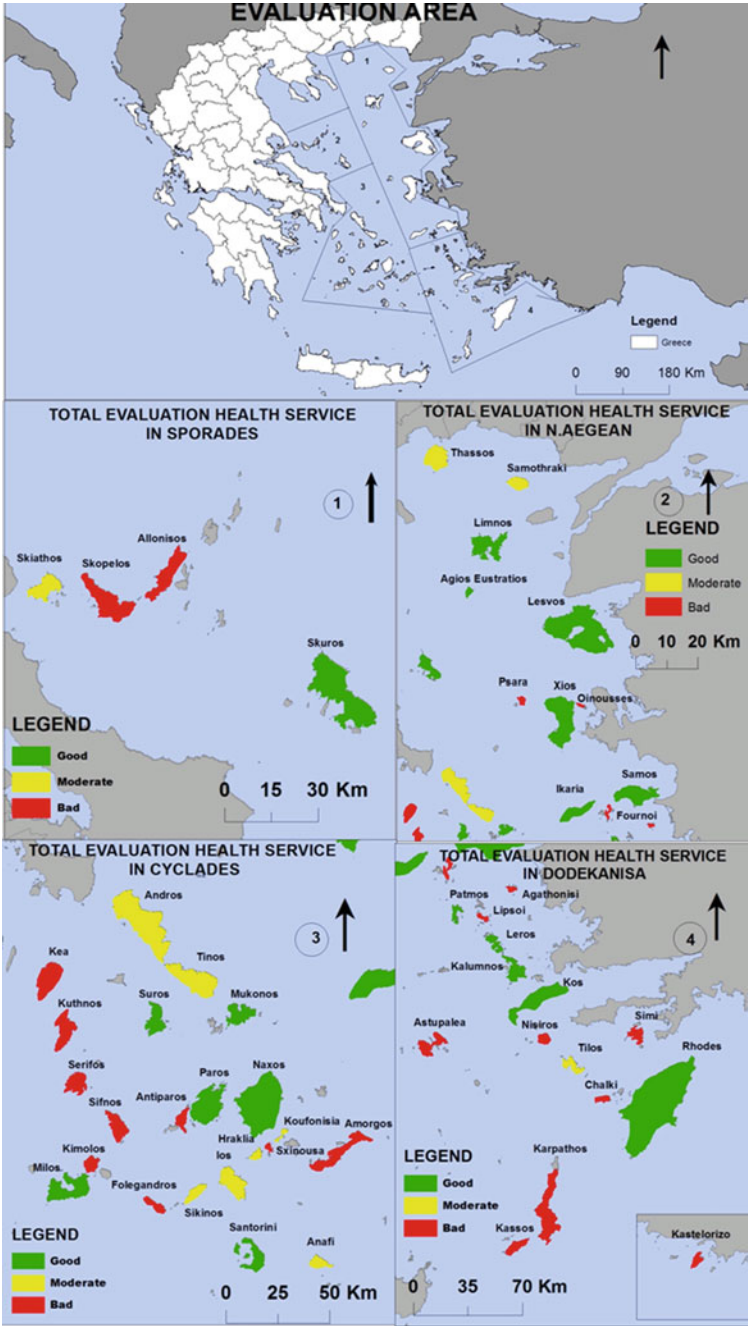

Fig. 1 Spatial distribution of the "overall measure of emergency evacuation" in the Aegean Sea

including data quality measures, for enabling data time series analysis for every island and informing local decision-making processes. In the context of this work, quality of results depends also on seasonal population data availability. A "smart" region decision support tool may include monthly datasets regarding population size in order to control against seasonality of population and produce monthly evaluations by island.

5 Conclusions

This work has elaborated on issues of smart decision-making at a regional level. More specifically, the focus was on insular regions, namely a very special type of regions and a peculiar characteristic of the Mediterranean Area. The scope of the study was to rank islands according to population size and structure, transportation links and health services availability. Taking advantage of spatial analysis technologies, GIS and BD, a general decision-making tool was constructed, serving the goal of building an integrated measure for assessing emergency evacuation demand. This tool is potentially useful in allocating resources, especially during summer period in insular areas of the Aegean Sea. Same methodological approach could be used by regional administration authorities in similar problems, requesting the assessment of demand for a public service, such as fire patrol services, road patrol services, litter collection and transportation services. The seasonality of population as well as the geographical fragmentation of such areas calls for smarter approaches regarding demand estimation and relocation of respective services. The results of this work illustrate that there is a need for relocation of some helicopter services in the islands during the peak summer period. There are some islands that may also require additional health services in order to satisfy escalating demand during some months of the year. The estimation of demand is based on generalized information regarding population size and population age-structure, but this may be extended with the use of additional datasets from various local authorities. The potential use of BD could expand the capabilities of such a "smart" decision-making tool.

A BD analytics system with access to transportation data by island may inform decision makers about the current population size (near real time); and identify possible over/under served areas. A health provision system requires information on current population in each service area as well as the potential accessibility options available for emergency evacuations. The combination of population datasets along with transportation data (in-flows of passengers, out-flows of passengers) for each single island could be potentially useful for a "smart" policy making outcome. The use of BD may enrich management and decision-making processes in regional scale decisions. Exploration of the relationship between BD systems and "smart" decision-making applications may lead to a more targeted decision-making process. This understanding will help to include the right data into the right application for reaching more informed and thus better decisions; and optimize various spatial systems such as the one presented in this work. The introduction of BD analytics in island regions' decision-making processes can support more tailored-made planning outcomes, faster and informed decision-making as well as scenarios' testing, monitoring and forecasting.

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Enabling Flexibility from Demand-Side Resources Through Aggregator Companies

Ioannis Lampropoulos, Machteld van den Broek, Wilfried van Sark, Erik van der Hoofd and Klaas Hommes

Abstract In recent years, several business models of the aggregator company have emerged in Europe, in response to a general quest for flexibility in power system operations. A systematic approach of analysing the organisational arrangements underlying a business model is still lacking, whereas the available information on the potential of aggregated resources in electricity markets is limited. This work contributes to the systematic development of the business model concept of an aggregator company, and provides insight into its economic potential. A set of elements is identified that can be used for analysing the various implementations of a business model. A revenue analysis is performed based on historical data from the day-ahead market and the imbalance settlement system in the Netherlands. The case study is about a hypothetical implementation of the aggregator company with focus on residential demand-side resources. The results show a significant theoretical potential and suggest an interesting business case.

Keywords Demand-side flexibility · Aggregator companies · Renewable energy · Energy management in buildings · Consumer empowerment · New business models

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1 Introduction

The increasing integration of intermittent renewable energy sources in power systems and the ongoing deregulation of electricity markets have resulted in a quest for flexibility both for system security and market optimisation (Van Hout et al. 2014). Flexibility is defined as a "general concept of elasticity of resource deployment providing ancillary services for the grid stability and/or market optimisation" (CEN-CENELEC-ETSI 2012). Until now, flexibility was mainly sourced from large generators at the supply-side. Currently, the focus of enabling flexibility is increasingly placed at the demand-side through flexible loads, distributed generation units and energy storage devices in the industry, commercial, and residential sectors. Unlocking the flexibility at the demand-side is considered a key factor for an effective energy transition which requires the active participation and empowerment of customers (EG3 2015). Besides the active involvement of customers, most of the energy resources in the built environment cannot contribute to flexibility services on their own because of limited capacity and controllability. Aggregator companies are organisations that can combine these distributed and dispersed energy resources into a single system resource, which can be utilised for the provision of flexibility services.

The concept of the aggregator company, a new entrant in the energy market, is connected with smart grid development, which subsequently links to the smart city notion due to the importance of energy at the urban level. Urban environments are highly dependent on reliable energy supply to sustain their functions. At the same time, cities are expected to contribute considerably in addressing global environmental challenges, though, the implementation of appropriate actions are subject to limited financial resources (Maltese et al. 2016). At European level, the sustainable development of urban areas has been recognised as a challenge of key importance. The current framework programme for research and innovation, implemented by the European Commission, addresses particular topics for smart cities and communities by focusing on integrated solutions in the areas of energy, transport and information and communication technology (ICT). A relevant example is about the aggregation of electric vehicles through ICT for the provision of ancillary services to the grid and market optimisation purposes. The coordinated scheduling of the charging processes and procurement of services between the aggregator company and the system operator can enhance the efficiency and security of a power system and reduce its environmental impact (Ortega-Vazquez et al. 2013). Integrated approaches recognise the inter-dependencies between urban systems, and offer various advantages by exploiting existing assets. Other identified objectives in research and innovation in relation to the development of urban areas in Europe are about enhancing citizen involvement and affecting user behaviour (Maltese et al. 2016). By taking advantage of new technology, new entrants in the energy market and innovative energy service companies should enable all consumers to fully participate in the energy transition (European Commission 2015). Aggregator companies can deliver new value propositions to customers, particularly by better linking wholesale and retail energy markets. Aggregator companies can also take advantage of the increasing introduction of new technologies in urban environments, such as distributed generation, storage and energy-efficient buildings equipped with advanced control systems and demand-response schemes (Calvillo et al. 2016), in constructing their flexibility portfolios. The smart city notion highlights the importance of using common infrastructures and appropriate standards to enable parties across different disciplines and sectors to work together in researching, developing and deploying advanced technological solutions. Smart technologies and appliances, under appropriate standards, will enable users, procurers and service providers of flexibility, including aggregator companies, to develop novel grid and retail products and services (EG3 2015).

Aggregator companies have to agree with their associated customers on the commercial terms and conditions for the procurement, dispatch and remuneration of flexibility. The financial benefits for the customers may be in the form of energy bill savings or other financial incentives. Demand-side flexibility could be used by various actors to serve several purposes and provide multiple benefits and sources of revenues (EG3 2015). An aggregator company might utilise flexibility to take advantage of price differences between wholesale and retail markets for electricity, to participate in ancillary services markets, and to provide *over-the-counter* services to other market parties. Unlocking the flexibility from an aggregation of demand-side resources involves technical, organisational and economic challenges. Several control schemes for demand response and aggregation entities have been proposed in the technical literature (Lampropoulos et al. 2013). Research activities have focused on the technical issues, but have not systematically analysed the organisational arrangements underlying the business model of an aggregator company, whereas the available information about potential and costs of demand response resources in the Netherlands is limited (Van Hout et al. 2014).

This work contributes to the process of systematically structuring the business model concept of an aggregator company. Insight is provided into the value creation and value capture by focusing on two developed markets in the Netherlands, i.e. the day-ahead market and the imbalance settlement system. First, a set of elements is identified that can be used for describing the various implementations of emerging business models around the concept of an aggregator company. These elements can also be used for identifying and analysing different organisational arrangements within the various business model concepts. Subsequently, the economic potential of one of these organisational arrangements is assessed in a hypothetical case study. In this case study, the aggregator company is organised in such a way that it combines the roles of the energy supplier and the balance responsible party (BRP). The focus is on an aggregation of demand-side resources of residential customers. An evaluation of the potential revenue that could be achieved with respect to the specified applications is performed through computer simulations by utilising an optimisation model, measured energy profiles and historical market data from the Netherlands.

The paper is structured as follows: In Sect. 2, the business model of the aggregator company is elucidated, based on a literature review; and the case study is presented. Insight into the value creation and value capture is provided in Sect. 3, where the research findings and results are presented and analysed. The paper ends with discussion and conclusions.

2 Literature Review and Research Methods

In this section, the literature review and the research methods are presented. The first part of the analysis is based on a literature review to identify those characteristics that outline the various possible implementations of the business model concept of an aggregator company, and subsequently the focus is placed on a case study.

In recent years, the business model concept has received significant consideration both from academia and industry. Despite this increasing momentum, there is still no commonly accepted framework or language to reconcile research and development efforts (Zott et al. 2011). To ensure the relevance of the research and to facilitate future progress on the topic, the performed analysis builds on a definition that has been given in the context of doing business electronically, including trade and the provision of services. A business model is defined as "an architecture of the product, service and information flows, including a description of the various business actors and their roles; a description of the potential benefits for the various business actors; a description of the sources of revenues" (Timmers 1998). Accordingly, the overall system architecture of the physical power system and the electricity sector organisation in Europe, including a description of the main actors and their roles, is presented in Sect. 2.1. This conceptual architecture allows for mapping the various system entities, domains, actors and their interactions, and can be used for describing the business model concept of an aggregator company. An actor represents a participant in a business transaction, and might consist of a composition of one or more roles (ENTSO-E 2015). In Sect. 2.2, a set of characteristics that can be used for describing the business model variations around the concept of an aggregator company is identified by reviewing emerging models in Europe. Emphasis is given on both the technical aspects and the organisational arrangements that drive the various variations of emerging business models. The case study about a hypothetical implementation of the aggregator company is presented in Sect. 2.3.

2.1 System Architecture and Overview of Main Actors and Roles

The liberalisation process of the electricity market and the directives for non-discriminatory access to the network, implemented in Europe (EP-CEU 2009), have significantly contributed towards the creation of competitive markets and a restructuring of the electricity sector. In Europe, each control area of the interconnected power system (ENTSO-E 2015) is operated by the associated Transmission System Operator (TSO), the legal institution that monitors the transmission network, ensures the connections with other control areas, and organises the markets for operating reserves and cross-border capacity and exchanges. A single control area might involve one or more Distribution System Operators (DSO), but every regional distribution system is associated to a single DSO company that operates as a natural monopoly. DSO companies connect individual system users to the transmission network, and provide the distribution of electricity through medium voltage and low voltage (LV) networks, which subsequently feed a large number of system users at the LV distribution level. Grid operators, i.e. TSO and/or DSO companies, are potential users of flexibility services, through the procurement of ancillary services, to perform their core tasks, to defer network reinforcements and investments, and to reduce grid losses (EG3 2015).

In Fig. 1, the residence of a system user, i.e. a residential customer, is illustrated as a private network interconnecting a number of energy demand and/or generation resources, such as distributed energy storage devices, generation units and loads. The resources of a residential customer can be characterised as: (a) non-flexible, i.e. critical loads, which are difficult or impossible to be displaced in time and amount without creating a sense of discomfort to the users, and uncontrollable generators, such as wind turbines and photovoltaic (PV) installations; and (b) flexible, i.e. non-critical loads, which are characterised by some degrees of flexibility, controllable generators and energy storage. The private network of a single customer is connected to the LV distribution grid at the point of connection (or main metering point), where the energy products of the respective user are measured or computed to support business processes such as calculation of energy volumes, financial settlement etc. For each connection point to the grid there is one associated supplier, i.e. a party that is sourcing, supplying, and invoicing energy to its customers, and a BRP, i.e. a party that has a contract proving financial security and balance responsibility (ENTSO-E 2015). The Dutch electricity market is open to competition for small-size system users since July 2004, and residential customers can switch to the supplier of their preference. For residential customers the roles of both the supplier and the BRP are typically taken on by the same market party. Suppliers and BRP could use flexibility services for portfolio optimisation and/or generation capacity adequacy (EG3 2015).

In Fig. 2, the overall system architecture of the physical power system and the electricity sector organisation, in the European context, is illustrated. The system

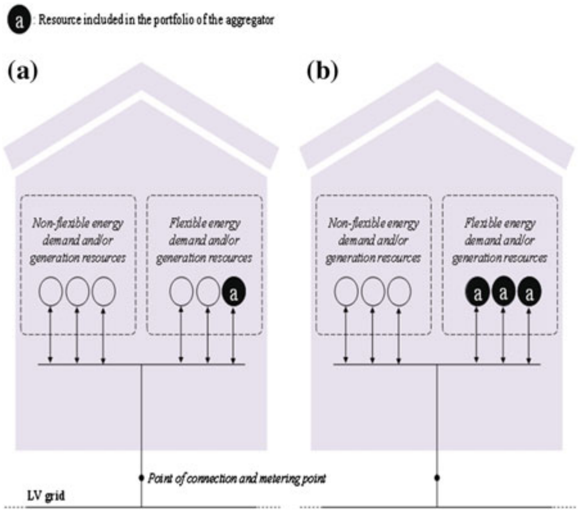


Fig. 1 Residential customers, i.e. system users, with both flexible and non-flexible resources. The aggregator company might include in its portfolio: **a** only one specific flexible resource, or **b** more than one flexible resource, or **c** all resources behind the point of connection of a given customer. The different possibilities outline the interest (or indifference) of an aggregator company to a specific target technology and subsequently different business models

entities (and domains) of the physical power system are attributed to the relevant actors (or roles), whereas both the power flows and the information flows are depicted. Note that the scheme illustrated in Fig. 2, maps the relationships within contemporary systems and indicates envisioned interactions at the distribution level. The main idea is that flexibility shall be combined as much as possible to serve different purposes and various actors. This can be enabled by developing a flexibility market at system level, where all flexibility offers are accompanied by a location tag to make possible also the provision of location specific services, such as network congestion management and/or peak-shaving at the distribution level. A DSO company is excluded by regulation from directly managing the energy resources within their customers' premises (behind the meter). In the future, a DSO might procure ancillary services from system users, if needed, in a similar way that the TSO procures ancillary services for balancing purposes. By setting a framework where DSO can buy flexibility options such as peak-shaving services, if needed, this creates a situation with natural incentives for the DSO to upgrade an aged network where peak-shaving services become necessary more frequently and subsequently more expensive. In the case that a DSO procures flexibility services, which might be in contrast with a request by the TSO for downwards (or upwards) regulation, it is essential to formulate exact criteria based on conditions and to outline an interaction framework between the TSO and DSO to avoid conflicting requests and inefficient operations. The system users that provide the flexibility

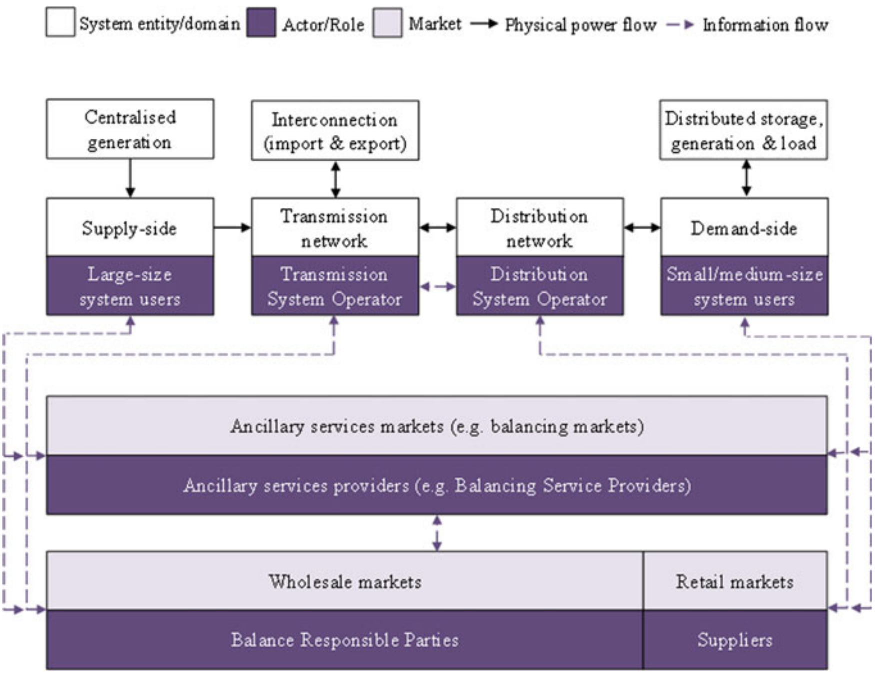


Fig. 2 Conceptual architecture of the physical power system and the electricity sector organisation in the European context. Inspired from Kling (2002)

services are expected to first act to solve a local problem when there is a relevant request, i.e. the modes of operation are prioritised. The logic is that local problems should primarily be addressed by the resources that are located close to the fault occurrence, whereas global challenges, such as system imbalances, can be addressed by all system resources. In the case of service provision at the distribution level, e.g. peak-shaving, the remuneration should not be valued less than other ancillary services so that market parties have a natural incentive to reserve resources for this purpose, e.g. these services should be valued at least at the same level with balancing services.

An aggregator company is in principle responsible for acquiring flexibility from an aggregation of system users, constructing a flexibility portfolio, developing and offering flexibility services to different markets and actors, with the aim of creating value and sharing it with its stakeholders. Value creation, through business models, involves an interconnected set of exchange relationships and activities among multiple actors (Zott et al. 2011). An overview of the main actors (and their roles) involved around the business model of an aggregator company, is provided in Table 1. Terms and roles have been aligned with those used in USEF (2015), and by ENTSO-E (2015; 2016).

Table 1 Main actors and roles around the business model of an aggregator company

Actors/roles	Description
System user	System users are the natural or legal persons that supply, or are being supplied by, a transmission or distribution system (ENTSO-E 2015). The system users are all the producers and consumers of electricity that own and operate within their premises any generation unit, load and/or storage device
Balance responsible party (BRP)	A BRP carries the role of energy nomination at the wholesale level (ENTSO-E 2015), and is responsible for balancing supply and demand for its portfolio
Balancing service provider (BSP)	The term BSP is used for the market participant that provides balancing services to its connecting TSO or in case of the TSO-BSP model, to its contracting TSO (ENTSO-E 2016).
Supplier	The role of the supplier is to source, supply, and invoice energy to its customers. The supplier and its customers agree on commercial terms for the supply and procurement of energy (USEF 2015). The supplier must be assigned the metering points of the customer it supplies (ENTSO-E 2016).
(Transmission) System operator (TSO)	A party that is responsible for a stable power system operation (including the organisation of physical balance) through a transmission grid in a geographical area (ENTSO-E 2015).
Distribution system operator (DSO)	A natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution network in a given area and, where applicable, its interconnections with other networks; and for ensuring the long-term ability of the network to meet reasonable demands for the distribution of electricity (ENTSO-E 2016).

2.2 *Emerging Concepts of the Aggregator Company in Europe*

In recent years, several organisations, either new or traditional players in the energy sector have attempted to explore the emerging opportunities for the provision of flexibility services from aggregated demand-side resources. In this section, a set of characteristics is identified around the business model concept of an aggregator company by reviewing historical cases and emerging models in Europe (Lampropoulos et al. 2013; USEF 2015).

The Aggregator Company and Targeted Flexible Technologies or Resources The system users that are associated with an aggregator company might participate in its portfolio with either a few or all of their resources. In the case of a residential customer that is characterised by both flexible and non-flexible types of resources, as illustrated in Fig. 1, an aggregator company might have an interest to include in its portfolio either only one specific flexible resource, more than one flexible resource, or all the resources, flexible and non-flexible, that are located behind the main metering point at the point of connection of that customer.

The different options unveil the interest (or indifference) of an aggregator company to a specific targeted technology and subsequently outline different business models. In the case of an aggregator company that includes in its portfolio all the resources of a system user, the conditions that influence the position of that system user are direct and unambiguous, and measurements at the point of connection are sufficient for settling any imbalance with the associated BRP and/or supplier. In the case of an aggregator company that is interested to include in its portfolio only one or a few selected resources of a system user, the measurements at the point of connection might be insufficient for settlement purposes. Presumably, additional requirements are created for sub-metering behind the point of connection to support the settlement process with the associated supplier and/or BRP. A historical case from France reveals the complications, due to the interdependence of commodities, when different market parties are representing the same system user in different markets but their actions are not coordinated or communicated. In that case, an aggregator company used to aggregate flexibility by offering to residential customers a device, which could switch off their electrical heating and space conditioning appliances. Consecutively, the aggregator company was placing the aggregate flexibility bids to the French TSO market for operating reserves. The call of those bids was resulting into imbalances at the position of the associated supplier, and the dispute whether the aggregator company should compensate the supplier or not was sent for settlement in the Council of State (Lampropoulos et al. 2013).

The Aggregator Company and Targeted Customer Segments An aggregator company might target particular customer segment, e.g. residential, commercial, or industrial customers. In this work, the focus is on residential customers, who are in principle non-professionals and are characterised by limited capacity and controllability. Larger system users, such as commercial and industrial customers, that are characterised by significant capabilities of flexibility can also perform within an aggregate portfolio and might even act as aggregator companies for optimising their own portfolios (USEF 2015).

The BRP and the Supplier Roles At the point of connection of a system user to the grid there should be assigned a BRP and a supplier. In Fig. 3, the possible organisational arrangements between two system users, and their associated BRP and suppliers, are illustrated. The aggregator company might take on either: (a) the role of the supplier; (b) the role of the BRP; (c) both of these roles; or (d) none of these roles. In the latter situation, the associated suppliers and BRP must be compensated for the energy supply and any energy imbalance entailed in their positions due to the provision of flexibility services from system users, with whom they have contractual relationships. In such a business model, the aggregator company acts as a third-party that aggregates flexibility from system users and sells it at its own risk to potential buyers, thus creating the need to formalise all the interactions with other market players (USEF 2015). In the situation that the aggregator company takes on the BRP role, all optimisations are performed directly within the combined portfolio. Otherwise, the aggregator company shall define

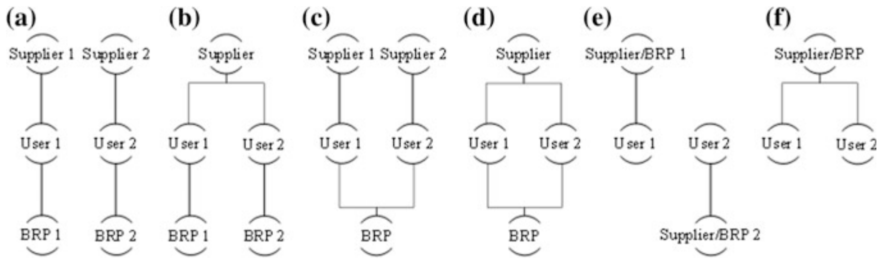


Fig. 3 Possible organisational arrangements between two system users, and their associated BRP and suppliers, when the roles of the supplier and the BRP are either distinct or combined. **a** Different BRP and suppliers. **b** Different BRP but a single supplier. **c** Different suppliers but a single BRP. **d** A single supplier and a single BRP. **e** The roles of the supplier and the BRP are combined, and the system users are associated with a different supplier/BRP. **f** The roles of the supplier and the BRP are combined and the system users are associated with a single supplier/BRP

contractual relationships with one or more incumbent BRP, but can also propose a new BRP to its associated system users. In the situation that the aggregator company takes on the supplier role, it becomes possible to offer to its associated system users a supply contract including flexibility options. The supplier can be the incumbent supplier, but the aggregator company can propose a new supplier to its associated system users (USEF 2015).

The Aggregator Company as a Pure Service Provider An aggregator company might act as a pure provider of flexibility services for one of the other roles, i.e. the aggregator company provides the means to aggregate flexibility and offers it to one of the other market parties in the value chain instead of trading flexibility at its own risk (USEF 2015). This type of business model might be implemented by organisations that have specific knowledge on particular technologies and techniques, e.g. ICT, computer science, etc.; and act as providers of integrated technical solutions.

Ancillary Service Provision to Grid Operators An aggregator company might provide balancing services as a BSP to its connecting TSO. Future conceptualisations consider aggregator companies as potential providers of a broad range of ancillary services to the TSO and/or DSO institutions.

2.3 The Case Study

The case study is about a hypothetical implementation of the aggregator company that combines the roles of the supplier and the BRP. The focus is on an aggregation of residential customers with local PV generation and energy storage capabilities. An evaluation of the potential revenue is performed with respect to the applications of energy arbitrage in the day-ahead market and passive contribution in system balancing (separately and in combination), based on historical market data from the Netherlands. In this section, the research design and the data collection are presented.

The scope is the economic optimisation of the aggregate energy storage system, i.e. the maximisation of profits or minimisation of costs, within the context of two developed electricity markets in the Netherlands, i.e. the day-ahead market (APX 2016), and the imbalance settlement system (TenneT 2010). The optimisation sub-problems are solved by utilising an energy storage model to schedule the charging and discharging processes over a time horizon. For the revenue analysis, the energy storage is modelled as a lossless process, i.e. excluding efficiency dependencies and associated energy losses. This design choice was driven by the research objective of computing the theoretical maximum revenues and presenting those in a generic form, i.e. per energy unit of effective storage capacity, without attributing those to a specific resource or technology, e.g. demand response of certain flexible loads, battery-based storage etc. The detailed model and the mathematical formulations of the different control strategies can be found in (Lampropoulos et al. 2015), including a sensitivity analysis about the effect of the storage system efficiency to the overall economic performance. Three control strategies are considered which address respectively, the application of energy arbitrage within the setting of the Dutch day-ahead auction in stand-alone mode; the passive contribution in the Dutch imbalance settlement system in stand-alone mode; and the combined energy arbitrage in the day-ahead market and passive contribution in the Dutch imbalance settlement system, i.e. hierarchical optimisation approach. The objective of the day-ahead optimisation is to maximise revenues from energy arbitrage in the APX day-ahead market, which is based on the two-sided auction model (APX 2016). By utilising available forecasts of the PV generation, the residential demand and the market clearing prices, the constrained optimisation problem is formulated as the minimisation of a cost function over a horizon of 24 h with discrete steps of 1 h. The passive contribution within the imbalance settlement system of the Netherlands is a voluntary scheme for participation in system balancing, which is attributable to the Dutch system organisation (TenneT et al. 2011). The Dutch TSO publishes the bid price ladder balancing table (TenneT 2016a), which includes price information for capacity bids offered for balancing; and the balance delta table (TenneT 2016c), which shows the most recent quantities that were requested for its operations. This combined information can be used by market participants to estimate the imbalance settlement prices. The imbalance settlement in the Netherlands is based on the net energy volumes per settlement period of 15 min (TenneT 2010).

For the day-ahead optimisation, historical data of the APX day-ahead market from 2000 to 2015 were utilised (APX 2016), whereas for the optimisation of balancing contributions the input consisted of historical data from the Dutch imbalance settlement system from 2001 to 2015 (TenneT 2016b). For the consumption profiles of the residential customers, the standard electricity consumption profiles of 2015 were utilised for the type of 3×25 A connections with single tariff counter (NEDU 2016). These profiles have been prepared on behalf of the

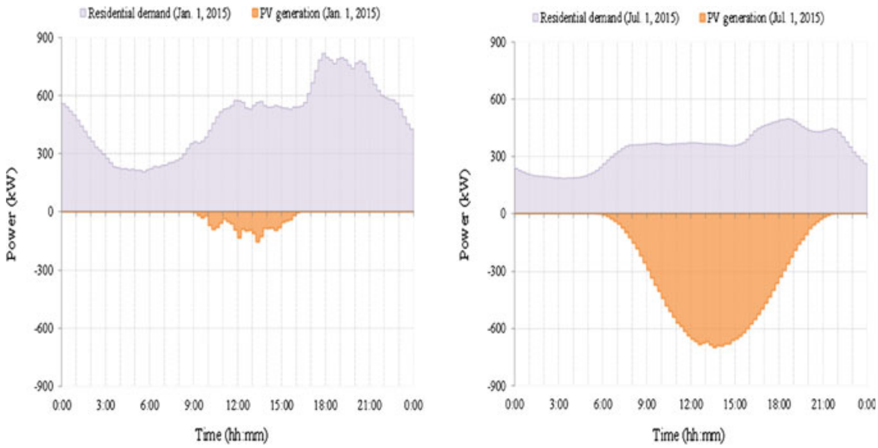


Fig. 4 Illustration of residential demand and PV generation power profiles for an aggregation of 1000 residences with a total of 1 MWp installed PV capacity for January 1st, 2015, and July 1st, 2015. Note that PV power generation is depicted in negative values

association of Dutch electricity grid operators, and represent the electricity demand per 15 min as a percentage of the annual electricity demand of a typical residence. In 2012, the average annual consumption of a typical residence in the Netherlands was 3495 kWh (Energie-Nederland 2014), and this figure was also used in this study. The PV generation profile was synthesised, based on actual metered data from 2015 with a resolution of 15 min. These data were collected from distributed PV systems, in the area of Utrecht, of an aggregate installed capacity of ~450 kWp, and were extrapolated to represent an aggregate installed capacity of 1 MWp. Missing data (due to errors with the data loggers) were completed with figures from adjacent dates. More information about the PV metered data can be found in (Vaz et al. 2016). The resulted profile provides a realistic potential of the annual PV generation. An example of the daily residential demand and PV generation is provided in Fig. 4.

3 Findings, Results and Analysis

3.1 *Elements of the Business Model Concept of an Aggregator Company*

Following the review in Sect. 2.2, a number of elements were identified that outline the various variations of emerging business models around the aggregator company concept. In this section, these elements are classified, under two categories, as *activity-specific* and *service-specific* characteristics. *Activity-specific* characteristics link to the particular knowledge of an aggregator company, e.g. regarding a process, resource, technology, technique, customer segment etc. *Service-specific* characteristics link to the focal services provided by an aggregator company, in relation to the distinct roles and responsibilities in deregulated environments. The following classification of identified elements is considered an advance in the process of systematically analysing and structuring the business model concept of an aggregator company. First, it supports the process of understanding the logic that drives the various business model implementations. Secondly, it can be used to identify potential organisational arrangements, within the various business model concepts; and to inquire the compatibility of those with established market designs and regulatory frameworks.

Identified elements of the business model concept of an aggregator company

- Activity-specific characteristics.
  - Targeted types of (flexible) technologies, e.g. aggregation of specific flexible technologies such as the charging of electric vehicles, versus aggregation of different types of flexible technologies.
  - Targeted types of (non-flexible and/or flexible) resources, e.g. aggregation of both flexible and non-flexible resources, versus aggregation of only flexible resources, which might be subject to additional requirements for sub-metering.
  - Targeted types of customers, e.g. aggregation of resources of specific types of customers such as residential, commercial, and industrial, versus aggregation of different types of customers.
  - Targeted techniques, e.g. utilisation of specific techniques for forecasting, communication, optimisation, and control purposes.
- Service-specific characteristics.
  - Energy trade at the wholesale level (BRP role).
  - Energy trade at the retail level (supplier role).
  - Pure service provision and no interaction with energy markets (service provider for another market party).
  - Balancing service provision to the TSO (BSP).
  - Other ancillary service provision to the TSO and/or DSO.

Each business model variation can be mapped to the above set of characteristics, and through this process it is possible to frame relevant requirements for implementation purposes. An example is provided in Table 2, where the aggregator company of the case study is mapped to the above set of characteristics; and to a number of pertinent requirements. By reviewing the above classification list of characteristics, it becomes apparent that, depending on the business model implementation, an aggregator company can potentially reach and build a wide range of relationships with various stakeholders. The stakeholder theory suggests that the idea of value creation in business is connected to the idea of creating value for stakeholders and questions what kinds of relationships the organisational members

Table 2 Mapping of identified characteristics to the aggregator company of the case study

Characteristic		Mapping of characteristics and pertinent requirements
1(a)	Targeted types of technologies	Non-specified types of flexible technologies, i.e. an aggregation of different technologies of energy storage and/or demand response
1(b)	Targeted types of resources	All types of flexible and non-flexible resources of an associated customer, i.e. PV generation, residential demand and flexible resources. Requirement for metering at the point of connection
1(c)	Targeted types of customers	Residential customers. Requirement for creating value for the associated residential customers
1(d)	Targeted techniques	Forecasting techniques for energy demand, PV generation and market developments, and optimisation techniques
2(a)	Wholesale trade	Requirements for being acknowledged as a BRP
2(b)	Retail trade	Requirements for being acknowledged as a supplier
2(c)	Pure service provision	N/A
2(d)	Balancing service provision	Passive contribution to balancing, which does not involve any additional requirements other than those related to 2(a)
2(e)	Other ancillary service provision	N/A

want and need to create with their stakeholders (Freeman et al. 2004). This seems to be a relevant question for every researcher or developer that conceptualises or implements business models around the concept of the aggregator company.

3.2 Case Study Results

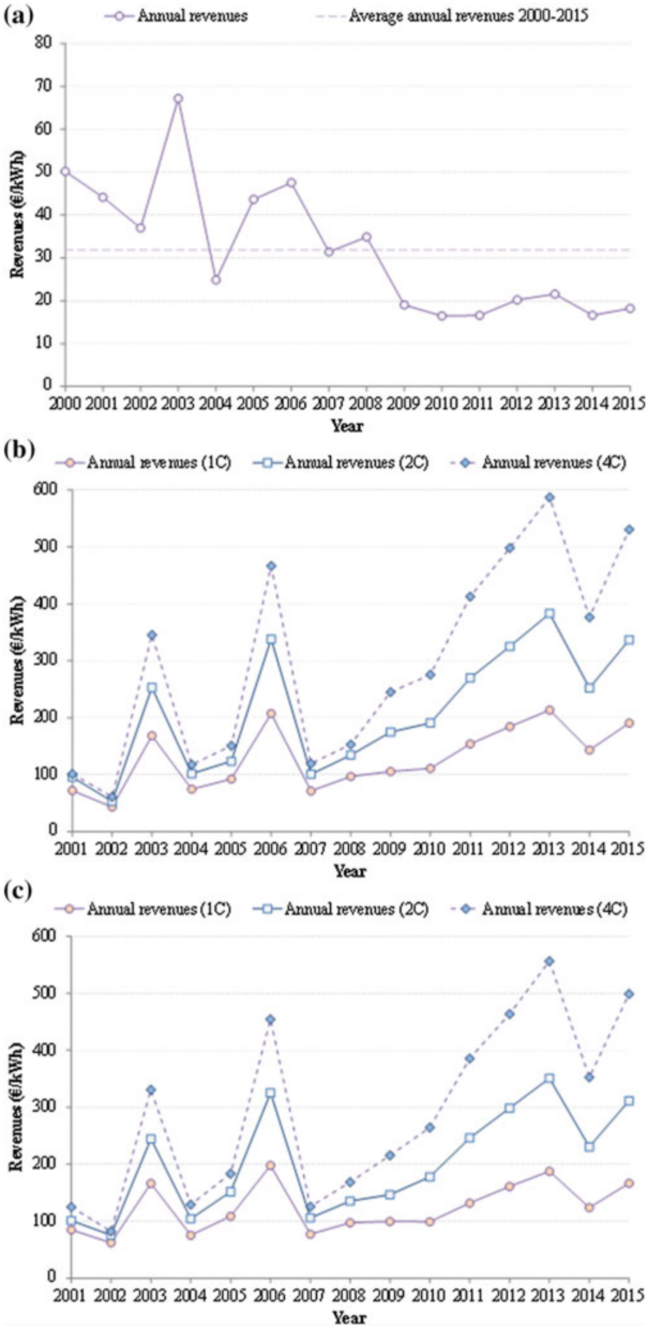
Business models seek to explain value creation and value capture (Zott et al. 2011). Although value is created by organisational members, it is argued that value capture is determined by the perceived power relationships between economic actors (Bowman and Ambrosini 2000). In order to determine value capture, a case study is performed which is about the hypothetical implementation of the business model of an aggregator company that combines both the roles of the supplier and the BRP. The focus is on an aggregate system, which consists of residential customers, local PV generation and distributed energy storage. An evaluation of the potential revenue from energy storage optimisation is performed with respect to the applications of energy arbitrage in the day-ahead market and passive contribution in system balancing (separately and in combination), based on historical market data from the Netherlands. The electricity demand costs with respect to the retail and wholesale market prices are estimated for both cases of including/excluding local PV generation.

In Fig. 5, the potential annual revenues are presented on a per (energy) unit basis and for all the years since the beginning of the day-ahead market and the imbalance settlement system in the Netherlands. These results can also be interpreted as performance indicators of the development of both markets through the years. The results reflect the optimisation of an energy storage system that can be fully charged/discharged within 1 h, 30 min and 15 min respectively, in analogy with the battery charge rates 1, 2 and 4C. Note that the charge rate of a battery, which is often denoted as C-rate, signifies a charge or discharge rate equal to the capacity of a battery in 1 h. For our purposes, a higher charge rate represents a more flexible resource. For the day-ahead market, it is indifferent to distinguish between 1, 2 and 4C, as the settlement period is 1 h and the results would look identical. However, the settlement period in the imbalance settlement system is 15 min, and therefore it is of interest to assess the results for different C-rates.

The day-ahead optimisation results are presented in Fig. 5a. Overall, the computed revenues from day-ahead market arbitrage are declining throughout the years; and are about 2.8 times less in 2015 compared to 2000, but this is also the case for the historical price volatility in the APX day-ahead market (Lampropoulos 2014), thus suggesting that market opportunities are decreasing with respect to the specified application. Price volatility is expected to be an important driver for the development of flexibility options, such as energy storage and demand response, which can take advantage of price differences. A study has attempted to determine volumes and prices of flexibility on the future day-ahead market given a scenario with increasing levels of intermittent renewable energy generation (Van Hout et al. 2014). The results show that next to an increase in the demand for flexibility, there will also be an increase in price volatility and the average price in the year 2023 will be considerably higher compared to 2012 and 2017, given the assumptions for higher coal and gas prices in 2023.

In Fig. 5b, the computed revenues are depicted for the case of the stand-alone passive contribution in the imbalance settlement. As can be seen in this figure, the general trend is that the potential revenues from passive balancing are increasing throughout the years; and are about 2.6, 3.3, and 5.3 times larger in 2015 compared to 2001 for the charge rates of 1, 2 and 4C respectively. The random distribution of potential annual revenues, depicted in Fig. 5b, is mainly driven by the development of system states and imbalance prices throughout the years. The nature of the imbalance market is highly stochastic. The development of system states and the amplitude of imbalances, within a control area, are driven by a number of factors related to cross-border trade, weather phenomena, and the portfolios of BRP, whereas the development of imbalance prices is also driven by the bidding strategies of BSP. Passive contribution in system balancing can be an additional source of revenues for decentralised market participants, though, the provision of control energy through passive contribution is delivered at the participant's own risk and might jeopardise any contractual payments (TenneT et al. 2011; Lampropoulos 2014).

In the case of hierarchical optimisation, the output of the day-ahead optimisation is employed as input in the optimisation for passive balancing, which results to


(a)
Annual revenues
Average annual revenues 2000-2015
Revenues (€/kWh)
Year
(b)
Annual revenues (1C)
Annual revenues (2C)
Annual revenues (4C)
Revenues (€/kWh)
Year
(c)
Annual revenues (1C)
Annual revenues (2C)
Annual revenues (4C)
Revenues (€/kWh)
Year

◀**Fig. 5** Computed maximum annual revenues from energy storage optimisation. **a** Exclusive participation in the APX day-ahead market, i.e. stand-alone day-ahead market arbitrage optimisation. **b** Exclusive contribution in the Dutch imbalance settlement system, i.e. stand-alone passive balancing optimisation. **c** Combined energy arbitrage in the day-ahead market and passive contribution in the Dutch imbalance settlement system when part of the capacity has been committed for the day-ahead market, i.e. hierarchical optimisation approach

additional constraints due to day-ahead commitments. In Fig. 5c, the computed revenues are depicted for the case of the hierarchical optimisation approach, i.e. combined revenues from both energy arbitrage in the day-ahead market and passive contribution in the imbalance settlement system. The simulation results show that, on average, the computed revenues for the case of the hierarchical optimisation approach are slightly less compared to the case of the stand-alone passive contribution in the imbalance settlement system. This is mainly due to the energy commitments that are made day-ahead, which restrict the full potential in the imbalance market.

In order to analyse the potential of an aggregate system, the simulation scenarios address an aggregation of 1000 residential customers, equipped with the options of local energy generation based on distributed PV technology (1 kWp per customer), and energy storage or demand response (equivalent to 1 kWh per customer). In Fig. 6, the results for all the different simulation scenarios are illustrated on a per customer basis for the reference year 2015.

The scenarios address: the electricity demand costs (scenarios 1–4) with respect to the retail and wholesale market prices, for both cases of including/excluding PV generation; and the potential revenues from energy storage optimisation (scenarios 5–11) with respect to the different control strategies described in Sect. 2.3. The focus is on the energy component, which effectively represents the possibilities for end-user cost reduction through switching to another supplier. In theory there should be an apparent relationship between retail and wholesale electricity prices, but in practice the correlation is low (Dromacque and Bogacka 2013). The scenarios 1–4 address the margin for retail customers cost reduction between the day-ahead wholesale and the retail price. The end-user electricity price (including taxes) in 2012 in the Netherlands was 19.28 c€/kWh, whereas the price breakdown corresponded to 43% for the energy component (including retail margins), 31% for distribution, 10% for energy taxes and 16 percent for value added tax (VAT) (Dromacque and Bogacka 2013). In the second half of 2014, the electricity price for residential customers (without taxes and levies) was 12.69 c€/kWh (Eurostat 2016). Assuming that 31% of the electricity price corresponds to distribution, based on the above mentioned price breakdown, the energy component (including retail margins) for the reference scenario corresponds to 7.32 c€/kWh. For the wholesale electricity price the APX day-ahead market clearing prices were utilised (APX 2016). In the case that PV generation exceeds the aggregate demand, the excess of energy is assumed to be supplied to the network at the corresponding retail or wholesale market price at that time period.

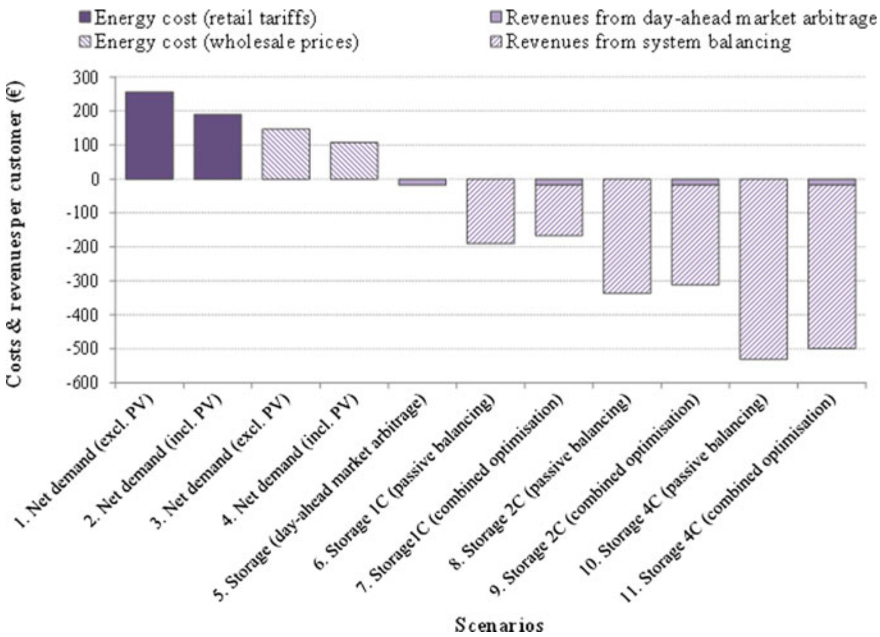


Fig. 6 Overview of annual costs and revenues per customer for all scenarios and for the reference year 2015. The case study is about an aggregation of residential customers where each customer is equipped with 1 kWp of PV capacity and with demand response or energy storage capacity equivalent to 1 kWh. Note that revenues are depicted in negative values

As can be seen in Fig. 6, the difference between the net demand costs for the two cases of retail and wholesale prices is about 42.5% when PV is excluded, and 43.3% when local PV generation is included, which outlines the opportunities for the aggregator company in taking advantage of price differences between spot markets and the retail price for electricity. In most of the energy storage optimisation scenarios 5–11, the revenues exceed the net demand costs corresponding to scenarios 1–4, outlining opportunities especially with respect to balancing contributions.

4 Discussion and Conclusions

Sustainable development of urban areas requires new, efficient, and user-friendly technologies and services, especially in the areas of energy, transport and ICT. In this context, the concept of the aggregator company, a new entrant in the energy market, is expected to take advantage of deployment synergies between smart grid technologies and smart city initiatives.

In recent years, several business models of the aggregator company have emerged in Europe, in response to a general quest for flexibility in power systems, which is mainly driven by the increasing integration of renewable energy sources and the ongoing deregulation of electricity markets. This work contributes to the systematic development of the business model concept of an aggregator company, and provides insight into its economic potential. The main contributions are about a set of identified characteristics that describe business model variations around the concept of an aggregator company, and a case study evaluation of potential revenues by focusing on two developed electricity markets in the Netherlands, i.e. the day-ahead market and the imbalance settlement system. The set of identified characteristics is an essential advance in the process of systematically structuring the business model concept as it supports the development of new flexibility services and appropriate regulatory frameworks. The outcome of computer simulations provided an informative insight into the historical potential of the investigated markets. Results show a significant theoretical potential of offsetting electricity costs and generating additional revenues for residential customers equipped with PV systems and with demand response or energy storage capacity. The simulation results show that the contribution to system balancing is a more profitable strategy, compared to the application of energy arbitrage in the day-ahead market; and this is mainly driven by the larger price spread and the more frequent occurrence of large price spreads in the imbalance market. However, the risks associated with the imbalance market are higher due to its stochastic nature. Therefore, through the hierarchical optimisation approach, the associated risks can be considerably compensated by giving preference to participation in the day-ahead market that is characterised by a diurnal pattern of prices, which makes the forecasting of day-ahead market prices more plausible.

A few limitations of this study should be considered. The electricity costs and potential revenues were computed under the assumption of accurate predictions, by utilising historical market data. Therefore, the computed revenues reflect the theoretically maximum. In a real-life application, forecast errors will inevitably occur and the potential revenues will always be dependent on the accuracy of the forecasting methods. An aggregator company has to plan and operate within an uncertain environment, and in order to deal with forecast errors and alleviate the adverse effects on its economic performance, robust control methods and risk management techniques should be developed. At last, the outcome of a revenue analysis alone cannot be considered as conclusive about the economic viability of certain business models. Emphasis was given on evaluating the potential revenues from the specified applications, although, in a real-life competitive environment the optimisation objective shall reflect the maximisation of profit, i.e. the excess of revenue over cost.

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Test System for Mapping Interdependencies of Critical Infrastructures for Intelligent Management in Smart Cities

Irina Ciornei, Constantinos Heracleous, Marios Kyriakou, Demetrios Eliades, Costas K. Constantinou and Elias Kyriakides

Abstract The critical infrastructures such as power distribution networks (PDN), water networks, transportation and telecommunication networks that are settled within the area of a city produce a large amount of data from applications such as AMI, SCADA, Renewable Energy Management Systems, Asset Management Systems, and weather data. To convert these massive data into useful information, visualization is an effective solution. Visualizing this large amount of data in a holistic view of critical infrastructures mapping at a city level is a missing link. Visualization means here to convert the flow of continuous coming data into useful information. In this paper we propose a technique to visualize critical infrastructure data by using a system that consists of Geographic Information System (GIS) for buffer spatial analysis and Google Earth in sync with realistic planning and operation methodologies specific for each infrastructure modelled. The major goal of this work is to design, model and validate a benchmark system that is capable to visualize and map as well as to prepare the next inter-linking phase of modelling

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and analysis of interdependencies of several critical infrastructures. Furthermore, we aim to provide the grounds for a theoretical framework that can capture the interdependencies between critical infrastructures using techniques from graph theory, machine learning, econometric science and operation research. The proposed framework for modeling the interdependencies between several infrastructures within a city territory is based on hybrid system automata and it is among the first steps needed in developing fundamental mechanisms for resilient management of critical infrastructures and the safe operation of smart cities. An example on how this framework can be applied is also presented.

Keywords City planning · Critical infrastructures · GIS · Power distribution systems · QGIS · Telecommunication networks · Visualization · Water networks

1 Introduction

Cities may be viewed as critical living habitats due to the concentration of critical infrastructures and people on a relatively small territory. Critical infrastructures are multi-dimensional systems of systems with highly complex inter- and intra-dependencies of collections of technologies, processes, and people. European Commission defines (2004) critical infrastructures (as) those "physical facilities and networks, which, if disrupted, would significantly affect the health, safety, security or economic well-being of citizens."

Failure in one component of a system of systems, such as the critical infrastructures within a city, may have cascading effects not only to the network to which the component is part of, but also to the other dependent and interdependent networks. To exemplify, a failure of a power transformer serving an area within a city may also lead to water supply shortage in the same area or even a larger part of a city/village, e.g. due to the interruption of a pump operation or at least creating low pressure conditions in the water distribution network (WDN).

Modeling interdependency between critical infrastructures became a key field of study since the early 2000s, with a number of modeling approaches proposed over the years, which are summarized in several works (Pederson et al. 2006; Eusgeld et al. 2008; Griot 2010; Satumtira and Dueñas-Osorio 2010; Heracleous et al. 2013; Ouyang 2014). To emphasize the importance of this field of study we may consider a major power blackout from 2003 in the United States (US), when traffic lights went out, computer systems went off, then subways and several trains did not run, businesses and banks had to close, stock exchanges closed, health care facilities had to run on emergency back-up power or close, sporting events cancelled, and schools closed early among other things. Furthermore, and most importantly, all these problems concomitantly happened in several major cities such as New York, Michigan, Ohio, Pennsylvania, and Canada. It is clear only from this single example that interdependencies between infrastructures played a crucial role in propagating and escalating the effect of an event occurred in a single network (the power system). Estimating and quantifying the consequences of propagation of an event over several infrastructures needs a reliable and accurate modeling of the networks and their interdependences. Preparedness mechanisms against major natural or man-made disasters, as well as designing resilient methods for the next developments of smart cities rely on the accuracy of this modeling.

Some of the most popular interdependency modeling approaches are the inoperability input-output methods, agent-based modeling approaches and network based approaches. The *inoperability input-output model* (IIM) can estimate at a holistic level the inoperability (i.e. the percentage of multi-function) of infrastructures using the dependency coefficients (also known as Leontief coefficients) (Setola and Porcellinis 2009). *Agent-based approaches* consider Critical Infrastructure Systems (CIS) as complex adaptive systems; and represent their components as agents, with interdependencies usually emerging from the interactions of agents (Panzieri et al. 2004; Kaegi et al. 2009). *Network-based approaches* generally assume that each CIS consists of a set of components (usually represented as nodes) forming a network, and any existing interdependency is represented as a type of relationship between nodes belonging to different networks (Chopade and Bikdash 2011; Holden et al. 2013). There are also several other approaches: a few are based on various probabilistic methodologies (e.g. petri nets, stochastic activity networks and Bayesian networks) (Gursesli and Desrochers 2003; Leoleis and Venieris 2007; Beccuti et al. 2012), some others are considering multi-layer modeling approaches, where infrastructures are seen at different layers and interactions between them are considered at different levels of granularity (De Porcellinis et al. 2009), and also some empirical approaches that analyze Critical Infrastructure (CI) interdependencies according to historical accident or disaster data and expert experience (McDaniels et al. 2007). From our research we believe hybrid systems and their open hybrid automata are also great for modeling infrastructure interdependencies (Heracleous et al. 2015). Their main advantage is that they can model components from any CI. Thus, they can be seen as a common modeling framework. Moreover, open hybrid automata allow the development of models at various levels of abstraction, i.e. very detailed models with many variables or quite simple ones, depending on the modeling objectives and the available data.

It is becoming widely accepted that technology forms the bone for empowering governments and city administrators with new ways of serving their citizens. Terrorist attacks and cyber intrusion actions on publically or private owned assets, raised the concern of many governments to take actions in treating all information related to CI as classified (Bagchi et al. 2009). Without real data about these systems, the research community has to develop virtual but realistic test systems, such that they can test and validate the performance and applicability of their methods. Several test systems were developed over the years as benchmarks to test specific models or applications related to a single network, such as a power system (University of Washington 2016), water network (Rossman 2000) or telecommunication network (Pajukoski and Savusalo 1997).

The concept of "*virtual city*" emerged from the computer gaming domain. Thus, in recent years we are seeing a high interest in software development for urban planning and smart e-governance of cities, based on the integration of "virtual cities", data analytics that are geographically stamped and augmented reality (Portalés et al. 2010; Videira Lopes and Lindstrom 2012). The state of the art with respect to the integration of data for CI in these virtual cities is however limited, if non-existent. A library of two virtual cities basically focused only on the urban topology and WDN was developed by a group of researchers at Texas A&M University (Torres et al. 2006; Brumbelow et al. 2007). To be noted however that only the small virtual city, called Micropolis, has been actually detailed in terms of two (only) CI (water and power distribution systems), while the second city has details only with respect to geographical, urban building assets and demographic data. The electrical distribution layer of Micropolis is documented with respect to several components and single-line diagram connections in Bagchi et al. (2009); however the corresponding GIS files for this layer are still not publically available. Another missing aspect is in the design itself of the power distribution network (PDN) of Micropolis with respect to the presence of renewable power generation, as well as universality of the design in a city distribution power network.

In this work we took the challenge in designing the power distribution system layer as well as the cellular telecommunication layer of Micropolis. This is an ongoing work and the authors plan to develop more layers of several other infrastructures, such as transportation, gas, and health system. The second aim of this work is to use realistic design methods, in sync with the current trends of developments toward smart cities (e.g. including advanced technologies for power distribution grids, WDN and advanced telecommunication networks), that lead to a comprehensive test system, fully integrated in a powerful visualization tool such as QGIS. Then, the modeling of interdependencies of CI is presented using the framework of hybrid automata. The model is validated with a realistic example, using the developed test system with three interconnected infrastructures of Micropolis.

The remainder of the paper is structured as follows: first a description on the virtual city called Micropolis is provided, then we dig into the theoretical background in developing generic test systems for critical networks such as WDN, PDN, and telecommunication networks, while next we detail the design methodologies and tools used in developing each sub-system layer. After the design of each infrastructure, we build the models of their respective interdependencies using the framework of open hybrid automata. At the end we conclude the work and provide suggestions for further research and applications in which the developed test system can be used.

2 Micropolis

The geographical layout of the virtual city of Micropolis was developed by a group of researchers at Texas A&M University. The design follows the development pattern of a small city of 5000 inhabitants over a period of 130 years at the beginning of the 19th century. The city covers a relatively small area, of about 3.6 km^2, has one main water source and one water stream. The terrain is almost flat, with very little elevation differences between one part and another of the town. There are three major destinations for the stock of buildings within Micropolis, such as: residential (single house and multiple apartment buildings), commercial and industrial. The number of inhabitants was randomly selected per type of building and according to their volume/surface occupied.

The legacy data available at the beginning of this work was the city's buildings, land use map, road and railway systems, as well as the water distribution system layers in GIS format. For the detailed description of the design of the WDN of Micropolis, as well as the main assumptions of this design the reader may consult Brumbelow et al. (2007).

In Table 1 we summarize the most important characteristics of Micropolis that impact the design of the three infrastructures developed and presented in this chapter.

3 WDN Layer

In this section we present the extension we have made to the water distribution layer already available in order to enhance our study from the CI point of view. Due to their vital role, water systems are considered among the CIs, along with power and telecommunication systems. Water systems are interdepended with other CIs, since power is needed to operate pumps, and telecommunication is required to facilitate the operation of the SCADA system. In addition, if an event occurs in the WDN, such as a pipe burst, it may affect power supply and transportation in the area.

Water quality sensors may be used for monitoring the system for hydraulic events, such as leakages, as well as for quality events, which may be caused due to

Table 1 Micropolis

Characteristic	Value
Area covered	~3.6 km^2
Population	5000
Number of buildings	868
Type of buildings	Residential, industrial and commercial
Building height	Between 10 and 40 m
Population distribution within the building	Random

accidents or even malicious attacks. In general, sensors which monitor water quality are important for improving the system's security. Typically, however, utilities have a small number of water quality sensors to install in a large-scale network, due to their high-costs. Deciding the best locations to install these sensors is a challenging research task.

The Quality Sensor Placement Problem The problem of deciding where to install water quality sensors within distribution networks for enhancing their monitoring and security capability has been widely investigated within the last decade by the water research community (Hart and Murray 2010). In most works, sensor placement has been addressed as an optimization problem, which aims to choose a finite subset of nodes out of the set of all the network nodes where it is feasible to install sensors, by minimizing a set of objectives (e.g. risk) with respect to certain impact metrics (e.g. the number of people affected) (Ostfeld et al. 2008; Eliades and Polycarpou 2010). Various challenges have been identified in research, which affect the sensor placement solutions: the uncertainties in the model and the water demands, the impact metrics and the risk objectives selection, the contamination scenarios selection, the sensor measurement uncertainties, the response time delays, the solution methodology and its computational efficiency (Krause et al. 2008; Preis and Ostfeld 2008; Dorini et al. 2010; Weickgenannt et al. 2010). The state-of-the-art in application software is the TEVA-SPOT, which is available under an open-source software license (Berry et al. 2012).

The lack of platform which could be used for scientific experiments and benchmarking has motivated the development and release of an open-source software, the "Sensor PLACEment Toolkit" (S-PLACE), implemented in Matlab, for computing sensor placement solutions, based on the mathematical framework proposed in Eliades and Polycarpou (2010). Figure 1 depicts the modular software architecture.

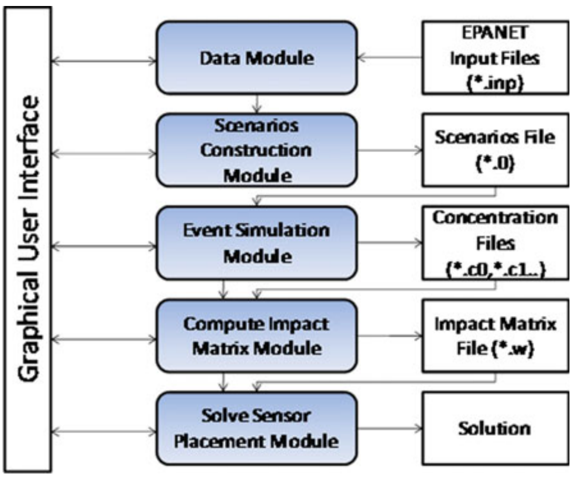

Fig. 1 Software Architecture of S-PLACE

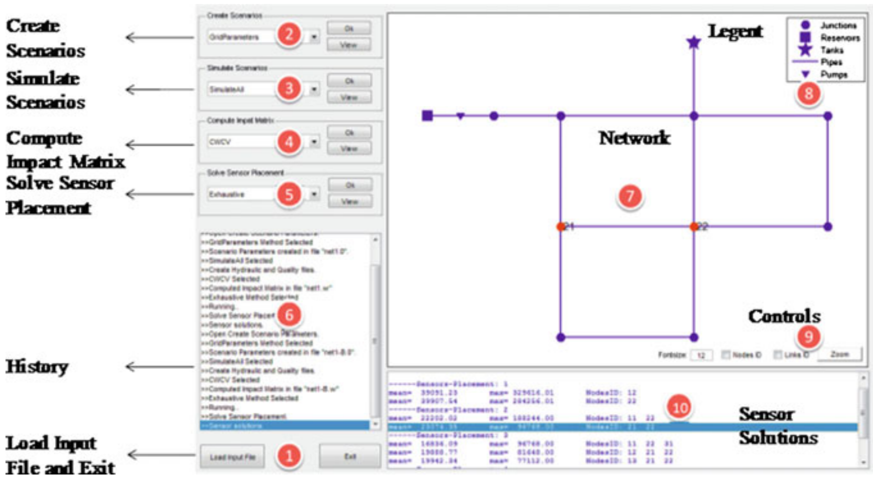

Fig. 2 The S-PLACE Software

The software has been designed to be user-friendly, both for the professional as well as the academic community, making it easy to evaluate solutions under various scenarios. In addition, its Graphical User Interface (GUI) provides an intuitive way of interfacing with the software and with the WDN. The software architecture is modular, and each module can be accessed independently through stand-alone functions. Furthermore, the S-PLACE is extendible, as it allows to adding, modifying or removing methods and network elements, in accordance to the research objectives. For instance, new risk functions can be programmed and used in optimization, new scenario selection algorithms can be evaluated or new nodes and pipes can be added to the network. The use of the software is illustrated on several benchmark networks, which capture different types of real network topologies, such as looped and branched networks. The software GUI is depicted in Fig. 2.

Micropolis EPANET Model Including the Quality Monitoring Sensors WDN can be modeled using the EPANET standard and simulated using the EPANET libraries. In general, WDN can be modeled as multiple layers in a GIS (pipe, junction, tank, reservoir, pump and valve layer) and through transformation they can be integrated into an EPANET model. A visual description of the Micropolis EPANET model is provided in Fig. 3. Each node in the graph has specific parameters, such as a base demand (i.e. the average daily water consumption); and an associated demand pattern, which captures the variation of water consumption throughout the day. The EPANET model is comprised of 1574 junctions, 2 reservoirs and one tank, 1415 pipes around 16 km in total length, 8 pumps and 196 valves.

Quality Sensor Placement for Micropolis To solve the quality sensor placement problem for Micropolis, a large number of contamination scenarios was simulated

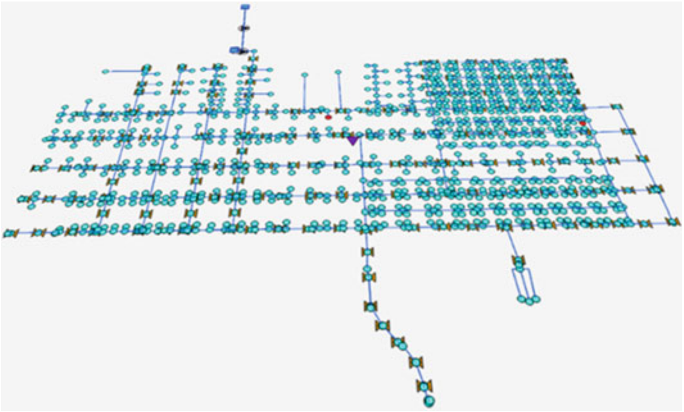

Fig. 3 EPANET model of micropolis. Reservoirs correspond to *blue squares*, tanks to *purple triangles* and pumps to *black circled triangles*. *Filled circles* correspond to junctions which link pipes or are locations where water is consumed. Two monitoring stations are assumed in the locations indicated with *red filled circles* (Color figure online)

Table 2 Pareto solutions for the 2-sensor placement problem

	Mean CWCV	Max CWCV	Pareto solutions
1	4001.384	358,616.903	[TN542, TN1738]
2	4019.937	285,457.754	[TN565, TN1738]
3	4254.197	171,002.608	[TN618, TN1738]
4	3874.398	359,132.322	[TN713, TN1738]
5	4178.960	221,563.445	[TN807, TN1738]

and analyzed. In specific, 1915 random scenarios where produced (i.e. injection of contaminant with 10 mg/L concentration at a single node within the first 24 h), with a simulation time of 48 h. No uncertainty was considered in the system parameters. For measuring impact, the Contaminated Water Consumption Volume (CWCV) metric was considered. It calculates how much contaminated water is used for consumer demands until it is detected by some sensors. The S-PLACE system searched for the optimal location of two sensors with respect to two risk objectives, which minimize the average and the maximum impact. An evolutionary multi-objective optimization method was used to identify the Pareto-front solutions, which are provided in Table 2.

4 Concepts of System Design for PDN

PDN were traditionally designed only to deliver power to loads, thus unidirectional power flow rules applied. Hence, increasing Distributed Generation (DG) penetration from photovoltaic (PV) systems, small wind turbines or even backyard thermal generators are causing profound changes for Power Distribution System Operators (DSO) in planning, operation and maintenance of distribution networks. Thus, planning a distribution network with renewable power generation is in itself a challenging task due to the limited number of design tools available as well as relatively small state of the art practice in doing so. Besides the technical aspects with respect to modeling and availability of "on the shelf analysis tools", there are also the regulatory aspects that impact the PDN planning methods in unbundled electricity markets.

Thus, our design methodology relies on the following assumptions:

- From the DG possibilities, we choose that only PV systems are integrated at the low voltage (LV) side of the distribution network of Micropolis.
- 30% of randomly selected houses from the total buildings asset of Micropolis have PV installed on top of their roof. This is indeed a close to reality scenario taking into account the European climate change targets, as well as the evolution of PV installations up to now. The random location of PV systems was based on the fact that, currently, there is no actual restriction with respect to the location of the PV installation, as long as the National Grid Codes are respected.
- Small residential buildings are supplied with single-phase circuit distribution lines, while the medium size residential and commercial buildings are supplied by three-phase circuit distribution lines.
- The MV system was modeled as a voltage source with impedance specified by the short circuit currents.

The model of the distribution power network of Micropolis followed the approach of the design of a typical European LV feeder test system, as documented by the Institute of Electrical and Electronics Engineers (IEEE) Test Feeders Working Group (IEEE PES 2016). Thus, in our design the LV PDN of Micropolis is a radial distribution feeder with a base frequency of 50 Hz. The feeder is connected to the medium voltage (MV) system through a transformer. The transformer steps the voltage down from 11 kV to 416 V. The main feeder and laterals are at the voltage level of 416 V. The one-line diagram of the test feeder is shown in Fig. 4.

The starting point in planning and sizing the PDN of Micropolis is to foresee the equipment to be connected and the resulting total power demand. Thus, the building destination is the major parameter to be taken into account for the choice of distribution equipment and wiring. Table 3 summarizes the various areas of land use and building destinations and their impact on the requirements for the electric distribution grid and equipment.

There are three basic configurations that can be adopted for power distribution grids, such as *radial networks*, *ringed networks* and *meshed networks*. The simplest and widely adopted in small towns and rural areas is the radial network configuration. This configuration was used in the design of the PDN of Micropolis. For the estimation of the power demand of each type of loads in Micropolis, we have used the data provided in Siemens (2005). Besides the average estimation of the

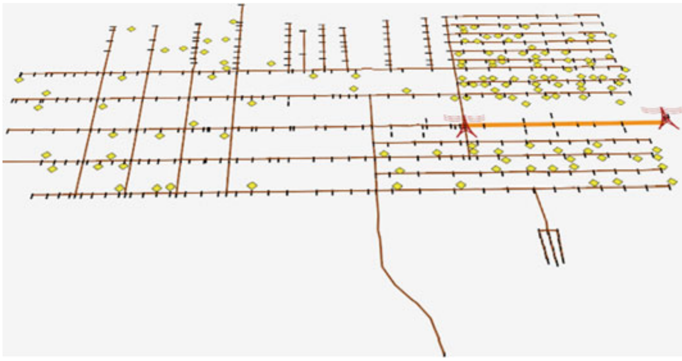

Fig. 4 Power distribution networks of micropolis: the *red towers* are the power substations; the *light orange line* is the MV distribution line; *brown lines* are the distribution feeders; and *yellow diamonds* are the PV systems installed (Color figure online)

Table 3 Land use and its impact on the electric grid equipment

Building type/land use	Characteristics	Requirements	Consequences on the PDN
Residential	Many small consumers	Low nominal currents compared to high system short-circuit power	Back-up protection
Offices/commercial areas/schools	Several workplace equipment with personal computers (PC), high protection of capacitive loads, general escape rules	Voltage stability and reliability of supply, protection against harmonics, safety of power supply	Choked compensation equipment and feed-in generators (uninterruptible power supply (UPS))
Medical locations	Life preserving machinery, electromagnetic sensitive equipment	High reliability of supply, good electromagnetic compatibility (EMC)	Redundancy, high – performance safety of the power supply (SPS), transparent network substrate (TN-S) grounding system to minimize stray currents
Industrial	Mainly motor loads	High power demand per area occupied	Busbar trunking systems

necessary power demand of each load one may take into account a set of calibration factors according to the building destination, such as: calibration factor for the building placement (k_{plc}), calibration factor for the room structure (k_{struct}), calibration factor for the level of comfort (k_{comf}), calibration factor for the air conditioning options (k_{clim}), calibration factor for the technical characteristics (k_{tech}), and calibration factor for building management ($k_{BA/TBM}$).Thus, the total estimated power demand for a specific building (end-load) is calculated as:

$$P_{spec} = P_{avg} * k_{total}, \tag{1}$$

where P_{spec} is the estimated power demand of a specific type of building (land use), P_{avg} is the average estimated power demand, and k_{total} is the total calibration coefficient, calculated as:

$$k_{total} = \frac{k_{plc} + k_{struct} + k_{conf} + k_{clim} + k_{tech} + k_{BA/TBM}}{6}. \tag{2}$$

According to the total estimated power demand, one may calculate the sizing of the main feeds as well as the sizing of the substation transformer. For detailed calculations, one may refer to Siemens (2005).

5 Concepts of System Design for Cellular Communication Networks

A wireless communication network (Rappaport 2001) is designed under the system-level idea of the "cellular concept"; instead of using a single, high power transmitter, a large number of low power transmitters are utilized, each one covering a small portion of the service area. In this way, all the available channels are assigned to a small number of neighboring base stations. These neighboring stations are assigned to different groups of channels, so as to minimize interference. The result is that the available channels may be reused many times. The geographic area served by a certain base station is called a cell. The design process of selecting and allocating channels to the base stations is called frequency planning. The actual radio coverage of a cell is called "footprint" and it is determined from field measurements or propagation models. The above definitions present the basic concepts used in planning a cellular telecommunication network. Following are the planning strategies and design steps we took in the development of the QGIS telecommunication layer of the virtual city of Micropolis.

Channel Assignment Strategies Channel assignment can be either fixed or dynamic. For the case of fixed channel assignment, a predetermined set of channels is assigned to each cell. If all the channels of a cell are occupied, an upcoming request for call is not established. One approach that is applied to overcome this problem is the borrowing strategy, where a cell borrows channels from neighboring cells so as to establish a request for a new call, if its own channels are completely occupied. This procedure is supervised by the Mobile Switching Center (MSC). For the case of dynamic channel assignment, channels are not permanently allocated to cells. Each time a call request is made, the corresponding base station requests a channel from the MSC, and the latter corresponds to this request according to a certain algorithm. Dynamic channel assignment leads to decreased percentage of blocked cells, compared to the fixed case.

Handoff Operation During a call, it is possible that the user is moving, thus shifting to a different cell. In this case, the MSC transfers the call to a new channel belonging to a new base station (handoff operation). Processing handoffs is an important task in any cellular radio system. Many handoff strategies prioritize handoff requests over call initiation requests when allocating unused channels in a cell site. Handoffs must be performed successfully and as infrequently as possible, and be imperceptible to the users. In order to meet these requirements, system designers must specify an optimum signal level at which to initiate a handoff. Once a particular level is specified as the minimum usable signal for acceptable voice quality at the base station receiver, a slightly stronger signal level is used as threshold at which a handoff is made.

Interference This is the major limiting factor of the performance of a cellular radio system. Sources of it can be another mobile in the same cell, an established call in a neighboring cell, other base stations, or other non-cellular systems. Interference can negatively influence the quality of a call in progress. It can also cause problems to the control channels, leading to missed and blocked calls.

- *Co-channel Interference*: Frequency reuse implies that in a given coverage area, there are several cells that use the same set of frequencies. These cells are called co-channel cells and the interference between signals from these cells is called co-channel interference. The latter cannot be cancelled by simple increasing the carrier power of a transmitter. This is because an increase in carrier transmit power increases the interference to neighboring channel cells. To reduce co-channel interference, co-channel cells must be physically separated by a minimum distance to provide sufficient isolation due to propagation.
- *Adjacent Channel Interference*: Interference resulting from signals which are adjacent in frequency to the desired signal is called adjacent channel interference. Adjacent channel interference results from imperfect receiver filters, which allow nearby frequencies to leak into the pass band. It can be minimized through careful filtering and channel assignments. Since each channel is given only a fraction of the available channels, a cell need not be assigned channels which are all adjacent in frequency. By keeping the frequency separation between each channel in a given cell as large as possible, the adjacent channel interference can be considerably reduced.

Trunking and Grade of Service (GOS) Cellular radio systems rely on trunking to accommodate a large number of users in a limited radio spectrum. The concept of trunking allows a large number of users to share the relatively small number of channels in a cell by providing access to each user, on demand, from a set of available channels. In a trunked radio system, each user is allocated a channel on a per call basis, and upon termination of the call, the previously occupied channel is immediately returned to the set of available channels. Trunking exploits the statistical behavior of users so that a fixed number of channels may accommodate a large, random user community. There is a trade-off between the number of available channels and the possibility that a particular user will not be able to find an available channel during the peak calling time.

The *GOS* is a measure of the ability of a user to access a trunked system during the busiest hour. The busy hour is based upon customer demand during a certain period of time. The GOS is a benchmark used to define the desired performance of a particular trunked system by specifying a desired likelihood of a user obtaining channel access given a specific number of channels available in the system. GOS is typically given as the likelihood that a call is blocked, or the likelihood of a call experiencing a delay greater than a certain queuing time.

Techniques for Improving Coverage and Capacity

- *Cell Splitting*: Cell splitting is the process of subdividing a congested cell into smaller cells, each with its own base station and a corresponding reduction in antenna height and transmitter power. Cell splitting increases the capacity of a cellular system by increasing the number of times that channels are reused. These smaller cells are called microcells.
- *Sectoring*: Another way to increase coverage is to replace the (single) omnidirectional antenna at the base station by several directional antennas, each radiating within a certain sector. By using directional antennas, a given cell will receive interference and transmit with only a fraction of the available co-channel cells. When sectoring is applied, the channels used in a particular cell are broken down into sectored groups and are used only within a particular sector.
- *Range Extension Using Repeaters*: Radio transmitters, called repeaters, are often used to provide range extension. They simultaneously send and receive signals from a serving base station. They work using over-the-air signals. Therefore, they can be installed everywhere. Upon receiving signals from a base station forward link, the repeater amplifies and reradiates the base station signals to the specific coverage region.

There are several algorithms used in the literature for base station placement in cellular communication networks. Some indicative algorithms are the following:

- *k-Center Algorithms* (Jain and Vazirani 2001): The k-center problem refers to the case of finding a subset of nodes in the network such that the maximum distance from any other node to the closest one of the selected nodes, is minimized. Algorithms that solve this problem can be utilized so as to allocate the base stations in the cellular network in a way that every point in the network will be close enough to at least one base station, so as to be able to be served by the latter.
- *Genetic Algorithms* (Mitchell 1997): These are search heuristics that imitate the process of natural selection. They belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using

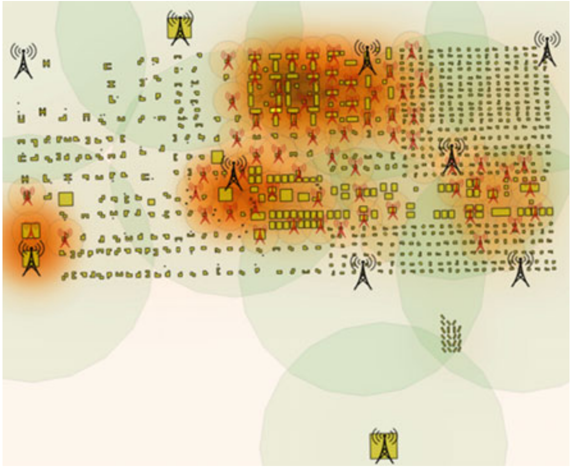

Fig. 5 QGIS layer of Cellular Network: *Black antennas* are the micro cells; coverage area of the microcells is the *circles* in *light green*; pico cell antennas are *small red*, and their corresponding coverage areas are the *orange circles* (Color figure online)

techniques inspired by natural evolution, such as inheritance, mutation, selection and crossover.

- *Simulated Annealing* (Kirkpatrick et al. 1983): It is a metaheuristic to approximate global optimization in a large search space.
- *Tabu Search* (Glover 1990): It is a metaheuristic search method, employing local search methods used for mathematical optimization. It constitutes an enhancement of the Neighbourhood Search.

In our implementation we have applied the k-Center Algorithm. We are assuming the following: Micropolis being a small city (near the size of a village), we have chosen to use only two types of cellular in our cellular communication network: micro and pico cells. The reference area to place micro-cell antennas (up to 1300 m coverage radius) is the entire territory of Micropolis. Thus, we first created heat maps with QGIS to determine the areas where pico-cells shall be installed (coverage area up to 100 m in radius); and then we apply the k-mean algorithm to place the two types of antennas. The implementation of the algorithm was done in Matlab, and the results (x, y axis of each antenna placement point) were then parsed to QGIS for actual positioning, as it is presented in Fig. 5.

6 Framework for Interdependencies Modeling

The normal operation of the three Micropolis infrastructure systems (water, power and communication) heavily depends on the various interdependencies that exist among them. For instance, the water and communication systems receive electricity from the power system to feed the water pumps and the cell antennas, respectively; while the power and water systems rely on the communication system for data transmission for their monitoring and control. If interdependencies break due to

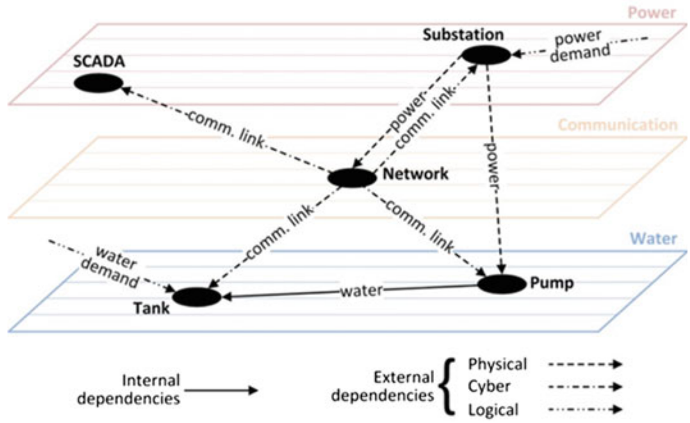

Fig. 6 Overview of Micropolis main infrastructures components and their dependencies

failure in one system, there will be a disruption to the normal operation of the other systems. Thus, it is important to study them and develop models to analyze their cascading effects.

To facilitate the identification, understanding, and analysis of interdependencies, we usually classify them based on their characteristics into the following four principal types (Ostfeld et al. 2008): (a) *physical*, if the operations of one infrastructure depends on the physical output(s) of the other and vice versa, (b) *cyber*, if there is information/signal transmission between different infrastructures, (c) *geographic*, if components of different infrastructures are in close spatial proximity, and (d) *logical*, due to any other mechanism (e.g. various policy, legal, or regulatory regimes) that can link logically two or more infrastructures. Interdependencies are bidirectional relationships while dependencies are unidirectional relationships. When multiple infrastructures are connected as "system of systems" and their individual components are considered, interdependencies are the result of multiple dependencies between the components of *different* infrastructures. These are often called *external* dependencies and they can be the same type as interdependencies, i.e. physical, cyber, geographic or logical, but just unidirectional. There are also *internal* dependencies, which are the connections between components inside the *same* infrastructure, for instance the connection inside the water infrastructure between a pump and a tank is an internal dependency.

For the city of Micropolis the main components of the three systems and their internal and external dependencies are shown in Fig. 6. Specifically, the following components are considered: for the power system (1) the substation that supplies power to Micropolis and (2) the SCADA that remotely monitors and controls the substation; for the communication system (3) the network that consists of a number of microcell antennas; and lastly for the water system (4) the tank that supplies water to Micropolis and (5) the pump to which the tank is dependent for water, thus there is an internal dependency between the two. As *external dependencies* among the components three types are considered: (i) the physical dependencies of the pump and the network on the substation for power supply; (ii) the cyber dependencies of all the components on the network, i.e. the communication links to the substation, the SCADA, the pump and the tank; and (iii) the logical dependencies, such as the power and water demands for the substation and the tank, respectively. Although there are geographic interdependencies between all the components, due to the close spatial proximity between them (Micropolis is a small town), we do not consider them in this work since they usually have an effect during intentional attacks or natural disasters (e.g. explosions, floods, and earthquakes) and given the size of Micropolis, such events would affect all the components at once without any cascading effects between them.

To model the main components of Micropolis and the dependencies between them in order to study possible cascading effects we use open hybrid automata as proposed in Heracleous et al. (2015), which the reader is encouraged to review for more information. The open hybrid automata are used as models for hybrid systems, i.e. systems with both continuous and discrete behaviors such as CI. For instance in a water system the start and stop of a pump is discrete, while the flow of water is continuous. With open hybrid automata it is possible to model the behavior of each CI component at the necessary level of abstraction, i.e. how the component will behave in case it fails or if there is no power supply or communication available. The dependencies among the components on the other hand, are represented by the connections between the inputs and the outputs of the various open hybrid automata models. Formally, connecting the inputs and the outputs of two or more open hybrid automata is called composition, and the result is another open hybrid automaton bigger and more complex that has the remaining inputs and outputs. The new open hybrid automaton is often referred to as the composition model and consists of all the open hybrid automata running in parallel. The composition model is the one that can be simulated for various scenarios where component(s) set to fail at specific time(s) and observe the cascading effects to the other components.

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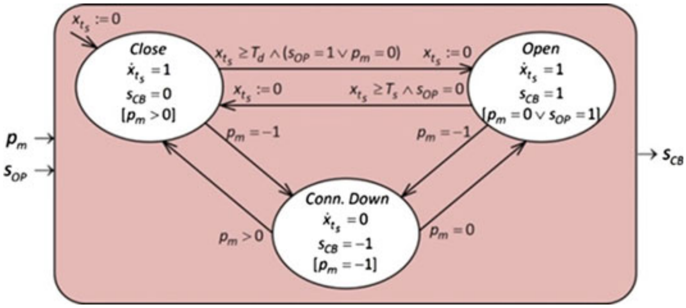

Fig. 7 Power SCADA open hybrid automaton model

model and consists of all the open hybrid automata running in parallel. The composition model is the one that can be simulated for various scenarios where component(s) set to fail at specific time(s) and observe the cascading effects to the other components.

In the next subsections, the open hybrid automata models for the main components of Micropolis are presented; and then the composition model is derived based on the dependencies among them (see Fig. 6). A very detail description with all open hybrid automata models is available in Heracleous (2016) (Fig. 7).

PDN Components—Substation and SCADA The Power Substation of Micropolis provides the necessary power to the area, including all the other infrastructure components. The open hybrid automaton model for the Substation can be found in Heracleous (2016). The model specifically represents the two modes of the substation operation, (i) Supply Power and (ii) Switch Off. When in Supply Power mode, Micropolis power demand is completely covered; and when in the Switch Off state the output of the substation is zero, which denotes outage in Micropolis. The transitions between the two modes occur either remotely from the SCADA operator or due to safety reasons, when the power demand is larger than the limit of the substation.

The SCADA component is responsible for monitoring and controlling the Substation. Specifically, it receives measurements from the Substation and informs the operator accordingly. Also the operator can remotely request the opening and the closing of the Substation circuit breaker. The detail open hybrid automaton model for the SCADA can be found in Heracleous (2016).

Communication Network (CN) Component The communication network is responsible for all the communication needs of Micropolis. The model of the network represents the three basic operation modes of the network: (i) when the network operates normally, providing communication services to Micropolis; (ii) in case of a power cut, where the power is not enough to feed the antennas and switches, thus the network uses UPS; and finally (iii) when the UPS runs out or a fault occurs and the network goes down. More detailed explanation for the network model can be found in Heracleous (2016).

WDN Components—Tank and Pump The WDN consists of two components, the tank and the pump. The tank receives and stores water from the pump and supplies Micropolis based on the demand. This has to be controlled accordingly, since too much water from the pump can overflow the tank, while less water can drain it. The tank model, which can be found in Heracleous (2016), represents this behavior with three modes based on the tank's volume: (i) healthy mode when the volume of the tank is larger than zero and smaller than the tank's maximum volume; (ii) overflow mode, when the tank's volume is maximum; and (iii) drained mode, when the tank is empty.

The pump supplies Micropolis' tank with water by receiving and comparing the tank's volume measurement with a properly defined threshold. For instance, if the tank volume goes below the threshold value, then the pump will start supplying water given that the substation provides the necessary power. There are also restrictions to the pump operation such as maximum working period and minimum resting period, while the pump can suffer technical failure as well. The pump's open hybrid automaton model is described in more detail in Heracleous (2016). The model has three modes to represent the pump's behavior: (i) the Pump Off when the pump is off; (ii) the Pump On when the pump is on and supplies the tank with water; and (iii) the Fault mode when there is power cut, network issues, or technical fault that prevent the pump to operate normally.

Composition Model The five open hybrid automata models are composed together as shown in Fig. 8 creating the composition model, a larger model that includes the various dependencies between the components. As elaborated above, there are physical, cyber and logical external dependencies between the components and internal dependency between the tank and the pump, that are all depicted in detail in Fig. 8. In the composition, the component models run in parallel with the output of

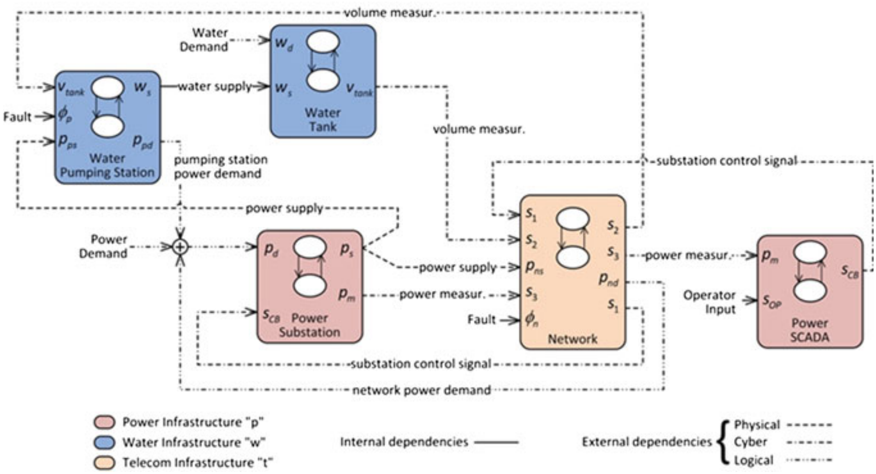

Fig. 8 Composition model

one model to become the input to the other, developing various feedback loops between them, which represent infrastructure interdependencies. For example, both the power substation and the SCADA use the network to transmit power measurements and control signals between them, as depicted in Fig. 8 with the necessary connections. The network is also depended on the substation model for power. These dependency connections create feedback loops between these three models, which subsequently form interdependency between the power and the communication infrastructure. This allows the study of cascading effects between the various components by running simulation scenarios with the composition model as presented in the next section.

Simulation Results and Discussions The component models and their composition model, as described in the previous sections, were implemented in Matlab's Simulink software with the purpose to study the cascading effects between the different infrastructure components due to (inter)dependencies. To achieve this, the composition model can be simulated for a number of scenarios, where different components set to fail at specific times and then observe how the state of other components changes. Thus, Figs. 9 and 10 show the results of one such simulation scenario. Specifically, Fig. 9 shows the simulation scenario timeline where, at the top, is the duration of the induced event at specific component, and at the bottom the consequences of that event to other components. Figure 9 shows for each component how the discrete states evolve and some of the inputs/outputs or states of the model, during the simulation scenario.

From the results it is clear that the composition model can represent cascading effects due to dependencies. For instance, when the Power Substation is down due to overload (Switch Off at 05:58), the Network immediately switches to UPS use and the Pump remains without power. Also a Network fault between 15:13 and 16:52 causes the SCADA to immediately lose communication and then at 15:34 the Tank to overflow, since the Pump does not receive measurements for the tank volume to stop once the tank is full. Finally, when at 20:13 the SCADA operator remotely switch off the Power Substation due to maintenance, at first the same consequence events during the overload at 05:58 occur, then since the substation remains off for more than an hour the UPS at the Network depletes (at this scenario

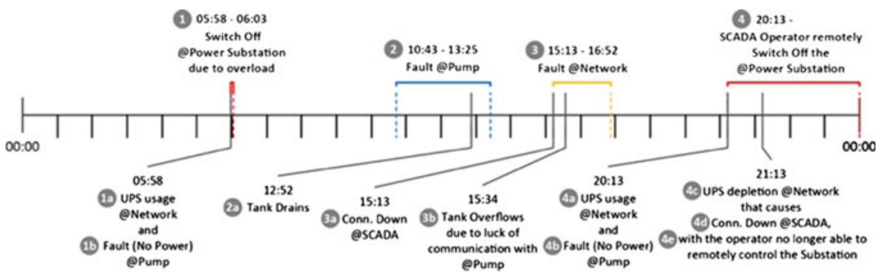

Fig. 9 Simulation scenario timeline with induced events/faults at the *top* and their subsequent consequences at the *bottom*

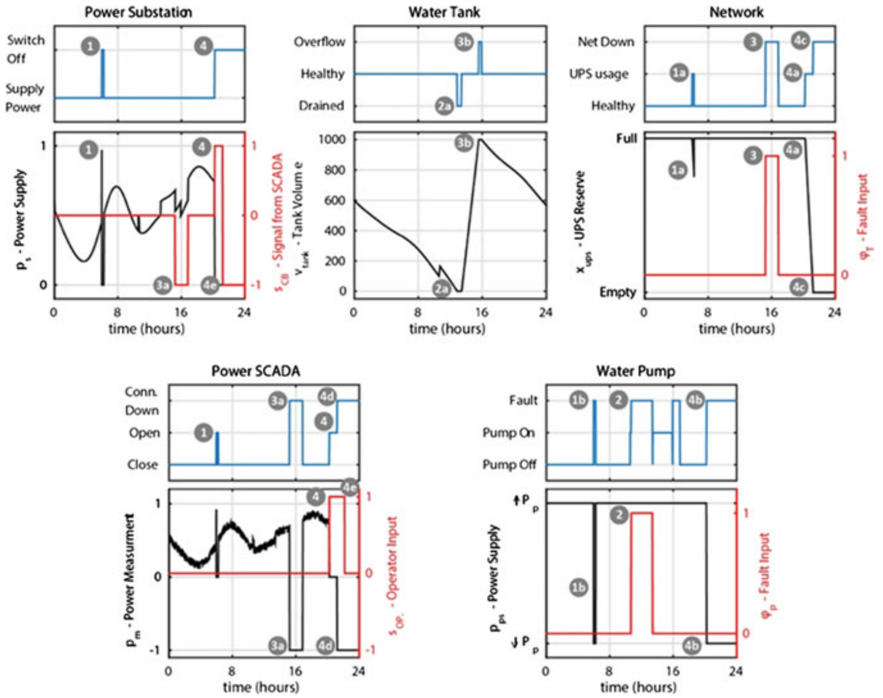

Fig. 10 Plots showing plots from each component associated with the simulation scenario timeline

UPS is set to hold the network operational for 1 h of power cut), leaving Micropolis without communication services and the SCADA operator unable to remotely control the substation.

7 Conclusions

CI analysis with application to *smart cities management* is an emerging field of study, with tremendous importance for the entire society. Test systems for such analysis are in need, especially due to the lack of public data available in the case of several real CI, such as power distribution systems, telecommunication systems, and water distribution systems. This work presented the design and development of such a *test-bed system* under QGIS platform, with the scope of making it available for the research community to serve in analysis to interdependencies and impact studies related to natural or man-made *disasters* or for developing strategies for *preparedness* in such events. The major contributions of this work can be summarized as follows:

- Detailed design concepts from planning to actual calculations and sizing of three CI within the virtual city of Micropolis were presented.
- All the planning approach took into account the recent trends for renewables in power systems, the monitoring of the quality of water in water networks and the trends to expand telecommunication over cellular networks instead of terrestrial wiring.
- We have developed a QGIS based integrated three-CI test system for the virtual city of Micropolis, where the critical components that interact between two or more CI are detailed (operational data).
- A detailed framework for modeling interdependencies between CI based on open hybrid automata was also presented in a practical manner.
- We have validated the proposed modeling framework for CI interdependencies, using the designed and developed test system for the virtual city of Micropolis.

The developed test system was released as open data and it is available to be freely downloaded at KIOS (2016). The authors hope that this work will serve the research community with a valuable tool to test and validate methods that relate to *smart cities security*, such as: disaster evaluations, preparedness and resilient designs, adaptive and resilient control, smart integrated governance, and so forth.

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Disaster Prevention and Emergency Response Using Unmanned Aerial Systems

Petros Petrides, Panayiotis Kolios, Christos Kyrkou, Theocharis Theocharides and Christos Panayiotou

Abstract This work highlights the important and advantageous use of unmanned aircraft systems (UAS) in emergency response operations and focuses on the importance of matching end-user needs with existing UAS technical capabilities, specifications and payloads characteristics to achieve best results. Firstly, a detailed procedure is derived for matching end-user needs to technological requirements. Thereafter the methodology to accurately estimate the overall mission time is derived based on the aforementioned needs and requirements. Finally, detailed evaluation of the proposed procedure and methodology is done through realistic examples extracted from missions set out by civil protection organizations. It is shown that properly configuring and operating UAS technology can significantly improve utilization both in preparedness and response to emergencies.

Keywords Disaster preparedness and response · UAS operation · Path planning · Resource utilization

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1 Introduction

Unmanned aerial vehicles are pilotless aircrafts that can be flown by a pilot via a ground control system, or autonomously through use of an on-board computer, communication links and any additional equipment that is necessary to operate safely. All these components together are jointly referred to as UAS. The term UAS is the official term used by the Federal Aviation Administration to describe these type of aircrafts. "Unmanned" defines that there is no human inside the aircraft; the term "aircraft" is used to comply with airworthiness and airspace regulations; and the term "systems" is used to emphasize the associated support equipment, control station, data links, telemetry, communications and navigation equipment, etc., necessary to operate the unmanned aircraft (Austin 2010). Other names are also widely used to describe these systems, such as DRONE (Dynamic Remotely Operated Navigation Equipment), RPV (Remotely Piloted Vehicles) and RPAS (Remotely Piloted Aircraft Systems) (Federal Aviation Administration 2016).

The use of UAS has shown to be extremely beneficial in many situations and their popularity is increasing in a very fast pace due to their great advantages over manned aircrafts. For instance, UAS are much cheaper to operate, can have a very small size and high deploy ability, and increase the probability of mission success without the risk of loss of aircrew resource. Furthermore, they can be exposed to extremely dangerous environments and can carry a series of payload equipment specifically designed for various operations (Wu et al. 2016). Finally, UAS can be used for long endurances without the loss of concentration and fatigue that aircrew personnel can suffer in manned aircraft operations. Undoubtedly, these features can prove extremely beneficial to civil protection missions (covering both prevention and preparedness), as well. In this work we seek to integrate these UAS capabilities to the specific *civil protection needs* with the end results of increasing operational effectiveness and decreasing operational costs; while concurrently decrease response time required in disaster prevention and emergency response missions. Evidently, the sooner a victim is located during search and rescue, the sooner medical aid will be offered and the better the chances of survival. Furthermore, UAS can support first responder operations and may increase situational awareness of civil protection agencies.

Camera sensors have a primary role on both strategic and tactical missions carried out in preventing, preparing and responding to disasters, as emphasized in DG ECHO (2016).

Collecting data from aerial camera sensors can be extremely useful in prevention activities including assessment and mapping, and in demanding field-missions such as search and rescue, disaster monitoring and control. This work will provide details on how to perform effective *data extraction* (image and video collection) using on-board camera sensors based on the primary functional features that include a camera's resolution and field-of-view (FOV) angle, as well as considering object characteristics, such as size, shape, texture, and illumination.

The image/video data collected from a camera sensor can be evaluated as useful/meaningful either by a human operator or through computer-aided assessment, using computer vision techniques. As shown in the sequel, this is an important feature of the overall processes and thus receives particular emphasis in this work.

Clearly, the choice of the aforementioned features has an impact on the performance of the UAS in terms of operational times and overall time management. The operational time is affected by a set of parameters such as flight altitude, camera specifications (i.e. weight and performance), UAS velocity, and characteristics of the object and region of interest (ROI). These parameters are interrelated, i.e. variations in one parameter can affect the performance of the others. The dependencies that emanate from this interplay will also be discussed in detail in this work. Examples of the overall time management during different missions will demonstrate the necessity of fine-tuning of functional features for best results.

2 Needs Assessment

Undoubtedly, UAS can offer many beneficial support services to civil protection activities in many ways. Broadly speaking, these services can be classified based on two main roles, that of a *helper* and an *informer/observer*. A *helper UAS* can be used to help first responders by shipping important dispensable equipment payloads quickly and effectively. For instance, a helper UAS can ship equipment such as a life vest, a defibrillator, a first-aid kit, a thermal blanket, water and food or any combination of these items, depending on the requirements of the situation. An *observer UAS* can be used to maximize situational awareness and aid civil protection personnel in deciding or planning their actions. Observer aircrafts for example, can monitor the evolvement process of field operations or can be used to identify threats or evaluate particular situations. Additionally, a fully autonomous UAS can be used to work on its own, trying to detect and track an object of interest and provide information to the control station only when deemed necessary. It can also be used to provide first responders a bird's eye view of the damage, helping them prioritize their search and rescue endeavors.

In general, situational awareness stems as a key necessity that enables prioritization of actions and allows responders to focus on the tasks that need immediate attention. UAS can achieve that effectively with the ability to provide unique viewing angles of the events that are either not possible, or are too time-consuming and costly to achieve using manned aircraft. Time is a crucial parameter and hence quickly available and highly deployable equipment is directly linked with mission performance. In that respect, UAS platforms provide an increase in operational effectiveness; while at the same time they decrease operational costs and operational response time.

The following list presents important operations that civil protection authorities are responsible for; and the corresponding needs for each operation, for which the use of UAS can prove invaluable (Austin 2010):

- *Reconnaissance and Mapping*: Need high-resolution visuals to help emergency responders' managers to flag critical infrastructure that requires securing before and immediately after a disaster. For example, there is a need to continuously monitor flooded areas and rising waters to avoid cascaded catastrophic consequences.
- *Structural Integrity Assessment*: Needs to gain access to areas too dangerous for risk engineers in order to detect deformations, shifts, and cracks in buildings and infrastructures both before and immediately after a disaster. Detecting for example cracks in gas pipes can prevent explosions associated with leakages of flammable gases.
- *Temporary Infrastructure/Supply Delivery*: Need to serve as temporary airborne notification and warning platform, when required; and provide connectivity by acting as a relay in a coverage dead-zone. There is also a need to deliver quickly small equipment or supplies (first aid kits, food or water etc.).
- *Wildfire Detection and Extinguishing*: Need to detect fire spots, monitor the fire front propagation through the smoke (depict shape and growth), and measure fireline wildfire intensity and directionality in order to improve coordination and provide spatial information to support fire suppression decisions (deployment of ground forces). Doing so ensures, for example that entrapped firefighters, avoid becoming trapped by enclosing flames or other dangers. There is also a need to detect assets at risk in front of the propagating fire and deliver sound messages to trapped people.
- *Chemical, Biological, Radiological, Nuclear, or Explosive (CBRNE) Events*: Need to reduce human exposure to unsafe environments; while providing continuous monitoring and data validation in the most extreme conditions.
- *Assisting Search and Rescue Operations*: Need to identify and locate missing or trapped people. Deliver first aid and rescue material to people in need. There is also a need to provide situational awareness to the rescue command center via real time video link. Doing so via UAS platforms allows for example for quick deployment and eliminates air-crew fatigue (accompanied in manned aircraft that decreases effectiveness in search operations and increases the likelihood of pilot error).

To address these needs, a number of *technical specifications* are required. Firstly, high deploy-ability is essential, since operations require quick response time and minimal pre-flight preparation. Furthermore, UAS platforms should be able to be deployed in as many terrain types easy and rapidly (e.g. in large open fields and tight spaces alike). Besides that, UAS platforms should be easy to fly (either manually or automatically) with minimal training, since most of the operating personnel are volunteers that do not have background knowledge, professional training or experience in UAS platforms. Hence, one of the most important UAS technical necessities required for the operations described above, is hovering. Hovering will allow the operator to monitor an event and take unique viewing angles easy and effectively, while the UAS will stay in place as much is required. Endurance is another technical capability that is critical for this kind of operations. Obviously, longer endurances provide higher performance as well as lower costs in terms of extra recharging/replacement components. Other parameters such as long range, maneuverability and heavy payload capability have a medium importance for these operations. At the same time, extremely long ranges are not required for operations that civil protection authorities are asked to undertake, which can be classified mainly to medium range. Additionally, having high maneuverability will not provide any significant benefit to the operator nor is required to any of the missions described above. Carrying heavy payload could be beneficial for some operations, especially when delivering equipment. High speed and high altitude requirements do not provide any significant advantages to the aforementioned mission types.

3 UAS Component Categories and Types

The category and type of available UAS components are the primary factors that define the operational capabilities of the assembled platform. These operational capabilities determine flying air speed, altitude, degree of autonomy, deploy ability, environmental capabilities, hovering, maneuverability, range and endurance, communications range and size. It is therefore vital for UAS operators to know the categories and types of available components to be able to synthesize the most suitable system that matches to the operational needs.

UAS platforms are divided into *six main categories*. The first category is “HALE” or High Altitude Long Endurance. In this category, UAS platforms are usually operating at high altitudes of more than 15,000 m and have extreme endurances, usually of more than 24 h. The next category is “MALE” or Medium Altitude Long Endurance. This category contains UAS platforms that operate in altitudes between 5,000 and 15,000 m, with maximum endurance of 24 h. A subsequent category is “TUAS” or Tactical UAS, in which aircraft platforms can operate in ranges between 100–300 km. The fourth category is “close-range” UAS, which have a maximum range of 100 km; while the most popular consumer-scale category is that of “MUAS” or mini UAS. These types of UAS are capable of ranges of up to 30 km; and have maximum takeoff weight of 20 kg. “MAV” or Micro Aerial Vehicles and “NAV” or Nano Aerial Vehicles make up the last two existing categories, with their main characteristics being their diminishingly small size and weight (Austin 2010).

For each of the above categories two distinct types of aircraft platforms are available, namely fixed wing and rotorcrafts. The advantages and disadvantages of both types are discussed in the sequel in order to better understand how different UAS configurations perform.

The *fixed wing configuration* has a stationary wing along the lateral axis, which is responsible for generating the lift force upwards. There are a lot of fixed wings setups such as high wing, low wing, mid wing, delta wing and canard. Fixed wings normally are capable of very high speeds as well as enormous endurances and ranges (Yeong et al. 2015). Since their wing is responsible for generating lift, these are very efficient in terms of power consumption, usually requiring only one main engine or electric motor to operate. Furthermore, fixed wings can glide requiring minimal power and offering the ability to land safely in an unexpected engine failure. They are capable of carrying relatively heavy equipment. In terms of launching and recovery, they require a runway for taking off and landing or a ramp accelerator which is a huge restriction. Due to these special requirements in launching and recovery, fixed wings have a high maintenance cost as well. An additional drawback is that they do not have the ability to hover in place. Finally fixed wings are hard to fly manually and require a lot of training and experience, meaning that they have lower airworthiness (Sosa 2013).

Rotorcrafts, on the other hand, generate lift force from their own propulsion systems and propellers. A plethora of rotorcraft setups are currently available including single rotor, co-axial rotor, tandem rotor, quadcopter, hexa-copter and octocopter. Rotorcrafts are capable of vertical takeoff and landing, therefore have high deploy ability in terms of launching and recovery, and relatively minimal restrictions; while they can be deployed almost from anywhere. Furthermore, rotorcrafts can move in any direction quickly and can fly in very tight spaces avoiding obstacles, which is a big advantage. Most importantly, they can hover giving the advantage of staying in one place as long as is required to monitor a situation and give any viewing angle that the operator needs. Finally, it is extremely easy to fly and even a beginner can fly a multi rotorcraft with minimal training and experience. However, due to the fact that rotorcrafts use their own propulsion engines or electric motors to generate lift, they are high power consuming units and have relatively short endurance, compared to fixed wings. Additionally, they are not capable of carrying heavy equipment (Sosa 2013).

Table 1 is a scoreboard of the operational capabilities of both fixed-wing and rotorcraft systems. The table first rates (in a scale of 5) the capabilities of each type of platform. It also provides a rating of the degree of necessity of each capability for the purpose of civil protection (as it emerges from the needs assessment) and then an overall rating is derived for each of the two types of UAS. Evidently, for specific missions the operational necessities might be different; and thus the values may be adjusted accordingly in the scoreboard in order to obtain more accurate selection decisions.

The scoreboard combines the capabilities of the two types of systems with the operational necessity to rate the available technologies. The capability rating of each UAS type, has a lowest value of 1 to indicate that the particular type is least capable in the specific field and a highest value of 5 meaning that the UAS is highly capable in that field. With respect to the operational necessity, a weight factor has a lowest value of 1 meaning that is least important and a highest value of 5 indicating that the capability is highly important in operation. In the scoreboard, the necessity

Table 1 Needs' assessment matrix for civil protection operations

Capabilities	Capability rating		Operational necessity	Overall rating	
	Fixed-wing	Rotorcraft		Fixed-wing	Rotorcraft
Carry heavy payload	5	2	3	3 × 5 = 15	3 × 2 = 6
Deploy ability	2	5	5	5 × 2 = 10	5 × 5 = 25
Easy-to-operate	1	5	5	5 × 1 = 5	5 × 5 = 25
High airspeed	5	2	2	2 × 5 = 10	2 × 2 = 4
High altitude	5	3	2	2 × 5 = 10	2 × 3 = 6
Hovering	1	5	5	5 × 1 = 5	5 × 5 = 25
Long endurance	5	2	5	5 × 5 = 25	5 × 2 = 10
Long range	5	3	3	3 × 5 = 15	3 × 3 = 9
Maneuverability	3	5	3	3 × 3 = 9	3 × 5 = 15
Total rating				104/225	125/225

factor is multiplied with the corresponding capability rating and summed up to give the total rating for each type of UAS. Notably, the ideal case would be the one where all factors were rated with full marks (i.e., 5/5), in which case the total rating would be 160/225. As it can be seen from the table, the three most important operational needs are deploy ability, easy to operate and hovering. The overall results clearly indicate that rotorcrafts are the most suitable UAS type for the general purpose of civil protection.

3.1 Propulsion Types

Existing UAS propulsion types are divided into two main categories, air-breathing and non-air-breathing engines. Air-breathing engines include piston-prop and jet, while non air-breathing engines consist mainly of electric systems.

Piston-prop engines are famous for their low fuel consumption leading to high endurance and hence UAS are capable of extremely long ranges. In addition, piston-prop engines are waterproof, providing a robust all-weather solution. However, these types of engines require frequent and careful maintenance, which is costly. Another important drawback is that these engines may be unreliable in cold environments and may fail to start.

Jet engines are capable of extreme high speeds and are waterproof. However, this type of propulsion has enormous fuel consumption and hence very low endurance. Furthermore, frequent maintenance is a must and is very costly, as well. Additionally, extensive knowledge is required to operate and maintain such type of engines.

Electric propulsion has a lot of benefits, compared to air-breathing propulsion types. Firstly, electric propulsion is relatively cheap and requires minimal maintenance. Moreover, electric motors do not require any preparation before operating, while the operating costs are minimal since they can operate on rechargeable batteries. However, their endurance is restricted, since battery densities are relatively low. Nevertheless, when high reliability and cost effectiveness is a must, electric propulsion systems are the most suitable type, especially in relatively low endurance missions.

3.2 Equipment and Payloads

As previously discussed, support equipment and onboard payloads are vital for the operation and are determined by the needs of the mission. Control or Ground stations are one of the key elements in UAS operations. These controllers may be stationary or movable mobile (e.g. installed in car, boat, truck) and through them, operators engage with the aircraft via two-way communication, through proper communication links. Control Stations usually support communication with external systems to acquire, for example, weather data, transfer information from/to command centers, and share information.

The UAS platform can carry a variety of payload equipment consisting of relatively simple sub-systems (such as a fixed camera with fixed lenses having a mass as little as 200 g) to more advance payloads (such as a video camera system with adaptive zoom support, gyro stabilizer as well as pan and tilt functions). Evidently, larger UAS platforms can carry a combination of different types of sensors (e.g., thermal imagers, radar scanners) to collect various data elements that can be processed and analyzed in real time to provide enhanced capabilities (Ambrose-Thurman 2014).

3.2.1 Electro-Optical Payload Systems

Electro-optical payload systems can be divided into three main categories, optical or visible light cameras, low light cameras and thermal imagers. Optical cameras, can only “see” as long as there is external light in the FOV. The effectiveness is restricted or eliminated in partial/total darkness, smoke, rain, and humid conditions. Low light cameras function in the same manner as normal cameras, but can operate effectively at as much as 1/10th of the light necessary for the normal cameras. On the other hand, thermal imagers use the infra-red spectrum and can see the heat emitted by hot spots or living organisms without the requirement of external light sources. Hence they can operate and be effective in total darkness, and when there is smoke, rain, and fog.

Some of the most important parameters of electro-optical systems are the camera resolution and the lens specification. A higher resolution camera provides a higher quality image or video, hence, more data/detail is captured, thus increasing the chances of detecting and recognizing an object of interest (of rather small size such as humans, cars etc.). However, higher data volumes increase the processing time by the onboard hardware and increase the communication requirements in data exchange. Both these factors can lead to higher power consumption and create a lag in real-time reception. The lens specifications also play an important role in the image quality and the coverage along ROI. Lenses define the horizontal and vertical angles of the FOV of the camera and thus govern the flight paths that need to be followed when in operation. Lenses can be categorized based on fixed or movable focal length lenses. A lens with fixed focal length is usually cheaper and does not have any mechanical parts inside. It, therefore, provides higher reliability and less weight. However, a fixed focal length lens will be restricted to fixed horizontal and vertical angles in the FOV as well as a fixed zoom capability. On the other hand, having a lens with movable focal length allows for a variable range of horizontal and vertical angles, as well as a zooming capability. These lenses are therefore very adaptive. Nevertheless, having movable focal length requires mechanical parts, which increase cost, weight and complexity.

3.2.2 Camera Mounting

Camera mounting units are important for camera stabilization and position control. Evidently, cameras can be attached to UAS platforms without any auto-stabilization equipment. This configuration is of course very cheap but extremely vulnerable to any disturbance, since the camera position and stability depends to the aircraft orientation and vibration, respectively. Alternatively, cameras can be mounted on a gimbal for stabilization purposes (Steen 2014). The gimbal uses gyroscopes and accelerometers to resist any external disturbance as well as UAS movements and keeps the camera extremely stabilized. Using such type of mounting equipment can provide very clear images or video, resulting to improved visual data for the operator. More sophisticated gimbals are also available that allow pan and tilt movements, which can be controlled by the operator or an automated algorithm.

3.2.3 Other Payloads

A list of other payloads and a brief description of each is illustrated below. These payloads include mapping units, such as hyper multi spectral imagers, light detection and ranging (LiDAR) and synthetic aperture radar (SAR), frequency analyzers, transmitters or receivers, air monitoring sensors, and dispensable payload:

- *Hyper multi spectral imagers*: Using the electromagnetic spectrum, these imagers can identify chemical leaks/spillage or other dangerous substances.
- *LiDAR*: Can be used to create high detail topographical maps or three-dimension (3-D) maps of ROI (e.g. highly precise flood maps).

- *SAR*: Provides detailed imagery of the ground day or night through cloud, fog, and smoke. SAR can detect metal objects or changes that can help mitigate disasters in their early stages (e.g. monitor a swelling river before it floods or monitor a slow but steadily advancing landslide).
- *FM repeater*: Emergency radio stations could be broadcast through UAS.
- *Mobile relay*: A cellular relay node in the sky to quickly re-establish cellular signal coverage over areas that are experienced outage.
- *Wireless sensors sink*: A mobile data sink to capture information from ground sensors and transmit them back to the command center. Ground sensors can be used to monitor water flow, water depth, motion detection for security, and the movement of earth in a landslide situation, amongst other applications.
- *Sniffers for pollution monitoring*: Device that take air samples and gives information about nuclear, toxic or any kind of chemicals existing in the area.
- *Mass notification loudspeaker and display* (or flash-light): To inform the public.
- *Collision avoidance systems*: Ultrasonic and light sensors used for obstacle avoidance.
- *Smartphones*: Can be used to exchange multimedia messages with other consumer electronics.
- *Dispensable payloads*: Carry and drop payloads such as first aid kits, and defibrillator.

3.3 Communication

Communication between the aircraft and the control station is divided in two categories, namely the up-link and down-link. *Up-link* refers to the communication from the control station to the aircraft and encompasses the following functionalities:

- Transmit flight plans, which are then executed by the aircraft automatic flight control system.
- Transmit real-time flight control commands when man-in-the-loop flight is needed.
- Transmit control commands to the aircraft-mounted payloads and equipment.
- Transmit updated control station location information to the aircraft.

Down-link refers to the communication from the aircraft to the control station to support the following functionalities:

- Transmit aircraft status and location data to the control station.
- Transmit payload imagery and/or other sensor data to the control station.
- Transmit aircraft housekeeping data, e.g. battery voltage to the control station.

The communication between the control station and the aircraft is usually achieved by radio. Radio frequencies are widely used because they can extend to large ranges and offer the opportunity for (encrypted) communication. UAS normally operate in the spectrum of ultra high frequencies (300–3000 MHz), in the L Band (1–2 GHz), S Band (2–3 GHz), and C Band (4–8 GHz). There are other ways of communication, such as fiber optics or laser, but these solutions are not popular. Lower radio frequencies are capable of supporting communication beyond the line of sight, since lower radio frequencies have higher penetration through obstacles (e.g. trees, buildings, hills). However, to operate a low frequency radio, larger antennas are required and the signal quality is not as good as in higher frequencies. Higher frequencies are capable of high quality signals and hence high quality video. Also smaller antennas are required when operating at higher frequencies and thus provide very good portability. The major drawback is that high frequencies are more susceptible to link quality degradations beyond the line of sight range. Hence, UAS controls normally operate at 2.4 or 5.8 GHz; while the video link normally operates at 900 MHz, 1.2–1.3 GHz, 2.3–2.4 GHz and 5.8 GHz, depending on the needs. Importantly, UAS control and data link frequencies do not match in order to avoid interference between them.

Choosing the appropriate antennas depends on the needs of the operation. A good antenna configuration will ensure reliable communications and provide the required range with minimal probability of signal loss. Signal loss is undesirable and threatens operational performance and safety.

Antennas are divided into two main categories, directional antennas and omni-directional antennas. Directional antennas have higher gain, meaning that they can transmit and receive signals over longer distances. However, they operate in very narrow and strict direction, meaning that directional antennas should be pointed at all times to the transmitter in order to effectively receive signals. Omni-directional antennas on the other hand, have lower gains and thus they are not capable of long range communications. Since they operate in all directions, the antenna is not required to be pointed to the transmitter. The best configuration is to use a diversity receiver with one directional and one omni-directional antenna. A diversity receiver is used to operate using simultaneously signals from both directional and omni-directional antennas, and by combing signal receptions provide higher reliability.

For professional configurations, a radar tracker can be used to automatically steer directional antennas to the position of the aircraft and track it. This ensures the minimum possible loss of communications. To further increase the communications range, higher transmit powers can be used. Indicatively, an amplifier can be added to increase UAS control and data ranges. For example, video link range extension power transmitters with ratings of 250, 600 and 1200 mW are usually employed; with a 600 mW transmitter being the most preferable choice to balance communication range and power consumption. Combining an appropriate antenna configuration with a 5.8 GHz transmitter of 600 mW power rating, it is possible to achieve ranges of up to 20 km.

Video link signals can be either analogue or digital. Analogue signals have traditionally being used in remote controlling the aircrafts. They provide average video quality but are capable of extreme ranges with minimal lag reception. Digital signals are capable of ultra high definition video and can provide encryption as well. However, a small lag exists in reception and they usually are restricted to average ranges. Telemetry and live feeds from onboard sensors can be displayed to the operator in single monitors or multi monitors as well as in first person view glasses. For professional configurations a video integration with UAS performance details is usually done. Together with the video link, integrated data can be superimposed in the video down link. These can include flight data, battery capacitance, and navigation data.

3.4 Navigation

It is necessary for the operator to know where the aircraft is at all times. It is also necessary for the UAS on itself to know its position to enable the plethora of autonomous features. Navigation is used in case of a partially or fully pre-programmed mission or in case of an emergency (return to home).

This is achieved by a combination of GNSS (Global Navigation Satellite System) technologies such as GPS (Global Positioning System) and Galileo that offer access to location information from geo-stationary satellites. For localizations, at least 4 satellites are necessary to determine a 3-D position of the UAS in space; while three satellites are needed to determine longitude and latitude coordinates and one to determine the altitude of the UAS. Satellite data is usually integrated with inertial measurement unit (IMU) and digital compass readings to provide a higher level of accuracy, precision and stabilization. However, environmental conditions can affect the performance of location estimation (e.g. clouds, rain, solar storm). Another method of navigation is through radar tracking, where the UAS has a transponder which responds to a radar scanner emitting from the control station. Radio tracking can also be used whereby the radio signal, used to carry data from the aircraft to the control station, is processed to determine its relative bearing from the control station and thereafter the range is determined based on the time taken for the signal to travel from the aircraft to the station. Direct reckoning is another more recent navigation approach, whereby the UAS position is determined by relating visible geographical features with their known position on the map.

Navigation is an essential part of flight planning through which a set of waypoints (i.e. unique locations on the map) that are specified by longitude and latitude coordinates, are used to lay out a flight route. Flight planning can be done in advance before the actual flight, where the operator can upload to the UAS a pre-programmed flight path in an area of interest by adding waypoints, velocity requirements, holding time over waypoints and other information as required. Flight planning can be done in real time, as well. The operator can upload or edit waypoints while the system is in operation; and dynamically adjust its path.

3.5 External Uncontrolled Conditions

External conditions are always present and in most cases cannot be controlled. It is very important to understand and keep in mind the consequences of these conditions. Extreme cold conditions can affect the performance of gyroscopes and accelerometers. UAS navigation and stabilization equipment depend highly on gyroscopes and accelerometers and hence, misbehavior of these components is undesirable. Furthermore, extreme cold conditions decrease batteries performance, can make materials to become brittle and eventually fail. Interestingly, the air is denser in cold conditions and therefore the blades at fixed revolutions per minute will produce more lift and eventually consume less power. Correspondingly, the air is less dense in hot weather; therefore the propellers will produce less lift at fixed revolutions per minute, leading to higher power consumption in maintaining altitude. Extreme hot conditions can also affect electrical components and motors, which may overheat and fail. Rain and humidity can lead to short circuits and electronic failures when the appropriate insulation or waterproof equipment is not used. The former conditions also decrease the performance of optical cameras due to lower visibility. Other important uncontrolled parameters include interfering frequencies from other communication signals, which can cause misbehaviors in compass and satellite navigation instruments; and can eventually lead to loss of communications or even to catastrophic failures.

4 Mission Functional Features

As stated in the introduction, camera sensors are the primary instruments used in disaster prevention and emergency response missions. These sensors are usually optical cameras operating over the visible light spectrum or infrared to operate in low light conditions by detecting emitted heat. All the image data collected by the camera sensors is translated into picture elements or pixels. The imagery collected can then be processed locally by an on-board computer system for purposes of image enhancement, object detection or recognition; or can be sent to remote control centers for processing.

4.1 Visual Data Collection

The procedure of visual data collection is vital in criticality assessment, search and rescue, and monitoring missions. Key to visual data collection is the ability of discriminating between objects of interest, where the task is to locate all instances of an object of interest in the captured imagery data.

In order to perform accurate visual analysis (i.e. identifying all objects/areas of interest correctly, without false positive/negative detections), a sufficient amount of information must be collected (i.e. the object resolution must be sufficient) (Waharte and Trigoni 2010). Johnson's criteria define the number of picture elements (pixels) required to discriminate an object on an image, based on three main levels with more than 50% probability of success (Kopeika 1998; TREC 2016). These criteria have been drafted with a human operator in mind and for night-vision cameras and, as such, may not be precise for automated visual analysis tools. However, the same principles apply for other camera types and analysis options and thus can be used to build a basic understanding on the camera sensor features.

The first level in Johnson's criteria is the *object detection* and is used to describe that an object is simply present on an image. According to the criteria, detection can be achieved when the object of interest has approximately 6 pixels. The second level is *recognition*, whereby the type of object can be distinguished; for instance, a person versus a car. According to the criteria, an object can be recognized when the object has approximately 80 pixels on an image. The third level of discrimination is *identification*, which is used when a specific object can be distinguished, for example a woman versus a man. To aid understanding of the three levels of Johnson's criteria, Fig. 1 below illustrates the discrimination achieved in terms of picture elements.

The number of pixels are proportional to the resolution of the camera, therefore, the information taken from a low resolution camera are relatively low compared to a high resolution camera. When there is not enough information, for example when trying to recognize an object from a low resolution camera, false positives can occur. Having a lot of false positives (i.e. recognizing an object to be person while actually is not) should be avoided during any critical operation, since this can lead to unwanted results such as reduced effectiveness, waste of resources, and additional personnel effort in checking erroneous results.

Out of the three discrimination levels, detection does not provide enough information about the object/area of interest for any useful mission results. Moreover, detection may produce numerous false positives as well as, false

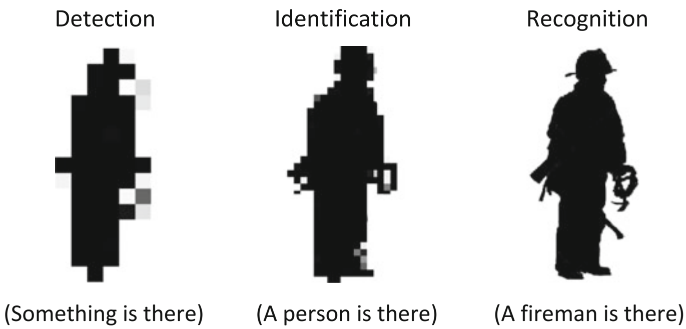

Fig. 1 Johnson's Criteria discrimination levels (Reproduced from UVSS 2016)

negatives (i.e. fail to recognize an object of interest while the object is present). On the other hand, the identification level could provide the best possible outcomes in terms of precision at the expense however of increased operational time. As shown in the sequel, the distance of the camera sensor from the object affects the image resolution and thus the flying altitude of a UAS carrying the camera is also affected, meaning that in order to have higher resolution per object/area of interest from aerial imagery, the UAS should fly in lower altitudes. Hence identifying an object will require a particular UAS platform to fly at lower altitude in order to achieve the higher resolution image, compared to recognizing or simply detecting an object. Flying at lower altitudes will have an impact on the flight performance, since the ground FOV of the camera will be narrower, leading in longer flight times needed to cover an identified ROI. Therefore, the discrimination level should be the one that provides enough information for the particular mission and maintains a feasible and useful flight plan, while eliminating any false positives/negatives (UAV Vision 2016). For the purpose of civil protection, recognition stems as the most appropriate target and, as such, this target is used in the derivations that follow in the next section.

4.2 Visual Data Analysis

Johnson's criteria assume that data analysis is performed by humans and consequently the processing unit is the human brain. The human brain is capable of effortlessly discriminating and classifying objects from among tens of thousands of possibilities almost instantly, despite the tremendous variation in appearance that each object produces such as shape, color and texture (Potter 1976; Biederman 1987; Logothetis and Sheinberg 1996). On the other hand, the analysis can be automated by machine learning algorithms and a processor unit. If the processing unit is a computer or any other hardware, recognition is far more difficult to achieve compared to human operators; and much more detail information is required to do so. Nevertheless, automation is always beneficial in order to reduce the effort to human operators that suffer from fatigue, especially in prolonged missions. As an example using Fig. 1, a human brain is more likely to recognize that the motorcycle on the recognition level is indeed a motorcycle, compared to an automated visual system that has minimal probability of recognizing that this is a motorcycle in such a low resolution. Consequently, the approximation of the Johnson's criteria cannot be used for computer-based visual analysis as they apply mostly to human operators. However, the same principles apply to automated visual analysis by adjusting the approximation of pixels for each of the three levels, according to the parameters of the computer vision system. For instance, a machine learning algorithm can be used to train the system for detecting particular objects, such as a car or a human being. This can be achieved by training a cascade classifier through for example linear binary patterns (He and Wang 1990), histogram of oriented gradients (Dalal and Triggs 2005), haar-like features (Viola and Jones 2001) or even with convolutional neural networks (Szegedy et al. 2013). According to the training set (which is a database of object and non-object images) used to train the classifier and the image processing pyramid constructed for the detector, it is possible to extract the discrimination capabilities of the detector in terms of distance of the sensor from the object and hence, the pixels required for the necessary discrimination level can be assumed.

The aforementioned visual data collection and analysis features, combined with the UAS features and other parameters discussed in the previous section of this work, provide a complete list of functional features for the use of UAS in *emergency response* as summarized below:

- Camera sensor
  - Resolution
  - FOV
  - Angle-of-view
- Object characteristics
  - Size, shape, texture, and illumination
- Object analyst
  - Human operator
  - Computer-aided assessment
- UAV characteristics
  - Flight altitude, velocity, battery capacity
- Communication
  - Transmission range, data rate
- ROI
  - Size
  - Terrain (on/off shore)
  - Topography (height difference)
- Weather conditions
  - Position of sun
  - Wind intensity and direction
  - Smoke, fog

The first three identified features govern the flying height for effective discrimination of objects on the ground; while the last four features govern the flight plan and the overall mission.

4.3 Mission Planning

Mission planning includes estimation of operational time and overall time management. As discussed above, camera sensor features and visual analysis are two of the main functional features that affect mission planning. An aircraft operational time is governed primarily by the selection of the platform and payload to be used, as previously indicated. The overall mission time is determined by the necessary flight plan set out to meet the operational needs across specific ROI. Computing estimates of mission times in advance allows for proper decisions to be taken in terms of how many units to commission; and which operation strategies to follow for individual UAS platforms. Having more than one UAS could perform an aerial camera network to cover a specific area (Ghulam et al. 2013; Avellar et al. 2015; Piciarelli 2015), resulting to greatly reduced mission times.

Evidently mission times depend heavily on the functional features of each mission. Firstly, the camera resolution affects the total operation time, as low resolution cameras require low flying altitudes in order to recognize an object of interest, resulting in smaller scanning areas. Since the scanning area is small, more time is required to search a given ROI, compared to when flying at higher altitudes, which provide larger scanning areas (Choi et al. 2016). Secondly, camera lenses also play a decisive role. As discussed above, camera lenses are responsible for the FOV angles of the camera. For larger camera FOV angles, the UAS has larger scanning area compared to lower FOV angles. Hence, for a given search area the UAS will require less time to scan the whole ROI. Obviously, the overall search time is directly related with the mission time; and thus if a large area needs to be scanned, then the overall mission time will be longer and vice versa.

Similarly, the same conditions apply to the object of interest. Searching for an object that has relatively low area footprint will require lower altitudes to be recognized, resulting to longer mission times, and vice versa. As clearly stated in the previous section, human monitoring or automatic machine learning monitoring will have an impact on the operational time, since the pixels required for the recognition level vary. Finally, the speed capability of arbitrary aircrafts is directly related to the overall mission time, and so is true for weather conditions and especially wind intensity and direction.

In what follows, a clear and concise procedure is detailed to determine estimates of the mission times, based on variable parameter settings. An image sensor is considered with a square scanning area that is employed to search across a particular ROI. Figure 2, illustrates the UAS scanning segments, camera FOV angle, UAS altitude and the overall ROI that is quantized into square scanning segments. The ROI can be divided into N segments of scanning elements. By calculating the time required for the UAS to travel from one segment to the next across the whole ROI, it is possible to calculate an estimate of the overall mission time.

The procedure used to calculate the estimated overall mission time is set as follows in Fig. 3.

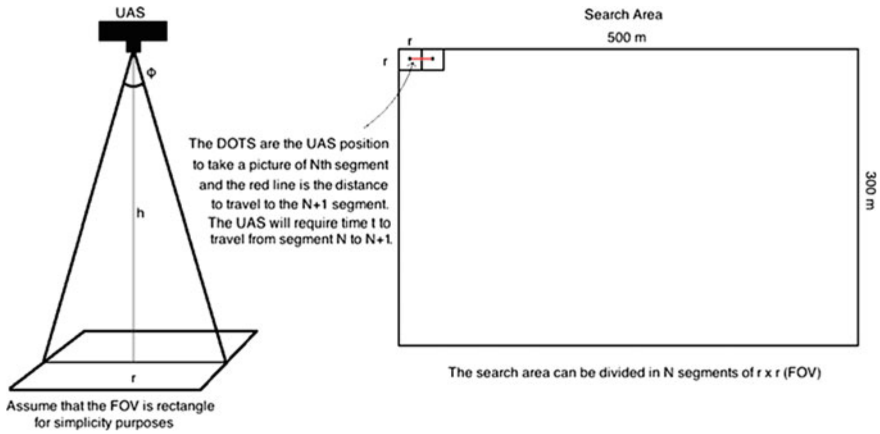

Fig. 2 Diagram showing the UAS FOV, height, overall search area and segments that the search area is divided according to the FOV

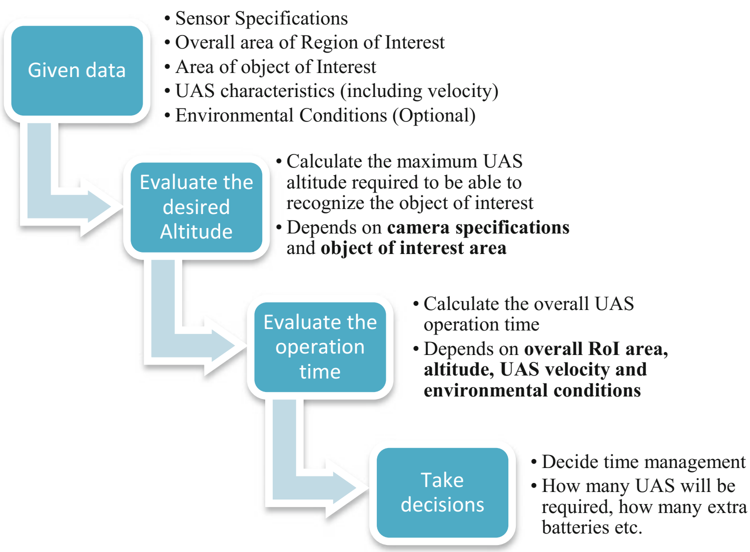

Fig. 3 Flow chart for estimating overall mission time

The area of the top-down view of an object of interest can be assumed by empirical data and known parameters. For instance, a small car can be assumed to have dimensions of 2.5 m in length and around 1.6 m in width, giving an overall area of 4 m^2. Similarly, areas of other objects of interest can be calculated. Table 2 below provides a non-exhaustive list of the most relevant objects of interest.

Table 2 Covered area for objects of interest

Object of interest	Assumed dimensions (m)	Area of object of interest (m^2)
Horizontal person	1.70 × 0.5	0.85
Children (under 12)	1 × 0.35	0.35
Vertical person	0.5 × 0.2	0.1
Small car	2.5 × 1.6	4
Saloon car	4.5 × 2	9
Truck	7.5 × 2.5	18.75
Spot of fire	1 × 1	1
Small boat	4 × 2	8
Cats (Pets)	0.3 × 0.1	0.03
Dogs (Pets)	0.8 × 0.25	0.2

Table 3 Equation parameters

Symbol	Meaning
h_d	Desired UAS altitude to recognize the object of interest (m)
$\hat{p}$	Average resolution of camera (pixels)
$\hat{\varphi}$	Average FOV angle of camera (degrees)
obj	Area of the object of interest (m^2)
r	Size of scanned area (m)
T	Total operation time (s)
A	ROI (m^2)
τ	Time hovering over each segment (s)
U	UAS velocity (m/s)
rec	Minimum number of pixels required for recognition

Combining the minimum number of pixels required for recognition along with camera specifications, UAS velocity and ROI characteristics, the following formulae are used to estimate the operation time, desired altitude and FOV distance. Table 3 shows the explanation of each parameter.

$$h_d \leq \frac{\hat{p}}{2\tan\left(\frac{\hat{\varphi}}{2}\right)} \times \sqrt{\frac{obj}{rec}} \tag{1}$$

$$r = 2h_d \tan\left(\frac{\hat{\varphi}}{2}\right) \tag{2}$$

$$\mathrm{T} = \frac{\mathrm{A} - \mathrm{r}^2}{\mathrm{U} \cdot \mathrm{r}} + \frac{\tau \cdot \mathrm{A}}{\mathrm{r}^2} \tag{3}$$

Equation 1 is used to estimate the maximum UAS altitude, where a specific object is able to be analyzed according to the Johnson's criteria by either a human operator or an automated system with a specific cascade classifier. This equation depends on the resolution of the camera, FOV of the camera and object of interest area. Anything higher than this altitude decreases the possibility of recognizing a specific object, while lower altitudes increase the probability of recognizing the object. As can be seen from the equation, the resolution of the camera is proportional to the maximum recognition altitude. This is due to the fact that higher resolution cameras will provide crispier images or video, allowing the object of interest to be recognized from increased altitudes. The maximum height is also proportional to the square root of the area of the object of interest. Obviously, as the object of interest area is getting larger it can be recognized from higher altitudes. On the other hand, the FOV angle is inversely proportional to the maximum UAS altitude. This happens because as the FOV increases and the resolution of the camera is kept constant; the information captured from the camera is spread along the larger space. This phenomenon decreases the probability of an object being recognized.

After calculating the maximum/desired altitude using Eq. 1, the size of the ground scanned area can be calculated using Eq. 2. The scanned area size is calculated using fundamental trigonometrical identities and depends on the maximum/desired altitude and the camera FOV. Finally, Eq. 3 is used to estimate the total operation time required. The operation time depends on total ROI, UAS velocity, FOV length/distance and time hovering over each scanning segment. The first term of Eq. 3 is used to calculate the total operation time required by the UAS to scan the overall region without stopping. The second term is used for adding any hovering time above each segment as requested by the operator. It is obvious that the operational time is proportional to the overall size of the region; while the UAS velocity and FOV distance are inversely proportional to the operational time.

4.3.1 Example Scenarios

Mission Type 1: Search and Rescue—Locate Missing Persons on Shore In this scenario we assume that we are searching for a person that has been lost. A single UAS is used that is equipped with a thermal camera with resolution 336 $\times$ 256 and 13 mm lenses. The UAV is capable of travelling at approximately 12 m/s and its maximum endurance is 35 min (Table 4). It is known that the person is injured and

Table 4 Planning for Mission Type 1

Equipment	Specification	Value
Thermal camera	Resolution	336 $\times$ 256 pixels
	Lenses FOV	13 mm; 25° $\times$ 19°
UAS	Velocity	12 m/s
	Endurance with payload	Approx. 35 min

Table 5 Assessment of parameters for Mission Type 1

Parameters	Value	Description
$\hat{p}$	296 pixels	Camera specifications
$\hat{\varphi}$	22°	Camera specifications
obj	0.85 m^2	Person is injured, therefore, he is most probably lying down => horizontal position
A	1,000,000 m^2	Decided by the rescue team
τ	3 s	It is decided to hover 3 s above each segment
U	12 m/s	UAS specification, assume zero wind conditions

his vehicle has been found at a specific location. Therefore, it is decided to search in an area of 1 km squared around the location of the vehicle. The following parameters can then be evaluated based on mission planning discussed above (Table 5).

Using the parameters above to recognize a human the UAS must fly up to a maximum height of approximately 78 m as calculated through Eq. 1; while the total operational time required is estimated using Eqs. 2 and 3.

$$h_d \leq 78.48 \text{ m}$$
$$\text{r} = 30.51 \text{ m}$$
$$\text{T} = 1 \text{ h } 43 \text{ min and } 15 \text{ s}$$

Knowing that the endurance of the UAS is approximately 35 min, then three batteries would be needed to complete the mission, based on the calculated time. Of course, any other configuration that includes more than 1 UAS would significantly reduce the overall mission time.

Mission Type 2: Search and Rescue—Locate Missing Car In this scenario the UAS configuration, equipment and search area are kept the same as the example above, but now the deployed team is searching for a missing car. Using the area covered by a car as detailed in Table 2, Eqs. 1–3 are recomputed accordingly to derive the necessary operational time.

$$h_d \leq 170.25 \text{ m}$$
$$\text{r} = 66.19 \text{ m}$$
$$\text{T} = 32 \text{ min and } 20 \text{ s}$$

As it can be clearly seen, searching for a car requires more than twice the altitude compared with searching for a person and thus the whole mission can be completed with a single UAV on a single battery charge.

4.4 Path Planning

It is assumed that the ROI for any mission type is known a priori. As indicated above, this region is segmented into N tiles that need to be covered in order to sweep through the entire ROI. Hence, the UAS should follow a path that covers all these segments before completing its mission. The operational time can be heavily affected by weather conditions as well as the topography of the ROI, both of which govern the flight patterns of the aerial vehicle.

As emphasized above, Eq. 3 provides an estimate of the total operational time for a specific mission type. For simplicity, this equation does not take into consideration either weather conditions (such as wind resistance and position of the sun) or topography, and thus can be used for an initial indication of the approximate operational time. To improve on this indication, these conditions ought to be considered when planning for a traversal path. For instance, having a path that leads the UAS rotorcraft to fly in a direction opposite to the direction of the wind could decrease performance dramatically in terms of power consumption as well as operational time. On the other hand, flying along the direction of the wind could help increase the performance of power consumption and operational time. At the same time, if the UAS is required to hover above particular areas for extended time periods, a lot of effort would be required from the UAS to decelerate and stabilize itself. Therefore, according to the operational needs, the path planning should vary. For instance, if the UAS will not hover in each segment and is just flying along all segments without stopping at all, then travelling along the wind's direction most of the time could be very advantageous. If the operation requires hovering and therefore stopping at specific areas, then the UAS could fly in a direction perpendicular to that of the wind's direction, as indicated in Qin (2014).

Figure 4 illustrates an arbitrary ROI taken from Google maps. This region has been segmented into 192 tiles that have been constructed as shown by the black grid lines. An arbitrary UAS path is illustrated with the white line. The wind's direction is assumed to be downwards. Considering the wind's direction, the path shown in Fig. 4b is not optimal, since the UAS is forced to fly towards the wind's direction for about 46% of its total flight path, which will give a high negative impact on its performance.

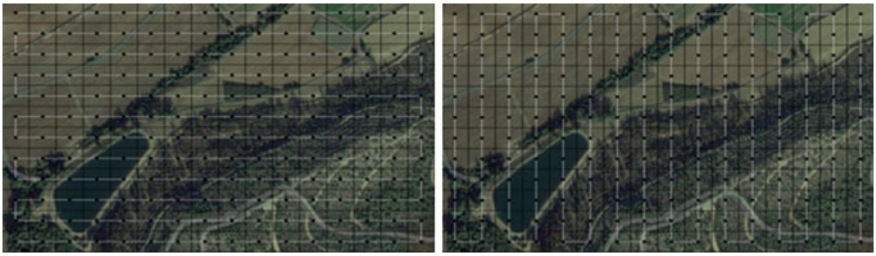

Fig. 4 Possible flight paths to cover the ROI

However, Fig. 4a shows a possible path of the UAS, where in around 94% of its flight path the wind direction is perpendicular to the flight path; and hence the wind has a lesser impact on the UAS performance. If the wind's direction is heading along the ROI with an angle not equal to 0°, 90°, 180° or 270°, then the wind's vector should be divided into vertical and horizontal vectors in the Cartesian coordinates system. Therefore, an optimal path could be considered the one that most of the flight path will be perpendicular to the greater component vector of the wind's direction.

The other important feature that needs to be considered is the ground elevation. UAS altitude is measured relatively to the takeoff point. Therefore, any elevation changes on the terrain could lead to variances in the FOV of the UAS. For instance, if the UAS is flying in a constant altitude relatively to the takeoff point and is flying above a hill, then the FOV of the camera will get smaller, since the terrain will come closer to the UAS as a result of higher elevation. This issue can be solved either by attaching a range finder equipment on the UAS that will measure the above ground level (AGL) altitude of the UAS so that it can be held constant; or by using a camera sensor and doing some computer vision processing called optical flow to estimate the AGL altitude of the UAS. The optical flow method is used to calculate velocity vectors of moving pixels on a sequence of images. If a camera sensor is attached underneath on the UAS so as to monitor the terrain perpendicularly, it is possible to estimate the velocity vectors of the terrain's pixels. Knowing the velocity of the UAS and analyzing the pixel velocities from the downward facing camera, the altitude can be calculated. The slower the pixel velocities the higher the UAS is, as indicated in Price (2013). These techniques will help maintaining a constant AGL altitude; and hence keep the FOV constant to match with the segmentation done on the ROI area.

4.5 Communication

Information gathered by UAS sensors is only useful when transmitted to the control station for analysis, situational awareness and evaluation. Clearly effective communication is a challenge under real conditions; while security is also becoming a primary concern, since signals should be encrypted and possibility for interception by third parties has to be eliminated (Luo et al. 2012).

Operations can take place under varying environmental conditions and under different terrains (including urban, rural, shore and off-shore regions). Data transmissions are limited primarily by extend of the communication ranges that may be required (Gowda 2015). Temporary or permanently loss of any communications due to weak communication signals could delay operations and reduce effectiveness in use of UAS in the field. Hence, the impact of any possible communication loss should be minimized. This can be achieved by minimizing the dependency on continuous communication. By uploading flight data such as flight plan (including waypoints, desired height, schedule) before take-off to the UAS on-board flight controller, the UAS will know the exact path to follow (including traversing velocities, hovering times) that will need to be carried out even if the communication is interrupted or lost at any given time. At the same time, downloading raw sensor data may not be necessary. Clearly, if the operator prefers to manually analyze sensory reading, then the UAS could send raw data without performing any automated visual analysis. However, this could lead to lag in transmission. On the other hand, to alleviate the problem of reduced communication capabilities, the UAS could perform on-board processing of captured measurements in order to make automated analysis (as discussed in Sect. 3.2). Then the image could be compressed to a lower resolution before transmitted to the operator, highlighting only any possible regions on the image that may contain important information. Doing so, would maximize communication utilization and hence operational performance.

5 Conclusions

This work provides a detailed analysis of the selection and use of UAS platforms for both strategic and tactical missions in prevention and response to disasters. Identified functional features include sensor payload (especially cameras), data analysis requirements (for human operators or automated computer system), UAS capabilities (in terms completing the mission, following a predetermined path and exchanging information) and communication, weather conditions and requirements in terms of objects and ROI. To achieve effectiveness and efficiency, the interplay of all these features need to be considered. It has been shown through examples that all these parameters affect the operational performance in terms of mission planning and response performance.

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