Eric Vaz *Editor*

Regional Intelligence

Spatial Analysis and Anthropogenic Regional Challenges in the Digital Age

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Social Issues and Regional Intelligence

Introduction: Regional Intelligence—A New Kind of Science

Eric Vaz

Conceptual Definition

Regional intelligence comes as a novel concept in times of profound anthropogenic change at regional level (Vaz, 2016). It responds to the recent dynamics of unprecedented economic, social, and environmental challenges. The Anthropocene sets out the stage to consider new methods to approach increasing geographical–regional issues (Crutzen, 2006). These issues are mostly a result of rapidly changing demographics and their consequences on environmental systems. It is through scientific advances that we have brought forth in recent decades a plethora of techniques to monitor, assess, and measure change (Vaz, Nijkamp, Painho, & Caetano, 2012). To a more considerable extent, due to the advances in the field of regional science (Nijkamp, Rose, & Kourtit, 2015), human-made impact throughout different scales of geographic interaction becomes measurable (O'Brien, 2011). The computational and geocomputational advances have brought a tremendous contribution to tackle such issues (Thill & Dragicevic, 2018). Despite these advances, several difficulties remain in relating to

(i) Scale: Not all quantitative measures address the challenges for different types of geographic regions adequately (Pinto, Noronha, & Vaz, 2018).
(ii) Data availability: The cognizance of digital data is often insufficient to measure the inherent complexity of environmental interactions (Rae & Singleton, 2015).
(iii) Computation: Computation has led to stellar prospects for regional decision support within the regional science corpus. Computational methods, however, often lack a knowledge transfer that can be integrated quickly and efficiently by policy actors and institutions to understand these challenges better (Fischer & Getis, 1997; Stimson, 2019).

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In this sense, the concept of regional intelligence remits to an integrative dimension of joining geography within socioeconomic interactions for regions. It takes advantage of spatial analysis and reaches a common framework for stakeholders' decision making that becomes more intuitive for stakeholders to apply (De Groot, Alkemade, Braat, Hein, & Willemen, 2010). Regions have inherently to become more resilient, adaptive, and intelligent to allow for a multi-equilibrium perspective to address the challenges of territorial dynamics we are presently facing. The mission of regional intelligence brings the ability of long-term monitoring to deal with concerning dynamics of change in the Anthropocene. It is, therefore, an evolutionary standpoint that sees regional interactions as a complex set of dynamic ecosystems looking for the maximization of steady-state equilibrium. Finding such a balance is inherently complex and almost impossible in the long run.

Nevertheless, the objective of this book is to target the potential of assessing and monitoring territorial determinants at multiple levels of interactions. As such, the methods explored to establish the framework of regional intelligence, dissecting significant issues, and respond to such topics efficiently through robust techniques and methodological integrations. Such methods deal with regional complexity, standing on the shoulders of the considerable advances in regional science in the last fifty years.

Geocomputation as an Aid for Regional Intelligence

The advances in the field of regional science have brought a great amount of new digital data sources. These are frequently open source and available to the community in general. Such advances allow for a positivist vision in regional science to harness a new dimension abridging the possibility to assess territorial dynamics through different approaches. At the center of such techniques lies the convergence of environment, demographic, and economic data. These contributions in the field of regional science are brought by spatial analysis, which caters tools and methodologies that allow assessing through computational techniques hidden patterns. The advancement of such tools has increased computational power and performance. New aspects in geocomputational methods and statistics permit a multi-dimensional understanding of present-day complex regional challenges. As such, geocomputation brings a ubiquitous approach for data analytics that revolutionizes new paradigms for regional science to explore the complexity and intertwining fields such as economics, planning, and geography. The traditional methods found in regional science in the last decades as well as the positivist vision have thus gained new momentum through geocomputation. The discipline itself calibrates to the creation of novel methods that rely on new paradigms such as artificial intelligence, deep machine learning, self-organization, agent-based modeling, and artificial neural networks that become key players in the future of regional decision support systems.

Behavioral scientists have further engineered new paradigms to be considered within the framework of regional science, such as the existence of large data combined with social networks, allowing for a critical point analysis of individual entities behaving throughout geographical space. This discipline, coupled with complex system theory, has led to the emergence of new avenues for regional science and to understand regional dynamics outside of the sandbox of linear modeling.

This sandbox extends to the public policy dimension, where, in fact, regional decision support systems become an essential tool to advance within the complexity of the current challenges of regions. In this sense, regional decision making together with geocomputation brings a new framework that explains internal and external regional dynamics and permits for successful territorial governance.

As to summarize, one should consider that understanding regional challenges in the future will be a result of merging complexity science with multiple scales of territorial interaction. Distinct levels of local and regional decision making can benefit greatly from toolboxes brought by spatial analysis, geocomputation, and statistics. The effort is thus linked to make decision making an efficient endeavor both in time and space that responds to the environment, social, and economic interactions of territorial systems. This is the key aspect of regional intelligence. The multi-dimensional approach of tools addresses different challenges for territorial cognition. Within the Anthropocene, and in a context of multidisciplinarity, it is these tools that allow to revolutionize and optimize sustainability. A bottom-up approach where local governance expands on the capacity due to data richness to support their own independent decisions becomes pertinent. Such an approach is fostered by both quantitative and qualitative methods, bringing together regional science and community. The stage is envisioned well beyond academia, further away from the textbook but applied to local analytics within policy and governance instead.

The availability of open data, open software, and thus the emergence of open regional science is crucial aspects for the blossoming of this paradigm. The combination of these aspects defines the core of regional intelligence, a new kind of science, and a new integrative vision for the future of regional development.

This integrative approach brings a series of relevant goals of this publication: to expand on the potential of regional intelligence within multi-levels of spatial interaction for regional decision support. This brings a functional research framework which addresses, although not limited to

(i) Territorial understanding of regional decision support systems at the local level
(ii) Empirical studies of spatial decision support systems for modern governance
(iii) Predictive and non-spatial models of territorial decision support
(iv) Clustering and regional analytics
(v) The assessment of regional interaction and resulting models
(vi) Implementation of territorial policies and governance.

Book Organization

A collection of chapters within the diversified field of regional and policy issues, planning, as well as economics and geography are intertwined in this book, catering an illustrative guide to regional intelligence. This is explored by the distinct geographical scales that encompass regional development issues and call for a transformative agenda of regional planning instruments. These planning instruments use distinctive methods that relate to the positivist approach further the usability of what defines regional intelligence.

This chapter explores the introduction of the book by Eric Vaz, claiming the importance of defining within regional science a multidisciplinary viewpoint. This viewpoint intertwines the multidisciplinary and spatiotemporal regional decisions to a broader spectrum of policy and governance interactions.

This is defined as regional intelligence and follows the emergence of recent advances in the field of spatial decision making. This initial introduction organically flows into the four distinct silos that constitute the contribution of this book.

Part I relates to *Sustainable Development and Regional Intelligence*, abridging a theoretical framework for the pressing issues of environment and ecosystem and landscape services in times of pressing change within the Anthropocene.

Intrinsically geographical in nature, this first part starts with Chap. 2 (Vaz and Agapito), exposing the fragile relations between archeological heritage preservation (an often neglected aspect of regional development) and recovering of archeological heritage landscapes, as a potential alternative for economic prosperity at local level. An identification of opportunity cost brought by an endogenous tourist demand at a regional level renders this possible. Chapter 3 (Loures, Gomez, Castanho, and Loures) brings several examples of how post-industrial redevelopment at region level must be equated in community-driven landscapes, where the intrinsic role of sustainable development is brought by a functional system of managing green space with spatially explicit methods of geographical representation that take into account community participation. The local-level design becomes an important aspect of successful planning, and henceforth, the visual aesthetics of the landscape become a part of regional intelligence. Finally, the role of community-driven development policies and its role to sustainable development are explored through the assessment of local-level communities, in Chap. 4 (Monteiro and Noronha). The complexity of sustainable local development in the communities becomes an intrinsic part of regional development throughout the need of local engineering and the symbiosis with local action groups, for several different fields where an area-based approach may be adopted. Altogether, this intertwines the complexity of sustainable development within a framework of regional development, accentuating the pertinence of maintaining the past, while working with local communities to warrant livability through green spaces, and the constant role of participatory interventions in communities as well as in endogenous economies. With the contribution of these first three chapters, the reader becomes aware that location and community-driven interaction

are not only important but a prerequisite for successful governance and policy interaction in the spatially explicit framework of regional intelligence. The first part, thus, considers the endogenous nature of local development, while Part II, entitled *Land Use, Economic Landscape, and Regional Intelligence*, focuses on the determinism of a more exogenous assessment. This section starts off with Chap. 5 (Sabir and Torre), offering a macro-analysis of land-use conflicts in developing and developed countries. From local, the book gears toward a global assessment, where the authors assess the complexity of ecological issues and socioeconomic impacts. The chapter concludes that land-use conflicts exist in both developing and developed countries in different forms and among different stakeholders. Regional intelligence methods must, therefore, be adaptive and consider a new integrative vision where the territories must consider specific toolsets and analytics empowered by social learning. Chapter 6 (Jokar Arsanjani and Vázquez) explores the consequential instruments brought from spatial analysis to deal with wildfires, a pressing issue at a regional level that often harnesses a set of environmental complexities that deterministically affect land and populations, oftentimes with irreversible consequences. By using space-time cluster analysis techniques, the author offers a combinatory approach linked with socioeconomic indicators, sharing insights into stakeholders on techniques for governance. This section ends with Chap. 7 (Cleave, Arku, and Easton), offering an emergent analysis of the integration of how spatial analysis can systematically support evidence-based economic development, continuing with the advances of clustering techniques, the authors bring to conclusion the pertinent importance of methodological advances, as studied in the previous chapter, how data, software, and analysis are a crucial tool for municipalities. Part III of the book entitled *Social Issues and Regional Intelligence* enables the social aspects of regional decision systems, exploring in the first two chapters the intrinsic value of the tourism industry. Chapter 8 (Aledo and Domínguez-Gómez) underpins the Mediterranean experience of the consequences of future impacts of tourism industry within changing regions. The importance of regional intelligence is highlighted through the need of cultural adaption and through a multidisciplinary effort of harvesting sustainable practices, particularly within coastal areas, that will largely be affected in the coming decades of the Anthropocene. Chapter 9 (Samora-Arvela, Vaz, Ferreira, and Panagopoulos) follows suit with the importance of changing tourist sectors to address the socio-emotional reasons for traveling, its impact within the integration of ethnographic analytics, and social impact analysis paves the road to not only an exploratory path of regional intelligence, but the necessity to re-adjust the markets based on a community-driven understanding beyond a political–technocratic agenda, but rather the emergence of a local and community approach for regions. This section ends with the broader picture for developing and developed regions. It has so far become clear that a regional analytical approach by robust methods that frame spatially enabled understanding must be taken in the Anthropocene. This claim of regional intelligence is assessed in Chap. 10 (Azzeddine, Bousbaine, Akkari, and Bryant), where a comparative approach is assessed for agriculture. The authors conclude the need for a spatial big data-driven framework to exist that generates a rupture from traditional monitoring techniques. This rounds substantially the findings of the previous

chapter, where novel methods of integrating data within digital repositories are prerequisite for times of utmost decisional complexity. The final section of the book, Part IV, *Complexity and Regional Intelligence*, intertwines these aspects meticulously in an agenda for the importance of defining regional intelligence within the pulse of big data analytics and complexity. Chapter 11 (Aversa, Hernandez, and Doherty) leverages through an example of business location decision the importance of data integration as tools for assessing opportunities and enhances corporate culture. This adds on the available techniques for commercial and business activity while bringing in the need for geocomputational power to support through spatial analysis of these methods. Deriving from the recent advances in scenario models, that naturally emerge from the refined aspects of digital data lakes, Chap. 12 (Esteves, Alves, and Vaz) summarizes the advances in agent-based models and the future prospects these hold for governance and spatial analysis of regions, and therefore, the immediate contribution of such methods can bring to address complexity and regional decision making within the framework of regional intelligence.

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Sustainable Development and Regional Intelligence

Recovering Ancient Landscapes in Coastal Zones for Cultural Tourism: A Spatial Analysis

Eric Vaz and Dora Agapito

Introduction

The growing interest in territorial expressions of history, heritage, and cultural assets in the tourism sector is in line with the current call for cultural identity of regions and communities. This is nested in the strong need for differentiation in tourism, based on unique landscapes, localized narratives, and sensory-informed experiences (Jansen-Verbeke, 2009; OECD, 2009). As such, diverse cultural resources derived from territorial linkages of human settlement with landscapes and regions are becoming driving forces in the process of creating and expanding the regional and local opportunities for tourism (Jansen-Verbeke, 2009; Richards, 2001). European policies are encouraging destinations to explore the potential of regional cultural landscapes and its association to traditional territorial products vis-a-vis its connection to the sustainability of landscape and available traditional land use types. This process reinforces the current "back to the roots" movement which is based on the fact that cultural landscapes illustrate the evolution of human society and settlement over time, representing the combination of works of nature and man (ESPON, 2006; Richards, 2001; Russo & Segre, 2009). The tangible and intangible heritage brings thus unique features, offering specific development opportunities, both in economical as well as social terms, for branding places and building strong reputation (Monteiro, Painho, & Vaz, 2015; Santagata, Russo, & Segre, 2008). This concept brings new challenges to the intelligence of territory and space by "(re)connecting cultural heritage resources in the process of the revalorization of territories and reviving regional identities" (Jansen-Verbeke, 2009: 25).

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By uncovering evidence of past societies, archaeology provides valued resources that may be used in defining local identities through the exploration of heritage and in providing the materials which contribute to the sustainable development of tourism based on local cultural assets (Pacífico & Vogel, 2012). Spatial analysis and available archaeological data have led to an increasing interest in a multidisciplinary approach within excavation and post-excavation activities. The available material evidence for archaeological sites oftentimes has unique geographical structures that can be allied to the landscape and thus contribute to a better understanding of the value of the region and of its location (Walker & Schiffer, 2006).

The growth of material evidence has brought a panoply of sources that have conciliatory with geographic information systems (GIS). The multidisciplinary approach, GIS adopts, links very well to the use of tourism studies (Li, Wu, & Cai, 2008; Vaz & Campos, 2013), and further foments the integration of heritage. Moreover, the combination of GIS-related logistic regression properties can reveal patterns of land use. The use of such technologies to "revive" past land use may be very valuable both for the historians wishing to better understand cultural complexity (Kvamme, 1990) and for the development of new tourism products.

The southern region of Portugal, the Algarve, corresponds to a rich historical and archaeological region, with a large scholarly archaeological interest since the nineteenth century. The Algarve, furthermore, is one the most active tourist regions in the world and holds its perimeter largely as a coastal region.

In the southern region of Portugal, the classical Roman Empire was well-established, resulting that a rich historical and archaeological legacy still remains in the Algarve. Since the nineteenth century, those studying the region have been interested in gaining a better understanding of the Roman socio-economic activity in the area. The territory itself has been a cradle for past civilizations, where its favorable geographic location has led to commercial and agricultural benefits since the Neolithic period. By combining a large amount of (although scattered) site information, Roman land use becomes a source of archaeological insights with ancillary environmental characteristics.

Despite the rich historical legacy, past land use has not been much explored in the Algarve, where the main tourism product still relies on the "sun and beach" features. The resulting problem of seasonality is increasingly gaining attention among decision-makers since the economy of the region is mainly dependent on tourism. In fact, this is the Portugal tourism destination with the highest number of overnights stays (Satistics Portugal, 2013). The availability of archaeological catalog and geo-information data, however, concerning the environment and supported by geo-statistical inference, enables a better understanding of past land use patterns and could shed some light on new opportunities to differentiate tourism products in the region. As the causal relations between georeferenced sites are established, environmental and geographical characteristics can help to recover spatial dimensions of archaeological evidence. Such a methodology allows a more accurate assessment of what might have been past land use during the Roman period in the region. This experiment is also useful to better comprehend and make a more appropriate interpretation of predictive modeling scenarios.

Against this background, this research argues that there is a certain social efficiency in recovering past landscapes to value the present through the use of archaeological information systems. Firstly, the roots of local and regional history often become better remembered, a process which contributes to sensitizing society to the existing heritage, and, secondly, by offering interesting solutions to meso-economic problems, sustainable and more integrated directions of regional tourism development based on cultural assets. Specifically, this study aims to analyze the potential of recovering ancient landscapes for cultural tourism, by using spatial analysis combined with statistical methodologies applied to an archaeological site in Portugal, using the region of the Algarve as a case study.

Archaeological Approach for Recovering Ancient Landscapes

The understanding of cultural legacy at the regional level starts with the application of spatial technologies in the context of detecting patterns of land use, in relation to the regional dimension of land use planning. Although usually left unconsidered for planning purposes, archaeology does have an important role and has long relied on survey data to facilitate the historic understanding of past civilizations. Thus, articulation of survey data brought from archaeology in the context of economic and spatial analysis is both an unprecedented and an important task. Predicting past land use scenarios unavoidably carries a certain degree of spatial uncertainty. However, surveyed archaeological site information not only allows the historical understanding of man's past activities to be questioned but also helps to recover local tradition and culture in a given region for a specific "place in time."

In fact, the tourism sector is increasingly concerning in research the impacts of tourism, with special focus on environmental aspects (Krippendorf, 1982; UNEP & UNWTO, 2005). Particularly, Tribe (1995) highlights the use of sinks/sources relating to environmental capacity. The author shows the consequences of permitting the accumulation of wealth from the production of goods and services and the exploitation of resources. The relationship between the production of goods and services and the utilization of resources necessary for this, combined with the scarcity of resources, defines the carrying capacity of the environment. Such consequences lead inevitably to land use change, pollution and the vulnerability of ecosystems, and thus sustainability is comprised. Accordingly, there is evidence that by recovering historical tradition, it may be possible to revive the past, as well as to set in motion interesting trends for future sustainable development (Holtorf, 2008) in order to avoid excessive exploitation of resources.

An Overview of Existing Methodologies

The combination of the spatial location of material evidence and environmental characteristics enabled a spatial assessment of Roman land use. Geographic information systems (GIS) have an important role in regional development and planning (Douven, Grothe, Nijkamp, & Scholten, 1993). Not only do GIS represent systems to access, analyze, and represent data (Longley, Goodchild, Maguire, & Rhind, 2006), but they are also able to cope with different data sets which allow quantitative methodologies to be used within various human sciences (Wheatley & Gillings, 2002).

Since the beginning of processual archaeology, material evidence obtained from archaeological excavations has had a key role in the interpretation of material culture (White, 1959). Because of their inherent spatial character (Schiffer, 1972), past activities based on spatial archaeological data become easier to understand (Hodder, 1972). Technological advances, statistical approaches, survey methods, and available information have become more important supporting methodologies for "quantifying archaeology." Although the consequences of environmental determinism are sometimes viewed with a certain skepticism (Burns, 2007), in a regional planning context, environmental determinism in archaeology may be overcome for the following reasons: (1) the possibility to observe past land use has shed light on road networks which lead to monuments of historic interest; (2) the context of historic urban and regional planning differs largely from traditional archaeological subjectivity; and (3) the articulation between tourism and archaeology or cultural heritage leads to a fusion of areas in which spatial environmental determinism already exists because of available infrastructures that complement the provision of the already available tourist industry.

Over the years, archaeology has greatly benefitted from spatial analysis and surveillance by remote sensing techniques, as well as database management and GIS in general (Conolly & Lake, 2006). The ubiquity of areas in which archaeology benefits has such a broad spectrum that the correct manipulation of data and research of collected material is often complex. Such complexity involves many different actors with different needs and demands within the archaeological subject. Information should allow the creation of innovative scientific processes, involving different actors in the archaeological frame. In a combined information flux, anthropologists, conservationists, field archaeologists, GIS experts, and cultural heritage managers, among many others, could work together to combine their information in an interdisciplinary way. Such an objective can only be achieved with a robust system that supports many different types of tasks and workflow levels.

The quantification of information in the human sciences is not always an easy process as quantifiable and technological processes are limited. However, some human sciences such as sociology, geography, anthropology and archaeology, have felt the need to dissociate themselves from the strictly qualitative sciences. Given the pragmatic character of real-world phenomena (whether past, present, or future), nature retains certain aspects of quantitative relevance. Such aspects of quantification are being explored by a handful of what are known as human sciences and have brought a

convergence between mathematical, social, and statistical methodologies. Attempts to provide quantitative and qualitative integrated future knowledge have led to lively debates such as the Dahlem Workshops 1 where quantitative and qualitative information combined have set the tone for new paradigms of a common sustainable future (Costanza, Graumlich, & Steffen, 2007).

For archaeology, an interest in quantitative and technological methodologies is justified by the possibility of quantifying material evidence (Doran & Hodson, 1975). With the evolution of archaeological science and GIS, the latter has developed into more user-friendly platforms which allow spatial interpretation. Nowadays, GIS represents an important tool for analysis, comparison, and the investigation of archaeological phenomena and information (Conolly & Lake, 2006). Thus, archaeological catalogs have developed from simple registries into large data containers with Dahlem Workshop Goal: to understand better the dynamics between human societies and their environment by linking various forms of knowledge on human history and environmental change at multiple temporal scales (millennial, centennial, decadal and future scenarios information that may be created, retrieved, eliminated and changed, and facilitated by GIS.)

The conditions for a database management system were established in the field of archaeology in order to enable the integration of information related to archaeological site phenomena. Nowadays, an archaeological database is not just advantageous for archaeological registry but is also an important tool for information management and retrieval, thereby permitting the generation of a knowledge flow between the different actors engaged in the archaeological sciences. Technologically, archaeological information demands the physical storage properties of databases. The resulting databases with information centrally stored keep data consistent and standardized over a multi-user support for data input and output.

The construction of an accurate and complete database is not always an easy task, as linking different actors is often not a standardized process and needs effective assembly. Henceforth, the relation between the abstract concepts of a logical archaeological database and the execution of operational support demands precise technical methods.

Ancient Landscapes and Cultural Tourism

Cultural tourism is currently considered one of the largest and fastest growing global tourism markets, tangible and intangible cultural resources being increasingly used to create local distinctiveness attracting visitors, residents, and investors (OECD, 2009). Concerns of the Council of Europe in actively developing cultural tourism stress the importance of cultural assets in contemporary society, which in addition to opportunities to generate economic revenues have a role in establishing and reinforcing local identity through tangible and intangible heritage. Following, decision-makers in the tourism sector face important challenges in “revive the territorial coherence between

a place and its people, their history, habitat, and heritage is a globalized world and cosmopolitan community" (Jansen-Verbeke, 2009: 26).

Although there is no consensual definition for cultural tourism, which in part results from the complexity inherent to the concept of culture (Ashworth & Tunbridge, 2000) and to the diverse perspectives of research (Richards, 2001), the definition has been expanded from limited to visiting monuments or world heritage listed places to the "interaction between tourism and all forms of the cultural heritage places, collections and the living aspects of the host communities" (ICOMOS, 2002). Learn about history and heritage of other people and about their contemporary ways of life seem to be drivers for cultural tourists to visit destinations that offer cultural tourism products (McIntosh & Goeldner, 1994), as well as related experiences that satisfy individuals' cultural needs.

In this context, taking into consideration not only conservation and protection aspects, but also a revitalization process of heritage and cultural assets, in regional planning in general and in tourism planning in particular, seems to be important to: (a) branding destinations (Ashworth & Tunbridge, 2000); (b) building favorable reputation impacting positive tourists' behavior (Loureiro & Kastenhoz, 2010; Monteiro et al., 2015); and (c) reinforcing territorial cohesion which influences favorable attitudes toward tourism and acts in a global composite product that should be perceived as coherent and of quality by visitors (Jansen-Verbeke, 2009).

Cultural Landscapes as Tourism Experiences

Bearing in mind that the concept of cultural landscape embraces a diversity of manifestations of the interaction between humankind and its natural environment, UNESCO (2008) proposes that cultural landscapes fall into three main categories: (a) landscapes designed and created intentionally by man; (b) organically evolved landscapes which result "from an initial social, economic, administrative, and/or religious imperative and has developed its present form by association with and in response to its natural environment" (relict or continuing landscapes); and (c) associative cultural landscapes, which are included in the World Heritage List, a process justifiable by the "virtue of the powerful religious, artistic or cultural associations of the natural element rather than material cultural evidence." According to Jansen-Verbeke (2009), the orientation of cultural landscapes to tourism depends on three factors: (1) protection and conservation policies with respect to tangible heritage; (2) skills and creativity in transforming cultural resources into drivers of a cultural economy; and mainly (3) capacity to integrate cultural assets in a dynamic and innovative tourism destination development.

Tourists are increasingly demanding for creative and dynamic experiences that are positive, appealing, meaningful, and therefore, memorable and sharable with others (Morgan, Lugosi, & Ritchie, 2010; Ooi, 2005). Hence, while tourist encounters are personal to each visitor, tourism planners should facilitate the development of the right environment, enhancing the likelihood of positive and memorable tourist

experiences emerging (Tung & Ritchie, 2011). At the same time, this process benefits and involves tourists, the tourism industry, and the local community (Manente & Minghetti, 2006). This idea assumes that, in order for destination marketing and management strategies be fully successful, creative opportunities should be sought to encourage the co-creation of positive, unique, and quality tourist experiences that can attract visitors efficiently (Binkhorst & Dekker, 2009; Jennings & Nickerson, 2006; Mossberg, 2007; Prahalad & Ramaswamy, 2004). In this context, cultural landscapes are able to integrate a particular destination tourism offer once they are valued by the visitor (Pacífico & Vogel, 2012: 1591), whether for its ecological, geological, aesthetic/symbolic, or historic values, and thus contributing to a meaningful experience (Jansen-Verbeke, 2009; Mossberg, 2007; Monteiro et al., 2015).

With the increasing focus on the experiential and symbolic aspects of consumption, the aesthetic dimension of consumption has boosted its relevance particularly in the tourism field (Gretzel & Fesenmaier, 2003; Oh, Fiore, & Jeoung, 2007; Williams, 2006). Inasmuch the landscape term is dominantly associated with visual representation, the inherent complexity of the concept that illustrates the way in which cultural practices defines visual experience should not be concealed (Rodaway, 1994). Several researchers in human geography reject the hegemony of vision, highlighting the role of non-visual senses in environmental perception, arguing that "what might first appear to be visual perception may on closer inspection be seen to include important auditory, olfactory, and tactile components" (Rodaway, 1994, p. 26).

The construct of sensescapes, carved in human geography field (Porteous, 1985), suggests that all the five senses—sight, hearing, smell, taste, and touch—can be spatially ordered and contribute to individual experiences with places, such as the case of destinations, which involve multi-sensory experiences of geographical encounters (Agapito, Valle, & Mendes, 2014; Dann and Jacobsen, 2003). Although the tourist experience globally entwines all the senses, the idea of sensescapes is referred to as sensory experiences of the surrounding environment, being each sensory modality particularized: visual landscapes, smellscapes, soundscapes, tastescapes, and haptiscapes (Rodaway 1994; Tuan, 1977; Urry, 2002). This suggests multiple sensory experiences in geographical encounters (Degen, 2008), which is the case with tourism destinations.

While the body can be seen as the vehicle of the travel art contributing to the construction of a mental map of the environment through which the tourist travels, the construct of sensescapes involves the assumption that destinations have unique sensory qualities related to cultural and natural assets. This process can support local narratives which generate positive and memorable destination experiences, resulting in positive tourists' outcomes (Agapito et al., 2014). Thus, territories with a strong historical legacy embrace particular cultural landscapes rich in multi-sensory effects that could be explored in the planning and marketing of stimulating sensory-informed tourist experiences addressed to segments of tourists suitable for sustainable local development (Agapito et al., 2014), which contribute to the competitiveness of destinations (Ritchie & Crouch, 2000).

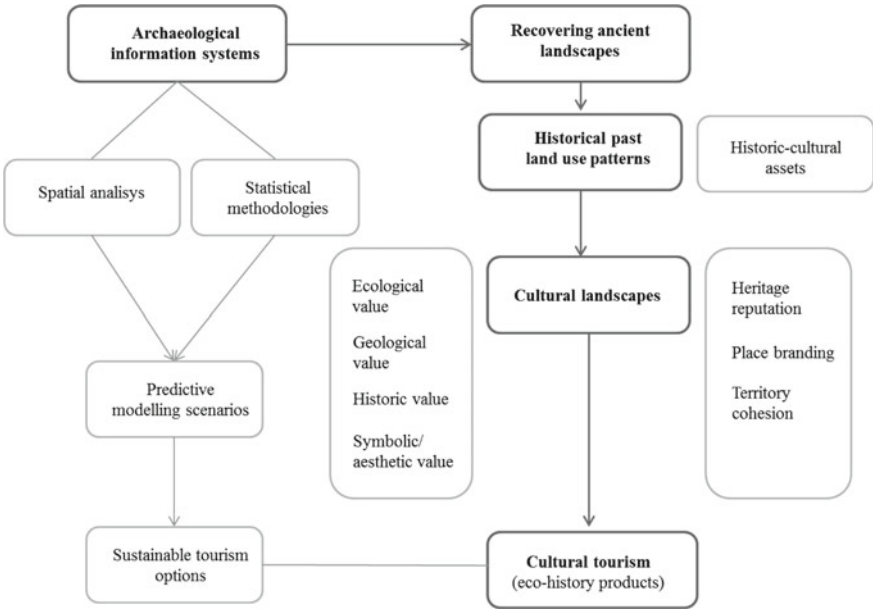

Fig. 1 Theoretical framework on recovering ancient landscapes for cultural tourism

Theoretical Framework: Recovering Ancient Landscapes for Cultural Tourism

Figure 1 synthetizes the literature review in a theoretical framework on recovering ancient landscapes for cultural tourism.

Recovering Ancient Landscapes in Portugal: A Case Study

The Setting

The Algarve region comprises a total area of 4899 km^2 which represents 5.5% of continental Portugal and is the most southerly region in Portugal. It is surrounded by the Atlantic Ocean to the South and West, and to the North a massive mountain range, the Serra do Caldeirão, separates it from the Alentejo. This basic morphology of the region has had a profound influence on its more temperate micro-climate compared with the rest of Portugal, contributing to a particular vegetation and wildlife in a unique habitat for many species. From a geomorphological perspective, the Algarve has three distinct layers of indigenous cultural, vegetative, and ecological characteristics.

The location of the Serra do Caldeirão is known as the Barrocal. As suggested by Malato-Beliz (1986) "(…) because of its climate and soil conditions, the Barrocal area has a very peculiar distinctive coverage, whose floral composition and grouping, if not exclusive, are certainly rare outside of this region." South of the Barrocal is the Interior, while the massively populated region along the coast is known as the Litoral. The lack of transportation networks has to a certain extent meant that the degradation of the Interior and Barrocal has been avoided. However, since the 1960s the coastal region has been affected by the mass tourism industry. This has led to great landscape pressure and urban growth, resulting from population increases due to local economic prosperity and the availability of seasonal jobs. Consequently, a remarkable contrast is found in the Algarve: The southern Algarve is highly populated and has extensive urban areas. Influenced by the economic development in the Algarve, the original scenic landscapes that were once characterized by picturesque whitewashed houses are becoming forever lost as a result of unprecedented city growth (Vaz & Nijkamp, 2009). Nevertheless, some kilometers north of the long stretches of modern buildings, a more remote and ancestral Algarve beckons as an interesting opportunity to reshape the predominant hotel and tourist package offers.

As a result of its privileged geographical and topographic characteristics, the Algarve has been of great economic importance since pre-Roman times (Gamito, 1997). Its unique location as a port for the Mediterranean areas (including Northern Africa) with its moderate climate and its well-charted waters, which allowed easy access to the lush pastures of the area formerly-known as Lusitania, was already acknowledged centuries ago by Strabo (2007).

With its high Neolithic presence (Nocete et al., 2005; Ramirez, Behrmann, & Bermejo, 2007) and several Bronze Age settlements, there has been archaeological interest in the region since the nineteenth century, first shown by archaeologists such as Estácio da Veiga who, among others, cataloged and described a wide range of archaeological findings in the region. The Algarve in the Roman period is well-documented (Alarcão, 1974; Bernardes & Oliveira, 2002; dos Santos, 1971; Teichner, 1994). The built-up heritage from the classical Roman period is still observable in the vicinity of the coastal cities. In the coastal areas, many cetarias (rectangular stone vessels) have been found. These vessels once contained a typical Roman fish spice, garum (Curtis, 1991; Étienne & Mayet, 2002), widely produced along the Algarve, and exported throughout the entire Roman Empire. The production of garum in southern Hispania has been identified as a key element to the Algarve's economic success during the Roman period (Edmondson, 1990; Osland, 2006).

The former area of Lusitania prospered from the reign of Augustus until the end of the antiquity. Major Roman civitates (cities) such as Ossonoba or Cilpes were fortified and reoccupied during the Moorish period. As a consequence of this heterogeneous mixture of styles, the Algarve shows a variety of Moorish, Roman, and Christian heritage within its cities' urban limits. Former Roman cities such as Ossonoba and Balsa, as well as the ruins of Milreu in Estoi or the ruins found in Vilamoura (Cerro da Vila), were economically important during this period.

Also, the abundance of the classical Roman period is visible by the in rich legacy monuments. Many of the mosaics which adorn the monuments have nautical motifs,

accompanied by a profusion of sea creatures and Gods. Such heritage presents a unique ecological vision of the Algarve as a coastal area of the past. Furthermore, it is endowed with an aesthetic dimension composed of the actual landscape together with its cultural archaeological heritage.

The large quantity of cetarias found in the Algarve region show that the region was once a proficient producer of garum (Silva, 2007). Overall, the Algarve in Roman times seems to have been an area of economic wealth, based on this production which was distributed to the entire Roman Empire, as well as being a place of leisure and worship of deities. Such socio-economic niches seem to be common throughout the entire southwest region of the Iberian Peninsula.

Portuguese Database Management System for Archaeology

In 1989, the first attempt was made to create a map of archaeological findings. Nevertheless, it was only in 1995 that this map (Carta Arqueológica de Portugal) was actually compiled. This initiative became the responsibility of the Portuguese Archaeological Institute in 1997. Thus, as of this date, this map has been recognized as an important landmark in the present information to support archaeological preservation in Portugal (Divisão de Inventário do Instituto Português de Arqueologia, 2002). A contextual framework, driven by the main objective of the Portuguese Archaeological Institute to "detect, protect and manage archaeological vestiges" (Decree no. 117/97, May 14th, Paragraph 1A, Article 2), reinforced this achievement. As an important event in the national archaeological framework, the Archaeological map (Carta Arqueológica Portuguesa) became a recognized asset for the validation and confirmation of research and excavations.

The archaeological information available in the Carta Aqueológica Portuguesa is organized into a database named Endovélico. This database allows the addition of current research, as well as spatial validation of past site information. The context of information systems from an archaeological perspective generates synergy among institutions and stakeholders. Thus, Endovélico may prove to have a central role in archaeological preservation and archaeological excavation in Portugal. Moreover, it is important to provide a common ground for the ubiquity of archaeological information.

Figure 2 is a graphical representation of the conceptual workflow of all the attributes stored in the Endovélico database. The structural relations are separate from the occurrence of archaeological sites and have a central role in the evolution of scientific as well as other important research. As sites are supported by bibliographic research, as well as fieldwork, people as well as institutions become an inherent part of the workflow process. Institutions, on the other hand, play an important role in proactively defining new projects to enrich the scientific work field and create new documents, reports, or ancillary scientific processes, and, as a result, inherent spatial dimensions might be framed in a geographic information system. The location of institutions and people as well as the location of sites share important spatial

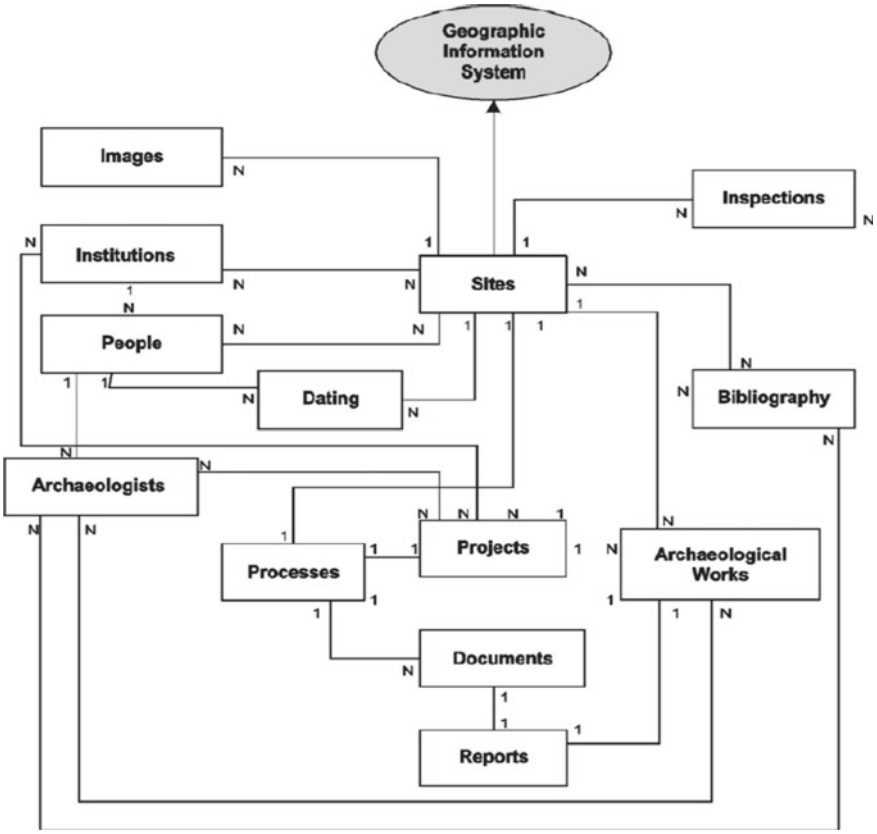

Fig. 2 Simplified ER diagram of Endovélico. Adapted from Divisão do Inventário do Instituto Português de Arqueologia (2002)

dynamics which are stored in the Endovélico and supply a coherent validation of archaeological data, as facilitating intra-institutional cooperation.

Data Collection and Analysis

Next, Sect. 4 explains the creation of such a framework for Portugal in an operational data experiment designed to identify Roman land use in the Algarve.

Understanding Roman land use depends on survey data resulting from almost two hundred years of Roman archaeological investigation in the Algarve. The distribution of material evidence results from the spatial location where the archaeological survey occurred, based on archaeological excavations. The collection of this spatial information has enabled a database to be compiled with 452 occurrences of archaeological

sites excavated from 1910 to 2006. The archaeological sites were interpreted in our study by employing a GIS which uses the Universal Transverse Mercator (UTM) as a geographic projection. Georeferenced archaeological sites were classified into socio-economic categories of ceramics, mosaics, coins, iron, and epigraphs.

Roman Land Use in the Algarve a Predictive Modeling Approach

The Roman land use prediction model for the Algarve was calculated by combining environmental variables with available archaeological material evidence. Furthermore, statistical inference on site location allowed a generalized land use propensity to be established (Kvamme, 1988).

After choosing a region of a total area of 5 × 5 km, a digital elevation model was generated to allow the calculation of slope and direction. The cost surface corresponding to the prediction of higher Roman activity propensity was based on the combination of those variables within a quantification standard of site densities (Fig. 3), brought from the Endovélico-confirmed regional data set.

As archaeological activity is supposed to reveal Roman behavior, information regarding elevation from the digital elevation model (DEM) provided a solid methodology to calculate other environmental surfaces (Hayakawa & Tsumura, 2009; Miller & Barton, 2008). The variation of weights related to the presence or non-presence of Roman remains depending on spatial location permitted us to generate specific weights based on a logistic regression of weight behavior throughout distances. The combination of those aggregated classes generated the propensity for the potential to find future archaeological sites and Roman land use.

As may be observed in Fig. 3, a greater potential for finding Roman remains exists in the area with low slope and lower elevation. Such conclusions are interesting, as this resembles contemporary settling preferences in contemporary urban growth, i.e., the vicinities of river basins or coastal shores, which establishes an interesting correlation between past and present human behavior as well as the central role of past land use traditions.

The accuracy of the land use model was investigated in a more regional context, making the following assumptions: (1) Roman settlement preferences are linked to higher elevations and shade; (2) south or north facing locations are preferred for human activity; (3) and so is proximity to river basins and coastal bodies of water. A generalized propensity model was next established via the comparison of the generated 5 × 5 km model, within a lower resolution spatial area. NASA's Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) with 90 m spatial resolution was used to calculate weights for comparable environmental characteristics.

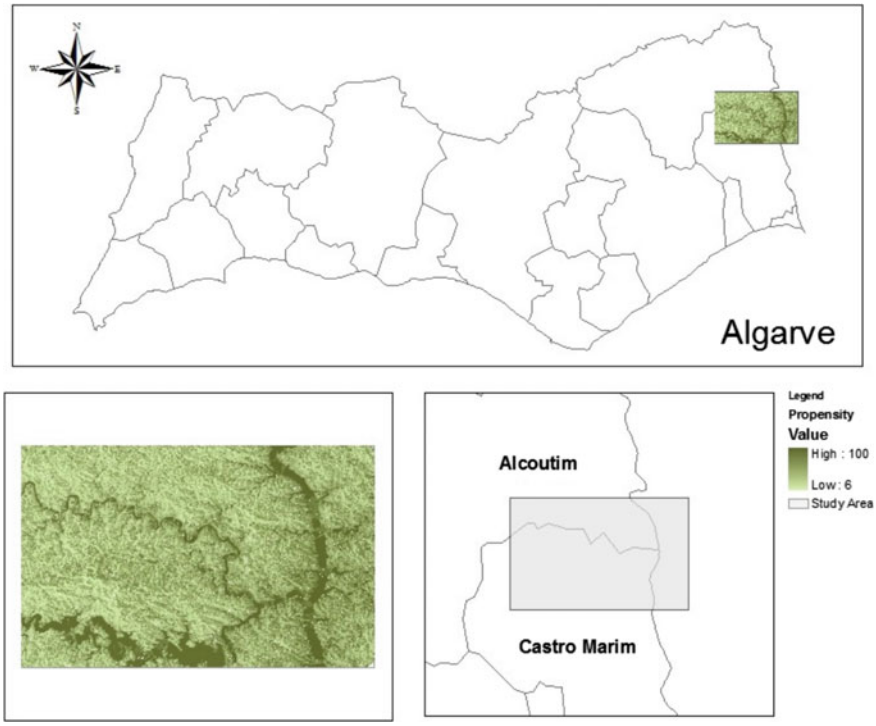

Fig. 3 Example of prediction within cost surface

A propensity map for regional comparison was generated by structuring a propensity equation with relative weights of elevation, slope, and aspect. The resulting formula may be expressed as follows:

$$P = (w_1 \times w_2 \times 2 + w_3 \times 3)/N,$$

where w_1, w_2, and w_3 represent the relative accuracy for each of the variables, and where x_1, x_2, and x_3 show the respective landscape variables used. It appears that most archaeological sites may be found in the 80–100% interval of the archaeological site potential, which supports the accuracy of generalizing local scale sites to a more regional scope of analysis.

Discussion and Conclusions

This research aimed to analyze the potential of recovering ancient landscapes for cultural tourism, by using spatial analysis combined with statistical methodologies applied to archaeological sites, such as the case with the Algarve region in Portugal.

Following the proposed methodology and theoretical framework on recovering past landscapes for cultural tourism, the main findings suggest that analyzing ancient landscapes by means of archaeological information systems can help destinations to equate sustainable tourism options, such as cultural tourism. This process seems to support the integrity of place where travelers go and to highlight coherently the local character, such as architecture, traditional gastronomy, handicrafts, heritage, aesthetic values, and ecology. This study suggests that this approach is in line with the sustainable approach for tourism which aims to optimize the use of the local assets and harmonize the current and future needs of local stakeholders, while simultaneously focusing on the high satisfaction of tourists by ensuring a meaningful and creative experience (Kastenholz, Carneiro, Marques, & Lima, 2012; UNEP & UNWTO, 2005).

In particular, in our case study area, to have a share in the Algarve's archaeological legacy value may be very interesting to the tourist industry because of the possibility to explore more sustainable tourism options rather than the "sun and beach" mass tourism offered traditionally in that region. This may lead to the development of a cultural tourism product based on historical, geological, ecologic, and symbolic/aesthetic values by recycling existing built environments and creating an opportunity to generate revenues related to cultural assets. As a result, cultural landscapes have the potential to be the main actor in the process of reinforcing heritage reputation, place branding, and territory cohesion. This agenda puts archaeology in perspective, not only as a historical domain but also as a sub-area of regional planning and tourism development.

The Archaeological Predictive Models

By comparing the propensities generated by local and regional models in our study, it was possible to determine the influence of scale in the archaeological predictive context. Comparing the model accuracy, we have witnessed the possibilities of combining local spatial strata into a more aggregated macro-analysis level. Our information combined stochastic methodologies leading ultimately to a generalized framework of Roman land use propensity. Some interesting questions were raised by this analysis: (i) possibilities of combining smaller and higher scales of study, as spatial patterns seem to be constant over regional territory for anthropologic behavior. The use of smaller scales may further allow the breakdown of the areas into simpler and more homogeneous units which would lead to higher data consistency, although this issue is often neglected by the archaeological community (Bevan & Conolly, 2009); (ii) calculated cost surfaces of Roman land use have confirmed that Roman land use and settlement occur in proximity to river basins; (iii) the spatial orientation that human settlements might have had obviously plays an important role in geoarchaeological circumstances.

Policy Implications for Cultural Tourism in the Algarve

The Algarve has experienced a rapid increase in its tourist industry since the beginning of the 1960s. Exploration of the tourist product related to "sol e praia" ("sun and beach"), strongly focused on the exploitation of coastal landscapes, has inevitably led to an increasing fragility of littoral ecosystems (Aguiló, Alegre, & Sard, 2007). The increasing vulnerability of marine ecosystems has been brought to light in particular as a result of the rising number of hotels and resorts. However, the depletion of scarce ecosystems in order to create leisure products should be analyzed critically from the perspective of the dynamics of the carrying capacity of the ecosystem itself (Tribe, 1995).

Tourism in the Algarve currently faces several competitors regarding tourism products, as low airfares encourage tourists to visit more tropical destinations, with unrivaled "sun and beach" attractions. The process of diversifying the tourism offer, by exploring the potential of other products based on cultural landscapes relating to the history and to the rich fauna and flora of the region, would enable the Algarve to explore a new concept of eco-history tourism, which would provide a more competitive and less environmentally exhaustive alternative. Clearly, the availability of a rich cultural heritage that is not located in the areas of current fragile coastal ecosystems brings an interesting opportunity to relieve tourist pressure on the littoral areas. The creation of new tourist attractions inherent to the richness of the region and based on existing and renewable resources seems to be an immediate answer to sustain tourism in the Algarve.

Thus, evidence of Roman land use in the Algarve and the existence of an abundant Roman historic legacy suggest that this regions should be promoted as a route of Roman past portrait in a typical Mediterranean landscape. Furthermore, recent studies (Campos Carrasco et al., 2008) describe the rich collection of Roman mosaics found in the southern part of the former region of Hispania (Algarve and South-Andalusia) which emphasizes the relevance of this area as one of the Roman Empire's poles of cultural heritage. If archaeology and the tourist industry were to collaborate in joint initiatives, then the role of scientific information would be to underpin the concept of eco-history tourism. This might represent a more ecological alternative by avoiding the consequences of the mass tourist industry and supporting an environmentally benign, cultural landscape.

This paper has suggested a new approach for the tourism sector, which highlights the idea of exploring an eco-history product. On the one hand, this tourist product relies on scientific information (such as archaeological predictive models), and, on the other, factual information on archaeological sites (by use of databases) to confirm relevant patterns. A good example to illustrate the first steps in such a direction is the project MOSUDHIS ("Roman Mosaics in the southeast of Hispania: Andalusia and Algarve", European Community INTERREG III-A, Measure 2.4, Axis II, URL: http://www.cepha.ualg.pt/mosudhis/). By combining spatial information and touristic information within a framework of scientific archaeological research is developing a new type of touristic product of past land use in regions. This information supported

by scientific findings may help to market regions on the basis of their archaeological legacy, offering a cultural tourism alternative which is an interesting solution for developing conservation and cultural sustainability alternatives. In the Algarve, such a product would adapt quite well, given the already-existing tourism infrastructures. In regions such as the Algarve, with a diverse and attractive fauna and flora, ecotourism is likely to do well, while simultaneously offering a past identity to the region focused on the existing historic monuments and archaeological heritage. Also, since 2013 the Mediterranean diet was inscribed in the representative list of the intangible cultural heritage of humanity, new opportunities arise to research and to explore, in an experiential and co-creative perspective, regional gastronomic skills, knowledge, rituals, symbols, and traditions associated with food.

The re-equilibrium of the asymmetric spatial properties of tourism in the Algarve demands new solutions to provide an attractive alternative to the mass tourism industry in the region. More attention to carrying capacity of existing infrastructures, whether natural or artificial (monuments and archaeological heritage), should be given (see also Coccossis, 2004). Lessons to be heeded are thus:

– Mass tourism exerts pressure on land use and affects natural and land resources. Therefore, the trade-off of providing a new tourist product in the Algarve related to ecotourism and cultural heritage may rebalance an already overexploited resource. The existing contrasts in the region, which is characterized by a diversity of culture, physical geography, and biology, can be managed in order to invigorate the tourism offerings, prolong the main product life cycle, and address efforts toward different segments of tourists;
– A profound awareness of impacts is necessary to comprehend more fully the actual state of local and micro-scale degradation due to tourism in the Algarve. As the coastal area seems clearly affected, pressure-state-response will lead necessarily to solutions which would spatially protect the resource.

The pressure-state-response is an environmental deterministic framework which measures existing environmental pressures (pollution, urban degradation, etc.), current state (How much pollution? What areas are degraded?), and policy responses (What can be done and how?) in a given location.

The resources available in the Algarve are many, and policy options regarding sustainability must have consideration for the environment. This paper has demonstrated the possibility of bringing alternatives of sustainable tourism to the Algarve. As highlighted in the proceedings of Património e Turismo (1999) by the coordinator of the national increment programme of cultural tourism: “Heritage tourism is a growing demand at national and European level that should be cherished and protected, while vitalized as an interesting alternative for tourism and development.”

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Benefits and Limitations of Public Involvement Processes in Landscape Redevelopment Projects—Learning from Practice

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The Use of Public Participation in Landscape Redevelopment—A Brief Review

When it comes to public participation it is mandatory to know what participation is. According to Shelton (1997) "*all forms of public involvement, whether in the environment or other areas, take place within a wider «social field» comprised of traditions, juridical-legal structures and political cultures. […] These 'social fields' are often difficult for outside observers to understand because they are rooted in history, tradition, politics, and culture. Yet, for any genuine assessment of the role of public involvement as an instrument of environmental-policy reform this wider 'social field' must be a subject of observation and analysis*" (p. 42).

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Therefore, before starting to address the topics related to public participation in landscape redevelopment, it is important to define what does public participation means. When it comes to public participation, as it is common among "concept definitions," the answer is not unanimous, once there are always different perspectives of understanding a specific concept. In this regard, the fact that "Democracy is a work in progress" (Creighton, 2005) contributes significantly to its evolving meaning over time.

Regarding normative definitions, dealing with governance means, searching for the answer of what good governance was or supposed to be: what is the best regime, the best constitution; what are the best tools, the best procedures that could enable us to cope with requirements of the today's situation? How should or could public action adapt itself in order to cope with new challenges we have to face? as an illustration of the definition of good governance.

Although, a shift in political power relations may encourage or impede participatory approaches (Weber, 2018), generally, governments look to provide community input in the identification of specific needs and problems, and in the design and implementation of remedial and preventive solutions (Loures & Crawford, 2008a; Creighton, 2005; Hartig, Zarull, Heidtke, & Shah, 1998).

Ladders, or spectrums, of participation, are a time-honoured metaphor used to understand differing degrees of participatory practices (Loures & Crawford, 2008a). Sherry Arstein's 1969 seminal article "A ladder of citizen participation" launched the ladder metaphor (Arnstein, 1969). Her work focuses on degrees of citizen power and local control in government decision-making scaling from non-participation to degrees of tokenism, to degrees of citizen power.

Desmond Connor followed almost two decades later with his ladder focusing on creating a progression for resolving the conflict about major issues (Connor, 1988). His approach begins with an educational approach and escalates through mediation and litigation to resolve conflicts.

Still, as analyzed by Loures and Crawford (2008b). Conors ladder does not extend to the point of engaging citizens in decision-making. William Potapchuk followed shortly after with a ladder emphasizing levels of authority or government decision-making from unilateral, to joint, to delegated (Potapchuk, 1991). His model acknowledges the power of citizens to block or support decisions and ramps upward from small-scale individual input to working with representative and special interest groups to build a decision support. The IAP2 spectrum (a twenty-first-century variation of the ladder) reflects and emphasis on the relationship of participation impact and agency decision-making (Bird, 2006). The spectrum includes example techniques employed to achieve the participatory impact goals. The first four levels (inform, consult, involve, and collaborate) represent situations where the government or organization retains final decision authority and responsibility. The fifth level culminates with empowerment, placing decision-making in public control (Loures & Crawford, 2008a). Bruns (2003) expands upon the 5th IAP2 level, empowerment. He extends empowerment into six levels: partner, delegate authority, establish autonomy, advise and enable.

Ross, Buchy, and Proctor (2002) re-visualize a participation ladder with a focus on natural resource management. Their work acknowledges that decision-making affecting natural resources and cultural resources includes more than just authority or government-controlled processes. The ladder includes resources controlled by private ownership, community collectives, organized interest groups, government stewardship and non-participatory government management.

According to Faga (2006) it is still common in Europe, "*elite professionals enter competitions and propose designs (often very exciting designs), that are selected by a panel of experts (…) a similar process is inconceivable in the United States, where community participation has become a central element in deciding what will be built*" (p. 13).

In this regard, public participation is not a neutral concept. Both, definition and degree of public participation are not neutral in the concept. Both, definition and degree of public participation are directly connected to the conception of democracy and citizenship, and to the role of political authorities (Henningsson et al., 2015). Public participation definitions can be wide or restrictive: for example, the definition of the World Bank about public participation has little in common with other conceptions. According to their definition, public participation is a process that "*enables the public to influence the quality or volume of a service through some form of articulation of preferences or demand*" (p. 22), a definition that is closely linked to the concept of governance (World Bank, 2000).

In a more direct definition, Beierle and Cayford (2002) defined public participation as "any of several 'mechanisms' intentionally instituted to involve the lay public or their representatives in administrative decision-making" (Beierle & Cayford, 2002).

Fiorino (1996) characterizes public participation as the involvement of people outside formal governmental decision-making processes (Fiorino, 1996). Nevertheless, there are still some authors (Britton, 1998; Pateman, 1970) that defend that public participation is one of the components (together with public consultation) of what they consider to be "public involvement."

For Britton (1998), public consultation includes education and information shared between decision-makers and the public in order to make better-informed decisions and public participation is the act that brings the public directly into the decision-making process (Britton, 1998).

The presented approaches are not contradictory in their main principles. All of them comprise public activities directed at cooperation and teamwork, providing the authority with opinions and information about the public will, needs and objectives.

The last decades have seen a rapid change in attitudes towards the environment, which reflects a greater environmental awareness of the environment among professionals as well as the general public (Loures, 2015; Loures, Loures, Nunes, & Panagopoulos, 2015a; Loures, Santos, & Panagopoulos, 2007; Özgüner & Kendle, 2006). Furthermore, there is a growing trend in government to conclude that the commitment and will of the population is a crucial element to the development of a sustainable city (Giddings, Hopwood, Mellor, & O'Brien, 2005), and that the reclamation of derelict, abandoned or underutilized land can play a significant role in the development of the city (Loures & Panagopoulos, 2007).

Table 1 Reasons to use public participation

Reason why should citizens have the opportunity to participate in planning
– Public involvement is a significant form of enforcing land use laws, once citizens informed about planning laws and with access to the planning process ensure that the laws are applied properly
– Generally, our systems of government and legal frameworks give citizens the right to have a voice in all matters of public policy, including planning
– The public should be involved in the collection and production of the information needed to develop, implement and maintain a comprehensive plan. Professional planners and local officials should collect and use comments and ideas from those who know the community best: people who live and work there
– Public participation educates citizens about planning and land use, contributing to the creation of an informed community, which in turn leads to better planning, giving a sense of ownership of the plan to the members of the community
– It fosters cooperation among citizens and between them and their government, leading to fewer conflicts and less litigation, reducing costs for re-planning and conflict resolution and leading to a higher acceptance of results
– Public participation increases planning security for planners, developers and investors, offering an additional chance to promote the project and giving the possibility to improve the project approach according to local needs

Adapted from RESCUE (2007)

Public participation has become increasingly more important, playing a relevant role in determining the way society will manage, protect and reclaim the environment (Loures & panagopoulos, 2010; Loures & Crawford, 2008a; Loures et al., 2007). Furthermore, the recognition that the economic and social dimensions cannot be dissociated from the environmental and cultural ones, contributed to increase the relevance of public participation (Loures, 2008, 2015).

As it was mentioned, public participation is one of the essential values of democracy. In this context, it is related to such categories as: civil society, principle of subsidiarity, decentralization, common will, articulation and representation of interests (Weber, 2018).

Once the role of public participation is to increase the efficiency of the local authority activities as well as to build a stronger social base for the authority, the reason why it should be introduced in the planning process is clear (Table 1) (Loures & Crawford, 2008a, RESCUE, 2007).

Forms and Processes of Public Participation in Landscape Planning

In opposition to an experiment, public participation instruments are conducted in a real-life context, and can be descriptive (using standardized questionnaires for describing a specific phenomenon) or analytical (using qualitative and quantitative

methods to find relations among variables and explanations) (Meireles Rodrigues, & Loures, 2017; Loures, 2015; Loures et al., 2015a; Loures & Panagopoulos, 2007). Thus, public participation may be generally defined as a descriptive and exploratory method, which enables the observation and analysis of specific issues and phenomena, allowing the establishment of relations among variables (Gil, 1994; Triviños, 1995). Indeed, a wide range of methods has been established all over the world, including new ways of people interacting, new types of event, new services and new support frameworks (Henningsson et al., 2015).

In this regard, governments look now to provide greater community input in the identification of needs and problems, and in the design and implementation of remedial and preventive solutions (Loures & panagopulos, 2010; Creighton, 2005; Hartig et al., 1998). For this reason, nowadays, public participation is recognized by a wide range of methods which have been established all over the world, including new ways of people interacting, new types of events, new services and new support frameworks (Loures & Crawford, 2008a).

As for forms, public participation in landscape reclamation and management can take several different forms (Beierle & Cayford, 2002; Creighton, 2005; Faga, 2006): Public meetings, workshops, charrettes, citizen juries, focus groups, Internet, mail interviews, face to face interviews, etc. each of them legitimate a priori, and justified by the context in which the project takes place (de Abreu, 2002).

Also, the selection of interviewees has to be made very carefully to obtain a representative selection, a fact that came up as being questionable for this method among our own interviewees. A suggestion to overcome this problem is to substitute individual interviewees with focus groups. In this way, more people can be involved in participation, making it easier to ensure representativeness (Loures, 2015; Eiter & Vik, 2015) (Table 2).

Public participation in planning, management and reclamation projects is, in fact, mostly accomplished through public workshops, where the different perspectives and possibilities are presented and discussed (Vasconcelos, 2001).

Also, public participation begins laying the ground work for sustainable practices in physical planning and management as well as social community building (Loures & Crawford, 2008a; Loures, Panagopoulos, & Burley, 2016). Creating sustainable communities (1) involves local citizens (Abbott, 1996), (2) allows citizens to analyse their own problems and fashion their own solutions (Carley & Smith, 2013) and (3) supports community initiatives which allow them to be the instruments of their own change (Baum, 2001). Attention to sustainable community development practices fosters social goals which can strengthen the connections between participatory practices and government or authority decision-making.

Moreover, there is a typology of participation levels. Indeed, according to the Regional Environmental Centre for Central and Eastern Europe (REC, 1996) there are different grades of participation which answer the questions "what role do you play as a citizen?" and "what role would you like to or think you should play as a citizen?". These grades go from passive participation to active participation and the intermediate stages are citizen as voter, citizen as constituent, citizen as respondent, citizen as consultant and citizen as decision maker (Fig. 1).

Table 2 Public participation techniques

Technique	Description	Problems
Advisory committee	A group of invited experts representing interacted parts	It requires full-time dedication from members, for a long period of time controversy may arise if the Committee recommendations are not accepted by decision-makers
Focus groups	Small discussion groups that help to estimate public reactions. There has to be several of them and led by professionals	If it allows estimating emotional responses, it does not provide any indication about how long they will last. It may be regarded as part of a process of public opinion manipulation
Dedicated phone line	Experts (or trained operators) answering questions from callers and providing information over the phone	It requires the availability of well-prepared personnel on a regular schedule base. Its success depends on public willingness to call…
Interviews	Interviews with people representing public agencies, NGOs, interest groups, or well-known personalities	It requires a lot of time and well-prepared staff
Talks	Meeting where experts or politicians present formal communications or give formal speeches	It does not facilitate dialogue; it allows exacerbation of differences of opinion. It requires plenty of time to organize
Conferences	The less formal meeting where people present their views, ask questions, etc.	Dialogue is still limited. It may require even more time (and people) to organize
Workshops	Working sessions of small groups dedicated to complete the analysis of a certain topic	It is not adequate for large audiences. It is frequently necessary to organize them in several places and on several topics. It requires plenty of people and time
Surveys	Carefully prepared questions are asked to a sample population	It provides a still image of public opinion, but it does not provide any sense of how it may change with time, and other factors. It requires professionals and is usually a very expensive technique
Referendum or Plebiscites	Counting votes within a community	It requires usually long and expensive phase of information and debate. The public may be more susceptible to emotional assertions than to reasoned opinions

Developed after de Abreu (2002)

According to REC (1996) the stage so-called passive participation since the expert provides more or less detailed information to people without the capacity for participants' reaction. In this case, the information flow is going in one direction and the relevant and available information is in hands of external experts.

In this regard, information to experts, the people answer questions asked by experts, but cannot influence the treatment of the given information. The correctness of the compiled information cannot be verified by the people. Only experts (and elites) are involved in decision-making.

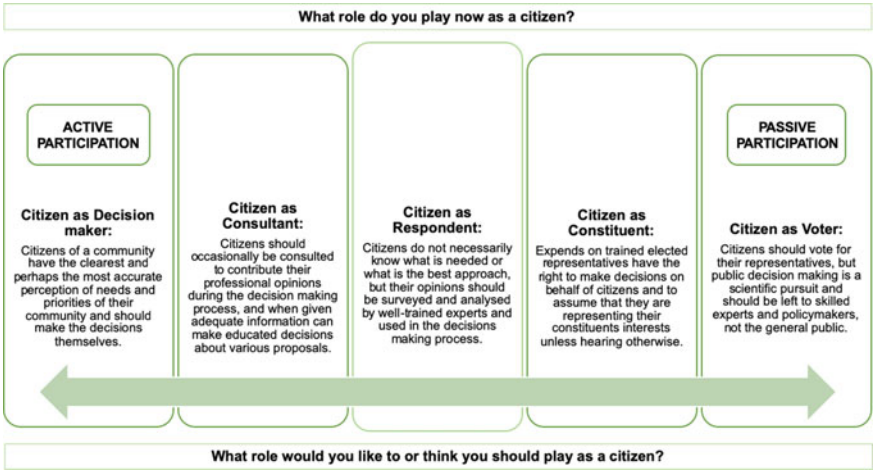

Fig. 1 Role of the citizen in the decision-making process. *Source* Regional Environmental Centre for Central and Eastern Europe—REC (1996)

As for consultation, the problems and solutions defined by the experts can be commented on by the people. Decisions on activities and process can be taken by the experts without exploring suggestions of the people.

Regarding active participation, local interest groups are involved in the design phase of the project but are excluded from the subsequent phases (decision-making, implementing, controlling and monitoring). They have the right to object to or protest against the projects of parts of it.

As for interactive participation, local people are involved in situation analysis and planning of activities. Local independent group structures are emerging or existing groups learn to perform better. These groups control the development process which can be maintained beyond project duration. Interdisciplinary approaches are used for analysing and planning, and well-structured training/education modules are offered to the people.

Regarding self-mobilization and participatory learning, people start their own initiatives on the basis of their own resources. They contact the necessary institutions to request well-specified (usually immaterial) support, e.g. information. The whole development process is controlled by the people. Objectives are evolving in the process; they are not pre-set by external stakeholders. A win-win situation for all the stakeholders could be achieved if the concepts of "irreversibility" of heritage, reasonable and fair compensation to the owners, and planning to improve the living quality are taken into account (Yung & Chan, 2011).

In general, the different ways of how individuals and institutions, public and private, manage their common affairs are thought to be a continuing process through which conflicting or different interests may be accommodated to take cooperative action. Moreover, it includes formal institutions and regimes empowered to enforce

compliance, as well as informal arrangements that people and institutions either have agreed to or perceive to be in their interest.

Furthermore, participation is a growing need in society. Several important stakes can be drawn concerning sustainability policies:

- the multiplicity and diversity of actors intervening in the regulation process: they need to be identified and given a precise role with real responsibilities,
- the role of "policy networks" between actors who do not have the same legitimacy nor the same abilities,
- the importance of "public space": whenever important public decisions are conceived, different social spheres need to communicate, express their opinions, debate together, criticize…

The Role of Public Participation in Planning and Redevelopment

It is believed that public participation may encourage awareness of "belonging to" a community, sharing common culture and creating identity. It improves community consciousness and responsibility while fostering a "collective sense." These are "feelings" of considerable importance in the development of new, satisfying and concerted projects. Indeed, public participation is thought to be one of the essential values of democracy. In this context, it is related to such categories as: civil society, principle of subsidiarity, decentralization, common will, articulation and representation of interests (Loures & Crawford, 2008a).

According to Beierle (1999), the use of public participation helps to achieve five different social goals (Fig. 2).

Generally, the social component is often recognized to play a relevant role in planning and management activities (Faga, 2006). Specifically, the social component

Fig. 2 Social goals got by the use of public participation. *Source* Beierle (1999)

plays a relevant role in urban planning and management activities, and that participation processes are linked both to landscape and strategic environmental valuation (Serra, Vera, Tulla, & Salvati, 2014).

Consequently, the selection of the public participation method is a relevant part of the process, Bass, Dalal-Clayton, and Pretty (1995) stresses that what decision-makers really need to understand is that science-based and interdisciplinary approaches are not enough to define social, environmental and economic needs; and that, therefore, public participation is a people-centred approach (Bass et al., 1995).

In this regard, the landscape design work also deals with an existing real-life situation, which becomes a reference to the following design development (Meireles Rodrigues, & Loures, 2017). For this reason, public participation is a systematic attempt to involve the citizen in the design, planning decision, implementation and evaluation of planning, management and reclamation projects (Loures & Crawford, 2008a).

Post-industrial redevelopment is a complex topic with many actors and stakeholders who often pursue contrasting aims in the development process. A socially well-balanced planning process, assuring participation opportunities for all the affected parties, provides the necessary conditions for sustainability standards and is as such a prerequisite for each post-industrial reclamation project (Loures & Crawford, 2008a; Loures et al., 2016).

Consequently, the use of public participation in the redevelopment of a post-industrial landscape should be an integral part of post-industrial landscape reclamation (Loures & Crawford, 2008a). Also, take into account that there is a growing trend in government to conclude that the commitment and will of the population is a crucial element to the development of a sustainable city (Giddings et al., 2005).

Benefits and Limitations of Public Involvement

Even with the changes that have been introduced in policy and attitude during the last decades, there are still a number of obstacles to a successful transition to a more participatory decision-making process. These obstacles range from low indices of trust in government (Krannich & Smith, 1998), to administrative, and policy-driven constraints (Moote & McClaran, 1997; Moote, McClaran, & Chickering, 1997), to the choice of the appropriate and most effective methods of public engagement (Glicken, 2000; Gregory, McDaniels, & Fields, 2001; Webler, Tuler, & Krueger, 2001).

Moreover, design professionals themselves can be an obstacle with concerns about relinquishing power in the design process, perceptions of participatory practices being unprofessional and scepticism about anaesthetic outcomes (Hester & Blazej, 1997) what is more current public participation methods are laborious, and if they reach few participants, they may be ineffective at gathering usable information for planning (Kahila-Tani, Broberg, Kyttä, & Tyger, 2016).

Even, may there have been wide disparities concerning participation systems. In other words, depending on the region and on the environmental issue, the level of participation allowed is considerably different (Okubo, 2016).

Besides, if the public is to be involved in the decision-making process, their role may not be one of legitimization, their contributions need to be introduced on the design process from the beginning. If this is not the objective of public involvement, participants ought to be informed, given that transparency constitutes an aspect that is considered to be indispensable in any project with an objective to serve the public is transparency (Table 3). As quoted by Faga (2006) "Transparency in an essential part of any fair process," and includes among other features openness and honestly.

The increasing need for public participation since the early seventies of the twentieth century (Fig. 3) is probably related to the growing dissatisfaction with the results of the technocratic administrative process (Alinsky, 1971; Desario & Langton, 1987), once as it is known, after World War II the role of the governments has expanded dramatically. Since then a long time has passed and the idea of an increasing necessity of introducing public participation into planning and management activities has been reinforced not only by governments and private associations but also by several international conventions as it is the case of the Rio Declaration on Environment and Development (1992); of the Aarhus convention on access to information, public participation in decision making and access to justice in environmental matters (1998); and of the recent Leipzig Charter on Sustainable European Cities (2007), among others.

Table 3 Transparency

Transparency
– The process should be open and honest
– There should be no secret meetings or assurances
– People should attend the meetings with an open mind being flexible with their opinions in order to enable the agreement among different parts
– Elected officials should be invited, and attend
– The process is portrayed honestly to the public in the clearest way possible
– All available information is released to the public

Adapted from Faga (2006)

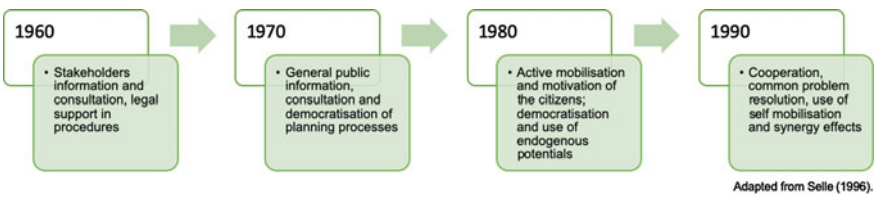

Fig. 3 Development of the participation—understanding. Adapted from Selle (1996)

The relevance of the social acceptability of a specific project should never be underestimated: often in the past, scientific and technological options having a negative environmental impact appeared to be inappropriate, not in terms of technical performance but for reasons of social acceptability (Oliveira, Tobias, & Hersperger, 2018). In recent years, due in part to a need to reduce social conflict and litigation, the planning paradigm has shifted to give the general public greater input in environmental decisions (Fischer, 2018; Steelman, 2001).

Still, designers have to be aware that different people have different ideas, perspectives, needs, and concerns, the reason why the participation process as to be as inclusive as possible, considering the opinion of each and every single group related directly or indirectly with the project (Meireles Rodrigues, & Loures, 2017).

This, not only to ensure and improve their social acceptability, but also to certify that public space is really being constructed according to the public will. Public participation will also contribute to expanding the number of possible choices, making them more precise and enabling that the different actors involved in the process take "ownership" of the decision.

Through ownership, commitment and the infusion of "local knowledge" in project development, unique places, genuinely native to the culture and environment, can be sustained (Beatley, 2005).

The social acceptability of results in a decision-making process is linked to the way the different parts involved in the process perceive it: if they feel it is adequate and equal, they find it legitimate. For this reason, improving the social acceptability of specific design options during the process often results in the higher legitimacy of the whole process, which in this way depends largely on how much people affected by the plan have been involved in it (Loures & Crawford, 2008a).

In the specific case of reclamation–rehabilitation projects, as they are often located in highly visible and accessible areas, public perception and support is essential to the long-term success of the project (Nassauer & Faust, 2013) and to enhance the social, economic and environmental benefits that they provide.

Frederick Steiner reinforces the importance of public engagement and ecological planning in that "the success of a plan depends largely on how much people affected by the plan have been involved in its determination," (Steiner, 2000).

One of the problems that happen in post-industrial reclamation projects is that sometimes the results do not match the original aspirations. Not only because some projects are just speculative, using "sustainable" and "communitarian" labels as a marketing device, but also because the public will is often not a relevant part of the project (Loures & Panagopoulos, 2007b; Loures & Crawford, 2008a; Loures et al., 2016).

In recent years, several architects, landscape architects, urban planners and other planning specialists have built a number of outstanding iconic landscape reclamation designs that do not represent the community of which they are an integral part. These fail in what should be considered essential in a landscape reclamation project: connectivity to the place and to the society (Loures & Crawford, 2008a).

Once public landscapes in general and reclaimed post-industrial landscapes, in particular, are viewed as "systems" that possess multiple intellectual, cultural and

social meanings able to influence public behaviour both physically and spiritually, it is evident that the integration of public will and needs in the whole urban planning and regeneration processes is crucial (Loures & Crawford, 2008a; Loures et al., 2016).

In fact, the integration of public participation in the decision-making process benefits both project quality and society. For this reason, it is essential to develop a framework that specifies how public participation can be introduced in the different planning phases (Loures & Crawford, 2008a).

Public Participation Applied to Landscape Redevelopment

It is believed that it is necessary to develop a new power of reclamation alignment between the social and the political sphere, enabling the creation of conditions for an active and participative citizenship, in order to ensure better organization and efficiency for landscape redevelopment. For this reason, it is thought that it is needed a greater public participation and involvement, insights into emerging social meanings (Llewellyn, Rohse, Day, & Fyfe, 2017).

In this regard, government development of large post-industrial landscape reclamation projects has increased on international, national, regional and local levels, in the past years. Professionals involved are becoming more and more aware of the fact that specific local human and social factors need to be considered and introduced in the planning process of rehabilitation of industrial derelict sites. Public participation holds nowadays an essential position in the post-industrial regeneration process (Loures & Crawford, 2008a; Loures et al., 2016).

Three projects are showed to exemplify the execution of public participation as an inclusive way so as to get a belonging feeling to a community.

Project 1

The Lorettowiese square is located in the city of Viena, in Austria. The square is part of the Floridsdorf District of the city.

A compensation area for playing and sports with an extend of 7.700 m^2 was created. The sports area includes: skate park, streetball area, volleyball courts and robinson playing area. A public participation procedure takes place, the youth from the neighbouring school and from the parish community is involved. The character of the present meadow is preserved, modern facilities for sports and playing are added (Landezine, 2009).

However, this project is a great example of the social acceptance of the projects implemented by citizenship (Fig. 4), since citizen participation wants certain modifications in the project as a construction of an ice rink, a lounge track for teenagers, three volleyball courts of street or beach, placement of area for dogs in the vicinity of residential houses, a new walkway in the area of the playground, expansion of the

Fig. 4 Lorettowiese square project. *Source* Bürgeniritiative (2009)

existing playground, a play area for young children, creation of a sandpit as stock and the installation of more drinkers (Sabine, Detzlhofer, Zingerle, & Stevanovic, 2010).

In this regard, among the activities carried out, stresses it was decided by the heads of the residents of the districts SPÖ, Greens and ÖVP in 2013 the prohibition of parking for the establishment of a place for skating. Precisely based on the procedure of participation, BI Lorettowiese citizens intend to allow parking in the area again.

Likewise, the huge acoustic pollution caused by the skaters is reported, as well as the increase in noise pollution by some teenagers through nighttime drinking events, noise and garbage disturbances, questionable public attraction at night, elimination of parking spaces.

In this regard, as a coordinated proposal, the relocation of the skating rink and the chil-out area to Überplattung located on the Danube canal, the maintenance of the area for dogs, the reuse of existing equipment in the playground are promoted, the abandonment of the basketball court (due to noise) and the use of the old place of kindergarten for new sports possibilities using noise-reducing coatings (without asphalt, without concrete). Precisely, the distance between the skating field originally planned and now proposed is about 600 m (Bürgeniritiative, 2009).

Project 2

Local participation can also be important for smaller urban units, such as a street. In this regard, the case of Potgieterstraat street located in the city of Amsterdam in the Netherlands stands out.

In this regard, the street is characterized by nineteenth-century buildings dating back to the first large extension of Amsterdam. For this reason, the existing typology corresponds to housing blocks. Precisely, this can lead to a disadvantage, because the inner courtyards of these blocks are not open to public use. In addition, the streets were not designed for the traffic that currently exists.

In general, there is a shortage of public squares and green spaces, the streets being dominated by cars and the recently built bicycle lanes as a solution precisely to traffic.

The district as a whole was up to a refreshing new strategy for children and pedestrians to strengthen and vitalize the public realm. Local inhabitants were asked in a political enquiry to agree upon and formulate new guidelines and were also involved in the selection of an architect (Landezine, 2009). For this reason, it was suggested that the street be completely closed to car traffic. In this way, this space could be dedicated for the use of citizens. In fact, the old street and parking area assigned to carve landscape architecture for the design has an area of approximately 1500 m^2 and the project was completed in 2010.

In this regard, the functional program changed the place changed traffic and parking, for a place intended for meetings and places of rest, a playground for children, an improvement of green quality (Fig. 5). In this way, a positive effect was obtained to balance the area destined for urban exploitation, but for the rest and enjoyment of the citizens of a greener zone. In fact, all surface materials were removed and not only existing trees were maintained, but new trees were added. The play areas were characterized by black rubber elements that can be used as a drawing surface, and their soft touch invites play. In addition, at the same time, it reduces noise levels (Blitz et al., 2010).

Although, the greatest benefit is the recovery of the local urban area by the community, because parents, and also citizens without children, interact and relax in these places. In fact, the place becomes a place for the interaction of the neighbourhood,

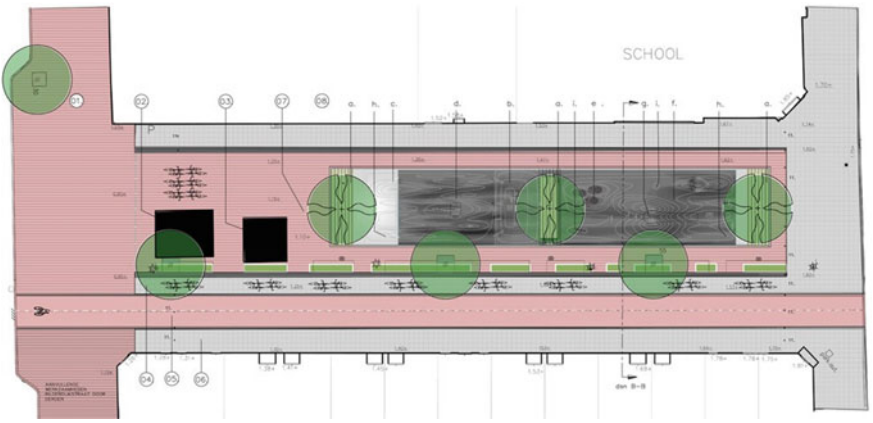

Fig. 5 Potgieterstraat street project. *Source* Carve Landscape Architecture

as well as for the surrounding blocks, helping people of different origins and ages to meet in one place.

Regarding participatory processes, these could be characterized by conflict rather than cooperation. First, conflicts with the city council, since according to a written survey 70% of the citizens of all the residents in the blocks of housing must agree with the plan.

In this regard, some residents did not want public parking places to move elsewhere, although, this was a nearby site. Likewise, there were also problems with the retailers located in this street, who were opposed for various reasons to the execution of the project.

Nevertheless, the perseverance of the social connection of this project overcame all the difficulties on the part of the citizens. Thus, with a certain delay nowadays, this place is an area of attraction that stimulates the establishment of social relations between the components of the neighbourhood.

Project 3

The concept of inclusive design through public participation to reinvent spaces has as one of its most illustrative and prominent examples Teleki Square. This square is located in Budapest, is one of the oldest and with more history of the city of Budapest.

Although it is located in one of the most socially diverse and colourful areas of the city centre, it is also characterized by being in one of the most disadvantaged neighbourhoods of the city.

Just the financing of the EU to renovate the square, began a design process in 2013 (Fig. 6) based on the transformation of a sterile space, plagued by crime, of bad reputation and without any clear functionality, through its construction in 2014 in a centre of vital that offers opportunities for recreational and social outdoor activities, taking into account public participation. By the way, spaces that the city of Budapest lacks to carry out this type of activities (Landezine, 2009).

In general, the aim of the inclusive community-based planning process was to enable nearby residents to actively participate in developing the design of their own Community Park by means of cooperation, interaction and participation. Specifically, a strong local community identity can be developed, since play an increasingly important role in societies of today.

Apart from the general and specific aims mentioned, one of the most important outcomes of the process was the formation of the Teleki Square Association so as to take part in the activation of the area. The residents already took part in the organization of numerous public art events (Dominika, Szohr, Kovács, & Ruso, 2013).

Fig. 6 Teleki square project. *Source* Ujirany/New Directions Landscape Architects

Lessons Learned and Final Remarks

Post-industrial redevelopment must be considered as one of the several components that influence the broader context of urban planning and economic development, since post-industrial landscapes represent significant assets to the community, which redevelopment will create wealth and jobs, while enhancing the visual and aesthetic quality of the community, fostering the sense of place and belonging and tackling urban sprawl and the loss of green space. (Loures, 2015). The use of public participation and the incorporation of human preferences and needs in post-industrial landscape reclamation is a safeguard to achieve success. Furthermore, public participation is an essential part of the process of developing a sense of community (Loures & Crawford, 2008b).

Besides, the application of public participation questionnaires increases the sense of social responsibility of the population, playing a key role in sustainable development and in future landscape planning, since it allows the acquisition of relevant information not only regarding landscape features but also considering public preference for landscape characteristics (Loures et al., 2015a).

It is critical to shift the power paradigm in the urban planning process to allow residents to proactively envision and create public green spaces that would reflect the diversity of the society it represents. The use of public participation and the incorporation of human preferences and needs in post-industrial landscape reclamation is a safeguard to achieve success and to develop a sense of community (Loures & Crawford, 2008a).

In this regard, the projects analysed show that involving locals in the design process plays an important role in exploring local identity and in creating socially comprehensive spaces since provides a base to social, hence physical sustainability.

Moreover, the community which takes the role of intermediary between the residents and the municipality, also it is responsible for the realization of the community project.

Overall like stablished Dominika et al. (2013), it can be said that the locals and the site have already become an active, integral part of the quarter's regeneration process, helping the social aspects of the rehabilitation. Hopefully, this process in time—thanks to the local involvement—will truly initiate a meaningful engagement between people and space, consequently helping the creation of an open and a culturally richer and socially embedded environment to arise.

In summary public participation encourages awareness of "belonging to" a community, sharing a common culture and creating an identity. It improves community consciousness and responsibility while fostering a "collective sense." These are "feelings" of considerable importance in the development of new, satisfying and concerted projects.

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Sustainable Development of Fisheries Communities: The Role of Community-Led Local Development Policies

Pedro Valadas Monteiro and Teresa de Noronha

Identifying the Problem

> More people than ever before rely on fisheries and aquaculture for food and as a source of income, but harmful practices and poor management threaten the sector's sustainability, is stated in FAO (2014).

The Ocean is more and more subject to pressures that arise out of human action, and in particular due to the fast-growing population in some regions of the planet. An important effect of this demographic pressure is the unsustainable fast consumption of living marine resources, which is preventing them from being renewed, whereby many species are already at serious risk of overexploitation, in particular, that result-

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ing from illegal, unregulated or unreported fishing,[1] or, at best, by poorly selected and inefficient practices. In many areas, primary activities such as farming, fishing and aquaculture are under pressure or in decline. These activities are, in particular, suffering from market competition, which is increasingly globalized, from the rise in input costs, be it fuel, feed or labour, and from unstable and often low selling prices. Jakobsen, Mortensen, Vikesland, and Cappelen (n.d.) mention that for Paul Krugman the concern about competitiveness is turning into "a dangerous obsession." His argument is that countries are not competing with each other. On the contrary, international division of labour and trade determines their economic wealth. Furthermore, he states that the only thing that really matters for long-term economic growth is domestic growth in productivity. The contemporary scenery, which is characterized by uncertainty and constant change, has led organizations to inflection moments which are decisive for their survival. The changes, in production processes and work organization itself, are the result of wider aspects, such as the internationalization of markets, the restructuring of production, advances in technology and issues that relate to culture. This context has required a repositioning of organizations over the traditional model, which has become insufficient to meet the new challenges.

The current use of coastal areas is multifaceted and highly competitive and a source of use conflicts for space allocation and resource depletion. This situation has highlighted the need for sufficient planning and regulations to optimize the management of the resources within a multiuse context. '*The health of our planet as well as our own health and future food security all hinge on how we treat the blue world'*, FAO Director-General José Graziano da Silva said. "*We need to ensure that environmental well-being is compatible with human well-being in order to make long-term sustainable prosperity a reality for all.*" The Pollnac et al. model (Fig. 1) apud Prabhu (2011) illustrates the relationship between multiple attributes that directly or indirectly influence well-being at individual and community levels.

[1] Illegal, unreported and unregulated (IUU) fishing conducted by vessels or countries that are part of a fisheries organization but violate the rules, or operate in waters without permission; caught by vessels without reporting to relevant authorities; or conducted by vessels under the flag of a country they are not part of, or not part of a fishery organization, is a serious global problem that contributes to overfishing, creates unfair competition and impedes sustainable fisheries. As a result of this, improved monitoring, control and surveillance has been an important preoccupation of fisheries policy makers for decades. Also, fish retailers are concerned about where their seafood comes from, spurring demand from informed consumers. The EU is working to close the loopholes that allow illegal operators to profit from their activities:

- The EU regulation to prevent, deter and eliminate illegal, unreported and unregulated fishing (IUU) entered into force on 1 January 2010.
- Only marine fisheries products validated as legal by the competent flag state or exporting state can be imported to or exported from the EU.
- An IUU vessel list is issued regularly, based on IUU vessels identified by Regional Fisheries Management Organisations.
- The IUU Regulation also offers the possibility to blacklist states that turn a blind eye to illegal fishing activities.
- EU operators who fish illegally anywhere in the world, under any flag, face substantial penalties proportionate to the economic value of their catch, which deprive them of any profit.

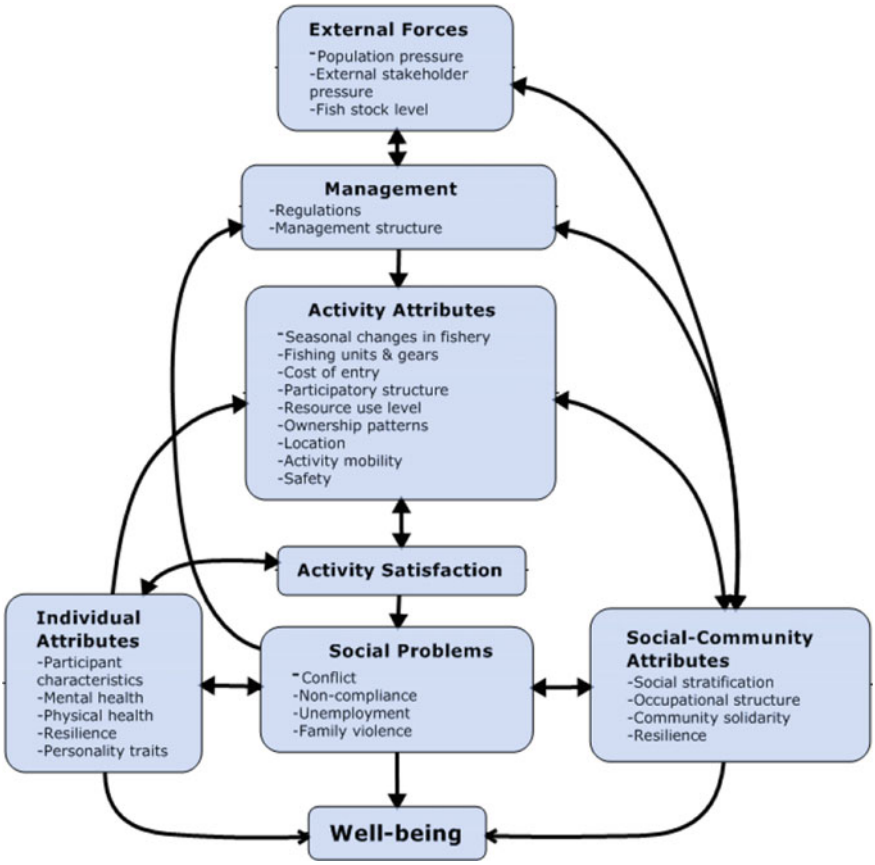

Fig. 1 Attributes that influence well-being at individual and community levels. *Source* Pollnac et al. apud Prabhu (2011)

Conflicts over the use of marine and coastal space tend to fall into two broad categories (Sørensen et al., 2003). The first category concerns to areas with existing regulated, restricted or prohibited access such as: major shipping routes; military exercise grounds, major structures,; sub-sea cables or pipelines; and marine protected areas for fisheries management or marine conservation. The second one refers to areas with conflicting uses exist such as: commercial and recreational fishing grounds; resource extraction areas; tourism and non-consumptive recreational areas; archaeological sites such shipwrecks; and those with cultural significance.

Pillay (2004) mentions that in the overall context of the environmental impact of human activities, particularly when compared with agriculture, domestic uses, industries and development of infrastructure, the contribution of traditional aquaculture systems was unquestionably small. Many of the traditional aquaculture systems functioned as efficient means for the recycling of agricultural and domestic wastewater,

whereby the water released by aquaculture had, in many cases, higher quality levels compared to the recorded at entrance. Quite different from what is found nowadays in some of the industrial units, considered potentially polluters and causing the degradation of wetlands. Intensive aquaculture has some significant impacts such as the production of waste that can stimulate or distort productivity and change the abiotic and biotic characteristics of water, genetic disorders of the natural ecosystem, the transmission of diseases and parasites to wild fish by fish culture and chemical contamination (European Environmental Agency apud CNADS, 2001). Large amounts of organic matter are introduced by treatments in semi-intensive and intensive fish farms and also by fish waste. These organic compounds (not to mention the waste of antibiotics and disinfectants) are deposited in areas of lower hydrodynamic sedimentation, which can generate situations of oxygen shortage (aerobic bacteria degrade organic matter and consume oxygen). This lack of oxygen threatens all aquatic life including fish from these wetlands and deep-sea fish that use these coastal areas to breed and grow. If we add the increasing regulatory concern and the level of food security, competition for the use of space with other economic activities and problems related with the falling world prices of aquaculture production due to markets globalization, there are many challenges facing this strategic subsector.

This trend often leaves the primary sector marginalized within territories where it has traditionally been the backbone of the community and the local economy. However, these territories have much more to loose from the disappearance of these primary activities than is sometimes realized. They are often inextricably linked to the area's identity and are a vital part of its image, thereby contributing to the local economy in ways that go well beyond their direct economic impact.

The Underlying Cause: Excessive Pressure Exerted Over Fishing Production by the Exponential Growth of Demand

According to FAO (2014), global fisheries and aquaculture production totalled 158 million tons in 2012—around 10 million tons more than in 2010. The share of fisheries production used for direct human consumption increased from about 70% in the 1980s to more than 85% (136 million tonnes) in 2012. Global fish production growth continues to outpace world population growth (China is by far the world's largest producer with a declared production of near 50 million tons, more than 30% of the world's total production, representing aquaculture twice the value of fisheries), due to the fact that although marine captures appear to be stable (around 90 million tonnes of wild fish captured by a total number of fishing vessels estimated to be about 4.7 million in 2012; in 1960, that amount was a little more than 30 million tonnes), aquaculture remains one of the fastest-growing food-producing sectors and is set to play a key role in meeting the rising demand for fishery products. The rapid expansion of aquaculture, including the activities of small-scale farmers, is driving this growth in production and fish farming holds tremendous promise in responding

to surging demand for food which is taking place due to global population growth (FAO, 2014). Global aquaculture production marked a record high of 66.6 million tons in 2012 (a raise of more than 4000% when compared to 1960), or 90 million tons if we include almost 24 million tons of aquatic plants. World aquaculture is heavily dominated by the Asia-Pacific region, which represents 89% of total production in volume and 77% in value. China alone accounts for 67% of the global production in volume and 49% in value. Out of curiosity, the Asia-Pacific area accounts for 98% of the world production of carp, 95% of the oysters and 88% of all shrimp. Norway and Chile are the world leaders for salmon farming, respectively, 33% and 31% of the global production.

With this increasing production and greater availability for consumers, per capita fish consumption continues to rise—up from 10 kg in the 1960s to more than 19 kg in 2012—driven by higher demand from a growing population, rising incomes, and more efficient distribution channels. In the EU-27, the average consumption ranged between 4.2 kg per capita in Bulgaria and 56 kg in Portugal, which is more than twice the EU average, representing the third place worldwide, just behind Japan and Iceland.

FAO (2014) also says fish now accounts for almost 17% of the global population's intake of protein—in some coastal and island countries, it can top 70%. Fish remains an ever-important source of energy, protein and a range of essential nutrients. Moreover, fish provided nearly 3 billion people with almost 20% of their intake of animal protein and 4.3 billion people with about 15% of such protein. Protein from fish is a crucial nutritional component in some densely populated countries where total protein intake levels may be low. Consuming fish is particularly important during pregnancy and the first two years of life and can help lower the risk of coronary heart disease mortality.

FAO estimates that fisheries and aquaculture support the livelihoods of 10–12% of the world's population as a vital source of employment and income. Since 1990 employment in the sector has grown at a faster rate than the world's population and in 2012 almost 60 million people are engaged in the primary sector, 90% small-scale fishers and 15% of them women (in secondary activities such as processing, this latter figure can be as high as 90%). Of these, 84% were employed in Asia, followed by Africa with about 10%.

Fish remains among the most traded food commodities worldwide, worth almost $130 billion in 2012—a figure which likely will continue to increase. The aggregate FAO Fish Price Index reached a record high in October 2013. Trade in fish and fishery products is especially important for developing nations, in some cases worth over half of the total value of traded commodities. Developing economies saw their share rise to 54% of total fishery exports by value in 2012, and more than 60% by quantity (live weight). This means fisheries and fish farming are playing an increasingly critical role for many local economies.

The fisheries sector (which includes aquaculture) of the EU-27 is the fourth largest in the world and 20 years ago this part its total production has declined slightly from year to year. In 2007, the EU-27 accounted for 4.6% of the tonnage in live weight of the catch and aquaculture. In 2006, despite the export of 2 million tons of fish

another 6 million tons had to be imported to meet EU requirements. This imbalance between imports and exports resulted in a more than 13,000 million Euros of deficit that year. In the EU-27, the four largest producers in terms of volume were, in 2007, Spain, France, the UK and Denmark, which together accounted for over 50% of total production.

Total aquaculture production in the EU is close to 1.4 million tons, worth some €3300 million (Eurostat figures). The overall production in marine and brackish water is slightly declining in volume but growing in value at the European level: Total production is estimated to reach €2500 million for 1.01 million tons in 2007 compared to €1600 million for 1.05 million tons in 1998. The EU consumes 5 million tons of products from aquaculture, but only produces as mentioned before 1.38 million tons (20.3% of the total production of the fishing industry in the EU). The relative weight of EU-27 in the world aquaculture production was on the same date of 2.6% in volume and 5.1% in value (data from 2007 in CE, 2010). The European aquaculture subsector comprises more than 16,500 enterprises and provides employment, directly and indirectly, for about 64,000 people. Despite their reputation as regards the quality standards of production, European aquaculture has failed to develop in order to meet domestic demand. Constraints menacing the further development of EU aquaculture are numerous and include, according to the European Commission: limited access to space and water, red tape, industry fragmentation, pressure from imports, insufficiency of medicines and vaccines.

In the mid-sixties of the late century, the Portuguese fishing industry reached its pick due to several factors: externally, abundant marine resources and virtually free access, which allowed the development of a LDWF in Northwest and South Atlantic (respectively, cod from Terra Nova and Greenland, and the hake from White Cape and Mauritania): the self-sufficiency rate jumped from only 16% in 1934 to 75% in 1966; from fifth European producer of dried salt cod in 1938, Portugal became the first world producer twenty years later (Garrido, 2001). Nowadays, cod catches by the fishing fleet represent slightly more than 1% of our consumption requirements (the Portuguese are world consumer leaders for dried salt cod; cod represents 40% of all Portuguese fish imports).

The Portuguese fisheries have, up-to-date, a total effect of 1.7% in national GDP and employ more than 90,000 persons (SaeR, 2009). The Portuguese fishing fleet ranked in 2009 among the EU-27 member states the 4th place in terms of number of vessels, the 6th place in gross tonnage and 7th in terms of total catches, and the employment generated represented, in 2007, 10% of all European jobs in this sector (4th place in the EU-27). On relation to production, it reached more than 260,000 tons in 2007 (see Fig. 2), representing 4.04% of the EU total (captures + aquaculture).

The increased consumption of fish products in Portugal, associated with the reduction in catches, origins that domestic production only fulfils about one-third of market needs, and therefore, there has been an increasing reliance on imports (especially for cod, which alone accounts for over 40% of the national trade deficit of fish, while in the canning industry almost 50% of the sardines used are imported). These entries are highly responsible for the formation of the national deficit for fishing products.

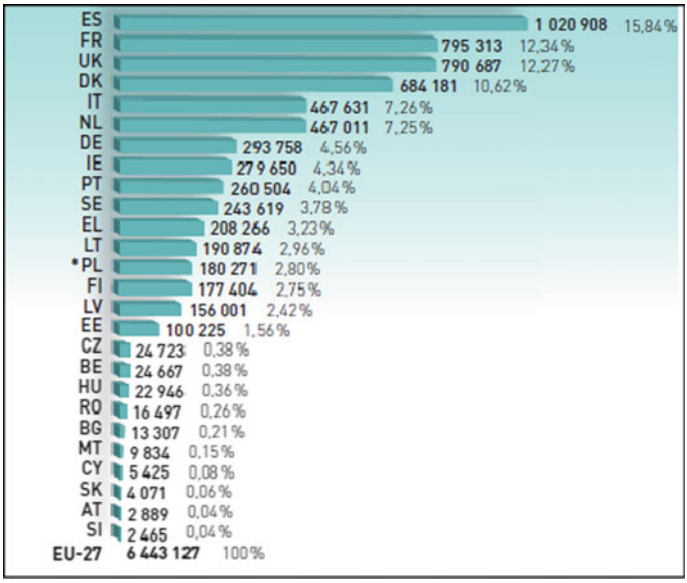

Fig. 2 EU member-state production (2007): captures and aquaculture (live weight tons and total percentage). *Source* CE (2010)

The pressure of demand has implicated a consistent negative record on the Portuguese commercial scales in this sector. The insufficient capture can be progressively reduced with the development of onshore and offshore aquaculture. Aquaculture only represents 3% of the total Portuguese production of fish. Portuguese aquaculture represents only 0.6% of total EC aquaculture production and a residual 0.016% of world production.

Hard Trends

Currently, slightly less than 30% of the wild fish stocks regularly monitored by FAO are overfished (FAO, 2014). Just over 70% are being fished within biologically sustainable levels. Of the stocks assessed, fully fished stocks accounted for over 60% and underfished stocks about 10%. Even not considering the problems of overfishing and those related to the inefficient methods of catching and processing of fish that still remain, and which result in high rejection rates (only the discards, represented in 2005 according to FAO data, 7.3 million tons of dead or badly damaged fish not retained on-board), fish stocks are increasingly limited. Since 2000, fishing has declined or stagnated in most of the OECD countries' marine areas once the wild stocks located in its Exclusive Economic Zones are already in full use or even above the permissible levels of sustainability. The fishing zones which exhibited a more critical situation

were Northeast Atlantic, the Western Indian Ocean and the Pacific Northwest. FAO identifies as the factors that contribute most to the unsustainability of resources, the following: high demand, governance deficiencies, inadequate policy incentives, lack of technical and scientific knowledge, and poverty and lack of alternatives in some fishing areas. Thus, although fishing continues to be an essential activity to meet a significant proportion of global consumption, a continued increase in world demand cannot be fully satisfied only through wild fish. In 2006, according to the data displayed in FAO (2009), the 10 species that contributed most to overall catches worldwide were the same as in 2004. This group of species, representing more than 30% of the total catches, comprised five species of small pelagic, two species of tuna (Skipjack and yellowfin tuna), two Gadidae of lower value, which are mainly sold in processed forms, and one bentho-pelagic specie, of which 90% of its total catches are reported by China.

Aquaculture's expansion helps improve the diets of many people, especially in poor rural areas where the presence of essential nutrients in food is often scarce. However, FAO (2014) warns that to continue to grow sustainably, aquaculture needs to become less dependent on wild fish for feeds and introduce greater diversity in farmed culture species and practices. For example, small-sized species can be an excellent source of essential minerals when consumed whole. However, consumer preferences and other factors have seen a switch towards larger farmed species whose bones and heads are often discarded. An estimated 1.3 billion tons of food are lost per year—to about one-third of all food produced. This figure includes post-harvest fish losses, which tend to be greater in small-scale fisheries. In small-scale fisheries, quality losses are often far more significant than physical losses. Improved handling, processing and value addition methods could address the technical aspects of this issue, but it is also vital to extend good practices, build partnerships, raise awareness, and develop capacity and relevant policies and strategies.

FAO (2014) also notes that illegal, unreported and unregulated (IUU) fishing remains a major threat to marine ecosystems and also impacts negatively on livelihoods, local economies and food supplies.

EU fishing fleets can, in most cases, exert a fishing pressure on the stocks that is two to three times its sustainable level according to the European Commission. There is presently an imbalance between the fishing capacity of the fleets, the abundance of fish available in the seas and the EU annually set 'fishing opportunities', which need to be urgently addressed in order to adjust the fleet to the availability of fishing resources. As new technology makes fishing vessels ever more efficient, the size and capacity of the fleet should be reduced to maintain a balance between fishing pressure and the quantities of fish available. Fishing capacity, defined in terms of tonnage and engine power and sometimes number of vessels, is one of the key factors that determine the fishing mortality caused by fishing fleets. Average size of vessels, although not usually considered as a measure of fishing capacity, is also an important parameter when assessing fishing pressure. Larger vessels generally have a larger fishing pressure than smaller vessels, namely because of the type of gear they

use and also of its level of activity, as well as the geographical coverage that these vessels can reach. In simple terms, excess capacity leads to overfishing and increased environmental pressure, which undermines the principle of sustainable use of marine resources.

Why Is the Search for a Sustainable Solution so Complex?

The classic work of Ciriacy-Wantrup (1952) prefigured many of the current concerns of sustainability with his development of the concept of 'the safe minimum standard'. First Ciriacy-Wantrup (1952) identifies the existence of 'critical zones' for many, especially renewable, resources, where such a zone means a more or less clearly defined range of rates (of flow of the resource) below which a decrease in flow cannot be reversed economically under presently foreseeable conditions. Long before a given resource is physically used up it may be 'exhausted' in the sense that further utilization is indefinitely discontinued because the costs of producing any possible quantity of this resource are larger than the revenues that could be obtained from this quantity (Ciriacy-Wantrup, 1968). On the other hand, a resource may be 'inexhaustible' in the sense that utilization can continue indefinitely because it is only economically feasible to use very small amounts, per unit of time, of resources which are available in only comparatively small physical quantities (Ciriacy-Wantrup, 1968).

Fisheries resources are the classic example of a renewable natural resource, because they have the capacity for self-regeneration, which does not mean that they cannot become depleted if exploited indiscriminately, or through significant changes in the environment where they develop. They are usually considered as public goods with open access (such as fisheries resources from the sea or rivers), although can also be private (in case of aquaculture resources). Over the past few centuries, an increase in the human populations of coastal areas and an improvement of fishing technology has led to an increase in the demand for marine resources. As a result, there has been an overexploitation of many fish and shellfish species. This overexploitation is not sustainable, and its negative effects on both the fish and human species are observable. For many communities around the world, the disturbance of these marine ecosystems impacts the local residents, both socially and economically. The overexploitation of resources has led to a decrease in fish populations, and, subsequently, has led to a decrease in the amount of fish caught by fishermen. Some communities have acknowledged the connection between overexploitation of the local fish population and their fishing practices. The imminent depletion risk of fishing activity relies not only on its open-access resource condition (albeit subject to regulation) and common property, but also because it develops in an environment with the same characteristics. Therefore, it becomes difficult to coordinate and/or control the entry of new fishermen and prevent environmental degradation through pollution, at the location where the activity occurs. IUU conducted by vessels or countries that are part of a fisheries organization but violate the rules, or operate in waters without permission; caught by vessels without reporting to relevant authorities; or conducted by vessels under the flag of a country they are not part of, or not part

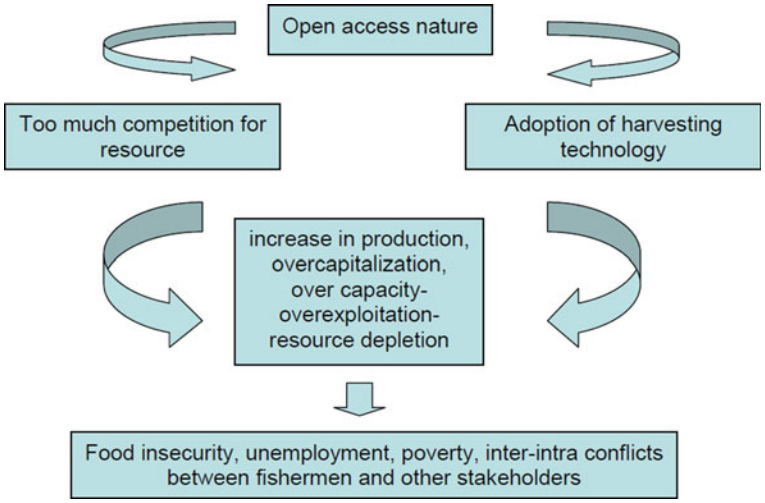

Fig. 3 Key issues in marine fisheries. *Source* Prabhu (2011)

of a fishery organization, is a serious global problem that contributes to overfishing, creates unfair competition and impedes sustainable fisheries.

High demand for limited resources and the prospects of making financial gains are likely to intensify pressures on governments to allocate more licenses. Overcapacity, overcapitalization and lack of alternative employment opportunities lead to poverty and give rise to conflicts between long-established coastal communities and newcomers. The complexity of many fishery systems and inadequate knowledge makes it hard for fishery authorities to identify the right course of action. Lack of governance, lack of co-operation between various department at the administrative level and lack of interaction between fishery, other sectors and its environment (Fig. 3).

Fishery is susceptible to economic interaction between ownership or stewardship and sustainability, otherwise known as the tragedy of the commons. The tragedy of the commons for fisheries, therefore, is that the unregulated fishery resulting from the open access will eventually be reduced to a biological state at which it generates zero or possibly even negative rent. All participants will lose everything ("ruin for all"), despite the existence of an option for managing the resource on an economically optimal basis (i.e. by keeping effort at the correct level). The Hardin's metaphor 'tragedy of the commons' (Hardin, 1968) presents a stark vision of the problems inherent with common property resources, i.e. resources characterized by low excludability, yet high rivalry. In other words, the use of the resource cannot be excluded, but the benefits obtained from the resource detract from other actors' abilities to obtain benefits. It sought to explain problems related, for example, to the overexploitation of species and their resulting extinction, in which multiple individuals, acting independently and rationally consulting their own self-interest, will ultimately deplete a shared limited resource, even when it is clear that it is not in anyone's long-term interest for this to happen.

Ineffective Solutions for Complex Problems: The Failure of Deterministic Public Policies

Fisheries management in practice is often relatively ineffective, particularly in exerting control over levels of catches and hence protecting fish stocks from depletion. For this reason, many countries have periodically attempted to intervene directly to reduce the size (capacity) of their fishing fleets by compensating firms for exiting the industry (through decommissioning or buy-back schemes). Fisheries are usually also subject to many regulations which are not designed to exert control over levels of harvest per se, but rather to reduce the adverse stock/environmental impacts of fishing.

For instance, the EU Common Fisheries Policy (CFP) increasingly has recourse to multi-annual plans (MAPs) which often combine different management tools.[2] Almost all important stocks and fisheries are managed by means of a multi-annual plan. The plans contain the goal for fish stock management, expressed in terms of fishing mortality and/or targeted stock size. However, MAPs failed so far to meet expectations and proved cumbersome to manage. Subsidies for construction/modernization and running costs undermined the efforts made, also with public aid, to eliminate overcapacity, by helping the introduction of new vessels into the fleet. MAP IV, which ended in December 2002, was therefore replaced by a simpler scheme, under the 2002 CFP reform (Council Regulation (EC) No. 2371/2002). Under this new scheme, the fleet capacity was reduced gradually, i.e. the introduction of new capacity into the fleet without public aid had to be compensated by the withdrawal of at least an equivalent capacity, also without public aid.

Restructuring the fleet and reducing its capacity (Fig. 4) do not necessarily led to reduction in fishing pressure as advances in technology and design allow new vessels to exert more fishing pressure than older vessels of equivalent tonnage and power. Besides capacity, other vessel characteristics, such as fishing gear, level of activity and technological developments must also be accounted for if fishing pressure and its impact on marine ecosystems is to be properly assessed.

In 2009, there were 8562 vessels registered in the Portuguese fishing fleet (while, in 1986, when Portugal formally joined the EEC, that number was 17,997, i.e. more than twice), totalling a gross tonnage of 104,018 GT and a driving power of 379,369 kW,

[2]Output controls mainly consist of limiting the amount of fish from a particular fishery, in particular through total allowable catches (see TACs and quotas). Total allowable catches (TACs) or fishing opportunities are catch limits (expressed in tonnes or numbers) that are set for most commercial fish stocks. The Commission prepares the proposals, based on scientific advice on the stock status from advisory bodies such as ICES and STECF. Some multi-annual plans contain rules for the setting of the TACs. TACs are set annually for most stocks (every two years for deep-sea stocks) by the Council of fisheries ministers. For stocks that are shared and jointly managed with non-EU countries, the TACs are agreed with those (groups of) non-EU countries. TACs are shared between EU countries in the form of national quotas. For each stock, a different allocation percentage per EU country is applied for the sharing out of the quotas. This fixed percentage is known as the relative stability key. EU countries can exchange quotas with other EU countries.

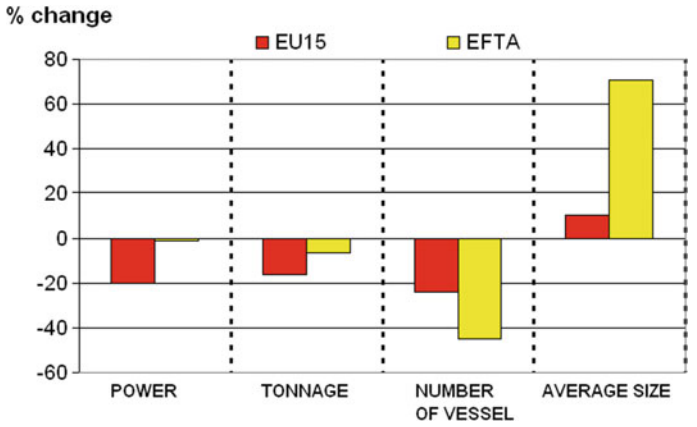

Fig. 4 % changes in the number of vessels, tonnage, capacity and size, and power, of the European fishing fleet. *Note* Countries have been grouped into the following categories: EU15—Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden and UK; EFTA—Iceland, Norway. *Source* EU—Directorate-General for Maritime Affairs and Fisheries

which, compared to 2005 (data from the Portuguese National Institute of Statistics—INE), reflects a reduction in the fleet, more significant in terms of the number of vessels (−14%), and not so much in terms of gross tonnage (GT) (−4.4%) and power (kW) (only 1.3% less).

This downward trend in the fleet, and subsequently in the inherent employment, resulted in significant and severe socio-economic consequences among coastal communities highly dependent on fishing, since the majority of the persons involved on this sector do it exclusively, with the aggravating circumstance of having a high number of dependents at its care and a weak inter- or intra-industry labour mobility, alongside with a reduced level of educational attainment of these professionals. In Portugal, fishing is a way of life for thousands of people with few or no opportunities for alternative employment. The recent evolution shows some structural change in how fishing is practiced. In fact, there has been a rise in the number of employers and a fall in the number of self-employed fishers and wage-earners. This last category has seen a 41.5% decline, one reason being the fall in the number of registered vessels in the Portuguese fishing fleet as pinpointed earlier. Although vocational training was strongly promoted from the late 1980s to the early 1990s, there has been no improvement in literacy among fishers. The situation of retired fishermen over 65 years is particularly onerous. Due to the fact that during almost their entire professional life, they did not made the social welfare deductions, the overwhelmingly receives very low pensions, which leads them to an almost total dependence upon their family to survive or forces them to continue informally engaged in fishing however disguised through recreational craft, in order to maintain a precarious livelihood.

The Urgency of a New Approach

The ocean is becoming more industrialized and competition among all marine space users is developing (Buck, Krause, & Rosenthal, 2004). More spatial competition can lead to conflict between ocean users themselves, and to tensions that spill over to include other stakeholders and the general public (McGrath, 2004). Pillay (2004) states that in the complex and conflicting situation in which resource management decisions have to be made, neither complete destruction of the natural environment nor complete avoidance of resource exploitation can be practical. According to the United Nations, sustainable development 'implies meeting the needs of the present without compromising the ability of future generations to meet their own needs'. A logical course would, therefore, be a balance between rational use, conservation and preservation in order to optimize man's use of natural resources on a long-term basis. Thus, multidisciplinary and transdisciplinary problem focused approaches are needed that combine different knowledge systems (e.g. authorities, decision-makers, local communities, science, etc.) to generate novel insights into the management of multiple uses of ocean space and to compliment risk justified decision making. Imposing top-down, detailed prescriptions for 'solving' collective action problems by policymakers located far from particular collective action problems has rarely been a successful strategy.

Despite all the efforts to improve environmental quality of coasts and seas around the world, degradation of ocean environments has continued. As well, the lack of an integrated approach when using this shared resource has often caused conflict among economic, environmental and social objectives. Management of ocean resources in a global, sustained and integrated fashion has remained elusive, despite several international agreements and initiatives. In the debate over the economic scarcity of natural resources, one significant change in recent years has been a greater focus on the ecosystem services and the resource amenities yielded by natural environments. The general conclusion extracted from Krautkraemer (2005) is that technological progress has ameliorated the scarcity of natural resource commodities, but resource amenities have become scarcer and it is unlikely that technology alone can remedy that.

Around the world in recent decades, awareness has emerged that the management and governance of the ocean, coastal zones and human activities associated with it should be addressed at an ecosystem approach, of sustainable development, based on a comprehensive view, not sectoral but integrated (EMAM, 2007). This configures the core of a long-term strategy to support sustainable growth in the maritime sector as a whole, in what has been recently designated as 'Blue growth' strategy. FAO is promoting 'Blue Growth' as a coherent framework for the sustainable, integrated and socio-economically sensitive management of oceans and wetlands, focusing on capture fisheries, aquaculture, ecosystem services, trade and social protection of coastal communities. Already in 2012, the EU presented a communication dedicated to 'Blue Growth' that defined and characterizes the 'Blue Economy' and establishes the fundamental areas for growth, which integrate the blue energy, the aquaculture,

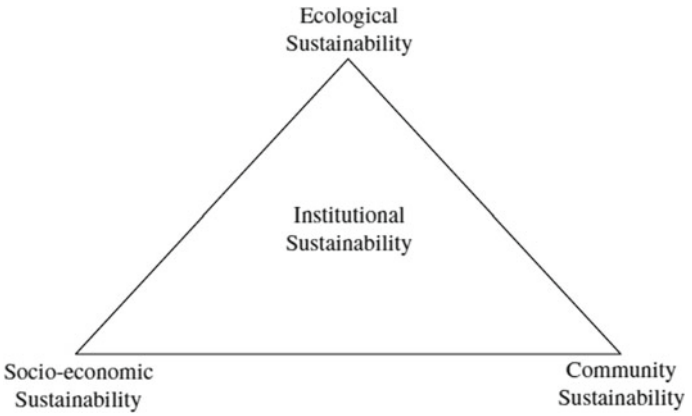

Fig. 5 Four components of resource sustainability. *Source* Boyd and Charles (2006)

the coastal and maritime tourism and that of cruises, the maritime mineral resources and the blue biotechnology. The 'Blue Growth' seeks to identify and support the activities with a raised potential for long-term growth, eliminating administrative obstacles that make growth difficult, promoting investment in research, as well as the development of skills through education and professional training. The aim is thus to increase the competitiveness of the economy and generate an increase in employing qualified staff, strengthening social cohesion.

Community-based resource management has emerged as a way to involve resource users and it reflects a holistic vision and is based on four components of resource sustainability—community, ecological, institutional and socio-economic sustainability—as proposed by Charles apud Boyd and Charles (2006) on Fig. 5.

A multidimensional and holistic concept for the sustainable management of maritime and marine resources must consider factors that increase the likelihood that individuals will engage in their own collective action to manage local resources. By understanding these factors and developing policies to enhance them, national and international agencies can increase the level of collective action generated at the local level (Ostrom, 2004).

Smith (2012) states that resources can be managed more effectively when stakeholders are directly involved in the resource management. The members of the community tend to have knowledge and experience that the government and their organizations lack. Additionally, when the townspeople actively participate, they are more inclined to comply with the regulations. According to the federal Sustainable Fisheries Act (SFA) that amended the Magnuson–Stevens Fishery Conservation and Management Act in 1996, '*…conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of*

fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities'.

Through participation, there is direct involvement in the process of identifying a problem, developing a solution, applying the solution and assessing the results. This empowers the resource users with the ability to make their own decisions with the aid of other organizations and governments. The government's role is to provide legitimacy and accountability for local organizations and help develop collective action institutions such as community-based and co-management organizations.

The Priority Axis 4 of the European Fisheries Fund (EFF)

Priority Axis 4 of the European Fisheries Fund (EFF) represents a new departure for structural aid in the fisheries sector. This area-based approach was introduced into the EFF for the first time in the period 2007–2013 and reflects the complex and rapidly changing forces affecting fisheries areas and communities.

Axis 4 seeks to go beyond merely tackling the short-term effects of the economic, social and environmental consequences of the depletion of fish stocks. Its purpose is to enable fisheries communities to create new and sustainable sources of income and to improve their quality of life. It does this by empowering local people, those who best understand both the problems and the aspirations of fisheries communities—providing them with the tools and resources to develop and adapt solutions to meet their real needs ('bottom-up' approach).

The overall approach can be characterized by three main and interlinked strands:

(a) the territory or area;
(b) the group or partnership; and
(c) the integrated local development strategy.

Fisheries Local Action Groups (FLAGs) are the main drivers of Axis 4. These are the groups that:

- develop and implement integrated local development strategies—*STRATEGY;*
- approve or reject projects delivered under Axis 4—*DECISION MAKING;*
- provide the administrative support base for of Axis 4 delivery—*ADMINISTRATION*.

FLAG aims to achieve the following objectives

1. To enhance the economic and social prosperity of the areas concerned and to add value to fisheries products;
2. To maintain and support job creation in the areas concerned through support for diversification and the economic and social restructuring of areas facing socio-economic difficulties as a result of changes in the fisheries sector;
3. To promote the quality of the coastal environment.

FLAGs consist of a Board, made up of public and private partners from the various local socio-economic sectors, selected according to the principle of proportionality. Based in 21 EU Member States there are over 300 of these public–private partnerships, set up at local level, each managing a budget to support a range of projects proposed and carried out by a wide variety of local stakeholders.

The FLAGs Experience in the Algarve

Algarve is the only region of Portugal that has higher percentage of immersed area than onshore. According to Lopes and Cunha (2010), the immersed sector (offshore) of the Algarve Margin occupies about 2500 km^2 until the 200 m isobath, occupying the area between the 200 and 1000 m isobath about 6000 km^2.

The sector of fisheries and aquaculture, which has a reduced expression in the Algarve's total GVA (1.9% in 2008, a decrease of almost 21% compared to 1995), contributed, however, in 2007, with 25.4% to the respective sectoral GVA nationally. However, its relevance transcends the purely economic value, because of the social contours of some significance that it still assumes, being the Algarve the region at national level with the higher proportion of the employed population engaged in fishing/aquaculture/processing and marketing of fish products.

Fisheries and fish processing industry (the tuna capture in the Algarve coast goes back before the Roman occupation) have always been crucial economic activities with a strong tradition (at the beginning of the twentieth century, there were until 17 bluefin tuna traps released throughout Algarve's nearshore; the first factory built in Portugal for the conservation of fish, essentially tuna, was the 'Casa Parodi', based in Vila Real de Santo António and inaugurated in 1879, and in the first half of the past 60 decade, there were 60 active factories across the Algarve). There is no city, town or village of the Algarve coast that has not had originated in fishing or related activities. Portimao, Faro and Vila Real St º António are typical cases of cities of the Algarve where today there is still a significant impact of fishing activities on its social dynamics.

Regionally, predominates small fishing using boats under 10 m long. In 2009, there were 3241 licensed fishermen in the Algarve (18.7% of the national total), about a third of those recorded a decade ago, and 1862 vessels were registered by the port authorities of the Algarve (in 1992 there were 1923), of which 12% of this total were associated to Producer Organizations. The regional seine fishing fleet is active mainly in three ports: Vila Real de Santo António, Faro and Portimao, while the drag fleet recorded, to date, 126 units (−6.7% compared to 2006), dedicated to the trawling for crustaceans and fish, as well as trawl 'ganchorras' to capture bivalves. A small part of the fleet operates in Spain under the Guadiana fishing agreement between Spain and Portugal. In the Algarve, the fishing port of Olhão is the one with the higher amount of discharges in volume (54.3% of the regional total in 2010). On relation to the value of the fish unloaded, clearly stands out the port of Vila Real Sto. Antonio because of the discharges involving crustaceans (which have a relatively

higher commercial value comparing to most other species of fish), which are almost entirely made in this port and destined for the Spanish market.

We have been witnessing a progressive loss of importance of the catches done by the regional fleet in external waters, compared to the increase observed in national waters (CCDR Algarve, 2007). Fish production in the Algarve shows relatively low levels of productivity, on addition to a high inefficiency rate in catches. One problem that, besides the waste, alters the balance of ecosystems and is likely to have unpredictable consequences. According to the work of the research group Biopescas—'Biodiversity in fisheries', lead by the Centre of Marine Sciences (CCMAR), about 69% of the 900 different species, caught by the fishing gear in the Algarve region, are always rejected and 27% are often rejected. For example, the average values of bycatch and discards of fish below the legal minimum size or of species with no commercial value registered in the fishing seine fleet are between 20 and 30% of the total catch, about 5000–10,000 tons per year.

Due to the excellent natural conditions for oyster production in lagoon systems (Ria Formosa and Ria de Alvor) and offshore (e.g. juvenile fattening), the Algarve oysters have an excellent quality and reach commercial maturity at 1.5 years old, while, for example, in Brittany, one of the major producing regions of France, they take 4 years. The official production data (which clearly err by default) totalize currently 1000 tons per year (with the ability to achieve in the medium-term 4500 tons), of which more than half are absorbed by the demanding French market.

The Pilot Area for Aquaculture Production of Armona (APPAA), near Olhão (Algarve), located 2.5 nautical miles offshore has a potential production of 18,000 tons/year, i.e. more than twice the current national aquaculture production (which was 7987 tons in 2008). Currently, almost half of a total of 60 lots are already in production (the big majority to the production of shellfish, mostly mussels, but also oysters and scallops). Offshore aquaculture units are also installed in other areas of the Algarve—Vila do Bispo, Portimao and Lagos, and several other are being implemented, mainly with the financial aid of the Portuguese Operational Programme for Fisheries (PROMAR). Recently, the Portuguese government created another two areas for offshore aquaculture production comprising 70 plots (located in Aveiro, in the centre of Portugal, and in Tavira—Algarve). The next bet concerns fish production (e.g. sea bass, gilthead bream, sea bream, meagre and tuna).

Only in the 1994 began to revive the blue fin tuna catching in the Algarve. Tunipex, a Portuguese/Japanese consortium, installed a modern tuna trap in the APPAA, descendant of the ancient Arab almadravas. The tuna caught there, before being killed, are fed with mackerel in a cage adjacent to the trap for a period of 4–5 months to gain weight after spawning in the Mediterranean. The fish is mainly destined for export and has as major destination markets, besides Japan (where its meat is the main ingredient for sashimi, a kind of ham that takes algae or vegetables, and sushi), also the USA and South Korea. Due to the high commercial value of bluefin tuna (which in Portugal is sold at about EUR15 per kilo, but for the Japanese market easily reaches up to 50 Euros), in addition to this structure, there are two more in operation since 2011 to capture tuna (and meagre), located in the offshore of Tavira (Barril)

and Faro (cape St. Mary), both cases co-financed by the Portuguese Operational Programme for Fisheries (PROMAR).

In 2009, two FLAGs, designated 'Sotavento do Algarve' and 'Barlavento do Algarve', were approved to operate in the Algarve region, from a total of seven FLAGs implemented in mainland Portugal under the Priority Axis 4 of the Portuguese Operational Programme for Fisheries (PROMAR). The composition of their respective partnerships is shown in Fig. 6.

Since then, 51 projects representing more than 7 million Euros of total investment and that have generated 28 jobs (20 permanent and 8 temporary jobs) were approved within these two FLAGs (see Fig. 7).

Among the various possibilities of eligible measures for EEF funding, the Portuguese Authorities opted to choose the three measures listed below (Fig. 8) for the purpose of implementing their national strategy. The objective related with investments in alternative economic activities which 'strengthen the competitiveness of fisheries areas'—regardless of whether they are directly linked to fisheries or provide employment for fishers—and 'develop actions to add value to local fisheries and

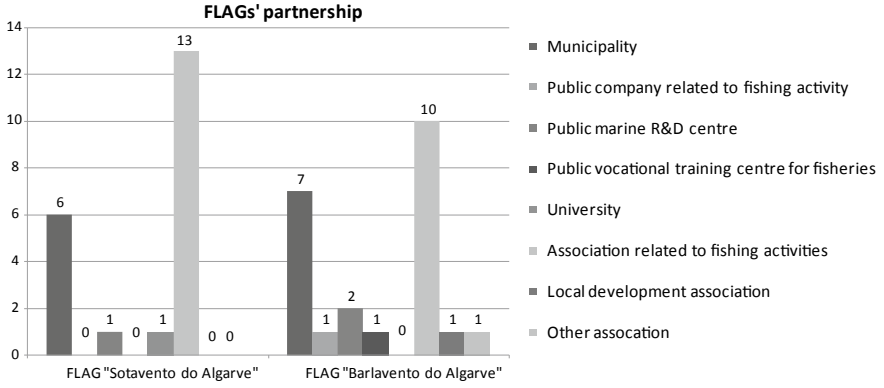

Fig. 6 Composition of the FLAGs' partnerships. *Source* Authors based on data from SI PROMAR

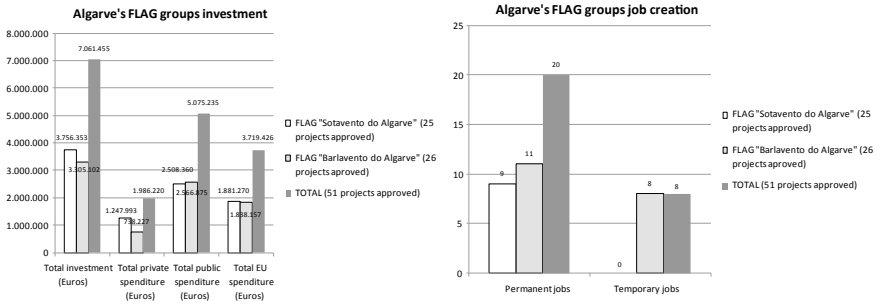

Fig. 7 Algarve's FLAG groups total investment and job creation. *Source* Authors based on data from SI PROMAR

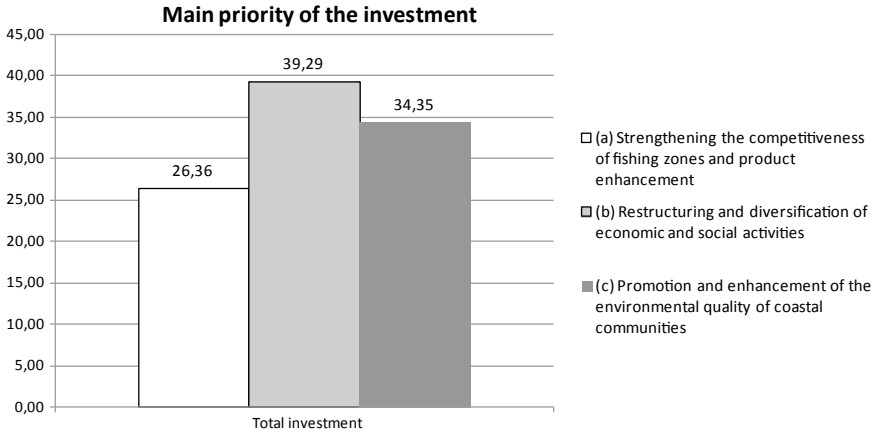

Fig. 8 Investment expenditure distribution in relation to Axis 4 main strategic objectives. *Source* Authors based on data from SI PROMAR

aquaculture products' is pursued by 49% of all investment projects, followed by the one concerning the restructuration and diversification of economic and social activities (31%). However, when we consider the amounts of investment expended (see Fig. 8) positions inverse and the 'restructuring and diversification of economic and social activities' (39% of the total investment) and the 'promotion and enhancement of the environmental quality of coastal communities' (34%) are the most relevant. One main purpose of the Axis 4 intervention, the 'Support for diversification', generally involves working to improve the linkages between fisheries and other economic sectors usually starting with activities closely related to fisheries and then broadening out.

On relation to the scope of the investments approved, the 'creation, restoration and modernization of structures, equipment and existing infrastructures that are within the development strategy, including small infrastructure related to fisheries and tourism' lead with 25 projects although they just represent a total investment of 1.861 million Euros, as displayed in Fig. 9, behind the 'restructuring and diversification of economic and social activities' which account for 39% of the total investment approved and the 'promotion and enhancement of the environmental quality of coastal communities' (34%). The latter two, concern to the physical and the human conditions required for sustainable development of those areas but they also permit local communities to organize their natural, cultural and social 'assets' in a way that creates economic opportunities and jobs at a later stage. However, in the first instance, these kinds of investments are generally 'premarket' or 'non-productive' and are mostly financed by public funds.

When we evaluate the type of investments carried out by the two FLAGs (Fig. 10), it clearly stands out the ones related to 'tourist activities and their support infrastructures' (with a 37% share of all projects). Many local strategies focus on tourism as a

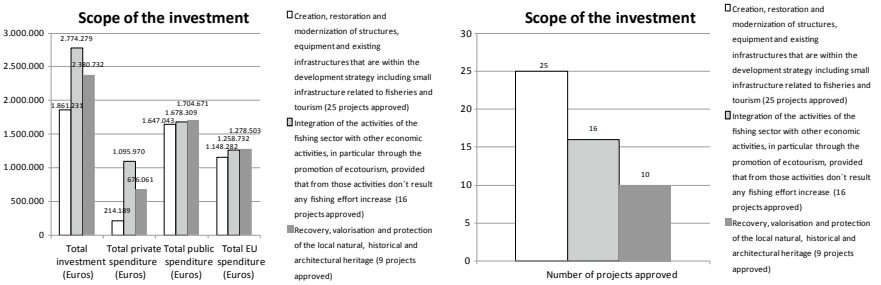

Fig. 9 Expenditure and number of investment projects approved by Algarve's FLAG groups on relation to the scope of those investments. *Source* Authors based on data from SI PROMAR

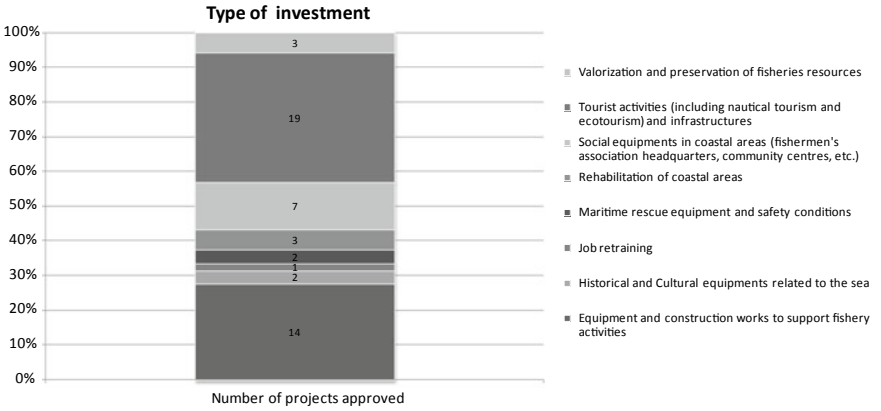

Fig. 10 Scope of the investment projects approved by Algarve's FLAG groups. *Source* Authors based on data from SI PROMAR

means to restructure and redirect economic activities like nautical tourism and ecotourism (mostly), but also local restaurants, markets, shops and other leisure activities that can both complement and have a strong multiplier effect on local fisheries. The second most relevant types are those concerning 'equipment and construction works to support fishery activities' with a 27.5% share.

Besides that, FLAGs have supported other types of activity both material investments, like, for example, protecting the environment, the requalification of fisheries areas and the promotion of safety conditions, revitalizing coastal hamlets and protecting and enhancing architectural heritage (e.g. signposting, thematic itineraries and paths, museums and interpretation centres, acquisition of maritime rescue equipment, rehabilitating historic buildings associated with fishing, cultural and social centres, preserving the areas' natural heritage, environmental services, etc.) as 'immaterial' investments to train local people, carry out research and make their assets known to a wider public (through the carry out of research on environmental, cultural and

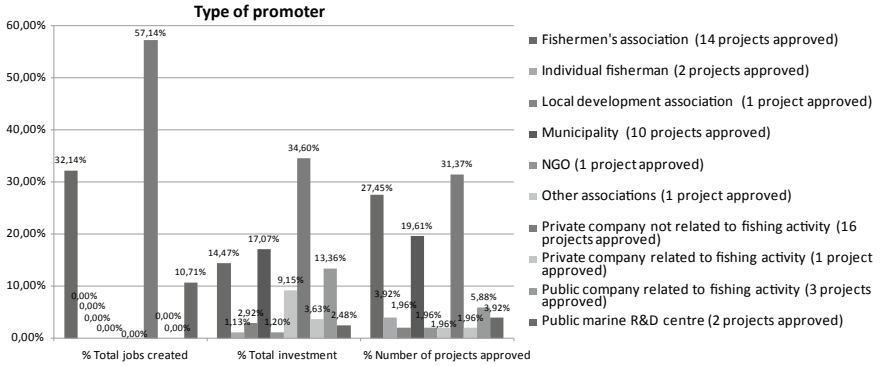

Fig. 11 Type of promoters responsible for the investment projects approved by Algarve's FLAG groups. *Source* Authors based on data from SI PROMAR

biological resources, such as valorization and preservation of fisheries resources, territorial marketing, generic publicity campaigns).

Concerning the type of promoter involved, we can observe (Fig. 11) the prevalence of 'private companies not related to fishing activity' in all the items analysed (16 projects approved, almost 2.5 million Euros in total investment and 31% of all the jobs created), seconded by the 'fishermen's associations' (14 projects approved, more than 1 million Euros in total investment and 9 jobs created). It is interesting to notice that public promoters (municipalities and other public institutions) are just responsible for 29% of the number of projects approved, for 33% of the total investment and only 11% of the jobs created.

As main observations arising from the evaluation carried out, we highlight:

(+) Some diversity among the investment projects approved;
(+) Adequate equilibrium of the approving rates of the two Algarve FLAGs, as well as in terms of the three thematic priorities established on their development strategies (competitiveness, diversification and environment, culture and society);
(+) Good acceptance by the promoters (number and amount of the investments carried out);
(+) Some dynamics on relation to job creation;
(−) The promoters linked to fisheries activities only represent about 1/3 of the output results (number of projects, total investment and job creation);
(−) The jobs created are excessively limited to three main types of investments. Besides tourism (mostly nautical tourism and ecotourism activities), the other two types have a short–medium-term ambit (coastal redevelopment works and R&D activities);
(−) Few projects concern adding value to fisheries products and the education/training of obsolete human resources (HR) dedicated to fisheries activities, understood as crucial aspects for the diversification and the economic and social restructuring of areas facing socio-economic difficulties as a result of structural changes in the fisheries sector;

(−) A very low percentage of projects are focused on education (of local young people) and job retraining (improvement of professional skills, worker adaptability as a way to facilitate the re-entrance in the employment market), which connects to the mentioned above;
(−) There is a lack of diversification into the new emerging sectors in fisheries areas and as well as their links to fisheries, for example, 'pesca' tourism (not yet regulated in mainland Portugal); 'green' products and services (including waste management, energy saving and alternative energy, …); 'smart' products and services (including uses of IT, creative and cultural industries, design, …).

Conclusions

1. The main advantage of bottom-up community-led local initiatives, like Axis 4, lies in their ability to mobilize additional ideas, energy and resources from local private, public and civil society actors, and to provide accessible and locally determined support. As main features we can stress:

    - Strategies are designed, and projects are selected by local entities so solutions can be tailored to local needs, facilitating the building of bridges and trust between people, private enterprises, public institutions and sectoral interest groups. People are no longer passive recipients of a policy but instead active partners and drivers of its development. This involvement brings a series of important benefits, such as the empowerment of local people to become co-producers of the solution; allows them to bring their direct experience to help on better adapting policies to real needs and opportunities; their involvement in the process increases their capacity to act and take constructive initiatives; this in turn induces a sense of local identity and pride as well as a feeling of ownership and responsibility.
    - The facilitation of linkages between sectors and actors in ways that have multiplier effects on local development and on the mainstream programmes. This can increase the effectiveness of policies and the reduction of context costs.

2. However still subsists:

    - A low percentage of projects are driven for adding value to fisheries products as a way to close the gap between fishing and consumers and to improve vertical links between actors at different points on the fisheries supply chain. There is a low impact in terms of maximizing synergies with other investments in processing and marketing supported, for example, under Axis 2 of the EFF, which is considered a very important way to absorb part of the obsolete HR discarded from fisheries.
    - The promotion of innovation and the induction and adoption of innovation processes by local promoters appear to have been in some way neglected. Still

fall short important aspects like: building the capacity and resources of local communities to take innovative initiatives; promoting small-scale investments in infrastructure that are pre-conditions for innovation and enhancing an adequate transfer and use of knowledge spillovers to 'fertilize' the experience of users with the specialized knowledge of different types of providers; financing small 'seed' and pilot projects required to test these out in practice.

As a contribution for FLAGs' future local development strategies for EMMF funding in the next Programming Period 2014–2020, we emphasize the following aspects:

1. Better understanding of the fisheries communities' economic system and cultural values.
2. Reinforce the integration between fishing (and within the fisheries supply chain) and other economic sectors or aspects of local life, including 'smart, green and inclusive growth' sectors that are recommended in the proposed new strategy for Europe 2020.
3. Strengthen the dimensions of organization and capacity building—for instance, where no local fisheries organization exists, or better channels of communication are needed, either among local fishermen or between fishermen and private and public organizations, the FLAG can play a important role.
4. Local 'engineering' for larger scale investments. Regardless of the extent or efficiency of fisheries organizations, the FLAG can carry out a series of 'soft' activities supporting or priming the pump for larger scale actions. These may be supported by the other axes of the EFF, or through other EU or private funds.
5. Clarify FLAGs's governance guiding principles and goals, both conceptual and operational.

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Land Use, Economic Landscape, and Regional Intelligence

Infrastructural Projects and Land Use Conflicts in Developing and Developed Countries: A Study Based on Comparative Review of Literature and Different Case Studies

Muazzam Sabir and André Torre

Introduction

Social and environmental impacts of land use change especially construction of infrastructural projects like dams and conflicts due to such projects have always been under heated debate by researchers around the globe. Under hydropower projects, these debates include mainly ecological impacts (Moran, 2004), administrative decisions and inclusions of all stakeholders, resettlement and livelihood, cultural life of communities and different conflicts among different stakeholders over land and property rights (Sabir, Torre, & Magsi, 2017). Several studies on big projects like dams emphasized different conflicts depending upon region and geographic conditions including protestation, legal action, threatening and road blockage, use of police force and death of affected people (Awakul & Ogunlana, 2002; Swain & Chee, 2004). Although projects like dams are in greater interests of society, they are opposed at local level due to their undesirable impacts on land rights and ownerships, inappropriate behavior of certain actors which marginalize others and can result in violent conflicts (Magsi & Torre, 2013).

Different land uses are so integrated with each other that actors cannot reduce their activities to single use without consequences for others leading toward conflicts. Land use conflicts appear as the result of dissatisfaction of one part of population with actions taken by their neighbors, private organizations or public authorities (Torre et al., 2014). Land use planning decisions have potential of generating conflicts due to negative impacts on environment and community (Kaya & Erol, 2016). Infrastructural projects have negative impacts in different forms like social, economic and environment depending upon the nature of project, geographic conditions and

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actors and generate conflicts. These conflicts also vary in intensity and expressions and mainly based on land acquisition, violation of property rights, resettlement and livelihood and environmental degradation.

Construction of dams becomes the need of a country during industrialization and development to fulfill the increasing demand for energy. However, these projects are also the source of conflict between different stakeholders (Swain & Chee, 2004). In developing countries, infrastructural projects like dams contribute to economic and social development as agriculture is the main economic activity, but such infrastructural projects force people to migrate from their lands and lead to dependencies among households, poverty and low living standard (Magsi, 2012). Affected population from such kind of infrastructural projects belong to remote areas or rural areas who have only rural skills which may not be of any use after displacement (Moran, 2004). Compensations and livelihood, displacement and resettlement are major issues causing tensions and conflicts due to infrastructural project (Oppio et al. 2015; Sun, 2013; Williams & Porter, 2006) which led to landlessness, unemployment and social disorder (Brown, Tullos, Tilt, Magee, & Wolf, 2009).

Large dams also has environmental impacts although there is an increased pressure from environmental legislation, i.e., the Kyoto Protocol on all governments to generate clean energy. Larger the hydropower project greater will be the adverse impacts on river ecology, riverside community, etc. Adverse ecological and environmental impacts include loss of ecosystem, biodiversity and architectural heritage, hindrance to fish migration, greenhouse gas emission and reduced delivery of sediments to sea (Moran, 2004; Sun, 2013; Williams & Porter, 2006). A massive damage to environmental conditions exists due to such kind of projects which cause conflicts among concerned stakeholders and project managers. Different dimensions of conflicts due to such projects exist including behavioral differences and varying expectations among different stakeholders (Awakul & Ogunlana, 2002), difference in local values and traditions and social and cultural differences among different stakeholders.

The goal of this article is to assess the main resemblances and differences between infrastructural projects and subsequent land use conflicts in developing and developed countries, based on comparative literature review and studies about two case studies. For the purpose of identification and analysis of conflicts and their impacts, secondary source of information is used. This source includes national and regional dailies, previously published literature on land conflicts especially related to infrastructural projects and other literature published by public and private organizations. It mainly deals with different conflicts related to land use and their social, economic and environmental impacts and goes into the literature of previously conducted studies of land use conflicts. It further discusses two case studies: one from developing country—"Bhasha dam project, Pakistan"—and other from developed country—"Sivens dam project, France." Then, it selects the main issues and conflicts discussed in the literature. The study analyzes the different socioeconomic and environmental impacts with respect to selected case studies and goes deep to examine the individual and common issues leading to conflicts in both developing and developed countries.

Finally, the article concludes the analysis and also provides policy measures and recommendations for better governance and conflict resolution in both cases.

Literature Review with Respect to Different Case Studies

This section deals with land use conflicts due to different projects, especially conflicts related to infrastructural projects and their impacts on different actors. A selected literature is discussed below, first from developing and then about developed countries.

Lessons Drawn from Different Examples in Developing Countries

Land use change due to different projects—especially due to big infrastructures—brings conflicts and has severe negative impacts on local population. Such local population is mainly residing in rural areas and low income, illiterate and related to farming business. People suffer from negative impacts and conflicts due mainly to land rights, compensations, resettlement and loss of employment opportunities and corruption and mismanagement in project activities.

Several case studies have been conducted on land use conflicts due to developmental projects. Land compensations are considered as the main source of conflict in infrastructural projects. No proper compensations and violation of compensation rights are highlighted in case of Chotiari Reservoir Pakistan, where compensation was based on the link with local landlords and some people also deprived of compensation who denied due to low land rate (Magsi & Torre, 2012). More than 3080 families lost houses directly or indirectly in case of Pak Mun dam Thailand and about 10,000 people in case of Bakun dam Malaysia have been displaced. In case of Bakun dam lower compensations, no compensation in case of refusal and use of police force is seen (Swain & Chee, 2004).

Many studies emphasized that the provision of compensation should improve the well-being of affected people (Moran, 2004; Magsi & Torre, 2014). Land quality becomes a major issue when the government provide compensation in the form of land to those whose profession was agriculture (Sun, 2013). Another fact is related to legal rights to land which the majority of the population in developing countries do not have and compensation goes to only few households or landlords (Flood, 1997; Moran, 2004). Compensation for land can be of any type, i.e., monetary compensation and/or land for land or both, etc. In fact, provision of compensation is emphasized in

many ways (Hui, Bao & Zhang, 2013) like social security, monetary compensation and employment alternatives, etc. (Qian, 2015). Moreover, even after the compensation payment most of the people are unable to handle the sum (Moran, 2004) and many people will lose the compensation amount in daily household expenditure or other activities.

Social and economic instability is the most important consequences of displacement and resettlement in developmental projects. Involuntary resettlement issues and negative sociological impacts of large dams are highlighted in some studies (Bui, Schreinemachers & Berger, 2013; Williams & Porter, 2006). Local affected people migrate not only during the construction but also after construction like people who live near the project area due to extreme weather and landslide (Sun, 2013). An acceptable resettlement program should appear necessary for better socioeconomics of local people, whereas resettlement plans fail to reflect the desires of affectees normally due to the hidden interests of land managers (Magsi, 2012). But national resettlement policy is absent in most of the developing countries creating land use conflicts and property rights violations.

Large projects like dams leave a large number of unskilled farm workers unemployed after they are displaced from their lands which could lead to social disorder (Brown et al. 2009). Less than half of the migrants can keep their original profession. Construction of the dam creates employment opportunities which are temporary and diminishes after the construction (Moran, 2004; Sun, 2013). In some cases, the government can arrange job opportunities for local people which are not according to their requirements. People who get cash compensation try to invest in business or land transactions and in most cases lose the compensation amount. This business investment depends upon their awareness to invest and needs training in this sector (Sabir et al., 2017).

Land right conflicts are also significant along with the compensation and livelihood and are of different types and among different actors. These conflicts are mainly due to land acquisition and violations of property rights. Land acquisition act in developing countries like India, Pakistan and Bangladesh cannot be challenged and affected people can challenge only compensation (Awasthi, 2014). Land right conflicts are not only between government and affected people but also among different groups of affected people based on ethnicity and historical settlements which gives the right to specific group. This historical inequality which disadvantages specific group is a source of conflict (Marx, 2016; Sabir et al., 2017). Rural communities most of the time do not have legal rights to lands leaving them without compensations. Tenure reforms involve biasness and favoritism and fail to protect informal land rights (Rigon, 2016).

Unfair allocation of formal land and lack of formal allocation of land are the main sources of land conflicts due to political favoritism and mismanagement (Admasu, 2015). Majority of the landowners are illiterate and socially inefficient because of which some of the stakeholders create fake ownership for compensation benefits (Magsi & Torre, 2013). Mismanagement, cronyism and corruption raise tensions and conflicts (Magsi & Torre, 2014; Swain & Chee, 2004), as World Commission

on Dams already criticized that accountability of government showed corruption, embezzlement and inequality of benefits (WCD, 2000).

Hydropower literature suggests that larger the hydropower project is more the adverse effects to river life, riverside communities and downstream impacts will be (Williams & Porter, 2006). Negative environmental and ecological impacts of large dam include GHG emission, obstruction to fish migration, deforestation, seepage and water logging, etc. (Magsi & Torre, 2012; Moran, 2004; Sun, 2013) which demands attention for better impact assessment and management. Moreover, one of the major issues which are a significant source of tensions and conflicts mentioned above is a lack of participation of all stakeholders in decision-making process. Several studied highlighted the participation of all actors in decision-making lack of which lead to severe conflicts (Diduck, Pratap, Sinclair, & Deane, 2013; Mahato & Ogunlana, 2011; Patel, 2016; Swain & Chee, 2004).

Lessons Drawn from Different Examples in Developed Countries

Land use conflicts are not just restricted to developing countries but also exist in developed countries depending upon land use change, interests and characteristics of actors. Acquisition of land is the beginning of several land use changes and is used by both government and private investors in order to control the land use (Obidzinski, Takahashi, Dermawan, Komarudin & Andrianto, 2013). Land acquisition is a complicated and opaque process, with national and sometimes territorial peculiarities, as different types of stakeholders with different interests are involved under the social, economic and political framework where knowledge about land acquisition becomes compulsory to understand and influence the land use (Van Assche, Beunen & Duineveld, 2014).

Several public or private actors are bringing the land use changes, and governments take land management measures for different purposes which also face substantial resistance from land managers (Rouillard, Reeves, Heal & Ball, 2014). For example, Scotland supports the uptake of rural land management measurements as a part of European flood risk management reforms (Spray, Ball & Rouillard, 2010; Rouillard, Heal, Reeves & Ball, 2012). However, these measures face much opposition not only due to few evidences of the effectiveness of land management measures (Wilby, Beven & Reynard, 2008) but also their socioeconomic impacts mainly on agri-businesses (Kenyon, Hill & Shannon, 2008; Posthumus, Hewett, Morris, Quinn, 2008). Land transactions started by powerful stakeholders like Governments involve interrelations among different stakeholders and activities which influence the behavior of landowners. Knowledge about land transaction is important for understanding and influencing the land use pattern (Broekhof, Beunen, Marwijk & Wiskerke, 2014).

Several land use activities and projects are responsible for conflicts in developed countries. Most of all, natural and agricultural landscape are at stake, especially

in peri-urban areas, where the development of large infrastructures is needed for the sake of urban dwellers. These areas are being devoted to urban developmental projects which upset not only the agrarian landscapes but also the social structures (Murdoch & Abram, 1998). Moreover, farmland use conflicts and their dependence upon the dynamics of territorial governance mechanism in metropolitan rural areas are also highlighted (Darly & Torre, 2013). Every year about one million hectares of land in Europe which is natural or being used for agriculture is transformed into a built area (Nilsson & Nielsen, 2008). Moreover, increasing number of conflicts over farming practices in Canada are also highlighted which come from change in practices, increasing number of large-scale production units and use of resources. Changing trend in social and economic structure of rural communities is a significant source of conflict (Owen, Howard, Waldron, 2000). This brings opposition among different activities like agricultural, residential and industry and also among different socioeconomic or interest groups like farmers, developers and residents (Henderson, 2005; Zérah, 2007).

Land use change especially related to development projects has immense importance for the well-being of the society but also carries heavy cost in the form of socioeconomic impact on affected community and generating conflicts. Such projects most of the time create opposition with local affected people, and there is always a problem with their social acceptance. Buchholz, Rametsteiner, Volk and Luzadis (2009) highlighted that the sustainability of bio-energy systems mostly relies on the support of many stakeholders with different perspectives in several dimensions including social, economic and environmental. In fact to carry on the acceptability with development is a complicated process. Moreover, according to an international energy expert group there exists no holistic approach for social acceptance of any project, however, which is dependent upon several practices combined (Huber & Horbaty, 2010).

Land use planning decisions are often felt on the basis of participation of few interest groups, which may become a source of conflicts due to lack of information and public participation (Mann & Jeanneaux, 2009). Several studies emphasized the consideration of all stakeholders during infrastructural project activities (Slee et al., 2014; Rouillard et al., 2014; Tilt, Braun, & He, 2009), but unfortunately, the perspective of planners is different. Partial advice and lack of information always created project opposition which has comprised economic and social opportunity wrinkled the trust in local government leading toward social unrest and conflicts. Moreover, social learning of participants is also encouraged if the process involves debate on nature, participant's knowledge, understanding and beliefs and how to question them (Rouillard et al., 2014).

Selected Case Studies

Sivens *Dam Project France*

Sivens dam project was visualized in 1969. In the early twenty-first century, the irrigation needs for agriculture especially for corn increased. The dam promoters said that it will benefit the high-value crops by providing them irrigation. In 2003, the water agency of Adour Garonne (AEAG) approved the plan. The dam was supposed to be 315 m wide, and its cost was €8.4 m financed publically (The Economists, November 8, 2014). Many technical studies of this project were conducted. To compensate the flooding of wetland area, CACG (the land settlement company for area of Coteaux de Gascogne) proposed to restore the 19.5 ha of wetland elsewhere. In response, an environmental association "Collectif Tester" emerged to protect the wetland threatened by Sivens dam. The opposition of the dam said that the wetland area is home to 94 species which will be destroyed and it will benefit a few farmers (The Guardian, October 31, 2014; RFI, October 27, 2014).

Several experts in 2012–13 evaluated the impacts on aquatic media and nature and raised questions on the relevancy of wetland compensation measures. After issuance of building permit in 2013, site occupation was started by nationwide activists called "Zadists." Riots squad was also sent on the request of local authorities. Violence between authorities and opposition party became routine and ended up on the death of an activist Remy Fraisse on October 25, 2014, which was first death after 1986 during a protest in mainland France. After that the work on the project was stopped (The Guardian, October 31, 2014). Government froze the project on 31 October, gave it up on December 4, 2015, and in 2016, the state court canceled the whole procedure.

A very limited interaction between all stakeholders and authorities' will to build the project at any cost was seen during this project. Stakeholders' involvement in project activities was limited to few actors and a few local elected officials supported by a lobbying group, manufacturing companies with the support of major national developer and a few farmers stating that they have no water forced through project and a dam (Pelletier, 2015). Feasibility studies regarding geomorphology, climate and urbanization were conducted with point of view of developer, i.e., CACG and was presented to Tarn council which approved the project and issued building permit. Public opinion was demanded for duration of 5 weeks, but local contest grew which attracted other contesters from all over France. Administrative court rejected the questions raised during public inquiry and authorized the project building to start. The contesters decided to prevent the work progress by occupying the site, faced several expulsions by police. Demonstrations were fought violently by riot squads which resulted in death of an activist with a concussion grenade (Roth, Gerbaud, Boix & Montastruc, 2017).

Diamer Bhasha *Dam Project Pakistan*

Diamer Bhasha dam project is located at the boundary of two provinces in northern Pakistan "Gilgit-Baltistan" and "Khyber Pakhtunkhwa." Diamer is a district in Gilgit-Baltistan, and Bhasha is a village of district Kohistan in Khyber Pakhtunkhwa. Almost all the project activities are located in the Diamer district, while Bhasha village contributes a small portion of land (Pakistan Bureau of Statistics, 2016). Total number of households in the area includes 12,039 in which directly affected households are 4228 dispersed in 32 villages in the form of different ethnic groups, local traditions and values (Sabir et al., 2017).

The project's estimated cost is US$13.684 Billion approved in July 2012, and "Water and Power Development Authority (WAPDA)," Pakistan, is the main agency carrying out this project (Dawn, 2006, April 27). The construction of the project has not started yet. The project on its completion has significant benefits in electricity generation and irrigation water storage, but construction of project has not started yet. In spite of importance of this project, there are disadvantages in the form of displacement of local people and their other socioeconomic losses. Thirty-two villages including 4228 households are going to be displaced due to this project, affecting seriously the livelihood and ultimately living standard of affected people. It will submerge about 2660 acres of agricultural land (GOP, 2014).

There is much opposition among different actors expressed in different forms like legal action, road blockage, threatening the contractors to bulldoze the infrastructure (Pamir Times, October 22, 2015; Mir, June 14, 2012) and death of three people protesting for compensations (GB Tribune, February 19, 2010; Mir, June 14, 2012). There had been severe conflict due to low land compensation rates. These compensation rates are, however, negotiated leaving behind the satisfaction of local people, and rates are accepted with a fear of further clash with government. Further conflicts are seen over corruption and mismanagement in land measurements and land category manipulations. Moreover, conflicts have also grown among different groups of local people on land rights and ultimately compensations from them based upon early settlers (owners) in this area are eligible for compensations and other (non-owners) are not according to local tradition. This conflict is on compensation from public lands which the government obliged to pay according to local law and also respects the local tradition.

A part of these conflicts, some negative impacts of the projects originated from improper resettlement plan and employment opportunities, out of culture resettlement and ineffective capacity building programs. Lack of information dissemination and participation of all stakeholders in nearly all project activities is absent which is a significant reason for conflicts in this project and negative impacts on the local population.

Major environmental impacts of the project include loss of 50,000 trees, depletion of fish stock, contamination of Indus water through a discharge of sewage (Singh, 2012), destruction of animal habitat and wetlands (Dawn, November 17, 2008).

Moreover, it will also impact 33,000 prehistoric rock carving in this area which is one of the rarest sites in the world with such big number of rock carving.

Discussion: Major Issues and Solutions in Developed and Developing Countries

Land conflicts due to infrastructural projects like dams are common in both developing and developed countries. Conflicts are almost built-in phenomenon in the scenario of land use change. They appear in different forms and expressions depending upon territory involved, uses of land and characteristics of actors (Torre et al. 2014) and vary from tensions to violent oppositions. Such conflicts are mainly based on land and property rights, socioeconomics and environmental degradation depending upon geographical conditions and characteristics of actors involved. Whatever the different dimensions of conflicts appear, they are born due to disagreement among two or more parties due to certain elements. Different types of elements are involved in conflict generation which could be common and different in both types of territories.

Land use activities are the source of conflicts among different actors in different ways, including geographical disagreement, superposition of interests and environmental hazards. These conflicts specifically related to infrastructural projects appear in different ways depending upon their intensity and have worse impacts on the affected population. Keeping in view, the case studies and relevant literature discussed above three issues are summarized which can be considered as the main sources of conflicts and under which different conflicts are discussed and analyzed.

Environmental Issues and Compensation Measures

Construction of infrastructural projects like dams is related to many significant environmental problems including inundation of landscape, water diversion and interruption of fish migration (Truffer et al., 2003). Mitigation measures like "fish passes" which allow fish to pass from lower part of the dam to reservoir part are managed in most of the dams in Europe like Norway included these measures while ignored in some countries like in case of Ilisu hydroelectric dam in Turkey (Moran, 2004). Most of the projects in developed countries take environmental consequences of big infrastructures seriously and lowering the environmental impacts is also one of the main agendas like hydrowind power plant in El Hierro in the Canaries (Roth et al., 2017). Significant awareness is seen about environmental issues in these countries and ignoring them could lead to violent conflicts.

Environmental impacts are also highlighted in developing countries, where environmental impact assessment is ignored (Magsi & Torre, 2012), and in some cases, they violate the guidelines about environmental assessment given by international

organizations like World Bank (Moran, 2004). Several studies emphasized the environmental and ecological impacts of large dams like reduced delivery of sediments to sea, loss of diverse ecosystem and greenhouse gas emission (Williams & Porter, 2006). Moreover, loss of architectural heritage and geological hazards are also significant losses of large dams (Sun, 2013) along with destruction of forests and wildlife.

In case of Sivens dam, the environmental association opposed the project to protect the 12 ha of wetland area which is home to 94 species. Several technical studies were conducted, and it was suggested to restore the wetland area of 19.2 ha elsewhere, but the opposition of the dam argued that it will destroy the wetland area and benefit only a few farmers. In September 2014, the clearing of riverside bushes and trees started and violence became routine between authorities and dam opponents which ended up on death of an activist. In 2016, the state court canceled the whole procedure. In case of Diamer Bhasha dam project, the government agency "Water and Power Development Authority" (WAPDA) estimated the environmental loss of 50,000 trees, wildlife and fish stock depletion, wetland and animal habitat. Most importantly, the cultural heritage impact of Diamer Bhasha dam project impacts on prehistoric rock carvings which are 33,000 in number. Environmental management strategies are claimed to be prepared on international standard mainly according to safeguard measures of expected donor agency "Asian Development Bank" (ADB). However, there are several concerns and reservations of local social workers and international organizations like ADB over these measures and their implementations. There is a lack of awareness of environmental issues and importance among most of the stakeholders.

It appears that infrastructural projects like dams have negative impacts on environment in one way or another and need attention for better management. Tensions among various actors and resistance to the project due to environmental impacts depend upon the regions, actors involved and their interests, awareness and capacity to influence the decision making on the basis of their knowledge. Conflicts in developed countries like in the case of Sivens dam projects were on the basis of destruction of wetland area where the opposition party was a group of environmentalists who were well aware of the impacts of the project. Failure to satisfy the concerned stakeholders on the feasibility of Sivens dam project by the government led to violent conflicts. In case of Bhasha dam project, several environmental impacts are observed like deforestation, submergence of prehistoric rock carvings and depletion of fish stock, wildlife and animal habitat. In spite of several concerns over environmental management strategies, no significant opposition over environmental impacts was seen. Local stakeholders lack the awareness, knowledge and importance of environmental preservation, and more importantly, they are significantly going through conflicts over resettlement and livelihood impacts.

Socioeconomic Issues and Land Conflicts

Socioeconomic issues are considered very sensitive in case of infrastructural projects which depend upon several project activities. These affect directly or indirectly the living standard of the affected population. Land acquisition, land rights and compensations are significant issues in both developing and developed countries, whereas resettlement and livelihood issues are prominent in developing countries, mismanagement of which could lead to worse impacts on local people and conflicts. Inappropriate compensation measures led to violent conflicts in case of developed countries as well (Roth et al., 2017). Several studies in developed countries discussed the severe socioeconomic impacts due to land management measures including land acquisition (Kenyon et al., 2008; Posthumus et al., 2008; Van Assche et al., 2014; Spray et al., 2010).

In developing countries, land compensation is a source of conflict mainly in the form of less or no compensation (Flood, 1997), favoritism toward selected people (Magsi, 2012) and threatening the local people to stop protests (Swain & Chee, 2004) due to which people even hesitate to take legal action (McMichael, 2016). Ineffective resettlement plans due to delayed or out of culture resettlement or in general against the desires of local people cause landlessness around the world in such kind of infrastructural projects (Scudder, 2005; Dams & Development, 2000). Moreover, loss of permanent employment and worse livelihood is another drawback of these projects (Moran, 2004; Hui et al., 2013) which could lead to unemployment and social disorder (Brown et al. 2009). Such projects in developing countries are most of the time in tribal/remote areas where local people are illiterate and lack the awareness to use and properly invest the compensation amount. Due to ineffective resettlement plan, people try to migrate and settle in other developed areas and lose the compensation amount in land transactions. In some other cases in developing countries, local people also lost the compensation amount in luxuries lives (Qian, 2015) or in business investments.

Land conflicts appear in different forms in case of land use change including big infrastructures in both developing and developed countries. Use of agricultural and natural land for developmental projects (Murdoch & Abram, 1998; Nilsson & Nielsen, 2008), urban sprawl, insufficient measures for restoration of natural areas and biodiversity are prominent sources of conflicts in developed regions (Roth et al., 2017). Whereas issues like lack of legal rights of lands (Anaafo, 2015; Flood, 1997; Lombard, 2016), political favoritism to specific stakeholders and mismanagement (Admasu, 2015; Zhu & Simarmata, 2015) are seen prominently in developing countries. Tenure reforms also fail to protect the land rights under informal settings (Rigon, 2016) and structural and historical inequalities among different groups of stakeholders also emerged as major source of conflicts (Marx, 2016).

In case of Diamer Bhasha dam, three people died and several injured while protesting for land rate compensations. Several flaws are found in resettlement plan of Bhasha dam where disputed land for construction of model villages and delayed resettlement is prominent. Design of model villages is not also according to local

culture. People lost the compensation amount during resettlement in other more developed areas for better economic and educational opportunities for their children. In order to resolve conflicts, Kaya and Erol (2016) suggested focusing on local people's exact interests rather on symbolic benefit. Several employment opportunities are claimed by the government including capacity building programs for local people. These capacity building programs are devoted to lower category jobs but people with cash compensation in hand prefer to invest in business. In fact, some of the people lost the compensation amount in business investments in case of Bhasha dam project (Sabir et al. 2017). Further, there are several conflicts related to land in case of Bhasha dam including less land measurements and manipulation of land category due to mismanagement and corruption (Singh, 2012). Another significant conflict is on land right and ultimately on compensation among "owners" and "non-owners" due to their historical settlements. The project is still under consideration where its land acquisition has almost completed, but construction is delayed mainly due to conflicts and lack of funds.

Tensions and conflicts due to socioeconomic impacts are significantly observed between directly affected people and Government authorities in developmental projects in different types of countries. Land acquisition, compensation, resettlement and employment opportunities are significant issues in big projects like dams, mainly due to poor planning, mismanagement, corruption and cronyism. Projects in developing countries like Bhasha dam project contain most of the problems mentioned above. There are tensions and conflicts over resettlement and employment where land acquisition and compensation issues created violent conflicts. Poor planning, corruption and mismanagement are major reasons which served in conflict generation. Sivens dam project suffered from violent conflicts which even led to the death of a protester but these conflicts are mainly based on the ecological impacts of this project.

Public Participation and Information Dissemination

Complete information dissemination and involvement of all stakeholders in decision-making process are directly related to conflict resolution (Lombard & Rakodi, 2016). Public participation always offers a chance to the affected people to express their preferences and leads toward fair decision making. Moreover, participation in decision making also builds trust among all stakeholders, avoids social unrest and diminishes tensions and conflicts. Ignoring the public participation as a whole or even partial information dissemination and public participation could lead to mistrust over government, social unrest, loss of economic opportunities and conflicts (Diduck et al. 2013; Hoogester, Boelens & Baud, 2016; Li, 2015; Magsi & Torre, 2012; Mann & Jeanneaux, 2009; Slee et al. 2014; Vignon & Lecomte, 2004). In short, public participation is of great importance (McMichael, 2016; Patel, 2016) and considering all stakeholders in decision making right from the start of the project help in resolving

the conflicts (Huber & Joshi, 2015; Magsi & Torre, 2015). However, public participation is criticized in some ways like lack of guidance on best practice (Carr, Blöschl & Loucks, 2012; Cooke & Kothari, 2001; Innes & Booher, 2004; Reed, 2008), where the evaluation of participatory programs are emphasized whether they are achieving the desired objective and to improve them accordingly (Carr et al., 2012). Collaborative participation is also highly emphasized (Innes & Booher, 2004), and it was argued that stakeholder's participation needs to be supported by empowerment, equity, trust and learning (Reed, 2008).

In case of Sivens dam project, very limited participation of all stakeholders is seen and authorities were determined to construct the dam at any cost, at the expenses of people protestations. The political will was only up to Tarn department council and they were collusive with the developers in the project initiation and selection. However, in some developed countries like Germany Public participation under the factors like accommodation of interests and conflicts resolution showed significantly positive results (Drazkiewicz, Challies & Newig, 2015). In case of hydrowind power plant in El Hierro in the Canaries, the project proved to be a success in terms of stakeholders' involvement, public opinion, political choice and support to local culture. In case of Sivens' dam project, another developmental vision was brought by ignoring the local culture. Compensation measures for restoring the wetlands were proposed two times but could not satisfy the stakeholders and opposition grew stronger. Hence, even if the legal rules about participation were applied, the process was not participatory enough and did not fit the society's will, the conflicts kept on rising which ended up on death of an activist.

In case of Bhasha dam project, the government claimed that the project was introduced to all stakeholders in the form of seminars, workshops and cadastral surveys. Local people, especially notables from the region, participated in different project activities, including land compensation decisions. Moreover, a national consensus for Diamer Bhasha dam was reported according to which all the provinces voted in favor of the project. However, public participation is still questionable in some dimensions, like participation in all project activities and participation of all stakeholders. Local people especially lower caste and non-owners were ignored in participation in several important project activities, which is one of the major reasons of tensions and conflicts in this area. Such project activities include mainly measurement of land, land category decisions, land rights decision on the basis of historical settlements of different groups of local people and land compensations. The subsequent conflicts are in the form of legal actions in the court, threatening the contractors and also death of some people while protesting for land compensations (Sabir et al., 2017).

Participation of all (groups of) stakeholders and proper information dissemination about all project activities are highlighted by several studies as conflict resolution or conflict avoiding mechanism in many ways. Studies from both developing and developed countries emphasized that ignoring public participation lead to violent conflicts. In case of Sivens dam project, conflicts on ecological issues were violent where participation of stakeholders opposing the project was ignored. Later even partial advice with them to restore the wetlands could not satisfy them which jeopardize the conflict resolution process and led to the death of a protestor. In case of Bhasha

dam project, proper information dissemination and participation of all stakeholders in all project activities were ignored and considered as major reasons of conflicts. Poor planning, mismanagement, corruption and cronyism were observed in several project activities like land acquisition, land compensation decisions, resettlement and employment opportunities, where no information dissemination, partial advice or in some cases no participation of stakeholders at all were also prominent.

Conclusion

Infrastructural projects like dams are vital need of the time in order to overcome the energy and water shortage problems. Such projects bring also, along with them, economic opportunities and put the country on the path of progress. But they also carry some heavy costs depending upon different regions and under different conditions in the form of environmental, social and economic impacts. Environmental losses include loss of forests, wildlife and fish stock depletion, wetland and animal habitat and more importantly the destruction of cultural heritage. For directly affected local people the socioeconomic issues include living standard, resettlement, employment and livelihood and property rights. Such issues create tensions and conflicts among various actors, which could take several expressions depending upon different region and conditions in the form of legal actions, bringing the matter to the notice of the public authorities, mediatization (bringing the matter to the attention of the media), assault or verbal confrontation, putting up signs and even in some brutal cases death of people (Torre et al., 2014).

Sivens dam project is an example of conflicts between authorities and opposition of this project on protection of 12 ha of wetland, which was according to them inappropriate both financially and economically. In spite of many technical studies to compensate and restore the wetland area the opposition against the project increased. Compensation measures for restoring the wetlands were proposed two times but could not satisfy the stakeholders and several experts raised questions on wetland compensation measures. Violence kept on increasing between authorities and opposition party, which ended up on death of an activist. Government froze the project, and ultimately in 2016, the state court canceled the whole procedure.

Diamer Bhasha dam project is facing much opposition, and there are several conflicts on different issues related to land rights and socioeconomics. There has been a lot of mismanagement and corruption in land measurement and land category decisions. Conflicts over land rights among different groups of local population mainly "owners" and "non-owners" on the basis of historical settings are also prominent. Moreover, there had been severe conflicts on land compensations. Ineffective resettlement plan is the cause of landlessness of many affectees. Such conflicts have different expressions like legal action in the court, road blockage, threatening the contractors and death of three protestors while protesting for compensations. Several employment opportunities are claimed on the project site for which capacity building programs are arranged. A lot of questions are raised over capacity building

programs which are devoted to lower category jobs and several people lost compensation amount in business investment. People needs proper education and training and lifelong compensation model and insurance must be considered in spite of one-time compensation model (Li, Huang, Kwan, Bao, & Jefferson, 2015). The Diamer Bhasha dam project is still under examination and the land acquisition has almost completed where dissatisfaction over land compensations and conflicts over land rights are still there along with corruption, mismanagement and cronyism in resettlement and livelihood activities.

Our paper reveals that land use conflicts exist in both developing and developed countries in different forms and among different stakeholders over disagreement among two or more (groups of) stakeholders. Several land use changes and land management measures are carried out in both types of countries which become the source of conflicts, sometimes violent, over social, economic and environmental terms including farming practices, construction of expansion of infrastructural projects, urban sprawl and disturbance to agricultural activities and environment. However, nature and deriving factors of these conflicts could be different in both places. In developed countries, several cases show that land acquisition faces very early resistance from opposition to any land use change over socioeconomic and environmental disturbance which could lead afterward from tensions to violent conflicts. In developing countries, significant resistance (which most of the time is local) to land acquisition for project is observed over socioeconomic issues including less land compensation, corruption, mismanagement and cronyism in land and property rights which are followed by landlessness, loss of employment opportunities and ultimately low living standard.

Conflicts over environmental/ecological issues are significant in developed countries whereas in developing countries several actors (which most of the time do not include local affected people) raise voices over environmental impacts of land use change but no significant conflict is seen over these issues. It appears that infrastructural projects like dams have negative impacts on environment in one way or another and have to be managed. Tensions among various actors and resistance to the project due to environmental impacts depend upon the regions, actors involved and their interests, awareness and capacity to influence the decision making on the basis of their knowledge.

Complete information dissemination and participation of all stakeholders in all project activities have significant importance in conflict resolution ignorance of which could lead to tensions and violent conflicts. A new developmental vision in an area and out of culture decisions by stakeholders responsible for the project is always highly disturbing for local stakeholders where their participation has absolute importance at each step to avoid the conflicts. Involvement of all stakeholders, NGOs, media in project activities and public debate could make the process transparent, protect the rights and satisfy all stakeholders especially in developing countries where transparency is highly required due to corruption, mismanagement and cronyism. Stakeholders responsible for the project must also consider its social acceptance at all stages of development. Strong political efforts especially in developing countries are

required to bring all stakeholders together and satisfy them. Although social acceptance is difficult to assess as it depends upon history, culture, identity and values of population (Roth et al., 2017) but it might be improved by some practices including policy and strategy of framework, individual cost-benefit analysis of the project, quality of life, participation of all stakeholders in decision making and strategy to overcome the preset ideas (Huber & Horbaty, 2013).

Capacity building and social learning are also necessary steps for better participation and decision making and ultimately conflict resolution in both types of countries. However, social learning is enabled where participatory process needs a debate on nature, source of knowledge of participants and beliefs (Rouillard et al., 2014). Capacity building and empowerment of local affected people in developing countries are necessary as the majority of them are illiterate and lack the different professional skills. These people need professional/business training to protect the livelihood opportunities. Moreover, higher capacity building of local people probably through NGOs or donor agencies is also needed in common negotiations for land resources and other economic opportunities, so that people can understand the project, express their opinion and defend their rights.

Annex: Methodology

In this paper, tensions and conflicts are as defined by Schelling (1960); opposition without engagement of declared clash is called tension, which turns into conflicts after engagement of one or more actors. This engagement is defined by the implementation of a credible threat, which could take different forms like legal actions, mediatization (bringing the issue to the attention of the media, press, radio, television, etc.), bringing the matter to the attention of the public authorities, protestations, assault or verbal confrontation, putting up signs (signs forbidding access, fences and gates, etc.).

For the purpose of identification and analysis of conflicts and their impacts secondary source of information is used. This source includes national and regional dailies, previously published literature on land conflicts especially related to infrastructural projects and other literature published by public and private organizations. This kind of secondary source was frequently used by the researchers (see Ali & Nasir, 2010; Mann & Jeanneaux, 2009; Torre et al., 2014) in order to cross-check the information from different sources and to carry out better analyses (Deininger & Castagnini, 2006; Mc-Carthy et al., 1996). Information on factors affecting land use conflicts and their impacts is collected from extensive literature review. Such factors include land rights and compensations, resettlement and livelihood, information dissemination and public participation and environmental impacts. Further information on two selected case studies is collected from above-mentioned secondary sources which then further compared and analyzed in light of selected literature of land use conflicts.

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Exploring the Potential Socio-economic and Physical Factors Causing Historical Wildfires in the Western USA

Jamal Jokar Arsanjani and Ruben López Vázquez

Introduction

Fires are often random events, which are difficult to predict with no empirical evidence in hand, and that's why '*fires are randomly located in the landscape*' (Boychuk, Perera, Ter-Mikaelian, Martell, & Li, 1997). Essentially, fire is a chemical reaction between a substance and oxygen. It involves the release of large quantities of heat, which in turn drive the reaction further. In those terms, fires can be seen as accidents that, once set in motion, propel themselves into disasters.

By defining fire, we have already identified three important underlying variables for modelling ignition: fuel, an oxygen source (i.e. an oxidant) and a threshold temperature. However, that is an understanding of fire within a laboratory, in contrast to the actual multilateral relations established between fire, humans and vegetation. This article studies the distribution of fires, but its aim goes further than that, and it evaluates these relationships as their driving variables. The reason for looking into such complex relations is to provide a discussion, one that attempts to understand wildfires under such topical questions as climate change, or the salient urban growth in the planet during recent decades (United Nations, 2014). There are already a number of studies on the topic, which has discovered interesting patterns. For instance, there have been modelling attempts directed towards finding differential traits between natural and man-made fires. Benavent-Corai, Rojo, Suárez-Torres and Velasco-García (2007) found that man-made fires are easier to put off, as well as that their location follows a random pattern that is not present on natural phenomena. Furthermore, they also conclude that forest fires become more scale invariant with the increasing density of human settlements. Other research conducted in nearby areas are Preisler

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and Westerling (2007) in Western USA, Parisien and Moritz (2009) in USA, Narayanaraj and Wimberly (2012) in Washington and West et al. (2015) in Wyoming and Colorado.

If we start by looking into the facts surrounding actual wildfires, then a factor like temperature begins to lose ground to a broader domain of weather phenomena. Precipitation, wind occurrence and lightning are not lesser factors than temperature (Agee, 1993; Granström & Schimmel 1993; Plucinski, 2012; Preisler & Westerling, 2007; Pyne et al., 1996; West, Kumar, & Jarnevich, 2016; Zumbrunnen et al., 2011). This is because the climate not only creates the conditions for ignition, but also for whatever is there to burn. Thus, for instance, the fact that the boiling point of water falls between the range of temperatures covered from the moment of ignition to a fully developed wildfire (for instance, from 25 to 400 °C) makes water a deterrent. Water consumes good part of the energy necessary for the reaction to continue; nonetheless, change the timing for the presence of water, set wet conditions preceding a period of drought, and then the presence of water noticeably furthers wildfires, as it will increase the available 'fuel load' (Clark et al., 2002; Kitzberger & Veblen, 1997; Swetnam & Betancourt, 1998; Zumbrunnen et al., 2011).

This fire complexity extends to other factors besides the purely climatological ones. Although fuel load and moisture content play an important role in wildfires, there is also the type of fuel involved in a fire. Fires are common to several ecosystems, and they even define the life cycle of some plant species. These are known to scientists as *pyrophytes*, which are plants that have established a certain relation to fire, since fire determines their growth. 'Fire adapted vegetative systems… require the infrequent application of fire to stimulate growth, scarify seedbeds, reduce resource competition, and ultimately maintain a balanced and healthy ecosystem' (California State Board of Forestry and Fire Protection, 2016). On the other hand, fire persists to be a hazard to fauna and human settlements. It is a hazard, especially for those settlements in hot and seasonally dry climates, amidst pyrophytic communities such as chaparral, savannah, Mediterranean woodlands, monsoon forests and tropical pine forests (Nasi, Dennis, Meijaard, Applegate, & Moore, 2002). These ecosystems, and their associated climate, allow fires to recur with a certain frequency, and as urban areas still grow worldwide, urban settlements are progressively exposed to a larger risk.

As plants develop adaptive strategies, these diversify. Some vegetative strategies fend off the flames, for instance the Mediterranean evergreen tree *Quercus suber*, which evolves its bark into thick cork, and uses it as a fire retardant and insulating layer. However, other plants encourage fires and their spread, like *Melaleuca quinquenervia*. Melaleuca sheds its bark as thin as paper, thus becoming a fire ladder towards the canopy; besides, it also produces essential oils that increase flammability. Thus, plants like Melaleuca seem to rely on their ability to re-sprout and recover faster than other species (Agee, 1993). Mountain ash (*Eucalyptus regnans*), a tree of temperate Australia, is another example that requires to burn the land cover and to expose the soil to full sun for the species to proliferate (IUCN/WWF, 2000; Nasi et al., 2002). Likewise pines have developed high levels of resinous contents, but also serotinous (late-opening) pinecones (Agee, 1993). This means that, while

everything else burns and takes most competitors with it, its seed-bearing organs are 'fire-resistant'. Notably, Jack pine (*Pinus banksiana*) and Lodgepole pine (*Pinus contorta*) have followed this strategy in North America (Gauthier, et al., 1996; Nasi et al., 2002; Radeloff et al., 2004; Schoennagel et al., 2003), and thereby, they provide higher flammability to the area of study, but also they incorporate fires into it as an essential structure.

In spite the fact that not all pyrophytes currently live in the most fire-prone climates, most of them can be easily identified by their bark adaptations, and/or by the presence of aromatic compounds in their leaves and/or wood, which reveals high concentrations of resin and/or volatile oils. These are adaptive traits, which give them a new dimension in relation to wildfires. However, due to the way we manage our environment within the predominant Western industrial culture, wildfires have only become a growing hazard to us (Pyne, 2015), a disadvantage, when they could also be the means to a healthy landscape. Fires are not just destructive; fires can be restructuring, reconstituting events to our environment.

Hence, vegetation has reached certain equilibrium in its association with climate and to fire, through a spectrum of adaptations. Now, we begin to add human interference in the form of new explanatory variables. Wildfires are not just a product of a fuel load and a climate; they might as well be tied to other causes. Obviously, there are still fires responding to 'natural' causes; however, as outlined by Ganteaume et al. (2013) and Cardille, Ventura and Turner (2001), now fires are caused by human agency and its circumstances. As revealed by several studies, humans are emerging driving forces of climate change, of land cover change and of the spatial appearance of fire. Our input to fires ranges from arson, to the abandonment of traditional agricultural/sylvicultural practices, to the choice of fire policy (Ganteaume et al., 2013; Moreno, Conedera, Chuvieco, & Pezzatti, 2014; Pezzatti, Zumbrunnen, Bürgi, Ambrosetti, & Conedera, 2013). It is therefore that we also need to reach an adequate relation to fire. This article attempts to assess that borderline between natural and man-made, which often straddle the clustered and random distribution pattern of fires. When Benavent-Corai et al. (2007) conclude that fires become more scale invariant with the increasing density of human settlements; they might be uncovering the human disturbance on what is, as we will see, a scale-dependent phenomenon.

In relation to the climate, we need to contemplate that the climate itself has been shifting over time since the beginning of life on the planet. There have been different atmospheric compositions, and this fact has fed back on fires and their relation to vegetation. The development of a fire adaptation in the genus *Pinus* took place 65–145 million years ago, during the Cretaceous (He, Pausas, Belcher, Schwilk, & Lamont, 2012). At the time, the atmosphere had a larger portion of oxygen than today's but, despite the reduction in oxygen levels, current shifts in climate may as well affect the relation we try to establish. Meteorological phenomena are becoming increasingly extreme. Therefore, after delving further into this issue, the already complex and interesting web of relations has only become more interesting: the frequency of ignitions might as well follow a pattern. Fires are part of a larger, iterative pattern, known as the pattern of fire disturbance, which is explained by the vegetation present, the weather-driven return period of fires and the intensity of each event within the

cycle (Boychuk et al., 1997; Pezzatti, 2011). This is important because low-intensity fires, which only burn the understory, remove biomass and prevent larger fires from happening thereafter, and also, because of the relationship that each species has established with fire.

Furthermore, Zumbrunnen et al. (2011) juxtaposed the difference between the fire frequencies in correlation to drought (as independent variable) observed on two different species. The original work on such correlations was done by two different investigations: The first by Carcaillet et al. (2001) evaluated some boreal forests in eastern Canada and reported a strong influence of drought on fire frequency. The second, by Fry and Stephens (2006), evaluated some pine forests of *Pinus ponderosa* in California and showed no correlation between drought intensity and fire frequency. This implies the need to establish custom-make fire policies. Fires cannot be dealt nor prevented with one simple and universal policy. The population as well as the fire policy in force needs to understand such cycles and be informed by their character and nature. There is a prominent role of the climate on wildfires, but vegetation and humans also play a role. This paper attempts to counsel on where policy should place its focus.

The remainder of this paper is structured as follows. The following section explains the materials and study area used in this study. Section 'Methods' describes the methods applied in the paper. Section 'Results' presents the results. Section 'Discussion' discusses our findings in connection to the quality and preprocessing of the data. Finally, Section 'Conclusions and Future Directions' lays out the conclusions and future research directions.

Materials

First of all, the most important piece of information to keep in mind is that any data on fires has a spatial and a time scale, since it is part of cycles. Furthermore, due to the complexity of the multilateral relation established between fire, humans and vegetation, several methods should be explored in order to analyse the complexity of the problem. The main type of analysis to be performed is a regression, which should establish the degree of correlation between explanatory variables (i.e. independent variables) and ignition. This means that our main method must attempt to return the probability that such combination produces the event. Therefore, our main method will be a Spatial Logistic Regression on climatological and socio-economic variables. Spatial Logistic Regression analysis has been a popular approach for predictive modelling by means of variation of inductive modelling (McCullagh & Nelder, 1989).

Study Area

The extent of our research was greatly conditioned by the actual availability of data. We had data on the entirety of the USA on fires, which was used on the hot spot analysis. That served the purpose of selection to an even smaller area, because, undoubtedly, the amount of data to be gathered and processed would have been colossal. Under such circumstances, we begun with a vast area, where fire data was available, the Western USA, and within a period spanning 30 years starting from 1984 to 2014. Such broad area is neither desirable for studying fire ignition, foremost because of its heterogeneity. The USA has a very large collection of climate types, but also extensive swaths of wilderness under almost every one of them, which provides us with a range of climates. At this point, our area encompassed the states of California, Arizona, New Mexico, Idaho and Montana. Thus, we reduced our study area by having in mind the most fire-prone climate, which would homogenise the climatological variable, and thus proceed to study fires in relation to the other socio-economical and fuel variables that lead to ignition. The final chosen area extends by the southern border of the Northern Forest Region, which corresponds to the actual border between the states of Idaho and Montana (see Fig. 1). Further detailed work on vegetation type and dominance was only supported by data on the Northern Forest Region.

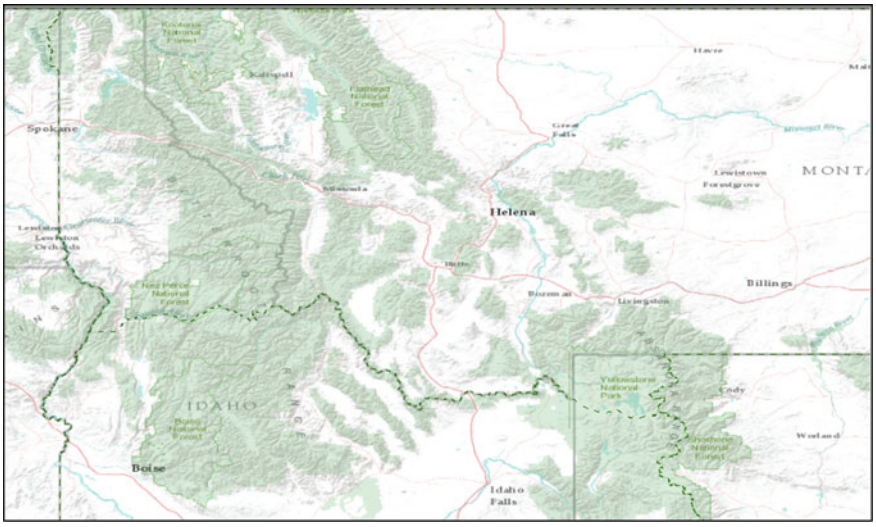

Fig. 1 Extent of the study area on top of ESRI base map in ArcGIS (the green dashed line delimits the border of the Northern Forest Region). Map produced by the authors

Preprocessing of the Input Data

For the database, we needed to make a selection of variables based on their presumed explanatory power, which demands a clear definition of the phenomenon. Therefore 'fire hazard' and 'fire risk were to be defined. Fire hazard takes into account the natural probability of ignition (i.e. the weather events and the presence of fuel), while risk accounts for the 'loss of key attributes being the change in values (damage)' to the environment and private property (Hardy, 2005). Risk has to do with the incidence of fire, and, according to the National Fire Danger Rating System, it has two main causes: (1) lightning risk (LR) and (2) man-caused risk (MCR) (Hardy, 2005). Based on this information, we initially assumed the following independent variables listed in Table 1 concerning ignition.

- T1—Maximum temperature (monthly)

The monthly maximum temperature (*t*-max) data is hosted by the National Oceanic and Atmospheric Administration (NOAA) and comes from the 'Livneh daily CONUS near-surface gridded meteorological and hydrometeorological data' (Livneh et al., 2013). It contains '*t*-max' values for all months between 1 January 1915 and the 31 December 2011. The spatial coverage of the dataset consists of a 0.0625° latitude by 0.0625° longitude grid (roughly 7 × 7 km) and uses World Geodetic System 1984 as spatial reference. This dataset is formatted to a Network Common Data Form (NetCDF), which is an array-oriented storage format. It can store multiple raster datasets (or other types), which can be accessed using an index number (e.g. a date).

Table 1 Independent variables in terms of their units and scale

Variable name				Independent variable
1	Climate factors	Air temperature	Absolute max. temperature monthly (°C)	T1
2	Fuel factors	Fuel moisture	Evapotranspiration monthly (mm)	M1
3			Monthly soil moisture (m^3)	M2
4	Human factors	Population age		H1
5		Population density		H2
6		Education		H3
7	Physical factors	Clustering of activities	Clustering of recreational uses	S1
8		Accessibility	Density of roads	S2

Dropped variables marked by asterisk

- M1—Evapotranspiration (monthly)

Data on the monthly averaged evapotranspiration in millimetres was provided by the same source (i.e. NOAA). Evapotranspiration represents the transfer of water from the soil into the air through evaporation from surfaces, and from plant respiration at their leaves. Similarly to the soil moisture data, its values are calculated by using the VIC hydrological model. It has the same spatial and temporal coverage, and it is provided in the same spatial reference system.

- M2—Soil moisture (monthly)

The soil moisture data contains monthly averaged soil moisture in millimetres from the 1 January 1915 through to the 31 December 2011. It represents the water quantity in the top first metre of soil. The spatial coverage is the same as the *t*-max variable, as well as its spatial reference system and data format (Livneh et al., 2013). Differently from the *t*-max data is the soil moisture dataset which is a model-calculated dataset generated using the variable infiltration capacity (VIC) hydrological model developed by a group of researchers (Liang et al., 1994) at the University of Washington.

- H1—Age of Population

Data on population age within our study area comes from the US Census Bureau as part of the County Intercensal Estimates (2000–2010).[1] It gives yearly intercensal estimates for resident population per county. This data was reclassified into two age groups, which balances the US population pyramid to equal age size. Thus, the representative age group oscillates unbiased per county according to which one is dominant. The first comprises citizens between 0 and 29, plus those above 65 years of age. The second consists of population between 30 and 64 years of age.

- H2—Population density

Data on population density is retrieved from USGS and comprises two datasets—one from the year 1990 and another from the year 2000. Both represent population density by block group. A block group is the second smallest geographic area used by the US Census Bureau for statistical purposes and consists of several census blocks which are the smallest units. Block groups usually contain between 600 and 3000 people. The data comes in raster format with a resolution of 100 metres, and each cell represents population density in people per square kilometre.

The population density values were extrapolated for the years between 2000 and 2010. This is based on a linear increase in density between 1990 and 2000. With the use of the 'Zonal statistics as table' tool, we extracted an average value to each lattice cell on population per square kilometre.

[1] Dataset: http://www.census.gov/popest/data/intercensal/county/files/CO-EST00INT-AGESEX-5YR.

- H3—Education

These data come from the US Census Bureau and are part of the County Intercensal Estimates (2000–2010). The preprocessed education layer is on the scale of the county, and each county is represented by a single level of education (either low, medium or high), i.e. schooled, trained on a trade, or having university studies. The values that represent each county polygon (low = 1, medium = 2 and high = 3) were assigned in accordance to which level has the highest contribution in percentage to the county. Because our assumption is that lower education will increase fire hazard, we assigned to each cell in the lattice the lowest value found. It is also important to remark that we do not have a temporal sequence to education, and thus, this variable remains constant over time, which is a shortcoming. It means that at each time step, the same education data is present.

- S1—Clustering of recreational uses

This variable represents the intensity and risk of recreational activities within an area. Data on recreational activities is retrieved from the Forest Service of the U.S. Department of Agriculture. It includes point locations of recreational activities that the Forest Service collects and distributes through their geoportal.[2] The value of these recreational activities is based on the fire risk they pose. Their risk was based on the type of activity, the duration in which one would generally engage in such activity, and its relation to vegetative areas. For example, winter- and water-related activities were generally seen as posing less risk compared to camping or picnicking. Table 2 lists the classification of activities found in the dataset, based on risk.

- S2—Density of roads

The network data used in this study is provided by the US Census Bureau and is called the Roads National Geodatabase. It is part of the TIGER Geodatabase and includes all roads for the USA, except for sensitive data, which comes in a geodatabase (.gdb) format. Moreover, it is provided in the North American Datum 1983 (NAD83) spatial reference system.

The dataset was retrieved from Data.gov, projected in the USA Contiguous Equidistant Conic projection and clipped to the extent of the five states that comprise our case study area by using the 'Clip' tool. The density of roads variable is a ratio between the amounts of road length against the area of each lattice cell. In order to get this ratio, the projected and clipped road dataset was intersected with one of the lattices using the 'Intersect' tool.

[2]USDA Forest Service Geoportal: http://data.fs.usda.gov/geodata/edw/datasets.php.

Table 2 Activities found in the dataset according to their fire risk

Activity	Danger level	
Winter sports	No danger	0
Beaches and dunes	Low danger	1
Cycling	Low danger	1
Nature sightseeing	Low danger	1
Outdoor learning	Low danger	1
Rocks and minerals collection	Low danger	1
Water activities	Low danger	1
Climbing	Medium danger	2
Fishing	Medium danger	2
Hiking	Medium danger	2
Horse riding and camping	Medium danger	2
Hunting	Medium danger	2
Other activities	Medium danger	2
Scenic driving	Medium danger	2
Camping and cabins	High danger	3
OHV riding and camping	High danger	3
Picnicking	High danger	3

Other Input Data and Preprocessing

- Topographical direction (northern region)

In order to correlate the topographical direction of fire events, we used FSTopo Drainage Line dataset provided by USDA Forest Service.[3] This layer was projected in the USA Contiguous Equidistant Conic projection to match the one containing the fire events. From this data, the secondary perennial streams were selected as the ones that indicate the main topographical slope at the scale of fire events. Furthermore, the data was digitised sometimes in the wrong order, i.e. the order of line control points did not match nor they were consistent with up-slope/down-slope direction. Features had to be dissolved and flipped, in order to have a consistent orientation. Then, dissolved by fire ID, each fire event also got a direction attribute using ArcMap tool 'Linear Directional Mean'.

- Vegetation dominance (northern region)

In order to identify how particular species contributes into fire extent, it was crucial to gather detailed vegetation data. The US Forest Service, an agency of the U.S. Department of Agriculture provides multi-level geospatial databases on vegetation. Nevertheless, responsibility and procedures for collecting and publishing data have been delegated to the regional and district offices. Thus, their data is not consistent

[3]USDA Forest Service FSTopo Drainage Line: http://data.fs.usda.gov/geodata/edw/datasets.php.

and differs in attributes and dominance classification. While type of dominance of species in one region is described as >60 and >40% of relative cover, other regions use different intervals.

After deciding to investigate the occurrence of pyrophyte species (mainly Pinus contorta) forests within the northern region were picked as study area (Fig. 1). The Vegetation Mapping Program[4] in this region resulted in releasing some geospatial databases covering forest extent within the borders of the states of Idaho and Montana. The base-level and the mid-level segmentations are available within these databases. Although the base-level Vegetation Map may not adequately capture vegetation structure for many reasons (Brohman et al., 2005), e.g. the quality of imagery used to produce the map, or a lack of training data collected within the examined area, the base-level map was still used in this study. The attribute indicating species dominance was based on 'Dominance group 6040' which establishes two thresholds of species cover: 60 and 40%. If the single most common tree species is ≥60% of the total coverage, the class assigned stands as representative code (e.g. PICO: Pinus contorta, PIPO: Pinus ponderosa…). If the abundance of the single most present tree species is <60 and ≥40% of total coverage, the class assigned is the most abundant species plus a subclass, such as PICO-IMIX or PIPO-TMIX (Brohman et al., 2005).

- Max monthly temperature (northern region)

It was obtained from the PRISM Climate Group dataset.[5] It is a 4-km spatial resolution grid, which represents monthly averaged daily maximum temperature. Their time series was modelled using climatologically aided interpolation (CAI) from 1981 up to recent. We extracted the values by zonal statistics as a table, georeferenced by USA Contiguous Equidistant Conic projection. The table was then joined back to each fire occurrence by fire ID feature class.

- Digital elevation model (northern region)

We downloaded a total of 58 tiles of the Digital Elevation Model layer of the National Elevation Dataset (NED) in 1 arc-second (approximately 30 m) resolution.[6] After merging the tiles and being projected in the USA Contiguous Equidistant Conic projection, it served as an input for elevation, aspect and slope.

- Monthly mean wind speed/orientation (northern region)

Monthly mean values of the wind speed as well as the wind orientation were delivered from NetCDF files provided by the National Oceanic and Atmospheric Administration (NOAA). In order to extract wind direction and magnitude values, two components, for instance U-Wind and V-Wind, were combined using 'Composite Bands' tool and projected in the USA Contiguous Equidistant Conic projection. In order to

[4]Northern Region Vegetation Mapping Program. http://www.fs.usda.gov/detailfull/r1/landmanagement/gis/cid=stelprdb5331054&width=ful.

[5]PRISM Climate Group. http://prism.oregonstate.edu/recent/.

[6]National Elevation Dataset (NED). https://www.sciencebase.gov/catalog/item/4f70a58ce4b058caae3f8ddb.

accelerate the process for numerous selections of NetCDF file dimension, composite and projection model builder has been introduced.

Methods

Selection of a Proper Spatial Unit

Once the necessary data has been retrieved, then our first priority is to establish the determining factors of ignition. For that we will use a grid analysis. Its cells will provide a homogeneous data unit, which will gather the variable's data on account of its topology and proximity (i.e. a neighbourhood), a move that requires some considerations. For instance, the database will be composed of spatially related data, as it exists in the neighbourhood of the phenomenon under scrutiny. Thus, we must be aware that this assumes the significance of the First Law of Geography (Tobler, 1970): 'everything is related to everything else, but near things are more related than distant things'. The question is what should be the size of the neighbourhood in relation to the phenomenon under consideration. At what distance things stop from being related? At what distance can we begin to ignore things? The very same Waldo Tobler qualified his law as being 'parochial', in the sense that it 'ignores most of the world'. We need to know what to ignore, and we need to understand that this is not a problem of quantity (i.e. size or distance), but one of scale (Pezzatti, 2011).

Thus, it is essential to establish the neighbourhood of the phenomenon, by enquiring at what scale it is better exposed. Throw a very large neighbourhood and data will be smoothed, i.e. results will become blind to local variation, and data will be simplified into central tendencies; use a very small neighbourhood and the event will appear seldom as a positive, for cause and effect will stand isolated, and nothing will appear relevant. Scale plays a role in what we see, because what we see is interrelated. This is a well-known concern in the field of landscape ecology, as well as in any other field where attention is paid to relationships. In such cases, we must be aware that '(s)cale plays a big role in determining the outcome of observations' (Levin, 1992; McGarigal & Cushman, 2002; Peterson & Parker, 1998).

To be able to establish a proper neighbourhood, Clark and Evans (1954) developed the methodology used here, which is based upon point topology. It differentiated between clustered, disperse or randomly distributed points. They started from the fact that, in a dispersed distribution of points, the average distance is the same as the distance between any pair of points within the distribution. Equally distributed points are placed at a distance, which equals the square root of the amount of points dividing the area covered. Hence, Eq. 1 should be used to determine our spatial unit, if fires were evenly distributed:

$$\sqrt{\frac{A}{n}} = d = \frac{1}{\sqrt{n/A}} \tag{1}$$

In a perfectly disperse population, such formula should be accurate and does not need any coefficient, but in a perfectly clustered population (in which all points would be coincident on a unique location), it should then return a value of 0, which means it should be multiplied by 0. In this order of things, since a random distribution would lie midway between a perfectly clustered one and a perfectly dispersed one, a random distribution should have a coefficient of 0.5. We also need to remember that each fire occurrence has a date in time, and that the occurrence of fire in one cell reduces the chances of that cell presenting a positive in the near feature. Therefore, the actual distance between fires needs to be calculated per season (read subindex i), and thus, it can be allowed to variate with every fire season.

Furthermore, the area of extent should as well be calculated per season anew, since it changes over time fruit of the action of fire plus land use changes. This means the equation needs to be slightly modified (see Eq. 2): the area (i.e. the sum of forests, shrubs and grasses) will be averaged per season (i); and the number of fires (n_p) will be the seasonal (i.e. yearly) number of events:

$$d = \frac{1}{2}\sqrt{\frac{\left(\sum_i A_i/n_i\right)}{n_p}} \tag{2}$$

Space–Time Cluster Analysis

The adaptation to our time variability should ensure that the scale of our sampling mesh is adequate, so that the cells will be populated by positives and negatives in a given neighbourhood. In order to calculate mesh size '*d*', five western states were used to calculate the mean distance between fire centroids. It equals 9.387 km (in AZ, NM), 8.729 km (in ID, MT) and 7.858 (in CA), which produce an average distance within the five-state area of 8.658 km. On the other hand, precisely in the Northern Forest Region, there is a mean distribution of distances between the centroids of the fire extents of 8.39 km. Thus, 8.5 km was chosen as the size of our sampling lattice.

Then, the space–time hot spot analysis method within a span of 30 years (between 1984 and 2014) was applied, which allows analysing the data across space and time. The third dimension of the cube consists of temporal steps relevant to the phenomenon (i.e. 1-year steps). The emerging hot spot analysis thus creates a cube, which results in temporal trends defined as new, historical, consecutive, oscillating, intensifying, diminishing, persistent and sporadic; as well as spatial trends defined as clustered, dispersed or random. Each location was then 8.5 km in width and length, and therefore, the neighbourhood distance was selected to 17 km.

Results

Fire Hazard Analysis

The first analysis focused on the differential relation that some vegetation types have established to fire. The main lead was their burned area in relation to their preponderance. The results exposed two clearly prominent vegetation types (i.e. shrubs and coniferous forests), and their switch at the forefront of burned surface in a decade. Figure 2 presents two histograms, which depict what vegetation classes are most affected by fire. It should be noted that under each class, there are several plant communities, sometimes mixed communities, other times climatic communities with a dominant species. The histograms are built from the % of pixels burned in each class.

From these results, we gain some insight into what probability these vegetation classes have to catch fire, as 'Harrington and Donnelly (1978) defined the annual fire probability as the mean annual burned area divided by the landscape area…' (Boychuk et al., 1997).

Nevertheless, on such probability not only intervenes the fuel type but also the climate. Hence, Fig. 3 presents the climates by their count of fire events. The climate abbreviations are as follows: arid steppe (Bsk), Mediterranean with dry and hot summers (Csa), Mediterranean with dry and warm summers (Csb), hemiboreal (continental) dry and warm summers (Dsb), hemiboreal (continental) warm summers (Dfb), boreal taiga (continental) warm summers (Dfc) and boreal taiga (continental) dry and cold summers (Dsc). In this way, climates are clearly classifiable as fire-prone or not. What these climates have in common is their seasonal lack of precipitation in summer, with the exception of Dfb and Dfc, which are continental, humid and cooler than the rest, due partly to their altitude.

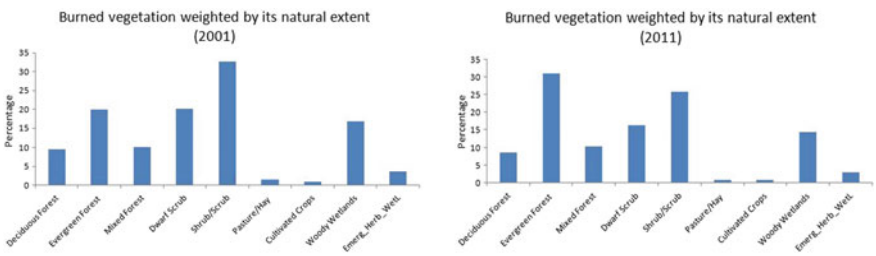

Fig. 2 Percent of burned area according to vegetation type in 2001 and 2011

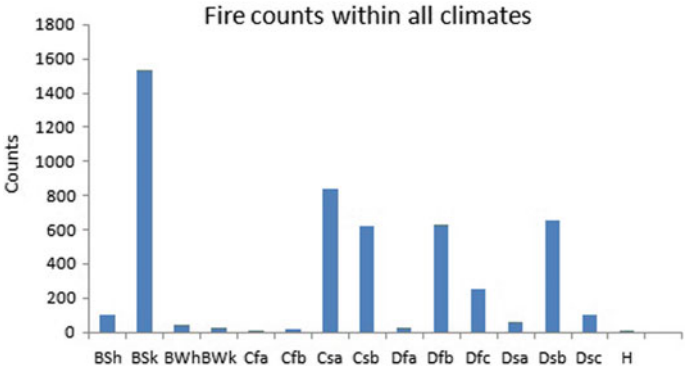

Fig. 3 Count of fire events according to climate within 1984–2014. Bsk (semi-arid climate) leads the count, followed by Csa (a Mediterranean climate)

Fire Spread Analysis

The second analysis was carried out in order to analyse the spatial metrics in order to gain insight on how fires develop after ignition. It correlated fire spread with the influence of topography and of climatological variables, e.g. temperature and wind. Fire boundaries are represented by the contour of the burned pixel area per each individual event, which should reveal the factors that define their final extent and geometry. The result of this analysis, represented in Fig. 4, shows that fire sizes have been growing over time, which coincides and echoes the report by Westerling (2016), which points at a 50% of the increase in large fires happened over the last decade, as values double and triple those attained during the 80s and 90s.

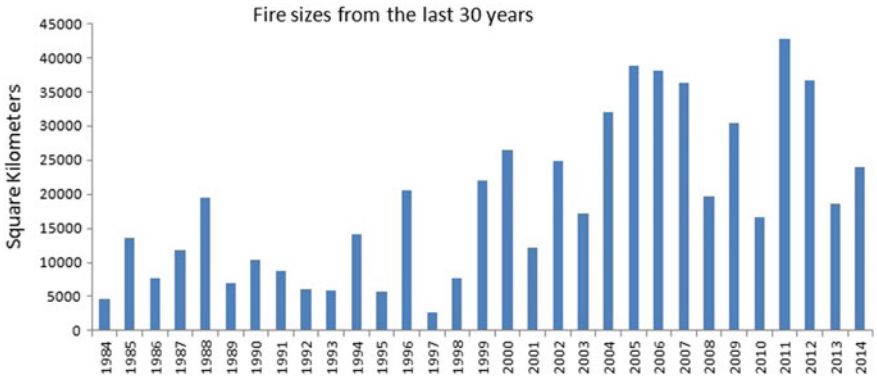

Fig. 4 Annually accumulated burned area for the USA from 1984 to 2014

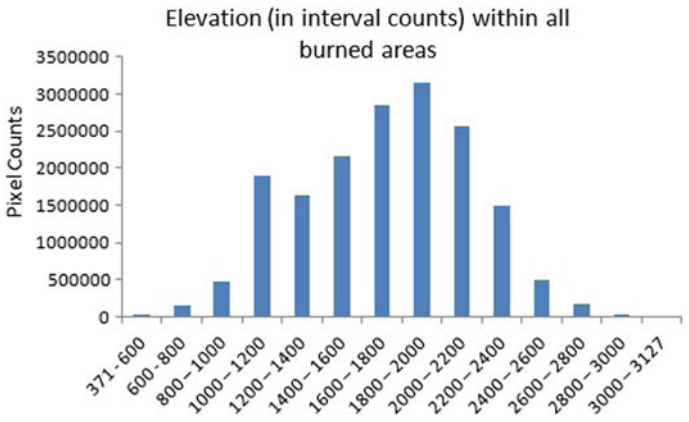

Fig. 5 Count of pixels corresponding to burned areas in the last 30 years, grouped in a histogram according to their elevation value within our research area. Each pixel equals to 900 m^2

We tested the correlation between fire sizes (in hectares) against fire hazard components (fuel, moisture and temperature) using a multivariate Least Squares Regression. The results show a rather poor significance, and the variables were weakly correlated. However, their sign matched the expectations. Fuel and temperature have a positive correlation with fire sizes (the bigger their magnitude, the increased fire size), while for moisture is negative (the larger its magnitude, the smaller the extent of fires).

Furthermore, on other spatial metrics, the correlation between the elongation of fires and wind speed was not found to be very significant at all. However, the correlation between wind direction (in degrees) against the dominant direction of fire extent (also in degrees) was found to have a positive correlation, although such relation still seems to be of very low significance. Concerning the correlation between topographical direction (in degrees) against the direction of fire extent (also in degrees), it was found to indicate that the direction of the relief was more significant and strongly correlated than the previous. Fires tend to move up slopes. Therefore, what defines fire boundaries based on these data, and explains best fire extents, is slopes. Fire tends to follow the topography, and although wind does explain partly the bounds of a wildfire, by being a component of its direction, the data has proven to be inconclusive to what extent it does. Still, this analysis has not been able to give an answer to why some specific moist climates concentrate so many fire counts, thus why are some locations prone to fire. This means to query with greater detail vegetation (including dominance of species and their classification as pyrophytes), besides taking a closer look at the topographical features and climatological conditions that are recurrent on fire locations.

In order to answer the question ‘where do fires happen?’, a series of factors were taken into consideration like: elevation, aspect, temperature, soil moisture and vegetation types. In Fig. 5, a count of burnt pixels per elevation range can be that

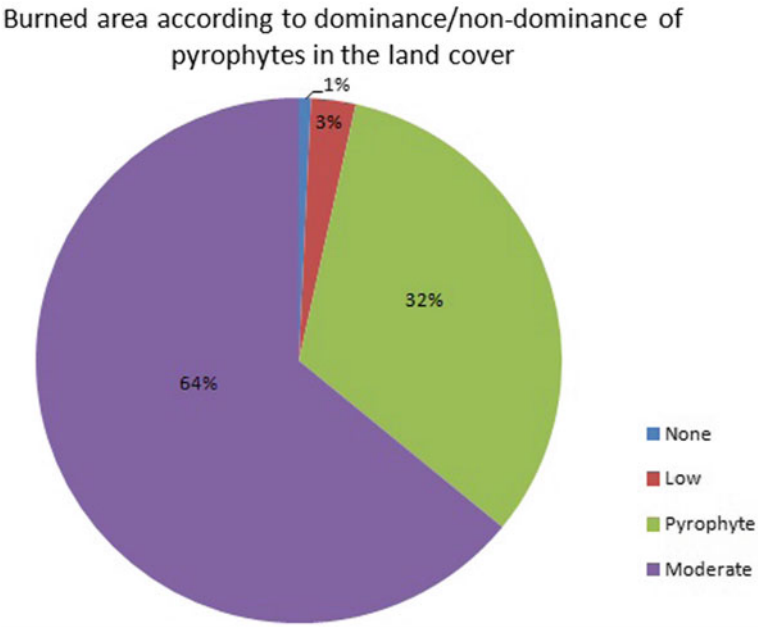

Fig. 6 Contribution of different vegetation types (burned pixels in our data) to the total amount of burned hectares. These types are classified in relation to the dominance of pyrophytes

fire events reach very high elevations, at more than 2600 m a.s.l. If this data was represented as a box plot, it would show that any fire above the median takes place above 1700 m, and that the top 25% of the fires occur above 1900 m of elevation. These figures reflect the natural elevation of the area within the Rockies, which in turn affect the climatological values where fires happen. Moreover, fires seem to display a slight preference for southern slopes, as it transpires from the pixel count of burned areas in relation to aspect. These are warmer and more exposed to direct sunlight in the northern hemisphere.

Concerning the type of fuel, most fires take place on a specific type of vegetation. If we analyse plants after classifying them between pyrophytes and non-pyrophytes, and we take into account their dominance within their stands, it can be easily observed that the number of fire events is very low where non-pyrophytes are present, but increases rapidly for moderate and dominant pyrophytes. From the pie chart represented in Fig. 6, it is clear that the percentage of the burned area is much bigger in areas where pyrophytes are present. In fact, it seems to suggest that some critical per cent of pyrophytes in the mix is enough to burn large swaths of land.

Modelling of the Socio-economic Indicators

Finally, this research attempted to clarify the mediation of humans, as part of the risk, on ignition. Since ignition is a binomial variable, we implemented a Spatial Logistic Regression, the results of which are on display in Table 3. Since climatological and topographical variables had been controlled (to a certain extent) in the sampling process, the range of variables to be tested were from spatial to socio-economic character (see the list of independent variables selected in Table 1).

The regression indicates that half of our variables have a statistically significant impact on the regression as they have their *P*-values < 0.05. These variables are: 'Evapotranspiration', 'Soil moisture', 'Recreation clustering', 'Road density' and 'Aspect'. However, none of the socio-economic variables ('Age', 'Population density' and 'Education') nor the climate variable '*T*-Max' and the spatial factor 'Elevation' have statistical significance. The coefficients of the relevant factors are quite small except for 'Evapotranspiration' and 'Road density'. The former has a high positive coefficient of 21,440, while the latter has a strong negative coefficient of −355.6.

Soil moisture, with a coefficient of −0.04681, has a weak negative relationship. It is thus coherent with the idea that moisture decreases the likelihood of fires, as it drives energy away from the reaction. The clustering of recreation activities with a positive coefficient of 0.2536 implies that an increasing intensity of recreational activities

Table 3 Training dataset (2000–2009) and logistic regression result

	Independent variables	Coefficient	Std. error	*Z*-value	*P*-value
Category					
Socio-economic	Age	1.073e−01	8.293e−02	1.293	0.195858
	Population density	1.842e−05	5.894e−05	0.313	0.754621
	Education	6.788e−02	5.867e−02	1.157	0.247241
Fuel	Evapotranspiration	2.144e+04	1.866e+03	11.494	<2e−16
	Soil moisture	−4.681e−02	5.808e−03	−8.060	7.61e−16
Climate	*T*-Max	2.571e−03	6.461e−03	0.398	0.690721
Spatial	Recreation clustering	2.536e−01	5.982e−02	4.239	2.25e−05
	Road density	−3.556e+02	4.380e+01	−8.117	4.76e−16
	Elevation	6.912e−06	5.296e−05	0.131	0.896154
	Aspect	2.362e−03	6.832e−04	3.457	0.000546
	Intercept	−6.371e+00	3.476e−01	−18.325	<2e−16

Pseudo-R^2 (adjusted): 0.018 (run on statistically relevant factors only)
N (samples): 616,696
Null deviance: 17,478 on 616,695 degrees of freedom
Residual deviance: 17,159 on 616,685 degrees of freedom

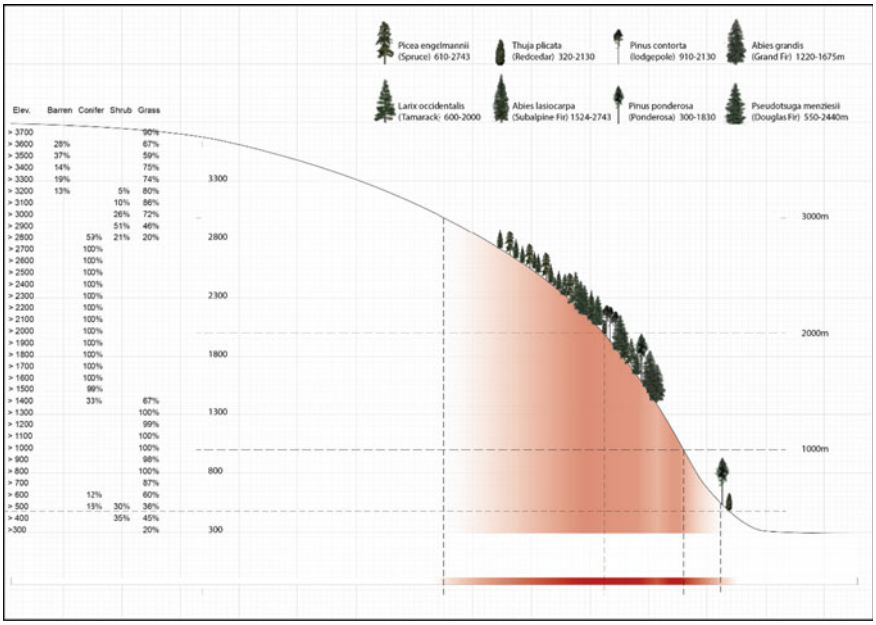

Fig. 7 Accumulated count of pixel value 'elevation' and frequency of fire events (burnt pixels) at each elevation (in red shades). A narrow lighter gap appears at about 1300 m

does have, despite being very modest, an impact on fire occurrences. Aspect, with a coefficient of 0.002362, has the weakest positive coefficient among the statistically relevant variables. It indicates that southern slopes are most likely to have a fire, which coincides with Heyerdahl, Brubaker and Agee (2001), when they point that ponderosa pine stands 'burned twice as frequently and earlier in the growing season in southern watersheds than in northern watersheds' in the Blue Mountains (Oregon-Washington state).

Analysis of Land Cover in Relation to Fires

It has already been stated that there are two clearly prominent vegetation types (i.e. shrubs and coniferous forests), who are responsible for most part of the burned area in the last decade (see Fig. 2). We also know that their adaptive traits to fire have made them only a bigger fire hazard. There is, however, still a small glitch or sign to be reported, concerning land cover. It regards the small reduction on burned area at 1200–1400 m above sea level (see Fig. 5), which coincides with the ecotone between prairie/grassland and forests in this area. Figure 7 corroborates such decrease on burned area (represented as a toning down of the red shade), which appears as grasses (67% of the land cover) turn into coniferous forest (33% of the land cover) at that

elevation. The land cover was assessed independently from the knowledge of such gap, by gathering the sum of pixels on each represented land cover over the total at each elevation range. Such decrease could just be a coincidence, yet that would not explain the actual reason for such reduction. Instead, such event supports the idea that fire events are linked to land cover (i.e. the species present). Besides a possible tiny microclimatic variation at the edge of the forest, due to the casting of shade, the variation of fuel quality due to a greater variety of species, distances between trees, or the presence of gazing livestock might also be possible explanatory circumstances.

Discussion

The first part of the analysis was merely descriptive and lacked subtlety and conceptual depth. It simply portrayed, in which vegetation was commonly affected through by fires (by % of burned surface present on each vegetation class under a supposedly fire-prone climate) on every season. However, in such analysis it was already possible to notice a difference between deciduous and evergreen forests, which has been sharpened further later on by the distinction on pyrophytes. Perhaps the salient result from this part of the analysis is the presence of moist climates among fire-prone areas, which poses further questions in relation to climate change and their evolution.

When inquiring what defines the extent to which land will burn, spatial characteristics like size, direction and elongation of burnt areas, wind speed and angle, plus the main direction of topography (i.e. direction of the drainage pattern), were used as input data to a regression that ended up being of little significance. An important reason to this outcome was the quality of available data. Our dataset on wind speeds was aggregated to monthly mean wind speeds, which rendered the correlation between size/elongation unachievable. Wind speeds can vary a lot in magnitude during each single day, let alone during an entire month. Still, though wind directions tend to shift too, we had some positive but weak correlation. Slopes, as unchanging as they are, did show a certain level of correlation, which leaves open the possibility, that their actual influence might still be weaker than the steering of the wind.

For the slope analysis, we actually used the drainage pattern, on which we calculated flow accumulation in order to obtain a vectorised stream network. This network was then edited by splitting its lines at intersection points, flipping those that would point upstream and then extracting an angle by using ‘Linear Directional Mean’. Then, in order to be capable of correlating any angles, the calculation required a transformation into an angle comprised within the first quadrant (0° and 90°), which was achieved by applying to every angle (α) the following rotation and flip: $\alpha_c = |\arcsin(\cos(\alpha))|$. Our results, which weakly correlate the main valley direction with the direction of most fires, seem to suggest that fires are often contained within valleys.

However, it was the splitting across the notion of pyrophytes that provided the clearest picture on where do fires happen and how big they turn. Basically, it is the location of such vegetation what clusters fires, as it is much more prone to get alight

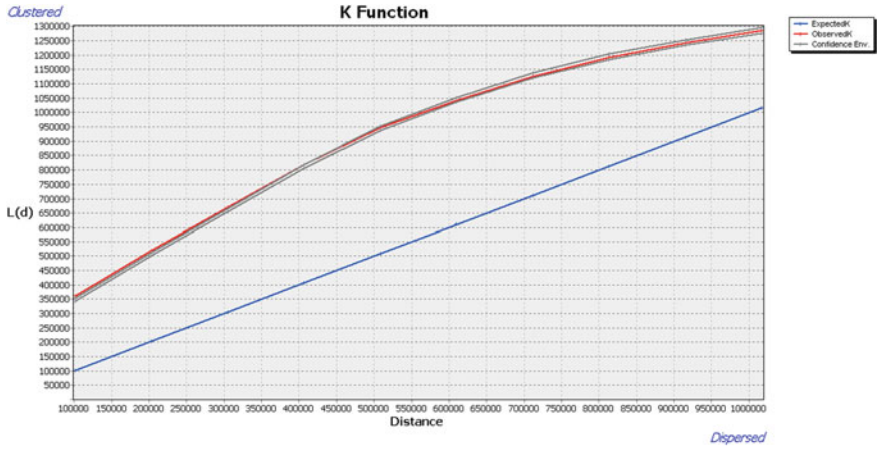

Fig. 8 Results of the multi-distance spatial cluster analysis (Ripley's *K* function)

than, for example, hardwoods. Fires might be driven by wind and to a certain extent contained by topography, yet their ignition will depend on a long process of fire hazard accumulation. Population density probably only randomises that accumulation, in the sense that it blots out differences, leaving fires to happen according to the randomness of their ignition event. That means, a time for fuel load to increase under the right climatological conditions is needed for fires to occur, which means that the climate and the type and amount of fuel will have the final word on where do fires take place. None of the socio-economic factors have seemed to withstand the test, and the remark of Benavent-Corai et al. (2007), regarding that, under such circumstances fire locations follow a random pattern that is not present on natural phenomena, agrees well with anthropic disturbance on its mobilisation and homogenisation of resources (i.e. intensification of production, monoculture…).

Socio-economic factors, like population age, tend to blur and are difficultly consistent. Even if they would seem to make sense, it is difficult to obtain any significance with regard to ignition. Population age, with a *P*-value of 0.2, is even three times as significant as population density (0.75). Nevertheless, even though the argument it stands for could sound appealing, as an elderly population is mostly retired, thus having increased time for recreational activities, while their health may reduce their involvement on the removal of biomass, thereby contributing to a less tidy countryside, it fails to have a significant slope (i.e. sensitivity) as an estimator. The problem is that such older population might still be interested on having some revenue by leasing their land, and/or a younger and more technical generation could take over such tasks. Socio-economic factors are intricately messy.

In any case, what seems irrefutable is that fire centroids appear clustered at any scale, as shown in Fig. 8. The reason for that lies in the location of the fuel load. Ignition is a random accident. Even the landing of a spark made for the purpose of igniting fuel is a random event. However, fires become clustered not just due to the

typical spatial correlation of climates, but especially because of fuel load, and fuel quality present in different kind of vegetation. Policy should acknowledge that, and probably it would even be good to tailor it to the type of vegetation standing.

Furthermore, fires still tend to correlate with desiccation, and thus to southern aspects on the slope, yet let us also remember, that in the final value of evapotranspiration tree species also has a say. In addition, that desiccation is important for ignition, yet if we consider wildfires as a problem, their spread will not only depend very much on climatic variables, but also on fuel quality (i.e. dry and of high calories) capable of sustaining its temperature and on features like fire ladders for the flame to reach the top winds. Figure 4 could be evidence that climatic events are playing on types of vegetation that have evolved adapted to fire.

Concerning the 3D cube analysis, we found hot spots in our data (see Fig. 9) that concur with the description of ignitions as clustered. This analysis was carried for the entirety of the USA, and one conclusive pattern is the appearance of hot spots dominantly in the south-east. In this case, fires in the south-eastern USA are prescribed, as part of the fire management policy. Prescribed fires are set alight in a controlled fashion and in repeated cycles, in order to control high levels of fuel, which creates hot spots. Thus, it makes sense to see large clustered hot spots on the south-east plains, opposing to 'sporadic', 'new' or 'consecutive' hot spots, far more sparsely found in the western mountainous range. It is also important to highlight that a third of them in the research area are 'new'. It supports the plausible idea that climatological changes might be expanding the distribution of hazard and coincides with the reported increase in size and number by Westerling (2016).

The nomenclature of these classes in the 3D cube refers to the time step intervals and to a critical threshold ratio of 90%. In this way, 'New' means that the most recent time step interval is hot for the first time. 'Consecutive' stands for an uninterrupted run of hot time step intervals (i.e. a year), comprised of less than 90% of all intervals.

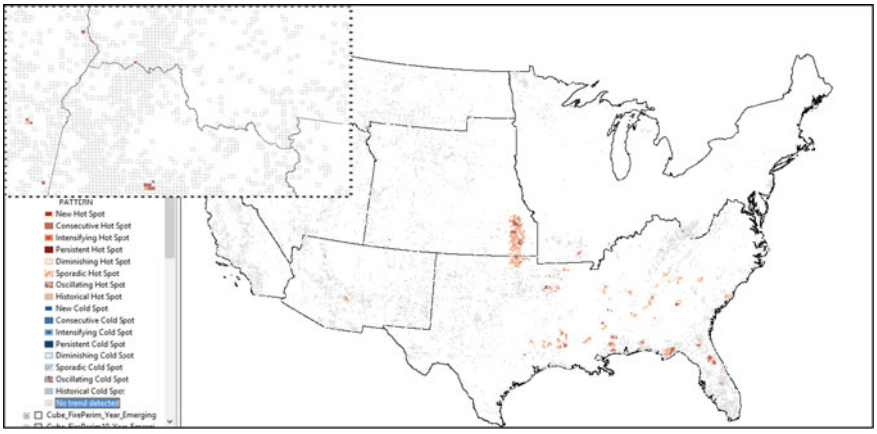

Fig. 9 Results of the 3D cube analysis representing fire ignition on an annual *Z*-axis visualised in ArcGIS. Map produced by the authors

'Intensifying' is when at least 90% of the years are hot and becoming hotter over time. 'Persistent' establishes that at least 90% of the years are hot, with no trend up or down. 'Diminishing' is the opposite of 'Intensifying'. 'Sporadic' means that only some of the years are hot, and 'Oscillating', that some are hot, same as others are cold. Yet again, wildfires seem to be on the rise in non-controlled areas.

Concerning the stability of our multivariate logistic regression we checked for collinearity, since we have socio-economic factors and other factors, which might come to represent the same dimension. There is always some degree of collinearity between predictor variables (Dormann et al., 2012). Many things are correlated in the real world, and modelling real things might require having to bring up different manifestations of the same, but in our case we can prove to have a great stability of the found slopes in our regression. Their presence and abundance, as well as the climate, should be the essential condition to any good custom policy.

The magnitude of our coefficients makes sense and aligns with what theoretically would be expected. Furthermore, there is no inconsistency between their scale and our value of R^2. Swollen values of R^2 would be regarded as a tell-tale sign of collinearity. Still, to be sure about a possible problem of collinearity in our model, we looked at the VIF and TOL factors, and both do not give any sign of trouble. Moreover, we ran a Ridge Regression, in order to see what our collinearity could be doing to our coefficients (or slopes). It should show how sensitive they are concerning the variance (Dormann et al. 2013), yet our coefficients have remained absolutely stable.

In order to understand the results of this research, one must first understand that there is some sort of time hierarchy between hazard and risk. It is very important to keep in mind that before ignition comes hazard; and before property damage comes the accumulation of fuel. All the variables that build hazard have to be satisfied, before the random event that defines the risk can take place. Regarding this, the relationship that exists between vegetation and wildfires is governed by a sequence of three distinct periods between events. The first is a period of growing hazard (i.e. a period of fuel accumulation and later desiccation), which is spatially clustered according to climatic (i.e. the distribution of max. temperatures, rain…), topographical (i.e. the distribution of soil moisture, aspect …), and other spatial factors. This is a critical step for attaining ignition. Ignition is then a very short period, which cannot take place without the previous. It occurs around a randomly distributed event (i.e. lightning strike, accident …) and then extends until the fire is self-sustained by the heat it generates. Ignition is a random event, yet one that will still conform to the clustered distribution of hazard, and that marks a shift in critical factors: moisture gives way to wind speed and direction.

From the presented results, the most important highlight should be that fire depends on ignition, since such event provides the extra amount of heat required for the reaction to take place, yet all the same, such dependency does not allow to predict fires. The amount of variation that the logistic regression can explain only reached a 1.8%. Ignition, as a random event, is the one that introduces most uncertainty to fires. One can have all what is needed for a fire to happen and yet, in spite of it all, it is not certain to happen. What this means is that the time of ignition is

uncertain, while its location, bound through its many dependencies to the spatially clustered accumulation of hazard, is still closer to be predictable.

From this, it is important to understand the relevance of *pyrophytes*, as they have proven to be a salient source of hazard. Fire policies must incorporate such awareness, as well as of the risk that poses the concurrence of climate change and driving urban development into such ecosystems. Thus, the best factors to model fire risk are the presence of *pyrophytes*, fuel load and the degree of desiccation of the vegetation, plus urban planning. In support of the role of vegetation is the unexpected decrease on fire counts, which coincides with the average elevation at which grasses turn to forests on our study area (see Fig. 7), plus the fact that most fires start at temperatures below 26 °C (see Fig. 8).

Conclusions and Future Directions

From all the aforementioned, we must conclude that, in order to understand fires, one must be aware of the presence of fuel (i.e. the type of fuel available), and that the distribution, amount and type of fuel will forecast better than any other indicator the probability of ignition. Such distribution is predictable and seems to be linked to land cover, more specifically, to the type of vegetation or even some particular species. The observed decline of fire frequency at the ecotone between low vegetation and coniferous forest points to the relevance of land cover, land use policies and its management. Finally, that evapotranspiration is the variable with the strongest relationship to fire. It is by far the one that best predicts fire hazard, as it has been thoroughly researched by Riley, Abatzoglou, Grenfell, Klene and Heinsch (2014) in the relation between drought and wildfires, which opens 'important implications', in their own words, in relation to 'future climates'.

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Spatial Analysis and Evidence-Based Economic Development Planning: A Case Study on Manufacturing Clustering in Southern Ontario

Evan Cleave, Godwin Arku and Megan Easton

Introduction

This chapter explores the role of GIS and spatial analysis in regional and local economic development policymaking and planning, using a case study on spatial patterns of manufacturing firms in the Province of Ontario, Canada. In doing so, this chapter serves a dual purpose: first, to better understand the potential role that spatial analysis can play in local and regional economic development; and second, to use the case study of manufacturing in Ontario (and in particular, Southern Ontario) to understand the role that human systems play in shaping spatial patterns of firm locations. By combining these two strands, the overall goal of this chapter is to be able to use spatial analysis to develop regional intelligence on the state of an evolving manufacturing sector in Ontario, and to use this knowledge to help guide and improve economic policymaking.

Since at least the 1990s, there has been a spatial reorganizing of political power and responsibility in advanced economies, with local and regional governments supplanting the state as those charged with economic development. As a result, local and regional governments are now tasked with maintaining and improving the economic health of their jurisdiction, with recent focus on sustainable development fostering economically, socially and physically healthy communities. Local and regional governments have historically struggled with crafting their economic destinies while dealing with challenges related to the global capitalist system in which

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they are integrated (Hayer & Nieweler, 2018). Over the past three decades, cities in advanced societies have faced critical challenges relating to economic restructuring, decline of manufacturing, declining tax base and fiscal shortages, and stiff competition from new markets in the global economy (Hall, 2015; Rogerson, 2018). With this increased responsibility and pressure, economic development has become a salient political issue, with planning and policy playing a "front-and-centre" role in day-to-day governance and elections.

A key limitation of contemporary economic development, however, is the lack of informed or evidence-based planning and policymaking. There has been a consistent call by academics for cities to become more systematic and analytical when developing and implementing policy (see Reese & Sands, 2013). Within this larger context, there is also a glaring lack of GIS and spatial analysis capabilities within the groups crafting local and regional economic development policy. Currently, there is limited knowledge on the role that spatial analysis plays—or has the potential to play—in understanding and addressing local and regional challenges in contemporary economic development policy and practice. While geographic information science and a wide array of spatial analyses are well established in the analysis of local and regional economies within academic spheres (see Lopez & Paez, 2017), this knowledge and technical skill has been slow to permeate into the public sector. Indeed, for an increasingly thinned public sector, basic spatial inventories of local assets and simple cartography represent the extent of ability. As a result, there is limited ability—but room for strong improvement—in incorporating spatial analysis into economic development policymaking and practice.

This lack of regional and local intelligence is notable as clustering and agglomerations have become central parts of economic development dogma in Ontario and other advanced economies. Embedded within economic development literature over the past century has been the concept of agglomeration economies, or the benefits gained by the clustering of firms and other public and private institutions (Delgado, Porter, & Stern, 2015). Perhaps due to the prominent work of Florida's (2002) creative class thesis, the concept of promoting the clustering of economic assets has become a key cornerstone of contemporary economic development policy (see Porter, 2007). It is known that there is clustering of firms within the province (see Rutherford & Holmes, 2014); however, information on what is causing these spatial arrangements is scarce. Without proper knowledge, it becomes infeasible or impossible to undertake sort of informed policymaking.

A key part of this chapter, therefore, is presenting the findings of spatial analysis on the overall manufacturing sector in Southern Ontario as well as six key sub-sectors. The goal of the research is to determine the overall spatial organization of firms in the province, examine whether there are definable spatial clusters and identify potential socio-economic drivers that help explain clustering patterns. Within this research is a comparison between more traditional manufacturing sectors (i.e. automotive, textiles, printing) and more high-tech and advanced ones (i.e. aerospace, high-tech, communications). This comparison allows for a more nuanced investigation as it explores whether there are differences in the patterns of firms from traditional and modern areas of manufacturing. By understanding these issues

related to manufacturing, this chapter can help address a key contemporary local and regional challenge.

The remainder of the chapter will proceed as follows: first, the chapter will present a discussion on informed economic development policymaking, and the potential role that spatial analysis and geographic information science can play. The chapter will then present the case study on changing spatial patterns of manufacturing in Ontario, the relationship between clustering and economic development will be explored, and the potential causes of these observed patterns. Finally, the chapter will conclude with a discussion that integrates both the context and research presented and draws key implications for future policy and practice.

Informed and Evidence-Based Economic Development

Planning and developing effective local economic development policy *is hard*. And despite its importance for cities and regions, formal local economic development remains an evolving area of practice and research, underscored by incremental improvements but considerable room for growth. In broad terms, the maturation of local economic development can be divided into two areas: focus of policy (Cleave, Arku, & Chatwin, 2019) and the strategy and approach to policy (Leigh & Blakely, 2017). Recent evidence points to major evolution in policy focus and the restructuring of economic bases of communities through new policy interventions (see Arku, 2014; Gertler & Vinodrai, 2005; Leslie & Rantisi, 2012).

Changes in strategy, however, have been slower to occur. For instance, the City of Waterloo (2008: 6) admitted that it "never had a comprehensive economic development strategy and therefore lacks a clear and distinct vision of where it wants the local economy to go or how it proposes to get it there." Waterloo is not alone, as local and regional governments have been criticized for taking extremely haphazard approaches to economic development. Previous critiques of economic development approaches have been described as "shoot anything that flies; claim anything that falls" (Rubin, 1988: 237) or based on "act now; think later" attitudes (Arku, 2015: 604). Within academic spheres, there has been a series of calls for economic development officials to modernize their approaches (Nourick, 2012), with Waits, Kahalley, and Heffernon (1992: 616) warning local officials that "new economic realities have rendered obsolete the old ways of doing economic development."

While there is increased emphasis placed on formalizing economic development strategies (see Cleave, Arku, & Chatwin, 2017), a glaring limitation of contemporary policy and practice is a lack of evidence-based informed decision-making. If economic development *is hard*, then evidence-based approaches are *even harder* and are particularly true in an era where public services in advanced economies are "thinning", resulting less technical skill, human resources and capital available to address problems. Paradoxically, this makes evidence-based even more important as increasingly limited resources now need to be deployed efficiently and effectively. And armed with knowledge, decision-makers can better understand the context of

their jurisdiction, evaluate obstacles more effectively and in the process can tweak or adjust policy and redirect limited capital, political and human resources in ways that are more effective and efficient to extend the benefits of policy interventions (Feldman & Lowe, 2017; Hamermesh & Nottmeyer, 2017). The ability to stabilize from external shocks, or to extend prosperity, depends on policymakers' understanding of how and whether interventions and investments contribute to local and regional economies. As Osgood, Opp, and Bernotsky (2012: 12–13) argue, "although no one can fault local governments for engaging in a broad array of strategies to attract economic development, they should still be vigilant about the extent to which those practices are indeed producing outcomes."

It is within this context of evidence-based and informed planning that GIS and spatial analysis approaches have a potential role to play. There is a strong tradition of these approaches being used by academics to understand a wide array of economic phenomena, building off of the findings of research to tangible policy recommendations. Examples include: Cleave and Arku (2014) and Sadler, Cleave, Arku, and Gilliland (2016) call for regional and cross-boarder collaboration of municipal place branding efforts in Ontario and Michigan; Delgado et al. (2015) and Lopez and Paez (2017) delineation of economic clusters in North America; Rikalović, Soares, and Ignjatic (2018) efforts to identify optimum sites for logistics centres in Serbia; and Yang and Pojani's (2017) analysis on the impacts of transit on urban and economic development in Australia.

As noted previously, despite the robust use of GIS and spatial analysis in research, it is slow to be adopted in economic development practice with most usage being limited to urban planning and engineering departments (Loyalist Township, 2009). In fact, many municipalities in North America have identified GIS and spatial analysis as a weakness in their current capacities (see City of Fredricksberg, 2006; City of Guelph, 2015; City of Penticton, 2018; City of Pullham, 2018; City of Richmond Hill, 2018) with a similar perspective being noted in regional development efforts such as the Government of Ontario (2016) Growth Plan for the Greater Golden Horseshoe. Factors limiting the usage in the public sector include software availability, financial considerations and overall lack of knowledge of the capabilities of GIS and spatial analysis. Additionally, when there is strong local capacity, it often centres on cartographic elements rather than analysis. However, governments see the benefits of growing capacity, with the City of Guelph (2015: 160) noting that improved spatial capabilities will allow for greater accuracy in analysis, decision-making, responses to issues, and overall improve the local economy.

A Case Study of Manufacturing Clustering in Ontario: An Example of GIS, Spatial Analysis and Economic Development Planning

The next section of the chapter will use the case study of manufacturing in the Province of Ontario to present a way to better understand spatial patterns of manufacturing and factors that help facilitate observed configurations of firms.

The Province of Ontario was selected as the study context for this research for several reasons. First, it is Canada's most populous province, hosting roughly 40% of all Canadian residents. Second, Ontario is the economic hub of Canada; it has the largest economy with a gross domestic product (GDP) approaching $800 million per year and representing nearly 39% of Canada's total economic outputs (Government of Ontario, 2017). As a result, it represents an area of vital importance in terms of retaining and expanding economic growth in Canada. Third, Ontario is traditionally seen as the manufacturing heartland of Canada. The province currently contains nearly 35,843 manufacturing firms, representing nearly 44% of all manufacturing operations in Canada, and accounting for 47% for the countries manufacturing sales output (Statistics Canada, 2015A). As elsewhere in the industrialized world, the manufacturing sector in Ontario has experienced substantial turbulence since the 1970s influenced by broader processes of globalization, technological change, macro-economic reform, series of recessions and deregulation have accounted for the challenges (Wolfe & Gertler, 2001; Midler, 2011). Arguably, the Ontario manufacturing industry has been spiralling downwards, since the year 2000 Ontario manufacturing has experienced employment drop from 15.8 to 10.3% of total employment (i.e. from 937,400 to 712,100 employees). Post-2000s period also saw manufacturing's share of GDP drop from 23 to 15% which represented the worst drop the province had ever experienced.

Ontario has economic issues similar to many other advanced economies—traditional manufacturing has eroded through the spatial fixes inherent in globalization and neoliberalism. In its place, more flexible high-tech and advanced manufacturing have emerged. The challenges facing the manufacturing sector have affected the economic fortunes of most cities in the province, especially the South-western Ontario area (Bourne, Britton, & Leslie, 2011). It is worthwhile to note that many of the economic challenges facing Ontario also exist in other advanced economic markets.

From an economic development policy perspective, identification and development of economic clusters appears to be an area where scholarship has translated into practice at local and regional scales (see Government of Ontario, 2019). This is underpinned by over a century of research that has emphasized the need for clusters and agglomeration economy (see Isenberg, 2011; Porter, 2000). A cluster is a geographic concentration of interconnected companies, specialized suppliers, service providers, firms in related industries and associated institutions in a particular field that compete but also cooperate (Porter, 2007) and whose proximity promotes the spillover of knowledge, skills, inputs and demands (Polanyi, 1962). A good cluster is one that captures and utilizes as many of these linkages as possible (Bramwell &

Wolfe, 2008). The close proximity of related industries is especially important as it creates a pooled market of workers, specialized inputs from suppliers, rapid flow of business-related knowledge and technological spillovers (Delgado et al., 2015). This co-location of industries in a cluster has significant role in enhancing the economic marketplace because for many industries, there is nothing more motivating than having their strongest competitors nearby (Birkinshaw, 2000). Proximity of industries thereby becomes a crucial influence on enhancing the productivity and productivity growth of a market. In Ontario, clustering has been applied in many sectors including the automotive industry, talent and the creative class, food and agriculture, and IT and high-tech sectors.

With the issues related to manufacturing in the Province of Ontario and emphasis on clusters within local and regional economic development planning, developing manufacturing clustering policy appears to be a potential area of policy expansion. And in the context of increased need for evidence-based planning, GIS and spatial analysis present a strong avenue to identify potential clusters and their causes which can be used to help in decision-making and policymaking. The next sections of this chapter will outline a methodology for identifying spatial patterns of manufacturing firms in Ontario, determining the extents of clustering and finding what socio-economic factors help drive these patterns. The findings of this analysis are also presented and used to help show how spatial analysis can be used to assist in economic development policymaking.

Research Questions and Study Area

The overall objective of the research presented in this chapter is to contribute to the understanding of the spatial distribution and socio-economic factors affecting manufacturing within the Province of Ontario, allowing for evidence-based planning. More specifically, this study investigated two key questions:

(RQ1) *Is there a spatial pattern of manufacturing in Ontario?*
(RQ1) *What are the socio-economic drivers of manufacturing in Ontario? Do they differ for traditional and advanced manufacturing sectors?*

These questions and research study help fill gaps in current academic literature but also present an opportunity to assist in informed economic development policymaking. By understanding these issues related to manufacturing, this chapter can help address a key contemporary local and regional challenge.

This research examined the manufacturing sector as a whole, as well as six key sub-sectors: three traditional manufacturing sectors (automotive, textiles and printing) and three advanced manufacturing sectors (aerospace, technology and communication). Since it is understood that Ontario's economy is in a period of transformation—with many local governments feeling pressure to redevelop their local

economies—providing analysis on both traditional and advanced manufacturing sectors provides insight into what conditions are needed to have a chance of success in the contemporary economic landscape. Additionally, since traditional manufacturing is not yet dead in the province, analysing historically important sectors also allows to identify factors that help communities be resilient and maintain some local economic development strength.

As alluded to previously, the study area for analysis is the southern region of the province, as it contains 75% of Ontario's municipalities (302/414), 95% of the province's population and 97% of manufacturing firms. As a result, this analysis focuses on the region with the greatest amount of economic and manufacturing activity. Additionally, the analysis will occur at two scales—the firm level and the municipal level—which is the primary spatial scale used. The municipal level was used because that remains the primary spatial scale that economic development policy is developed and implemented, with potential regional policies emerging in a bottom-up way, where municipal governments decide to collaborate.

Methodology and Data

To address the two research questions, three forms of analysis are used: a Firm Intensity Quotient (FIQ) based on point density analysis manufacturing firm locations in Ontario, which is used in addressing both research questions; Moran's I to address RQ1 by determining spatial autocorrelation of clusters at the municipal level; and spatial regression analysis for examining the relationship between FIQ and socio-economic characteristics of each municipality.

The FIQ is similar to location quotient, a local economic development analysis tool, by identifying clusters where the local conditions (i.e. number of firms or employees) are greater than what is expected based on regional characteristics (Leigh & Blakely, 2017). However, location quotients are non-spatial. FIQ provides a spatial delineation of clusters where a continuous firm density estimate is compared to an expected density (i.e. average density of firms in a region). Following similar interpretations of location quotients, areas with a Firm Intensity Quotient over 1.25 were identified as being areas with a strong agglomeration of firms.

This density estimate was developed through point density analysis, which is a spatial modelling technique that creates a density surface model based on a set of known point values which in this case were the locations of manufacturing firms in Southern Ontario. Areas with greater concentrations—or clusters—of points will produce a higher estimated value on the surface model. Firm location data was collected from the Dun and Bradstreet Million Dollar Database (MDDI) and was exhaustively examined to develop a comprehensive list of manufacturing firms operating in Southern Ontario. Filtering by NAICS codes to identify firms involved in the manufacturing sector, a final dataset of 35,843 firms was identified (see Table 1 for more detail on the sub-sector firms). An FIQ was estimated for each of the 302 municipalities in the study area.

Table 1 Summary of manufacturing firms operating in Southern Ontario

(Sub) sector	# of firms	Description
Manufacturing	35,843	This includes all firms from the 24 manufacturing sub-sectors operating in Southern Ontario
Automotive (traditional)	862	These industries consist primarily of assembly plants and manufacturers for automotive systems and parts. Automobile manufacturing production in Southern Ontario began in 1904 and has remained a prominent industry since initial development
Textile (traditional)	700	These industries consist primarily of cloth furnishing and processing. Textile production in Canada dates back to 1827, with the creation of the first Canadian mill
Printing (traditional)	3199	Printing industries involve industries primarily engaged in printing (e.g. newspapers, books and business cards) and printing related services (e.g. data imaging and book binding)
Aerospace (advanced)	166	Aerospace industries involve civil aircraft and structure production, alongside some other space, simulation and aircraft components or systems
Communication (advanced)	263	Communication manufacturing focuses on development for wireless communications equipment such as GPS, satellite or broadcasting equipment
High-tech (advanced)	780	Comprised of industries that focus on technological development of high-tech items for use among sectors in all areas like transportation, communication and energy

A key assumption of contemporary economic development policy and planning is that there are no spatial interactions between municipalities. From other economic development research (see Cleave et al., 2017), it has been demonstrated that there is often spatial autocorrelation between municipalities in regard to local economic development. This can lead to misspecification if the analysis is based on the assumption that each municipality is independent of all others (Baumont, Ertur, & Le Gallo, 2001). Moran's I with a standard Queen's case weight matrix was used to test whether there was global spatial autocorrelation of FIQ. The null hypothesis is that no spatial autocorrelation exists (tested with a Z-score, see Anselin, 2005; Rogerson, 2010). The Moran's I test serves two purposes for this case study, as it determines if there are global patterns of autocorrelation across municipalities in Southern Ontario which would indicate an underlying spatial pattern of manufacturing—indicating regional clustering (addressing RQ1).

The second purpose of using Moran's I is to provide preliminary evidence for spatial dependence, which needs to be considered for the regression analysis used to address RQ2. While the point density analysis identifies hot spots of manufacturing intensity, it does not provide any information on the local socio-economic conditions that may influence where firms locate. To explore this—and achieve a key research goal of the study—spatial regression analysis was utilized. Non-spatial regression analysis typically utilizes an ordinary least squares (OLS) estimator to

model the relationship between dependent and independent variables. If there is spatial dependence, the endogeneity of the regressors causes standard OLS estimator to become biased and inconsistent and produces inefficient estimates and the potential for invalid statistical inference (Abreu, de Groot, and Florax 2005). In cases of global spatial autocorrelation, three forms of spatial regression models could be used to model manufacturing intensity. First is spatial lag, where dependent variables are influenced by observed independent variable values in neighbouring areas. Second is spatial error, where there is correlation in the error between neighbouring regions. For the first two instances when OLS assumptions are broken, a maximum likelihood (ML) estimator is needed to produce a valid model between dependent and independent variables. Anselin's (2005) taxonomy of spatial econometric models argues that the model can be global or local, as well as modelled in the error term or un-modelled. The third way in which the assumptions of an OLS are broken is when there is a combination of both spatial lag and spatial error influencing the dependent variable. In this case, a generalized method of moments (GMM) estimator is needed to produce valid variable co-efficient estimates for the independent variables. As opposed to ML estimators, which require assumptions about the distribution of variables and the error term, GMM allows models to be specified while avoiding often unwanted or unnecessary assumptions, such as specifying a particular distribution for the errors. This lack of structure means GMM is widely applicable, particularly when there is potential spatial lag and error.

The regression analysis was conducted first using OLS regression with the Queen's case weight matrix included. Along with Moran's I, the diagnostic tests for Lagrange multiplier (LM) for spatial lag and spatial error were analysed. If one of the LM lag or LM error methods was significant, then a ML regression was implemented to account for that form of spatial autocorrelation. If both the LM outcomes were significant, the robust LM indicators were examined. Again, if one of the robust LM lag or robust LM error methods was found to be significant, then a ML regression was needed to produce unbiased estimates. Finally, if both the robust LM lag and robust LM error were found to be significant, the GMM estimator was used (for the specific models for each regression, see Table 2).

But what was being modelled through this analytical approach? The FIQ for each municipality for overall manufacturing and the six sub-sectors were the dependent variables in this analysis. The independent variables were nine socio-economic factors drawn from the most recent 2016 census. More detailed information is provided in Table 3 and Fig. 1; however, the nine independent variables were: population, population change, population density, household income, unemployment, workforce, education, creativity and science. These were also grouped into three indicator categories: demographic, which included population, population change and density; economic (income, unemployment and workforce); and talent (education, creativity and science).

The analytical approach outlined above was completed 91 times. First, each of the seven dependent variables was modelled using bivariate regression analysis. Then, multivariate regression was used on the three indicator categories. Finally, a model using all nine independent variables was run. The results of these models

Table 2 Summary of the analytical approach used in this case study

Analytical Step	Description
STEP 1: Detecting spatial dependence with OLS regression using a weights matrix	$y = x\beta + \varepsilon$ where $\varepsilon \sim N(0, \theta^2)$ where y is the response variable, x is the explanatory variable and β is the estimate of the co-efficient. The error term (ε) is assumed to be normally distributed ($\varepsilon \sim N(0, \theta^2)$)
STEP 2: ML regression if spatial lag was detected by the Lagrange multiplier diagnostic	$y = \rho Wy + \beta x + \mu$ where $\mu \sim N(0, \theta^2)$ where ρ is the lag co-efficient and Wy is the weighted matrix for FIQ values in other municipalities
STEP 3: ML regression if spatial error was detected by the Lagrange multiplier diagnostic	$y = \lambda W\varepsilon + \beta x + \mu$ where $\mu \sim N(0, \theta^2)$ where λ is the error co-efficient and $W\varepsilon$ is the weighted matrix for the error modelled in other municipalities
STEP 4: GMM regression if both spatial lag and error were detected by the robust Lagrange multiplier diagnostic	$y = X\beta + \gamma Y + u$ where $u = \lambda Wu + \varepsilon$ and $\varepsilon \sim N(0, \theta^2)$ where Wu is the spatial lag of the errors, λ is the autoregressive parameter and ε is a "well-behaved" error term ($\varepsilon \sim N(0, \theta^2)$)

were explored through an examination of independent variable co-efficients, whether the modelled relationship was significant (using a t-test), and finally by considering the r^2.

Findings and Analysis

Due to space considerations in this chapter, this section will present the relevant and top-line findings from this approach to understanding manufacturing in Southern Ontario. Figure 2 presents the regional FIQ for the manufacturing sector as a whole, as well as the six sub-sectors considered in this analysis. Of note, all of the sectors analysed have strong clustering in the Greater Toronto Area. Interestingly, clusters for traditional sectors tend to be more consolidated, while clusters of more advanced sectors are distributed across the province. Additionally, for all the sub-sectors identified, the clusters extend across multiple municipalities. This suggests that a more regional rather than local approach is needed within economic development which is a concept that is currently scarce in Southern Ontario (and other advanced economic regions) where municipal competition is the status quo. This overall approach provides immediate evidence on how a GIS/spatial analysis-informed approach could pay immediate dividends in affecting economic development planning and policy.

This need to consider a regional or cooperative approach is reinforced by the findings of the Moran's I analysis (see Fig. 3 for summaries). Based on the exploratory spatial analysis of the dependent variables using a global Moran's I measure, it is

Table 3 Summary of the independent variables

Variable	Description
Population	The total number of people living in a municipality based on the 2016 Statistics Canada census. Municipalities with larger populations are likely to be more urban and developed, and therefore are expected to be key centres of manufacturing. Response in FIQ reported by changes of 1000 people
Population change	The percentage change in a municipality's population between the Statistics Canada 2011 and 2016 censuses. It shows whether a municipality's population is increasing or decreasing in size, and at what rate this is occurring. This acts as an indicator of the overall health of the municipality. Response in FIQ reported by changes of 1%
Population density	The number of people per square kilometre living within a municipality's boundaries. Higher population density allows for greater interaction between individuals allowing a greater exchange of ideas and knowledge, which are viewed as key drivers of innovation and economic growth. Response in FIQ reported by changes of one person per square kilometre
Household income	Measures the amount of wealth (in $CAN) at a household level, averaged among all households in a municipality. This acts as a proxy for economic health of a municipality, as places with greater household income are likely to have higher paying wages, indicating healthier businesses. Response in FIQ reported by changes of $10,000
Unemployment	Measures the percentage of the municipality not currently employed. This is another measure of economic health of a municipality, as low unemployment rates indicate that there are ample jobs for the local workforce. This suggests that firms in the municipality are successful, as they are employing—rather than laying off—workers. Response in FIQ reported by changes of 1%
Workforce	The population of a municipality between the ages of 18 and 65. This variable indicates the size of the workforce available to take on employment. Having a large workforce indicates potential for economic health, as there are many suitable employees located within a municipality. Response in FIQ reported by changes of 1000 people
Education	The percentage of individuals within a municipality that have a university education. This can be viewed as a proxy for the skill and talent level within a workforce, with higher education indicating greater overall skill. This is particularly important for advanced manufacturing, which requires a skilled workforce. Response in FIQ reported by increases of 1000 people.
Creative	The percentage of people in the municipality working in non-manufacturing- and non-agriculture-related sectors. This acts as a proxy for the number of people working in creative industries. A higher concentration of creative industries and individuals suggests a talented workforce that is likely to be generating innovation, which is a key indicator of future economic growth. Response in FIQ reported by increases of 1000 people in creative fields
Science	The percentage of the population with science related-degrees. This acts as a proxy for the skill of the workforce, as it suggests that the population is receiving training that is pertinent to the knowledge and skill-intensive requirements of advanced manufacturing. Conversely, a less educated population may be more closely aligned with the labour needed in traditional manufacturing sectors. Response in FIQ reported by increases of 1000 people with science degrees

clear that there is spatial dependence, as the measurements of the distribution for each variable produced a z-score greater than the 1.96 critical value (at $\alpha = 0.05$). This suggests that a municipality's FIQ is likely to be similar to that of its neighbours. This further suggests that there is a spatial pattern of manufacturing in the province and presents the proposition of the need for inter-municipal collaboration.

The results of the Moran's I also indicate that an OLS regression may not produce reliable estimates. This is further supported by the diagnostic tests as all 91 analyses showed evidence of spatial lag and error (significant at 0.05) through the LM tests. Eighteen of the models required ML regression for spatial lag, and twenty of the

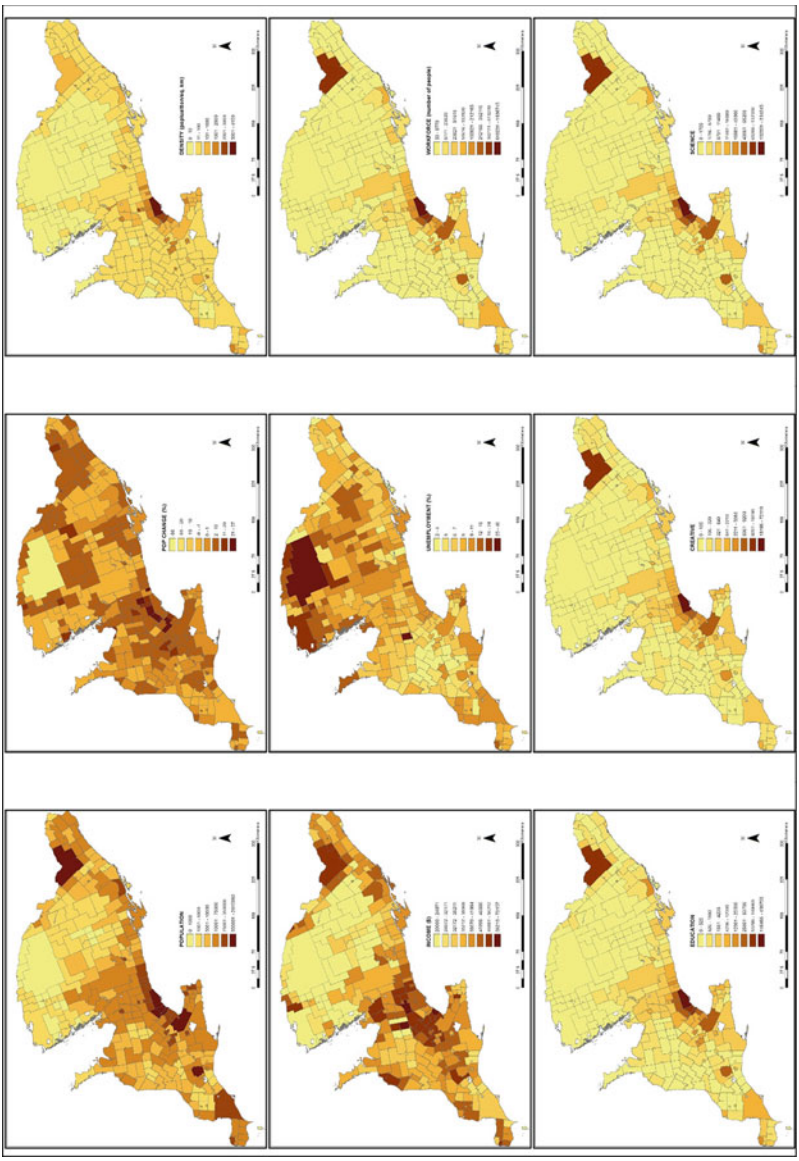

Fig. 1 Socio-economic characteristics of municipalities in Southern Ontario (based on 2016 census)

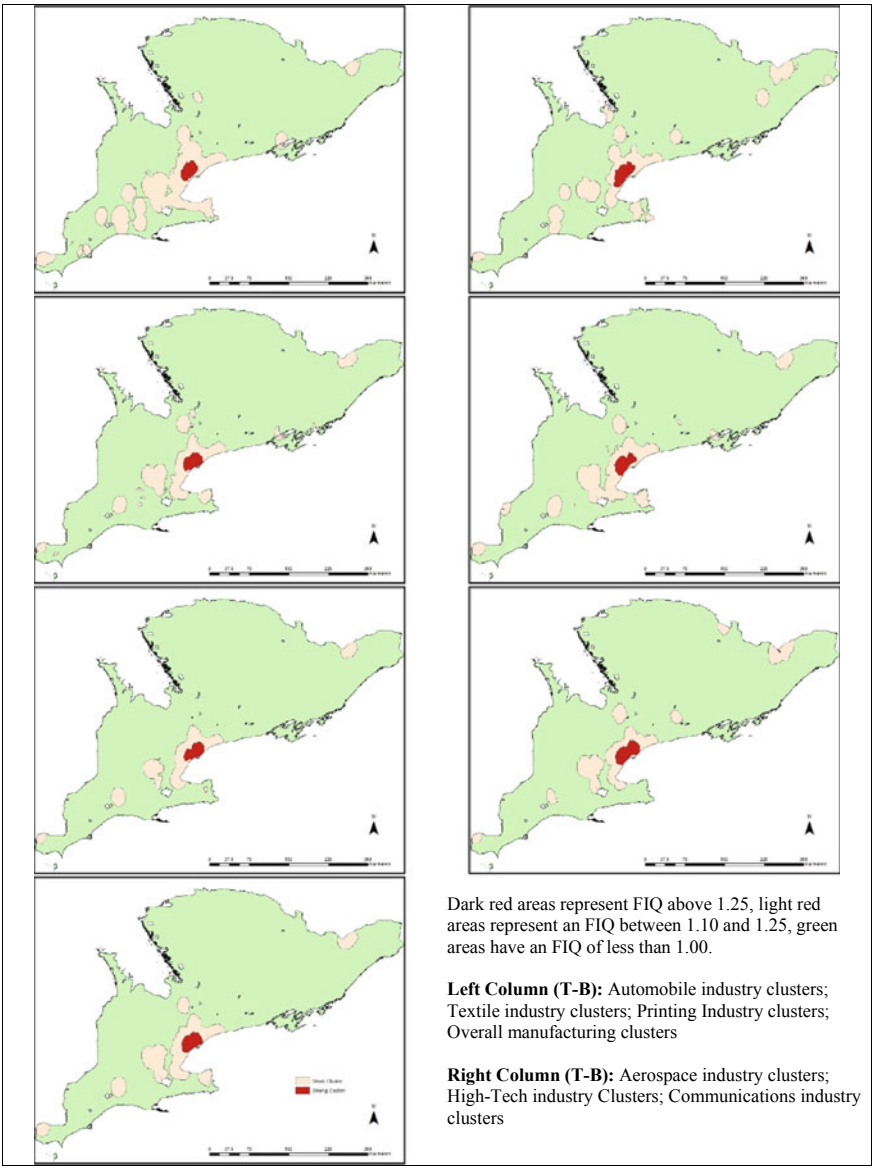

Fig. 2 FIQ intensities for Ontario

models required ML regression for spatial error, while the remainder required GMM regression as the robust LM indicated spatial lag and error. This suggests that both the levels of FIQ in its neighbours had an influence on the FIQ of a municipality. This suggests that a regional perspective is needed on policy regarding manufacturing and clustering, as there is a spatial interaction between municipalities. Additionally,

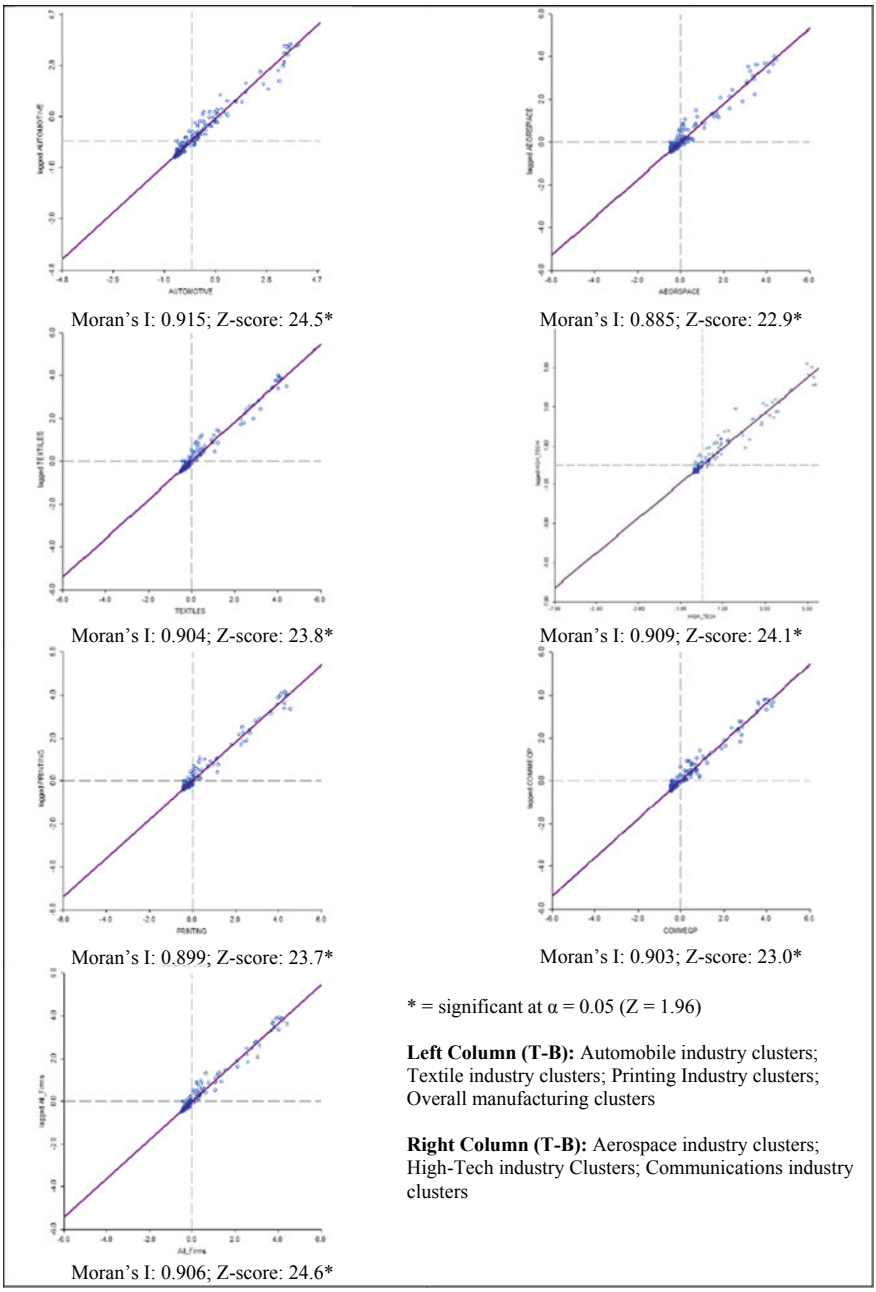

Fig. 3 Estimates of Moran's I for spatial autocorrelation of manufacturing intensity

the need to model spatial error suggests that there are other independent variables that are unaccounted for—suggesting further analysis into potential what non-socio-economic could influence the spatial pattern of manufacturing (i.e. presence of roads, railways or universities). This is supported by the r^2 estimated by the models, which were consistently between 0.10 and 0.40 (with the exception of the combined model). While these are good for a complicated issue such as economic development, they also indicate that the models used in this study do not fully explain the variability in FIQ across municipalities.

Table 4 summarizes the findings of the bivariate regression analysis. Overall, besides population there were no significant relationships with any socio-economic drivers for the traditional manufacturing sub-sectors. This could reflect two things: that these industries are influenced by socio-economic drivers that were not analysed in this study (e.g. mobility, health) or, that as longstanding industries in Southern Ontario their relative locations reflect initial needs and opportunity rather than specific drivers. Oppositely, advanced manufacturing was influenced by population change and density, workforce, education, creative and sciences.

As noted, population was shown to have a significant relationship, which was quite strong for overall manufacturing, but relatively subtle relationship for the three traditional sub-sectors. For the advanced sub-sectors, however, population has non-significant influence. Interestingly, an opposite pattern was noted with population density, as greater density was significantly related to FIQ for the advanced sub-sectors but not for the traditional ones. Taken together, this suggests that traditional manufacturing is receding from all but the largest municipalities; however, the advanced sectors that are replacing it are attracted to high-density areas. This finding is in line with work on the creative class and on knowledge-based economies that stress the need for high concentrations of people from which innovation can emerge.

This finding is supported by the results of the bivariate models comparing municipal levels of creativity, education and science against the FIQ in each municipality. Perhaps unsurprisingly, there were significant positive relationships identified between these and the advanced manufacturing sub-sectors, and non-significant (and slightly negative) relationships delineated with the traditional sub-sectors. This makes conceptual sense, as advanced sectors of the economy require both well-educated and highly skilled workers to function, and by extension firms in these sub-sectors would be drawn to places that have the capacity to meet their needs. From an economic development planning perspective, this is anecdotally acknowledged in most city plans (see Cleave et al., 2017), but this analysis provides empirical support for this planning.

Table 5 summarizes the findings of the multivariate analysis on the demographic, economic and talent models. At the top-line level, the findings generally support the initial bivariate analysis, as population was the only variable in the demographic model that was significantly associated with traditional manufacturing FIQs, while population density—but not change in this stage of analysis—was noted to have a significant relationship with advanced sub-sectors. Similarly, the talent model was

Table 4 Summary of the bivariate regression models

	All	Auto.	Text.	Print.	Aero.	Tech.	Comm.
Population							
Co-efficient	0.226*	0.284*	0.322*	0.169*	0.001	0.000	0.000
Regression estimator	GMM	GMM	GMM	GMM	MLE	MLE	MLE
R-squared	0.19	0.17	0.19	0.20	0.11	0.09	0.12
Population change							
Co-efficient	0.017	0.054	0.044	0.022	0.103	0.261*	0.171*
Regression estimator	GMM	MLE	GMM	GMM	MLL	GMM	GMM
R-squared	0.20	0.12	0.16	0.14	0.16	0.17	0.17
Population density							
Co-efficient	0.068*	0.030	0.012	0.054	0.027*	0.015*	0.019*
Regression estimator	MLL	GMM	GMM	GMM	MLL	MLL	MLL
R-squared	0.42	0.15	0.17	0.18	0.25	0.25	0.26
Household income							
Co-efficient	0.008	0.005	0.004	0.002	0.001	0.001	0.001
Regression estimator	GMM	GMM	GMM	GMM	MLE	MLE	MLE
R-squared	0.120	0.13	0.12	0.14	0.07	0.08	0.05
Unemployment							
Co-efficient	−0.055*	−0.035	−0.024	0.011	−0.066*	−0.033	−0.010
Regression estimator	MLE	MLE	MLE	MLE	GMM	GMM	MLL
R-squared	0.12	0.09	0.07	0.11	0.10	0.14	0.09
Workforce							
Co-efficient	0.043*	0.003	0.001	0.001	0.061*	0.057	0.018*
Regression estimator	GMM	MLE	GMM	GMM	MLL	MLE	MLL
R-squared	0.19	0.20	0.13	0.15	0.21	0.19	0.21
Education							
Co-efficient	0.007	0.003	0.003	0.000	0.008*	0.003*	0.001*
Regression estimator	MLL	GMM	GMM	GMM	GMM	GMM	GMM
R-squared	0.26	0.13	0.15	0.16	0.17	0.15	0.18

(continued)

Table 4 (continued)

	All	Auto.	Text.	Print.	Aero.	Tech.	Comm.
Creative							
Co-efficient	0.010	0.007	0.007	0.004	0.001*	0.008	0.003*
Regression estimator	MLL	MLE	MLL	MLE	GMM	GMM	MLL
R-squared	0.18	0.11	0.12	0.13	0.14	0.14	0.17
Science							
Co-efficient	0.002*	0.005	0.005	0.020	0.001*	0.005*	0.002*
Regression estimator	GMM	MLL	MLL	MLE	GMM	GMM	GMM
R-squared	0.19	0.15	0.18	0.12	0.21	0.18	0.22

* = significant at $\alpha = 0.05$; MLE—maximum likelihood estimation for error; MLL—maximum likelihood estimation for lag; GMM—generalized methods of moment estimation for lag and error

Table 5 Summary of the demographic, economic and talent models

	All	Auto.	Text.	Print.	Aero.	Tech.	Comm.
Demographic model							
Population (co-efficient)	0.181*	0.314*	0.288*	0.200*	0.002	0.000	0.001
Population change	0.014	0.049	0.051	0.020	0.112	0.251	0.133
Population density	0.056	0.020	0.015	0.051	0.027*	0.016*	0.016*
Regression estimator	MLL	MLE	GMM	GMM	MLL	MLE	MLE
R-squared	0.41	0.36	0.38	0.38	0.38	0.37	0.39
Economic model							
Household income	0.007	0.004	0.003	0.003	0.001	0.001	0.001
Unemployment	−0.055*	−0.002	0.001	0.004	−0.064*	−0.033*	0.010
Workforce	0.003	0.001	0.001	0.001	0.063*	0.062*	0.018*
Regression estimator	GMM	MLE	GMM	MLL	GMM	MLE	MLL
R-squared	0.39	0.36	0.35	0.35	0.38	0.37	0.37
Talent model							
Education	0.005*	0.002	0.003	0.001	0.008*	0.004*	0.001*
Creative	0.009	0.007	0.005	0.004	0.001	0.009*	0.001
Science	0.008	0.004	0.004	0.013	0.001*	0.005*	0.003*
Regression estimator	MLL	GMM	MLL	MLE	GMM	GMM	GMM
R-squared	0.29	0.19	0.22	0.24	0.24	0.21	0.25

* = significant at $\alpha = 0.05$; MLE—maximum likelihood estimation for error; MLL—maximum likelihood estimation for lag; GMM—generalized methods of moment estimation for lag and error

Table 6 Summary of the combined model

	All	Auto.	Text.	Print.	Aero.	Tech.	Comm.
Combined model							
Population (co-efficient)	0.192*	*0.309	0.255	*0.188	0.001	0.000	0.001
Population change	0.011	0.062*	0.076*	0.020	0.090	0.188	0.125
Population density	0.049	0.015	0.013	0.044	0.025*	0.018*	0.014*
Household income	0.006	0.004	0.002	0.002	0.001	0.001	0.001
Unemployment	−0.048*	−0.001	−0.001*	0.000	−0.050	−0.035*	0.000
Workforce	0.002	0.001	0.001	0.001	0.065*	0.059*	0.009
Education	0.005*	0.001	0.002	0.001	0.007*	0.003*	0.001*
Creative	0.010	0.005	0.005	0.002	0.002*	0.010*	0.000
Science	0.006	0.004	0.002	0.009	0.001*	0.006*	0.003*
Regression estimator	GMM	GMM	GMM	GMM	GMM	GMM	GMM
R-squared	0.56	0.44	0.44	0.45	0.55	0.56	0.54

* = significant at $\alpha = 0.05$; MLE—maximum likelihood estimation for error; MLL—maximum likelihood estimation for lag; GMM—generalized methods of moment estimation for lag and error

shown to be a significant influence on advanced manufacturing, while a slight negative driver of traditional manufacturing. There was a slight difference in the economic model compared to the initial bivariate models, as workforce and unemployment were found to have a significant influence on all three advanced manufacturing sub-sectors, suggesting that a robust local economy may play an important role in attracting and retaining firms in emerging manufacturing sectors.

Finally, the combined multivariate model is summarized in Table 6. As with the previous two analytical approaches, overall manufacturing was found to have a significant relationship with the majority of socio-economic drivers. Similar patterns also emerged for the traditional and advanced sub-sectors: population was significant for traditional FIQ while science, education and creative were identified as having significant positive influence on advanced FIQ. However, when taken together, population change and workforce are no longer significant for advanced firms.

Overall, when comparing the three stages of analysis, several key points emerge that have implications for economic development planning. First, while the top-line summary of analysis showed broad consensus within advanced and traditional sub-sectors, there were some key differences that emerged. As one example, workforce was found to be significant for high-tech and aerospace in the economic multivariate analysis, but not for communication firms (see Table 5). And this is even more evident when overall manufacturing analysis is compared to that of the individual sub-sectors. Second, socio-economic drivers should be considered both individually and together, as there does appear to be a mediating influence when FIQs were analysed using the multivariate regression. This differs from current planning approaches that tend to

consider potential strengths and drivers of the economy in isolation, so considering factors in conjunction with each other can provide more accurate and realistic models from which decisions can be made. Finally, spatiality and the economic state of nearby municipalities need to be considered. Beyond needing to take a more regional and collaborative perspective on policy, this analysis has shown that spillovers and interconnections between neighbours can be influential. Therefore, planners and practitioners need to begin to think more regionally to place their current situation into a better context. Current approaches such as location quotients lack the specificity needed to conduct this analysis. Together, these points which have emerged can significantly improve evidence-based and informed planning and decision-making if taken into account.

Concluding Thoughts

The goal of this chapter was to present a method for understanding the clustering of manufacturing in Southern Ontario, within the context of using GIS and spatial analysis in informed economic development planning and policymaking. Understanding the structure of the economic landscape and what municipalities should do to remain relevant are vital questions being asked by local and regional governments. Using the case presented here, the analysis has shown key drivers of manufacturing in Ontario that can help shape policy. For instance, there appears to be a pathway forward for municipalities to attract advanced manufacturing firms by enhancing the overall skill and knowledge of the workforce. Alternatively, traditional manufacturing has been identified as a fool's errand to chase, as it appears to be receding to only the largest population centres—suggesting that there is very little that local governments can do to recapture any past success. However, traditional manufacturing remains a priority for many local governments. Therefore, this analysis provides a key data point to allow for better and more informed economic development policy decisions.

The question is how does this translate from theory to practice? There appear to be three potential areas that require consideration: data, software and analysis. Data and software are relatively straightforward, as there is significant socio-demographic and business data available through government (i.e. census data, firm inventories, economic data) or university partnerships (i.e. the data set constructed here), while the software used here is industry standard (i.e. ArcGIS) and open-sourced (*R* and *Geoda*). Therefore, the current limitation is technical skill needed to complete the analysis. The approach put forward here is conceptually straightforward and does not require significant background to understand and implement but may be beyond current capabilities. Fortunately, this is an area that has been flagged by municipalities in their GIS inventories as a potential weakness. Moving forward, local and regional governments should emphasize the development of analytical capacity along side the development of their cartographical capacity, or to find potential partnerships that can help fill gaps in their knowledge and skill (i.e. university partnerships or contracting consultants for specific spatial analysis work).

As evidence-based planning becomes more ubiquitous within economic development, there is great potential for using GIS and spatial analysis to better understand human world and its impacts on local and regional economies. While ostensibly about manufacturing and cluster analysis, the approach presented in this chapter can be imported into other areas and act as a framework for other types of analysis. But it demonstrates the value that a GIS or spatial perspective can have on improving understandings of the economy and what municipalities should do to move forward.

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Social Issues and Regional Intelligence

Tourists, Residents and Experts Rethink the Future of Mediterranean Regions: A Question of Regional Intelligence

André Samora-Arvela, Eric Vaz, Jorge Ferreira and Thomas Panagopoulos

Introduction

The regions assumed as Mediterranean in their coastal situation and/or their climatic amenity, mainly, focus their development base on the sun and beach tourist product.

Among the other regions corresponding to this framework, the Algarve region, south of Portugal, constitutes a territory that, despite its diverse landscape, grounds its socio-economic base in coastal seaside delight.

In contrast to this lack of diversification of tourist products, several are the tutelary instruments that have the goal of qualification and tourism diversification through the enhancement of natural and cultural heritage as strategic axes of development, such as the *National Program for Spatial Planning* (MAOTDR, 2007; Simões & Ferreira, 2010, p. 1064; DGT, 2018), *Tourism Strategy 2027—Leading Tourism of the Future* (TP, 2017), *Regional Plan for Spatial Planning of Algarve region* (CCDRAlg, 2006, 20), *Prospective Diagnosis "Algarve—Preparing for the Future 2014–2020"* (CCDRAlg, 2013) and *Strategic Marketing Plan for Algarve Tourism 2015–2018* (TA, 2014).

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On the other hand, climate change and its impacts may, in this context, create a disruptive character upon regional development by the consequent loss of beach area by sea level rise, which is the basis of the main product and socio-economic activity of the region.

Thus, it's imperative to study strategic and spatial alternatives that can contribute to the diversification and enhancement of other tourism products, so it is important, in the first instance, to study the willingness of tourists and residents to redirect their recreational practices, in addition to beach, in spaces that are available or can be created, information that is analysed in this chapter for the purpose of further instruction of incremental public policies of regional resilience.

These activities relate to spaces that, besides the coastal beach, are available for enhancement, in order to increase the diversification of tourism offer, based on the promotion of alternative, creative and sustainable tourism practices. As such, this strategic option can represent a way of strengthening resilience and regional sustainability through diversification and, therefore, can represent a major measure of cultural adaptation, not just instrumental, to the impacts of climate change.

In this context, an inquiry was carried out on coastal tourists and residents in the region, demonstrating, in terms of results, that the complementary preferences for other spaces, besides coastal beaches, for alternative tourism and recreational activities are relevant, which was concerted with experts' acquaintance. The knowledge emanated from the present study must help the design of public policies and the sustainable redirection of tourism promotion of Algarve landscape as a whole, which remains unknown for most of its visitors.

Tourism and Climate Change

The importance of tourism in the Mediterranean region's socio-economics that depend heavily on it may be affected by the impact of climate change.

Being so, it is not surprising that, in the present and future, climate change is an element of drastic disruption of a sector as vulnerable as tourism (UNWTO, 2008, pp. 61–68), where direct impacts are expected, such as the consequences of climate change on the seasonality of tourism demand, as well as changes in the running costs of tourism establishments (Casimiro, Gomes, & Almeida, 2010, pp. 6–7), and environmental impacts, such as temperature rise, sea level rise and extreme events (heatwaves, intense precipitation, floods and droughts), which will be reflected in the scarcity of water resources, coastal erosion, beach area reduction, increase in the number of fires, decrease in agricultural production, reduction of snow surface, degradation of aesthetic quality of landscape and higher incidence of vector-borne diseases, due to the disappearance of climatic barriers, among others (Simpson, Gossling, Scott, Hall, & Gladin, 2008, p. 13; Becken & Hay, 2007, pp. 38–50).

Such degradations may imply alterations in the geography of tourist attractiveness, corresponding to societal impacts on destinations, such as unemployment, social

exclusion and political instability with a danger to public safety, constraining the development of these regions (UNWTO, 2008, pp. 67–68).

The PESETA I and II projects, modelling the Tourism Climate Index (TCI), define climate suitability for tourism purposes, through factors such as temperature, humidity, hours of sunshine, precipitation and wind, projecting, in general, a degradation of thermal comfort for tourism purposes in Mediterranean regions (Amelung & Moreno, 2009, pp. 16–25; Ciscar, Feyen, Lavalle, Soria, & Raes, 2014).

For the Portuguese case, the SIAM II project uses the Bioclimatic Index of Physiological Equivalent Temperature (PET), which is based on the indexation relationship between meteorological conditions and human thermophysiological conditions, projecting to 2100, for the case study of Faro, example of the climatic character of the Algarve region, a decrease of thermal comfort in the summer months with increasing frequency and duration of heat waves, which in addition to thermal discomfort may lead to an increase in diseases related to heat stress (Santos & Miranda, 2006, p. 251) and vector-borne diseases. The assertion projects up to 2100 also an increase of thermal comfort in April, May and October in relation to the present situation, just as it is expected that climate change will still lead to a decrease in the number of months with any degree of stress due to cold, with the greatest reduction in January, a month that often is characterized by the highest number of days of extreme or severe stress due to cold (Santos & Miranda, 2006, p. 251).

These changes will have a beneficial impact on tourism, since they will lead to a reduction in seasonality and greater use of the pleasantness of months previously considered as low season, and there may be an increase in tourist demand in spring and winter, particularly between the elderly population (Santos & Miranda, 2006, p. 251).

However, in addition to the generalized increase in temperature, other expected major impacts are the reduction of water resources availability, and a potential decline in agricultural and forest productivity, as the SIAM project, explicitly, states (Santos, Forbes, & Moita, 2001, pp. 15–21). The region of the Algarve, south of Portugal, is likewise largely exposed to sea level rise, its extreme meteorological levels and wave height, so that the IPCC (2013, pp. 1182; APA, 2014, p. 49) projects an increase in the order of 0.42 to 0.98 m of the mean sea level rise by 2100, which will increase the saline intrusion in the aquifers, increase the phenomenon of coastal erosion and reduce sand beach area (Oliveira, Dias, & Catalão, 2005), a preponderant tourism resource for the sun and beach tourism, the recurrent main driver of the regional economy.

Tourism and Product Diversification

In the present society of consumption and spectacle, the consumption of certain products and places is not only a material practice, but also an activity of systematic manipulation of the signs that support the symbolic imagery, where the object of consumption needs to have a meaning. As such, the merchandise becomes a sign

and the sign into a merchandise (Costa, 2018, p. 673), so that tourism products are, essentially, experiences, which are paramount regarding the tourist choice and satisfaction (Smith, 1994, p. 582).

There may be several strategies for managing and promoting tourism products, including diversification or concentration, which may take different scales, such as mass intensification or the creation of niches (Benur & Bramwell, 2015, p. 214). It should be noted that the success of diversification requires coherence in the establishment of synergies and links between tourism products (Benur & Bramwell, 2015, p. 214; Romão & Neuts, 2017).

The tourism products diversification, that is, offering a varied set of recreational experiences and activities, contributes to the competitiveness of tourist destinations, keeping open a flexible and, therefore, resilient range of options for tourism, able to respond fluctuations of preference and their demand tourist.

Although the argument about the competitiveness of a destination is pertinently valid, the first advantage of tourism diversification through the encouragement of alternative products is to increase the sustainability of destinations, derived from the appreciation of the destination intrinsic character promotion (in opposition of its anomic depreciation homogenization), community involvement and local ownership, and respect for the carrying capacity of territories, where the small scale of tourism use does not require the implementation of infrastructures of enormous size (Bramwell, 2004). The gains of diversification are made not only in terms of efficiency but also in effectiveness, which can be achieved by establishing synergy, cooperation, coordination and cost-sharing relationships in an integrated marketing strategy of its panoply of products (Benur & Bramwell, 2015, p. 214), based on a plural and transversal capacity to satisfy the requirements of each specific market of tourist demand. In some cases, the concentration brings advantages in the face of diversification, in particular by circumscribing, locally, the pressures and impacts of some mass tourism products, as is the case of beach tourism and its coastal urban spaces.

Bramwell and Benur (2015, p. 214) postulate that the sustainable development of tourism can be achieved by the alliance of mass concentration of one or two products with the diversification into alternative product niches, an option considered, indeed, suitable for Mediterranean regions (Bramwell, 2004; Weaver, 2000, 2006).

In this sense, new combinations can arise in the definition of tourist experience that should be understood as a whole, complete, co-created and shared by tourists, operators and local communities, determined by the resources of each destination (Benur & Bramwell, 2015, p. 216). New combinations allow to diversify the tourist experience, attracting new segments of tourists and consolidating the demand of the existing ones.

Diversification is, thereby, according to Benur and Bramwell (2015, pp. 216–217), parallel or integrative. In the first, the establishment of synergies and complementarities is not verified, which can generate tensions and conflicts. Regarding the second, integrative diversification is based on the interconnection between products, the combination of their complementarities and synergies through organized packages or

flexible/informal visit patterns, based on close cooperation between the various operators involved in promoting the various products in a region/destiny. A true example of destinations with vocation for integrative diversification is Mediterranean sun and beach tourist regions that can, synergistically, connect with nature-based tourism, cultural and landscape touring, among others, by delineating new routes and excursions in Mediterranean territorial context, characterized by a variety of tourism resources by its spatial proximity between them and its small-scale niche profile.

This type of diversification can, by enhancing tourist experience at any destination, affirm a new and rejuvenated image of it (Hall, 2018), increasing its competitiveness, sustainability and, as such and above all, the resilience of Mediterranean regions, too much dependent on coastal tourism.

Green Infrastructure, Tourism and Regional Resilience

It is now important to explain the concept of green infrastructure and how it can contribute to the resilience of regions and, in particular, those heavily dependent on tourism.

As such, it is understood that green infrastructure can be defined as a network of natural and semi-natural spaces within and around urban spaces, including gardens, lakes, parks, cycle paths, green roofs, wetlands, green corridors, rivers, streams, agricultural land and forest areas of sustainable use, whose interconnection confers additional benefits and strengthened resilience (EEA, 2011, 30–35). This network is based on the preservation and enhancement of ecosystems connectivity in order to maintain or increase the provision of ecosystem services and their resilience, which contribute to mitigation and adaptation to climate change.

Sussams, Sheate and Eales (2014, p. 186) state that the green infrastructure concept is in line with the ecosystem approach, developed at the Convention on Biological Diversity (CBD) COP5, which adopted a strategy for integrated management of soil, water and living resources, emphasizing the need for increased cooperation at all levels. The Millennium Ecosystem Assessment (MEA), by bringing to the economic sphere the importance of ecosystem services, represented an opportunity to recognize the importance of green infrastructures' planning. Thereafter, the converging bridge of the concept with adaptation to change was the White Paper on Climate Change Adaptation that assumed green infrastructure as crucial in the provision of social and economic benefits in extreme climatic conditions (Sussams et al., 2014, p. 186). The main mitigation opportunities to be achieved through the enhancement of green infrastructure are (Samora-Arvela et al., 2016) are:

- Carbon sequestration (Nowak, Greenfield, Hoehn, & Lapoint, 2013, p. 235);
- Reduction of energy use in heating and/or cooling of buildings by increasing the area in green spaces and green roofs (Cit. Demuzere et al., 2014, p. 109);
- Agricultural production and other materials in the vicinity (Beatley, 2000, p. 7);
- Incentive to sustainable locomotion (NRDA, 2010, p. 32).

The key adaptation options based on the green infrastructure are:

- Reduction of the urban heat island effect and increase of thermal comfort (Oliveira, Andrade, & Vaz, 2011, p. 2191);
- Regulation of water quantity and quality (NRDA, 2011, p. 36);
- Storage and drainage of water, reducing river floods (Demuzere et al., 2014, p. 109);
- Attenuation of sea floods (NRDA, 2010, p. 40);
- Connectivity between habitats (EEA, 2011, pp. 36–38; NRDA, 2010, p. 46);
- Alternative recreational and leisure opportunities: central point of research presented in this chapter;
- Public health benefits, stimulation of adaptive capacity and education (Tzoulas et al., 2007, pp. 169–175; Demuzere et al., 2014, p. 111).

Drawing on concepts emanating from various research forums, the European Commission, in 2013, also defined green infrastructure strategy as a strategically planned network of natural and semi-natural areas, designed and managed to provide broad range of ecosystem services. It incorporates green spaces (or blue ones, if involving aquatic ecosystems), such that the terrestrial green infrastructure is present in both urban and rural spaces. Today, its enhancement is considered a priority of the Europe 2020 Strategy and is reiterated by the European Union's Biodiversity Strategy for 2020 (EC, 2013).

Within the framework of the Portuguese territory, the green infrastructure is synonymous with the concept of ecological structure, which includes the Public Water Domain (DPH), National Agricultural Reserve (RAN), National Ecological Reserve (REN) and the Fundamental Conservation Network of Nature (RFCN) (Magalhães, 2013, pp. 6–9).

It should be noted that the diversification of tourism, based on the resources of the green infrastructures, has the purpose of varying the activities that hegemonize the socio-economic base of, for example, the Mediterranean regions. The rural and low density territories are no longer limited to the strict function of agricultural production. Nowadays, rural development is assisted by the contribution of rural tourism, nature-based tourism, cultural and landscape touring, among others (Zasada & Piorr, 2015; Sharpley, 2002).

Rural amenities result largely from the construction of a partly declining agricultural landscape, where rural communities seek to generate complementary income to agriculture, the recovery of demographic levels, the conservation and/or recovery of the architectural heritage, and the valorization of regional products, such as gastronomy, handicrafts and, above all, the sustainable landscape enhancement (Pereira da Silva, 2005: 196).

Through this framework and in view of the expected impacts of climate change, it's paramount to plan the incrementation of regional resilience, that is *the ability of a region to adapt in the short and medium term and to restore its long-term development* (Boschma, 2015). In the case of the Mediterranean regions, the most important is not

the level of productive differentiation per se, but "*the presence of different domains and the valorization of their complementarities are exploited by different operators*" (Cainelli, Ganau, & Modica, 2018, p. 3).

Thus, the Mediterranean regions dependent on sun and beach product are deeply vulnerable to sea level rise (Ferreira, Dias, & Taborda, 2008), given the respective and potential loss of coastal beach area, so that the diversification of tourism products, based on the natural and cultural attributes of these territories, could constitute, within the framework of public policies, a prolific strategy to reinforce regional resilience by virtue of its ability to absorb and circumvent, opportunistically, the disruptive magnitude of this impact by diversifying the regional socioeconomic basis and attenuate the narrow dependence on coastal tourism.

On the other hand, the International Panel on Climate Change (IPCC, 2014, pp. 59–60) projects that the aggravation of impacts in this century will lead to the inability of governments to contingently finance adaptation to all impacts inherent to climate change. This raises doubts about the future of coastal communities, which are heavily dependent on their geographical situation, but also on their economic dependence, which is the major in the relationship between conventional beach tourism and the beach resort.

Given this, the case of Portugal, due to its landscape diversity, mild climate and social stability, has a clear aptness for tourism and leisure activities, allowing the satisfaction of a varied list of motivations and determining its choice as a tourist destination (Pereira da Silva, 2005, p. 190). The demand for new tourist products is one of the main strategies to reduce excessive dependence on beach tourism (Pereira da Silva, 2005, p. 192), especially when it is expected that the beach area, as a resource, will be greatly reduced.

From this comes the urge to study the willingness of tourists and residents to adopt alternative recreational practices in the landscape units of Algarve region, south of Portugal, essentially through activities within green infrastructures.

The Case of Algarve Region, Portugal

The Landscape

In the words of Luís Batista (Cit. Martins, 2011, pp. 6–7) "*economically, tourism (a playful view of experienced places) revitalize local economies as it gives opportunities to municipalities, regions and nations to make promotional use of their inheritance, so as to take advantage of it*".

It is on this premise that from the 1960s, Algarve region, following the growth of tourism in Andalusia and the rest of the Mediterranean basin, was marked by an intense process of urbanization for leisure and consumption, placed on coastal area, and on the dispersion of villas in areas furthest from the coastline (Cit. Martins, 2011, pp. 2–3), such that this urban expansion was devoted to the massification of two

forms of accommodation, namely tourist accommodation and secondary residence (Cit. Martins, 2011, p. 3).

It was verified that there is an intensive and high seasonal use on the Algarve coast (Fig. 1d–f), already demarcated by coastal erosion due to its disorganization and urban occupation (Simões et al., 2013, pp. 401). In the landscaped and territorial unit between the coastal and regional interior, the limestone Barrocal (C), characterized by its almond, fig and irrigated citrus groves, has proliferated the secondary residences (Cobuci, Kastenholz, & Breda, 2011).

As for the innermost unit, the mountains of Algarve (A and B) are marked by their cork oaks, where the phenomena of abandonment (Cancela d'Abreu, Pinto Correia, & Oliveira, 2004, pp. 173–181), combined with the frequency of fires, have led to desertification.

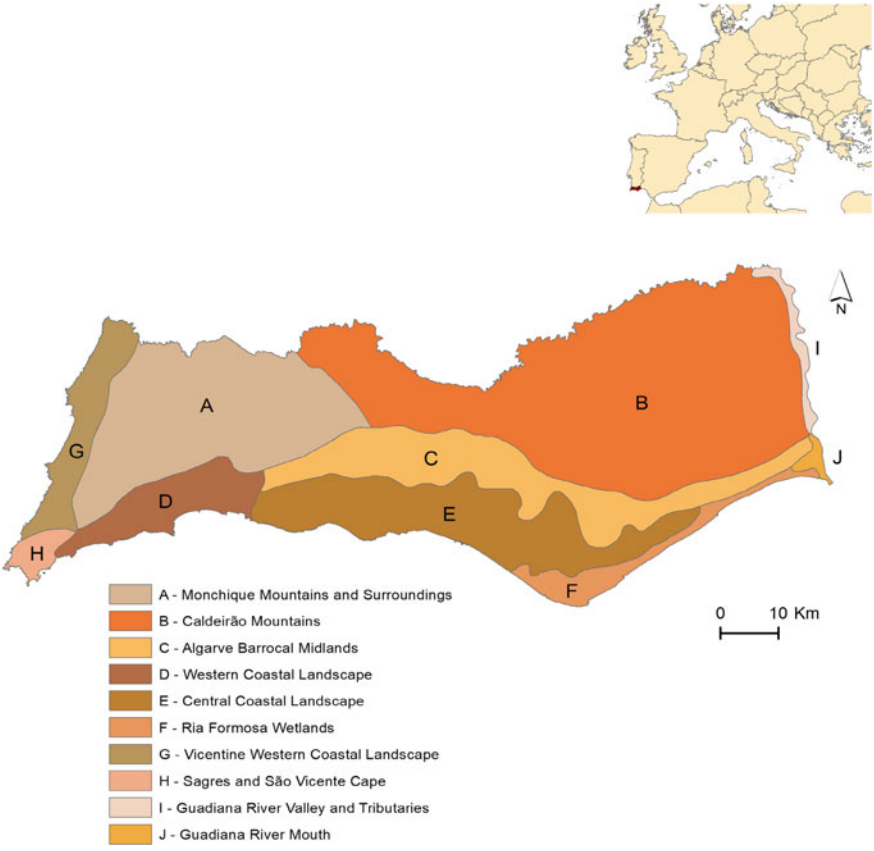

Fig. 1 Landscape units that cross the Algarve region, south of Portugal. Adapted from Cancela d'Abreu et al. (2004, pp. 173–181)

Public Policies

The qualification of tourism must be governed by the use, preservation and enhancement of regional specificity. As such, the great paradigmatic transition of the first modernity and the first rurality, based on the anomic, supermodern urban expansion of non-places (Augé, 2012) and the city-countryside binomial, into the second rurality can emerge, while the *Global Landscape* (Telles, 2011), the *Eco-region* or the *City-region* will enable the dissolution of the previous binomial model by its fusion, integration and diversification with a view of creating new functionalities and territorialities and, by that, new opportunities (Covas & Covas, 2012).

Therefore, the diversification by the association between tradition and innovation could be a valuable contribution to the sustainability of Algarve region, where Mendes, Henriques and Guerreiro (2015), in their inquiry of municipalities, companies and cultural associations, identified more than 1500 cultural resources of the Algarve region that can be the base of tourism products.

It should be noted, in this context, that about 60% of tourists point out the Algarve cultural heritage as an important criterion in the decision to choose the region for their holiday destination (Silva, Mendes, Valle, & Guerreiro, 2007).

Valle et al. in their study (2011), based on a survey applied to tourists visiting the region, researched that 87% of them seek to have other experiences beyond the sun and beach.

For this reason, several tutelary instruments assume as priority the tourism diversification through the structuring of attractive tourism programmes in rural areas, based on the conservation of nature and cultural value of architectural, landscape and intangible heritage (Simões & Ferreira, 2010, p. 1065), namely the *National Program for Spatial Planning* (PNPOT) (MAOTDR, 2007; DGT, 2018), *Tourism Strategy 2027—Leading the Tourism of the Future* (TP, 2017; CCDRAlg, 2006, p. 20), *Prospective Diagnosis "Algarve—Preparing for the Future 2014–2020"* (CCDRAlg, 2013) and *Strategic Marketing Plan for Algarve Tourism 2015–2018* (TA, 2014). Based on this formulation in favour of diversification, the *Algarve Regional Operational Program CRESC 2020* (CCDRAlg, 2014) contemplates that its enhancement and promotion can be useful in combating intraregional social disparities through the integrated enhancement of low-density territories.

As such, several options can be put on the table, one of them being the increase of the diversification of tourist products and the promotion on non-intrusive and alternative tourism to take place, mainly, in the abandoned interior, as a transformative and resilient redirection of tourism.

Thus, tourism diversification militates not only in strengthening competitiveness and regional resilience to extrinsic challenges, but also can be planned for the development of intrinsic precariousness (Samora-Arvela, Ferreira, Panagopoulos, & Vaz, 2018a).

Nevertheless, the public policies to be implemented and pursued, according to this strategy should, in the first instance, be instructed by the auscultation of the complementary preferences of tourists for alternatives by its comparison to their

adherence to sun and beach. Other spaces and tourism products, existing or to be created, in each Mediterranean region should be promoted through the knowledge of tourist's receptiveness in order to increase the destination and regional resilience by the encouragement diversification. Despite that, a recreational and leisure structure cannot be planned for tourists only, so residents are, equally, eligible to express their complementary preferences. Finally, the degree of preference expressed by tourists and residents has to be agreed with the knowledge of experts, adequating the ecological and cultural suitability of Algarve landscape to the diversification of tourism and/or recreational activities.

Methodology

The main methods that have been operated were:
6.1. Inquiry by questionnaire of tourists and residents, and descriptive statistical analysis of answers in order to reveal the degree of preference for recreational activities in the green infrastructure of Algarve region, in addition to sun and beach product, and the willingness level for substitute or complement their recreational experience with the indicated alternative activities: the questionnaire survey was the most congruent way to study the tourists' and resident preferences, namely by inquiring four hundred ($N = 400$) tourists and four hundred ($N = 400$) residents.

It was thus inferred, beyond and beside the beach, the preferential complementary degrees of preference of tourists and residents for other activities of the Algarve green infrastructure, by the indication of:

- Degree of preference for cycling, birdwatching, camping, landscape touring and picnicking, among many others;
- Level of agreement on the importance of climate change;
- Level of willingness of tourists and residents of Algarve region to enjoy the same alternative activities and respective spaces, in a scenario of beach absence or reduction.

With regard to the sample of tourists, the selection was made using the stratified random sampling method (Marôco, 2011, p. 10) of the number of guests in tourist accommodation establishments by municipality in 2015 according to the country of residence (INE, 2016). Tourists were inquired on the beaches of the municipalities of Silves, Albufeira and Loulé, from 03/03/2017 to 09/28/2017 (Fig. 2).

The stratified random sampling of residents inquired was performed from the number of individuals over 18 years old, living in the municipalities in question, given by the 2011 National Census (INE, 2013). The questionnaire was applied to 03/02/2017 and 10/01/2017.

Finally, descriptive statistical data analysis was done in Statistical Package for Social Sciences 24 (SPSS) (Laureano & Botelho, 2012; Marôco, 2011).

Fig. 2 Study area: the municipalities of Silves, Albufeira and Loulé, Algarve region, southern Portugal

6.2. Concentration of the degree of preference of tourists and residents, indicated in the previous method, with the knowledge of experts, using the Delphi technique, assessing the aptness of alternative recreational activity to each landscape unit of Algarve region: Participation of three experts of environment, economy and societal scientific areas, invited to a first round of individual questions of differentiated grades, having each expert been confronted at the end of the same round with the mean results of all group. The repetition of the Delphi rounds allowed the answers to be cleared, establishing and consolidating the degree of tourists and resident's preference inferred with the opinion of experts. The identity of the expert participants was to be kept anonymous among them, avoiding, therefore, the inter-influence among experts, due to the questions of authority, personality or notoriety, in order to collect the impartial contribution of their technical and creative wisdom in the configuration of green infrastructure.

All this method will make it possible to conciliate the revelation of the hedonic needs of tourists and residents with the scientific knowledge of experts in the pursue of a model of sustainable and resilient development for Algarve region through tourism and recreation.

Potential for Tourism and Recreational Enhancement of Algarve's Green Infrastructure: Results and Discussion

Tourists and Residents' Inquiry

The results of application of the questionnaire survey of coastal tourists and residents from the municipalities of Silves, Albufeira and Loulé are presented here, following the sequence of questions answered (Fig. 3).

The 400 tourists inquired considered *Recreation and Tourism* the most important benefit, with the same benefit having the highest degree of importance (5.27).

As in the case of tourists, resident individuals also consider *Recreation and Tourism* to be the green infrastructures' benefit of the most importance. The level of important results is expressed in the highest mean degree (5.38) (Fig. 3).

Within the Algarve's green infrastructure, tourists point out with a reasonable degree of preference the activities of health and wellness (4.89); walks, orientation and keep-fit circuits (4.85); rural accommodation (4.78); gastronomy and wines (4.72); landscape touring and picnics (4.63); outdoor shows and markets (4.63); outdoor fairs and markets (4.61); touring architectural and archaeological heritage, and museums (4.40); cycling (4.27) and bathing, canoeing and fishing in rivers or lakes (4.26) (Fig. 4). With regard to recreational activities that can be appreciated in green infrastructures, the following stand out among the residents: health and wellness (5.21); outdoor shows and performances (5.18); gastronomy and wines

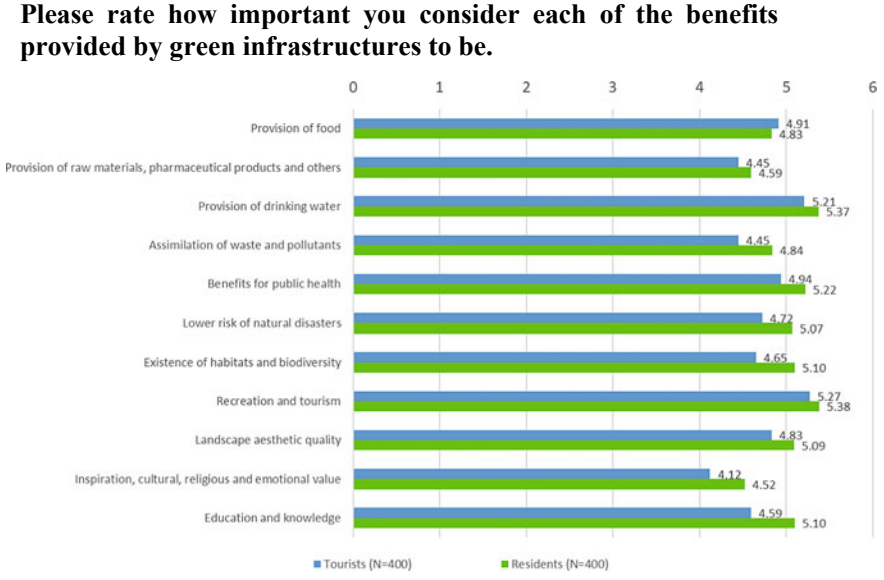

Fig. 3 Inquiry to tourists and residents—level of importance of green infrastructure benefits

(4.98); walks, orientation and keep-fit circuits (4.95); other outdoor activities in sports centre (soccer, basketball, tennis, etc.) (4.86); rural accommodation (4.86); outdoor fairs and markets (4.81); landscape touring and picnics (4.50); touring architectural and archaeological heritage, and museums (4.46); camping (4.28); cycling (4.22) and bathing, canoeing and fishing in rivers and lakes (4.10).

Most tourists (83.25%) prefer tourist establishments with green roofs installed on their façades and/or roof. As in the case of tourists, residents (73.50%) prefer the use of green roofs as an element for the conversion of old and low-quality facades and roofs of buildings in the region, mainly from 1970s to 1980s (Figs. 5 and 6).

The interior landscape units (Interior Mountains and Barrocal Midlands) gather a greater degree of preference within tourists. In the case of residents, the most appreciated landscape unit is Coastal Landscape (Fig. 7).

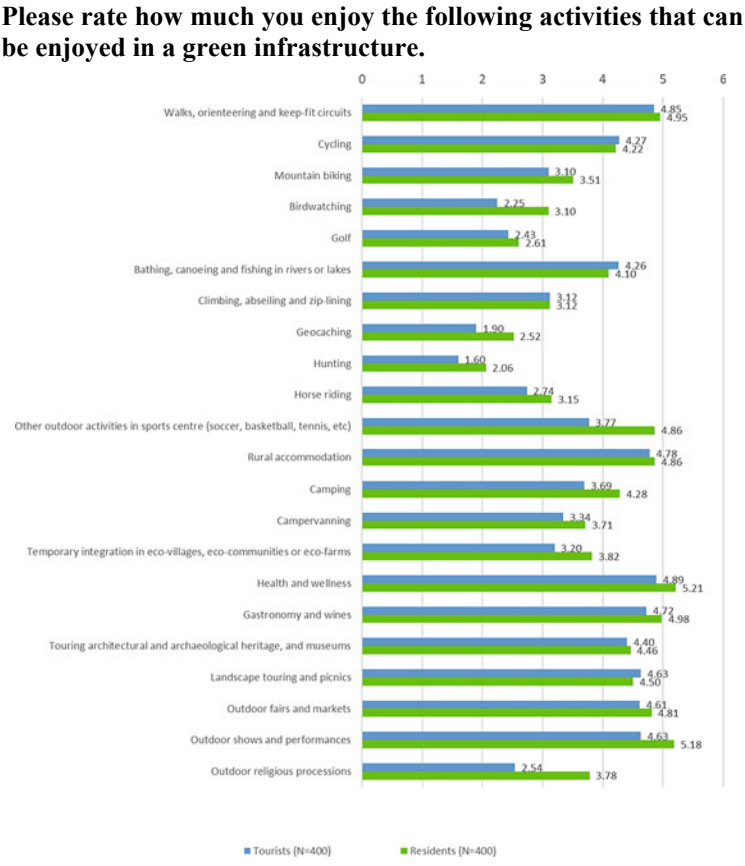

Fig. 4 Inquiry to tourists and residents—degree of preference between nature-based and culture-based activities (Samora-Arvela, Ferreira, Panagopoulos, & Vaz, 2019)

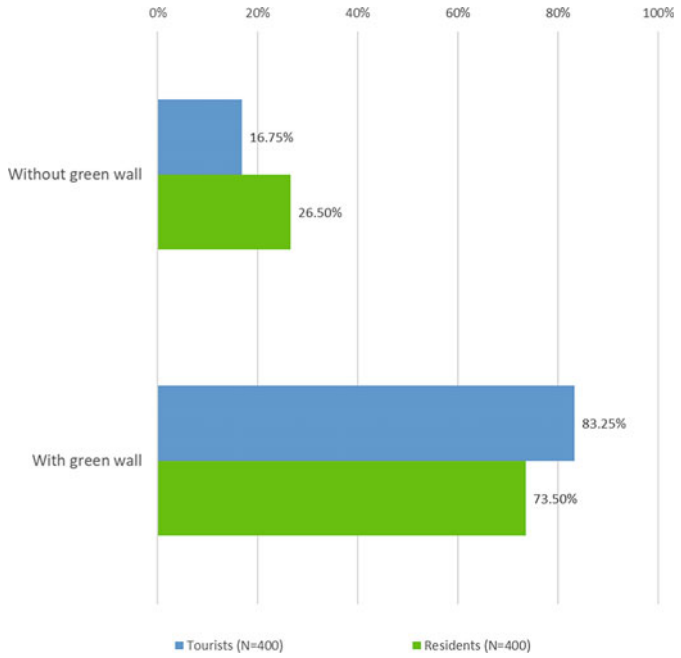

Fig. 5 Inquiry to tourists and residents—preference about the presence or absence of green roofs

There is also a great lack of knowledge of tourists with regard to non-coastal landscape units, such that 56.30% of tourists said that they are not fully aware of them.

Obviously, most residents (89.50%) claim to know the Algarve's landscape diversity, although 10.30% of residents states knowing its fullness (Fig. 8).

The greatest degree of preference of tourists is related to citrus fruits; gastronomy of meat, fish and shellfish (including olive oil, herbs, among others); wines and liqueurs; honey and carob fruits, almonds, olives and figs.

The resident community, predominantly, enjoys the agricultural products of the dry land (carob fruits, almonds, olives and figs) and of irrigation (citrus fruits), honey, traditional sweets and gastronomy of meat, fish and shellfish (including olive oil, aromatic herbs, among others). Curiously, the most deprecated identity element for residents is vernacular architecture (Fig. 9).

The Internet and the circle of friends represent the main sources of promotional information for the Algarve region as a tourist destination.

Own knowledge, the Internet and the circle of friends are the main sources of information that residents have about the various attributes of the Algarve region (Fig. 10).

Please rate how much you like this landscape.

	1. I don't like	2. I slightly like	3. I relatively like	4. I reasonably like	5. I like	6. I like very much	Don't know/No answer
A	○	○	○	○	○	○	○

Please rate how much you like this landscape.

	1. I don't like	2. I slightly like	3. I relatively like	4. I reasonably like	5. I like	6. I like very much	Don't know/No answer
B	○	○	○	○	○	○	○

Please rate how much you like this landscape.

	1. I don't like	2. I slightly like	3. I relatively like	4. I reasonably like	5. I like	6. I like very much	Don't know/No answer
C	○	○	○	○	○	○	○

Fig. 6 Inquiry to tourists and residents—questions to evaluate the degree of preference for each landscape unit

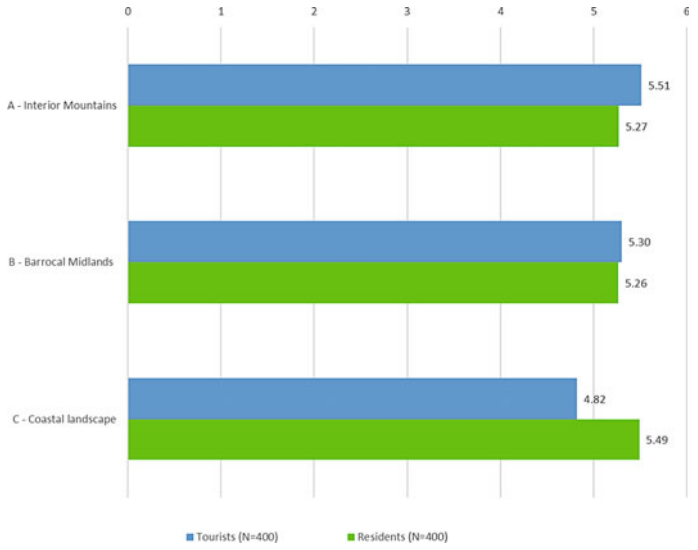

Fig. 7 Inquiry of tourists and residents—degree of preference for each landscape unit

Within tourists, there is full recognition of the seriousness of climate change. Residents agree almost completely on the severity of climate change (Fig. 11).

More than 80% of tourists inquired believe that climate change will have an impact on the tourism potential of Algarve region (Fig. 12).

The most conspicuous impacts are coastal erosion, reduction or disappearance of beach area (58.00% of tourists); change in the feeling of comfort with the Mediterranean climate (51.00%), reduced precipitation and availability of water resources (38.25%) (Fig. 13).

It should be noted that 91.30% of the resident community believes that climate change will impact their place of residence and region (Fig. 14).

This question was only applied to resident individuals. The impacts that most concern the community are mainly the reduced precipitation and availability of water resources (58.50%); coastal erosion, reduction or disappearance of beach area (58.25%); impacts on agricultural and forestry production (52.75%); loss of biodiversity (47.25%); and changing sense of comfort with the Mediterranean climate (41.75%) (Fig. 15).

Residents agree to recognize the threat that climate change poses to the development of Algarve region (5.17) (Fig. 16).

It should be noted that 87.80% of residents inquired believe that the green infrastructure can, through adaptation and mitigation, shield the territory from the impacts of climate change (Fig. 17).

The main contributions for the adaptation and mitigation of climate change, pointed out by the residents, are the increased thermal comfort and reduced energy consumption for cooling and heating in cities by increasing urban green spaces

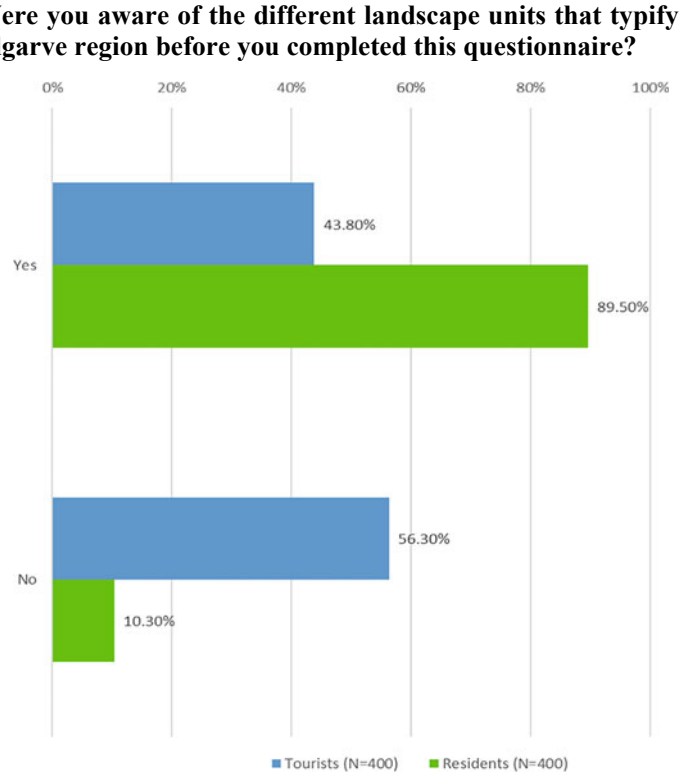

Fig. 8 Inquiry to tourists and residents—knowledge about the different landscape units

and green roofs (54.75%), alternative tourism, recreation and leisure opportunities beyond the sun and sea, such as nature tourism, and cultural and landscape touring (49.00%), and public health benefits (45.50%) (Fig. 18).

The tourists' willingness to visit the region in the absence of beach (3.80) is relative to reasonable.

The recreational attempts of resident individuals do not stick, strictly, to the beach, so in a scenario based on their absence, they are willing to take advantage of other attributes of the region (Fig. 19).

Experts' Inquiry

Finally, a group of experts identified the most appropriate tourism and recreational activities to be enhanced in each set of landscape units (Interior Mountains, Barrocal Midlands and Coastal Landscape) (Fig. 20).

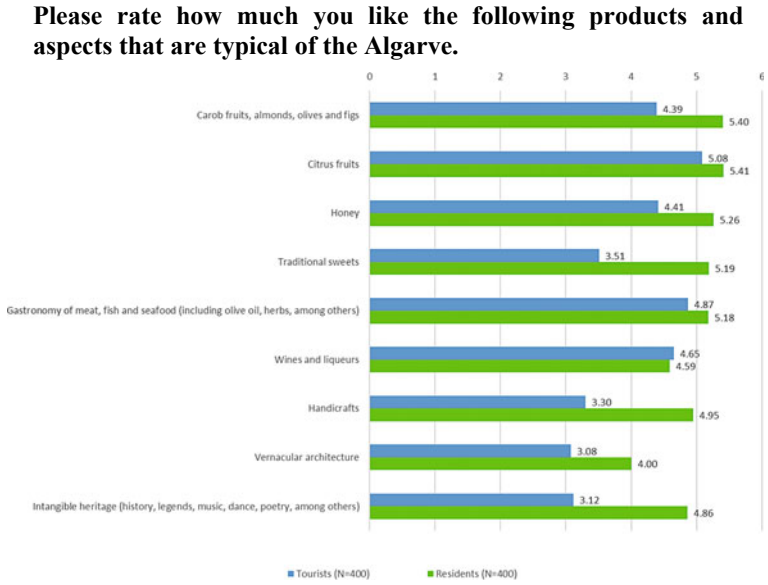

Fig. 9 Inquiry to tourists and residents—degree of preference among various products and identity elements of Algarve region

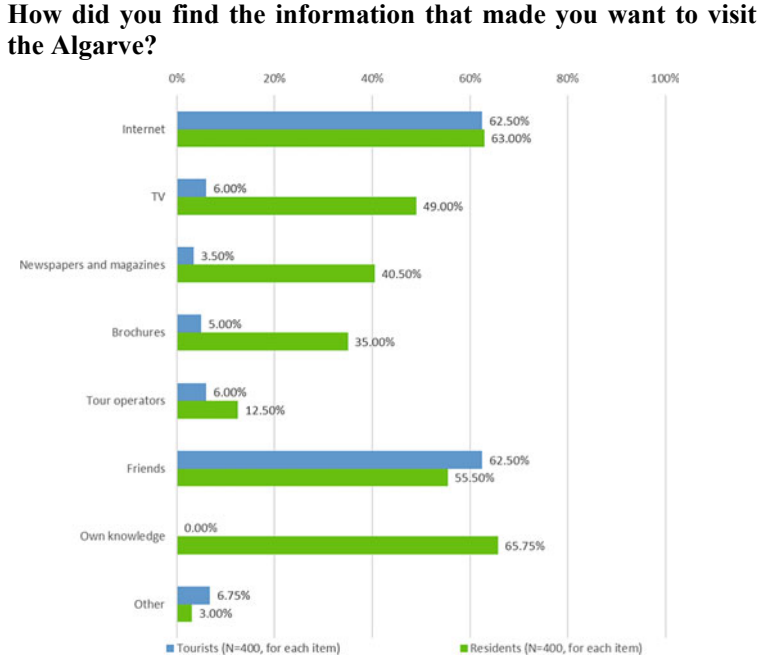

Fig. 10 Inquiry to tourists and residents—main ways of obtaining information to motivate the visit and know about the Algarve region

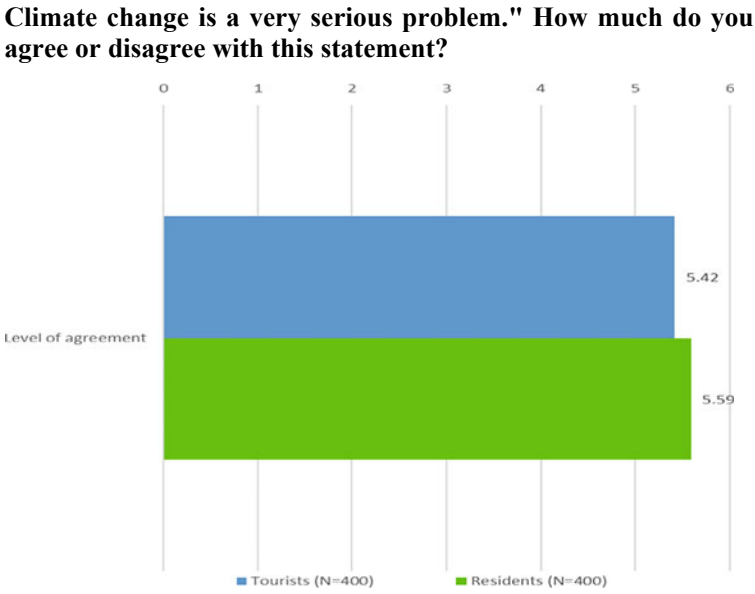

Fig. 11 Inquiry to tourists and residents—level of agreement on the recognition of climate change

In this sense and for the landscape of the Interior Mountains, experts consider it more appropriate to enhance walks, orienteering and keep-fit circuits (6.00); bird-watching (6.00); geocaching (5.33); bathing, canoeing and fishing in rivers or lakes (4.67); climbing, abseiling and zip-lining (4.67); horse riding (4.67); cycling (4.33) and mountain biking (4.33).

For Barrocal Midlands, the most suitable activities are walking, orienteering and keep-fit circuits (5.33); mountain biking (5.00); birdwatching (5.00); geocaching (5.00); cycling (4.67); bathing, canoeing and fishing in rivers or lakes (4.33); and horse riding (4.33).

In the case of Coastal Landscape, walking, orienteering and keep-fit circuits (4.67); cycling (4.67); other outdoor activities in sports centre (soccer, basketball, tennis, etc.) (4.67); bathing, canoeing and fishing in rivers or lakes (4.33); and bird-watching (4.00) are considered the most adequate tourist and recreation activities to enhance in this landscape unit (Fig. 20).

In regard to the potential for the enhancement of cultural activities in Interior Mountains, the most appropriate, according to expert opinion, are health and well-ness (5.67); rural accommodation (5.33); touring architectural and archaeological heritage, and museums (5.33); landscape touring and picnics (5.00); temporary inte-gration in eco-villages, eco-communities or eco-farms (4.67); gastronomy and wines (4.33); and outdoor fairs and markets (4.00).

For Barrocal Midlands, rural accommodation (6.00); camping (5.00); touring architectural and archaeological heritage, and museums (5.00); landscape touring and picnics (4.67); temporary integration in eco-villages, eco-communities or eco-farms

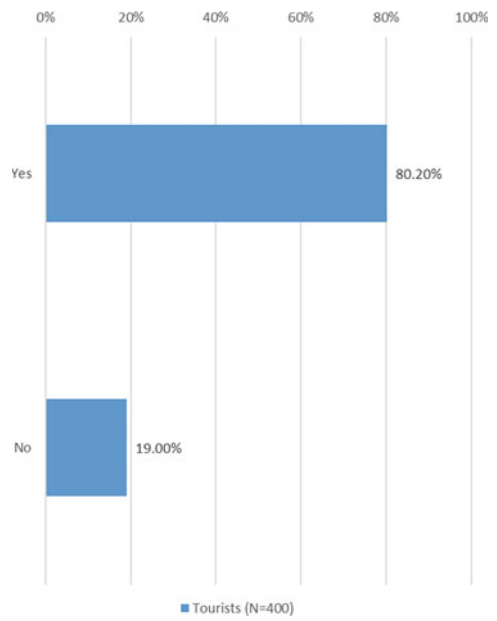

Fig. 12 Inquiry to tourists—consciousness about existence or non-existence of impacts on tourism potential of Algarve region and its tourism attractiveness due to climate change

(4.33); health and wellness (4.00); outdoor fairs and markets (4.00); and outdoor shows and performances (4.00) are the cultural activities considered as the most adequate.

In relation to coastal landscape, the cultural activities assumed as more appropriate were temporary integration in eco-villages, eco-communities or eco-farms (5.00); health and wellness (5.00); outdoor shows and performances (5.00); gastronomy and wines (4.67); touring architectural and archaeological heritage, and museums (4.67); landscape touring and picnics (4.00); and outdoor fairs and markets (4.00) (Fig. 21).

Conclusion

The tourists, residents and expert's inquiry will allow the structuring of social and cultural aptness that, together with biophysical suitability, could produce a landscape management and recreational promotion model in order to reinforce the regional resilience through activity diversification based on the regional green infrastructure.

It should be noted that the degree of preference of tourists and residents for tourism and recreation activities, alternative to sun and beach, is not misaligned with the

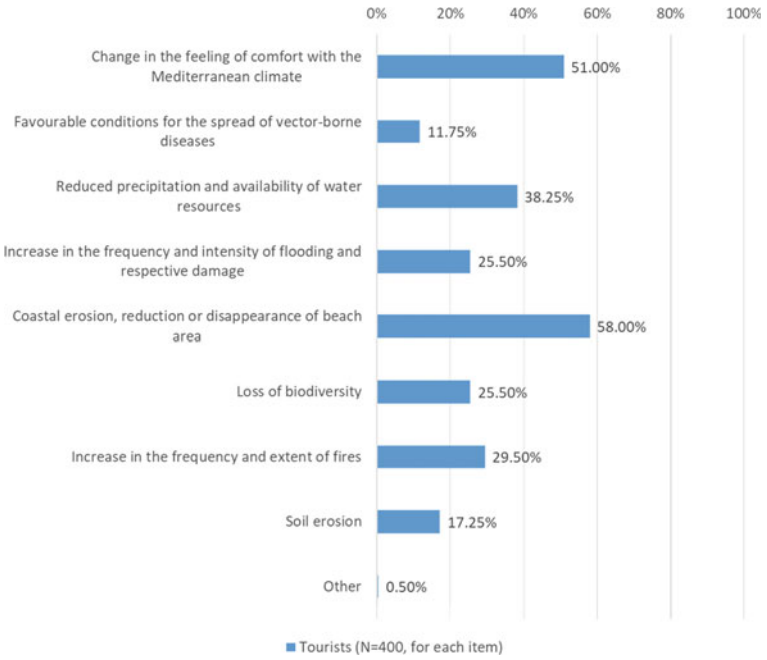

Fig. 13 Inquiry to tourists—the most expected impacts of climate change on tourism potential and tourism attractiveness of the Algarve region

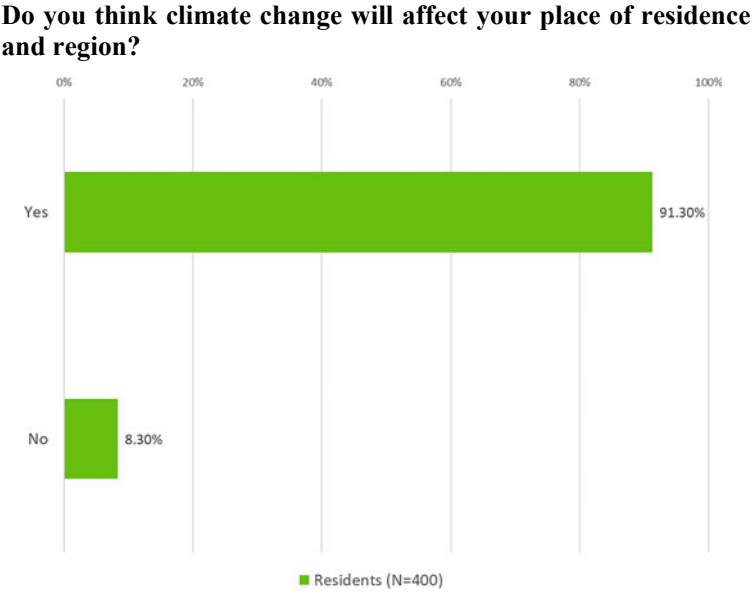

Fig. 14 Inquiry to residents—consciousness about existence or non-existence of climate change impacts in Algarve region

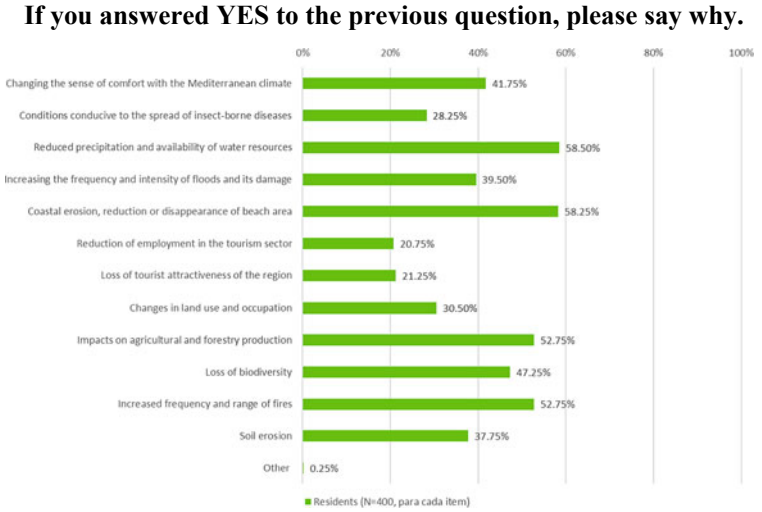

Fig. 15 Inquiry to residents—the most expected impacts of climate change on the Algarve region

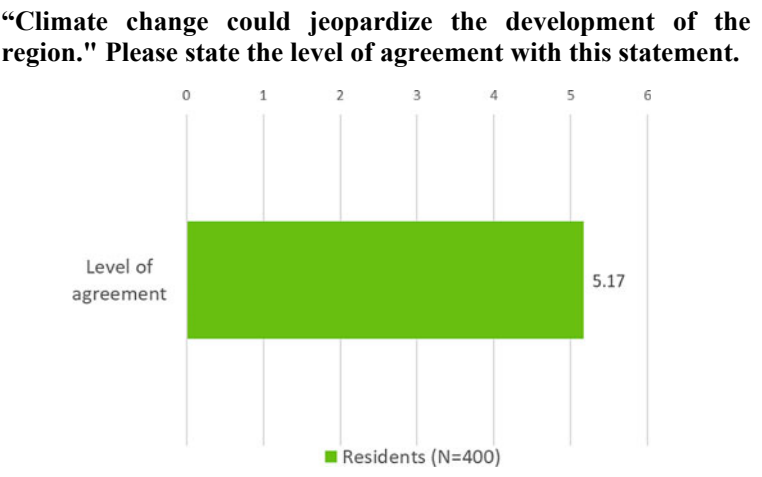

Fig. 16 Inquiry to residents—level of agreement on recognizing the risk of region's development being compromised by the impact of climate change

opinion of experts. Thus, expert knowledge not only validates the adequacy of each recreational activity to each landscape unit, but also informs about the prioritization of its enhancement.

So, the increase in regional resilience due to the diversification of tourism products can only be achieved through the sustainable promotion of alternative attributes to the sun and beach, which remain unknown to most tourists, being of note that Internet is, will and should be the first way of its promotional communication.

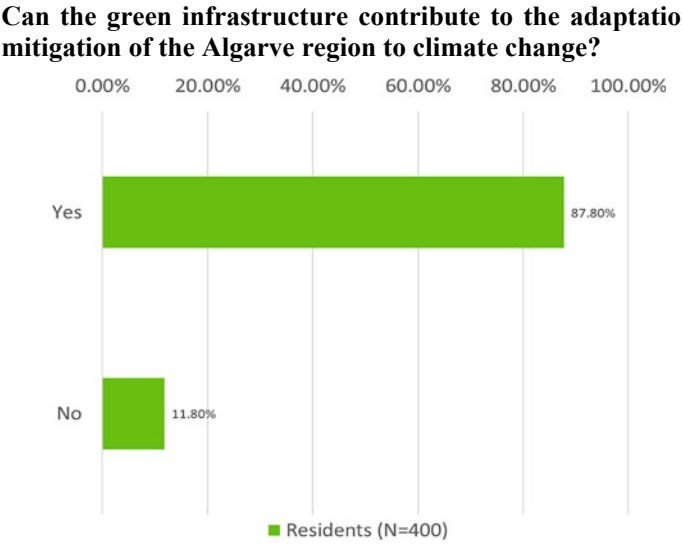

Fig. 17 Inquiry to residents—consciousness about the contribution of the green infrastructure for the adaptation and mitigation of the Algarve region to climate change

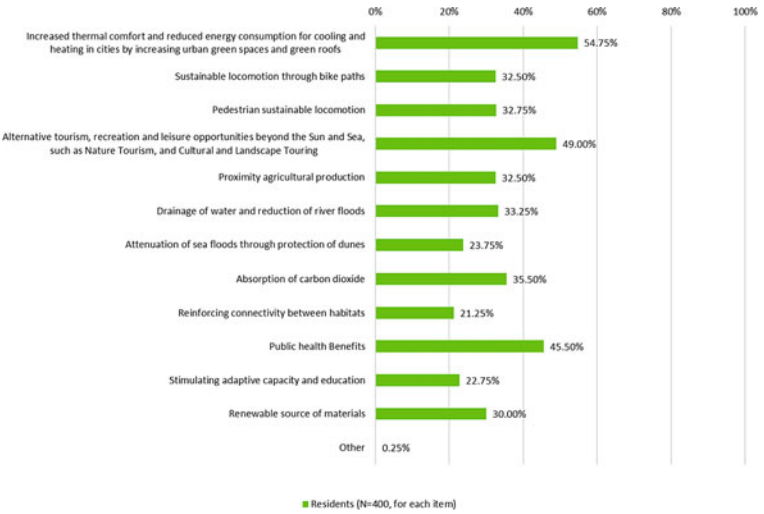

Fig. 18 Inquiry to residents—the most considered contributions of the green infrastructure for the adaptation and mitigation of the Algarve region to climate change

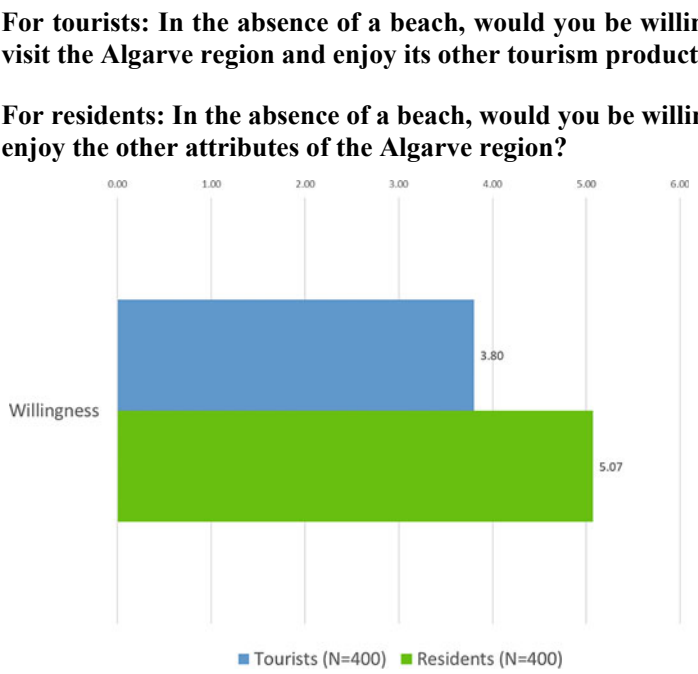

Fig. 19 Inquiry to tourists and residents—level of willingness of tourists to visit the Algarve region in the absence of a beach and to enjoy the other tourist products, and the level of willingness of residents to enjoy the other recreational attributes of Algarve region (Samora-Arvela, et al., 2018a; Samora-Arvela, et al., 2018b)

Thereupon, the re-weighting of tourism and recreational activity assumptions in the Algarve region can constitute a serious opportunity to direct public and private stakeholders for rural space enhancement, which, in any scenario, will always represent a win-win strategy, whose contribution goes beyond the strict role of shield to the impacts of climate change, mainly, contributing to local development, territorial cohesion, enhancement and efficient use of endogenous resources. It can only be achieved through innovative diversification in interior territories, characterized by its singularity that only low density tourism promotion allows to preserve.

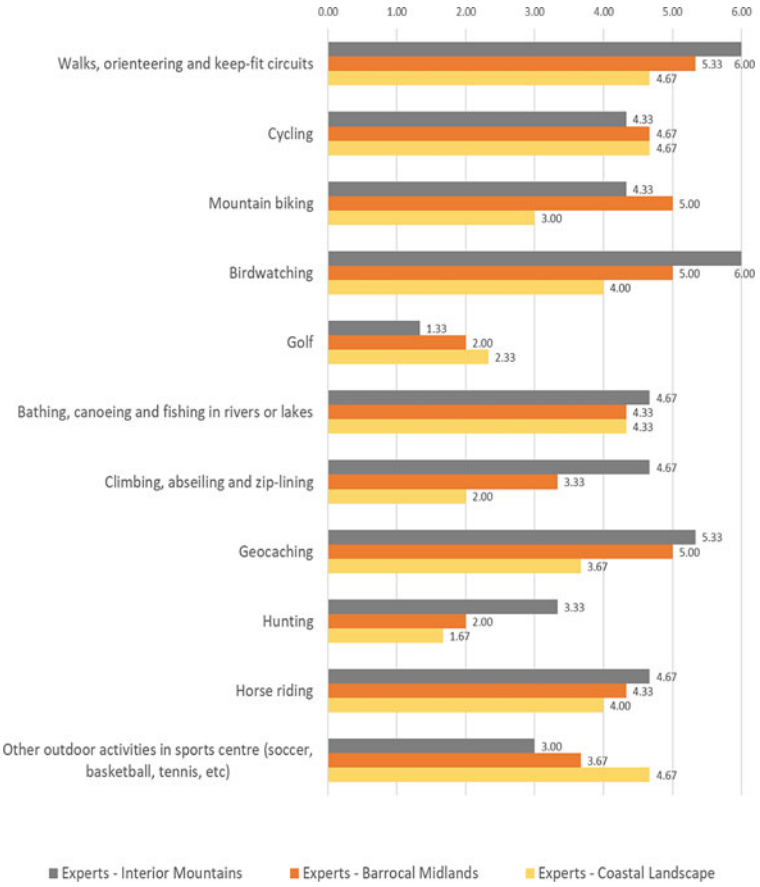

Fig. 20 Inquiry of experts—potential for enhancement of nature-based activities in each landscape unit

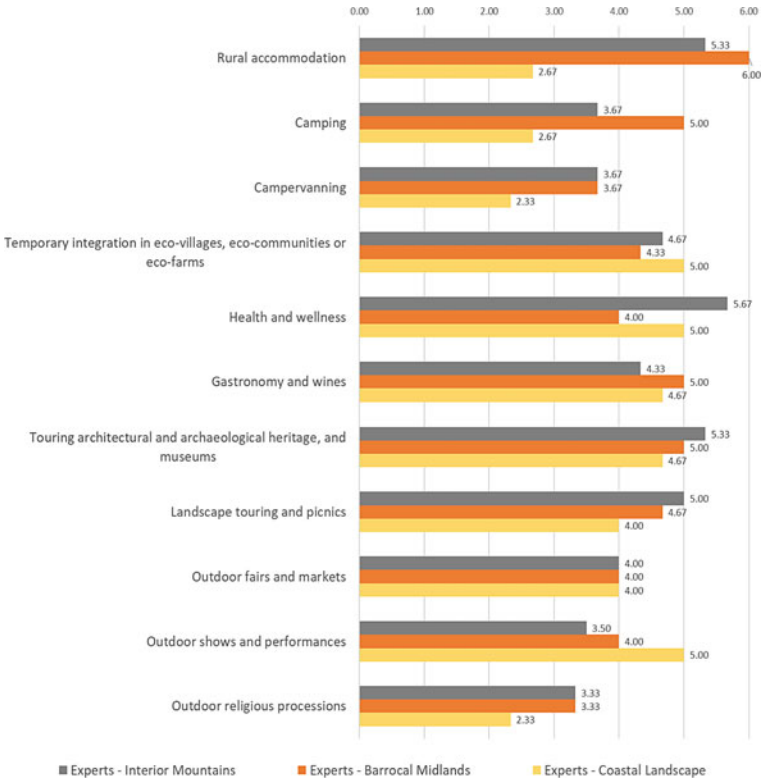

Fig. 21 Inquiry of experts—potential for enhancement of culture-based activities in each landscape unit

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Socio-Emotional Reasons and Loyalty to Mass Tourism Destinations

Antonio Aledo and José Andrés Domínguez-Gómez

Introduction

In the course of the last decade, studies of mass tourism have taken an interesting turn. The traditional approach (Shepherd, 2002) warned of its negative impacts (Crick, 1989) and the unsustainability of the model and foresaw its inevitable future decline (Agarwal, 2002; Cooper, 2006; Knowles & Curtis, 1999). In contrast, recent studies put forward novel views of this type of tourism. These new ideas can be grouped roughly into two categories. The first is economicist and managerial in style, while the second focuses more on the social and emotional grounds for choice of destination.

The new economicist–managerial approach can be encompassed by the term sustainable mass tourism (Aguiló, Alegre, & Sard, 2005; Bramwell, 2004; Claver-Cortés, Molina-Azorín, & Pereira-Moliner, 2007) and bears witness to the success and endurance of many mass tourist resorts. These studies analyse the restructuring undertaken, or that should be undertaken, by these destinations, in order to minimize negative impacts, manage resources properly and improve and diversify the quality of their product (Ivars, Rodríguez, & Vera, 2012; Weaver, 2012). The second line of research, less abundant but highly suggestive, attempts both to reveal and to heighten the value of holidaymakers' performance: their emotions, feelings, experiences, practices and behaviours (Caletrío, 2009; MVRDV et al., 2000; Nogués-Pedregal, 2012a).

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Until not much more than a decade ago, tourist studies had judged these socio-emotive aspects pejoratively, basing themselves on preconceived notions of authenticity, banality or quality (Franklin & Crang, 2001; Obrador, Crang, & Travlou, 2009; Reisinger & Steiner, 2006; Wang, 1999). But, the new approach calls into question all a priori typologies, stereotypes and clichés around holidaymakers. And, developing this same tendency to reappraise the tourist experience, the space and time dimensions of mass tourism has become the object of particular attention.

Thus, space and time are no longer conceived of as merely physical factors, subject to seasonal stress and overcrowding but are now seen as dimensions which suggest multiple cultural signifiers (Caletrío, 2009; Minca, & Oakes, 2006), relevant to the individual and the family group (Larsen, Urry, & Axhausen, 2007; Kyle & Click, 2004; Trauer & Ryan, 2005) through the physical and sensory experience of the environment (Crouch, 2004).

This second approach forms a part of what has been called "the social turn in tourism" (Haldrup & Larsen, 2003; Heimtun, 2007; Urry, 2003). It introduces, redefines and/or calls into question concepts such as place, family and friendship (Coleman & Crang, 2002; Inglis, 2000, Obrador, 2012) and positions them as key objects for tourism studies (Larsen et al., 2007; O'Reilly, 2000). Thus, variables which had previously been fundamental to definitions of tourism, such as the differences between being at home and being away, lose their centrality. Further, these new studies highlight how some important functions of the home travel with holidaymakers to their destinations (Larsen et al., 2007; Trauer & Ryan, 2005). Also, the concept of the tourist is called into question through focusing on the actual holidaymaker's experience (Römhild, 2012). Ethnographic studies show that some people categorized as tourists—under statistical or academic definitions—do not define themselves as such but prefer to see themselves as forming part of the place and community of destination; in fact, they act and behave in this way (Caletrío, 2009; Janoschka, 2011; Obrador, 2003; Van Noorloos, 2011).

These studies offer rich descriptions of individuals' and their families' experiences relating to others in holiday periods and locations (Löfgren, 1999; Smart & Neale, 1999; Wagner & Minca, 2012). Thus, new insights into the tourist experience emerge. Holidaymakers become a "chorus" (Wearing & Wearing, 1996) which creatively integrates itself into the construction of tourist areas (Caletrío, 2009), thus distancing themselves enormously from the stereotypical tourist, caricatured by some authors (Bauman, 1996; Urbain, 1991) as extraneous and unwilling to forge meaningful social ties in the destination. And this reinforces Urry's (1990) argument that in the high modern age, tourism became a fundamental element for the reproduction of postmodernism's social architecture.

Loyalty to "Stagnating Destinations"?

In many Mediterranean Spanish towns, from the last third of the twentieth century until the 2007 property crash, residential tourism had become the main and almost

sole economic driver (Durán, 2008). Forecasts for this sector noted that the model was already showing signs of stagnation preceding its decline (Aledo & Mazón, 2004; EXCELTUR, 2005; García-Andreu & Rodes, 2004; Knowles & Curtis, 1999). Studies highlighted the excessive concentration of building in coastal areas and the high level of seasonality, resulting in overcrowding in these resorts. Such research stressed that overdevelopment, along with poor planning, had led to shortfalls in infrastructures and services, combined with a degree of environmental deterioration which undermined the overall quality of the product (Greenpeace, 2009; Mazón, 2006).

However, these predictions have been stubbornly contradicted by reality (Claver-Cortés et al., 2007). Residential accommodation is still the majority option for Spanish tourists for their holidays within the country. The percentage of summer visitors taking up this choice has risen constantly. While in 1999, 67% of tourist journeys were to non-hotel accommodation; in 2011, this had grown to 73.1% (FAMILITUR, 2012). Foreign tourists also prefer residential accommodation: in 2012, 52.6% of foreign tourist overnight stays in Spain were in residential accommodation (FRONTUR, 2012, p. 44). The stock of residential tourist accommodation is huge. One 2008 study by the consulting company Live in Spain counted 203,710 dwellings catering to the tourist market on the Costa Blanca alone, followed by the Costa del Sol with 173,880 holiday homes.

Thus, a clear contradiction emerges. On the one hand, a phase of stagnation and decline in residential tourist destinations is foretold; on the other, however, the tables show strong loyalty to these destinations on the part of holidaymakers. The stock academic explanation for this has been so-called captivity or submission to structural forces. Residential holidaymakers are seen as enslaved to their second homes. Buying a second home on the coast obliges them to visit it year after year in order to recover their investment (Fernández & Barrado, 2011; Obiol & Pitarch, 2011; Torres, Esteve, Fuentes, & Martín, 2006). But, also, the second home purchase is explained as heavily conditioned by economic structures and agents (the property and financial sectors), since it has been encouraged by the deployment of fiscal and financial policies (Colom & Molés, 2004; Gili, 2003) making buying a second home a credible, profitable investment. The Spanish property marketing and advertising sectors, taking advantage of a national culture that has traditionally favoured purchasing over renting property, (Gutiérrez, Viedma, & Callejo, 2005; Méndez & Díaz, 2001), have also boosted the mass acquisition of the second homes. Thus, it is argued that in Spain, possessing a second home has become a privileged marker of social status (López, 2003). In brief, the second home tourists are characterized as passive, conditioned, incapable of rebelling against market forces, obliged to return constantly to their second homes in overdeveloped resorts and compelled to suffer an inevitable deterioration in tourist services and the environment.

A second explanation for the contradiction previously noted draws on the economic rationale underlying the decision to acquire a second home. Various analysts have highlighted the desire to make an investment (Fernández & Barrado, 2011; Gili, 2003) as one of the main reasons for the second home purchase in tourist areas. This investment is made especially by three types of buyers: (1) families where the

parents are between 45 and 60, at a stage we may call "retirement planning" (Gallent, Mace, & Tewdwr-Jones, 2005; Hall & Múller, 2004; López, Cabrerizo, & Martínez, 2007); (2) families whose purchasing power has increased, albeit temporarily (Paris, 2008), to the point that they can afford to plan an investment in a second home; and 3) people wishing to escape from the stress of large cities (Norris & Winston, 2010), whose expected returns on investment are enhanced by the hoped-for reduction in stress.

The study presented here, in contrast, positions itself in line with novel, more social and emotional, interpretations of tourists' loyalty to mature residential tourism destinations. The "social turn in tourism" considers the social networks—of friendship, family, feeling or identity—that are constructed in these highly developed areas to be co-participants in the holidaymaker's decision to return regularly to the same destination.

Loyalty is defined as a stable commitment to future purchases of a service or product of the same brand despite the endeavours of other companies (in this case, other tourist resorts) to change this behaviour (Oliver, 1999). However, the concept of loyalty in tourism has different characteristics, since the consumer has to travel, sometimes thousands of kilometres, to the site of consumption, and because the satisfaction with the previous stays clashes with the excitement of novelty. George and George (2004) have sought to define tourist loyalty as "frequency of past visits" plus "intention to return to the destination", while other researchers have used "the number of days spent in a particular destination" as a measure (Lee, Backman, & Backman, 1997).

Yuksel, Yuksel and Bilim (2010) cite studies which have stressed the link between loyalty and the sense of belonging to a place (Brocato, 2006; Schultz, 2000; Walker & Chapman, 2003). This feeling of belonging stems from the way place forms a part of personal identity; from the form and meaning of emotional interactions occurring there (Kyle, Graefe, & Manning, 2005; Rubinstein & Parmelee, 1992) and from the social and affective relationships constructed in the tourist destination. Through these factors, the resort becomes a special emotional domain in visitors' affective memory (Kyle & Click, 2004; Trauer & Ryan, 2005).

In a study carried out in seven mature sun-and-sand residential tourist resorts on the Costa Blanca (Alicante) and Costa de la Luz (Huelva), we investigated the reasons why Spanish holidaymakers faithfully return season after season to these highly developed areas. The initial hypothesis was that emotional reasons, linked to the construction of personal identity, sociability and memory and grounded in the social relationships built within the space and time of summer visits, contributed substantially to the loyalty of these tourists to their destinations. The main goal of this paper was to use quantitative data, derived from a macro-survey ($n = 2602$), to test the ideas of scholars such as Obrador et al. (2009), Caletrío (2009) and Nogués-Pedregal (2012a) who provide more complex and less pejorative and aprioristic ethnographic views of the mass tourist in residential tourist destinations. Many of these studies reflect an interpretivist (Haldrup & Larsen, 2009; Nogués-Pedregal, 2012a; Wang, 2000) and

phenomenological approach (Cohen, 1979; Li, 2000; Obrador, 2003; Rakic & Chambers, 2012; Toledo, 2003), with a predominance of qualitative techniques (Nogués-Pedregal, 2012b; Rakic & Chambers, 2012). Unlike these studies, our research is aligned with the post-positivist current of thought (Gale & Botterill, 2005), and we used a survey as the method of collecting data. Our adherence to this current is based on an ontological position which sees data as a product and which is primarily interested in unveiling the meanings given by actors to their multiple interpretations of reality (Henderson, 2011, p. 343).

Method

Study Area

The study designed to test our hypothesis aimed to analyse the social profile of the national summer visitors and their reasons for choosing the destination. A summer visitor (population universe of reference) was defined as any Spanish national staying for a holiday period equal to or longer than seven days during one or more of the European summer months (June, July and August), either in their own house or flat, or one that was rented or loaned. A survey was carried out of seven Spanish coastal towns: Denia, Altea, Benidorm, Santa Pola and Torrevieja on the Costa Blanca and Punta Umbría and Matalascañas (Almonte) on the Costa de la Luz. These towns were chosen for their specialization in summer sun-and-sand tourism (Domínguez-Gómez & Aledo, 2005; García-Andreu & Rodes, 2004; Mazón, 2006; Mazón & Huete, 2005), the high number of non-hotel places on offer (EXCELTUR, 2005) and their specialization in national summer residential tourism.

Data Collection

A total of 2602 people[1] were interviewed face to face in the seven towns during July 2008. Given the elusive nature of our population (from a technical-methodological point of view), Domínguez-Gómez, Aledo and Roig-Merino (2016) was taken as a methodological model in developing a validated sampling method. Grouped according to the towns surveyed, the final distribution of valid interviews was: 218 in Altea, 395 in Benidorm, 398 in Denia, 397 in Santa Pola, 393 in Torrevieja, 401 in Punta Umbría and 400 in Matalascañas, according to the data sources available when analysing the sample (FAMILITUR, 2012). The last sample unit (the respondent) was chosen by random selection at peak times and in the most crowded areas of the towns (i.e. beaches during the day and commercial areas in the evening).

[1] $P = Q$, maximum $E = 0.06$, Conf. Level = 95.5%.

Table 1 Reasons for choosing a destination

Question: Please indicate three reasons why you have come to visit this area for your summer holiday (multi-answer, yes/no)
(1) I enjoy the area's climate
(2) I own a property here
(3) I have friends who spend their summers here
(4) It is the place where a member of my family used to come or still comes
(5) This is a place which has a special sentimental value for me (for my family)
(6) I enjoy spending time on the beach
(7) Nightlife
(8) Closeness to my habitual residence

Original survey formulation

Data Analysis

To determine whether loyalty to a mature residential tourist destination was related to tourists' social or emotional motivations (i.e. *socio-emotional* reasons), a two-phase analysis was carried out:

(a) Firstly, a cluster analysis was made of the reasons for choosing the destination surveyed in TVC. In Table 1, the set of reasons and their original formulation in the survey are shown. To enquire into these reasons, dichotomous multi-response options were used (i.e. the interviewee could answer yes or no to each reason). All of the reasons contained in the questionnaire (except the option of "others", due to its low response frequency) were included in the clusters. The two-step method of clustering was selected due to its suitability to large samples (Cea, 2002).

Our analysis yielded three clusters to which almost all cases adhered.[2] Two of these, as we show below, had a high level of affinity with the concept of socio-emotional motivation in choice of destination. Our approach to grouping was verified with a multiple variance analysis. Therefore, in the analyses below, the independent variable adopts two values: either belonging to this group of cases (termed socio-emotionally motivated) or not.

(b) Secondly, a bivariate analysis of this independent variable (socio-emotional motivation vs other motivation), obtained from the clustering, was carried out with each variable considered dependent in our hypothesis. The dependent variables (Table 2) refer, directly or indirectly, to destination loyalty and correspond to the indicators featured in the literature as valid for measuring loyalty. These are: (1) length of stay in a resort, where the holidaymakers who stayed longer were more loyal; (2) visiting the destination at times of year other than the summer and thus contributing to its de-seasoning, where the tourists who visited

[2] % of a typical cases inferior to 0.2%.

Table 2 Dependent variables

Question: How long will you be on holiday in this resort?
Answer options: One to two weeks/from 15 days to a month/between 1 and 2 months/between 2 and 3 months
Level of measurement: Ordinal
Question: In the last two years, have you visited this resort at times of year other than the summer?
Answer options: At Easter/long weekends/weekends (multi-answer)
Level of measurement: Each option is taken as a dichotomous nominal variable
Question: How many years approximately have you been spending your summer holidays at the same house or flat?
Answer options: This is the first year/between 2 and 5 years/between 6 and 10/between 10 and 20/more than 20 years
Level of measurement: Ordinal

Original survey formulation and level of measurement considered in the analysis

most at other times of year were more loyal; (3) and finally, we questioned respondents directly on destination loyalty, specifically asking how many years they had been visiting the resort.

In the bivariate relationship analysis we used the contingency coefficient for dichotomous variables and Cramer's *V* for variables with more than three categories.

Reasons for Choice of Destination

The data obtained from the TVC survey showed a similar spread of reasons for choosing the destination to other studies on the same topic (Rioja, 2009). Affective reasons, friendships and family were shown to be strong motives for choosing a holiday resort. These three reasons together accounted for 57.85% of answers, positioning them as the second-ranking motive after climate, which totalled 74.2%, while the beach came in third place. Climate and the beach are the expected answers for destinations where sun and sand is the sole product; however, as Obrador and Caletrío's work has shown, sun and sand have important qualitative attributes for tourists; in other words, they are much more than mere flat, sensory, physical spaces (Table 3).

Table 3 Reasons for choosing destination (multi-answer)

	%	*n*
Climate	74.18	1336
Socio-emotional reasons	57.77	1041
Beach	54.28	977
Own property	48.42	872
Closeness	12.10	218
Nightlife	6.55	118
Other	1.94	35

Source Authors

Socio-Emotionally Motivated Tourists and Destination Loyalty

Once the importance of socio-emotional reasons in the choice of destination had been established, it was necessary to determine which tourists could be defined as "socio-emotionally motivated". Our cluster analysis yielded three groups into which 99.8% of the sample could be sorted (see Table 4).

It can be seen from the composition of the clusters (Table 5) that numbers 1 and 2 came closest to the visitor profile with socio-emotional ties to the residential tourist destination. These two groups together accounted for more than 75% of all interviewees, and the main difference to cluster 3 was found precisely in the items indicating socio-emotional reasons (friends, family and specifically the sentimental value of the destination for them). This table alone signals the substantial emotional content of the residential tourism resort. The compositional differences between clusters 1 and 2 were found mainly in nightlife, the beach and principally climate: the three reasons most chosen by group 1, particularly climate, present in 64% of its components (contrasting with none in group 2). Group 3 differentiated itself from the others mainly in the socio-emotional reasons, as we mentioned previously, and also because of the higher likelihood of having a second home in the resort (53%). This reason, combined with the differences in the "closeness" option (not chosen by anyone in this group), resulted in a group 3 profile of typically seasonal

Table 4 Distribution of clusters

	N	% of combined	% of total
Cluster 1	1.164	44.8	44.7
Cluster 2	794	30.6	30.5
Cluster 3	639	24.6	24.6
Combined	2.597	100.0	99.8
Excluded cases	5		0.2
Total	2.602		100.00

Source Authors

Table 5 Composition of clusters

	Cluster 1		Cluster 2		Cluster 3	
Reasons	%	*n*	%	*n*	%	*n*
Friends	21.05	245	32.75	260	27.70	177
Family	24.57	286	32.12	255	0.00	0
Sentimental value	9.54	111	21.41	170	8.45	54
Climate	100.00	1.164	0.00	0	100.00	639
Own property	12.29	143	53.27	423	100.00	639
Beach	57.47	669	57.93	460	46.48	297
Nightlife	12.37	144	10.71	85	0.00	0
Closeness	21.74	253	31.61	251	0.00	0

Source Authors

holidaymakers, conforming to the tourist type seen in the literature as the "classical" domestic summer tourist with residential motives. In order to statistically verify the three-group clusters, we made a multiple variance analysis of the eight reasons for choice of destination. All the F tests showed significant mean differences between groups ($p < 0.000$; $p < 0.000$ for the Levene homogeneity of variance tests).

These results should be evaluated positively in the light of the sociological profiles of the residential tourists, especially in the case of this survey. As we remarked above, our study was carried out in residential tourism resorts in the south of Spain, which have habitually been taken as the model in research analysing residential tourism from the 1960s onwards (Fernández & Barrado, 2011; Nieves, Terán, & Martínez, 2008; Sousa, Matias, & Selva, 2016). Thus, our survey was undertaken with "pure type" of tourist, a model in itself, with a markedly homogeneous sociological profile. In our view, it is extremely interesting to find such clear statistical differences within this group.

In order to address our research question (differences in destination loyalty according to tourists' socio-emotional motivations), we divided all cases into only two groups: socio-emotionally motivated (included in clusters 1 and 2) and non-socio-emotionally motivated (the remaining respondents). Tests for the relationship between reliability and belonging to one group or another yielded statistically significant results in all cases. In other words, socio-emotional reasons in choice of destination were related to loyalty. The values of the coefficients calculated varied between a minimum of 0.129 and a maximum of 0.295, while all showed very interesting values for statistical significance ($p < 0.000$ in all cases).

Observing in more detail the relationship between socio-emotional reasons and destination loyalty (Table 6), we can comment briefly on the behaviour of each fidelity indicator. In the first place, it can be seen that the longer the duration of the stay, the greater the probability of giving socio-emotional reasons. This tendency appears clearly, with socio-emotional reasons growing in importance over the length of the summer visit while other reasons progressively lose weight.

Table 6 Socio-emotional motivation and destination loyalty

		Rest		Socio-emot. motiv.		Totals
		n	%	*n*	%	*n*
Duration of stay	One week–fortnight	948	52.56	377	47.44	1325
	15 days–one month	824	45.68	431	54.32	1255
	One month–two months	857	47.52	417	52.48	1274
	Two–three months	769	42.68	455	57.32	1224
Years holidaying in resort	First time	1186	65.79	272	34.21	1458
	2 years	1105	61.27	308	38.73	1413
	3 years	952	52.82	375	47.18	1327
	From 4 to 6 years	1055	58.50	329	41.50	1384
	From 7 to 9 years	968	53.70	368	46.30	1336
	From 10 to 12 years	1006	55.79	351	44.21	1357
	More than 12 years	677	37.55	496	62.45	1173
Visits at Christmas		797	44.21	443	55.79	1240
Visits at Easter		809	44.85	438	55.15	1247
Visits on long weekends		807	44.77	439	55.23	1246
Visits at weekends		767	42.56	456	57.44	1223
Only visits at summer		979	54.30	363	45.70	1342

Although the tendency is not as clear in the direct indicator of loyalty ("years holidaying in the resort"), we found two indications that socio-emotionally motivated tourists were more loyal to the destination: (1) almost twice as many socio-emotionally motivated visitors chose the same destination for more than 12 years (the oldest) and (2) among first-time visitors, socio-emotional reasons were (almost) half as frequent as other reasons. General observation of the tables in this crossing of variables suggested that socio-emotional reasons gained weight with the repetition of summer visits to the same resort. This observation may be related to the increasing density of social relationships and the establishment and strengthening of emotional ties with the destination over the years.

Lastly, de-seasoning indicators also tended to confirm our hypothesis. The likelihood of finding socio-emotionally motivated tourists was greater at all times of the year except the summer. Only for the "pure" summer visitors (i.e. those who only visit during the summer) was this likelihood lower, with an interesting inversion of frequencies appearing.

Discussion and Conclusions

The data yielded by our TVC study concur with and support the work of Obrador et al. (2009), Caletrío (2009) and Nogués-Pedregal (2012c), all of whom offer a new and more complex view of the holidaymaker. Family relationships and friendships produced and reproduced during the holidays, in addition to affective identification with the resort, appeared as strong reasons for a sizeable segment of residential tourists when choosing their destination.

Our study thus shows the positive relationship between these socio-emotional reasons and residential tourists' loyalty to their summer destinations. It is notable that the longer the duration of the summer stay, the greater weight these reasons bore. Furthermore, they became more significant with the increase in the number of years visiting the same resort; so much so that "emotional" tourists were those who visited their second homes more often out of season, when neither climate nor beach (the classical attractions in Spanish residential tourism) were factors with a decisive or crucial interest for the resort.

The main limitation of this study is that our data were collected for a research project whose objectives were not specifically to analyse the social or emotional motivations of domestic holidaymakers. However, the research team found regularities which suggested the hypothesis we test here. The statistical techniques used were adapted to the situation revealed by our data, data which came from a "pure", homogeneous type of tourist, exactly as defined in the specialized literature. This is clearly an important limitation when distinguishing between "sub-profiles" corresponding to motivations for destination choice from within this "pure type". Here, our contribution is represented by our quantitative approach to research into social and emotional tourist motivations, and we would suggest that more quantitative studies specifically designed to analyse these motives be carried out.

The data yielded by our survey give quantitative support to the most innovative ethnographic analyses of summer tourism. Holidaymakers' cyclical visits to overdeveloped beach resorts can no longer be understood as a passive and alienating activity, conditioned by structural factors or pressures, or by material and economic calculation. On the contrary, destinations are given historical meaning, where the tourist's family meets other families and where, year after year, intense social relationships are recreated and strengthened. Thus, our summer resorts are becoming affective landscapes where highly valued personal relationships are constructed. Arguments of banality and superficiality found in the classic literature are being superseded by a new description of holidaymakers in highly developed resorts.

In the area of planning, our findings indicate the need to rethink objectives. Public intervention in the destinations analysed has traditionally been characterized by excessive growth in the supply of properties and attempts to enhance this supply through megaprojects (large-scale events, hypermarkets, emblematic buildings, etc.). These are politico-technocratic policy decisions in which local social actors rarely participate, and this approach is defined by its distance from the local context and its lack of consideration for tourists' needs and desires. Our data suggest alternatives

for local public policies that would be better oriented to visitors' real motivations. An important part of destination loyalty comes from factors closer to day-to-day sociability and personal interaction and from the preservation of a physical, social and affective landscape rich in meaning for the holidaymaker's personal history.

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Action Research: An Essential Approach to the Development of the Agricultural Field of the Mitidja Plain, North of Algeria, and Comparisons with Other Territories in Developed Countries

Azzeddine Bellout, Antonia Bousbaine, Chérine Akkari and Christopher Bryant

Introduction

Urban Sprawl in the Mitidja Plain, Studies Based on an Analysis of Satellite Imagery Data, and Fundamental Concepts.

Urban sprawl has been a common process in many countries. Even in Quebec, Canada, the initial legislation in 1978 to protect agricultural land was frequently by-passed by the provincial government to authorize different forms of urban development. This has changed substantially because of changes in the legislation during the 1990s and then asking the Municipal Regional Counties to undertake development plans (similar to strategic development plans for agriculture) in the agricultural reserves. We will return to this later in this article. But it is still the case in many countries and territories (e.g. in other provinces in Canada) that in trying to improve food security one of the issues is related to the need to conserve good quality agricultural land to conserve farm and food production activities on this land, especially near urban agglomerations (Bryant, Bousbaine, & Akkari, 2018, 2019).

Urban sprawl is an extremely important societal issue of concern to all land-use actors as well as increasingly for different segments of the population in several

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countries. Urban sprawl is characterized by the development of urbanized areas on the outskirts of major cities for residential, industrial, commercial and infrastructure purposes. Moreover, these urban developments are generally characterized by a low density of structures built at the expense of farmland (Bryant & Loudiyi, 2017). The agricultural areas near urban agglomerations are so often seen as mere real estate reserves for future reconstruction regardless of their agricultural value and its other economic and environmental roles; this has increased the pace of consumption of agricultural land in both developed and developing countries. For instance, this led to a decrease in the agricultural area in the European Union countries between (1961–2003) by about 30 million hectares (FAO, 2007), and some studies have indicated (p. ex. Pointereau & Coulon, 2009) that France has lost about 5.1 million hectares of farmland (1960–2007) almost like a whole department every 5 years, and the pace of land consumption has remained high in recent years in the range of 60,000 ha/year (Balny et al., 2009). Similarly, Canada has lost about 1.2 million hectares of agricultural land since 1971 due to urbanization, half of which was classified as high-quality agricultural land (Hofmann, 2001). Two provinces however have put in place conservation legislation, British Columbia in 1972 and Québec in 1978 (Bryant et al., 2019).

In the Arab world, where agricultural land accounts for only 4.4% of the public space (69.24 million hectares) (Statistics of Inter and Intra Arab Trade Competitiveness, September, 2001), the extension of cities and their expansion has led to a shrinking of agricultural lands in most of these countries (Hofmann, 2001; Haicheur & Bryant, 2018). The consequences of this phenomenon are important in particular because these losses of farmland are generally irreversible.

Peri-urban agriculture has had to contend with continued urban expansion, including urban sprawl in many countries despite land use planning. Peri-urban farms, as elsewhere, also have to cope with difficulties in their functioning, partly related to agricultural machinery becoming larger and larger making it increasingly more difficult to maintain their farm operations (i.e. the globally competitive form of industrialized agriculture that has become so important in many Western countries) (Bousbaine, Akkari, & Bryant, 2017) because of traffic circulation problems in these territories. In addition, with this industrialized form of agriculture that has become very dominant in many countries, there are also increasing concerns about the negative effects of this form of agriculture on the environment and on human health.

The agricultural and land policies of developing countries have followed two main models: collectivization in the so-called socialist countries and the great properties in the so-called capitalistic countries (Petit, 2006), and the collection and improvising of the land has strongly marked the farms of the socialist countries. After independence, Algeria has followed a collectivization policy (Imache et al., 2009). At the end of the 1980s with a rapid commitment of the State, collective farms (ASCs) replaced the major socialist areas. The ASCs were then asked to set up proximity arrangements in order to be able to produce outside the imposed collective framework. Such arrangements are a form of non-market coordination, indispensable for the actors who put them in place (Beuret, 1999). In the irrigated plain of Mitidja in

the north of Algeria, existing arrangements are still informal and still not recognized by the State.

This article focuses on the importance of Action Research in understanding the dynamics of peri-urban agricultural spaces from the perspective of territorial public action, the potential involvement of a whole range of actors, including citizens, and the processes of governance that can be put in place to make the agricultures dynamic and broadly supported by the different actors and segments of the population (Albaladejo & Casabianca, 1997; Bousbaine & Bryant, 2016; Bryant & Chahine, 2015). This article contributes to the work that has traced the dynamics that have influenced the management of agricultural land resources, the evolution in the contexts of territorial public policies and the development of different forms of agricultural production. Agricultural land resources are seen as important spaces by actors, governed through private and public law, and are an indispensable means of production for agriculture, but also they have often been seen as important political resources for the development of urban areas and the communities outside of the urban agglomerations. This approach to land resources immediately puts the emphasis on the parties involved in the changes of these resource spaces, their multiplicity and diversity, their multiple logics and the modalities of activities and associated actors. The governance of these resource spaces thus expresses the modalities of coordination and construction of agreements around a shared property or spaces, by composing with differentiated representations, legislative contexts and fluctuating policies, as well as with actors at several scales of action. The governance processes thus question the formal and informal arrangements implemented to discuss both local and global issues of the development and the preservation of nearby agricultural areas (Bryant & Loudiyi, 2017).

Methodology

Study Area

The Mitidja plain is situated in the North of Algeria. It extends over an area of about 1450 km^2. It is bordered in the east by the Mediterranean Sea, and in its northern part by the Sahel mountains (260 m l.a.s). In the south, it is bordered by the Blida Atlas (1630 m l.a.s), and in the west by the mountains of the Dahra (1560 m l.a.s) (Fig. 1). It lies between latitudes 36° 25′ N and 36° 48′ N, and between longitudes 2° 32′ E and 3° 20′ E. The plain of Mitidja hosts a dynamic agricultural economy, which has become prosperous because of the existing water resources and topographic features, and with being endowed with vast fertile and gently sloping lands. It has been focused on cereals, vegetables, fruit trees and other crops (Bouderbala, 2018; Khouli & Djabri, 2011). Administratively, it spans four wilayas or States, Blida, Algeria, Boumerdes and Tipaza.

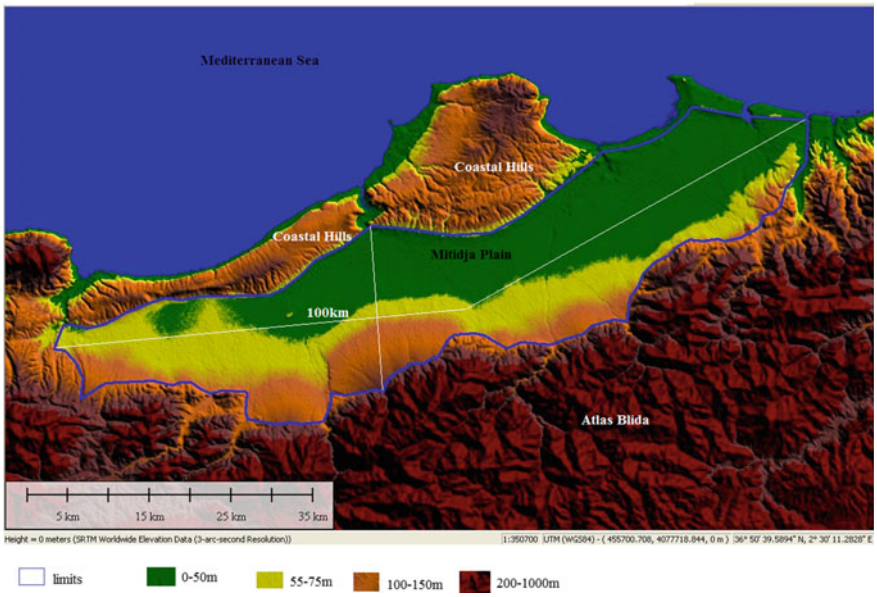

Fig. 1 Location of the Mitidja plain. *Source* Preparation by Bellout Azzeddine

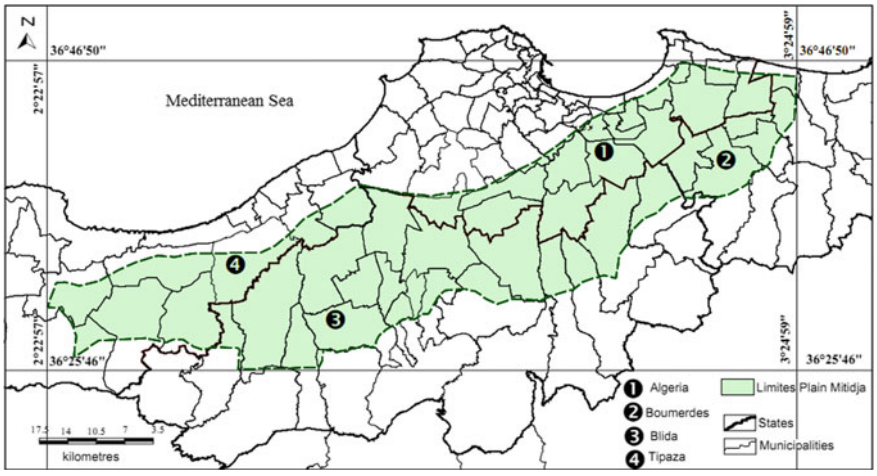

Fig. 2 Another representation of the location of the Mitidja plain. *Source* Preparation by Bellout Azzeddine

The Mitidja plain (Figs. 1 and 2) is a narrow, 100 km long littoral plain located in the Centre of northern Algeria. It enjoys a Mediterranean climate favourable to agricultural activity (Imache et al., 2006). The Mitidja plain owes its richness to several advantages:

– rich soils with good irrigation ability.
– a favourable climate (650–700 mm of precipitation per year).
– a long experience of irrigated agriculture (arboriculture and market gardening).
– proximity to the potential market represented by the capital and other neighbouring cities.
– a well-developed road infrastructure.
– a large capacity for storing and packaging agricultural products alongside an important concentration of the agri-food industry.
– agricultural training and research institutions which are well represented in the Mitidja plain.
– finally, the plain is well located in relation to the potential for mobilizing significant water resources (MacDonald & Parteners, 1997).

Monitoring of Urban Sprawl on Agricultural Land

The methodological challenge of our work is to better understand the relationships between urban systems and agricultural systems by looking beyond the 'rural–urban divide' by separating urban perspectives from agricultural perspectives and examining the interactions between these systems. We have used this systemic approach in the comparison of three maps which can be used to show the use of the Earth in the Mitidja plain for the years (1987, 2005, and 2012) (Figs. 3, 4 and 5) that were completed by three space-based visuals for the same years, in addition to the statistical data of the National Bureau of Statistics.

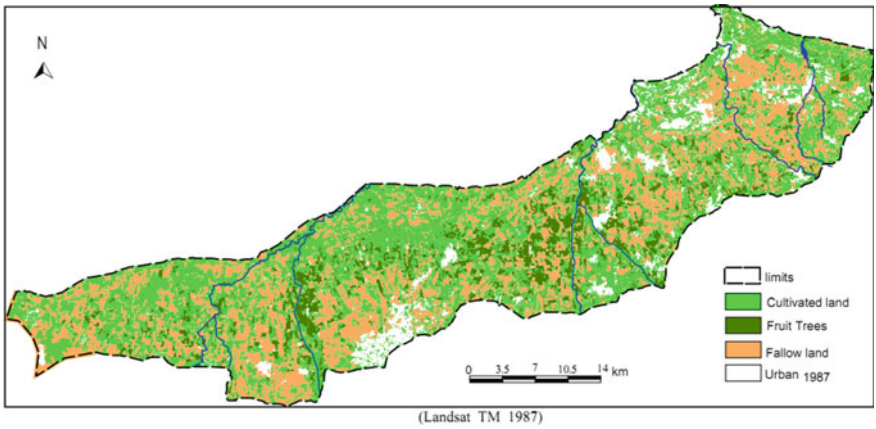

Fig. 3 Land use map of Mitidja plain, 1987. *Source* Preparation by Bellout Azzeddine

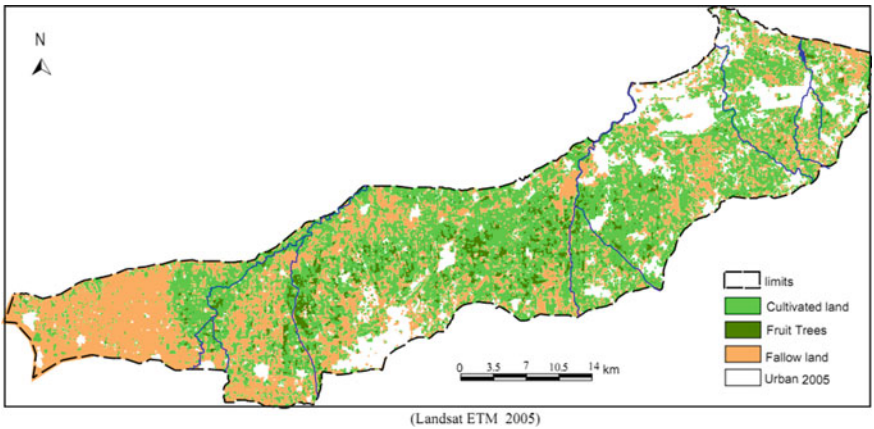

Fig. 4 Land use map in Mitidja plain, 2005. *Source* Preparation by Bellout Azzeddine

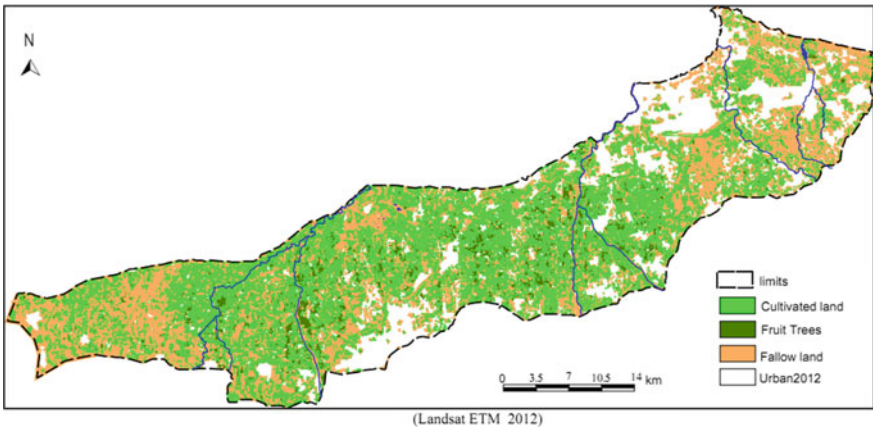

Fig. 5 Land use map in Mitidja plain, 2012. *Source* Preparation by Bellout Azzeddine

Through the spatial visualization of data relied upon in the completion of the three maps, the development of land use in the period (1987–2012) can be easily identified, thus identifying the area of agricultural land consumed by urbanization. Figures 6 and 7 summarize the results obtained.

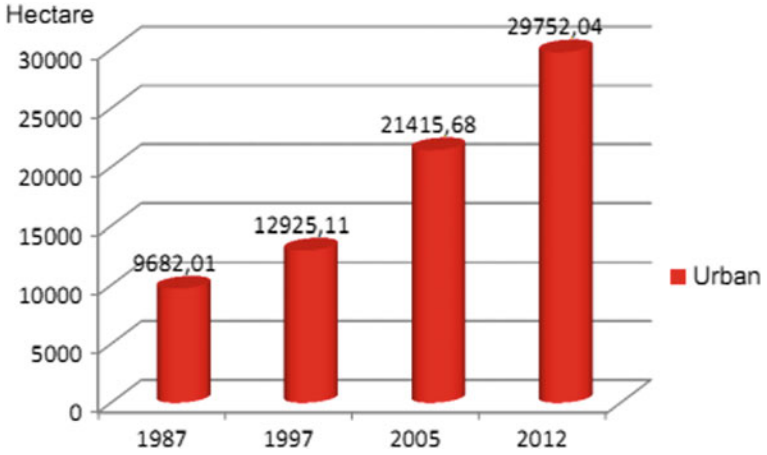

Fig. 6 Evolution of the area of the urbanized area in the Mitidja plain (87–2012). *Source* Preparation by Bellout Azzeddine

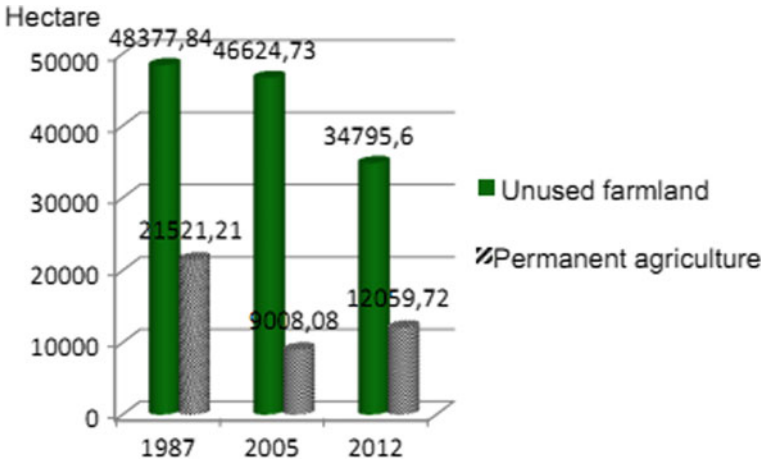

Fig. 7 Decreasing agricultural area (1987–2012). *Source* Preparation by Bellout Azzeddine

Results and Discussion

Delimitation of the Agricultural Zone and Urbanization Perimeters

– Through the Maps (Figs. 3, 4 and 5), we have been able to monitor the area of urbanization, which was not more than 9682 ha in 1987 (i.e. 7% of the total plain area) and 29,752 ha in 2012 (22% of the total area of the plain). Thus,

the reconstruction process consumed about 20,070 ha of high-quality agricultural land over a period of not more than 25 years (between 1987 and 2012), with a consumption rate of over 802 ha/year (see Fig. 6).

– Based on Fig. 5, land consumption has accelerated over the last 10 years (1990–2010) as a result of security conditions in Algeria (The Black Decade), resulting in a large internal migration from Algeria's inner cities. Most of this expansion has been at the expense of non-cultivated areas (fallow land), which lost 13,652 ha of its area, and permanent agriculture (fruit trees) which lost more than 9461 ha, as shown in Fig. 7. The development of agricultural land consumption in the Mitidja plain during the period (1987–2012) has seen two phases:

Phase I (1987–2005): Urbanization in this period consumed more than 11,734 ha, at a rate of 652 ha/year as shown in Fig. 8, and most of the land was consumed in this period (66%). The eastern region (Mitidja Eastern) (Fig. 9) attracted residents from rural areas that understood the instability of security, in addition to allocating large tracts of farmland to shelter those affected by the natural disasters that have affected many neighbourhoods of the capital and its suburbs (e.g. the floods of Bab City 2001, and the Boumerdes Earthquake 2003).

Phase II (2005–2012): According to the results achieved through the processing of spatial imagery data relied upon in land-use mapping in the Mitidja plain, Tameer consumed at this stage more than 8336 ha (Fig. 6) with a consumption rate of 1060 ha/year, taking over the land of the plain which is the most fertile of the plains.

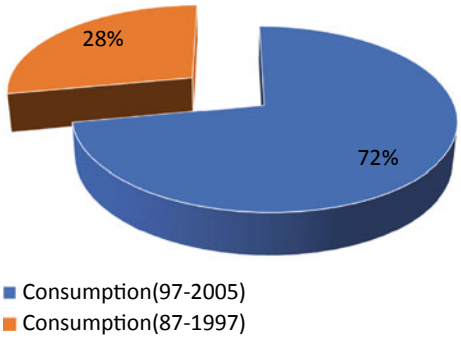

Fig. 8 Evolution of agricultural land consumption (1987–2005). *Source* Preparation by Bellout Azzeddine

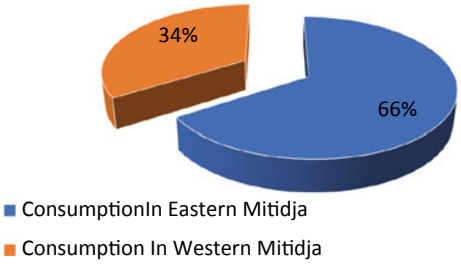

Fig. 9 Agricultural land consumption in eastern and western Mitidja. *Source* Preparation by Bellout Azzeddine

Algerians are prone to gradual demise if this excessive consumption of agricultural property persists.

Thus, it is clear that the Mitidja plain lost about 20,000 ha during the period studied (1987–2012) at the rate of 800 ha/year, and 60% of these lands are located in the Eastern Province, so it is necessary to protect these lands, which had been a major supply source for the capital in terms of food but also the northern bank of the Mediterranean Sea with vegetables, citrus and grapes. This urban (including peri-urban) agriculture (UPA) has to face many challenges; the researcher can in many cases contribute to the emergence of solutions, while at the same time remaining open and willing to meet the demands of the actors involved and exchange with them. The researcher's roles remain essential in this Action Research approach— as informant, advisor and in accompanying the actors in their construction of pertinent and, today, sustainable projects (Bousbaine & Bryant, 2016, 2018). This article will now focus on the importance of Action Research and the challenges posed by agriculture in the urban peri-oceanic plain in the northern part of Algeria; and this form of research involves different actors, including, in the context of this article, farmers, their families and associations but also political actors and professionals and citizens, all of whom eventually can, if they so desire, work together to create sustainable agriculture and farmland (Ibid.).

Proposed Solutions for the Protection of Agricultural Land and the Development of Agriculture in the Mitidja Plain

First, it is important to recall the important losses of farmland in the study area. Whatever forms of land use and development planning existed early on were certainly not capable of conserving agricultural land and its important farm activities. On the other hand, in many countries similar conclusions can be reached in relation to a country's, a province's, a municipality's or a county's ability to conserve agricultural land and the farm activities on those lands. When we investigate the capacity of other territories such as the province of Québec in Canada, it is clear that various forms of urban development were privileged early on over the maintenance of good quality farmland and its farming activities. In Québec, even after the enactment of legislation to protect agricultural land in 1978, much of the relevant literature emphasized how the province, sometimes working directly with local municipalities and regional counties, was able to remove good quality agricultural land from the agricultural reserves in order to encourage for instance the development of industrial parks or even subdivision developments (Bryant & Johnston, 1992; Bryant & Loudiyi, 2017).

It became clear that something else was required! In the context of the province of Québec, this started to happen in the late 1990s with the modification of the legislation to protect agricultural land to also include the conservation of farm activities. This provincial government in the next few years decided that in order to conserve good quality agricultural land, it was also important to conserve farm activities that

were important. This led the provincial government to recommend to the regional municipalities to initiate a new planning process that would create a development plan for agriculture (i.e. a strategic development plan for agriculture in an agricultural reserve) by including all pertinent actors (farmers, their associations, tourist agencies and businesses, the citizens, and other actors). While putting these development plans together was not an absolute requirement for the counties, they were encouraged to do so. One of the key ideas was to ensure that the farmers and non-farm actors including for instance actors concerned with the important role of water in agricultural development (Imache et al., 2006) and citizens were all encouraged to express their values for the conservation of good quality agricultural land and its farm activities (Bousbaine et al., 2017). This experience in Québec was at the time practically unique but now other territories and countries have begun to encourage such development planning processes.

Évidently, putting in place such development planning processes for agriculture really depends upon the cultural values of the different segments of the population and the cultural values of the different actors. Thus, establishing such processes in the context of this case study of Algeria requires a significant implication not only of the farmers and their families but also of other segments of the population and the various actors who have an interest in agriculture and agricultural production as well as the values associated with the agricultural landscapes. Based on this proposal, some solutions have been proposed that have been drawn from research work with farmers, and the various bodies involved to reduce the chaotic urbanization by planning for integrated development, the most important of which are:

- Monitoring of urbanization in the agricultural field by remote sensing and geographic information systems (GIS) to provide a database to help manage the use of the agricultural field and to manage reconstruction.
- To pay attention to peasants in terms of rehabilitation and continuous training by organizing training courses for peasants on various aspects of agricultural activity.
- Rationalization of the consumption of natural resources and control of the management of agricultural property through the intensification of the construction of the urban area of cities and residential complexes and emphasizing the preference of collective housing (vertical expansion) on individual housing to avoid consumption of agricultural property in the Mitidja plain.
- Strengthening the control apparatus and the deterrent authority for the control of reconstruction, because the chaotic reconstruction in the study area is due primarily to the lack of respect for the legislative acts related to the reconstruction and maintenance of agricultural property.
- Growing urban population consumption of water destined for agricultural irrigation has a negative impact on agriculture, so water allocated to agricultural irrigation should be controlled including by allocating sufficient water from irrigation dams or using wastewater after disinfection.
- The development of environmental sensitivity and preoccupation in the community and environmental education which can be considered the trend to change the

mentality of citizens in the direction of the environment so that all energies can be recruited to do so.

The authors of this article believe that this is possible in the case study of this article, but that it would require putting in place a research action process involving the different segments of the population and the different actors, including of course the farmers and their families. The aim of such a process is not for researchers to study and then suggest how to undertake development planning, but rather for the team of researchers to work with the different segments of the population and the different actors, to answer questions when these actors pose questions and to accompany the different actors in moving eventually towards a development planning process that could also be integrated into any of the land use planning tools.

This Action Research process recognizes the responsibility of the various actors, the pôliticians of municipalities, the farmers, their families and their professional organization(s), and citizens with an interest in local sustainable food production and food security, and this process can help in the development of the roles of the different actors, with the researchers never imposing their views on the citizens and actors.

This Research Action process can involve accompanying the actors in:

a. Developing a strategic development plan for agriculture in the different territories or municipalities such as drawing on the vast experience of actors in many of the Regional Municipal Counties in Québec, and
b. Creatingconstructive projects such as building on the potential opportunities for successful development of sustainable agricultures and food production, which can also draw upon the experience around several cities in other countries, such as the Food Land Belt around Liège in Belgium, and equivalent projects such as système alimentaire montréalais or the Montréal food system (SAM), or other food projects at smaller geographic scales (e.g. the network of a set of farmers in the Plaine de Versailles west of the Paris agglomeration).
c. And in developing a first class source of data on the principal dimensions underlying the development of sustainable agricultures and their production of healthy foodstuffs. Both farmers and consumers can support the development of sustainable agricultures and healthy foodstuffs. In the research literature, there are many references to sustainable agricultures and healthy foodstuffs in different territories and countries. Most of the discussions centre on different sources of information and frequently, the sustainable agricultures and healthy foodstuffs are simply discussed without any real discussion about what each of these terms really consist of. In this Action Research process at the base of this article, it is suggested that the first set of interviews with farmers and consumers, among other actors, address the meaning that farmers and consumers give to sustainable agricultures and healthy foodstuffs. This information can be turned into data that can be analysed. However, it is already well-known among many researchers that: (i) over time the number of farmers and consumers that support these two terms will likely increase and (ii) the meaning of the two terms will also likely evolve as well.

Therefore, when this first Action Research project is completed in this territory, it is not unlikely that the general interest in sustainable agricultures and healthy foodstuffs will increase and in all likelihood will evolve. This suggests that over a longer period of time it would not just be interesting but also important that these two terms evolve and also it be recognized that they may well evolve differently in different segments of farmers and consumers. Undertaking similar research, say 2 or 3 years later, by interviewing the same set of farmers and consumers again, as well as any new segments of the farming population and the consumer population, will contribute to creating a real database that can be used in different analyses. Thus, the information that was important in the first step of interviewing farmers and consumers about these two terms gives rise to a database that can be dynamic over time, and can therefore become very significant in the planning and management of the development of sustainable agricultures and the production of healthy foodstuffs.

This is more than simply interesting because it refers to how numerical governance can be created by the creation of such new data which can also be used in management processes by government as well as different segments of actors such as farmers and segments of the consumer market. This approach was recently the object of a workshop in Montreal (Fillion, 2019) organized by the Institut de Gouvernance Numérique (Institute of Numerical Governance) in Montreal involving researchers and practitioners in different domains, including agriculture and climate change, to which Bryant, one of the co-authors of this chapter, was invited.

Conclusion

It is clear that the territory of the Mitidja plain, in the North of Algeria, is in need of an effective planning process in order to conserve good quality agricultural land and the farm activities that produce products that are substantially desired by the local and regional populations. It is evident when we draw upon the experiences of other countries such as Canada and France that land use planning alone is not capable of conserving good quality agricultural land and its highly valued agricultural produce especially healthy food produce. What is needed is a form of development planning in which the whole range of interested and pertinent actors are involved in the discussions. The involvement of actors and population segments in addition to the farmers and their families is suggested as a major way of mobilizing the population also to support the conservation of good quality farmland and sustainable agricultures. The approach that we have suggested should be adopted is that of an Action Research process to help mobilize and involve a whole range of actors and population segments in the process of developing a development plan for agriculture. Furthermore, the information that becomes turned into temporal and geographic data over time can provide a dynamic database that the different actors can use (together) to ensure that the development plan evolves to take into account the changing values of the different actors by integrating this changing database into the ongoing development planning process.

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Spatial Big Data and Business Location Decision-Making: Opportunities and Challenges

Joseph Aversa, Tony Hernandez and Sean Doherty

Introduction

Geographic perspectives have contributed unique solutions to diverse problems, centred on the complex relationships between humans and their surrounding environments. Understanding and explaining these complex spatial arrangements are essential when making business location decisions. By incorporating platforms that allow for the expansion of both the type and amount of data it works with, known as big data, businesses are moving towards greater reliance on data-driven decision-making. Advancements in big data and big data technologies have provided businesses with an ability to obtain more granular-level information on consumer behaviour, which ultimately can help them make better decisions. While the economic value of location is not a new phenomenon (Ghosh & McLafferty, 1987; Jones & Simmons, 1993), the increasingly competitive consumer marketplace and advances in information technology and e-commerce have placed added pressure on businesses to improve their understanding of the spatial implications of individual activity patterns (Aversa, Doherty, & Hernandez, 2018; Cheng et al., 2005; Rogers, 2007). With paradigm changes in consumer behaviour being facilitated through the widespread adoption of e-commerce business models, there are increasing questions surrounding the need and use for physical space (i.e. store networks and associated distribution centres).

An integral part of informing the business location decision-making (BLDM) process is the application of data analytics (the techniques, technologies, systems, methodologies, and applications that analyse critical business data) used to help businesses better understand their market and make timely business decisions (Chen,

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Chiang & Storey, 2012). Given the ever-increasing scale of investment and the subsequent increase in the risks associated with business location decisions, it is not surprising that the use of data in BLDM has become a growing area of interest. Spatial big data (SBD) and associated analytics promise to offer comprehensive, interconnected, spatiotemporal data that can provide an increased level of sophistication and a more detailed understanding of consumer behaviour. It presents the possibility of a new era of BLDM centred on data-driven decisions that will challenge the boundaries and nature of decision support. It may result in a transition from old and relatively simple theories and models to more complex methodologies (Aversa et al., 2018; DeLyser & Sui, 2014; Kitchin, 2013; Goodchild, 2013).

This chapter builds on the theoretical and empirical foundations of BLDM studies within the fields of retail, marketing, and business geography. The key objectives are: (i) to provide a research context for the study of spatial big data (SBD) and associated data science (DS) approaches in business; (ii) to identify the awareness, availability, use, adoption, integration, and development of SBD and DS within BLDM; and (iii) to explore the opportunities and challenges associated with integrating spatial big data in business organizations.

Data-Driven Decisions

Businesses have increased their reliance on data-driven decision-making (Byrom 2001; Hernandez, Bennison, & Cornelius, 1998). Much of the growth in data has been largely driven by a growing interest amongst businesses wanting to understand consumers in more detail (Aversa et al., 2018; Ramanathan, Subramanian, & Parrott, 2017; Vigneron & Johnson, 2017). With the ongoing collapse of traditional business models, fuelled by innovations such as omnichannel retailing (Piotrowicz & Cuthbertson, 2014; Verhoef, Kannan, & Inman, 2015), there has been a growing need for greater consumer insight. By having more granular-level information of consumer behaviour, businesses have a better understanding of how products and shopping destinations are selected (Brosekhan, Velayutham, & Phil, 1995; Carolan, 2018; Lloyd & Cheshire, 2017; Zerbino, Aloini, Dulmin, & Mininno, 2018). Collecting data at a spatial/temporal scale enables the identification of linkages between a potential consumer's lifestyle and individual activity patterns.

A major area of promise with SBD is in the area of obtaining more granular-level data about consumers. Smartphones and other mobile devices provide large streams of data tied to people, activities, and locations (McAfee, Brynjolfsson, Davenport, Patil, & Barton, 2012). This data can be placed into two categories: (i) app data collected by the app companies directly from built-in sensors on the phone such as GPS, accelerometer, magnetic field, and gyroscope and (ii) spatiotemporal network-level data collected by the telecommunication companies such as user ID, location (GPS), device type, timestamps, and type of service (Cheng, Li, & Yu, 2017). Several studies have looked at using tracking technologies to understand consumer/patron behaviour

at a more granular level. For example, Yaeli et al. (2014) combined customer movement data (collected via Wi-Fi) with floor layout data and sales data to conduct visual analysis on consumer movements. Lee (2013) used data from smartphone sensors to examine the correlation between adjacent activities (cross-shopping) time of day. Ruiz-Ruiz, Blunck, Prentow, Stisen, and Kjærgaard (2014) used smartphone detection over a 15-day period, utilizing a hospital's Wi-Fi network to classify visitors and to create various visualization tools (e.g. heat maps). Other studies have looked at utilizing GPS in order to infer travel demands (Siła-Nowicka et al., 2016; Gong, Liu, Wu & Liu, 2016). Siła-Nowicka et al. (2016) analysed human mobility patterns from GPS trajectories and contextual information. Furthermore, Gong et al. (2016) used mobile data to infer trip purposes and uncovering travel patterns from taxi trajectory data.

There are some institutional challenges around big data adoption. One major challenge identified by Brown, Chui, and Manyika (2011) is the fact that the bulk of this data is often stored in department-specific "silos", delaying the use of such data. This is important because if organizations fail to leverage the real-time dimension of big data, the business value can be lost. Another challenge with such data is what Brown et al. (2011) refer to as "*information hoarding*". This specifically refers to the fact that business organizations do not share data between departments. Examples of this can be seen within financial institutions, as they suffer from their own failure to share data amongst diverse lines of business, such as financial markets, money management, and lending (Brown et al., 2011). This can ultimately prevent these companies from forming a comprehensive view of their individual customers. This is not a new phenomenon, as several studies identified similar problems with the sharing of data and software licences within organizations (Byrom, Bennison, Hernández, & Hooper, 2001; Hernandez et al., 1998; Reynolds & Wood, 2010; Wood & Reynolds, 2012; Aversa et al., 2018).

Lavalle, Lesser, Shockley, Hopkins, and Kruschwitz (2011) identified that the leading obstacle to widespread adoption is a lack of understanding of how to use analytics for business improvement purposes. Being able to visualize data differently becomes increasingly valuable as executives want better ways to communicate complex insights so that the decision-making process can move quicker (Lavalle et al., 2011). With the data being so big, it is very difficult to find user-friendly visualizations, and therefore, new techniques and frameworks to tell and show stories will be needed (Jadhav, 2013). Other challenges exist around the ability to actually attain data and the lack of skilled professionals (data analysts) who can manage, organize, and synthesize the data. Large amounts of possibly useful data are being lost since new data is largely unstructured and untagged. In 2012, it was estimated that 18% of the USA's digital universe would be "useful" if tagged and analysed (Gantz & Reinsel, 2012). Despite the opportunities afforded by big data, businesses need to proceed with caution as investments in analytics can be useless and costly unless employees can incorporate that data into complex decision-making (Provost & Fawcett, 2013).

The awareness of both the significant challenges and opportunities associated with SBD is fundamentally remodelling the traditions of BLDM (Kitchin, 2013;

Table 1 Key data science terms (Cao, 2017)

Key terms	Description
Advanced analytics	Theories, technologies, tools, and processes that enable an in-depth understanding and discovery of actionable insights into big data, which cannot be achieved by traditional data analysis and processing theories, technologies, tools, and processes
Big data	Data that are too large and/or complex to be effectively and/or efficiently handled by traditional data-related theories, technologies, and tools
Data analysis	The processing of data by traditional (e.g. classic statistical, mathematical, or logical) theories, technologies, and tools for obtaining useful information and for practical purposes
Data analytics	Theories, technologies, tools, and processes that enable an in-depth understanding and discovery of actionable insight into data. Data analytics consists of descriptive analytics, predictive analytics, and prescriptive analytics
Data science	Is the science of data
Data scientist	Professionals whose roles very much centre on data
Descriptive analytics	The type of data analytics that typically uses statistics to describe the data used to gain information or for other useful purposes
Predictive analytics	The type of data analytics that makes predictions about unknown future events and discloses the reasons behind them, typically by advanced analytics
Data mining	Data mining is made up of a diverse and distinct set of methods that can be employed for identifying patterns. These include summarization, classification, clustering, association, and trend analysis

Lee & Kang, 2015; Thatcher, 2014). As Cao (2017, p. 43) notes, "*this paradigm shifting is driven not just by data itself but all other aspects that could be created, transformed, and/or adjusted by understanding, exploring, and utilizing data*". The field that is responsible for managing this transformation can be referred to as data science (DS), that is, the field that includes everything that involves the "collection, management, processing, analysis, visualization, and interpretation of vast amounts of heterogeneous data" (Donoho, 2017, p. 745). The potential of data science to facilitate spatial data-driven processes is increasingly being recognized (Lee & Kang, 2015; Thatcher, 2014), and it involves not only computing, informatics, GIScience, and statistics, but also the social sciences and business (Cao, 2017). Cao (2017) outlines several key terms, often used interchangeably, that are associated with DS (Table 1).

The Interviews

In order to develop more understanding of how SBD and DS are impacting BLDM, a series of semi-structured interviews were conducted with 24 business analysts

and managers responsible for BLDM. Interviews were used because they provide an opportunity to explore knowledge gaps and investigate the complex behaviours and motivations associated with SBD and DS. Collectively, the interviews are used to identify consensus and differences in industry experiences and opinions. Semi-structured interviews have been used in comparable studies of BLDM (Woods & Reynolds, 2012) and were viewed as a valuable and reliable method to gain information.

Respondents were selected using purposeful sampling methods. The three methods that were utilized for this study were: (i) snowball sampling; (ii) criterion sampling; and (iii) convenience sampling. Snowball sampling, often called chain sampling, identifies research subjects by having research subjects to identify potential participants (Atkinson & Flint, 2001; Biernacki & Waldorf, 1981; Szolnoki & Hoffmann, 2013). All respondents were asked if they knew of anyone that would be willing to participate, and they often made introductions. Criterion sampling is a method that involved selecting respondents that meet a set of criteria which are important to the research (Patton, 1990; Palinkas et al., 2015; Sandelowski, 1995). It was essential to the study to have a variety of respondents who held different positions across different sectors that varied in sizes. As a result, individuals were sought out to add to the level of diversity in the respondent list. Convenience sampling is a technique that selects participants based on ease of access or convenient accessibility (Emerson, 2015; Etikan, Musa, & Alkassim, 2016).

Table 2 identifies the list of the 24 respondents interviewed, by position and business sector. The sampling goal was to ensure diversity by business sector and organizational role. The perspectives and opinions of industry practitioners will differ based on the amount of time the respondent has spent in the industry, and therefore it was important that analysts and managers/senior executives were included in the interview processes. In order to gain a broad view of how SBD is being adopted and the challenges and opportunities, multiple business sectors had to be surveyed.

The interview questions were separated into primary and secondary questions. Primary questions were used as opening questions, which encouraged the respondents to initiate discussion on a new topic. Secondary questions were used as prompts that were meant to encourage respondents to follow up or expand on issues (Hay, 2005, p. 83). Interviews were manually documented to make the respondents feel more at ease and encouraged them to be more forthcoming. The interviews included a combination of phone and in-person interviews.

Table 2 Interview respondents

Respondents' position	Retail sector
Partner	Retail consultancy
VP of real estate market strategies	Grocery
Senior director branch distribution	Financial
Market and location analytics manager	Casual dining
Senior analyst	General merchandise
Director of market development	Pharmacy and personal care
Senior vice president of real estate acquisition	General merchandise
GIS analyst	Developer/leasing/brokerage
Senior director of physical planning	Financial
Senior manager of physical distribution	Financial
Market research analyst	Developer/leasing/brokerage
Research analyst in asset research	Developer/leasing/brokerage
Analyst—analytics, insights, and innovation	Developer/leasing/brokerage
Manager of development and portfolio analytics	Casual dining
Senior director, market research	Developer/leasing/brokerage
Development lead	Fast food
Development manager	Fast food
Senior market analyst	Grocery
Senior director of physical distribution strategy	Financial
Development lead	Fast food
Director of network delivery	Financial
National director of strategy and insight	Fast food
Marketing analytics and research manager	Casual dining
Spatial research analyst	Fast food

Business Location Decision-Making Insights

The Big Data Challenge: Growth, Granularity, and Geography

All 24 interviewees indicated that there was growth in the *volume of data* available within the organization. The interviewees documented that this increase in data volume was coming from both external and internal data sources. Customer transactions, for example, are increasingly leaving a digital imprint, and therefore, organizations are looking at ways to capture this information. Nineteen interviewees indicated that the major increase in customer data was a direct result of internally generated loyalty card data and the growth in their e-commerce divisions. The five interviewees that did not indicate growth in customer data were all from the food services sector. Seventeen interviewees reported that they are now using new or different techniques to improve the collection of customer information. All of the food service interviewees (7) indicated that customer information acquisition was a challenging process.

> More customer data would be great but it's difficult.
>
> **Fast Food Retailer**
>
> No customer loyalty data … we are developing a loyalty program to access our own data.
>
> **Casual Dining Retailer**

These food service interviewees were asked why it was so difficult to get customer information. The challenge was commonly linked to the nature of their business. For instance, two of the casual dining interviewees indicated that it was a result of the fact that they lacked one single point of contact (like a centralized cashier) and had to rely on service staff who are more focused on service quality as opposed to data collection.

> It's harder when your full service … there is no single point of guest interaction. You rely on the server's… their main focus is getting food to the table and not screwing up an order.
>
> **Casual Dining Retailer**

These companies were also less likely to have loyalty programmes in place. All of the retail interviewees indicated that the development of an internal loyalty programme or the improvement of an existing programme is a major priority. However, six of the seven food service retailers indicated that their business environment did not lend itself to the effective integration of these types of programmes.

> …food service is not ubiquitous… before everything else food quality, experience and service matter more than points…therefore loyalty becomes a secondary motivation when deciding to visit one restaurant over another.
>
> **Casual Dining Retailer**

Half of the interviewees (12) reported seeking more granular-level data in order to gain significant insight into consumer spatial behaviour. While traditional transactional data was identified as valuable by virtually all interviewees (23), it does not always to provide an exact measure of individual behaviour as many of the methods of data collection have significant flaws. A significant challenge of loyalty programmes, regardless of whether they were internally operated or outsourced, was a lack of participation as highlighted by 21 interviewees. For example, loyalty programmes do not typically capture all customers as it is rare to have 100% consumer adoption and usage (unless you are a membership-based business, such as Costco). Fourteen of the interviewees indicated that while they have long been collecting customer data (some for over 50 years) at the point of sale (POS), they are now undergoing a shift in the data being collected, specifically as it pertains to variety. For instance, 11 interviewees reported they are looking at the potential of triangulating their POS data with data collected through a variety of technologies that can track customer movement both inside and outside of the retail locations providing new opportunities for spatial analysis. Four-fifths of the developer/leasing/brokerage interviewees indicated that they have already implemented tracking technologies including advanced traffic counters, digital signage with retina recognition, internal positioning systems, as well as mobile phone tracking.

> Digital signage in our shopping centres have eye-tracking and facial recognition used to get demographic data.
>
> **Developer/Leasing/Brokerage**

While it appeared that the development sector was the most active in this area, they were not the only ones that indicated they were adopting new methods of tracking customers. Three of the five fast-food interviewees were looking at adopting a variety of consumer tracking technologies such as facial recognition software and mobile phone data. It is important to note that seven interviewees indicated it was difficult to extract insights from customer data, including all the financial sector respondents, the pharmacy and personal care respondent, and one developer/leasing/brokerage respondent.

> We are not using new techniques…the tools have not changed, analysis has not changed and does not look like it is changing… Risk mitigation will not improve…we will paralyze the business if we use more data.
>
> **Pharmacy and Personal Care Retailer**
>
> We are now looking at cell phone pings to track people during the day.
>
> **Fast Food Retailer**

While this real-time data was viewed as vital for some (9 interviewees), many (14 interviewees) indicated that they were not concerned with real-time data analysis. Six of these interviewees indicated that while there may be benefits for marketing purposes, it is not realistic to leverage such data when making long-term retail location commitments.

> Hard to use real-time data. We are making 20-year decisions, and this is not happening on yesterday's data.
>
> **Grocery Retailer**
>
> Day to day data is not important … period data is important.
>
> **Pharmacy and Personal Care Retailer**

A catalyst for the increases in the variety of data sources was linked to the automation of consumer data collection and the ability for data to be generated from a diverse set of digital devices, as indicated by 19 interviewees. This automation included the following: customer surveillance data, cell phone ping data, crowdsourced data, and social media data. However, few interviewees reported effective integration, adoption, or utilization of this data into BLDM. Only three interviewees indicated that they were able to leverage these data sources, and none of the interviewees indicated that they were effective at this in BLDM process. All the respondents that identified the increase in variety coming from the automatically collecting data (19) identified that it was tough to establish a single depiction of each customer across multiple sources of customer information (point of sale, loyalty programme, social media, etc.). Therefore, a significant challenge appears to be finding a way to identify the various ways the same customers are represented across different methods of collection.

> An inability to do this [link customer records] presents problems with filtering and compressing data in a usable way.
>
> **Developer/Leasing/Brokerage**

Techniques and Technologies

There was a great deal of variability in the adoption of BLDM techniques that were able to accommodate these new dimensions of data (variety, volume, velocity). The level of decision-making sophistication being adopted was linked to a number factors including (i) the business environment in which they operate; (ii) the nature of the location decision being made; and (iii) availability of technology.

The Business Environment

The likelihood of adopting more advanced methods for decision-making was linked to internal and external factors related to the business environment. For instance, three of the fast-food interviewees and two of the casual dining respondents, for whom franchising was the dominant growth strategy for these firms, indicated that franchises were involved in the retail location decision process. In such cases, the use of more sophisticated techniques and data becomes less prevalent in comparison with retailers that were opening and operating corporately owned stores. Companies that relied on franchising as a corporate growth strategy encountered a unique set of challenges. These five interviewees all indicated that the franchisees' willingness to invest in a property would hold precedence over any other form of decision-making. In other words, if a potential franchise was adamant about a specific location, it was common practice for the corporate real estate departments to move forward with the location acquisitions without relying on data-driven analytics. Moreover, 15 of the interviewees worked for organizations with multiple brands, of which ten indicated that they had to rely on more data-driven decisions because of needing to manage multiple brands. In other words, they indicated that because of the complexities of selecting the right brand for the right market, they had to lean heavily on data. Twelve of these fifteen interviewees indicated that they feared cannibalization amongst their brands.

> We need to apply advanced analytics and detailed customer data in order to make sure that our brands are reaching the right customers.
>
> **Grocery Retailer**

Another common environmental factor influencing the use of BLDM techniques expressed by 15 interviewees was the fact that they pay close attention to how competitors make business decisions. Explicitly, they stated that they keep tabs on the data inputs and the use of technologies within decision-making from comparable businesses in the same sector. If there is a perception that a company's competitors are engaged in more advanced data-driven decision-making, then it becomes a higher priority.

Based on the interviews, it appears that some sectors are better equipped to collect data. All financial sector interviewees (5) indicated having access to the largest volume and variety of internally collected data when compared to the other respondents. Participants were asked which data-generating methods were utilized when generating data sources. Specifically, participants were asked whether data was generated by: (i) created data; (ii) provoked data; (iii) transaction data; and (iv) captured data methods (Table 3). The financial sector interviewees were the only ones that indicated that they actively generated data from all four of these methods. Four out of the five interviewees indicated that the main reasons for generating data from all these sources were based on the collective view that having a large data repository could help with all aspects of their business including marketing, real estate, and operations. It is important to note that the collection of data did not necessarily indicate that the data generated was being utilized regularly. These financial sector interviewees only regularly used created data and transaction data for BLDM, rarely integrating provoked and captured data. Outside of the financial sector respondents, no other participants indicated that they collected data from these four methods of collection. The next closest to this was the developer/leasing/brokerage interviewees as four participants indicated that they generate data by created, transactions, and captured methods of collection. Three interviewees did, however, indicate that while transaction data was collected, it was not provided daily nor were they able to see individual purchases but instead they were provided with aggregates over an extended period (typically monthly).

An organization having access to data does not necessarily indicate that they are using the data for decision-making. The financial sector interviewees (5) indicated that they only regularly used created data and transaction data for BLDM and that they rarely integrate provoked and captured data. Furthermore, a total of 16 of the interviewees indicated that a lot of the data that was used was too detailed and not useful and thus SBD adoption was not present in their departments—that is, research departments or real estate departments were not responsible for SBD or

Table 3 Data-generating methods

Data-generating methods	Definition	Example
Created data	Is created because it would not exist unless a mechanism was put in place to collect that information	Loyalty programmes, market research surveys, asking for postal codes
Provoked data	Would not exist unless you invited people to express their views	Product review, service review, etc.
Transaction data	Generated every time a customer makes a purchase	POS
Captured data	Is information gathered passively from an individual's behaviour	GPS from mobile devices

SBD analytics integration. They indicated that this is left in the hands of marketing departments whose objectives were more in line with using advanced internal data sources and targeting customer groups and individual customers.

The Nature of the Decision

It was a common trend that the more complex the location decision is the greater reliance is placed on data-driven decision-making. It is important to note that the interviewees, more often than not, defined complexity as the cost of the decision; that is, the higher the cost, the greater the complexity and risk. Twenty interviewees indicated that experience was an effective tool for driving high-level ideas from a creativity perspective and aids in validating decisions on the ground but cannot be used in order to make more complex location decisions. For example, understanding complex relationships regarding customer interaction is not possible through experience alone. The following are several statements that reinforce this idea:

> Big Level decisions are never made without data analytics…
>
> **Financial Sector**
>
> Experience alone does not dig deep enough… it's impossible to understand the implications of store size… through experience.
>
> **Grocery Retailer**
>
> Some things cannot be categorized in data, so we rely on the experience of our brokers to aid in the decision process.
>
> **Casual Dining Retailer**
>
> Intuition and experience will never disappear… we start off with a qualitative thought, and we try to support it and quantify it with data.
>
> **Financial Sector**

Irrespective of the growth in the availability of data, the decision-maker's experience continues to be an essential factor when making business location decisions, as was apparent in the results of the online survey. Twenty-one interviewees indicated that while there is strong growth in data-driven decision-making techniques, experience is still vital in order to extract real meaning and organizational context. Seven interviewees even argued that experience was more important than ever given the data deluge. They stated that there was a greater need to filter through big data to find the data that is relevant to BLDM.

> Greater reliance is being placed on departmental experience in order to filter down the data in a more meaningful way… It is hard to filter through the noise.
>
> **Grocery Retailer**

Conversely, some of the interviewees were looking to break away from having a human element in the decision-making process altogether. Four of the food service companies that stated they either never or very rarely relied on data-driven decision-making now wanted to remove the experience element completely. These retailers indicated that the fear of lawsuits from franchises, as a result of cannibalization, is the most significant catalyst for no longer wanting to rely on intuition or experience alone.

> We have made decisions solely based on intuition and it has not bode well…Experience is still a vital resource but we do not want to make decisions without the validation of data.
>
> **Fast Food Retailer**

Availability of Technology

An organization's ability to integrate more data is one that relies heavily on the available technologies within the organizations. The SBD gap was linked to issues with data mining-related technology. Sixteen interviewees indicated that they were challenged by a lack of computer processing capacity to discover patterns in SBD sets. These issues presented problems with adopting machine learning and artificial intelligence. It was unanimously expressed that the only way to leverage more granular-level data into the decision-making process would be to develop or incorporate better software capable of handling SBD. Twenty-one interviewees further indicated a clear need to fuse the new data that is being collected with a technological infrastructure that is capable of allowing for more granular-level data to be integrated, ultimately improving the quality of decisions being made. The adoption of software capable of handling non-traditional forms of data (unstructured and semi-structured data) has not been realized by over half (14) of the interviewees. Twenty interviewees indicated an inability to handle these new data sources.

> There is a need for more data but retailers need to become IT companies in order to effectively integrate the data.
>
> **Grocery Retailer**

Furthermore, the ability to get the data appears to be a significant challenge for all respondents. All of the interviewees indicated data silos to be a problem, mainly because cloud computing and other data storage are not accessible across the organization. There is a significant lack of awareness between departments of the data

sources that are available. While some (three interviewees) are actively breaking down these barriers, the majority are not.

> We know the data is out there (through social media and other sources)…we lack the infrastructure to accommodate that data.
>
> **Grocery Retailer**
>
> We are looking at introducing a data lake for all institutional data to be accessed by everyone within the organization.
>
> **Developer/Leasing/Brokerage**

Organizational Culture

There were some clear, corporately driven obstacles to SBD adoption. One major impediment stated by all of the interviewees was a lack of understanding of how to use SBD analytics to improve BLDM. There was apparent confusion amongst the interviewees in regard to the BLDM solutions that SBD can offer. As a result of the increased rhetoric that SBD can present unmatched opportunities to extract greater insights, there appear to be strong motivations for retailers to collect customer data. It is evident that retailers are getting lost in a sea of data (indicated by 21 interviewees) and that without more clearly definable deliverables it is ultimately providing no valuable output. Most interviewees indicated that while that data may be novel and "cool", it does not actually provide any decision-making benefit.

> But just because we can measure, monitor and access everything doesn't mean we should. **Pharmacy and Personal Care Retailer**
>
> I am not really sure what the benefit is…Constantly collecting new data but it adds little value. **Financial Sector**
>
> We buy data to prove the mall is not dying. Not actually changing how we make decisions. **Developer/Leasing/Brokerage**
>
> People are slow to adopt solutions… It's difficult because it's overwhelming…What does it (data) mean?…How do we use it?…New data has brought new problems. **Developer/Leasing/Brokerage**

Another corporate challenge seems to be related to a lack of executive or senior manager buy-in for SBD adoption. In the 14 organizations where senior management is on board with adopting SBD and SBD analytics, there appears to be a greater appetite to incorporate new methods, ideas, and product innovations. The departments responsible for BLDM do not appear to be well versed or capable of

looking at non-traditional data sources to make evidence-based decisions. Wherever new methods are being adopted, senior managers are attempting to leverage new employee skill sets by bringing in individuals with knowledge of machine learning methods, predictive modelling, and artificial intelligence. This requires new data tools and analytics platforms that can handle both structured and unstructured data. This was apparent in ten of the organizations surveyed as they indicated that they either recently hired or were actively searching for employees with a strong data science background. In some situations (three organizations), much of this is outsourced to third-party companies. In the 12 instances where upper management have not looked at advancing their decision-making capabilities to include SBD practices, seven reported competing priorities as being a significant challenge. The reluctance to advance SBD was strongly related to tight budgets creating an inability to accommodate any innovation in terms of software, data, or even expertise. The majority of interviewees (20) indicated that they were concerned about the perceived costs of SBD and SBD analytics versus the projected benefits it would provide. Furthermore, nine interviewees expressed serious displeasure with the current state of decision-making at their organization. This was mostly due to limited access to the analytical tools needed to develop and improve their BLDM.

> Just keep doing what you are doing … May not be right … the process of using data has not changed even though data and markets changing … if you ask me it is ridiculous.
>
> **Pharmacy and Personal Care Retailer**
>
> Politics vs numbers. Definitely there are still senior people who make decisions. The last 3 to 5 *years people are starting to trust the process a bit more.*
>
> **Grocery Retailer**

Eleven interviewees indicated that they did not feel like more data nor new models would be able to increase the ability of their department or organization to make better decisions. One general merchandise retailer even indicated that the success of a store location was solely driven by demographics and incorporating any other variables or new methodologies would be a complete waste of time.

Discussion and Conclusion

The dialogue with the respondents indicated that challenges appeared to centre on three major themes related to data operations: (i) data warehousing and mining; (ii) data integration and analysis; and (iii) data interpretation. Most respondents indicated their lack of effectiveness at data warehousing and mining. Generally, the complexities associated with SBD made it difficult for organizations to compile and organize data into an appropriate data infrastructure, which therefore makes the

process of extracting meaningful data for analysis challenging. This raises questions around the increasing role and need of data blending practices, that is, the process of combining data from multiple sources into a functional data set (Bazeley, 2009). The growth in software packages such as Alteryx and Tableau can be partially attributed to their ability to create single views of data even when multiple data sources exist.

A definite challenge associated with SBD is the business' effectiveness at integrating data (new and old) into the decision-making process. This is brought about by diverse types of data sources and data formats. It does not appear that a lack of data is an issue for any of the businesses interviewed, as all respondents identified having an abundance of data, the real problem seems to be related to data integration. Twenty-two respondents highlighted the fact that their data warehouses, which were designed to handle structured data, are not equipped to integrate multiple forms of SBD. This challenge, in the variety of data, is related to integrating unstructured data and semi-structured data which do not conform to existing data models. This makes it increasingly difficult to create new knowledge that ultimately improves decision-making. Similar to what was identified in Marr (2015), it is clear that most companies are "data-rich but insight-poor". This has to do with a lack of understanding of how to use data by most retail organizations.

> It's a challenge because customer data is defined by multiple actions…not just one point of interaction. This makes data variety the major challenge.
> **Financial Sector**

With regard to data analysis, there appear to be significant barriers for businesses to start to perform analysis and modelling involving new data formats. If the ultimate goal of collecting SBD is to deliver better insights and value in decision-making, it is essential to find and refine methods that are capable of supporting new data. The lack of experienced personnel (i.e. data/spatial scientists) within the BLDM departments, capable of using and developing machine learning techniques and improving data collection procedures, was a common issue. While some departments are starting to hire data scientists to tackle some of these data-driven challenges, the transition has not been smooth. One of the significant challenges documented stems from the fact that these data scientists lack industry-specific knowledge, which makes it difficult for them to communicate their findings effectively to senior management.

> A disconnect from the data scientist as they don't have industry knowledge.
> **Developer/Leasing/Brokerage**

Data interpretation has always proven to be a challenge with spatial data analysis, as documented in several studies (Stone et al., 2003; Kohavi et al., 2004; Jagadish et al., 2014). It is essential to make the results and conclusions generated from data

analysis understandable and interpretable for senior decision-makers. A major challenge exists in business corporations in understanding how innovations in analytics and database technology have evolved to allow SBD sources to be retrieved, aggregated, examined, and interpreted. The real power of SBD adoption has to do with the process of interpreting and gaining new insights from new, untapped data sources. Data visualization proves to be a significant challenge with data interpretation. Data visualization methods allow decision-makers to have easily understandable visuals, as the more complex the data becomes, the more difficult it is to offer easily interpretable information for decision-making. One respondent went into detail about the difficulties in the packaging of data and analysis in an understandable way.

> We talk about our mechanisms for data reporting on a regular basis… like an iceberg, all the data processing and data-driven analysis happens beneath the surface…upper management only cares about what is above the surface…we are always trying to find new ways to package our findings and recommendations in clear easily digestible ways.
>
> **Financial Sector**

To efficiently establish SBD decision-making practices, initiatives need to be directly linked to corporate strategy. There needs to be a level of understanding and synergy between the initiatives and the subsequent value that they provide to the organization. It was apparent that the most successful organizations had corporate buy-in for the collection of new SBD sources as well as any subsequent technologies that may be required. If support for an appropriate data environment was not coming from the top-down, it seemed less likely to gain any corporate traction. If an organization can prove that their team, or the organization at large, has a capacity to apply SBD analytics to solve essential business problems, corporate buy-in becomes more manageable. From a data perspective, organizations need to create value from in-house (internally collected) data before purchasing or collecting new data sources. With that said, some organizations cannot maximize the value of their in-house data sources because they lack adequate technologies required to do so. The organizations that are consistently successful at SBD initiatives are the ones that have created decision-making models that can leverage the benefits of the data and advanced analytics in a repeatable way. This allows for the streamlining of the decision-making process. The successful data-driven businesses can align the organization's strategies, the data systems, processing, and analysis in order to make better location decisions.

As businesses move towards demanding more SBD-driven decision-making, there is added pressure to leverage data into the decision-making process. Generating data-driven results to inform the strategies and processes for BLDM represents a major challenge. The interviewees identified that information hoarding, a lack of understanding from senior management on how technologies, methods, and data can be used for BLDM, and a lack of skilled data analysts who can manage and synthesize

the data be significant hurdles for SBD adoption. Businesses at the forefront of SBD analytics have dedicated time and money, including the hiring of new personnel with data science skill sets, in order to foster the development of new methodologies. With SBD and SBD analytics technologies being the most influential IT innovations in the last decade (Wang and Hajli, 2017), attention needs to be given to both the technical challenges and the organizational strategic views that could obstruct the advancement of SBD analytics. The findings presented in this chapter have suggested that the adoption of more formalized SBD practices is starting to impact BLDM, but there are many challenges to fully integrating SBD within BLDM. As a result, despite advancements in data availability, analytical methods, and technology, traditional techniques still hold an important place in BLDM, although the huge potential offered by SBD is increasingly challenging them.

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Coupling Agent-Based Modelling with Geographic Information Systems for Environmental Studies—A Review

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Introduction

The exponential growth of the population is leading to a progressively transforming world (Liu, Chang, Chen, Zhou, & Feng, 2017). The increasingly inhabited areas are subject to high levels of various forms of stress, namely economic, social and environmental pressures (Bickel, 2017), surpassing the carrying capacity of those locations, i.e. "the largest number of any given species (e.g. *Homo sapiens*) that a habitat (e.g. Earth) can support indefinitely" (Shaker, 2015). The relationship between our behaviour and the carrying capacity of Earth can be viewed through the Ecological Footprint tool, which represents the "human demand on the planet's ability to provide renewable resources and ecological services" (WWF, 2016). At present, we need a yearly amount of 1.6 Earths to deliver the demand for goods and services, meaning that, in a business-as-usual scenario, human demand on Earth's regenerative capacity is expected to grow steadily and overshoot this capacity by approximately 75% by 2020 (WWF, 2016).

This increasing pressure adds to the threat of climate change (CC) (Bickel, 2017; Victor et al., 2014). CC has been one of the leading issues focused on the worldwide environmental agenda. The definition of the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report, is "*a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the*

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variability of its properties, and that persists for an extended period, typically decades or longer" (Cubasch et al., 2013). Although large-scale natural phenomena—such as extreme weather events—have always existed and are an intricate part of Earths' processes, research shows that they are exacerbated by CC (De Sario, Katsouyanni, & Michelozzi, 2013; Mann, Lloyd, & Oreskes, 2017).

Global mobilisation has begun throughout the last decades, with the latest relevant meeting having occurred in Paris in 2015. Leaders of the entire world gathered to focus on CC. The resulting Paris Agreement (UNFCCC, 2015) aims to "*strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty*". One of the ways to attain this is by "*holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change*". However, the 2018 *IPCC Special Report: Global Warming of 1.5 °C* (IPCC, 2018) assesses new scientific data of the climate system, as well as the associated impacts on natural and human systems, by focusing on a global warming change of 1.5–2 °C above temperatures in the pre-industrial period. In general, findings showed that many of the assessed impacts of climate change in the report have significantly lower associated risks at 1.5 °C compared to 2 °C, meaning that maximum temperature increase should not surpass the 1.5 °C mark.

The scientific community has recognised the urgency in this matter. Over 15 000 scientists have issued a notice to humanity (Ripple et al., 2017), where caution has been urged about the unsustainable ways humanity continues to undertake, and that adaptation measures to CC are dire. By implementing decisions and actions, these measures mobilise the capacity to reduce risk and vulnerability; seek opportunities; and build the capacity of nations, regions, cities, the private sector, communities, individuals, and natural systems to cope with climate impacts (Noble et al., 2014). Because of the delayed reaction to CC, we will deal with the effects of past emissions for at least 50 years. It is, therefore, dire to put these measures into action (Kennedy, Cuddihy, & Engel-Yan, 2007).

Sustainability

Sustainability is seen as a synonym for everything good and desirable in society (Holden, Linnerud, & Banister, 2014). It is a core term used nowadays to relate to the way planning and development should be perceived. However, what does it truly imply? The term sustainability development became broadly known after The Brundtland Report (Brundtland, 1987), where it was defined as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". However, due to the increasing complexity of modern society, this definition is no longer satisfying. Recently, defining the concept of sustainability has proved challenging, where scholars are currently attempting to determine a concept for sustainability and sustainable development for the present era. Walker

(2017) examines its meaning and shows how different perspectives can be taken when analysing sustainable development. Holden et al. (2014) attempt to create a definition for sustainable development which encompasses the four primary dimensions mentioned in the Brundtland Report (safeguarding long-term ecological sustainability, satisfying basic human needs, and promoting intra- and intergenerational equity). Ramcilovic-Suominen & Pülzl (2018) analyse several concepts of sustainability and sustainable development and how they are (re)adopted and reformulated in the current EU bioeconomy policy debate. However, despite all the different points of view or definitions, what is generally agreed upon is that sustainable development relies on social, economic, environmental and governance factors (European Commission, 2015; Ramcilovic-Suominen & Pülzl, 2018).

Sustainability is now imperative in our society, involving environmental, social and operational management strategies. Protection and maintenance of the landscape's integrity is a social responsibility and a commitment to pass on our heritage to future generations (Vaz, Cabral, Caetano, Nijkamp, & Painho, 2012). Thus, scientists and politicians will be challenged to reduce negative impacts of humans on the environment, by simultaneously keeping safe the economic and social benefits derived from them (Amato, Maimone, Martellozzo, Nolè, & Murgante, 2016; Esteves, Vaz, & Alves, 2017). As suggested by Vaz (2016), spatial analysis and particularly regional decision-making can have a leading role in assessing these paradigms from a local and regional planning perspective (Esteves et al., 2017).

GIScience in Practice

Monitoring urban development to assure future sustainability is fundamental, where decision support requires spatial information to be able to forecast development trends (Panagopoulos, Duque, & Dan, 2016; Vaz, 2016; Vaz, Kourtit, Nijkamp, & Painho, 2015). Agent-based models, cellular automata and micro-simulation models may be used to aid territorial policy and planning, presenting as an opportunity for dialogue between model builders and stakeholders (Batty, 2012; Esteves et al., 2017).

Land-use plans are fundamentally spatial, so the spatial visualisation component of GIScience is determinant to support territorial planning and decision-making (Alves et al., 2014; Brown, 2006; Campos et al., 2017; González, Donnelly, Jones, Chrysoulakis, & Lopes, 2013; Li & Kwan, 2017; and Vaz, 2016). Socio-economic and environmental issues and impacts are considered simultaneously, so by integrating evaluation methods and tools in geographic information systems (GIS), we can use computational methods to juxtapose traditional quantitative thinking to decision-making (Vaz, 2016). Creating tailor-made decision-making tools is vital to analyse baseline information and systematically predict potential impacts. Multiple-scale, multi-period, multiple-objective and multiple-user needs may be equally satisfied (Chrysoulakis et al., 2013). Consequently, it is a powerful driving engine in the technical and socio-organisational implementation of integrated platforms for informed analysis (Brown, 2006; González et al., 2013).

Significant advantages in using GIScience in environmental studies include (Batty, 2011; Caputo, Pasetti, & Bonomi, 2016; Chrysoulakis et al., 2013; Li & Kwan, 2017; Yan, Xia, & Xiang, 2014):

- A geovisualisation aspect of GIS, with the use of tangible visual representations and human visual abilities to generate insights about geographic problems. The visualisation may be in 2D or even 3D, greatly enhancing our ability to comprehend complex issues and patterns;
- Fast correlation between acknowledging local particularities such as morphology, prevalent economic activity, history and tradition, recent significant modifications and features;
- Select weak areas or performance areas to better research their features and orient local policies;
- Easily accomplishing sensitivity analysis and simulation of scenarios, varying the benchmarks and levels of importance of the parameters considered by the model;
- GIS determined features such as radiative exchanges, surface carbon concentration, surface characteristics, surface turbulent sensible and latent heat fluxes, urban heat island and heat waves, precipitation and air quality aid the assessment of urban metabolism components;
- A wide variety and combination of tools and models can be used to accurately assess environmental issues, taking elements from different software packages and building these directly into models as needed, creating an abundance of possibilities when it comes to performing good representations and simulations;
- Depending on the analysis type, large-scale operational models may be used (e.g. with agent-based modelling) or, when necessary, finer-scale models to simulate movement patterns and change, particularly the local movement of individuals and specific changes in territorial development (e.g. cellular automata models).

Agent-Based Modelling

Agent-based modelling (ABM) application in GIScience has been gaining popularity in system analyses, where it is seen as a new age of simulations (Dragicevic, 2008). Its capability to replicate the processes and dynamics that occur within a geographical system (Heppenstall, Crooks, See, & Batty, 2012) is a desirable trait in such studies, where the system's complex, nonlinear behaviour is addressed (Jokar Arsanjani, Helbich, & de Noronha Vaz, 2013). In ABM, the system being analysed is modelled as a collection of autonomous, heterogeneous and active decision-making entities called agents, where each of these have diverse knowledge and abilities and can interact with one another and their environment, by individually assessing its situation and deciding an outcome based on a set of rules inputted into the system. The behaviour of the whole system results from the aggregated individual behaviour of each one of these agents (Ausloos, Dawid, & Merlone, 2015; Crooks, 2015).

Local understanding is therefore increased through bottom-up analyses, independent of all scales and constrictions (Crooks, Malleson, Manley, & Heppenstall, 2019; Heppenstall et al., 2012; Jokar Arsanjani et al., 2013). Contrary to reducing the system to the idea that the territory operates from the top-down where results are filtered to its individual components, ABM adopts a reassembly approach, leading to an individualistic bottom-up approach for planning the geographical form and creating public policy (Crooks, 2010, 2015).

ABM has been the resource to undertake many recent studies in several realms, such as in GIScience, ecological and social systems, social and human sciences, urban systems, or land-use systems and science (Dragicevic, 2008). There has been a longlasting development of ABM: from the emergence of theoretical and technological advances that lead to the invention of the computer, Thomas Schelling's 1971 use of a cellular automata model to define segregation patterns, to the evolution of autonomous agents that move freely from the restrictions of their cells, into present studies in, e.g. environmental modelling or the impact of policy in geographical areas (Heath, 2010). Heppenstall et al. (2012) and Crooks et al. (2019) mention a wide array of applications for ABM. The ability to link agents to geographical locations is crucial, as most everything is connected to a place, allowing modellers to ponder on how these agents or their aggregations are fluid in space and time (Crooks, 2015).

Methodology

A region's environmental behaviour can be understood by resorting to tailor-made information systems so that effective strategic methodologies for territorial coordination can be defined (Catalán, Saurí, & Serra, 2008; Hinkel et al., 2014; UN, 2007). Using GIScience to produce different scenarios is key to integrate local, urban or regional processes with ABM approaches, presenting itself as an innovative combination of factors in determining the sustainable development of an area.

The following questions triggered this review: how have ABM and GIS been combined in recent studies to determine environmental issues? Do these methodologies aid in sustainable planning for the region? Framed to no particular study area, it aims at highlighting some of the most used methodologies concerning the use of GIS technologies coupled with ABM.

Interest is given to the support these studies might provide to both researchers and policymakers. For researchers, it may provide insights into the assessment of the environmental, economic and social affairs, as well as development elements to measure environmental sustainability in different contexts. On the other hand, decision-makers may use the clear information produced by these models to propose greener protection policies that are more effective, so that the economic performance may be balanced with a sustainable performance (Piña & Martínez, 2016).

To collect research papers on the coupled use of ABM and GIS, the methodology in Fig. 1 was followed.

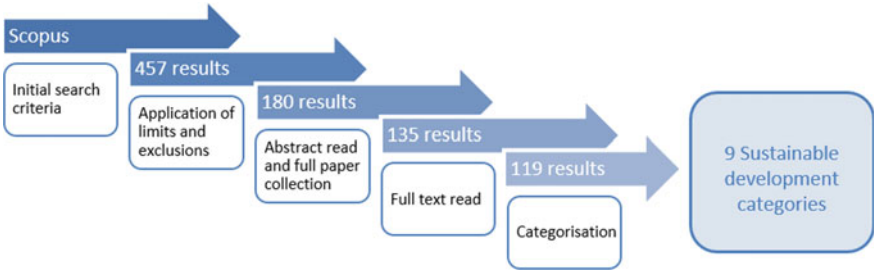

Fig. 1 Methodology for paper categorisation

Four initial web-based searches were made with the Scopus database, using the following criteria:

(1) (TITLE-ABS-KEY (agent-based AND modelling) AND TITLE-ABS-KEY (geographic AND information));
(2) (TITLE-ABS-KEY (abm) AND TITLE-ABS-KEY (gis));
(3) (TITLE-ABS-KEY (abm) AND TITLE-ABS-KEY (geographic AND information));
(4) (TITLE-ABS-KEY (agent-based AND modelling) AND TITLE-ABS-KEY (gis)).

These terms were searched within the article title, abstract and keywords of the papers. This search initially resulted in a total of 457 documents, where it intended to take account of the multidisciplinary and historical aspect of this domain area, to have a grasp on how they have been used throughout different subjects and time.

After collecting pertinent information, limits and exclusions were applied to the initial results, where the refinement of the search criteria was based on:

(1) (TITLE-ABS-KEY (agent-based AND modelling) AND TITLE-ABS-KEY (geographic AND information)) AND (EXCLUDE (SUBJAREA, "BUSI") OR EXCLUDE (SUBJAREA, "MEDI") OR EXCLUDE (SUBJAREA, "PHYS") OR EXCLUDE (SUBJAREA, "MATE") OR EXCLUDE (SUBJAREA, "BIOC") OR EXCLUDE (SUBJAREA, "ECON") OR EXCLUDE (SUBJAREA, "ARTS") OR EXCLUDE (SUBJAREA, "CENG") OR EXCLUDE (SUBJAREA, "DENT") OR EXCLUDE (SUBJAREA, "PHAR") OR EXCLUDE (SUBJAREA, "CHEM") OR EXCLUDE (SUBJAREA, "IMMU") OR EXCLUDE (SUBJAREA, "NURS") OR EXCLUDE (SUBJAREA, "PSYC") OR EXCLUDE (SUBJAREA, "VETE")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "ch") OR LIMIT-TO (DOCTYPE, "re") OR LIMIT-TO (DOCTYPE, "bk") OR LIMIT-TO (DOCTYPE, "ip")) AND (LIMIT-TO (LANGUAGE, "English"));
(2) (TITLE-ABS-KEY (abm) AND TITLE-ABS-KEY (gis)) AND (EXCLUDE (SUBJAREA, "PHYS") OR EXCLUDE (SUBJAREA, "BUSI") OR EXCLUDE (SUBJAREA, "MATE") OR EXCLUDE (SUBJAREA, "MEDI")

OR EXCLUDE (SUBJAREA, “CHEM”) OR EXCLUDE (SUBJAREA, “IMMU”) OR EXCLUDE (SUBJAREA, “BIOC”) OR EXCLUDE (SUBJAREA, “CENG”) OR EXCLUDE (SUBJAREA, “ECON”) OR EXCLUDE (SUBJAREA, “VETE”)) AND (LIMIT-TO (DOCTYPE, “ar”) OR LIMIT-TO (DOCTYPE, “ch”) OR LIMIT-TO (DOCTYPE, “re”) OR LIMIT-TO (DOCTYPE, “er”) OR LIMIT-TO (DOCTYPE, “ip”)) AND (LIMIT-TO (LANGUAGE, “English”));

(3) (TITLE-ABS-KEY (abm) AND TITLE-ABS-KEY (geographic AND information)) AND (EXCLUDE (SUBJAREA, “EART”) OR EXCLUDE (SUBJAREA, “PHYS”) OR EXCLUDE (SUBJAREA, “MATE”) OR EXCLUDE (SUBJAREA, “MEDI”) OR EXCLUDE (SUBJAREA, “BUSI”) OR EXCLUDE (SUBJAREA, “BIOC”) OR EXCLUDE (SUBJAREA, “CHEM”) OR EXCLUDE (SUBJAREA, “IMMU”) OR EXCLUDE (SUBJAREA, “ARTS”) OR EXCLUDE (SUBJAREA, “CENG”) OR EXCLUDE (SUBJAREA, “ECON”) OR EXCLUDE (SUBJAREA, “HEAL”) OR EXCLUDE (SUBJAREA, “PHAR”) OR EXCLUDE (SUBJAREA, “VETE”)) AND (LIMIT-TO (DOCTYPE, “ar”) OR LIMIT-TO (DOCTYPE, “ch”) OR LIMIT-TO (DOCTYPE, “ip”)) AND (LIMIT-TO (LANGUAGE, “English”));

(4) (TITLE-ABS-KEY (agent-based AND modelling) AND TITLE-ABS-KEY (gis)) AND (EXCLUDE (SUBJAREA, “BUSI”) OR EXCLUDE (SUBJAREA, “PHYS”) OR EXCLUDE (SUBJAREA, “MATE”) OR EXCLUDE (SUBJAREA, “MEDI”) OR EXCLUDE (SUBJAREA, “BIOC”) OR EXCLUDE (SUBJAREA, “ECON”) OR EXCLUDE (SUBJAREA, “ARTS”) OR EXCLUDE (SUBJAREA, “IMMU”) OR EXCLUDE (SUBJAREA, “CENG”) OR EXCLUDE (SUBJAREA, “CHEM”) OR EXCLUDE (SUBJAREA, “PHAR”)) AND (LIMIT-TO (DOCTYPE, “ar”) OR LIMIT-TO (DOCTYPE, “ch”) OR LIMIT-TO (DOCTYPE, “re”) OR LIMIT-TO (DOCTYPE, “bk”) OR LIMIT-TO (DOCTYPE, “er”) OR LIMIT-TO (DOCTYPE, “ip”)) AND (LIMIT-TO (LANGUAGE, “English”)).

This way, exclusions were applied to the study fields of veterinary, psychology, nursing, immunology and microbiology, chemistry, dentistry, pharmacology, toxicology and pharmaceutics, health professions, economics, econometrics and finance, chemical engineering, arts and humanities, biochemistry, genetics and molecular biology, business, management and accounting, medicine, materials science, physics and astronomy. Conference papers and conference reviews were also discarded from the initial selection.

The search was this way limited to the fields of computer science, engineering, social sciences, mathematics, environmental sciences, agricultural and biological sciences, earth and planetary sciences, energy, decision sciences, multidisciplinary, and undefined. Articles, reviews, book chapters, articles in press, books, and errata that were written in the English language were otherwise considered.

A total of 180 papers were found from this secondary search. The abstracts were read, and only the ones related to the environment were selected. The criteria used was to choose the ones that mentioned subjects in natural resource management,

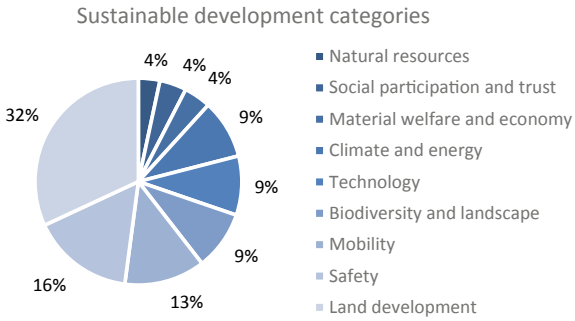

Fig. 2 Amount of studies per sustainable development category

conservation and biodiversity, environmental assessment, sustainable development, environmental health, wildlife management, sustainable building, water resources, land systems, policy and law, climate change, quality of life, energy and renewables. Besides framing the subject area to the environment, a further selection was made upon reading the abstracts, where studies from the same authors and study area were discarded, having retained only the most recent one. Other rejected results were the ones where we were unable to obtain the full text. This new selection yielded a total of 135 results.

Full-text reading was initiated at this phase, and another 16 papers were discarded due to further analysis revealing them not being pertinent to this review. A final tally of 119 results was obtained, for studies ranging from 1998 to 2019.

A final table was created, where the final results are analysed and distributed between nine sustainable development categories: natural resources, social participation and trust, material welfare and economy, climate and energy, technology, biodiversity and landscape, mobility, safety and land development (Fig. 2).

Results and Discussion

In this review, an effort has been made to scrutinise the results above to demonstrate the wide variety of fields that the coupling of ABM and GIS can encompass. An array of information has been collected, relating to all sorts of study fields, where predominant keywords are listed in Table 1. 65 of the articles were published in repeated publications (Table 2).

As previously mentioned, from the articles that were analysed, ABM coupled with GIS technologies were used to determine land-use development 38 times, 19 for safety, 15 for mobility, 11 for biodiversity and landscape, 11 for technology, 11 for climate and energy, 5 for material welfare and economy, 5 for social participation and trust and 4 for natural resources (Fig. 2).

ABM and GIS have been used for complex system analysis and simulation for quite some time. A result from 1996 was listed but was immediately disregarded, once the ABM keyword that was found related to something else than agent-based

Table 1 Ten most repeated keywords from selected papers

Keyword	Count
Agent-based models	88
GIS	50
LUCC	25
Cellular automata	9
Complex systems	6
Simulation	6
Decision support system	5
Geosimulation	5
Simulation model	4
Complexity	3

Table 2 Repeated publications in different journals

Journal	Articles
International Journal of Geographical Information Science	15
Computers, Environment and Urban Systems	7
Transactions in GIS	6
Journal of Geographical Systems	5
Ecological Modelling	4
Environment and Planning B: Planning and Design	4
Journal of Environmental Management	3
JASSS	3
Environmental Modelling and Software	2
Natural Hazards	2
Waste Management	2
Environmental Modelling and Software	2
Simulation Modelling Practice and Theory	2
Understanding Complex Systems	2
Geocarto International	2
ISPRS International Journal of Geo-Information	2
Understanding Complex Systems	2

modelling. So, from the initial search, one realises that steps have been taken to further these studies at least since 1997, where the 1997 International Conference on Spatial Information Theory (COSIT 1997) had started to analyse the issue at hand (Hirtle & Frank, 1997). It was only until 2004 and 2005 that scientific production increased drastically for this subject area, where up until then, there was a scarce work yield. Looking at the final correspondent selection, 2009 was the year that environmental studies linked to the coupled use of ABM with GIS had a more profuse

Table 3 Amount of coupled ABM and GIS results per year for the initial search and the final paper selection and percentage of the final selection in relation to the initial search

Year	Initial search	Final selection	%
1996	1	0	0
1997	1	0	0
1998	3	1	33
1999	0	0	0
2000	2	1	50
2001	2	1	50
2002	3	1	50
2003	6	3	50
2004	9	1	11
2005	14	2	14
2006	16	1	6
2007	17	4	24
2008	26	4	15
2009	40	11	28
2010	24	8	33
2011	25	6	24
2012	26	7	27
2013	50	12	24
2014	39	8	21
2015	41	11	27
2016	34	9	26
2017	34	7	21
2018	32	16	50
February 2019	12	5	42
Total	457	119	26%

production. By analysing Table 3, one can see that the percentage of environmental studies concerning the total amount of papers from the initial search is continuously varying, although, in the last two years, it corresponds to roughly half the production.

In respect to the coupling of these technologies, some general remarks can be made before diving into each of the sustainable development category analysis. Overall, these ABM and GIS were not used alone, where they were also combined with other types of tools, such as mathematical or computational ones, depending on the subject being analysed. Game theory was an interesting take used in three studies, where agents were programmed to find the best strategy to improve results.

Another general characteristic is the multitude of subjects that are analysed in the 119 final paper selection. Even within the same subject area (e.g., land use), studies vary widely and are frequently applied in different manners, even though the basic tools that are used are the same. Study areas are also wide-ranged, covering sites

from all over the world, for both developed and undeveloped countries. By analysing the scale application of the models, it can also go from the local to the regional scale.

In terms of aid in policymaking, it is a significant aspect for most studies, once each of the created models intends to learn how to contribute to the solution of a specific issue. By allowing to better understand the problem at hand, in most cases, scenario simulation is possible, and through result analysis, key management options can be adopted, focusing resources to the best possible solution. This possibility to create different scenarios speaks to the flexibility of these tools, where some of the models saw suited application to various subjects or study areas, presenting as a significant advantage. In terms of limitations, many of the models mentioned the oversimplification of input data, where it is considered a necessary evil to better interpret results. However, these results may also leave out critical aspects of the analysis, revealing to be a delicate task finding a balance between too little and too much information.

Another limitation was the lack of a suitable benchmark for the studies, rendering them unable to be evaluated (Grimm et al., 2010). Being a relatively recent technology, and considering the wide range of application, there is still no standard format for documenting and communicating ABMs, and validation of the methodology and respective results remains diverse throughout the studies, where no standard validation or verification method exists for these models. Therefore, there is limited replicability, an undesired trait for a scientific tool. Grimm et al. (2010) have attempted to overcome these limitations by creating his overview, design concepts and details (ODD) protocol, by which ABMs can be documented through a basic format and a standard structure. This protocol will enable the reader to better understand the model descriptions, once they are written in a more complete and efficient fashion. Replication can be enhanced, and the ABM can, therefore, be considered as a more robust scientific tool (Grimm et al., 2010). Müller et al. (2013) have recently extended this protocol to the ODD+D, incorporating options to describe human decision-making.

In terms of software, several packages were mentioned, being the most frequent ones NetLogo, GAMA, ArcGIS and Repast. It is worth mentioning that different types of software were frequently used together in the same methodology, taking advantage of the most robust features of each one.

Many of the studies considered future work on their models, meaning that the limitations were recognised and continuous enhancement of the studied model was deemed necessary.

For the analysis in the following sub-sections, only literature from 2015 to February 2019 was considered, once the aim is to analyse the most recent work available in the field of ABM and GIS. All studies have a spatial component to them, where those that did not have one were immediately discarded. The analysis will be based on the number of papers that exist for each category, for the most significant amount of analysed papers (land development), to the smallest (natural resources). In respect to the analysis of the studies within each sub-section, no particular order was followed.

Land Development

Urban growth, urban redevelopment, urban transformation and urban planning were four of the keywords used in studies that, in one way or another, proceeded to analyse land use/cover change (LUCC) to find solutions for an environmentally related issue. Many of these studies were centred on LUCC, and how to sustainably do so in order to minimise negative impacts.

Tan, Liu, Zhou, Jiao, and Tang (2015) and Ahlqvist, Khodke, and Ramnath (2018) use game theory in their models, albeit not entirely in the same manner. The first authors use the mathematical method of game theory to quantitatively analyse the agents' behaviours, how their decisions are interrelated, and how they determine land-use change. On the other hand, Ahlqvist, Khodke, and Ramnath (2018) use a multiplayer online game to create a simulation environment that can engage actual real human stakeholders in a role-playing game, where they can generate empirical data to calibrate agent attributes and behaviours. Although the study is primarily an educational tool to convey the key aspects of the Green Revolution in developing countries, these authors find that replacing coded agents with real individuals can identify emergent behaviours typically expected from complex systems.

QuanLi, Kun, GuiLin, and YuLian (2015) use a different approach, combining an ant colony optimisation artificial intelligence algorithm with ABM to analyse non-point urban and agricultural water pollution from LUCC. This algorithm allows simplifying rule construction for agents, which leads to enhanced simulation accuracy. Though innovative, they, however, find that the ant colony optimisation algorithm is not well suited for all land-use types.

For the rest of the studies, they are, in general, a straightforward analysis of LUCC by using ABM and GIS. Barau and Qureshi (2015) analyse investment-driven land fragmentation (patterns and characteristics) and its ecological implications; Giełda-Pinas, Dzieszko, Zwoliński, and Ligmann-Zielińska (2015) assess ecological management practices and land-use change impacts when managing Lakeland landscapes; Li, Oyana, and Mukwaya (2016) study the LUCC at a national scale in Uganda; Cantergiani and Gomez Delgado (2016) study urban growth by including social and economic factors into the model; and Alghais and Pullar (2018) model future land-use patterns through population estimates and planning policies.

As for aid in policymaking, all studies revealed themselves as essential tools for decision-making. Stakeholders can use the simulation or scenario results to see how real-world human action influences the territory, providing information on how specific environmental, economic and/or social characteristics may be affected, which can allow them to develop sustainable planning and policy options.

Safety

Although not directly associated with the environment, safety issues were also considered in this analysis. CC contributes to extreme natural events to which populations need to cope with. Safety strategies can be developed by using ABM and GIS, being considered as important resources to, e.g. quickly allocate relief teams or simulate evacuation strategies. These studies also analysed other pertinent questions, such as risk analysis related to insurance payouts or even focussing on the disaster recovery processes.

Torrens (2015) and Hooshangi and Alesheikh (2018) address the earthquake response issue, although with a slightly different approach. Torrens (2015) intends to evaluate how human populations respond to the built environment in an earthquake event, by unifying process modelling, GIS and the virtual representation of the world. The second authors created a simulation model in post-earthquake urban search and rescue operations, designing it flexible enough to adapt to the environment and consider incompatible time-spatial and behavioural complexities. For both cases, no validation of the model is possible because there is no ground truth data of their study area, although Hooshangi and Alesheikh (2018) did do an uncertainty analysis. As for assisting in policymaking, Torrens (2015) gives a better representation of the world through the use of 3D mesh modelling and GIS, while Hooshangi and Alesheikh (2018) can provide such an analysis that timely and accurate decisions can be made in an earthquake crisis. Although not directed solely to earthquake occurrences, Na and Banerjee (2019) model evacuation of no-notice natural disasters with the use of agent-based discrete-event simulation, where they apply it to a large-scale earthquake evacuation. With this, they intend to contemplate scenarios with multiple types of evacuees and evacuation vehicles to improve evacuation strategy in a no-notice natural disaster. Like the previous authors, Lichter, Grinberger, and Felsenstein (2015) create a model with web-mapping services, ABM and GIS to generate and divulge outcomes in disaster management to a broader audience. The aim is to use a network community-based approach to use the internet as a facilitator so that stakeholders can improve access to information to enhance resilience to shocks. They considered two working scenarios: an earthquake event and a missile attack.

Widener, Horner, and Ma (2015) and Yang, Mao, and Metcalf (2019) analyse response and evacuation for hurricane events, respectively. While the first seek optimal locations for relief teams during simulation hurricane events, the latter simulates the hurricane evacuation process by using an empirically grounded model that can be adapted to other coastal areas. Therefore, the study made by Widener et al. (2015) can aid decision-makers to understand the potential of relief teams to encourage non-evacuees to move to a nearby shelter, while Yang et al. (2019) can help design more reliable future hurricane evacuation plans in the Florida Keys.

On the other hand, Eid and El-adaway (2017) study disaster recovery processes, representing recovery dynamics on the impacted community based on the decision-making processes, interactions and learning behaviours. Although their study area

was subject to hurricane events, the authors intend to test their model on other problem domains. The main advantage to decision-making upon disaster recovery is that it may increase the communities' welfare by better guiding the redevelopment processes so that balanced short-term redevelopment goals and long-term social vulnerability reduction goals are met.

Floods are also a study subject in three of the selected papers. Liu and Lim (2016) examine flood evacuation planning, where their ABM and GIS models provide escape instructions for vulnerable households located within a 15 km service area and proposes locations for new shelters. Dressler, Müller, Frank, and Kuhlicke (2016) study the performance of disaster management and understand how it is affected by change, while Dubbelboer, Nikolic, Jenkins, and Hall (2017) analyse changes in flood risk and the role of insurance in this dynamic. In general, all three studies mention the oversimplification of the input data, and how more complex data may forego result comprehensibility and transparency. As for aid in policymaking, Liu and Lim (2016) state that it may help stakeholders understand the big picture of large-scale evacuation and provide a feasible and organised way to manage the evacuation situation. Dressler et al. (2016) create a virtual lab that rapidly implements new ideas and tests hypotheses to obtain a better mechanistic understanding of the system behaviour, while Dubbelboer et al.'s model (2017) helps assess public–private partnerships and understand how socio-economic development can affect levels of surface water flood risk.

Although it may provoke some flood-like situations, a different study for tsunami events was made by Makinoshima, Imamura, and Abe (2018). The authors study tsunami evacuation by using real-time evacuation data into the simulation so that they can forecast congested areas during the disasters and rapidly estimate an evacuee population distribution at each evacuation site. Although no car agents are considered in the simulation, it is of great importance in decision-making once it allows the evaluation of evacuee congestion both in buildings and bottlenecks in the city.

Wirth and Szabó (2018) and Macatulad and Blanco (2018) simulate building evacuation. These local scaled studies use ABM and GIS (although Macatulad and Blanco (2018) use 3D-GIS features for model input) to determine evacuation times for their study area as well as panic rate in agents, where, in each study, panic was measured differently. Aid for decision-making may come in the form of a better understanding of how to address public safety issues, in terms of architectural and design aspects, and proper determination of the evacuation protocol and regulations of space. An adequate measure of the effects panic can have in the egress of building occupants may also be determined.

Bandyopadhyay and Singh (2018) study urban fire emergency response plans, which can support in establishing different theories and observe and ascertain exceptional patterns, that is, to detect where attribute variations help determine the micro-deficiency in urban infrastructure related to urban emergency planning.

Mobility

In terms of mobility, it is integrated into this review due to climate change issues. Considering that the more mobility issues are sustainable, a favourable effect should be verified in what refers to air pollution and emissions.

Three studies were found that analyse waste management and the optimal path to collect and manage these residues. Nguyen-Trong, Nguyen-Thi-Ngoc, Nguyen-Ngoc, and Dinh-Thi-Hai (2017) examine municipal solid waste management, where the use of GIS analysis, equation-based model and ABM will allow simulations to optimise the strategy for collection and transportation of municipal solid waste to improve the current collection system. Elia, Gnoni, and Tornese (2018) use a hybrid simulation model of system dynamics, ABM, GIS and discrete events simulation to analyse dynamic collection schemes for Waste from Electric and Electronic Equipment (WEEE). The considered advantage is that, unlike fixed services, a dynamic collection can allow for control of management costs and reduction of the intensive use of vehicles due to the flexibility of the service. This way, environmental performance can be enhanced when designing adequate WEEE collection schemes. The third study was made by Kim, Kim, and Kiniry (2018), who intend to pinpoint optimal locations for biomass storage facilities. With this simulation, some of the main biorefinery concerns may be resolved, such as a steady supply of material, uniform feedstock properties, stable feedstock costs and low transportation costs. This study will allow an experimental performance analysis of approaches to the sharing of shortest path information in a large-scale transportation scenario.

Analogous studies as the previous were made, but instead of dealing with waste management, Démare, Bertelle, Dutot, and Lévêque (2017) and Kin, Ambra, Verlinde, and Macharis (2018) analyse goods distribution and their respective logistics. The first authors use ABM, GIS and graph theory to create a behavioural model of a logistic system to describe flows throughout the Seine axis (France), enabling stakeholders to understand at a multi-scale level how the logistic system works and how the actors dynamically structure and organise the flows within a territory with decentralised decisions. Kin et al. (2018) tackle last-mile deliveries, creating a synchronisation model for the Belgian inland transport system that simulates modal choice alternatives. The resulting model may test new ideas in a risk-free environment so that they may assess what-if scenarios prior to implementation. Tucnik, Nachazel, Cech, and Bures (2018) use ABM, GIS and pathfinding algorithms in a large-scale setting to analyse the experimental performance of approaches to the sharing of shortest path information.

Other studies use traffic simulation to evaluate transport networks (Bonhomme, Mathieu, & Picault, 2016), quality of life (Makarov & Okrepilov, 2016), transport network expansion (Jacobs-Crisioni & Koopmans, 2016) and dynamic transport systems (Lu & Hsu, 2017). In general, these studies aid decision-makers in enhancing and enabling better decisions when intervening in transport systems.

Biodiversity and Landscape

Biodiversity and landscape issues included in this review encompass studies related to the dispersion of species throughout the environment, either through a negative (invasive species) or positive (species protection) view.

Anderson and Dragićević (2018) study the dispersion of an invasive insect infestation with a dynamic spatial network so that stakeholders can better understand, measure and analyse the influence that geographic space and network structure have on network dynamics so that in an ecological management perspective, the characterisation of dispersal patterns may be particularly useful. On the other hand, Gray et al. (2017) study the effects on biodiversity in bushmeat hunting by using a 4P (purpose, processes, partnerships and products) framework for participatory modelling so that the issue of bushmeat hunting sustainability may be turned into a matter of common concern at a sub-regional scale and to stimulate villagers to engage in community-based hunting management. Three studies analyse species distribution, where Heinänen et al. (2018) use hydrodynamic modelling to model and simulate realistic distributions, movements and migration of the Atlantic mackerel so that movements present in nature can be reproduced to better understand species characteristics. This model may also be applied to other species and pressures. Similarly, Carpenter-Kling et al. (2019) simulate the at-sea movement and distribution of a land-breeding marine predator to understand their foraging ecology and life-history traits, allowing for high-resolution information about location and foraging behaviour of wild animals. Scott, Middleton, and Bodine (2019) simulate population dynamics of the Santa Cruz Island fox and to determine the average number of years that the fox population can exist before going extinct in the absence of conservation efforts.

Technology

This section exists to consider studies that have no actual study area or application subject, only defining technical issues for ABM, which was something that we thought could not be ignored at this time.

For that, de Sousa and da Silva (2016) intend to create a spatial simulation in the context of GIS for non-programmers by creating a domain specific language for spatial simulation scenarios (DSL3S). This language facilitates communication between programmers and analysts and other stakeholders lacking programming skills, and GIS analysts may be able to focus their work on the actual modelling and ignore issues that are specific to programming, data input or platform dependencies. Vahidnia, Alesheikh, and Alavipanah (2015) create a model to simulate a system for moving reasoner agents by combining a multi-agent system with GIS, logical deduction and qualitative reasoning. The designed framework can potentially be applied for task-oriented problems such as vehicle motion planning, disaster management and military scenarios. Lastly, Gallagher, Richardson, Ventura, and Eddy

(2018) use R to generate synthetic population ecosystems of the world (SPEW) that may be applied to any type of agent and environment or location due to the flexible data input, enhanced user control in both data input and sampling methodology and automatically generated summary reports for each region.

Climate and Energy

CC is an important issue in discussion worldwide. As mentioned, temperature rise must be drastically controlled to warrant conditions for future generations of all species worldwide. This category considers studies that relate directly to the production or management of energy and the creation of infrastructures to encourage non-motorised transportation.

Robinson and Rai (2015) and Lee and Hong (2019) analyse the adoption of renewable energy (solar photovoltaic) for a given area, where the first use empirical information, ABM and GIS to do so, while the latter use ABM, GIS and logistic regression. These studies may help to successfully predict solar technology adoption so that policy and incentive structures may be adequately designed, and the electricity generation strategy planned and managed accordingly.

Imran, Schröder, and Munir (2017) determine suitable locations for the installation of a biogas power plant so that its operation can run smoothly and economically. Aziz et al. (2017) study the development and expansion of walk–bike infrastructure in cities so that the impact of infrastructure expansion in terms of the number of people using the expanded walk–bike facilities can be assessed beforehand.

Material Welfare and Economy

In what respects to the material and welfare section, it comprehends studies that determine economic characteristics of the territory, whether by studying individual economic behaviours or by identifying how the level of management of interconnected infrastructures may bring economic gains.

Filatova (2015) created a Risks and Hedonics assessment in Empirical Agent-based land market model (RHEA LMM) to explore the land market's performance under various microeconomic behaviours of individual agents. This model will aid decision-making in understanding the aggregate patterns and economic indices that outcome from the many individual interactions of the economic agents. By doing so, decision-makers are then able to explore the extent of changes in the economic system, so that they may be able to, e.g., respond adequately and timely to adverse consequences of climate change, as well as determine the impact of adaptation policies.

Bhamidipati, van der Lei, and Herder (2016) combine multi-sector infrastructures (pavements, sewer pipes, electricity sub-stations, bridges, etc.) to understand

the implications of their interconnectedness to define the optimal level of asset management. This will allow stakeholders to design and realign infrastructure systems to cope with the consequences of, e.g. CC. By being aware of the vulnerabilities of their infrastructures and the ones that are interconnected, stakeholders can collaborate with other asset managers to repair their assets.

Social Participation and Trust

This section focuses on studies that are directly related to the individual, which studies their level of involvement and where they may make a significant difference through their actions.

The location of creative industries, that is, industries that are mainly concerned with the generation or exploitation of knowledge and information, may shape a given territory in a significant way. This is the focus of Liu, Silva, and Wang (2016), where they explore the dynamics of the interactions between creative industries' development and urban land use. With their work, the authors can determine the potential that creative industries have for urban regeneration, innovation and sustainable development. By understanding location preferences for these industries, their influence on the urban landform may be understood to help formulate customised plans and policies.

In terms of green infrastructure, Zidar et al. (2017) compare different green infrastructure implementation strategies by individuals to aid in designing financial instruments for private property owners, as well as determining physical and financial barriers to program delivery.

Natural Resources

The natural resources section is considered for the inclusion of studies that revolve around issues such as ecosystem recovery, water management, sustainable tourism practices and natural resource allocation. Although four papers were selected for this review, none are later than 2015 (the most recent one is from 2012), so an in-depth analysis will not be made at this time for this section.

Conclusions

The increasing rate of population growth has had a gradual negative impact on many systems on earth. Issues in this respect are greatly discussed, where the realisation has dawned that, whether in developed or under-developed countries, issues such as

poverty, inequality, climate, environmental degradation, prosperity, peace and justice should be treated as a whole, so that a better, sustainable future can be an achievable solution for all mankind.

Studying sustainability is not an easy task. It usually comprehends extremely complex issues, with many variables and relationships between them that are hard to uncover. The use of suitable tools to aid in these complex issues is key to a proper analysis of the problem at hand. The famous quote "modelling for insights, not numbers" comes to mind (Huntington, Weyant, & Sweeney, 1982), where the potential of allying ABM to GIS is vast, and the complex interactions may be modelled to show spatial inequalities that are determined by economic, geographical, institutional and social factors (Esteves et al., 2017). Support in planning decisions is also an important aspect, where visualisation enhancement comes from taking alphanumeric data, flows, and processes and transforming them into a visual aid, geographically pinpointing the cause/effect of a given occurrence (Campagna, 2006).

As previously analysed, the selected papers have shown that there is a wide range of applicability for the use of ABM and GIS. Whether with just the use of these two technologies or by complementing them with other techniques, algorithms or theories, many issues related to environmental sustainability may be addressed. Even within different sustainability categories, studies with similar subject matter and aims may end up presenting diverse results. By realising the problem, researchers may create tools and models to address those issues so that they may solve them or aid stakeholders in perceiving the best solution possible, given the reality that is presented.

For the studied papers, in many of them a general remark was that the more complex the model is, the less transparent it becomes, reflecting in the ability to understand the achieved results. The challenges for creating an ABM are varied: ontological and epistemological issues, conceptual design, model implementation, etc. (Dragicevic, 2008). Therefore, a delicate balance between input information and model development should be taken to heart in order to minimise these limitations. Additional setbacks are related to validation issues and a lack of a suitable study benchmark to compare studies.

Despite these restrictions, we have had the opportunity to learn a great deal with the studies included in this review. They present themselves as valuable steps into the vast potential of the coupled use of ABM and GIS. We are still in the early stages, but the future seems promising.

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