Smart City: The Importance of Innovation and Planning

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Abstract. Smart Cities are in particular focusing on the implementation of new technologies with the purpose to tackle urban challenges like climate change, urban competitiveness and other problems of sustainable development. During the last years the ways of collecting data, of computing and using big data and of communicating evidence had been improved significantly. Smart Cities show a wide range of new technical facilities and services which are the outcome of specific concepts of innovation and urban planning approaches.

With respect to urban transformation processes coping with mentioned challenges, technical innovations are important. They enable the realization of energy efficiency, reduction of energy use or mitigation of emissions. At the same time technically-driven transformation processes in mobility conditions and communication are supporting the attractivity of cities. Smart cities very often claim to provide a 'better life' and sustainable development. In front of these developments it becomes obvious that technical innovations play a crucial role but at the same time we can assume a mutual relation with specific approaches of urban planning beyond such transformation processes.

The main objective of this contribution is to elaborate these different concepts of innovation and the corresponding role of urban planning. Based on a short description of the technical core of a Smart City which enables a more comprehensive data collecting, a more precise analysis of bigger and better integrated data sets and a faster communication, three different forms of innovation and their mutual relation with planning approaches are elaborated. Doing so, special attention is given to the basic understanding what is a city, who are the crucial actors, and which role do planning approaches have. Finally, it is shown that the concept of 'open innovation' can be used in a technical and in particular in a predominantly socially integrative way through the enforced co-creation of 'urban innovation'. The corresponding planning tool for its identification, conceptualization and implementation is the concept of an 'urban Living Lab' which enables and supports a smart and evidence-based understanding of urban planning.

Keywords: Smart City · Innovation · Triple and quadruple helix · Urban Living Labs

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1 Introduction

Cities are facing different challenges like growth, competition between cities or climate change. Related to these challenges, the most crucial question is how to meet problems of sustainable urban development and to enable corresponding urban transformation processes increasing their respective resilience. In particular, Smart Cities with their main focus on implementing new technologies are expected to foster a better quality of life and to strengthen sustainable urban development. [1] Generally, the introduction of new technologies into the urban fabric is not new [2], but in particular the progress of information and communication technology (ICT) provoked the idea of the 'Smart City' considering specific technical qualities and different relevant components. Since some years this issue is discussed intensively based on former concepts like the 'information city', 'wired city' or similar labels. [3] Along with this discussion of the Smart City understanding, city-specific concepts with special focus have been implemented, realized or even changed; for instance, in Barcelona, Amsterdam, Vienna, Tallinn, Graz and many others.

Specific requirements of transformation processes are provoking a wide range of technical innovations. Komninos, Kakderi,, Panori and Tsarchopoulos [4] showed the evolutionary character of technical innovations and identified several innovation circuits having an impact on urban development conditions. Considering these new technologies, planners and urban researchers successively emphasized and demonstrated the new possibilities and options for planning. For instance, Balducci [5] underpinned the new possibilities of participatory metropolitan planning; Batty et al. [6] elaborated in a comprehensive perspective the role of new data and the importance of better ICT-technologies for measuring, calculating and simulating in urban planning. Very obviously, the new technical conditions offer new options for specific planning approaches. Accordingly, in this contribution the main objective is to demonstrate that certain planning approaches come along with technical innovations as they are mutually enabling each other. Facing this development, it is finally concluded that the character and the quality of technical innovations is changing towards a new form of 'urban innovation' which comes along with an increasingly place-based understanding of integrative planning enforcing the concept of 'open innovation'. [7]

Hence, the basic objective in this contribution is to show the interrelation of specific concepts of innovations with planning approaches and corresponding understandings of Smart City development. These different interrelations are elaborated by answering following questions: What is the core of the Smart City discussion? Which concepts of innovation can be distinguished? How do planning approaches support respective concepts of innovation? From a planning point of view the question is dealt with which actors are involved predominantly? Specific attention is finally given the quadruple helix understanding discussing the city as a complex system which asks for 'open innovation' and demands for new forms of planning approaches.

In Sect. 2 the complexity of urban challenges is elaborated. In Sect. 3, on the background of the Smart City discussion specific concepts of innovation are decribed in combination with distinct planning approaches – with a special focus on the quadruple helix model as base for open innovation and related planning tools. Section 4 is concentrating on specific features of urban Living Labs and discusses corresponding options for their implementation using more or less new technology. Section 5 concludes with some requirements of integrative planning supporting adaptive capacity as pre-condition of resilient urban development.

2 Challenges of Urban Transformation Processes

Regarding climate change, the increase of CO2-emissions is identified as one of the driving factors of global warming. This increase of CO2-emissions is caused through anthropogenic activities starting in the period of industrialization. Until now, human activities are estimated to have an impact of appr. 1,0° [8, p.6] Due to the evidence of higher climate-related risks, IPCC proposes in particular the limitation of CO2-emissions effecting an increase of temperature by not more than 1,5° latest until 2052. This evidence led to the definition of the 17 SDGs which are defined in the 2030 Agenda for Sustainable Development. [9] Even though most countries committed themselves mitigating their emissions, total emission of CO2 is still growing.

In this climate change contexts, the increase of urbanization becomes very important. On the global level the urbanization process is very strong: since appr. 2008 more than 50% of world population lives in urban agglomerations and it is an on-going trend. However, the degree of urbanization will increase during next decades differently [10]: since some decades these trends are very strong in China or some countries in Africa and Southeast Asia. Countries in Europe, Latin America or North America already show a high degree of urbanization, but reduced increase goes on at a high level within next decades. According to estimations of UN, in well-developed countries of OECD the urbanization degree will increase from 78% in 2015 to appr. 85% in 2050; in less developed countries the degree increases from 49% to 63% in the same period. Both trends indicate the need of transformation of the mechanism of the 'urban fabric' and as a follow-up the 'production of places' regulating growth and enforcing mitigation and adaptation strategies.

Besides, cities are experiencing strong changes for urban development through globalization and economic integration processes. Since some decades technological progress in transportation technologies and ICT as well as the decrease of national barriers through politically induced integration processes the meaning of certain components of territorial capital lost in importance on the national level but increased on the urban and city level. Thus, ICT and transportation infrastructure as well as cooperative and strategic planning approaches have become important to make cities more competitive and more attractive than others. [11, 12] Therefore, cities are increasingly challenged to identify, assess, activate and use their potentials aiming at the goals of competitiveness and attractivity. But these goals are strongly conflicting with goals and interventions aiming to strengthen sustainable and inclusive urban development. [13] Approaches of strategic planning enforcing cooperation between different stakeholders and aiming at mitigation and adaptation, have become crucial.

3 Innovation and Planning: A Mutual Relationship

Cities intend to enforce transformation processes through policies triggering the reduction of emissions, increasing energy efficiency or adapting to climate change and at the same time strengthening a city's competitiveness in the European or even global context. [1, 14, 15] Smart City initiatives come up and enforce the implementation and use of new technologies in order to cope with urban growth, a better life in a more efficient or even sustainable way. Several publications are demonstrating that the Smart City development changed its character in terms of goals and instruments and in particular of the implementation of technology. [3, 4, 16–18] In this contribution in a next step it is discussed how the concept of innovation and certain planning approaches evolved in a mutually influencing way.

Innovations in Smart City

Progress of ICT and in particular the change of web technology from 1.0 towards 2.0 supported the idea of the Smart City built on new technical facilities for a more effective steering of urban development. [19, 20] These new technologies provide increasingly more powerful and differentiated possibilities

– to collect information about recent trends and provide evidence in recent urban situations and to integrate information from different sources;
– to compute (big) data in three different ways: to create situational awareness in a descriptive way, to optimize real-time-decisions in a prescriptive way and to provide analytical results in a predictive way; and
– to communicate evidence, partly in real-time.

In front of changing possibilities of data production and collection, computation and analysis of integrated big data sets from different sources (including social media) and communication, now it is elaborated which concept of innovation is applied in interplay with certain planning approaches.

In general, urban development and technological progress always triggered cities as 'places of innovation' – in a technical and social way. [21, 22] Already 40 years ago Nelson and Winter [23] stated that innovation is a purposive but inherently stochastic activity which underlies selective mechanism driving urban competitiveness but also change and growth. In these contexts, innovations are therefore regarded as result of the complex urban system which is challenged permanently over time. Lambooy [24] already stated that cities or urban agglomerations offer effective contexts for evolving innovations meeting respective challenges through its cognitive and organizational competences.

On that background, Komninos et al. [4] argue that in the meantime three different 'innovation circuits' (IC) approached asking for and enabling a specific form of planning: IC1 is characterized by the creation of the digital space. "The overall smart urban system is made of heterogenous and uncoordinated initiatives by the public administration, global social media companies, national telecom companies, IT developers, e-service providers, and users; each actor adding some digital component to a common pool of resources, and each one offering new modes of user engagement, participation, and empowerment.". [4, p.4] Besides, these authors distinguish between the IC2 and IC3. IC2 provides more informed decision-making for different stakeholders of a city driving its development. IC3 finally, "guides the use of urban space and infrastructure through intelligent systems …", [4, p.4] In a Smart City all three Innovation Circuits ICs are existing at the same time and allow for the authors a smart planning which is based on these technical innovations.

Accepting that innovations do not only have a technical or social character [2, 25], it should be acknowledged that cities have certain competences for learning, assessing and also governing urban systems. This means that the design of the 'urban fabric' and the respective production of 'urban space' is not only outcome of the technical innovation but interlinked with further components which are responsible for transformation processes through the introduction of 'urban innovations'. Thus, innovations are not only differentiated by its technical or social characteristics, but also through its feature of being a 'product- and process innovation' or a 'systemic innovation' which is based on the general implementation of the first one. They are called innovation of first and second order. Suitner, et al. [26, p.10] based on Fagerberg's argumentation [2] underpin following important components for the production and introduction of innovations in general: cognitive-intellectual and physical-economic resources in order to implement planning strategies; creative and technical facilities and competences for the adaptation and design of planning processes; cognitive and analytical competencies and facilities for the assessment of spatial trends; and place-based knowledge on global trends and local conditions for its assessment and decision making.

Smart City Planning and Innovation

The basic idea was originated from the 'information city' using new ICTs innovatively and the ICT-centered smart city which is highly instrumented for optimizing decision making in the short and long term as well as for better managing and controlling city systems in about real time functioning. In that early stage of Smart City-development the basic understanding on innovation was a techno-economic one. Corresponding planning activities supported this concept of techno-economic innovation in a rather strict top-down understanding of planning as many new problems of procurement, implementation, organization and management had to be tackled by the city administration. The basic idea was – similar to IC1 – the increasing use of smart technology in order to produce the digital twin city in order to reduce their environmental impact and offer citizens better lives. Smart urban planners elaborated concepts how to establish, use and integrate new data sources in a technocratic evidence-based planning which predominantly is aiming at the efficiency of urban systems. This Smart City regards the city exclusively as a technical system in which a top-down planning approach is fostering the efficiency in different urban domains. [6] Citizens are not involved directly in this approach. According to Barcelona's first strategy [27, 28] the plan was to catch the anatomy of the city by 12 different domains and to translate it into digital space through 24 different layers. The 'digital twin city' should enable the integration of differently produced information as well as the simulation and communication of several trends and information in order to improve citizens' welfare and quality of life. [29] Due to its character of a data driven understanding of the Smart City which is clearly supported by a technocratic top-down approach of planning in which cities are regarded as technical platforms, we call this approach Smart City 1.0 (SC1.0).

In a different Smart City understanding a specific concept of innovation is combined with a changed planning approach. It is based on the triple helix and its enhancement towards the multiple helix. Basically, innovation is assumed from a systemic view as outcome of the collaboration of industry, science and governments. This collaboration of actors with their specific competences, facilities and expertise is more effective if corresponding processes between them are established. This means the processes of knowledge production and exchange (university – industry), of mutual learning (university – governments) and of market entrance (industry – governments). Caragliu, et al. [1] as well as Leydesdorff et al. [16] underpin the importance of smart technology for implementing the multiple helix and at the same time the changing role of city's governance and planning. Cities' representatives (planners and other stakeholders) are at the same time user but also participating producer resp. driver and customer of 'urban innovation'. DG Internal Policies [30, p.24] sum up "*Smart City' initiatives as multi-stakeholder municipally based partnerships aimed at addressing problems of common interest with the aid of ICTs*". Correspondingly, many Smart City projects are implemented based on this understanding of innovation through the active involvement of city planning in a place based smart solution finding process. For instance, several projects had been initiated by FP7 or HORIZON2020 of the European Commission aiming at the energy transition through increase of energy efficiency, reduction of emissions and restructuring the energy delivery in favor of renewable energy sources. Projects like PLEEC [31] had been based on a sound definition of domains with potentials for energy transformation, of weaknesses and strengths of urban performance and of collaboration between city stakeholders from the different domains. Hence, innovation becomes a new character because of the changed role of planning. The evidence-based outcome of a local solution finding process is now governed by an integrative planning approach involving small and medium-sized enterprises (and not exclusively a global player of technology provision), corresponding experts within domains and the local planners. However, it is still technically dominated as citizens can be involved but participation is considered in a relative late moment of the project initiative. Caragliu [1, p.70] defines SC „.. *when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through a participated governance.* Due to its triple helix-based understanding of innovation and a corresponding stakeholder-oriented conceptualization of the Smart City planning approach, this approach is called Smart City 2.0 (SC2.0).

Usually, urban problems and challenges are perceived and assessed on the local level in different ways because of an increasingly heterogenous urban society. Thus, the ways of solution and decision finding are increasingly based on local evidence and, in particular, on the involvement of local actors in a co-creative way. Hence, the concept of innovation is enhanced in form of the so-called 'open innovation' which is regarded as the interplay of the quadruple helix. This is an enhancement of the triple helix, explicitly considering residents as important actors similar to the other groups of actors. Basic idea of this concept of 'open innovation' is the outside-in-process which means the integration of external knowledge which helps an organization to become more innovative in a highly competitive environment or more effective in problem definition and solution finding. [7]

The city is regarded as a complex system which needs a multi-level planning perspective for understanding urban transformation processes. This process will take place through interaction processes within and between three urban levels: niches (micro level), regimes (meso level), and a socio-technical landscape (macrolevel). [32] In this perspective a new instrument of 'living labs' has been conceptualized for steering urban transformation processes in an increasingly complex environment. Generally Living Labs are defined as a user-centric innovation milieu which combines every-day practice and research. Correspondingly, this innovation concept needs a planning approach which enables this outside-in process of all engaged partners in real-life contexts and which enforces creating sustainable values. [33, 34]

Based on this understanding of a Living Lab, an urban Living Lab (uLL) in addition is embedded in a smart technical environment. It is defined as "*a physical region in which different stakeholders form public-private-people partnerships of public agencies, firms, universities, and users collaborate to create, prototype, validate, and test new technologies, services, products, and systems in real-life contexts. … Urban Living Labs are oriented on 'urban' or 'civic' innovation. This means that Urban Living Labs are often supervised by (or have a close relation with) the local government and have a strong focus on social value creation and civic engagement.*" Juujärvi et al. [35, p.22] Thus, ULLs may start as a niche-approach but will evolve as a driver transforming regimes and systems. From this point of view, urban planning becomes a crucial role in a smart technical environment. In place-based evidence, it is enforcing the transformation of cities in a bottom-up way. In comparison to former understandings this approach involves citizens in a co-creative way in an early stage and is even using smart technologies in order to bring outside knowledge through web based or direct communication into local smart activities. Because of its strong differences to former approaches, we call it Smart City 3.0 (SC3.0).

4 Smart City and Open Innovation

In the Smart City 3.0 exist different ways applying the concept of open innovation. Compared to the SC2.0, the character of innovation again is changing due to the involvement of additional actors (most of all residents) in an early stage of decision finding processes. [36] From a technical point of view Komninos et al. [7] argue that cities are now able to evolve the IC3: they are increasingly providing interactive open concepts for any user. This reaches from open data concepts to those of open source concepts including problem specific hackathons, until the use of collective intelligence [37] in algorithm-based decision finding processes, for instance in automated car driving or other domains applying artificial intelligence approaches.

A well-known way of enforcing collective intelligence is the involvement of citizens as experts on the local level. This has become prominent through the concept of urban Living Labs. They activate external knowledge through their implementation at the neighborhood level and integrate it into bottom-up organized initiatives. In this quadruple helix perspective, Smart City development explicitly considers the role of citizens with their value systems, creativity and local evidence as important components in open solution finding processes. [34] Thus, initiatives are strongly resident centered, technology is regarded as an instrument supporting processes, but not as a goal. In a real-life setting, communities are established at the level of quarters.

However, uLL have become a prominent project approach funded by different institutions (European, national, urban) for instance in the domain of mobility or the domain of energy transformation. SINFONIA is an example of a HORIZON2020 funded European project in collaboration with the City of Innsbruck and Bolzano and with local actors focusing on energy transformation through local production and use of wasted heat or renewable energy or through thermal renovation of buildings. In some parts these projects show the features of open innovation although its enrollment into the whole urban system is still limited because of its complexity of decision making of different stakeholders involved. [38, 39]

Another project that is enforcing uLL as instrument for an open innovation process, is E_profile [40] a project in Austria by FFG and in collaboration with the City of Linz. This project aimed at the energy transformation process in local quarters with support of a web-based communication tool. This tool enables the description and modeling of the recent energy demand of buildings and allows the simulation of future energy demand reduced through thermal renovation activities, use of solar energy or wasted energy as well as the calculation of renovation costs. As the transformation process has to consider the recent local physical conditions of buildings but also social conditions and expectations of involved actors (citizens as house owners or renters) a web-based tool for simulation and communication was established.

Figure 1 shows the basic idea of an open innovation approach supporting the activities of an uLL in any urban quarter. In this approach a mutual flow of knowledge is considered empowering and enhancing an open innovation concept: First, the flow of knowledge from outside into the Lab is triggered as local actors have expertise on their conditions, preferences and expectations. Second, a flow of knowledge from inside-out (scientists, technicians and planners towards the neighborhood) is enabled and communicated through simulation of preferred future energy solutions and visualization of effects in terms of reduction of energy use, change towards renewable energy sources

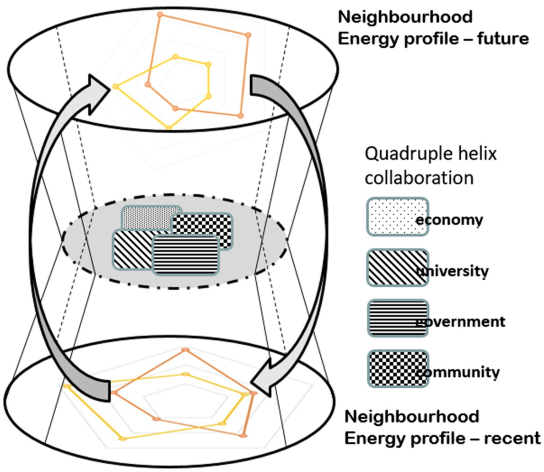

Fig. 1. quadruple helix approach for energy transformation of quarters. Own design based on Kolehmainen, et al. [41].

and costs of rehabilitation investments. Hence, the planning approach conceptualized as an urban Living Lab has a clear mutual understanding of knowledge production in planning and decision finding processes: technical support of monitoring, simulation, visualization and communication of relevant knowledge supporting fosters a bottom-up process of decision finding and at the same time a top-down process of communicating the impacts on the energy transformation process of a quarter.

5 Conclusions

The differences of Smart City understanding for urban development become obvious when looking at the concept of innovation and corresponding planning approaches. In a technical perspective they vary remarkably regarding their changing possibilities determined by web1.0, web2.0 and the establishing of collective or artificial intelligence for decision making. In a planning perspective one can distinguish between different approaches: top-down, bottom-up or counterflow principles, data driven against inclusive or integrative understanding.

As described above, technical innovations show a certain evolutionary character. This implies that there is a certain path dependency which concept of innovation can be realized depending on the existing urban technical standard. At the same time, it becomes evident that the application of a specific innovation concept needs a corresponding planning understanding for its effective implementation into the urban fabric. Obviously, there is an intrinsic logic regarding the combination of a certain concept of innovation with a corresponding planning approach.

Cities following the SC1.0 understanding predominantly improve their technical 'smartness'. In comparison, the SC2.0 and SC3.0 combine concepts of innovation in a much smarter way with recent planning approaches including three resp. four different groups of actors. In particular, the SC3.0 expects the inclusion of local evidence (monitoring and local expertise) which supports place-based decision making but also inclusive learning processes. In that case of SC3.0, the pure technical innovation is replaced by the concept of an 'urban innovation' which is characterized by the integration of technical and social innovation on the local level and through its replication it is likely to change urban development in a more profound and comprehensive way. Of course, all these concepts are usually not applied in a strict and exclusive way but in mixed combinations. However, these differences indicate that cities have the option to decide in advance which innovation concept in combination with certain planning approaches should be implemented.

Facing these different options, cities are challenged to decide how to handle technology and how to enforce a distinct concept of innovation as it will become important for the design of a certain planning approach impacting urban development. In particular, in the SC3.0 the concept of open innovation based on smart technical standards, can be used in different ways for learning processes: in a more technical way for algorithm-based decision finding or in a more socially inclusive and creative way. So, this open innovation concept needs for its implementation an integrative planning approach in form of urban Living Labs: it uses smart technology for the support of collective intelligence or the co-creation in solution finding processes.

However, smart urban development is designed by the mutual relation of innovations and respective planning approaches. Smart City understandings as described above will improve each of the four components (cognitive-intellectual and physical-economic resources; creative and technical facilities; cognitive and analytical competencies/facilities and place-based knowledge on global challenges and local conditions) using technology in more or less specific ways; i.e., it's specific combination of the concept of innovation and respective planning approach. It is obvious that that SC1.0 enforces in particular the 'product- and process innovation' making the 'urban fabric' and 'production of places' more efficient. Thus, SC1.0 improves the existing mechanism of efficiency of the urban systems, but the question remains open whether technical innovations alone will meet the urban challenges in an effective and adaptive way increasing the city's resilience? SC2.0 and in particular SC3.0, both combined with a strong integrative and place-based planning approach can also enforce technical innovation, but they have the chance to predominantly encourage the 'systemic innovations' through mutual learning processes as well as through its strengthening of a city's adaptive capacity. In that contexts, technology enables both innovation of first and second order. But what is even more important, is the conclusion that in particular SC3.0 will strengthen the more a city's resilient development the more it is producing and integrating knowledge of global trends and local conditions in a co-creative way.

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