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# Management of urban smart systems

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**Abstract.** Planning activity is complex process assuming the term "complexity" as a group of elements interconnected each other. The common knowledge about city planning underlines its main aim as: figuring the present, imaging the future, governing every day the territory and the way people use and live it at different scales. When considering the strength of technological opportunities and the spreading of ICT and IoT devices within everyday life, that mean within the life of cities, the complex nature of the urban system increases with the intensification of information and their connections. Recent orientations about urban and regional planning try to carry the discipline to a more flexible approach in respect to the hyperdeterminant role of direct technical applications. This passage is a fundamental aspect considering the faster and faster modifications of social and economic assets at the global and local scale. At the same time, the "environment question" became more and more relevant at the worldwide scale within the 2015 UN 2030 Agenda for Sustainable Development. Another relevant aspect about the recent urban planning orientations regards the role of the different subjects that are part of the planning process. Approaching the government of smart cities means to define how every subject, with different roles (public or private), could enrich the knowledge of the functioning of the "urban machine" and the awareness of participation of people and city users in the quality of urban life. In the paper author starts defining recent approaches in urban planning, then the nature of the city as a complex system is analyzed from the point of view of planners and of the different subjects that act in the city. Then the smart city is introduced as a further level of complexity and finally author propose the basic element of a Planning Support System.

**Keywords:** smart city; urban complexity; urban management

## 1. Introduction

During the modern movement, the future of the city was not a question mark, but it was the result of an equation. The superiority of technical knowledge over the human wishes was not appearing for the first time in history because every scientific revolution carried to evident consequences on all the other knowledge fields (Reclus 1895).

The predictive capacity, that should have been the goal of urban planning, founded its legitimacy in technical planning tools that, nowadays (after the season of ICT based urban models), show their weakness. At the same time, it is clear that the speed of changing of the typologies of requests from citizens, does not correspond to the immediate satisfaction by the local administrations. So, if speed is a problem, economic uncertainty and the inability to predict market trends do not give the possibility to hypothesize credible and effective city plans (De Lotto 2011).

It is well known that urban planning deal with at least the following issues: legal framework; political governance; cultural framework; economic framework; social framework; ecology discipline; architecture discipline; geography discipline; landscape discipline. Moreover, planning activity is composed by two main elements: the substantial component (the city plan itself, its content, and its rules definitions); the processual component (the people involved in the process, their role, their knowledge, their interactions). All the issues and the components interact each other in a nonlinear way.

## 2. Recent approaches for flexible city planning in complex contexts

Scholars nowadays can certify that the uncertainty of the future on the one hand, and the natural tendency of scholars to reach universally valid rules on the other hand, risk to point out the problems at a very general scale and define solutions that may be not suitable for specific contexts and times; nevertheless, some practices (such as the rigid zoning) continue to be applied as basic rule for city planning and design.

One interesting topic that is stressed by the idea of smart city is the slow time of the city modifications (Sennett 2000) compared with the high speed of technological city production. In this sense, the symbolic value of some elements of the city depends on the historical stratification as much as on the strength of the ideal they represent (in example, the financial power is represented by high-rise buildings that could assume the same role of historical buildings, such as in London and Milan).

About flexibility, complexity, and uncertainty we can refer to a definition by Portugali, that define city as a

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"dually complex systems", because composed by two fundamental elements: the artificial component (system of well-defined elements till the smallest details, even if complex, from bridge to bolt) and the urban agents (those who relate with the artificial elements and transform them into functional elements, for life and their survival).

So, we can say that the cities are modeled by the actions of urban agents on the artificial components and on the mutual connections among all components or, as defined by Bertuglia and Staricco, by the system's organization (Bertuglia and Staricco 2000). For a complex system, the organization is a fundamental characteristic: the ability to act on its own organization is one of the fundamental properties of a system and can be expressed as an evolution of interaction. Consequently, organization becomes a constituent property of a system (Gargiulo and Papa 1993).

Defining the city as a complex system means affirming that the city is linked to a set composed by elements in relation to each other (system). As it is well known, it is not possible to manage and control the processes inside a system with deterministic instruments; considering the city as a complex system (Bertuglia and Staricco 2000) the development of the city is not linearly predictable, basing on the knowledge of initial conditions (dynamically complex system). The non-linearity of interactions among urban actors and the plurality of urban systems description effectively connects the definition of city with definition of complex system.

## 3. Actors of the urban complex system

We can consider three principal actors (that are a part of 'urban agents') of the development urban process:

Citizens: intended as a group of private individuals.

Public administration: intended as official bureaus hierarchically organized.

Planners: urban science experts.

In what way they interact inside the urban process? What is the action they complete inside the urban process? From the classical modernist urban system point of view (characterized by a deterministic process), the action of 'urban agents' is simple to be read as follows. The citizens' action inside the planning process are related to the directly living space: house, workspace, free time spaces and connective systems (i.e., the road system). The active action in the process is limited to the daily sphere. As a single individual, the citizen interacts partially with the other daily spheres, unless different types of processes are activated (i.e., collaboration, informal associations, urban conflicts, …). The action of the public administration has a top-down decision-making model: according to the decisions of the different administrations, the programs' development of the city is modified in a more or less incisive way, acting on the citizens without direct interaction. The main action of the planners is to translate public administration strategies on 'paper' by acting on the urban structure at all levels of detail - from large to small scale (Morelli di Popolo 2014).

## 4. Lack of certainty in planning activity for public actors

When a certain scenario of the future of the city is defined, it is always approved (worldwide) by the public administration depending on the hierarchical scale (usually: national, regional, municipal). So, the final responsibility to furnish answers to the emerging questions coming from the other subjects is a public responsibility. In a complex and flexible context, planning activity is buried under uncertainty.

Some authors clearly described this last aspect in a recent paper (Moroni and Chiffi 2022). In the literature review about decision making in conditions of uncertainty, it emerges that urban problems are always defined in a "wicked" way, without many details, without a certain finish line and, often with a concomitant occurrence of understanding and resolution (Balint *et al*. 2011).

Urban problems under uncertainty are defined by Moroni and Chiffi as follows:

"We distinguish among conditions of certainty, risk, and (severe) uncertainty:

i. in a situation of certainty, possible events are listable; the consequences of each choice are known to the decision-maker; and choices indubitably lead to specific outcomes.
ii. in a situation of risk, possible events are still listable, and the decisionmaker can assign (meaningful) probabilistic values to them.
iii. in a situation of severe uncertainty, the decision-maker is unable to assign well definable or computable probabilities and may even be ignorant about what states of affairs are possible." (Moroni and Chiffi, 2022, pag. 239).

Certainty and risk are easily referrable to mathematical and physical models like the deterministic, heuristic, and statistical ones. Severe uncertainty is the real exception in city understanding and management. Uncertainty emerges when, given a specific question, the answer is not obvious (Floridi 2015). So, it is very close to the complete un-deterministic problem.

It must be noted that urban planning is the sum of the spatial decisions taken by a public bureau (i.e., a Municipality); it acts in two main different fields: in its own property (this is the case of public works, roads, services, etc.), and in the private properties (furnishing detailed or vague indication about what to do or not). So, from the decision-making point of view, it must be noted the non-homogeneous nature of public decisions when considered as a whole (as an urban plan).

### *4.1 Hyper-determined planning VS free rules*

If urban planning is the science that studies the development of territorial and urban systems, that forecasts and governs its development, it is easy to understand that the hyper-determination of urban planning does not coincide with current criticalities previously cited.

A deterministic system like the one used until modernism to role the planning cities, has already demonstrated its limits. This kind of plans has always been ineffective and inefficient; the rigidity of the technical tools and of the structure of decision making give little scope to unpredictable changes. To these basic elements, we must necessarily add the role of technological innovations and globalization, able to distribute knowledge, but also to simplify and conform, activating phenomena that cannot be controlled a priori.

To work into such a complex condition, researchers need firstly to redefine the role of the actors that act inside the process: expectations, rules, training.

Then, researchers need to change the approach to "planning" itself, with reference to the planners' role (Moroni 2013).

## 5. Smart city and smart citizen

The "smart city" derives from the consciousness of the presence of innovative technological principles, applications and results into the systemic structure of the city (Fistola 2013); this is not a very new topic, and its origins can be tracked around the last two decades of the XX century, when new ICTs reduced (or eliminated) physical distances among people and when people started thinking to the city as regardless to a delimited physical space.

At least on the last 10 years, many scholars focused on urban smartness, while a shared permanent definition of the concept is still missing, maybe because the same technologies are in constant transformation and development. The scientific literature agrees in considering "smart" a city that is well performing in six macro-areas: Economy, Environment, Mobility, Governance, People, Living (Komninos 2002, Giffinger *et al*. 2007, Shapiro 2008, Van Soom 2009). According to Portugali, the first three areas are related to the physical part of the city, the last three are related to the urban agents. From the systemic point of view, all of these six macro-areas are sub-systems or, better, complex sub-systems.

The 2014 report "Mapping Smart City in the EU" – commissioned by the European Parliament's Industry, Research and Energy Committee considered the cities that were developing initiatives aiming to become smarter, starting from some indicators that could evaluate the success of a smart city and the effectiveness of targeted improvement in the six macro-areas previously cited (EU Report 2014).

Robinson proposed some "Smart City Design Principles" from different sources and scientific debates; the most relevant for the actual dissertation are here reported (Robinson 2016):

Principle 1: Consider urban life before urban place; consider urban place before technology.
Principle 2: Demonstrate sustainability, scalability and resilience over an extended timeframe.
Principle 3: Demonstrate flexibility over an extended timeframe.
Principle 7: Ensure that information from its technology systems can be made openly available without additional expenditure.
Principle 9: New developments should demonstrate that they have considered the commercial viability of providing the digital civic infrastructure services recommended by credible research sources.
Principle 10: Any data concerning a new development that could be used to reduce energy consumption within that development, or in related areas of a city, should be made open.
Principle 21: Any information system in a city development should provide a clear policy for the use of personal information. Any use of that information should be with the consent of the individual.

The hard infrastructure of the city, such as IoT devices, sensors, data producers, determined the origin of smart city but then they have been integrated in the more extensive city definition that, in ancient times were composed by: urbs (the physical part of the city), civitas (the inhabitants of the city), and polis (the governance of the city).

For their nature to furnish more information and to elaborate them into some forms of rough knowledge, the technological infrastructure should help to solve some problems that seems to be uncertain for the need of data: "The selection of rational goals is constrained by the contingent fact that organizations may have too few resources to deal with all the information and alternatives required to formulate and implement optimal goals" (Moroni and Chiffi about Simon, p. 238). The first worldwide impression about smart city was incredibly positive because it was promising the solution to many unsolvable urban and social problems.

Then, it emerged that the technology alone could not be the answer, but that a smart city should inhabited by smart citizens.

The same optimism is now emerging about the Artificial Intelligence applications. Artificial Intelligence extracts new forms of knowledge from the correlations and patterns (ex-ante stated) and it can fill some void of information. It can support the decision-making processes and governance topics (Zamponi and Barbierato 2022) but it cannot translate the nature of decision making into a deterministic model.

## 6. The environmental topics and the smart environment

For what has been described until now, it is clear that in last decades scholars several times destabilized and re-assembled city planning following the changing of paradigms of "planning theory". According to the complex system approach, the urban development and management is still based on the relations among social groups and physical elements (Portugali 2000). This approach carried to focus also on the procedure together with specific spatial

aspects (that were the basis of the modern urban planning); the spatial analysis and planning developed fast in the last decades with the availability of computer-based instruments.

The "environmental issue" has been always a part of the classical city and regional planning and, even if the theme of respecting and safeguarding environment has become more and more relevant and urgent, it is not possible to consider this as a "new" theme for urban planning. In example, considering the urban expansion (sometimes a real explosion happened in ex-emerging economy contexts – such as China), the measure of soils consumption and the spatial implications in the relation between enlargement of cities and natural or agricultural territory have been underlined with the critics to the sprawl (Duany *et al*. 2000).

To reinforce this statement, in Italian context the territorial plans have the main goal "to protect environment" and landscape, as well as to pursue social and economic development.

The whole process that carried to recognize sustainability as main strategical behavior for all human beings, started in the early seventies (with the U.N. Conference on the Human Environment in 1972, in Stockholm) and the principles exposed in 1972 should be applied to every human action (individual and collective), considering urban and regional panning as a key point.

The goals of sustainability, developed during time until the 2030 UN Sustainable Development Goals and the New Urban Agenda (that is a specific targeting of the UN principle to cities and citizens), always refer to behaviors more than to specific spatial indications; so, it is an interesting issue to analyze in which way these goals may be achieved throughout spatially oriented actions.

The ecological planning has been schematized by the landscape ecology (among all, Steiner 2000), that is the science of studying the complex relationships between ecological processes in the environment and ecosystems. Key research topics in landscape ecology include ecological flows in landscape mosaics, land use and land cover change, scaling, relating landscape pattern analysis with ecological processes, and landscape conservation and sustainability (Douglas and James 2015).

From the introduction of the Strategic Environmental Assessment (SEA), defined in Europe by the Directive 42/2001, the process of regional, urban and city planning has been sustained using specific techniques, methodologies, and indicators.

Combining smart cities principles and environment protection, the smart behaviors that preserves the environment is the best description of the smart environment (Vinod Kumar 2020).

## 7. Drivers of urban development and spatial planning

Without considering specific local themes and issues, it can be generalized that, over the last decades, the theme of territorial development and competitiveness, addressed for a long time exclusively in economic terms (Porter 1990, Storper 1995) has been enriched with new visions and approaches that consider competitiveness as a complex concept, multidimensional and deeply linked to the principles and objectives of sustainable development (Kitson *et al*. 2004).

A competitive territory is capable of producing wealth and economic prosperity for its citizens (economic competitiveness) and, at the same time, enhancing the environment, guaranteeing the protection of natural resources and historical-cultural-anthropological-territorial heritage (environmental competitiveness) and encouraging the joint intervention of different subjects and different institutional levels (social competitiveness).

In each territorial context, the presence of an efficient production system can represent a valid possibility to pursue the concept of competitiveness in all its components. The use of innovative tools aims at promoting economic growth and synergies between institutions, citizens, and businesses, and reducing environmental impacts (De Lotto *et al*. 2017) The success of these experiences is partially due to the planning process that identifies the complex elements that characterize it and define its predisposition to be the right place of certain economic activities, clarifying its vocation. The analysis of the small-scale territory's vocation is a fundamental requirement to guarantee the protection and enhancement of the territory itself and of its competitiveness.

The main scope (spatial location of productive activities) can be analyzed from the general supply and demand law that in territorial meanings may be translated in two points of view: the first as an activity that wants to establish itself in the city and therefore expresses a demand (What-Where), the latter as a planning process that guides the development of the city by defining its offer (Where-What).

Defined the production activity type and its specific characteristics, the What-Where model allows to identify the most appropriate areas for their location.

Otherwise, given a specific area of intervention, the Where-What model allows to highlight the functional vocation to be attributed, taking into account the area morphological peculiarities and the mutual influence with the territorial context (De Lotto *et al*. 2015, 2016) In the planning choices of both models, a plurality of territorial stakeholders contributes (including public administration bureaus, tourists and city users, business companies, monitoring agencies, common citizens, labor unions, research centers, etc.).

According to a multi-level governance, that is one of the pursued goals that could make the urban machine work better, every subject is a part of the system and interacts with all the other subjects in order to identify factors, conditions and enhancement actions for the establishment of more efficient urban plans.

## 8. Conclusions: Planning support system's structure

Nowadays, it is recognized the possibility to pursue (according to sustainable principles) the competitiveness of

the production system through localization choices capable of guaranteeing economic development, environmental protection and the involvement of different public and private subjects.

To guide the planning process and then the design activities of urban city center, author developed a methodology based on a set of tools and techniques, Planning Support System (PSS), which allows focalizing roles and interests of the different involved stakeholders.

These kinds of systems recognize both the substantial and the processual nature of urban planning; moreover, the users' interface can be designed according to the level of knowledge that the same user might have, or to the attitude that he/she/they can have to build mental maps.

The PSS allows to decide the hierarchy and the structure of all the elements involved in planning activity (from spatial characteristics to different roles of subjects). For this purpose, it is enough to make use of not such sophisticated technologies or software such as a partially automatic GIS tool, based on: a Decision Support System (DSS), a Knowledge Discovery Data Mining (KDDM) and an Expert System (ES) (Densham 1991, Brail 2008). More than the technological novelty of the elements it is the way the modules are interrelated that creates the success of the PSS.

We can consider a PSS as an instrument to help different users (professionals, public bureaus, stakeholders) in making decisions, in evaluating the effects (direct and indirect) of actions and in monitoring results. Starting from the previously cited model "What-Where" and "Where-What", any spatial problem can be simplified with a supply-demand structure. When approaching complex systems, by definition, a certain level of simplification is mandatory. The relations between and among the different elements of the six macro-areas involved in the planning activity, can be translated into a hierarchy of sub-models that consider the territorial development with specific reference to certain urban fabrics; the widespread and specific territorial marketing; the territorial attraction to urban activities; the definition of new relationships between territorial, economic and social systems; the urban regeneration of misused areas and the definition of optimal scenarios for the regeneration of territorial, environmental, economic and social elements.

A Planning Support System is typically based on an analytical, multidisciplinary, and trans-scalar approach of the territory, that can be divided into logical steps: Data finding, geo-localization and data management; Multicriteria analysis and sub-systems hierarchy creation; GIS query structure and spatial analysis applications.

So, for what have been previously said about the Portugali approach, to manage (or at least to try to manage) the entire system the PSS should be able to connect the physical elements that compose the physical elements with the involved subjects.

To conclude, it must be noted that all the modules of a PSS must be strictly connected one to each other, and that the process does not finish with the survey of data (simple data or big data), or with the creation of a practical expert system, or with the use of a GIS tool: it is necessary to recognize in the PSS the nature of a process. That means that all the involved subjects are part of the whole evolution of the city and, following the smart city principles, all of them contribute to the creation of a shared understanding about the city. So, the public bureaus and the private stakeholders should share every step of the knowledge building to let urban planners to adapt the city plan (the substantial part) to the changing of the economic and social conditions in a flexible way.

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