Chapter 14

Smart city as the city of knowledge

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1. Introduction

In 2015, more than 190 world leaders have adopted 17 Sustainable Development Goals (SDGs) and 169 associated targets, defined by the United Nations (UN), to be achieved before 2030 (United Nations, 2015a). The main aim of these goals and targets is to stimulate fundamental actions for humanity and the planet before 2030.

Among these 17 goals, Goal 11 "Make cities inclusive, safe, resilient, and sustainable" has a direct connection with Smart Cities, another research field which has been debated in the last 10 years. A simultaneous analysis of Goal 11 and Smart Cities can lead to advantages of economies of scale, of complementarity of many aspects, and of avoiding unnecessary overlaps. A lot of experiences related to smart cities are mainly concentrated on technological aspects without considering if all these innovations are useful for the city (Murgante & Borruso, 2013, 2014). In order to accelerate national progress to achieve the sustainable development goals (SDGs), the Agenda 2030 for Sustainable Development (United Nations, 2015b) has been defined ensuring that no one will be left behind and moreover to reach the furthest behind first (Fleurbaey, 2018).

There are five key factors in analyzing who is left behind: discrimination, geography, governance, socioeconomic status, and vulnerability to shocks (United Nations Development Programme, 2018). In order to implement the Agenda 2030 these factors can be applied adopting an integrated approach based on three axes:

- Examining all kinds of weaknesses that people have to face in the five factors.
- Empowering people including those left behind in decision-making by means of inclusive mechanisms of civic engagement.

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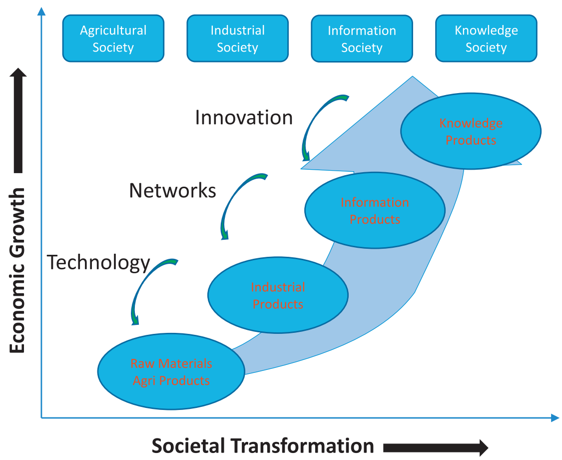

FIG. 1 Evolution of the civilization (Paul, 2014).

- Enacting change implementing policies, laws, reforms, interventions for reducing inequalities and for increasing the minimum standards of well-being.

In order to reach this result, it is fundamental to increase the level of knowledge in cites and societies.

Several authors (Bindé & Matsuura, 2005; Castelfranchi, 2007; Lytras & Sicilia, 2005) say that we are entering the knowledge society. For instance, Paul (2014) explains that gradually (Fig. 1) the civilization has passed from the agricultural, industrial, information society to the current knowledge society.

What exactly does anyone mean speaking of the knowledge society? And about cities, not only at management level but also for the daily life of citizens? Here are the research questions that will be examined in this chapter. The discussion in this chapter is structured as follows. First, various definitions of the knowledge society are examined with special attention to encyclopedism, governance in companies and in urban planning with respect to rationality. Do not forget that some knowledge chunks can come from public participation and overall electronic participation. This chapter develops also examples of encoding rules, as knowledge components, in urban planning.

In the conclusion, it will be stressed that new acquired knowledge demonstrates the idea of revisiting strategic approach for economic and spatial planning.

2. The knowledge society: Issues and implications

What do we mean exactly when speaking about the knowledge society? What could be the differences with the information society? In this section, we will try to answer those questions, by clarifying both concepts of information and knowledge. For computer scientists, it is common to distinguish data, information, and knowledge. In a very simple way, whereas data are bits, numbers, and strings of characters, information corresponds to data with their meaning, and knowledge is defined as information potentially useful to solve a problem. In English, the word "knowledge" is very general. When it is important to consider a piece of knowledge, several authors use the expression "knowledge chunks"; whereas several connected knowledge chunks can be regrouped into a "knowledge bundle," for instance, a set of knowledge chunks relative to freight transportation, water supply, touristic activities, etc. In fact, several categories of knowledge exist. Knowledge can be explicit or implicit; by explicit, one states that knowledge chunks can be explained to somebody else, perhaps with a natural language; by implicit, difficulties occur when explaining them.

From a computing point of view, two main sources of knowledge exist:

- From experts: in this case, experts can give a few sentences corresponding to what they know; those knowledge chunks are often explicit; in this category, we can easily add legal and physical laws and also best practices.
- From data or text mining or from big data analytics (Shekhar & Vold, 2020): it may be based on frequency analysis, knowledge chunks can be extracted; sometimes their meaning is mainstream, but often the causal explanation is not immediate; however, everybody has to be aware of possible spurious correlations; in this category, we can include the analysis of sensor data in real time.

Moreover, according to Afgan and Carvalho (2010), "the development of the Knowledge Society is focused on the following objectives:

- To inspire and enable individuals to develop their capability to the highest potential level throughout life, so they can grow intellectually, be well equipped for work, can contribute effectively to society and enjoy active personal fulfillment;
- To increase knowledge and understanding for their application at local, regional, national level;
- To play a major role in shaping a democratic, civilized and intellectual society;
- To learn, evaluate, assess and validate economic, environmental, social and technological advancement to produce benefits based on the knowledge society."

Based on these considerations concerning the whole society, what could be told regarding the impact of knowledge, and especially geographic knowledge for smart cities and territorial intelligence?

Of course, there are other definitions and points of view. Our goal is not to examine all of them, but rather to identify the main characteristics of the knowledge city.

3. The knowledge city

Currently, 50% of the world population is living in cities. Consequently, the knowledge city must be considered as a piece of the knowledge society. But this is not only a problem of scale, but rather different levels of preoccupation. According to an NSF workshop (Edwards et al., 2012), knowledge infrastructure must include at least the following: education, libraries, publishing industry, intellectual property, research, knowledge-based industry, and knowledge expertise. In this section, we will not develop all those aspects, but rather emphasize only on knowledge-based education, knowledge-based economy in cities. The special case of knowledge-based urban planning will be treated in the subsequent sections.

As we consider human evolution, one can see that continuously men and women have tried to transmit their knowledge to their kids, i.e., the ways to survive personally and collectively in different contexts. Gradually the so-called the hunter-gatherer nomadic tribes evolved to Neolithic agriculture and small settlements characterized by a progression of behavioral and cultural features and changes, including the use of wild and domestic crops and of domesticated animals and marked by the development of metallurgy, leading up to the Bronze Age and Iron Age and the creation of cities. More or less in parallel, scripture was invented as a way to transmit knowledge. And more recently to the industrial economy and the digital age with the advent of smart cities. Do not forget that the covid-19 crisis must force people to increase their medical knowledge, to adopt new behaviors, and to invent new relationships between people.

Along this evolution, parents have taught their children how to survive in jungles, in deserts, in seas, in mountains, and in cities. In the future, it will be perhaps on other planets. In other words, one has to consider a mixture of adaptation and evolution of knowledge along millennia. It is not the simple accumulation of knowledge, but, overall, the reconstruction and the reorganization of knowledge may be done by abandoning some bundles of knowledge which were no more in adequation with the context.

In other words, the human condition is characterized by its ability to learn and transmit knowledge to other people. But, now with the acceleration of history, education must be revisited not only based on pure learning for the lifetime but also based on learning to learn.

Discussing with elder people, maybe with centenarians, they can explain that they were born in a different world and all their life they were obliged to learn and adapt to new contexts. And those who had not this potentiality have been and will be in great difficulties.

Presently, is education based either on information or on knowledge? As the goal is to learn something, it can be considered as information, the best knowledge in education is to learn how to learn. So, this is a set of methodologies which must be created, perhaps rediscovered, however, formalized in order to be easily understood, learnt, and transmitted to other people.

Throughout history, humans have invented a lot, and those skills, know-hows, and knowledge have been transmitted to other people; think about agriculture, metallurgy, scripture, etc.

During centuries, perhaps millennia, libraries were the place where to accumulate knowledge as, for instance, the famous Great Library of Alexandria which was said to store many hundreds of thousands of scrolls. Later in the 18th century, with many contributors, Diderot (1751) launched the huge project of the "Encyclopedia, or a Systematic Dictionary of the Sciences, Arts, and Crafts" which was supposed to concentrate the whole knowledge and know-how of this period. Fig. 2 gives the visual organization of knowledge back of the Encyclopedia, and with actual vocabulary, it can be seen as a preliminary of a global ontology.

Later, there were the inceptions of Encyclopedia Britannica, and more recently of Wikipedia with similar goals, but at different times and different technologies. Maybe, in the future, since knowledge and technologies are evolving, with other media, other trials will be made to organize knowledge.

However, knowledge-based education is supposed to be organized at the level of the world, maybe with some cultural or linguistic differences. However, back to cities, a sort of scale level could be distinguished, for example, in history and geographic, a greater focus could be made so that local citizens may have more information and knowledge about the place they live by, finally, more general and synthesized knowledge at upper level, and more detailed at lower level.

Back to education in smart cities, the question is: how to organize teaching so that knowledge can be easily accumulated, stored, used, and transmitted? For the moment being, several recommendations can be given

- Educate kids to the actual world and possibly to the future world.
- Increase their ability to learn by themselves by means of different media including common books and Internet.
- Educate for sustainable development.
- Educate grown-ups to learn on to increase not only their cultural level but also new technological, medical, ecological, and sociological issues.
- Educate to help people with physical, intellectual, and social disabilities.
- Educate to respect other opinions and to empower citizens especially regarding the life of their city.
- Educate to think about the discovery and the defense of general interest, at short term as well at long term.

3.1 Knowledge-based economic activities

Two kinds of companies must be distinguished, conventional businesses and consulting firms. Indeed, the production of consulting firms is essentially knowledge whereas others can be anything, from products to services (Yigitcanlar, 2015). Remember that knowledge can be defined as information potentially useful to solve a problem, whereas it is clear when facing a present problem, what kind of information could be useful for the future? Theoretically, any!

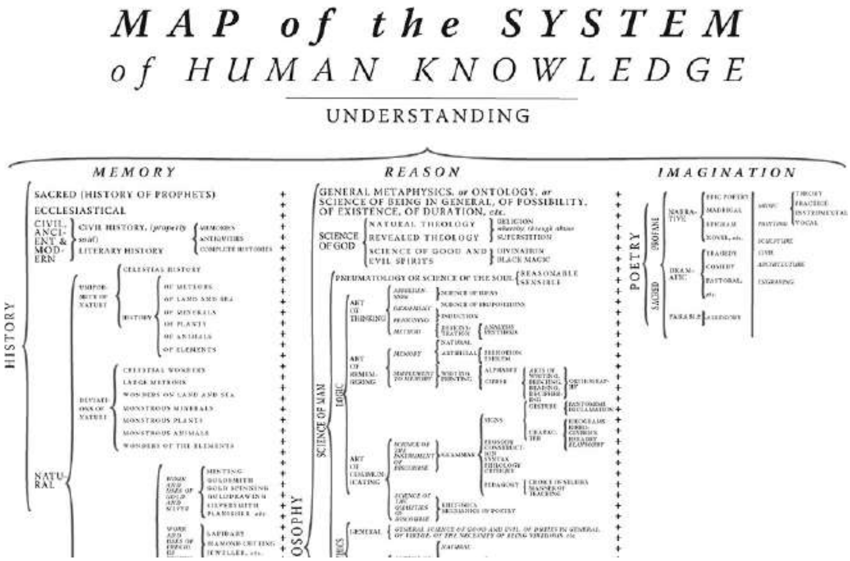

FIG. 2 Excerpt of the map of system of human knowledge within the Encyclopedia with three main branches: memory, reason, and imagination (Diderot, 1751). A complete original in English can be seen at https://quod.lib.umich.edu/d/did/tree.html.

3.1.1 Conventional companies

What kinds of knowledge companies use? Even if the knowledge vocabulary is little used, a lot of information coming from various origins will be the base of a company's knowledge. As illustrated in Fig. 3, knowledge can come from organizational theories, juridical context, guild recommendations, financial information, local authorities' regulations and projects, without forgetting information about customers, suppliers, competitors, and trade unions. Sometimes, when necessary, some of them call consulting firms for advice, to increase their efficiency. In addition, some companies must follow sociological trends and base their strategy on local authority projects, national information, and international opportunities. Finally, good knowledge management gives the company a competitive edge.

However, among knowledge chunks, one is very important, namely insider offences: in other words, it means that sometimes even if a company is aware of something, maybe financial information, it may not use it because it could be a criminal offense.

Second, in output (Fig. 4), we can mention knowledge bundles for internal organizations and regulations, production and human resources management, etc.

3.1.2 The special case of consulting firms

Differently from other companies, the essential outputs of consulting firms are the advice they sell to other companies.

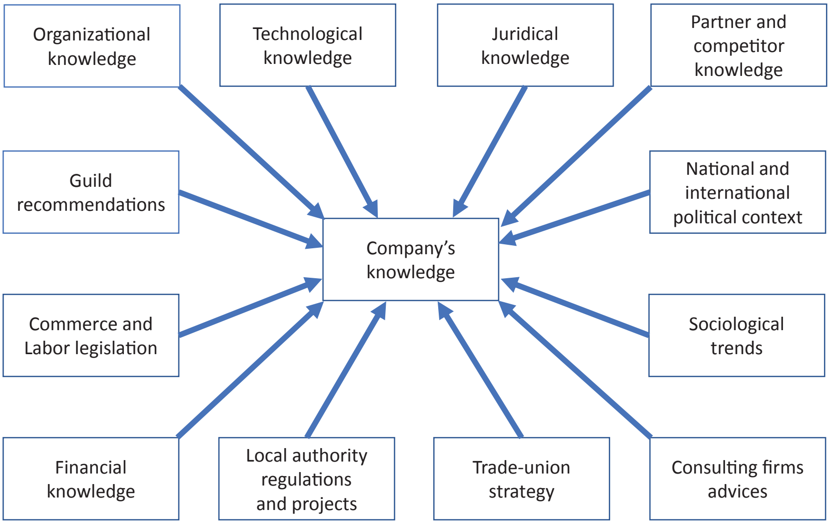

FIG. 3 Origin of company's knowledge.

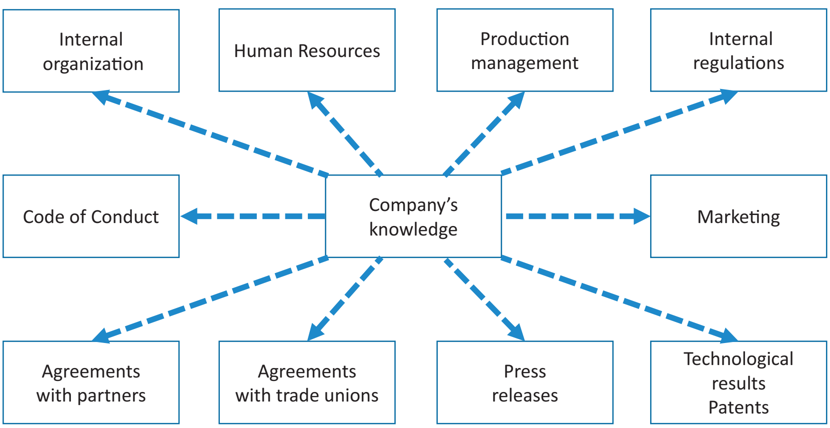

FIG. 4 Knowledge bundles issued by a company.

To illustrate their importance, according to Forbes (Valet, 2020), the consulting business boomed, growing 3.4% to revenues of $259 billion from more than 774,100 firms since 2014. In other words, more and more companies desiring to better their development strategy are seeking to ask the assistance of the knowledge business.

Another way to get knowledge is identified as big data analytics. Daily companies are creating billions of data and information pieces, so the goal is try to extract useful information and knowledge, first by data mining and then with deep learning.

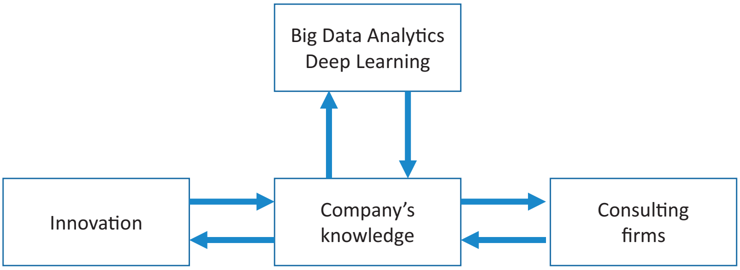

FIG. 5 Information and knowledge synergies.

Taking all that into account, cross-fertilizations can be discovered as depicted in Fig. 5: not only big data analytics, deep learning, innovation, and consulting firms bring fresh knowledge to companies but also this newly acquired knowledge can renovate visions.

In addition to that, nonprofit and not-for-profit organizations can contribute to the development of a city; and for them, knowledge is a key issue not only for their development but also for the whole economy. Among them, let us mention sportive, cultural, humanitarian, religious activities, etc.

4. Knowledge-based urban management and planning

In order to plan and manage a city, it is interesting to store and position data, information, and knowledge. As data are dealt with geographic information systems and information through metadata linked to GIS, currently there are no commercialized tools to deal with geographic knowledge, or more exactly urban knowledge. What could be the main characteristics of an urban knowledge repository, and how can it be used to plan and manage a smart city?

Even if urban and regional planning imply a vision only for a particular portion of the world, it is true that human settlements are representatives of a large portion of the outcome of human activities and of the human ability to change the Planet. So, any plan targeting urban transformation could mean to select objectives staying precisely tuned with a general view on the Planet.

First under an operational point of view, knowledge has to be based on information which corresponds to questions useful to identify problems, their location and people concerned and consequent objectives.

In this way, according to Laurini (2017), geographic and urban knowledge can be used for explaining, managing, monitoring, planning, understanding the past and innovating (see also Angelidou, Gountaras, & Tarani, 2012; Angelidou & Mora, 2019).

In the next section, after a short overview on the UN 2030 Agenda, we wish to stress the path from data to knowledge, starting from the need to know problems until to try to solve them by a plan activity. Along this path, we will develop competence and needs for education.

4.1 Objectives and problems

Following the large reflection on the geographic knowledge definitions, in the field of urban planning and management, it is interesting to analyze classic literature. More precisely, considering the cornerstones of strategic planning, a lot of authors (Chadwick, 1978; McLoughlin, 1969) have discussed the close relationships between objectives and planned actions and the application of the well-known principle "survey before plan" (Faludi, 1987; Geddes, 1915).

Using a temporal scale, we can

(a) Explain present and future trends, and understand the past trends.
(b) Monitor present trends.
(c) Manage (manage and monitor) present and future trends.
(d) Plan for solving problems of the future, through innovation.

In this general view, we are looking for those main contents needed to permit us to go from data to knowledge and creativity.

We think that a point remains central in the past as well as for the present or the future understanding: the most relevant and diffused social concerns.

In this short paper, it is not a question to present a list of concerns, but to reflect on a process where it must be clear that the scope of investigation is to support a collective decision.

An attempt to represent that process is made Table 1.

As the basis of strategic planning suggests, it is a process organized around an objective-based system and addressed toward a generalized consensus and implementation of the aftermath.

So, following Chadwick (1978), the objective detection remains very crucial; equally the central question remains: if the aim of the plan is to achieve those objectives, then how are objectives and social concerns linked?

Following some authors (Faludi, 1987) as objectives are to remove problems, and problems are everything that impedes that goal, the question becomes: if problem detection precedes objective detection or vice versa [first the chicken or first the egg? "Ovum ne prius extiterit an gallina?"]. Following classic, ancient Greek philosopher Parmenides showed how this famous paradox plays a role in explaining the relationship among *being* and *becoming* and, in our operational view, put the question: **problem first or objective first**?

This question that seems to be a very philosophical one is related to an attempt we are caring: to ground planning activity on a strong rational base (Las Casas, Scorza, & Murgante, 2019) in which any preconized action is proposed to solve some problems and if possible, by a multicriteria comparison, try to demonstrate if any proposed action is the **most efficient, equitable, and sustainable**.

TABLE 1 **Actions of evolution from competence toward knowledge.**

Actions and connected knowledge level → ↓ Point of view	Evaluate	Compare	Select and Propose
	To make a comparison with a measure unit	Through space and time to detect critical situations or alternative solutions	Choice plan or management solution and select; innovate when needed
	⇒ Competence	⇒ Information	⇒ Knowledge and Creativity
EQUITY	Explanation and an analytic description	List of problems and connected objectives and their evolution	"A planned course of actions" and the effects evolution
	DISPARITIES AND EQUITY	DISPARITIES AND EQUITY	DISPARITIES AND EQUITY
EFFICIENCY	Explanation and an analytic description	List of problems and connected objectives and their evolution	"A planned course of actions" and the effects evolution"
	POINT OF VIEW OF EFFICIENCY	POINT OF VIEW OF EFFICIENCY	POINT OF VIEW OF EFFICIENCY
SUSTAINABILITY	Explanation and an analytic description	List of problems and connected objectives and their evolution	"A planned course of actions" and the effects evolution"
	ON NATURAL RESOURCES CONSERVATION	ON NATURAL RESOURCES CONSERVATION	ON NATURAL RESOURCES CONSERVATION

4.2 Links with the UN sustainable development goals

So, the next reflection deals with the universality of those objectives. There is a link with juridical principles in occidental democracy where a rational and equitable use of resources is recognized as a general right. In France, as in Italy, e.g., emerge principles of equality and justice. The first article of the French Constitution states that "It ensures equality before the law of all citizens regardless of origin, race or religion." French Environment Charter (2004), which has validity as a constitutional principle, states that "in order to ensure sustainable development, choices to meet the needs of the present must not compromise the ability of future generations and other peoples to meet their own needs."

The same happen in Italy (Article 3): "all citizens are equal before the law." More in Article 9, the Italian Constitution puts under the responsibility of the Nation "the protection of the landscape and the historical and artistic heritage of the nation." And in Article 44: "In order to achieve rational land use and to establish fair social relations, the law imposes obligations and constraints on private land ownership, sets limits to its extension according to the regions and agricultural areas, promotes and requires land reclamation."

The same attention is reserved as the basis of the majority of European countries. For instance, we can quote the European Constitution in which the Treaty of 2004 states the sustainability and rationality in the use of resources and the need to guarantee citizens facing the Human Rights equality.

Briefly the 17 SDGs resume a long evolution developed in the entire world under the UN guidance which has produced a lot of documents, among other we underline "Guideline for urban and regional planning" where concepts are enlarged until they become the opportunity for deep innovations in practices.

So, the three basic principles are suggested in this work as a diligent selection, after a verification, that there is no contradiction and we can find a substantial accordance.

We can suggest that 17 SDGs are mainly addressed to equality and sustainability, but their very rich argumentation shows efficiency, i.e., rational use of any resource could be included in that general picture.

In effect, 17 SDGs seem to pertain to three groups: inequalities reduction (G1-G5, G10); sustainability and Planet and natural process defense (G6-G9 and G11-G15); peace and social justice (G16-G17) conclude the list as the most important precondition to realize remaining goals.

Once the robustness of that principle is accepted, in the following, we can try to show as they became operational in the knowledge process development. Indeed, as all those goals are defined for the whole Planet or society, they have all an incidence over cities. Especially, Goal 11 states that "Make cities and human settlements inclusive, safe, resilient and sustainable" and Goal 6 "Ensure availability and sustainable management of water and sanitation for all." In other words, this is the role of smart city governance to include those goals not only in the management of their daily activities but also for planning the future.

In other terms, those 17 SDGs must be transformed into knowledge chunks. Don't forget they belong to a "Knowledge Platform."

4.3 Equity, efficiency, and sustainability

(a) Competence

Under **equity**, we have to **evaluate** whether geographic or temporal situations are also different from each other. Competence, defined as techniques of measure or statistical indicators of inequalities, can become the object of a specific education (e.g., spatial distribution of health structures per capita or sick men percentage, statistical distribution of the distance among hospitals and citizens, etc.).

From the **efficiency** point of view, both absolute and comparative costs need to be taken into account (e.g., transportation or accessibility cost, construction and maintenance, running costs, etc.).

From the **sustainability** point of view, the common concern becomes the word conservation in its different aspects. Considering urban and regional planning, the main aspects with regard to human settlements and natural resource consumption and usual indicators are how much persons live in or in proximity of rare resources or use or abuse those? Which resources are under the risk of extreme consumption?

The output is a sort of explanation or an analytic description of a given situation.

(b) Information

The application of this kind of competence could generate **information** when a **comparative** exercise, aimed to put in evidence the most weak or critical situations, is implemented.

Changes through time is an aspect of **historical analysis**; it could be **creative** when important interpretations which **innovate** traditional interpretations are proposed; moreover, monitoring of it is self-evident.

The outputs are a list of problems and consequent objectives. The reached information is based on a relevant social interaction where people participate in the detection of critical situations comparing its needs and aspirations.

(c) Knowledge

In this exercise another level of creativity, maybe the most important, is that level where a course of actions is planned to transform a given situation.

Also, very important is the capacity to learn lessons from the past (historic point of view and the experience value) and also from successful experimentations made in other cities.

The output is a plan, i.e., "a planned course of actions" in which every single action can be justified because of its contribution to solve any diffused problem.

4.4 The importance of models in using data

During the past decades, the main problem in decision processes was the lack of data availability, but in recent years the wide diffusion of electronic devices containing geo-referenced information generated a great production of spatial data. Volunteered geographic information activities, public initiatives (e.g., Open data, Spatial Data Infrastructures, Geo-portals), Google and other spatial platforms, and also social networks produced an overabundance of spatial data, which, in many cases, does not help the efficiency of decision processes. The increase of geographic data availability has not been fully coupled by an increase of knowledge to support spatial decisions.

The British mathematician Clive Humby (2006) defined "Data as the new oil" and Palmer (2006) extended this concept with the following sentence: "Data is just like crude. It's valuable, but if unrefined it cannot really be used. It has to be changed into gas, plastic, chemicals, etc. to create a valuable entity that drives profitable activity; so, must data be broken down, analyzed for it to have value." The Italian cognitive scientist Scaruffi (2019) analyzed the difference between oil and data considering that "the product of oil does not generate more oil (unfortunately), whereas the product of data (self-driving cars, drones, wearables, etc.) will generate more data (where do you normally drive, how fast/well you drive, who is with you, etc.)."

But despite the huge amount of data "the paradox of the great civilization change consists in the fact that we have practically unlimited access to information and data and yet we are nearly unable to use it in any way" (Castells, 2009). Consequently, models can be considered the new gold.

The inclusion of spatial simulation techniques in recent GIS software favored the diffusion of these methods, but in several cases led to the mechanism based on which buttons have to be pressed without having geography or processes in mind.

Spatial modeling, analytical techniques, and geographic analyses are therefore required in order to analyze data and to facilitate the decision process at all levels, with a clear identification of the geographic information needed and reference scale to adopt.

But knowledge is not owned by someone, but it must be shared to the public.

4.5 Public participation and knowledge sharing

In recent times, a lot of activities have been developed with the support of mass cooperation. This tendency often adopted in public agencies and local authorities is based on an open government approach. This concept is based on a more participative method to government where citizen's ideas and activities have to be considered and collected in a sort of a continuous flow. Consequently, public involvement, collecting ideas, suggestions, or simply data/information production, is a daily activity considered as fundamental in decision-making. Obama's administration has given a great impetus to this approach, implementing such a policy and enlarging the possibility to capture public imagination by means of social networks, blogs, and all possible solutions for directly interacting with citizens (O'Reilly, 2009a).

This new approach is often called Gov. 2.0 (Jaeger, Bertot, & Shilton, 2012; O'Reilly, 2009b). Open government (Lathrop & Ruma, 2010) without a

2.0 approach is still based on a direct action. "Providers" is a sort of Right to Information where the administration tries to inform people but having interaction just with the main stakeholders. Gov. 2.0 is a more open approach, which "enables" citizens to have an important role in defining policies as well as in producing user-friendly, ubiquitous, and personalized services.

Social media and all 2.0 platforms are key elements in generating direct contact with citizens. Extensions of 2.0 philosophy have changed the relationship between citizens and administrations completely. People directly realize services that public administration is not interested to carry out, and the private sector does not consider convenient to realize.

Web 2.0 tools, such as WEBSITE, BLOG, WebGIS, and mobile applications, for smartphone and tablet represent a sort of transition from "one-way" to "two-way" information and interaction tools able to share ideas, compare opinions, and collect information (Evans-Cowley & Conroy, 2006; Murgante et al., 2019; Murgante, Tilio, Lanza, & Scorza, 2011).

In 2.0 planning approaches, citizens, probably unconsciously, face many of the typical steps adopted in the planning process, reaching the highest level of Arnstein, Kingston, and Haklay Ladders. In terms of planning theory, 2.0 planning can be seen as a renewed approach to Advocacy Planning (Davidoff, 1965), where the collector of instances is a virtual environment. The advocacy planner represents all people generally unheard in the decision process, and the needs of marginalized neighborhoods, generally absent at decision-making tables. While in advocacy organizations, a sort of hierarchy remains between the mass of people and their representatives, in 2.0 planning all people have the same position on a scale of responsibility. The development of 2.0 planning is strictly related to social media growth. Facebook, Twitter, and the other social networks were born to look for old classmates, military service friends, and university colleagues; today these are powerful media and places where it is possible to exchange ideas and opinions (Rocha, Pereira, & Murgante, 2015; Rocha, Pereira, Loiola, & Murgante, 2016; Resch, Summa, Zeile, & Strube, 2016).

The use of social networks has enabled a significant expansion of participatory basis, beyond the constraints of space and time (Salvini, 2005). Social scanning (Pang, 2010) is a fundamental instrument for collecting ideas, opinions, etc., from citizens. Social platforms can lead from a closed model of decision-making based on professionals' government and representative democracy, where participation is mainly relegated to election (Noveck, 2009) to an integration of representative democracy and collaborative approaches in which a decision maker has the possibility to directly consult citizens in order to make a particular decision. If, on one side, it is important to avoid pitfalls highlighted by Michael Bloomberg in an interview to the New York Times (Grynbaum, 2012), where Twitter has been defined as a source of everyday referendum leading activities only to short-term actions because great part of people is not interested in future programming activities; on the other side, social platforms can produce social mobilization, claims, and real changes in people quality of life (Healey, 2001).

This approach generated all over the world smart communities. Murgante and Borruso (2015) defined the three main pillars of a smart city:

1. Connections—as networks and technological infrastructures.
2. Data—open and public or public interest data to allow the development of innovative solutions and the interaction between users/citizens and the city.
3. Sensors—have to be intended not only in terms of technology, but also in terms of citizens to be able to actively participate in a bottom-up way to city activities and data production.

Such pillars need to be accompanied by an urban governance to be able to harmonize them and particularly to represent a set of minimum "driving rules," regulating a smart city in a neutral way, without entering too much into details concerning contents and applications developed by citizens, urban users, private companies, local associations, etc.

In such terms, a true smart city acts as an enabling platform for the activities that citizens are able to develop, linking those inherited from the past to those that can be realized in the future, so it is not focused just on applications but also on the possibility that citizens realize them.

But, now the problem is: how to practically deal with knowledge?

4.6 Rules for urban planning

Rules constitute a very important component of knowledge. In artificial intelligence, the representation of rules is based on several mathematical theories, such as classical logics. Moreover, according to Graham (2006) and Morgan (2008), rules should be considered as first-class citizens in computer science. In this section, first, generalities about geospatial rules are examined, and then some preliminary elements to get them machine processable are given.

4.6.1 Generalities about geospatial rules

Consider some examples of knowledge chunks in smart cities, some of them coming from physical laws, administrative regulations, or best practices (Laurini, 2020):

- When planning a metro, move underground networks.
- Each building must be connected to utility networks (water, electricity, gas, telephone, Internet, etc.).
- If a crossroad is dangerous, install traffic lights.
- In city centers, transform streets into pedestrian precincts.
- When a commercial mall is planned in the neighborhood of a city, shops located in the city center will be in jeopardy.
- If the number of car parking lots is insufficient, encourage using buses or bikes.
- At the vicinity of an airport, limit building heights.
- When a big plant is closing, unemployment will increase.

- At the vicinity of an historic building (listed monument), no modifications of building are allowed.
- When defining a new industrial area, unemployment will diminish.
- If a recreational park is inside a city, provide bike lanes coming to this park.
- In France, it is forbidden to open a new tobacconist shop within 500 m from an existing one.
- If there is one or several rivers crossing a city, design systems to mitigate floods.
- In a city with many hills, consider cable cars linking them.

Unlike business rules, which are encoded with logic, those geospatial rules need to integrate computational geometry, topology, and operation research (especially for looking for optimum).

Generally, the implementation of rules is based on two grammatical structures: IF-THEN-Fact and IF-THEN-Action (Ross, 2011). The first serves above all to involve new facts, that is, for us, new objects, attribute values, and new relationships between geographic objects. And the second is to involve new actions. But who will be in charge of such new actions? In some cases, the computer itself may run procedures; in others, particularly in regulatory contexts, a decision maker (for example, the Mayor of a municipality) must himself initiate the action. Another interpretation could be the choice of alternatives of an action, for example, when a law, in some well-defined contexts, opens many perspectives.

4.6.2 Languages for rule encoding

Several languages to model rules exist. For instance, Boley, Paschke, and Shafiq (2010) suggested several XML extensions to model rules. The simplest of these is as follows:

```
<Implies>
        <if>
                <..>
        </if>
        <then>
                <..>
        </then>
</Implies>
```

Laurini (2019) proposed a mathematical language for rule encoding, but not yet a computer language, essentially because it depends on the structuring of geographic knowledge base and system in use. This language can be simplified with the following specifications:

- Antecedents will be represented as a context with quantifiers ("∃" or "∀") followed by the symbol ":" and some Boolean expressions to model conditions.
- The symbol "⇒" when the implication is mandatory.
- Consequents (as acts or actions); if there are many, they will be parenthesized by "{" and "}," and each separated by ";".

But rules will be based on different elements which constitute a spatial knowledge base, namely, geographic objects (identifiers, toponyms, geometry, and attributes), gazetteer, ontologies, external knowledge, etc. (see Laurini, 2017 for more details). Consider a place *P*, we will denote its geometry by *geom* (*P*), and its name by *Topo* (*P*). In addition, there are conventional topological relations (contains, meet, etc.) and geometric functions (union, centroid, buffer, etc.).

4.6.3 Example: Projected buildings and urban planning rules

To illustrate, let us take an example in planning zones as depicted in Fig. 6, each with its own regulations. For instance, campsites are not allowed in Downtown. To simplify, three zones are defined, Downtown (*ZoneA*), suburban area (*ZoneB*), and rural area (*ZoneC*). However, historical monuments are located downtown, and it is forbidden to construct new buildings around them (for instance, within 200 m). In the rural area, there is an airport for which some limitations exist.

Let us begin by *ZoneB*, which is the simpler rule in which building height is limited to 15 m.

$$
\begin{gathered}
\exists\, C \in City,\ \exists\, ZoneB \in Terr,\ \forall\, B \in Project.Building,\ \forall\, P \in Parcel,\\
Topo\,(C) \equiv \text{"Smart Town,"}\\
Topo\,(ZoneB) \equiv \text{"Suburban Area"}\\
\models Contains\,(Geom\,(C),\ Geom\,(ZoneB)),\\
\models Contains\,(Geom\,(ZoneB),\ Geom\,(P)),\\
\models Contains\,(Geom\,(P),\ Geom\,(B))\\
:\\
B.Height \le 15\\
\wedge\ Area\,(Union\,(Geom\,(Floors)))/Area\,(Geom\,(P)) \le 4\\
\wedge\ Area\,(B)/\,Area(Geom\,(P)) \le 0.70\\
\Rightarrow\\
\models B.ZoneB\_Approved \blacksquare
\end{gathered}
$$

Rule 1

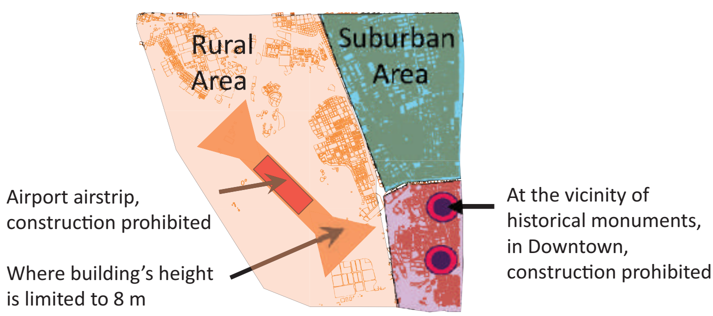

FIG. 6 Planning zones.

For Downtown (*ZoneA*), it is more complicated because of the buffer zones of 200 m around historical buildings.

$$\begin{gathered}
\exists\, C \in City,\ \exists\, ZoneA, ConservA \in Terr,\ \forall\, B \in Project.Building,\\
\forall\, P \in Parcel,\ \forall\, M \in Monuments,\\
Topo\ (C) \equiv \text{"Smart Town,"}\\
\text{Topo}\ (ZoneA) \equiv \text{"Downtown,"}\\
Geom\ (ConservA) \equiv Union\ (Buffer\ (Centroid\ (Geom(M), 200))),\\
\models Contains\ (Geom\ (C), Geom\ (ZoneB)),\\
\models Contains\ (Minus\ (Geom\ (ZoneA), Geom\ (ConservA)), Geom\ (P)),\\
\models Contains\ (Geom\ (P), Geom\ (B))\\
:\\
B.Height \leq 12\\
\wedge\ Area\ (Union\ (Geom\ (Floors)))/Area\ (Geom\ (P)) \leq 3\\
\wedge\ Area\ (B)/\ Area(Geom\ (P)) \leq 0.80\\
\Rightarrow\\
\models B.ZoneA_Approved \blacksquare
\end{gathered}$$

Rule 2

For the Rural Area, taking the airport into consideration, we need to consider three areas: the area outside the airport, the airstrip in which any building is forbidden, and finally in the "bowtie" with additional limits (Rule 3). Technically speaking, we have to use an "exclusive or," noted ⊕ between those three possibilities.

$$\begin{gathered}
\exists\, C \in City,\ \exists\, ZoneC, Bowtie, Airstrip \in Terr,\\
\forall\, B \in Project.Building,\\
\forall\, P \in Parcel,\\
Topo\ (C) \equiv \text{"Smart Town,"}\\
Topo\ (ZoneA) \equiv \text{"Rural Area,"}\\
Geom\ (Bowtie) = Polyg\ (640, 243; 657, 290; 748, 387; 796, 405; 743, 459; 729, 406; 636, 316; 580, 297),\\
Geom\ (Airstrip) = Polyg\ (670, 311; 724, 365; 707, 386; 650, 330),\\
\models Contains\ (Geom\ (C), Geom\ (ZoneC)),\\
\models Contains\ (Geom\ (P), Geom\ (B))\\
:\\
(Contains\ (Minus\ (Geom\ (ZoneC), Geom\ (Bowtie)), Geom\ (B)),\\
\wedge\ B.Height \leq 12 \wedge Area\ (Union\ (Geom\ (Floors)))/Area\ (Geom\ (P)) \leq 0.5\\
\wedge\ Area\ (B)/\ Area\ (Geom\ (P)) \leq 0.30\ )\\
\oplus\ Disjoint\ (\text{Geom}\ (Airstrip), Geom\ (B))\\
\oplus\ (Contains\ (Geom\ (Bowtie)), Geom\ (B))\\
\wedge\ B.Height \leq 8 \wedge Area\ (Union\ (Geom\ (B.Floor)))/Area\ (Geom\ (P)) \leq 0.5\\
\wedge\ Area\ (B)/\ Area\ (Geom\ (P)) \leq 0.30)\\
\Rightarrow\\
\models B.ZoneC_Approved \blacksquare
\end{gathered}$$

Rule 3

5. Conclusions

An article published in The Wall Street Journal explains how US major metropolitan areas produce a higher GDP than the economies of entire nations. Urbanization is also different in terms of city size classes in the two areas. In

Europe, 67% of urban inhabitants live in medium-size urban centers, less than 500,000 inhabitants, while just 9.6% are located in cities having more than 5 million inhabitants. In the United States, one out of five urban inhabitants lives in major cities having more than 5 million people. Consequently, it is very easy to understand that, despite common opinions against the quality of life in big cities, in most cases living in large cities becomes a necessity. Glaeser (2011) defines the city as the greatest invention of mankind. Using the advantages of the agglomeration principle, a city emphasizes the strengths of a society. Despite the evolution of modern and contemporary cities having led to disadvantages resulting from congestion, urban poverty, and security, living today in an urban context, even one that is not of high quality, involves more benefits than living in remote areas. Consequently, cities play a central role for humanity, offering the opportunity to learn from each other, face to face. Despite economic contexts and production patterns having been radically changed, a city always represents the most vital element of the economy of a nation. Generally, in every developed country, cities are the economic heart and the most densely populated places, very attractive for people who want to exchange or build knowledge because cities have the capability to provide something for everybody, only because, and only when, they are created by everybody (Jacobs, 1961). Batty (2013) defines cities as kaleidoscopes of plurality, a multiplicity of ideas, perceptions, theories, and models. Consequently, cities can be considered as an enabling environment where it is possible to create, build, and exchange knowledge.

Most recent events seem to put in crisis that point of view, even if it is day by day, it is diffused and appreciated as we consider cities also a concentration of problems, and a hypothesis to check whether a good relationship is possible between city and nature or scattered settlements. As complexity that this question poses, is truly relevant, any effort has to be produced by scientific research; maybe an effort is needed to deal with a renovated approach to a large-scale planning, i.e., a renovated approach to strategic planning where actions are strictly depending on objectives, and spatial transformation to economy development. In particular Archibugi (2008) declares that the goal is a well-founded activity based on an accountable approach that respects carefully the legitimacy of the request to use resources in a rational way, i.e., the best compromise among equity, efficiency, and natural resources conservation. Finally, the path to the city of knowledge will be a sort of cross-fertilization between economy, education, and urban planning based on public participation.

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