Smart cities, smart people, smart planning

Antonio Leone*

Abstract

The paper starts from the evidence, in many cases, of confusion between smart city with digital one, while the real goal of a smart city should not consist in filling the city with electronic toys, but taking care of the whole urban environment in a clever way. In this sense, smart city is a pleonasm, because cities have always been smart, also if, recently, they have lost their smartness.
After discussing these concepts, this paper proposes a wider smart city approach, aimed at environmental sustainability, through the prevention and treatment of urban pathologies. Based also on thermodynamics concepts, the paper illustrates how to prevent environmental pathologies, because a really smart city controls and constantly checks its metabolism.

Keywords

Smart city, Environmental processes, Thermodynamics thinking.

Introduction

Cities are becoming more and more the center of worldwide development, not only from an economic point of view, but also from a social and civil one. This on-going urbanization process is a well-established fact, the world's urban population having recently (in 2009) overtaken the rural population. Cities have always been the center of human civilization and development,

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* DAFNE Department, Tuscia University, Viterbo (Italy)

but this new scenario presents another, greater, challenge for cities, whose most important capital (environmental, intellectual and social) needs to be strengthened, rather than physical capital (houses and infrastructures).

The birth of the "smart city" concept dates back to 2007, thanks to European Union and its energy management policies, aimed at fighting energy waste and reducing greenhouse gas emissions (Franz, 2012). Models to evaluate the smartness of a territory have also been devised, such as Allen's Smart Growth Index (Allen 2001), developed to characterize existing or proposed developments, by elaborating GIS data inputs.

Thus, this is an encompassing concept today, in some cases exaggeratedly so, which embraces all modern urban factors in the planning and designing of a city. Smart(er) cities have also been used as a marketing concept by companies and by the cities themselves, as a territory brand.

The focus of the "smart city" concept consists also in the growing importance of Information and Communication Technologies (ICTs), which should be aimed at increasing social and environmental capital (by community governance: Camarda, 2012), not simply considered a value in itself. This is the fundamental difference between smart cities and digital cities.

ICTs' role consists in shortening the distance between individual citizens and between citizens and administration, i.e. the construction of a modern *agorà*, a public meeting place where people can participate in decision processes, access knowledge and training, take part in the social life, debate modalities of exercising rights, manage and control territorial transformations. All these actions aim both to ameliorate urban quality of life, and to meet the EU's 20/20/20 objectives in terms of environmental sustainability: energy saving and amelioration of the whole urban environment (improving urban air quality, climate mitigation, rainwater runoff management and biodiversity increasing).

To achieve these aims, a change in the organization of urban spaces (and consequently in cities' planning and governance) is necessary. The new urban development should not be based on vertical ICT solutions, leaving an unsustainable sea of systems and market islands (Hernández-Muñoz et al., 2011).

Pursuing the goal of a smart city does not entail filling the city with electronic toys, but taking care of the whole urban environment. In this sense, *smart city* is a pleonasm, an exotic term intended to draw away attention from the current urban planning crisis. Too often the term *smart city* is spoken of as a new approach to city management and planning, while, traditionally, cities have always been *smart* and only recently have lost their *smartness*, due to mismanagement. Above all in Italy (Scattoni, 2004), the actual roots of cities lie in the Middle Ages and their consolidation in the Renaissance, as a consequence of precise human needs, strongly interacting with the environmental context and related processes. This guarantees balanced and "elegant" (synonymous for "smart") land evolution, the key for construction of the Italian landscape, a strong characteristic of this country (Leone, 2007). It is no accident that the concept of "elegance" is related to that of perception, and perception is what distinguishes landscape from physical territory (Diamantini, 2013).

How we perceive a landscape is its characterizing factor, its Aristotelian quintessence, greater than the sum of physical and social factors.

After discussing the *smart city* concept, in actual town planning practice, this paper proposes a wider *smart city* approach, aimed at environmental sustainability, through the prevention and treatment of urban pathologies. Pursuing these goals, it is necessary to work on causes, because a really smart city controls and constantly checks its metabolism, considering the whole territory, both urban and rural.

Discussion

Semantic pinpoint: What is smart? What is clever?

First of all, a semantic specification: smartness and cleverness are synonyms in common speech, and, probably, the former is an Americanism. Nevertheless, slight differences can be stressed: clever indicates a problem solving capacity, the ability to elaborate robust solutions, which are the result of a deep reflection and analysis; smart is the quick and competitive intelligence. For example, smartness is the ability to learn rapidly rules, while cleverness is the ability to speculate about the reasons behind the rules. Both these kind of intelligences are important, but, surely, true intelligence is the ability to think beyond common thoughts, to pursue not only individual aims, but also collective desires, at the same time avoiding extravagance. An example of the greater intelligence is that of great innovators, who think up great new concepts, which nobody has been able to envisage before. True intelligence is visionary, but sufficiently humble to distinguish dream from reality.

At town and regional planning level, this means pursuing the best urban and territorial organization, to guarantee an optimal habitat for humans and other species[1], distinguishing the proper measure of the dream, from what is actually achievable in the assigned time.

Cleverness is necessary to define strategies, it is reflective and empathic, able to pursue complexity, because only complex systems can generate a place's identity. But complexity is immaterial and eludes milestones of deterministic science: measurability and slavish repeatability. In consequence, complex systems cannot be built in a deterministic way, like a material thing. It is the value of the whole which is greater than sum of the parts; the difference between the value of a system and the sum of each of the system's component values; in one word: the Aristotelian quintessence. If this difference is algebraically less than zero, the system is poor and unstable and it will never develop an identity. If this difference is greater than zero, the system will reach the right equilibrium (increasing entropy is controlled) and perturbations (for example: a new organization planned) will sediment. In the latter case, when the dust bloom and the use signs are defined (Peregalli, 2011), a new, appreciated identity will characterize places. A new, appreciated, landscape (the region's DNA: Chaudhuri and Clarke, 2013) will be born.

The time factor is fundamental for this process and, necessarily, a long time is required, just as the DNA of a living species takes

a long time to evolve. Only cleverness can interpret this, while smartness can help to seize opportunities for realizing single projects, to collect the bricks necessary for the complex building.
In this sense, another parallel with biological systems appears significant: ecological systems are at the top of the scale of complexity, due to the dynamic equilibrium defined by the age-long struggle among conservation factors of individuals (and related food chains) and the dominance of stronger species over weaker ones. Each individual fights the struggle through tactics and smartness, quick and competitive, with short time effects, lacking any concern for the context. Cleverness lies, rather, in instincts which are the result of a long process of evolution and transcend the individual and are concerned with the more relevant problem of species conservation.
On a parallel with physical sciences, the environment can be represented as a field of forces, with which individuals and species have to interact to pursue their aims: tactical for the former (individual survival) and strategic (a long time species conservation) for the latter. These behaviours generate the ecosystem's complexity, by symbiosis, adaptation, accumulation of resources etc.
Two more cornerstones of ecosystems characteristics are:

1) The very low efficiency of energy supply in biological systems. All species need energy, whose unique source is solar radiation, collected by chlorophyll-based photosynthesis. The efficiency of this process is around 1% (Blankenship et al., 2011), surprisingly low, at least by human technological standards. However, this is not a problem, rather it is an opportunity, because this low efficiency is the tool for building ecosystems' complexity. In fact, it forces species to adopt behaviours such as symbiosis, adaptation and accumulation of resources. Paradoxically, if photosynthesis had higher efficiency in collecting solar energy (for example 35-40% like that of human power plants, a level still considered too low by technocrats), complexity would be not so necessary and biodiversity would be much lower. In consequence, probably, the evolved human species would never have appeared.

2) "Errors" and defects in reproduction. No individual reproductive event ever respects perfectly the deterministic low of 50% of parental genetic inheritance: each reproductive event has "mismatches" and generates specificities, which are randomly distributed and will be measured against the context. Environment (by means of its force fields) will regulate errors and defects, rewarding or penalizing them. In this way, the system evolves by a dynamic equilibrium, in a way that progressively increases its robustness (resilience) and complexity; it can expect a series of different opportunities, that allow the transcendence of changes and adversities, benefitting the community, rather than individuals.

The lesson for urban and regional system planning and management consists in considering the deterministic approach, where all is foreseeable and programmable into a plan, in the light of a chimera. A model of linear, simple systems (typical of the Newtonian reality) can be considered "perfect", i.e. the model foresees very well where a missile propelled with a known acceleration and angle will fall. On the contrary, a model of a complex system should be used with much more caution, because it can interpret only one of the set of possible, randomly distributed solutions. In these cases, to think deterministically, accrediting as sure what is only one of several solutions, leads to disaster. The example of the Wall Street 2007 collapse, and the role that misused very sophisticated mathematic models played in it, is very significant (Derman, 2011).

Mirroring this, the technologies connected to the smart city approach, are only useful provided that they are instruments rather than aims.The Lorenz (1963) "butterfly effect"[2] explains this concept very well. On the other hand, it is necessary to prevent the opposite error, throwing out the baby with the bath water: mathematical models and technologies are very useful, provided that manager is awarded of their limits.For example, models can be very useful for assessing the set of best management practices (BMPs), to simulate each BMP behaviour in the environment. Later, it is necessary to be aware that the system will adapt to the BMPs set in a way that is not completely foreseeable. However, this is not important, because, if each

BMP pursues righteousness, the new landscape organization coming from the BMPs set, surely will produce a virtuous combination; not completely foreseeable, but surely virtuous. In terms of smart cities, if each BMP is smart, the system where BMPs are implemented creates a better quality than the sum of the single BMPs' quality, i.e. it provides the quintessence of a 'clever', complex system.

Why smart cities

The current necessity to build smart cities derives from the loss of traditional human development which took local resources into consideration; these forgotten traditions offer the key to a new quality landscape building. This is particularly true in the Mediterranean area, whose great and unique physical diversity generated biological and social diversities and a very high and unique landscape identity, a way of life and of managing territory that is surely sustainable. On the contrary, all modern age development is based increasingly on allochthonous resources, considered indefinite, and it is blind to the second law of thermodynamics (fig.1). This generated a diatribe among Mediterranean (and, in general, among the world's south-east) way of life and the north-west way of life (Cassano, 1996), this latter considered more modern and productive, but also blind to the second law of thermodynamics and affected of a deep crisis. A new development paradigm is then necessary and world's south-east can offer an opportunity.
Figure 1 shows a scheme useful for clarifying these concepts. Landscape is the consequence of the interactions among production systems (agriculture, livestock and forest) and the consumer system (city). In the tradition scheme, all systems are connected and all interact functionally and their functionality is the insurance of a good equilibrium. Wood is sacred in all pre-modern cultures, above all northern ones, because wood is the main energy supply and, without energy, it is not possible to survive winter. Furthermore, wood is an insurance against famine, both forage for livestock, but also food for humans, in extreme cases (Licinio, 1998).

At about the time of the industrial revolution, when western society discovered fossil fuels (the equivalent of infinite woods, the sum of the carbon accumulation of all geological ages) Man was inebriated by this abundance, planning the future and developing society on the axiom of unlimited energy availability and related the unlimited "development".
Indeed, this model works well, as does the Newtonian- model for simple systems such as the missile example referred to previously (Scandurra, 1995). Today, this model is at the end of its cycle and it is easy to understand that two centuries of (western style) human "development" is unsustainable and new paradigms are necessary.
These thoughts should not be confused with fogydom, a refusal to accept modernity, they affirm that the "development" of the last two centuries has been too blind to complexity, which can be rediscovered by looking at tradition systems. For example, the systems of tradition in fig. 1 "produced" the Italian landscapes, with their unequivocal identity, recognized worldwide. Thus, the current landscape crisis is the crisis of the traditional-complexity generator systems and no plan can solve this dilemma if complex thinking and aging is not rediscovered.
A more substantial development is necessary, which takes into account the second law of thermodynamics and the concept of entropy. From this point of view, what mechanist man calls "error" is, in fact, only the consequence of complex system unpredictability. If a system is robust, it can adapt to "errors" and, furthermore, if they prove to be more functional, the system transforms them into opportunities. In this way a sustainable dynamic equilibrium is achieved.
The time factor is fundamental; for example, technically, plants and livestock are genetically modified organisms (OGM), derived from the millenary selection practiced by humans and random variations ("errors"). The difference from the present day, industrially produced OGM is the time factor, because OGM are developed in laboratories over a very short time and are technologically perfect, but they do not have the quintessence, i.e. the cultural contents, that only slow evolution, with its continuous adaptations, allows. Consequently, a system based on

OGM is not dangerous because it is "toxic", but worse than toxic: it is very simple and fragile, much more sensitive and unprepared to face unexpected events.

Hence, it seems clear how these concepts translate into the context of town and land planning.

The following points summarize the general, gross organization of the territories of a liberalist economy:

- mono-functional cities, based on the maximum exploitation of land property income (and the related myth: private transport by car), even though they are very rich in technological infrastructures, they will be always poor and fragile;
- territories simplified by specialized, mono-functional agriculture, more and more dependent on agrochemicals and laboratory-OGM;
- abandoned wood and rangeland.

This type of order does not develop quintessence, and its related complexity and organicity. In the short term, this organization may allow an economy to grow, but, in the long term, a high entropic price must be paid for such growth.

Empiric evidence supporting these statements is clear, as demonstrated by the current economic crisis, city crisis, landscape crisis, pollution of natural resources and hydro-geological break down of the territory. Cities and territories have to be technologically smart, but first of all should be clever, being sufficiently complex, i.e. robust, resilient and rich in quintessence.

How to create smart cities

Smartness is easy to pursue, but not so easy to put into practice, because it requires a radical change of thinking. First of all, strategy is necessary, pursuing the cleverness typical of ecosystems: open systems (in the thermodynamic sense), connected by matter and energy exchanges; where symbiotic mechanisms are established and, above all, the concept of waste is unknown. It is then possible to pursue anti-entropy and to slow the inexorable increase in disorder (i.e. the system's death).

Another cleverness milestone comes from thinking about efficiency, i.e. the ratio between work produced and energy input. Thinking in a Newtonian-linear way, the main aim is to pursue maximum efficiency, with the mirage of reaching values closer to 100%, thanks to technological development. By following this utopia, the second law of thermodynamics (the entropy law) is forgotten, so that the order created in a limited part of the earth system (specifically, the north-west region of the world) causes a higher disorder in another part of the same system (the south-east region).
Thinking about ecological systems, on the contrary, shows us that efficiency in energy use is not very important, as the whole of Earth's evolution, until *Homo sapiens*, demonstrates. Much more relevant is the capacity to build complex systems, characterized by lots of synapses, which are consequently robust and dynamic, able to transform accidents into opportunities.
The first law of thermodynamics is written as follows:

$$\triangle U = Q - W$$

where $\triangle U$ is the system's internal energy variation, Q the exchanged heat, W the work done by the system. In fig. 2 there is a scheme of the most famous interpretation of this law, which is Carnot's theorem.
In the Newtonian-simple approach, the focus is on the produced work W, that should be as high as possible. It is perfectly logical, because the aim of Carnot's law is to build "simple" machines. This is smart because machines allow humans the opportunity for a cheap, great empowerment and, really, this capacity was one of the first industrial revolution milestones. It was effectively "smart".
Carnot's law, schematized in fig. 2, allows an interesting parallel: for "simple-smart" machines the focus is on W: the smarter the machine, the higher is W, and the related efficiency in energy transformation of work. On the other hand, for "complex-clever" systems the focus is on Q_c, in particular on the system's ability to utilize Q_c, transforming it in a resource, while, for

Carnot's machine, it is only a waste, a factor of efficiency reduction.
A practical approach to this concept is reported in figure 3 (modified from Rydin et al., 2012), where a scheme of the integration of rural and town systems is reported. It shows how wastes and local resources use can built a complex landscape.
Generalizing: "smart-simple" is represented by physical infrastructures, encompassing also information and communication technologies (ICTs); "clever-complex" is represented by the strategies that increase human social and environmental capital, also thanks to physical infrastructures and ICTs.
Information is energy of high quality (transformable in any other kind of energy) and communication gives robustness to the system. ICTs give smartness if they can pursue these aims, expanding urban space (summing digital space to the physical one), where it is easier for citizens to participate in urban development, increasing its synapses. In this way it is possible to shift from a hierarchical organization of separate components, to a complex system, that grows simulating ecosystems, where what is waste for one component, can be a resource for another component.
This is not a novelty, because the "traditional" systems of fig. 1, even if unconsciously, pursued this approach: work W was modest, but wastes and pollution were absent, thanks to interacting sub-systems, for which there is always a part of the system that can metabolize and/or reuse what is waste for another.
Hence, the challenge for the future consists in saving the baby and dumping the bath water: maintaining what is good of modernity (high W), thanks to technology, but consider that it is no longer sufficient for present and future needs, since a more organic world development is required.
Mutatis mutandis, the future paradigm is ambitious: to conserve technological level to keep high W values, typical of the modernity, but also to rediscover complexity, reducing Q_c, typical of tradition.

Another question emerging from these considerations is the necessity to enlarge the smart city's concept to a more holistic vision of sustainability. In fact, the current smart city approach is prevalently aimed to energy saving and reducing greenhouse gas emissions. It is also necessary to consider further environmental questions: water (quantity saving and quality amelioration), air pollution prevention, soil conservation, increasing biodiversity etc.
This is the challenge for a really smart-clever city, this is smart-clever social development.

Conclusions: Smart and non-smart

Energy supply

Cities are great energy consumers and consequently great greenhouse gas producers. While green economy is undoubtedly smart, the trap of oversimplification must be avoided: complexity (cleverness) is also necessary. Hence:
- *Smart/clever*: a) saving energy by building renovation and reutilization; b) diffuse energy production and proximity between production and consumption; c) *Second Law Thinking and Acting*: thinking and planning considering the laws of thermodynamics, minimizing entropy and energy losses, building synapses, utilizing energy residues (heat cascades), thanks to synapses.
- *Non-smart* is the green economy that apes the traditional energy supply approach, but with high concentrations: solar fields, wind parks, no-food crops etc. These productions may avoid new CO_2 air emissions, but are not able to create complexity and, in fact, have high environmental and landscape impacts.

Green and blue infrastructures

The greatest contemporary (and future) city challenges are urban environmental care and green and blue infrastructures, probably the only reformist innovation of last decades of planning crisis. Much more than aesthetics and amenities, green infrastructures are cities' stomach and lungs, fundamental complexity factors, because green infrastructures can lead to the control of flashfloods and extreme climatic events, to the prevention of pollution, to local biomass energy production and to biodiversity.

Together with blue infrastructures, green infrastructures are cities' main metabolising factors.

Planning, designing and managing green and blue infrastructures is not a question of simply planting and a return to an idyllic Arcadia, but of complex managing and technological challenge, above all necessary in consolidated cities.

– *Smart/clever* is the multifunctional and integrated network of green and (above all) agricultural areas, connected and functional to the city, producing more services: a) increasing urban land permeability, leading to hydrological benefits and water quality tutelage; b) air dust and noise interception; c) urban heat island attenuation; d) biomass for energy production; e) the possibility of digesting some wastes; f) increasing biodiversity; e) increasing social capital, thanks to social opportunities coming from shared gardens. So many components contribute to building complexity.
– *Non-smart* is the green maquillage, unnatural vertical woods and crops climbing buildings, with all the serious problems of modern agriculture: specialist, monopolistic, heavy consumption of resources (water, energy, agro-chemicals), probably OGM-dependent, due to unnatural arrangement.
– *Non-smart* is the country integrated to the city in the worst way, losing its identity: no more food production, but houses and hovels.

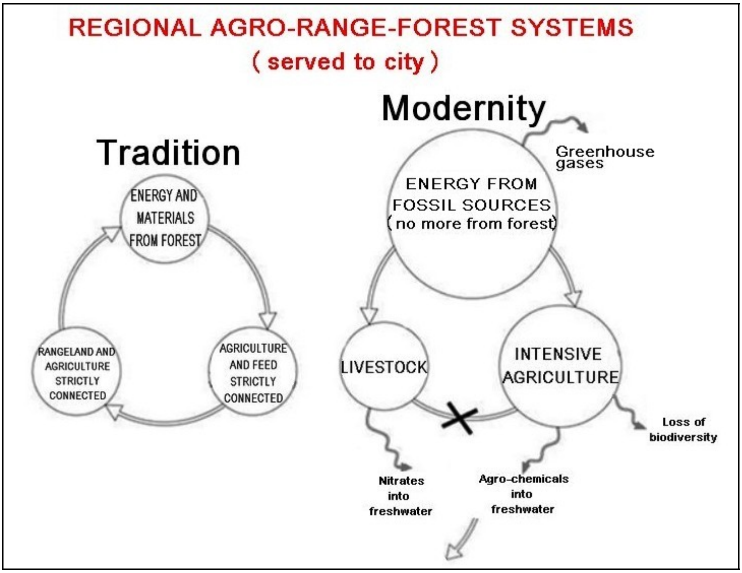

Figure 1: Schemes of regional systems

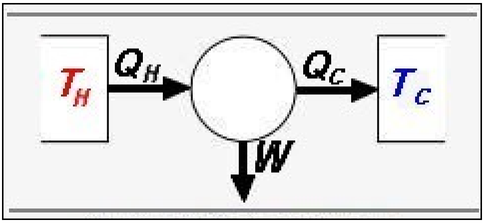

Figure 2: One of the many expressions of first thermodynamic law: the Carnot's principle

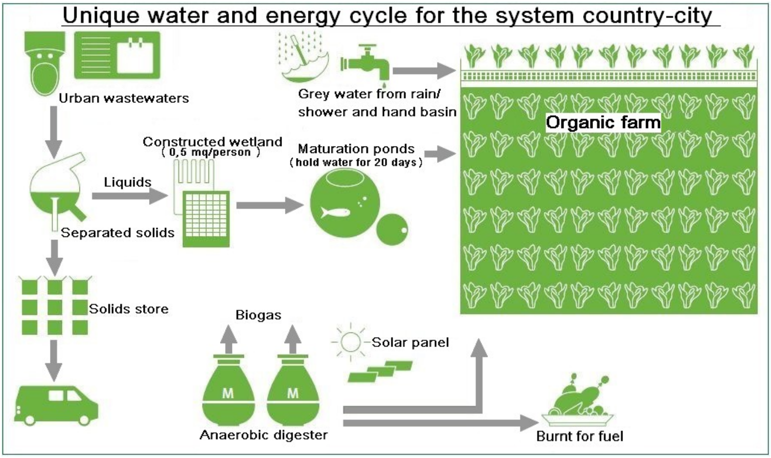

Figure 3: The creation of a virtuous cycle of connections with urban agriculture (after Rydin et al., 2012, modified)

[1] Landscape is man's habitat (Bevilacqua, 2009).
[2] The butterfly effect is the sensitive dependency on initial conditions in which a small change at one place (a butterfly beat in Brazil), in a nonlinear (complex) system, can result in large differences in a later state (a hurricane in Texas).

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