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This special issue collects a selection of peer-review papers presented at the 8th International Conference INPUT 2014 titled "Smart City: planning for energy, transportation and sustainability of urban systems", held on 4-6 June in Naples, Italy. The issue includes recent developments on the theme of relationship between innovation and city management and planning.

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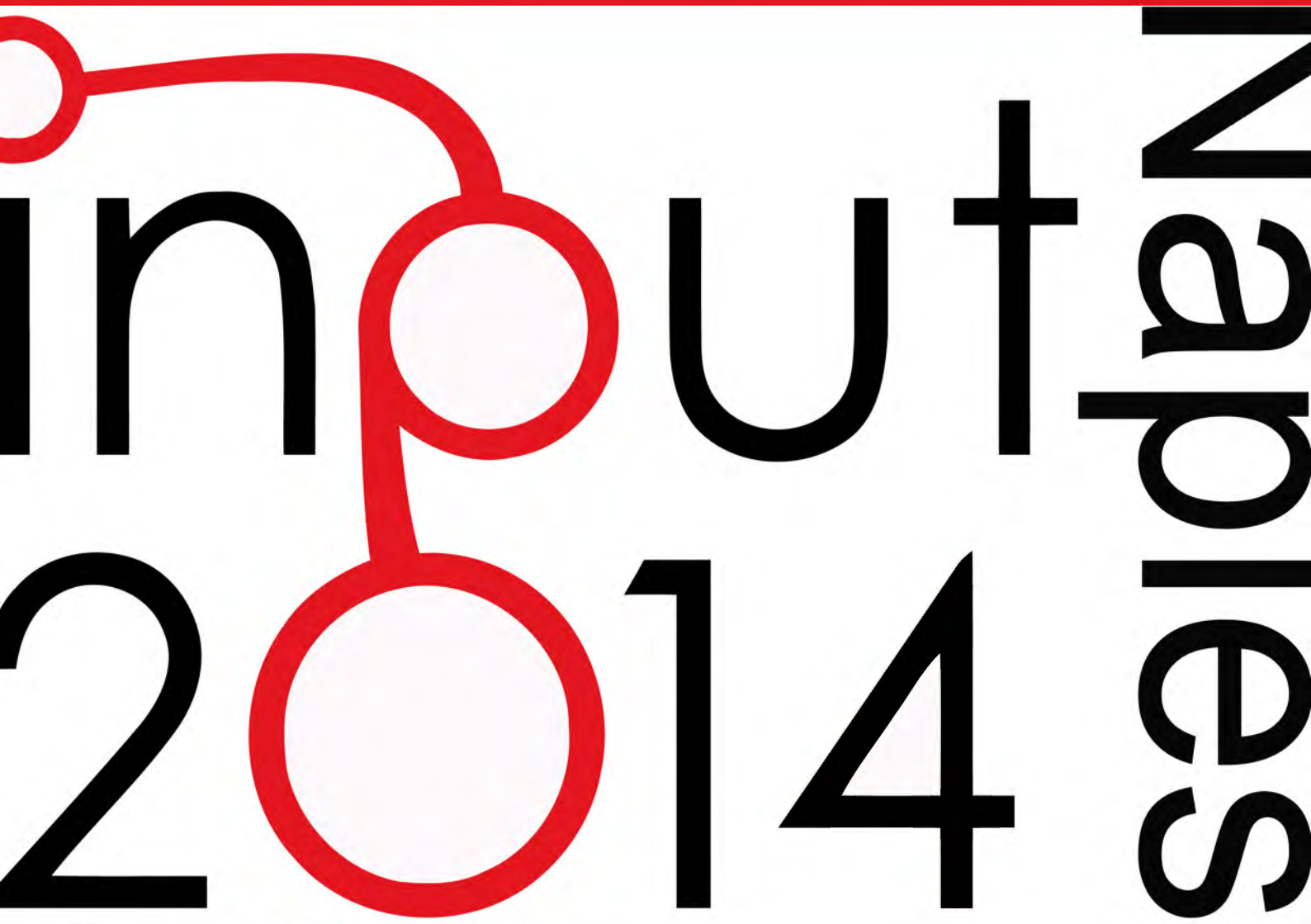

Smart City

planning for energy, transportation and sustainability of the urban system

Special issue, June 2014

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SMART CITY

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Laboratory of Land Use Mobility and Environment
DICEA - Department of Civil, Architectural and Environmental Engineering
University of Naples "Federico II"
Piazzale Tecchio, 80
80125 Naples
web: www.tema.unina.it
e-mail: redazione.tema@unina.it

TeMA Journal of Land Use, Mobility and Environment

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TeMA Journal of Land Use, Mobility and Environment

This special issue of TeMA collects the papers presented at the 8th International Conference INPUT 2014 which will take place in Naples from 4th to 6th June. The Conference focuses on one of the central topics within the urban studies debate and combines, in a new perspective, researches concerning the relationship between innovation and management of city changing.

TeMA Journal of Land Use, Mobility and Environment

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EIGHTH INTERNATIONAL CONFERENCE INPUT 2014

SMART CITY. PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

This special issue of TeMA collects the papers presented at the Eighth International Conference INPUT, 2014, titled "Smart City. Planning for energy, transportation and sustainability of the urban system" that takes place in Naples from 4 to 6 of June 2014.

INPUT (Innovation in Urban Planning and Territorial) consists of an informal group/network of academic researchers Italians and foreigners working in several areas related to urban and territorial planning. Starting from the first conference, held in Venice in 1999, INPUT has represented an opportunity to reflect on the use of Information and Communication Technologies (ICTs) as key planning support tools. The theme of the eighth conference focuses on one of the most topical debate of urban studies that combines , in a new perspective, researches concerning the relationship between innovation (technological, methodological, of process etc..) and the management of the changes of the city. The Smart City is also currently the most investigated subject by TeMA that with this number is intended to provide a broad overview of the research activities currently in place in Italy and a number of European countries. Naples, with its tradition of studies in this particular research field, represents the best place to review progress on what is being done and try to identify some structural elements of a planning approach.

Furthermore the conference has represented the ideal space of mind comparison and ideas exchanging about a number of topics like: planning support systems, models to geo-design, qualitative cognitive models and formal ontologies, smart mobility and urban transport, Visualization and spatial perception in urban planning innovative processes for urban regeneration, smart city and smart citizen, the Smart Energy Master project, urban entropy and evaluation in urban planning, etc..

The conference INPUT Naples 2014 were sent 84 papers, through a computerized procedure using the website www.input2014.it . The papers were subjected to a series of monitoring and control operations. The first fundamental phase saw the submission of the papers to reviewers. To enable a blind procedure the papers have been checked in advance, in order to eliminate any reference to the authors. The review was carried out on a form set up by the local scientific committee. The review forms received were sent to the authors who have adapted the papers, in a more or less extensive way, on the base of the received comments. At this point (third stage), the new version of the paper was subjected to control for to standardize the content to the layout required for the publication within TeMA. In parallel, the Local Scientific Committee, along with the Editorial Board of the magazine, has provided to the technical operation on the site TeMA (insertion of data for the indexing and insertion of pdf version of the papers). In the light of the time's shortness and of the high number of contributions the Local Scientific Committee decided to publish the papers by applying some simplifies compared with the normal procedures used by TeMA. Specifically:

- Each paper was equipped with cover, TeMA Editorial Advisory Board, INPUT Scientific Committee, introductory page of INPUT 2014 and summary;
- Summary and sorting of the papers are in alphabetical order, based on the surname of the first author;
- Each paper is indexed with own DOI codex which can be found in the electronic version on TeMA website (www.tema.unina.it). The codex is not present on the pdf version of the papers.

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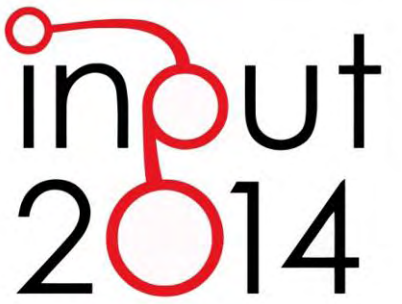


SUSTAINABILITY AND PLANNING

THINKING AND ACTING ACCORDING TO THERMODINAMICS LAWS

ANTONIO LEONE[a], FEDERICA GOBATTONI[b], RAFFAELE PELOROSSO[c]

[a, b, c] DAFNE Department, Tuscia University, Italy
e-mail: [a] pelorosso@unitus.it
[b] f.gobattoni@unitus.it;
[c] leone@unitus.it

ABSTRACT
The paper deals with environmental sustainability, in terms of intrinsic vulnerability and thermodynamics laws concepts, applied to urban green infrastructures. This approach gives also the track to build more resilient and complex landscapes. Integrating intrinsic vulnerability and thermodynamics laws concepts, an effective strategy could be conceived to face best management practices in planning more sustainable and healthy cities.

KEYWORDS
Landscape sustainability, Urban planning , Ecosystem Services, Second Law of Thermodynamics, Resilience

1 INTRODUCTION

Environment is a fundamental pillar of sustainability science (Ahern 2012), usually handled by planners with different point of view and sectoral approaches that could lead to an heterogeneity of assessments and, sometimes, to the lack of a holistic vision required by an effective sustainable development. For instance, residence buildings with high energy saving performances are usually defined sustainable even if any attention is not paid to other environmental, landscape and social characteristics. Indeed, the LEED certification (the U.S. national standard for the evaluation of buildings' sustainability) primarily deals with the architectural objects and not with the larger scale of the processes (landscape/territory scale) involving towns and cities.

To pursue a more holistic approach, much more attention should be focused on contexts' specificities, investigating the interaction between Environmental Intrinsic Vulnerability (EIV) and related human actions.

This paper reports some discussions aimed to increase awareness on environmental sustainability concept applied to urban environment, by two synergic strategies related to greening: increasing EIV and thinking (and planning) having thermodynamics laws as a reference.

1.1 SUSTAINABILITY AND PLANNING

EIV is defined as an inherent property of an environmental system which determines its sensitivity to external actions. This definition integrates and, in part, juxtaposes the definition of resilience, which is the property of environmental systems to absorb disturbances or changes, still maintaining its functional and structural characteristics (Ahern 2012).

The combination of EIV degree with human action degree defines the real risk.

This formulation can also be interpreted as an operative contribution to the evaluation of Rees and Wackernagel (1996) ecological footprint, where: human action is the print (load on the environment) and EIV is the environmental stretchiness (print entity) or carrying capacity.

As a consequence, environmental impacts are always specific, due to the different combinations between EIV (that can be «high», «medium» or «low») and anthropic load that, independently by EIV, can be «high», «medium» or «low». Not necessarily a high load generates relevant environmental impacts, if EIV is «low» (high carrying capacity); vice versa, a «medium» or «low» load can generate high impacts if the environment is highly vulnerable.

Considering a typical approach of Building Science, the following symbolic sustainability equation could be formulated:

$$\sigma \leq k \times \sigma_{amm} \qquad (1)$$

where σ is the effective stress, i.e. the load on the environment or the unitary weight that generates the ecological footprint; σ_{amm} is the admissible stress (or intrinsic vulnerability or carrying capacity of the environment), depending on the environment sensitivity to external actions; k is a safety coefficient, always less than 1 and as far minor as lower is the acceptable risk degree.

Stated these definitions, it is clear that σ and σ_{amm} descend from technical and scientific analyses, while k definition involves both technical and political spheres. In this sense, planning and sustainability are the same thing, if we consider the town planning definition by Salzano (2007), as the product of political decisions «technically supported».

1.2 THERMODYNAMICS AND NEW PLANNING PARADIGMS

Sustainability, intrinsic vulnerability and resilience are concepts usually related to complex systems, such as landscape and cities. These concepts are easy to define, but not so easy to put into practice, because it is necessary a radical change of thinking, and a consequent deep change in the society organization. Thermodynamics is probably the more structured science of complex systems and many concepts developed in this discipline found applications in other fields, such as ecology (Naveh 1987), sociology (Mckinney 2012), economy (Georgescu-Roegen 1998), Industrial ecology (Stremke, Van den Dobbelsteen and Koh 2011) and planning (Scandurra 1995; Pelorosso, Gobattoni, Lauriola and Leone 2014).

Thus, a strategy following the ecosystems behavior appears essential. Ecosystems are 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. In this way, it is possible to pursue anti-entropy and to slow the inexorable increase in disorder, i.e. the system's death.

Another sustainability milestone comes from thinking about efficiency, i.e. the ratio between produced work 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 causes a higher disorder in another part of the same system and, in general, to the whole Earth system (climatic change, for example).

Thinking about ecological systems, on the contrary, shows us that efficiency in energy use is not very important, as the whole of Earth evolution, until Homo sapiens, demonstrates. Indeed, the main natural energy supply is photosynthesis, whose efficiency is only 1% (Blankenship *et al.* 2011). In ecological systems, much more relevant than efficiency in energy use, is the capacity to build complex systems, characterized by a large amount of synapses, which are consequently robust and dynamic, able to transform accidents into opportunities.

The first law of thermodynamics is written as follows:

$$\triangle U = Q - W \qquad (2)$$

where $\triangle U$ is the variation of internal system energy, Q the exchanged heat (from a "hot" to a "cold" source), W is the work done by the system. In fig. 1 there is a scheme of the most famous interpretation of this law, which, integrated with the second thermodynamics law, allowed Carnot to formulate his theorem, about the perfect thermal machine working[1].

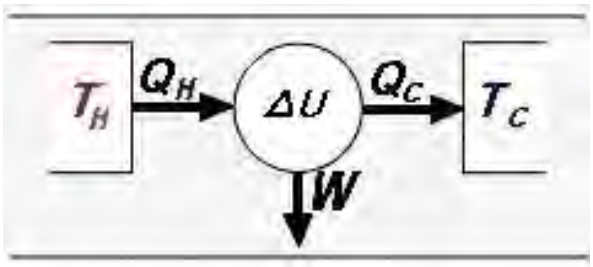


Fig. 1 One of the many expressions of the first thermodynamic law: the Carnot's principle

[1] For a further confirm of the chimera associated to efficiency concept, it can be considered the Carnot's theorem: also an hypothetical perfect machine cannot have a 100% efficiency.

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" and "smart" machines, producing work for human development. They are smart because they provide the opportunity for a cheap, great empowerment and this capacity has been the main milestone of Industrial Revolution. On the other hand, smart empowerment not necessarily means clever development. Clever indicates a problem solving capacity, the ability to elaborate robust solutions, which are the result of a deep thinking and analysis; smart is the quick and competitive intelligence. For example, smartness is the ability to rapidly learn rules, while cleverness is the ability to speculate about the reasons behind the rules (Leone 2013).

Moreover, while Modern Age (and related Industrial Revolution) development has really been smart, this smartness is now limited by a missed awareness of resources limits. After more than two centuries from the Industrial Revolution beginning, the signs of the wrong postulate of unlimited development are evident and it is time to be conscious of environmental and social impacts[2] produced in the mean time.

Carnot's law, schematized in fig. 1, allows to highlight these concepts: for "simple-smart" machines the focus is on *W*: the smarter the machine, the higher is *W*, and the related efficiency in energy transformation in work. But we have seen that this approach became obsolete, due to the high entropy production, i.e. a too high *Qc* dispersion into the environment. The epochal change needed for the immediate future looks at "complex-clever" systems rather than "simple-smart" ones. In this case, the focus is no more on *W*, but on *Qc*, in particular on the system ability to utilize *Qc*, transforming it in a resource, while, for thermal machines, it is only a waste, a factor of efficiency reduction[3].

A practical approach to this concept is reported in fig. 2 (from Rydin *et al.* 2012; modified), where a scheme of the integration of rural and town systems is reported. It shows how the use of wastes and local resources can build a complex landscape.

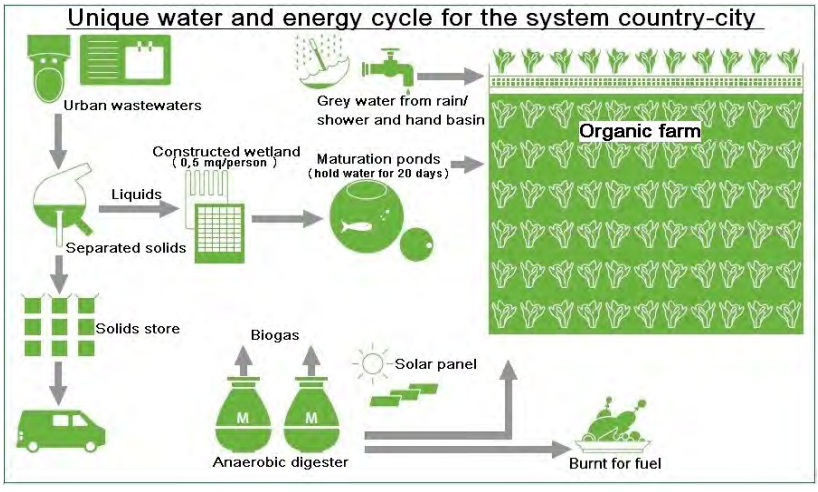


Fig. 2 The creation of a virtuous cycle of connections between urban and agriculture (Rydin *et al.* 2012 modified): an example of care for "Qc" in fig.1.

Generalizing: "smart-simple" is the characteristic of the Modern Age development, represented by technology: physical infrastructures, encompassing also information and communication technologies (ICTs); "clever-complex" is the new paradigm, represented by the strategies that increase social and environmental

2 See in the next section the world's north-west versus south-east dualism in development.

3 It is not casual that Sadi Carnot is the son of Lazare, mathematician, but also politician, member of Directory during French Revolution. French Revolution was one of the Modern Age social milestones.

capital, also thanks to physical infrastructures and ICTs, which are not the aim, but the tools to obtain more resilient systems, fulfilling the sustainability equation.

Some forgotten characteristics of pre-Modern Age should be, therefore, re-discovered (see fig. 3): they were unconsciously sustainable, due to low technology and consequent deep attention and respect for resources: 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 in modernity (high *W*), thanks to smart technology, but considering that it is no longer sufficient for present and future needs, since a more organic (clever) world development is required.

2 HOW THESE CONCEPTS CAN BE USEFUL IN PLANNING PRAXIS

Sustainability is not easy to pursue, because it requires a radical change of thinking, above all for the present western society and its way of life, whose crisis is evident and whose implications have an impact on city's, landscape's and planning's related crisis.

For example, the current necessity to build smart cities derives from the loss of traditional human development which took local resources into consideration; the rediscovery of these forgotten traditions offers 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, a way of life and of managing territory that is surely sustainable. On the contrary, all modern age development is increasingly based on allochthonous resources (fig. 3), considered unlimited. Consequently, this development proceeded blind to the laws of thermodynamics for more than two centuries, in particular for the last 70 years generating a diatribe among Mediterranean (and, in general, among the south-east part of the world) way of life and the north-west way of life, the former in modernity retard, waiting to become a "north-west" and, in the mean time, depressed and backward (Cassano 1996). This phenomenon hides an erroneous behavior, since it induces a lethal uniformity, which simplifies the system and reduces its resilience, with the risk of bringing the system to not be able to solve crises. The present north-west crisis could be a signal of this occurrence. A new development paradigm is then required and the south-east part of the world can offer an opportunity.

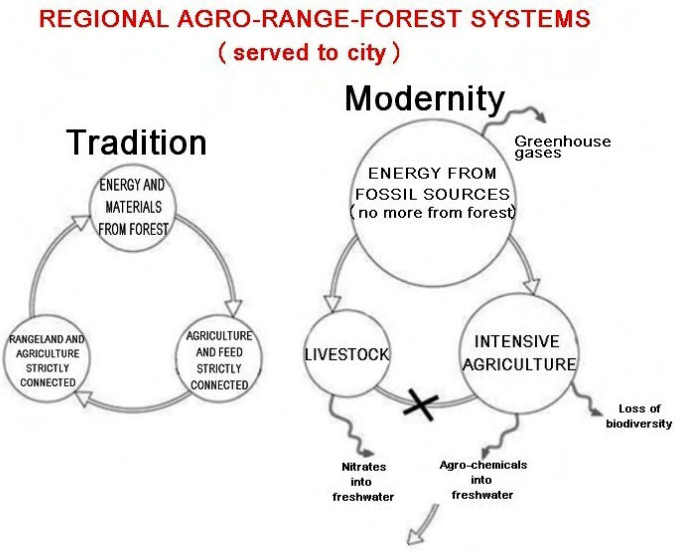


Fig. 3 Schemes of regional systems

The scheme in fig. 3 is 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, where wood is the main energy supply and, without energy, it is not possible to survive winter. Furthermore, forest is an insurance against famine, reservoir of forage for livestock, but also food for humans, in extreme cases (Licinio 1998).

The scheme of traditional management in fig. 3 is much closer to nature and cleverer rather than smart and, for this reason, can produce beauty and harmonic landscape, intended as equilibrated territorial product of the integration between human activities and nature, as stated in the Florence European Convention (2000) and in the consequent Italian Landscape Code (2004).

Translating these concepts into planning praxis, the paradigm is synthesized by 3-Re: Reuse, Recycle, Renewal of the existent, above all related to built environment. To achieve this objective, landscape should be re-thought according to a holistic vision, retrieving the organic approach of the fig. 3.

A practical approach to this concept is shown in fig. 2, where a scheme of the integration between rural and town systems is reported, in a post-modern lecture. It illustrates how wastes and local resources use can build a complex landscape, following the 3-Re approach and related symbiosis.

3 AN EXAMPLE OF CLEVER URBAN PLANNING

A concrete realization of the above mentioned approach is going to be applied in the case of Bari (Southern Italy). In this city, as well as in other Mediterranean cities, soil sealing, in the entire historic urban fabric and large part of the periphery, has compromised the land permeability and the rainwater drainage network that is no more able to manage the meteorological precipitations in the current climate change context. In turn, the city structure defines therefore a high Environmental Intrinsic Vulnerability that induces damage, risk to the safety of people and threats for water quality in wide stretches of the sea coast.

To control storm water on the urban territory, several Best Management Practices (BMPs) were proposed (Pelorosso, Gobattoni, Lopez and Leone 2013) with the aim to:

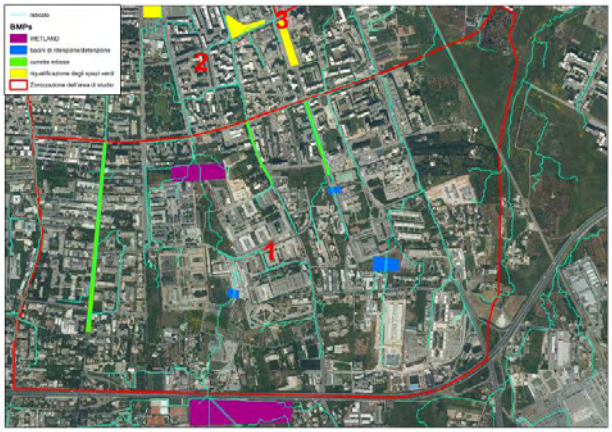
- increase urban soil permeability, through greening and other permeable surfaces in the compact city.
- identify landscape zones where it is possible to store storm water, preventing its runoff, into natural depressions and permeable areas (ponds, constructed wetlands, infiltration and filtering areas)

Fig. 4 presents a scheme of these concepts applications.

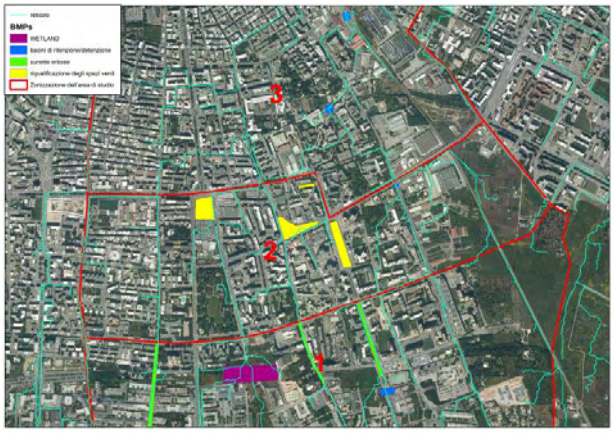
Urban green primary function is hydrological, reducing city impervious areas, whose percentage is an indicator of intrinsic vulnerability of urban environment. In synergy, BMPs can furnish many other functions (related to the so-called Ecosystem Services), in a fully positive feedback:

1) Freshwater preservation from pollution.
2) Urban heat island attenuation with consequent reduction of energy consume for cooling.
3) Possibility to increase urban biomass production, integrating it with humid fraction of solid wastes, with consequent possibility to produce energy from renewable sources.
4) Reduction of greenhouse gases, such as CO_2.
5) Biodiversity increasing and growth of local ecological network.
6) Construction of leisure and socialization spaces.
7) Improvement of aesthetical aspect of the city.

Zone 1: Surroundings, where possibilities for different BMPs are more, thanks to more space.



Zone 2: Peripheral areas, where space for BMPs is lesser.



Zone 3: City centre, where it is necessary to rethink the already built

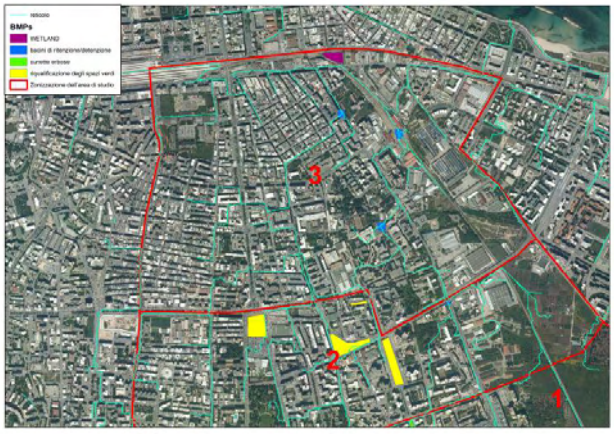


Fig. 4 Possible BMPs set for different city characteristics. The case of Bari (Pelorosso *et al.* 2012).

These positive functions are able to build new landscapes, with strong identity: this means that their global impact is greater than the sum of each function, which is the Aristotelian quintessence. The consequence is a more complex system, more robust and resilient, characterized by less EIV and higher carrying capacity and able to better sustain human pressure. Finally, the quality of life of citizens is increased because more green areas can satisfy their social needs, as well as enhance the health status of the system.

In this way, theoretical principia of sustainability and thermodynamics laws thinking are satisfied, indeed:

a) The green infrastructure reduces city impervious areas and water storage capacity. In this way, EIV is reduced and it is more probable that eq. 1 could be satisfied, in this first step from hydrological and water quality point of view. Eq. 1 can be developed quantitatively, estimating the return time of urban drainage crisis (and related water quality), with and without planned green. This difference is a quantitative sustainability indicator, i.e. efficiency of the planned infrastructure.
b) Planned greening can be evaluated also in terms of climatic and air quality effects. Even in this case, it is possible to quantitatively evaluate the reduction of urban system intrinsic vulnerability, as urban surface temperature difference, with and without the green infrastructure. The difference is another sustainability indicator, associated with the reduction of CO_2 emissions (Akbari 2003).
c) Planned green infrastructure can be evaluated in terms of biomass production, that, joined to CO_2 saving explained in the previous point b), gives a contribute to urban sustainability in terms of climatic change mitigation.
d) On the other hand, renewable energy production from biomass is also a contribute to urban symbiosis, i.e. the reuse of *Qc* of eq. 2. Also in this case, a quantitative indicator can be derived.
e) Green infrastructure can be quantitatively evaluated in terms of its ecological and biodiversity values, linked to a landscape connectivity index (see the PANDORA model in Gobattoni *et al.* 2011).

Integrating these five processes, also through a multivariate analysis of them, it is possible to satisfy eq. 1 and 2, building both smart and clever cities.

4 CONCLUSIONS

This paper demonstrates how it is possible to transfer formal concepts of sustainability (eq. 1) and of thermodynamics laws thinking (eq. 2) into quantitative and measurable approaches, useful to give an integrated, holistic perspective to city management aimed to a more comfortable urban environment. Indeed, citing Costanza *et al.* (2014): " It is often said that what you measure is what you get. Building the future we desire requires that we measure what we want, remembering that it is better to be approximately right than precisely wrong".

In the study case of Bari City, it was demonstrated that the thermodynamics principles can be applied recurring to a re-thinking of planning and design of green areas. The minimum green infrastructure was then planned on the basis of hydrologic and water quality aspects while, in the following step, the resulting infrastructure may be evaluated (and eventually increased) on the basis of the other functionalities. Clearly, each case is different and the core criteria defining the starting point in the definition of planning strategies can change. However, ecological functionality of water, soil and air systems should firstly be preserved and the safety and health of citizens should always be kept in mind during the assessment process.

The consequence of the proposed method is a more complex landscape, able to increase city resilience and the delivery of a more diversified and stable range of Ecosystem Services. In this view, the integration of the thermodynamic approach within Ecosystem Services framework could further contribute to a cleverer planning science that effectively supports practitioners in building sustainable city and landscapes.

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AUTHORS' PROFILE

Antonio Leone

Full professor of Land Engineering at University of Tuscia, Industrial Engineering course. Member of the Teaching College PhD "Land and Urban Planning" at Politecnico di Bari and "Environment and landscape design and planning" at Sapienza University of Rome. Participant and responsible in several projects financed by the European Union within 5th Framework Programme, Interreg IIIB Research Program, COST-actions, LIFE programme and other national and regional research programs (e.g. Nature 2000 sites). Member of Scientific International Committee for Metropolitan Strategic Master Plan "Terra di Bari". Member of Scientific Committee for University Consortium for Socio-economic and Environment Research (CURSA). Author of more than 100 scientific papers in the area of landscape and environmental planning.

Federica Gobattoni

She has a Master Degree in Environmental Engineering at University of Perugia, PhD in "Science and Technology for the Forest and Environmental Management", and she's a post-doctoral researcher at University of Tuscia. Her research

activity is mainly concerned with landscape dynamics, environmental modeling in GIS environment, decision support systems for planning and management of natural resources, development of mathematical models for landscape evolution and equilibrium scenarios assessment. She was Convener of the "Landscape functionality and conservation management" session at European Geosciences Union General Assembly of 2010, 2011 and 2012. She is peer reviewer for many international journals as: Journal of Water and Climate, Ecological Complexity, Water, Air and Soil Pollution, Chemical Engineering and Technology, Earth Science Informatics.

Raffaele Pelorosso

He is a researcher in Landscape and Urban Planning at the University of Tuscia. He holds a PhD in "Science and Technology for the Forest and Environmental Management" at University of Tuscia. Lecturer in Ecology, Cartography and Planning. His research activity is mainly focused on landscape functionality, urban green, land use planning, analysis of landscape dynamics, land cover and land use change. Associate Editor of International Journal of Sustainable Land Use and Urban Planning. He is authors of more than 50 scientific papers and peer reviewer for many international journals as: Land Use Policy, Landscape and Urban Planning, Environmental Management, Journal of Environmental Engineering and Management, Advanced in Space Research, Science of the Total Environment.