CSEJournal

ISSUE 2

City Safety Energy

Le Penseur Publisher

ISSN 2283-8767 www.csejournal.net - ISSUE 2 | July - December 2014 | Semiannual publication

International Journal of Geology, Planning and Land Safety, Sustainable Urban Mobility, Environmental Design, Building Technologies, Energy Efficiency in Buildings and Districts, Materials Engineering

CSE Journal
City Safety Energy

International Journal of Geology, Planning and Land Safety,
Sustainable Urban Mobility, Environmental Design, Building Technologies,
Energy Efficiency in Buildings and Districts, Materials Engineering

Le Penseur Publishing

CSE Journal City Safety Energy

International Journal of Geology, Planning and Land Safety, Sustainable Urban Mobility, Environmental Design, Building Technologies, Energy Efficiency in Buildings and Districts, Materials Engineering

www.csejournal.net

Cover image

Bevagna, Map of the Minimal Urban Structure; annex to the Programmatic Document of the General Municipal Plan, 2013.

ISSN 2283-8767 print

ISSN 2284-3418 online

Journal registered at the Court of Potenza (Italy) - no. 219/2014

Editorial office

Via Salvator Rosa 121 | 80136 NAPOLI - ITALY

Publisher

Le Penseur di Antonietta Andriuoli

Via Montecalvario 40/3 | 85050 BRIENZA (PZ) - ITALY

For all informations about policies and scope of the journal, peer review policy, author guidelines, submission process, copyright notice, privacy statement, prices subscriptions or purchasing single Issues, see the website **www.csejournal.net**

CONTENTS

ISSUE 2 | JULY - DECEMBER 2014

ENVIRONMENTAL DESIGN

BUILDING TECHNOLOGIES

MATERIALS ENGINEERING

BOOK REVIEWS

Since the first issue of CSE was published on line, thousands of visitors to the website have been recorded. We are proud of such success: it encourages us to invest time in making continuous improvements to the journal.

The interest generated by the editorial philosophy of CSE is reflected by the large number of submissions for issue no. 2, which covers different topics in the general subjects converging towards an integrated vision in the environmental sector.

Issue no. 2 presents the following articles:

Planning and Land Safety

Earthquake, urban form and city planning: research perspectives (by Cappuccitti) presents an overview of the main points of the research lines about the seismic vulnerability of cities and urban fabrics, briefly discussing their respective content and specific features. The seismic vulnerability study is conducted simultaneously with a study regarding the appropriate integration of urban-planning and regional tools.

With the article *Feeding the City. Foodsheds and Urban Agriculture in San Diego*, Ricci, Mattogno, Monardo, Palazzo and Valentino explore the most recent general policies in the United States, recounting an experience within the distressed neighborhood of City Heights in San Diego, CA, both in research and planning practice about 'Urban Agriculture' (UA), that can give new perspectives to urban revitalization strategies, particularly for fostering social inclusion in contemporary, fragmented communities.

Smart city models and energy efficiency related to the metropolization of the city of Reggio Calabria (by Fazia) is the title of research in progress, providing a tour of the possible candidates for *Smart cities*, focusing on the prerequisites, on the spheres involved, on existing and feasible strategies required to set up a Smart Project. The possible application of smart features to metropolitan cities is explored in the case study of the forthcoming metropolitan city of Reggio Calabria.

Sustainable Urban Mobility

Innovative parking strategies through the application of variable pricing techniques (by Ferrari and Maternini) describes a methodological approach tested in San Francisco to apply variable parking pricing in medium-sized cities. A pilot project is analysed, known as "SFpark", whose final evaluation report was published in June 2014.

Environmental Design

The article *Environmental Design Criteria through Geoindicators for two Mediterranean Coastlands* (by Valente, Stamatopoulos, Donadio) aims to the define environmental design criteria along the Mediterranean coasts such as beaches, cliffs and techno-coasts. Scientific methods to define critical points and appropriate instruments are applied. The results indicate how the adaptive approach and the non-imposing solutions contribute to reduce anthropogenic impacts in regions with a high

degree of environmental hazard.

Towards Sustainability Assessment: A Case Study of International Indicators and Trial Assessments of Kashiwa-no-ha Plans in Japan (by Miyawaki et al.) is the title of the research report concerning sustainability indicators that should be applied in the planning process. After comparing the international indicators of sustainable development, the Eco City and the Smart City, the authors consider a Japanese case study by verifying the sustainability characteristics of the two main plans.

In the report *Bioclimatic simulation, environmental based urban design and architectural redevelopment in the Mediterranean Area* Calcerano et al. present a synthesis of the research "Bioclimatic simulation, environmental based urban design and architectural redevelopment in the Mediterranean area", focusing on the case study of a district in Rome, which deals with the theme of the self-reliant city, of mitigating the heat island effect and of the energy and environmental efficiency of building.

Building Technologies

The article *Parametric planning for the restoration and rehabilitation of architectural heritage* (by D'Auria, De Feo and Di Ruocco) shows the efficiency of BIM (Building Information Modeling) in projects regarding the rehabilitation of historical buildings. However, BIM protocols for existing buildings are not available at the moment as they are only used in designing new civil and industrial buildings.

Materials Engineering

Advances in nanoscale science and engineering are providing unprecedented opportunities to develop more efficient and cost-effective materials. In *Recent advances in the field of nanoporous materials for energy and environmental applications* (by Caputo, Gargiulo and Aprea) a brief overview is shown on current and prospective uses of nanoporous materials in environmentally friendly processes.

The *Durability and mechanical properties of a composite fibre reinforced concrete* are investigated by Coppola, Scarfato, Incarnato and Di Maio. Water absorption, freeze/thaw cycles and the sulphate attack test demonstrate that concrete durability increases with the volume of the fiber fraction.

We are therefore most pleased to share the contents of the second issue n. 2 with our readers.

The Scientific panel of CSE

EDITORIAL

The global climate change challenge

by Loreto Colombo

The world heading towards a single objective

The damage from catastrophes produced by climate change in recent decades is calculated to amount to US$ 500 billion. While for the first time over one million people recently demonstrated to demand economic, energy and social policies that safeguard the future of planet Earth, the Climate Summit 2014 opened in September on the occasion of the 69th UN General Assembly.

As long as a quarter of a century ago, the peoples of the world started along the road of global cooperation against atmospheric warming and to save the planet. However, the many international conferences and summits of Heads of State and Governments, from that of Rio de Janeiro (1992) to those of Lisbon (1996), Kyoto (1997), Hanover (2000) and Johannesburg (2002), to Aalborg+10 (2004), have produced inadequate results, showing difficulty in overcoming vested interests and national egoisms.

In June 2012 the Rio+20 World Conference concluded with the statement *The future we want*, which invites States to define sustainable development objectives and draw up suitable measures to manage environmental resources at the global level, to improve food security, enhance protection of the oceans and promote the "green economy". However, the statement contains no concrete indications for launching the necessary policies: there are no deadlines and it may be concluded that for the umpteenth time the opportunity to achieve ambitious objectives has been lost.

Yet in 1987 the UN Commission on Environment and Development, with the *Brundtland Report*, had defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". That "future" began some time ago, but not even the Rio+20 Conference has taken significant steps forward compared with the 1992 Earth Summit, which first launched the concept of sustainable development, shared at the international level, with its three distinct component parts, namely economic, social and environmental.

Twenty-two years ago, in 1992, the precautionary principles and the "polluter pays" policy were integrated with the principles of the right to development and equity, as "common but differentiated responsibility". Moreover, on that occasion the Heads of State and Government from the industrialised countries undertook to fund and effect technology transfer to developing countries. Two binding international agreements were signed: the UN Convention on Biodiversity and the UN Framework Convention on Climate Change.

In December 2009 the 15th UN Conference on Climate Change was held in Copenhagen, with the aim of negotiating a new treaty under which the international community would undertake to take measures to stop global warming. The agreement was to replace the Kyoto Protocol, whose first commitment period ended 2012, extending its effects in 2020 or 2050, with the binding commitment of those nations which had not ratified the Kyoto Protocol or which had been exempted from the cuts in greenhouse gas emissions so as not to curb their growth (such as China, India and Brazil). However, also the Copenhagen summit concluded with a minimal agreement which left all parties dissatisfied. The final agreement contains no quantified undertaking on cuts in CO_2 emissions.

The Intergovernmental Panel on Climate Change (IPCC) has shown that, to eliminate the most serious effects of climate change, by the year 2020 the industrialised countries will have to reduce their emissions by 25 to 40% with respect to 1990 levels, and will have to halve global emissions by 2050.

The negotiations that could have led to a more ambitious declaration at the end of the Rio+20 summit in 2012 were blocked on four key questions: the *green economy*, *sustainable development objectives*, the *institutional framework for sustainable development* and *policy implementation instruments*. The meaning of *green economy* was not sufficiently agreed upon and was still obscure for many developing countries. It was thus first necessary to define it: the green economy was recognised as *one of the instruments available to States to achieve sustainable development [...] which should contribute both to eliminate poverty and to promote sustained economic growth.*

The G77[1] group and China stressed that all States must make undertakings for the environment, but it is the industrialised countries, given their higher economic capacity and pollution production, which should be the first to make commitments in environmental protection, but also in funding and technology transfer to developing countries. The Conference drew up a plan to define **sustainable development objectives**. Unfortunately the list of objectives was not defined, and this task was delegated to a working group of 30 countries, agreeing that by 2015 the **sustainable development objectives** would be tied to the Millennium Development Objectives.[2]

As regards the **institutional framework for sustainable development**, the lack of strong international institutions devoted to sustainable development led the Conference to strengthen the role of the Commission on Sustainable Development. However, the European Union, Norway and Switzerland proposed the institution of a Council for Sustainable Development which would have adequate financial resources and would meet periodically. Yet, as mentioned above, at the Earth Summit in 1992 the developing countries had sought and obtained recognition of the principle that to be able to pursue environmentally compatible development concretely, they would need funding and technology transfer from the industrialised countries.

The issue of **implementation tools** was one of the most controversial at the Rio+20 Summit. The developing countries requested a fund of $30 billion a year for the transition to more sustainable forms of production. However, the European financial crisis did not permit the industrialised countries to go beyond a generic undertaking to increase fund allocations. At the end of the day, also the Rio+20 Summit disappointed citizens and scientists, and some spoke of a "failure of epic proportions".

Some concrete results were achieved outside the assembly halls, with agreements being concluded on investment in public transport, "green accounting" and the reduction in environmental impact on the part of local government representatives with firms supplying services.

The last day of the Summit, at the same time as the adoption of the final declaration yet independent of this, the "civil society" approved the *People's Sustainability Manifesto*, containing an autonomous and collective programme for the sustainable future. The manifesto hoped for a system of concrete actions that might help *move simultaneously toward a more localized socio-economic structure and toward a supra-national mindset that helps us transcend the parochial concerns of a corporate-capitalistic globalization to activate a global citizens movement*.[3]

Much hope is placed in the upcoming CoP21 (2015 Paris Climate Conference), which will have to constitute a decisive stage in the negotiations for the future international agreement on the climate after 2020, on the basis of what was decided in Durban, on the part of the major greenhouse gas-producing countries. France is aiming towards a significant binding agreement thanks to which, amongst other things, the old objective of a 2°C reduction in mean air temperature may be reached. The agreement will have to be positioned half way between the Kyoto approach – commitment to an arithmetic split of the reduction in emissions, starting from a common maximum limit permitted – and that of Copenhagen – a set of national commitments which are non-binding and differentiated. It is then hoped to bring about a paradigm change, considering the climate challenge not as a necessary sharing of inevitable emissions, but as an opportunity to create jobs and to innovate in production and consumption.

The question of global warming now calls for urgent responses and is a priority issue for humankind. While international politics pursues formalised agreements with uncertain results, it has become indispensable for everyone to play his or her part responsibly, from citizens to experts in science and culture, each in relation to personal status and possibilities.

To establish an acceptable equilibrium between the natural environment and the human environment in the respect of the carrying capacity of natural ecosystems, a joint effort needs to be made in three directions:

- geographical spread, since all continents are called upon to make an effort;
- different intensity: countries which place resources under greater pressure due to their greater economic weight must make a greater commitment than others;
- integration of different knowledge and technologies, in a context of information and action that ranges from planning to technology design, to new materials, but especially to scientific and professional training.

The keyword in the task awaiting us in the next few years is *precisely* integration: comparing different skills and stimulating dialogue, and interaction between actors with different roles to play, namely States, institutions and public administrations, researchers and enterprises, to overcome the serious delay in reforming residential and production systems with an improvement in their energy efficiency. Knowledge and

1. The group of 77 arose in 15 June 1964, formed by 77 developing countries, signatories to the "Joint Declaration of the 77 States", signed at the first session of UNCTAD in Geneva.

2. With the Millennium Declaration of the United Nations, signed in September 2000, all the 191 Member States of the UN undertook to achieve for the year 2015 the following eight *Millennium Development Goals* (MDGs): 1. halve the number of undernourished people; 2. make primary education universal; 3. promote gender parity and empower women; 4. reduce infant mortality; 5. improve maternal health; 6. combat HIV/AIDS, malaria and other diseases; 7. ensure environmental sustainability; 8. develop a global partnership for development. Each of the objectives has specific stated targets and precise dates to achieve them.

3. Cited from the People's Sustainability Manifesto at the Rio+20 Summit at http://sustainabilitytreaties.org/

technological progress are now up to the challenge: they need to be employed continuously and extensively, also rediscovering teachings and events from the past.

Utopia and reality

Utopia stems from humankind's tendency to go beyond its limits, imagining perfection as the destination of a liberating pathway which originates in the awareness of imperfection. Some urban and urban-rural settlements show the periodical return to principles of faith and ideology, re-proposing the close relationship between a new social order and the urban form for organised co-existence.

The European utopians of the early 1800s imagined people living together on the basis of ethical principles, of equality and emancipation from exploitation. The Garden City movement in England led to the creation of low-density suburbs as an alternative to the congestion of the industrial city. The movement transmigrated abroad. Le Corbusier structured his *ville radieuse*, the archetypal functionalist town, an artificial geometric universe, according to space specialised for functions: high environmental quality was expressed by the wealth of green areas and the separation of motorised traffic and pedestrian routes. *Broadacre City* is the organic Wrightian utopia, based on town-country integration without limits of space. Arcosanti, developed by Paolo Soleri and his young co-workers, is not only a town based on the use of solar energy and on low-cost farm produce, but the embodiment of the idea of living together, namely Arcology (architecture/ecology). Through a foundation set up to spread its concepts, the town plays host to young participants from all over the world, participating in workshops and then working on priority projects.

In India, Auroville, "the universal city in its making" upon the initiative of a group of volunteers inspired since the 1960s in Sri Aurobindo's principle of universal harmony with the support of UNESCO and the Indian government, gathers citizens of various provenance according to the principles of "friendly" ecology of harmony and is organised for rural neighbourhoods for sustainable agriculture. In New Zealand, Waitakere (200,000 inhab.), founded in 1989 to integrate four pre-existing entities (Waitemata and three of its suburbs), arose with the aim of fusing the principles of Agenda 21 with the traditional values of the Maori culture. In the US, Green Village Philadelphia, an example of an Urban Ecovillage conceived in 2008, was imagined to fill, with only retrofitting, the gap between the more affluent parts of the city and the poor, degraded areas.

In many cases, satisfying the principles of ecological sustainability led to the rediscovery of the simplicity of ancient construction techniques which respected the natural hydrological cycle; they used solar energy for heating and natural ventilation for cooling; they inserted with discretion and harmony every building into the natural landscape.

Several of the cited projects remained on paper, others were only partly carried out. However, each of them left a trace. Without the dream of visionaries, reason on its own would lose its thrust to go beyond its limits, to aim towards ambitious goals with all its force.

In the late 1960s the new concept of "environmental planning" reformed the traditional urban + land use plan which faced growing needs, without ever satisfying them, with ever more buildings, overlooking the most complex variables such as the hydrological regime and hydrogeological and seismic risk, soil use, and the environmental impacts of new interventions; finally, all those factors that affect the dynamism of equilibria and which must be known and interpreted to control the exchanges between artificial and natural ecosystems to mitigate their conflict.

Nowadays, strategic assessment of the impacts not only of works, but also of objectives and action plans, integrates the approval procedures obligatorily. This route must be pursued, conceiving protection plans and standards regulating urban transformations, albeit shortening the time required to draw them up and approve them.

Research

Various pathways have been mapped out to disseminate research and innovative practices with a view to going beyond the consumption of fossil fuels and hence CO2 emissions. Equally diverse are the uses of energy from renewable sources for residential buildings and the methods of rationalisation of systems to extract and treat water. Likewise, there are many criteria for greater and more purposeful distribution of green spaces.

At times, basic principles, linked to an inadequate formulation of how to achieve them, assume the connotation of real ideology. In other words, they are not restricted to methodologies and instruments, but together constitute a philosophy of life, based on equity, on the protection of rights and at times on a sort of enlightened determinism, reproducing the strict relationship between the social order and its spatial embodiment which resurfaces cyclically in urban planning.

The initiatives of academia and research institutes, of NGOs and of several social movements do not always manage to blend to bring about tangible results. Such initiatives range from ambitious, faith-based, totalising visions to minimal programmes, which reflect more than anything else the business interests of producers of technologies and materials, whose diffusion, albeit beneficial, is not enough on

its own to achieve systematic results. Further, at the linguistic level, there is the current plethora of terms beginning with the prefix *eco*, all belonging conceptually to a single family referring to respect for the environment.

In the USA it was a milestone when the *2009 Stanford University study ranked energy systems according to their impacts on global warming, pollution, water supply, land use, wildlife and other concerns*.[4] This study opened the way to a research strand which proceeds and spreads under the assumption that **"**wind, water and solar technologies can provide 100 percent of the world's energy, eliminating all fossil fuels. The plan includes only technologies that work or are close to working today on a large scale, rather than those that may exist 20 or 30 years from now. The plan calls for 3.8 million large wind turbines, 90,000 solar plants, and numerous geothermal, tidal and rooftop photovoltaic installations worldwide; the cost of generating and transmitting power would be less than the projected cost per kilowatt-hour for fossil-fuel and nuclear power; shortages of a few specialty materials, along with lack of political will, loom as the greatest obstacles."
"The very best options were wind, solar, geothermal, tidal and hydroelectric power, all of which are driven by wind, water or sunlight (referred to as WWS). Nuclear power, coal with carbon capture and ethanol were all poorer options, as were oil and natural gas. The study also found that battery-electric vehicles and hydrogen fuel-cell vehicles recharged by WWS options would largely eliminate pollution from the transportation sector.
Renewable energy comes from enticing sources: wind, which also produces waves; water, which includes hydroelectric, tidal and geothermal energy (water heated by hot underground rock); and sun, which includes photovoltaics and solar power plants that focus sunlight to heat a fluid that drives a turbine to generate electricity".[5]

In Europe, the principles of sustainability and criteria for intervention in cities have been the subject of research and cooperative agreements in various institutional contexts and elsewhere. Of the organisations and research institutes in the sector, mention should be made of the *School of Environment and Development at the University of Manchester*, which coordinates *The Bruntwood Initiative for Sustainable Cities*; AESOP (the *Association of European Schools of Planning*), which formulated at the Congress of Vienna (2005) the *Objectives for a Transit Oriented Ecocity Development*; the *International Association for Urban Climate* of Stuttgart for the study and adaptation of cities to the effects of climate change; the *Wessex Institute of Technology*, which held the *2012 Sustainable City I*nternational Conference in Ancona (Italy).
In Italy, research and programming need to be boosted. The following activities are currently under way: the Association of Disused Urban Areas (AUDIS), with the GBC (Green Building Council) Italy and Legambiente, promoted in May 2011 the project *Ecological quarters in Italy: a pact for urban regeneration* to contribute to establishing urban and environmental regeneration as the strategic key for development on the basis of the principles laid down in the Urban Regeneration Charter;[6] the *EERA Smart City* network (ENEA, CNR, various universities).
In general, knowledge and research on these subjects are still being consolidated: Master's and Doctoral courses in environmentally sustainable building development have been established, blending general aspects of planning and design with those regarding technology, energy use, plant and materials.

Project executions

Initiatives to design and create ecological cities are multiplying worldwide. However, they clearly present great variability in their environmental, economic and social sustainability elements, distinguished by ambition, user profile and stakeholders.
There are three phases in the process: several initiatives are being designed, others are under construction, and others have been executed. There are three approaches to urban "ecologicity": that of technological innovation; that of a joint vision/planning of sustainability; that of citizen participation. The designs and executions under way substantially differ between developing and industrialised -chiefly Western - countries. The former, in which there are evident social and economic inequalities, feature urban areas largely consisting of slums and *favelas*, with poor or inadequate infrastructures; these contrast starkly with privileged areas, in which modern business buildings represent the symbols of acquired power. Such cities often have important old towns, although conditions of degradation and inefficiency are such as to require large urban renewal programmes. Such large-scale

4. M. Z. Jacobson, M. A. Delucchi: *A Path to Sustainable Energy by 2030*, research abstract in "American Scientific", November 2009.

5. Society, say the authors, has achieved massive transformations before. During World War II, the US retooled automobile factories to produce 300,000 aircraft, and other countries produced 486,000 more. In 1956 the US began building the Interstate Highway System, which after 35 years extended for 47,000 miles, changing commerce and society.

6. The objectives of the *Ecological Quarters* project focus on cities and their surroundings, assuming as a priority the re-design of public and private residential quarters built in the 1950s-1970s, today experiencing a structural crisis, and the restoration of disused areas (industrial, services, military, state-owned). The project intends to work on two fronts: identification of a model of a "pact for urban regeneration" as the basis to define systems of responsibilities, rights and duties, guarantees and benefits for all the contracting parties; definition of a support tool to accompany an *ecological quarter* project from the initial decision-making phase to the design and execution of interventions, through integrated and participatory design and including guarantees for all those involved.

difficulties have made countries like China and India opt to build new towns and cities as well as renovate quarters or entire urban areas, while other Asian countries, such as Japan or Indonesia, prefer to upgrade their existing cities.
However, the construction of new towns (under way chiefly in China, India and South Korea) is both costly and challenging, and may be useful in areas which are unable to cope with great urbanisation caused by rapid economic growth and a poor urban infrastructure. These countries are thus forced to divert towards unbuilt areas (albeit close to existing cities) the creation of infrastructures, services and residences suited to the needs of emerging (and evolved) classes which are both the effect and further cause of economic growth.
The case of Western countries is different: they have a more solid urban structure, albeit in need of environmental renewal. In the old Europe, for example, the construction of new cities in the absence of space and at the cost of sacrificing farmland and natural areas and the failure to modernise its thousands of old towns or more recently built but inefficient quarters would be a suicidal path to take, leading in the opposite direction to the path of energy efficiency.

The projects and their execution have increased from 79 in 2009 to 174 in 2011[7] and are still increasing. Three main categories of eco-city may be distinguished: ecological cities "of foundation"; expansion of existing cities; cities undergoing urban renewal in keeping with the principles and technologies of sustainability (so-called *retrofit*).[8]
For Europe, Germany is the undisputed historical leader of environmental town planning. A notable example is Freiburg (the 1970s), which earned the city the title of the country's environmental capital. In the early 1970s the decision to build 30 km from Freiburg a nuclear power station was strenuously opposed, and the city became the centre for experimenting with alternative energy, attracting researchers and experts in this field and a high concentration of institutions, industrial initiatives and designers who supported what has become the mayor's famous plan based on four main choices.[9]

In European countries, although there is widespread sampling of both newly built and "ecologically adapted" ecological quarters, overall expansion prevails over technological modernisation. The number and extent of the interventions clearly depend on the economic capacity of the various countries. Of the former Eastern block only the Czech and Slovak Republics and Bulgaria have initiatives under way, while most of the interventions are concentrated in France, Germany, the UK, Sweden and Spain. Ecovillages are in construction here and there, at times constructed by initiative of the local communities as a shared venture.

Since the year 2000 the European Union has launched two programmes, to be renewed or extended, on the initiative of the Commission, which comprised both expansions (new quarters) and retrofit interventions.[10] The programmes were as follows:

- *Ecocity*, *Urban Development towards Appropriate Structures for Sustainable Transport* (2002–2005), which involved for two years 30 partners from seven European countries. In Italy the project proponents were PRAU and the Agency for Energy and the Environment of Perugia Province for the pilot *comune* of Umbertide; the other cities were Bad Ischl (Austria), Barcelona Trinitat Nova (Spain), Györ (Hungary), Tampere (Finland), Trnava (Slovak Republic) and Tübingen (Germany). The programme envisages specific interventions according to individual cases, ranging from

7. Source: *Eco-Cities – A Global Survey*, Univ. of Manchester, 2011.

8. In 2010/2011 alone, the following were launched: 3 eco-cities in Europe - at Paphos (Cyprus), in Norway (a district of the city of Trondheim) and in Glasgow; 6 in Asia, comprising 4 in China (one involves three ecological quarters), 1 in India and 1 in Japan); 3 in North America (Living City – Washington, Living City – Denver – and in Seattle). Of the 174 main projects actually executed, there are 27 foundation cities: 15 in Asia and Australia; 2 in Europe; 4 in the Middle East and Africa; 6 in the Americas. There are 72 expansions of existing cities: 17 in Asia/Australia; 45 in Europe; 4 in the Middle East and Africa; 6 in the Americas. There are 75 examples of urban restoration: 37 in Asia/Australia; 23 in Europe; 2 in the Middle East and Africa; 13 in the Americas (source: op.cit. note 5).

9. **For traffic**, the reduction in private car traffic; improvement in public transport extending to a regional area of 50 km^2; creation of 400 km of cycle paths (one third of trips currently use bicycles, involving a sizeable reduction in emissions); **for energy and climate**, limitation of consumption for new buildings (passive solar energy by window design and building exposure). The cost of consumption has been reduced by 30%. State and regional subsidies for the production of active solar energy have resulted in economies of scale, with a drop in prices. Freiburg is still the German city which uses most solar energy. Methane from household waste produces electricity for 10,000 inhabitants, achieving a 30% reduction in emissions. On its own, Freiburg produces 50% of the energy which it consumes; **for waste**, separation into four types, one of which, the organic fraction, is collected in public *bio-bins* (paper containers); waste has been reduced from 140,000 tons in 1988 to the current 50,000. From 2005 heat treatment was in use to make the organic components inert and reduce gases, then switching to low-emission waste incineration; **for soil use and protection of natural resources**, zoning protects 42% of the Freiburg area from urbanisation (with a ban on building both houses and roads).

10. By this term we mean all operations, whether technological or managerial, aiming at a new (if non-existent) or better (if inadequate) performance of existing buildings in terms of energy efficiency, that is, rationalisation of energy flows between the building system (casing and plant) and the external environment to: improve the comfort of internal environments; contain energy consumption; reduce emissions of pollutants and their impact on the environment; use resources rationally (renewable energy sources) as a replacement for fossil fuels; and optimise the management of energy services.
The main interventions able to ensure a beneficial *retrofit* concern both the building's technological system and the energy management, namely: improvement in performance (increase in heat insulation, replacement of fixtures, installation of suitable systems of solar screening); replacement of obsolete components of the heating and lighting plants with other more energy-efficient components with less environmental impact in terms of emissions produced; use of solar energy to generate electricity (photovoltaic panels) and heating (solar collectors); natural ventilation and passive cooling with a view to limiting the diffusion of air conditioning plants which involve the increase in electricity consumption; revision of the contract for energy services (mechanisms of financial incentives/disincentives); introduction of individual energy accounting systems to enhance awareness of consumption reduction.

transport to energy and socio-economic development;
- *EU CONCERTO Eco-City Programme* (2005–2010), which involved the cities of Helsingør-Helsingborg (Sweden), Trondheim (Norway), Tudela (Spain) and Zilina (Slovak Republic). Also in this case, there were mixed interventions, ranging from transport to the hydrological cycle to solar energy, biomass and sensitisation of the citizenry.

Conclusions

In the world, the climatic future and the compatible use of natural resources depend on the integration between research and action and between formal international agreements and the coordinated activities of authorities, institutions and businesses. However, this universe of research and intervention must be sustained by the participatory responsibility of citizens, based on recognition of the ethical importance of behaviour. There is no longer any space for initiatives which pursue individual or group interests conflicting with the principle of responsibility.
In the world of production there is space only for initiatives of the Green Economy, the only one able to combine fair profits and increased employment with the ultimate goal of protecting humankind's living environment. The peoples of the Earth have their destiny in their hands: there is now a considerable level of awareness of what must be done, although such awareness must be better distributed between industrialised countries and less developed countries, between countries which are democratic and those which are not. We need to act while there is still time. Further postponement could lead to irreversible consequences.

Planning and Land Safety

Earthquake, urban form and city planning: research perspectives

Antonio Cappuccitti
Department of Civil, Building and Environmental Engineering, Sapienza University of Rome, Italy – antonio.cappuccitti@uniroma1.it

Keywords: Earthquake, City planning, Urban morphology

Abstract

The study on the seismic vulnerability of cities and urban fabrics, referring to the susceptibility to the loss of a city's organization during an earthquake, has become a scientific field which for some time now has acquired own particular specificity, and which involves different research lines and experimentations in the broad area of the sciences on the relationship between earthquakes and human settlements. This is due to several different reasons.
Firstly, building vulnerability in a settlement and the intrinsic vulnerability of the urban structure have been considered for a while to be closely inter-dependent and complementary, and that the appropriate approach to their study should begin from basic hypotheses and concepts which are quite different.
In particular, the studies on a town's seismic vulnerability mainly depend on a series of factors directly linked to the different underlying content and approaches which are, in fact, from a different point of view, the features of the urban-planning discipline. These factors are mainly linked to the concepts of urban structure and urban fabric, concepts which have always been of key importance in the study and design of urban form.
Concerning the above, at the present moment in Italy, some principal fields of experimentation and research can be identified, regarding the relationship between earthquakes and towns.
The aim of this paper is to present an overview of the main points of the most important of the research lines, briefly discussing their respective content and specific features. Therefore, a brief but specific detailed study will be made, based on a "field" experience currently being carried out in the town of Bevagna in the Umbria region. It is a case where the seismic vulnerability study of a town is being conducted simultaneously with a study regarding the appropriate integrating of urban-planning and regional tools. Finally, some important development and research lines will be outlined, where specific perspectives for refining the studies and tools will be highlighted.

1. Seismic vulnerability of the city and urban form

On a properly urban scale, the "response" of a town to a seismic event depends also on the many features and condition of the town's buildings. But firstly, the features and layout of the settlement are of key importance in these situations, and they can be linked to the concepts of *urban structure* and *urban fabric*, key concepts in the study of towns and urban design.
The concept of *urban structure* has been defined and dealt with by many authors in the history of urban-planning, and on the basis of extremely different viewpoints and approaches. The main recurring and important meaning, and which is also of particular interest concerning the studies on urban seismic vulnerability, selectively refers to a system of places – poles and connections – of *primary importance* in a town. Therefore, it is a selective and targeted concept, intended to bring out what are the most "important" aspects (from a morphological, perceptual, functional and important urban viewpoint) and to highlight a clear hierarchy regarding the underlying elements of urban form.
From the specific point of view of urban seismic vulnerability, the elements that can be defined as "priorities" and crucial in an urban structure, that is places and connections of primary importance, may be quite different in nature. They may include strategic structures, different areas important for civil protection targeting, sites and building complexes with special functions, the town's main sites, entry points, etc.. At the same time, the connections of primary importance may be very different in nature including main thoroughfares of different degrees of importance, main technological networks of different types, etc.. In any case, the concept of *structure* allows for highlighting, selectively and hierarchically, the many different features – and problems – of the system of places and areas, of the buildings and urban connections that are of special and particular importance where the response of a seismic-risk town is concerned. This is both in terms of urban vulnerability and the usability and practicability of the urban space in an emergency, requiring maintenance and care, reducing or eliminating problems, continuously strengthening and adapting the capabilities to recover after the event.
Besides the concept of urban structure, other concepts directly linked to a town's seismic vulnerability concern the morphology of the settlement, the pattern of its building "fabric". The layout and density of the building fabric, the size and proximity to each other of its buildings, the size and morphologic "grain" of the construction elements, influence, differently and in many ways, the response capability of a seismic-risk town.

At the same time, still considering the issue of seismic vulnerability from an urban-planning viewpoint, the need arises to ensure that the regional and urban planning tools are able to translate earthquake vulnerability mitigation into the appropriate laws and regulations, and into comprehensive previsions and action plans, as well as, into urban recovery projects in line with the content and procedures of the plans forecasted by the legislation.

In this case, a dual and basic problem arises, typical of regional and urban planning. Firstly, how can the two integrate organically the studies and regulations on urban seismic vulnerability when, already, many and quite different plans exist (from the so-called "vast area" to the different single municipal plans). Secondly, how can the carrying out of these studies and regulations be divided, rationally and developmentally, into the different phases of drawing up and approving the urban-planning programs (procedures, which, moreover, may involve important differences among the different regions, with their different regional laws and regulations).

Therefore, the studies on urban seismic vulnerability, and the availability of plans and projects to reduce this vulnerability, underlie the concepts (and problems) that properly concern the urban-planning discipline, specifically regarding town morphology, urban design, regional and urban planning and regional legislation.

2. Earthquake and cities: main research fields

Thus, by limiting our focus to a specific urban scale, we can highlight that the studies and research on the relationship between earthquakes and the physical layout of a city can be mainly divided into four broad principal fields of research which are currently being carried out in Italy.

The first of these fields has been, for a while, the subject of a considerable and extended series of studies and involves the study of the *seismic vulnerability of urban and regional systems*. The researches have analyzed the regional seismic vulnerability on different scales and of different degrees, from regional and urban interdependence to municipal vulnerability, studying town centers and urban sectors, developing methods for data collection and interpretive analyses, as well as models and proposals for projects involving the application and study of different regional contexts.

A second important field of research involves analyzing a town's seismic vulnerability based on the concept of *urban structure*, specifically referring to the concept of *Minimal Urban Structure* (MUS)[1], a now widely accepted and shared term in the field of urban-planning. It is an analytical approach mainly based on urban design and linked to planning, analyzing a settlement's features and problems using specific structural analysis categories, developing planning actions on different levels for urban seismic vulnerability mitigation. Important studies have been carried out in this area of research and are being now carried out, particularly in the Umbria and Abruzzo regions. Valid research results underlie the text for important regional legislation (Umbria Region).

A third area of study concerns directly the relationship between the town's physical layout and emergency management in the case of an earthquake. It is research that deals with the analyses of urban layouts using methodologies of observation and interpretation typical of the urban-planning discipline, as well as a structural approach. However, its aim is to clearly attain the most appropriate conditions for a fully efficient action in the case of an emergency, and where these conditions depend on the town's structural layout and the efficiency of certain established elements (buildings, areas, infrastructures, building complexes). In this case, in Italy the development and application of analysis methods in the territory is made available by public Institutions (Department of Civil Protection).

A fourth important area of research and of a markedly inter-disciplinary nature, regards the relationship between the settlement vulnerability and the differences in the distribution of seismic movements in the urban area and in the earth itself.

In this context, the studies of *Seismic Microzonation* are aimed at individuating, on the right observation scale (typically municipal or sub-municipal), the geological and geo-technical conditions that can cause important variations in the seismic movements in the area (especially with "amplification" effects), or can produce an instability or permanent ground strain or displacement. In this specific case, the planning and experimentation carried out have for some time provided results widely shared in the technical field, as well as regulations formalized into specific laws in the different regions and a standard and official definition of the survey methods and criteria to be used.

These are, of course, four macro-contexts with their reciprocal correlations and numerous mutual implications and ties, which, however, can be quite distinct as autonomous fields of research and experimentation, in this classification, based on concepts, methods and diverse issues.

In the following part of this paper, we will focus on the second and third of the two conceptual and research fields mentioned above, dealing with the areas where the complementarity between seismic vulnerability of the town's

1. ["Struttura Urbana Minima" (SUM)]. This expression is officially defined, in particular and among other sources, in a regional official resolution of the Umbria region, as explained later in this article.

areas, urban morphology and regional and urban planning are more evident and significant.

These areas are characterized, respectively, by two main concepts (and operative tools): "Minimal Urban Structure" and "Limit Condition for an Emergency".

As established in the "Guidelines for defining the Minimal Urban Structure" included in an official resolution adopted by the Umbria Region in 2010, the Minimal Urban Structure is the system of roads, spaces, urban functions and important edifices for the urban response to earthquakes in an emergency phase, and for the maintenance and recovery of normal urban activities, both economic and social, and the follow-up in the successive phase of the seismic event. Therefore, this structure is the fundamental system for the town's response to the earthquake, also for dealing with the possible collateral chain events caused by the earthquake (fires, landslides, unstable sites and hydrogeological phenomena, etc.).

Thus, the Minimal Urban Structure is made up of all the elements of a town which are strategic from a functional and accessibility point of view (road networks, infrastructures, communication networks and their relative hubs, evacuation routes and safe areas, key functional hubs),

but also those places linked to community identity, and productive and cultural functions which can play an important role in the town's recovery. However, along with these elements, the relevant problems and critical aspects must be identified. These are the susceptibility to damage or loss of functionality arising from the physical damage of single factors or systems. This assessment is necessary to forecast the appropriate and gradual increase in the functioning of the structure, through actions and rules encompassed in the targeted urban planning and projects.

Different and appropriate field experiments have been carried out in different regions, while this tool was officially adopted in the legislation for the Umbria Region, where the 2005 Regional Urban-planning Law n.11 introduced in the "General Plan - structural part ", the individuation of the Minimal Structural Plan (MUS)[2] in order to reduce Urban Seismic Vulnerability[3].

Instead, the concept of the "Limit Condition for an Emergency" describes the condition of an urban settlement where, also following the damage caused by an earthquake, should it result in the almost total interruption of urban functions, including residential, the operability of most of the strategic emergency structures, and their connections and accessibility to the regional context, would be, however, maintained. In other words, it is the "minimum" condition to overcome the emergency in the case of a violent earthquake, when all urban functions are interrupted, but the management of the emergency is maintained.

Research in this area has produced some results, such as the drawing up of operative analysis methods and also documents adopted and formalized by the Department of Civil Protection with rules and protocols already experimentally applied in different urban contexts. This institution has specifically prepared methods and standards of data recording in order to define the Limit Condition for an Emergency, identifying the following elements: buildings and areas guaranteeing strategic functions in an emergency, strategic infrastructures linking the town with the region and possible critical factors, urban aggregated fabrics or single structural units which can intervene in accessibility conditions.[4]

The present state of the studies, the experimentation and the institutional resolutions concerning, respectively, the Minimal Urban Structure and the Limit Condition for the Emergency highlight the close complementarity and similarities (and, at the same time, the various differences) of the two tools (Fabietti, 2013. Olivieri, 2013). The first specifically regards the design and planning aspect and is linked to the town's morphological aspects, and the second is mainly linked to the essential emergency conditions. These differences and complementarities have been emphasized by different authors directly involved in important research in their respective scientific fields, and clearly highlight the diversity, but also the potential for further experimentation and integrating these tools in the future.

Some Italian regions, which have already experienced serious earthquakes in the last years, have actually become "laboratories" for research, experimentation and regional legislation regarding the relationship between earthquakes and urban settlements. Different organizations have coordinated the research including regional government institutions, universities and research organizations, using

2. The 2010 Resolution n.164 of the Umbria Regional Junta contains a text regarding the "Guidelines for defining the Minimal Urban Structure (MUS) in the General Plan, to reduce urban seismic vulnerability" ["Struttura Urbana Minima" (SUM)], the result of a specific research by the Umbria Region and the Department of Regional and Town Planning of the University of Rome "La Sapienza" (coordinated by M. Olivieri), which in specifying the features and content of the study to be carried out on the MUS also underlined the importance of the relation between defining the MUS and planning, as well as the sequence of the operative phases for assessing the structure's problems.

3. The 2010 Resolution n.164 of the Umbria Regional Junta defined *Urban seismic vulnerability* as the "susceptibility to earthquake damage and the loss of organization and functionality of an entire urban settlement".

4. A special "Technical Commission to support and monitor the Seismic Microzonation studies", cross-institutional and located in the Civil Protection Department, set up by the Ordinance of the Presidency of the Council of Ministers n. 3907/2010 - "Contributions for seismic risk prevention programs", prepared and formalized standards of representation and analysis of representation and recording of studies on Seismic Microzonation and analyses on the Limit Condition for an Emergency ["Condizione Limite per l'Emergenza" (CLE)]. [http://www.protezionecivile.gov.it/jcms/it/commissione_opcm_3907.wp].

and integrating the results attained into regional laws and different types of official measures.

3. Mitigation of seismic vulnerability and coordination of planning tools: the case study of Bevagna, Umbria

As previously mentioned, an important and significant case is that of the Umbria region, where the studies on the Minimal Urban Structure established the tools and procedures now defined by law for the General Municipal Planning tools, and, thus, already applied in different contexts.

As in other Italian regions, the Regional Urban-planning Law for the Umbria region (Regional Law n. 11/2005 as cited above) forecasts a general municipal plan divided into three basic parts and also phases (Programmatic Document, Municipal General Plan – structural, and Municipal General Plan – operative). A 2010 regional official resolution, containing specific "Guidelines", establishes and explains the phases of drawing up the Minimal Urban Structure in a Municipal General Plan.

Bevagna is one of the municipalities in Umbria where the new general town plan was submitted in the drawing up of the Programmatic Document[5], which contains schemes and evaluations for the Minimal Urban Structure. Currently (June 2014), the "Preliminary Consultation for the Strategic Environmental Evaluation[6]" is being carried out. The drawing up of the Programmatic Document, an important step in developing the Plan, occurred at the same time as that of a strategic plan ("Strategic Framework for the Valorisation of the Historical Center") and a sector plan ("Civil Protection Plan"). This was an opportunity to provide for an effective integration of planning tools.

As far as the tools are concerned for urban earthquake vulnerability mitigation and the management of environmental emergencies, the Bevagna Municipal Administration raised again the opportunity of integrating the basic points of the Programmatic Document and the contents of the Civil Protection Municipal Plan. The latter was drawn up by a working group from the Province of Perugia - Service for the Supervision of Construction and Civil Protection, Civil Protection Office, in collaboration with the Municipal Administration, and completed in February 2011. This integration is based on the fact that, by introducing the Minimal Urban Structure into the municipal urban plan, the plan itself identifies and consolidates the physical and functional conditions which contribute to effectively carrying out the activities and the rules forecasted in the Civil Protection Plan in the emergency phase immediately following a seismic event (Imbesi, Cappuccitti, Di Berardino, 2011).

Therefore, the Programmatic Document includes, in the part regarding the analysis of the municipal area, the "Maps of the Minimal Urban Structure", divided into two levels of interpretation, for the whole municipal area and the main town, and an initial overview of the "critical aspects" of the MUS. This overview is also a part of the "Evaluation Report", which together with the preliminary report on the Strategic Environmental Evaluation, constitutes the basis of the Programmatic Document.

The "Maps of the Minimal Urban Structure" present the structural elements of the municipal area distinguishing between the existing ones and the "project" ones, the subject of previsions for a new adaptation of the plan. This involves a sub-division of these elements into the following categories: *mobility and accessibility system, safe open space system, strategic buildings and structures system, cultural heritage and meeting place system, economic activity and main urban function system, main technological network system ("lifelines"), economic/productive sites.*

Moreover, the two maps include the symbols indicating the relevant *critical aspects of the urban components*, dividing them into the following categories: potentially critical elements for the r*oad infrastructure network* (classified based on morphological, size, location and building presence factors), *potentially critical constructions* (bridges, overpasses, town walls, supporting walls, historical town entry gates, edifices bordering the roads), *uses in building structures along roads*, *hydrogeological problems* (areas at hydraulic risk or damaged).

Therefore, these maps establish the framework for the information, the assessment and the planning forecasts to reduce urban seismic vulnerability from different and complementary perspectives. They highlight the urban elements which are necessary to ensure an appropriate response to the seismic event, and where the previsions for further strengthening and adjustments must be focused, indicating the sites and urban aspects which can positively impact the post-event recovery. They also provide a series of assessments and projects, and offering to those responsible for managing the emergency a clear indication of the elements to verify the efficiency for a timely and suitable intervention. These aspects, with their differences and interactions, clearly show how the content of the Minimal Urban Structure responds to the needs of both the general planning and the civil protection.

5. Working group of the Municipal General Plan of the Municipality of Bevagna: Giuseppe Imbesi (Coordinator), Antonio Cappuccitti (scientific collaboration), Mario Cerqueglini (Geology), Paolo Colarossi, Carlo Di Berardino, Paola Nicoletta Imbesi, Elio Piroddi, Carlo Sportolaro (Agronomy).

6. ["Valutazione Ambientale Strategica" (VAS)]. The 2013 Resolution n. 423 of the Umbria Regional Junta establishes technical specifications and procedures in the field of Strategic Environmental Evaluation in urban-planning tools in Umbria.

Figure 1 – Bevagna, Umbria. Aerial view of the Town centre and the surrounding areas (Aerial photo of the Municipality of Bevagna).

However, this framework of the urban form also provides important guidelines for many of the policies regarding conservation and development on which to base the planning choices, and for the rules and regulations governing the development of the planning on a building and urban level. This involves the layout of the public spaces and roads, the types of programs for new constructions and for building redevelopment on which the "operative part" of the Municipal General Plan will be based.

The Municipal Civil Protection Plan, with regard to its specific contents, provides for a detailed operative organization under the responsibility of the Municipal Administration, the actions to be carried out, the procedures for the different phases (*normal, warning, pre-alarm, alarm*), the guidelines and requirements for the different types of risk (*seismic, hydrogeological, heatwave*), the sites and use of civil protection evacuation areas (*waiting, rally and assembly points, evacuation shelters*). Moreover, it also includes, as annexes, specific plans for snow emergencies, fires and the management of heatwave risks.

The coordination of the two tools involves an analysis method of issues and was carried out in collaboration with groups working on drawing up the two plans, specifically concerning hydraulic and geological problems and the individuation of territorial and urban structurally important elements. This led to the drawing up of maps which, as previously mentioned, is equally important for the planning competences of the Municipal General Plan and the Civil Protection Plan.

As far as individuating the base elements of the Minimal Urban Structure is concerned, particularly referring to the *system of safe open spaces*, the coordination was aimed at fully integrating the contents of the two tools, so that this system of areas would be made up of important urban public spaces representative of the town and well-known to the community and, at the same time, the best places in terms of civil protection measures. Therefore, the system of "safe open spaces" laid down by the Minimal Urban Structure is completely in line with the system of "civil protection areas", each of them being defined in detail, using the appropriate technical diagrams found in the Civil Protection Plan, how to use them, the restrictions and the types and preconditions of use.

Then, the case of the Minimal Urban Structure of the Programmatic Document of the City of Bevagna can highlight the benefits of a coordination of planning tools and authorities

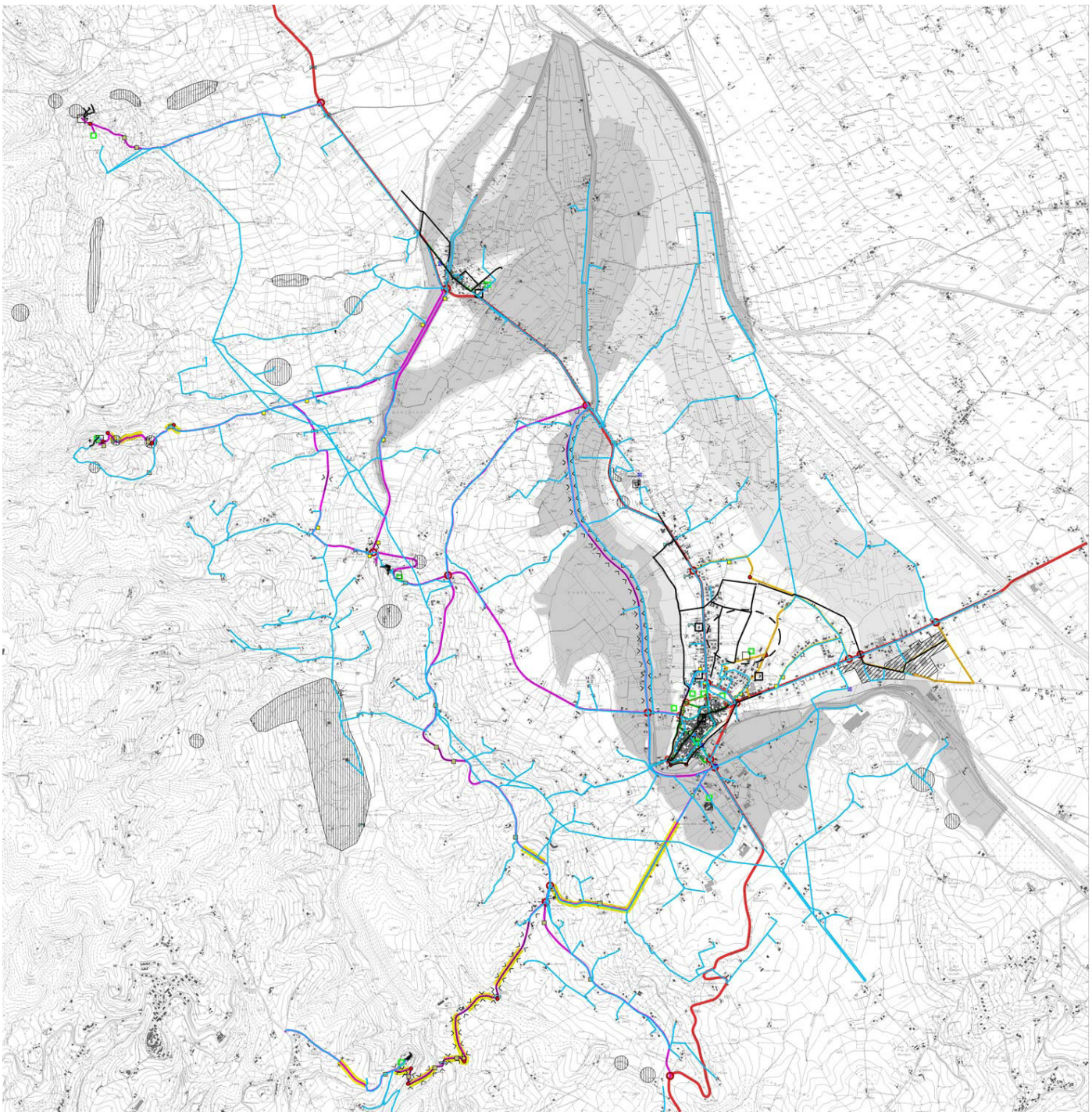


Figure 2a – Bevagna, Map of the Minimal Urban Structure (whole municipal area); annex to the Programmatic Document of the General Municipal Plan, 2013.
http://www.comune.bevagna.pg.it/mediacenter/FE/articoli/nuovo-prg-comunale-procedura-di-vas.html.

operating in the territory, in the particular case of tools and actions aimed at reducing urban seismic vulnerability. The full integration of planning decisions regarding the future structure of the city and the seismic vulnerability has resulted in a coordination regarding the planning tools, but also the actions of the municipal and provincial authorities, and this coordination has been adopted in the phases of analysis and decisions set out in the Programmatic Document. Obviously, this coordination action will continue at various stages of development of the Municipal General Plan and during the completion of the Minimal Urban Structure, in the manner prescribed by laws and regional guidelines mentioned above. The coordination of the two tools by the Bevagna Municipal Administration, and some of its essential features that we have summarized here, could be, in some aspects, a reference point, given that these experiences are quite recent and

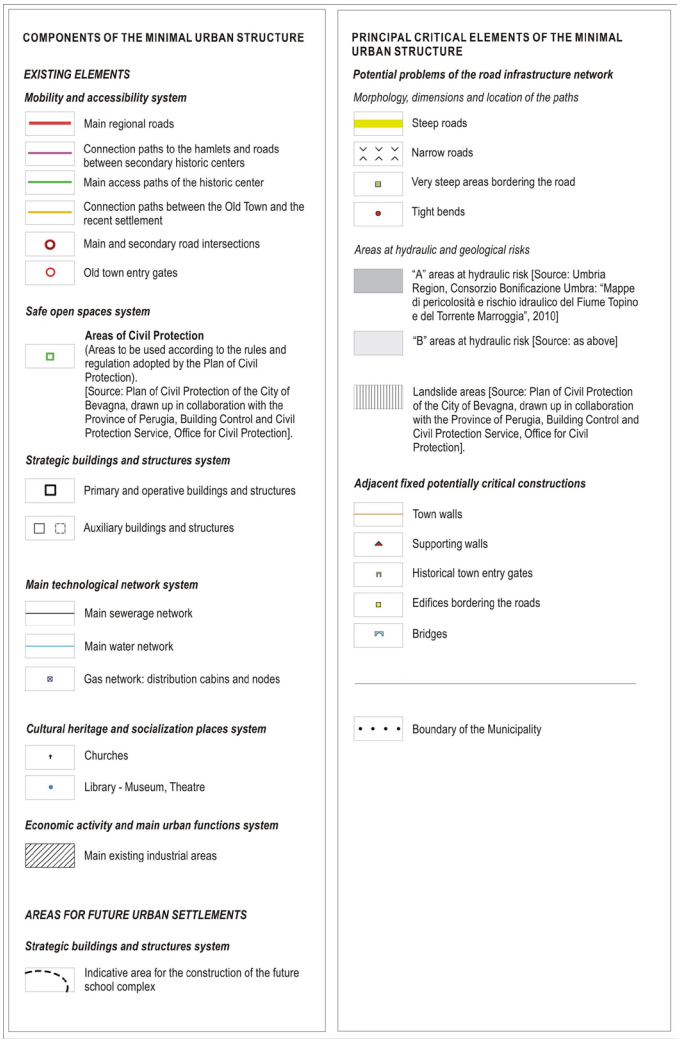


Figure 2b – Bevagna, Legend – key of the Map of the Minimal Urban Structure (whole municipal area).

relevant to the recent enactment of some important regional laws. However, they could also play a useful role in the drawing up of structural maps to reduce seismic vulnerability and to be extended to a regional level, with the view to individuate the "Minimal *Regional* Structure". The latter has already been indicated as an objective for research to be commissioned and carried out by the Umbria Region.

4. Four keywords for research perspectives

The research and experiences being conducted, the legislation, and the results of the different recent planning experiences such as those we have briefly outlined above, reflect the state and developments of the research underway in this field. However, they also point out potential future research areas. These can be summarized into some key and mutually related terms and research issues – *integration, extension, coordination* and *programming* –.

The first term, *integration*, concerns different types of potential and valid integration – the integration of the planning tools, integration of the sector tools for urban earthquake risk mitigation and the integration of knowledge and data –.

The integration of the planning tools means making use of coordinated and possibly unified tools, at a moment when too much division and sub-division of tools is seen as an important factor leading to inefficiency and difficulties in urban planning management.

The integration of the sector tools means integrating, usefully and increasingly, the contents and knowledge of the complementary sector tools. Here the complementarity, overlapping and reciprocal implications and correlation of tools such as the "Minimal Urban Structure", "Limit Condition for an Emergency" and "Seismic Microzonation" are clearly evident.[7] A further integration of these tools and the relevant knowledge and data systems could lead to a more direct and easier use on the part of institutions and those who must, for different reasons, use them. It could also establish a more useful planning of projects and works to redevelop and strengthen the urban structure.

Integration also means, at last, a synoptic and complete overlap of cognitive data of different types, which is easily accessible and usable for accurate assessments by all the institutions involved. We are talking about GIS maps which contain, for the different parts of the city, an overlay of data on the urban structure, the morphological configuration and the inherent vulnerability of the urban fabrics, the building-level vulnerability, the local amplifications of seismic motion, the other vulnerabilities of different types, the urban functions. An overlay of this kind could make it easier an accurate assessment of the state of vulnerability of settlement structures, facilitating the strategic planning of necessary actions on the basis of an appropriate and rational order of priority.

At the same time, such an overlap of information and thematic contents could be an important tool for knowledge and management at all stages of the life of the city, providing a full operational efficiency of the authorities in case of need, but above all an awareness of priorities and critical aspects in case of emergency, before, during and after the event. Then it would be not only a tool for planning the future reduction of urban vulnerability, but also - if properly used - a tool for urban management.

7. The overlay field of these three concepts has been recently explored, in the particular regional context of Umbria mentioned above, by the research of the Umbria Region and Sapienza University of Rome (Department of Planning, Design and Technology of Architecture) *Rischio sismico urbano. Indicazioni di metodo e sperimentazioni per l'analisi della Condizione Limite per l'Emergenza e la Struttura Urbana Minima* (Olivieri M. Coordinator). Final research report (november 2013) published on-line on the WEB site of the Umbria Region.

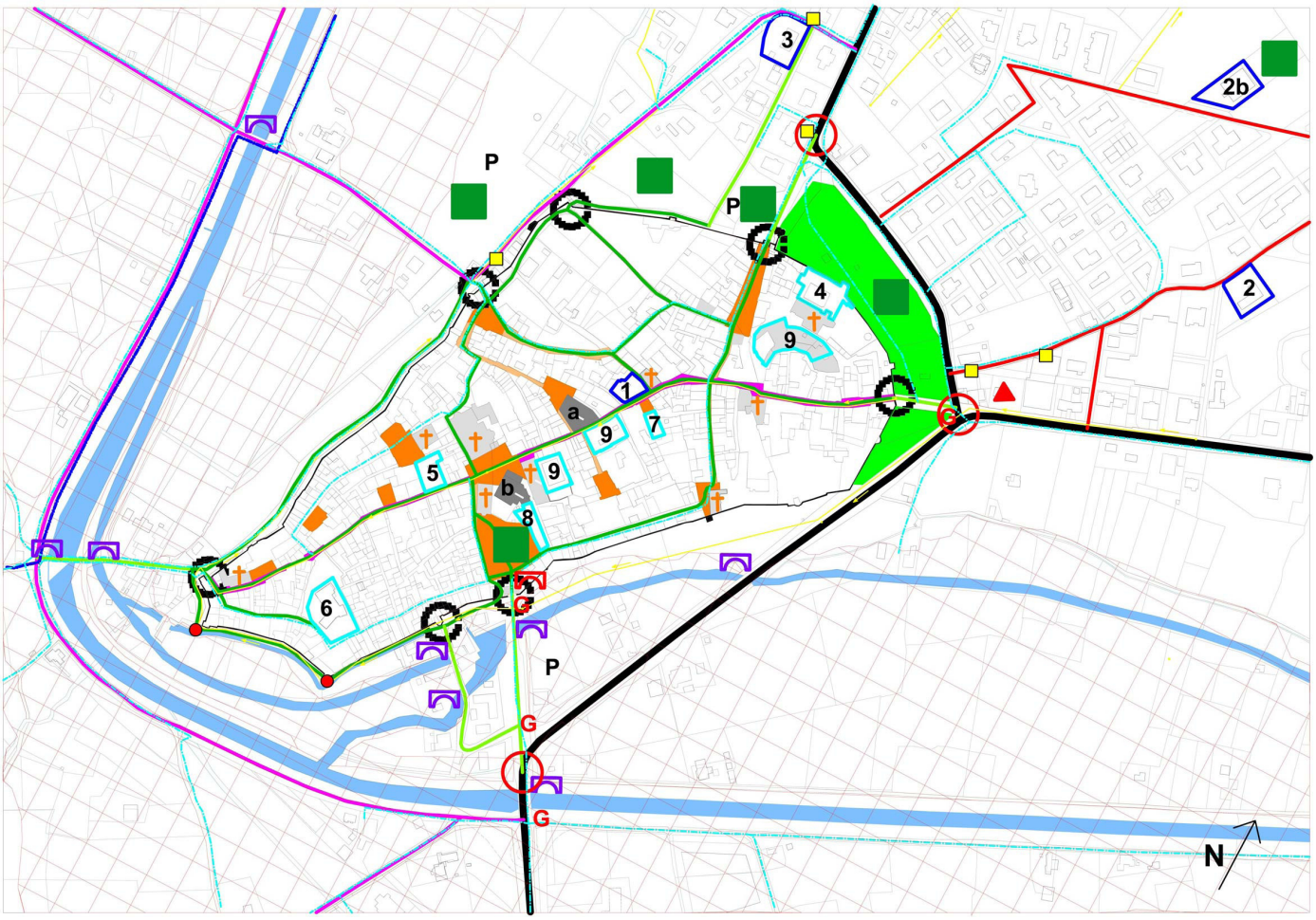


Figure 3a – Bevagna, Map of the Minimal Urban Structure (Town Centre); annex to the Programmatic Document of the General Municipal Plan, 2013. The map clearly highlights the close complementarity between the Minimal Urban Structure and the morphological structure of the historical settlement.
http://www.comune.bevagna.pg.it/mediacenter/FE/articoli/nuovo-prg-comunale-procedura-di-vas.html

Extension is a key word that, instead, concerns the extent of the area involved in the organizational and qualification actions, and for which, for some aspects, can be undoubtedly adapt a "vast area" point of view, in lieu of the prevalently municipal one which represents the majority of recent experiences.

The term *coordination* regards an indispensable operative coordination of the different entities and institutions responsible for land use planning, but also, and especially, a correct coordination of the laws and regulations that are often different from one region to another.

Finally, *programming* is a term concerning the required division and progress over time of the planning actions to reinforce and redevelop the urban and regional structures, improving their ability to respond to an earthquake emergency. Programming that, with the right decisions regarding priorities, must be based on the appropriate and correct availability of knowledge and data, and on the right measures and actions in different plans and, at different moments, in drawing up those plans, all suitably coordinated.

These are concepts and perspectives of research that are of major importance in areas, such as in parts of Italy, very often exposed to environmental risks and, thus, extremely vulnerable.

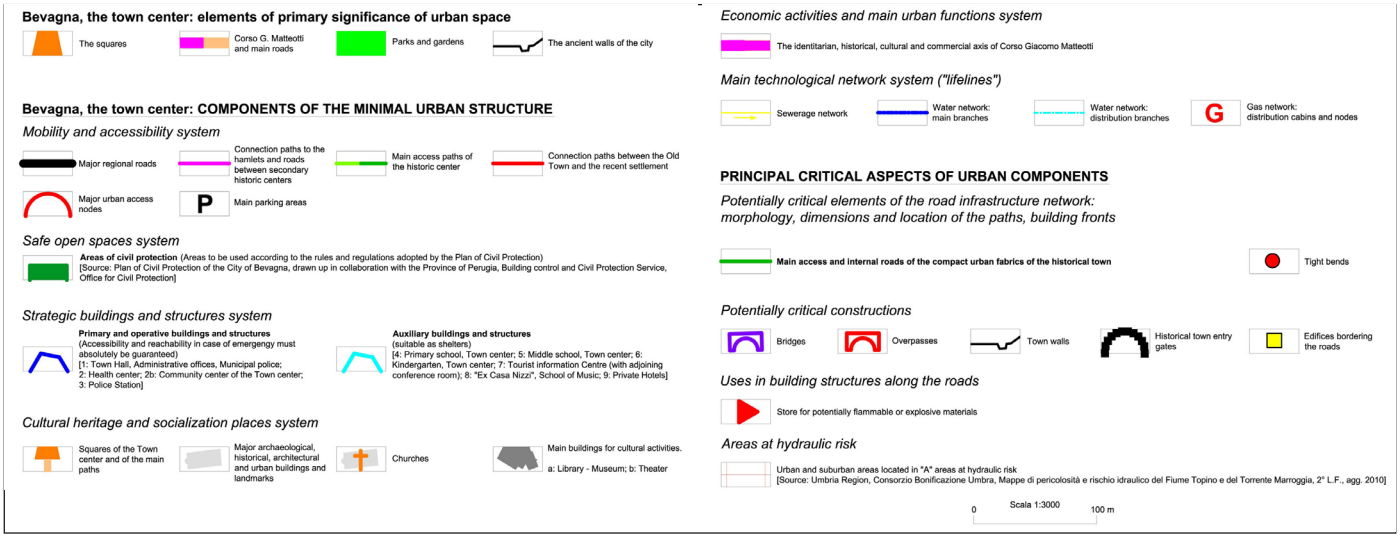


Figure 3b – Bevagna, Legend – key of the Map of the Minimal Urban Structure (Town Centre).

Figure 4 – Bevagna (Perugia), View of the Old Town (photo A. Cappuccitti).

Figures 5, 6 – Bridges and historical town entry gates: urban morphologic landmarks and critical elements of the Minimal Urban Structure at the same time (photo A. Cappuccitti).

Figure 7 – Bridges and historical town entry gates: urban morphologic landmarks and critical elements of the Minimal Urban Structure at the same time (photo A. Cappuccitti).

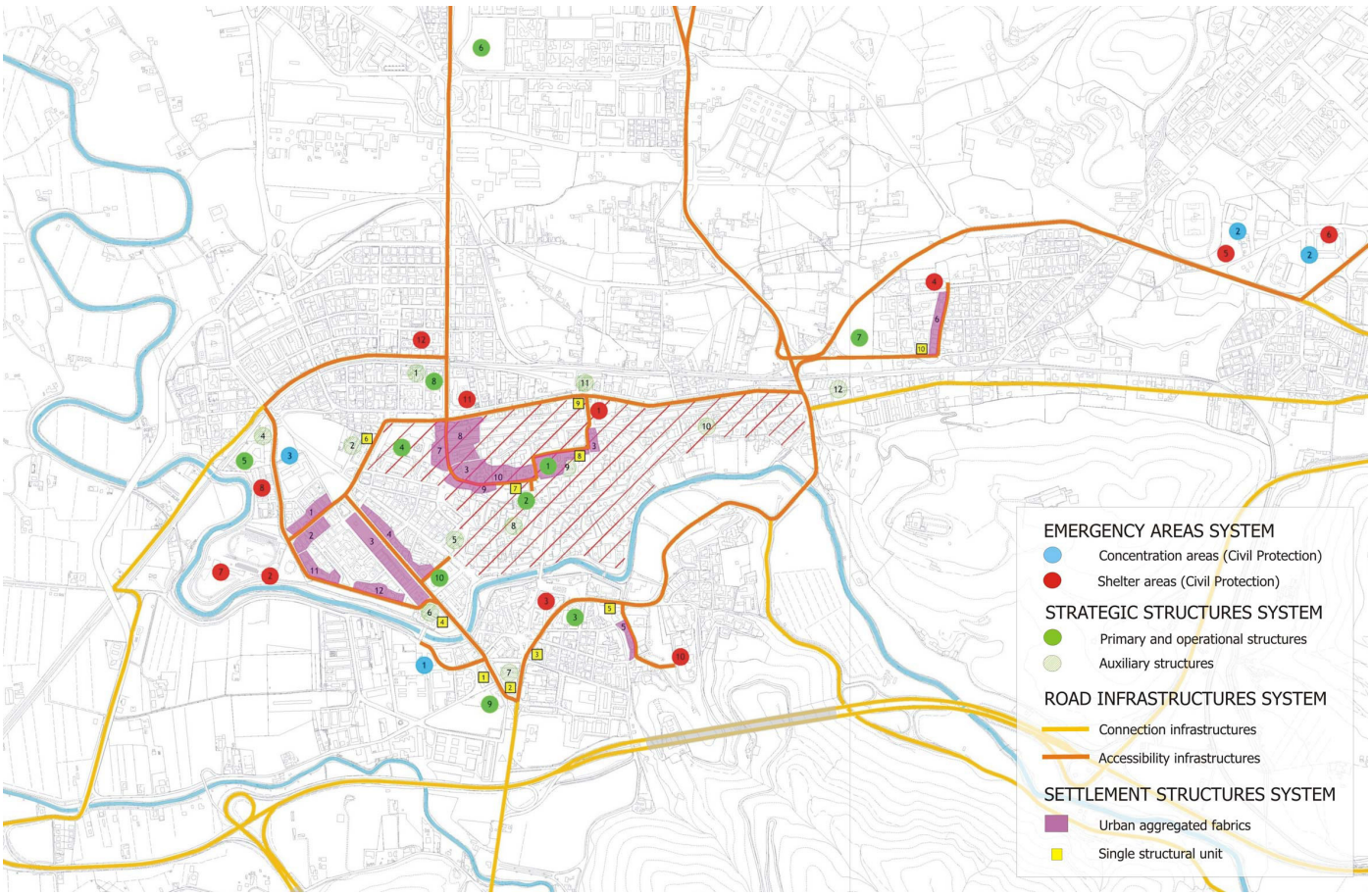


Figure 8 – An experimental schematic map of "Limit Condition for an Emergency" for the city of Rieti, Lazio, drawn in the Degree Thesis "Minimal Urban Structure for the mitigation of the seismic vulnerability of the city of Rieti"; Specializing Degree Course in "Engineering of Building Constructions and Environmental Systems", Pole of Rieti of the University of Rome "La Sapienza". Author: Alfredo Angeloni; Supervisor: Antonio Cappuccitti, 2014.

References

Bramerini F., G.P. Cavinato, and V. Fabietti (eds) *Strategie di mitigazione del rischio sismico e pianificazione. CLE: Condizione Limite per l'Emergenza*. Roma: *Urbanistica Dossier* 130, INU Edizioni, 2013.

Caldaretti S., V. Fabietti and A. Riggio, *La vulnerabilità sismica dei sistemi territoriali*. Roma: Edizioni DEI, 1987.

Cappuccitti A., and E. Piroddi (eds) *Il Nuovo Manuale di Urbanistica. Volume III, Lo stato della Pianificazione urbana in Italia. 20 città a confronto. Torino, Milano, Trento, Bolzano, Trieste, Venezia, Genova, Bologna, Firenze, Ancona, Terni, L'Aquila, Roma, Napoli, Campobasso, Matera, Bari, Reggio Calabria, Palermo, Cagliari.* Roma: Mancosu Editore, 2009.

Cremonini, I. (ed) *Rischio sismico e pianificazione nei centri storici. Metodologie ed esperienze in Emilia Romagna*. Firenze: Alinea, 1994.

Cremonini, I., and A. Galderisi (eds) *Rischio sismico e processi di piano: verso l'integrazione*, *Urbanistica*, n° 134. Roma: INU Edizioni, 2007.

Dipartimento della Protezione civile e Conferenza delle Regioni e Province Autonome, *Indirizzi e criteri per la microzonazione sismica*. Roma: Dipartimento della Protezione civile, 2008.

Fabietti, V. (ed) *Vulnerabilità urbanistica e trasformazione dello spazio urbano*. Firenze: Alinea, 1999.

Fabietti, V. "Dalla CLE alla SUM: i contenuti urbanistici della protezione dei rischi". *Urbanistica Dossier* 130. Roma: INU Edizioni, 2013: 38-40.

Fera G. *La città antisismica. Storia, strumenti e prospettive per la riduzione del rischio sismico*. Roma: Gangemi editore, 1991.

Galderisi A. *Città e terremoti – Metodi e tecniche per la mitigazione del rischio sismico*. Roma: Gangemi editore, 2004.

Imbesi G., A. Cappuccitti and C. Di Berardino. "Rischio sismico e strumenti urbanistici nel PRG di Bevagna". *Urbanistica Informazioni*, n° 237. Roma: INU Edizioni, 2011: 60-63.

Olivieri M. (Coordinator), F. Fazzio, R. Parotto, and B. Pizzo, *Linee guida per la definizione della Struttura Urbana Minima nel PRG*. Regione Umbria, DPTU – Dipartimento di Pianificazione Territoriale e Urbanistica, Sapienza Università di Roma. *Deliberazione della Giunta regionale della Regione Umbria 8 feb. 2010, n. 164 "Linee guida per la definizione della Struttura Urbana Minima (SUM) nel PRG, ai fini della riduzione della vulnerabilità sismica urbana (Art. 3, comma 3, let. d) della LR 22 febbraio 2005, n. 11*, Official Bullettin, Region of Umbria, March 2010.

Menoni S. (ed) *La salvaguardia dei valori storici, culturali e paesistici nelle zone sismiche italiane. Proposte per un manuale*. Roma: Gangemi editore, 2006.

Monaco A., and R. Monaco, *Urbanistica Edilizia e rischio sismico*. Napoli: Sistemi Editoriali, Gruppo Editoriale Simone S.p.A., 2012.

Municipality of Bevagna (Region of Umbria, Province of Perugia) *Documento programmatico del Piano Regolatore Generale*, *October 2013. Schemi della Struttura Urbana Minima.* Working group: G. Imbesi (Coordinator), A. Cappuccitti (scientific collaboration), M. Cerqueglini (geology), P. Colarossi, C. Di Berardino, P.N. Imbesi, E. Piroddi, C. Sportolaro (agronomy). Published on-line in March 2014 on the WEB site of the Municipality of Bevagna. [http://www.comune.bevagna.pg.it/mediacenter/FE/articoli/nuovo-prg-comunale-procedura-di-vas.html].

Olivieri, M. (ed) *Vulnerabilità urbana e prevenzione urbanistica degli effetti del sisma: il caso di Nocera Umbra*. Roma: *Urbanistica quaderni 44*, INU Edizioni, 2004.

Olivieri, M. "Dalla SUM alla CLE: strategie a confronto per la sicurezza degli insediamenti". *Urbanistica Dossier* 130. Roma: INU Edizioni, 2013: 34-37.

Regione Umbria. *1997-2007. Dieci anni dal sisma. Oltre la calamità: sviluppo e innovazione.* Perugia: Quattroemme, 2007.

Regione Umbria – Direzione Regionale Programmazione, Innovazione e Competitività dell'Umbria – Servizio Geologico e Sismico; Sapienza Università di Roma – Dipartimento di Pianificazione, Design e Tecnologia dell'Architettura. Research *Rischio sismico urbano. Indicazioni di metodo e sperimentazioni per l'analisi della Condizione Limite per l'Emergenza e la Struttura Urbana Minima* (Olivieri M. Coordinator), november 2013. Final research report published on-line on the WEB site of the Umbria Region. [http://www.rischi.regione.umbria.it/Mediacenter/FE/CategoriaMedia.aspx?idc=392&explicit=SI]

Feeding the City – Foodsheds and Urban Agriculture in San Diego[1]

Manuela Ricci*, Claudia Mattogno*, Bruno Monardo*, Anna Laura Palazzo, Pietro Antonio Valentino***

* 'Sapienza' University of Rome

** 'RomaTre' University of Rome

Keywords: Urban Agriculture, Social Inclusion, Healthy Food Policies

Abstract

'Urban Agriculture' (UA) in its multifaceted forms can give new perspectives to urban revitalization strategies, particularly for fostering social inclusion in contemporary, fragmented communities. The paper aims to explore the most recent general policies in United States and particularly in California both on research and planning practice. Plans, programs and local projects within the general context of 'healthy food access', are exploring new strategies to pursue a valuable framework for agricultural re-use and rezoning of vacant and derelict urban areas. The experience within the distressed neighborhood of City Heights in San Diego, CA, shows intriguing potential, matching social inclusion and physical-economic redevelopment.

1. Healthy food culture and Urban Agriculture phenomenon in America

Policies to sustain Urban Agriculture (UA), although declined in various forms, characterize many US cities. The policies practised in San Diego have many features in common with those experienced in Boston or New York or in many other cities in USA.

It is the relationship between urban and rural that increased in rank, in the last 20-30 years, in many countries and not only in the United States.

The increasing interest for urban rural policies has its origin in the stunning growth of urban population that has created a number of questions over how to deal with sustainability in terms of transportation demand, housing needs, recreational interests, food supply.

As the UN outlook doubles global urban population by 2038, the UA could make a positive impact on the world's food systems. Cities must generate food security for themselves, since food distribution becomes more complicated as a metropolitan area grows (Smit et al.1996)[2].

The United States is one of the countries with the highest rate of urban population in the world: on the basis of World Bank data, in the period 2009-2013 the 83 percent of population is living in metropolitan areas.

But in this country, UA is been redesigned not only to solve this problem.

Many explanations have been given about the importance of this production sector in the American cities. Some have a more 'scientific' basis and others are more 'ideological'. The debate is still open.

In general, UA is not a fairly simple topic because it impacts a community in a variety of ways, from providing food security, environmental benefits, and even modifying a city's urban form.

Yet, UA does not just happen. It is a result of complex policies that include zoning ordinances, comprehensive plans and, in some cases, state legislation.

The specificity and complexity of these policies will be illustrated in the following pages analysing those implemented in San Diego.

Before, it might be useful to summarize the most common explanations about the increasing reputation of urban rural policies without providing any consideration about their level of "scientific".

In the debate, the relevance of UA policies is based at least on three main issues: food security, climate change and healthy food culture.

1.1 Food security

With the increase of metropolitan areas, as already mentioned, it is necessary to reduce the transportation costs, and then the prices of agricultural products, specially to satisfy the demand of disadvantage urban population. Presently, food must travel through a complex network in order to supply American cities.

Generally speaking, food travels between 1,500 and 2,500

1. This paper is related to the dissemination of the EU research project "CLUDs" (Commercial Local Urban Districts), Seventh Framework Programme, Marie Curie Actions People IRSES, 2011-2014. The program implementation is based on networking four EU universities (Mediterranea Reggio Calabria, "Sapienza" Roma, Aalto Helsinki, Salford Manchester) and two USA universities (Northeastern University Boston and San Diego State University).

2. For UN, Urban Agriculture also contributes to a community's nutritional self-reliance, reducing hunger and malnutrition in urbanizing areas around the world.

miles from farm to fork, about 25% farther than in 1980. "At the same time, people's expectations of a food's freshness continue to increase. Only food with a high durability can make a long journey and still appear fresh on the supermarket shelves. Consequently, appearance often trumps taste and nutrition in many supermarkets" (Halweil, 2002). This problem has led to the birth of what has been defined *urban horticulture (*or *agriculture)*. The UN provides an exhaustive definition of it. "[Urban horticulture] is an industry that produces, processes and markets food and fuel, largely in response to the daily demand of consumers within a town, city, or metropolis, on land and water dispersed throughout the urban and peri-urban area, applying intensive production methods, using and reusing natural resources and urban wastes, to yield a diversity of crops and livestock" (Smit et al.1996).

The urban farmers' markets "flourished in the early 20th century but then disappeared mid-century as downtown districts declined and suburban shopping malls proliferated. Concurrently, processed foods replaced fresh foods in the national diet with the growth of the convenience and fast food industries.

In 1977, the United States Department of Agriculture (USDA) initiated a significant urban gardening program to assist low-income people in cities to grow and preserve vegetables, primarily for nutrition and food security. At its zenith in 1989, almost 200,000 gardeners, of whom 64% were minorities, were producing vegetables on 800 acres of 'farmland' in 23 major cities. For every dollar invested by the USDA, gardeners grew an estimated US $6 worth of food" (Hynes, Howe, 2004).

1.2 Climate change

Since the mid-20th century, most large cities of the United States have been warming at more than twice the rate of the planet as a whole and, on the basis of a large number of studies, the action plans designed to reduce emissions of greenhouse gases have been put into question because they are not the strongest driver of warming in cities. It is better to proceed through the combination of tree planting and vegetative cover (Stone et al. 2012).

More general, many researchers have identified *green infrastructure* as an important means to meet this goal. Green infrastructures are "an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife" (Benedict, Mc Mahon, 2006).

These researchers recognize also *urban forests* as a key green infrastructure element (Amati, Taylor, 2010). Urban forests are defined as "the aggregate of all community vegetation and green spaces that provide a myriad of environmental, health, and economic benefits for a community"(SUFC, 2010). Urban forests contribute to green infrastructure by providing a spectrum of public goods, including the "psychological, sociological, economic, and aesthetic benefits trees provide society" (Helms, ed. 1998). However, realizing these benefits through planning is still a challenge (Schwab, 2009).

1.3 Healthy food culture

Obesity is one of the most pressing public health issues facing the developed world today. Due to changing social structures, dietary patterns, and urbanization, low-income urban areas in industrialized countries are particularly vulnerable to high obesity rates and inadequate healthful food access. Within the United States, recent government policies have sought to make farmers' markets sources of fresh, healthy foods in underserved urban communities to combat growing obesity rates.

The United States has the highest rates of overweight and obesity among industrialized nations and the world as a whole. Over one third of US adults are obese (Centers for Disease Control, 2013). One way that the US has sought to combat urban food access disparities and rising obesity rates is by supporting farmers' markets.

USDA "has implemented several measures to support regional food systems and urban agriculture programs that connect city residents to locally sourced food. The *Know Your Farmer, Know Your Food* program is a USDA-wide effort to carry out President Obama's commitment to improving local and regional food systems. The initiative increases community viability, promotes new opportunities for farmers and ranchers, supports locally and regionally produced and processed foods, and encourages healthy eating habits by educating and empowering consumers. Such efforts strengthen UA programs, farmers' markets, and small farms near cities to increase healthy, fresh food production and availability for urban residents" (Campbell, 2013: 7-9).

According to the USDA, farmers' markets "provide access to fresh fruit and vegetables for consumers - especially minority consumers in the inner city - who would otherwise not be able to get fresh produce" (Friends of the Earth, 2013).

Another argument in favor of UA is the widespread presence of so called 'food desert' areas, a term commonly used to define areas where residents have little access to affordable food options owing to households economic conditions and to availability of private transport for commuting[3].

3. The USDA defines a *food desert* as a low-income census tract where a substantial number or share of residents has low access to a supermarket or large grocery store. To qualify as a 'low-income community', a census tract must have either: 1) a poverty rate of 20% or higher, or 2) a median family income at or below 80% of the area's median family income. To qualify as a 'low-access community', at least 500 people and/or at least 33% of the census tract's popula-

Under USDA criteria defining food deserts, "about 10 percent of the 65,000 census tracts in the United States meet the definition of a food desert. They contain 13.5 million people with low access to sources of healthful food. The majority of this population — 82 percent — live in urban areas" (USDA ERS, 2012).

2. Policies and strategies for small farms in California and San Diego County

The dimension of farms, specific of periurban territory, is very important for every policy of food security. For this reason the State of California and the San Diego County support, in many ways, the small farms.

Agricultural production in California is large and remarkable, diversified, and high quality. According to data from the California Conservation Center, it includes more than 200 different types of crops from greenhouses, nurseries and farms. The average size of a farm in California is equal to 126.6 hectares (313 acres), while in Europe the average size is 12.6 acres and Italy is only 7.9 hectares. However, in USA small farms are defined in terms of their gross revenues: the farms with less than 250 thousand dollars are considered small (USDA, 2007).

California State supports specific programs of financial education in order to diversify, and improve the quality of small farms. As long ago as 1990, a report published by the UC Davis put in light the State's interest improving small farms, as they:

- are actively involved in diversified, organic production with high quality crops. Most of small farms are located close to urban center, so they could improve urban agriculture and the supply of the farmer's market. They are responsible for most of the state's renowned agricultural diversity;
- are a broad mix of ethnic (first of all Hispanics and Hmong coming from Southeast Asia) and social groups. They enrich local communities by living where they farm, by linking rural and urban life, and by being a part of community's schools, libraries, and service organizations. They take care of land, contributing to an enrichment of society;
- have to increase their income, which is relatively modest, compared to big companies, which carry out intensive agriculture and raking in a very substantial chunk of revenue;
- are, in general, very sensitive to environmental issues, using renewable energy and organic products. They make a real contribution to environmental protection and demonstrate their ability to form a strong network of resilient and innovative activities;
- are located in the vicinity of urban centers: they are a favorable opportunity for job creation, and a great opportunity to improve the quality of the food system.

One of the most successful State programs is the *Small Farm Program*, launched in the mid-seventies and constantly refinanced. It is a six-month full-time training carried out within Agriculture and Resource Economy Department at the campus of UC Davis, in Yolo County, not far from Sacramento, the state capital. It has been active for years and includes:

- training at various levels from undergraduate to doctorate;
- specific assistance, with the allocation of limited resources to activities relating to valuable crops, such as blueberries, strawberries and melons;
- development and dissemination of programs for proper nutrition, contrasting junk food;
- consultancy to set up innovative practices in marketing and management, also developing farm holidays.

As far as the results of the UC Small Farm Program, recent outcome assessments are focused on four axes without any qualitative or quantitative evaluation: 1) water quality education to underserved farmers, 2) support to agritourism as an economic alternative, 3) help to family farms for avoiding huge fines, 4) incentives to high value crop production[4] (USDA NIFA 2014).

Agriculture can have many environmental benefits over development, including benefits associated with air quality, aesthetics and wildlife conservation. Agricultural lands can also provide habitat for wildlife.

San Diego County agriculture is unique because most of its production has historically occurred and continues to take place among sensitive habitat and biological communities that include threatened and endangered plants and animals. In San Diego County, agriculture is very important and ranks fifth among the productive sectors, strongly contributing to the local economy. The farms have an average size of just over 2 hectares (5 acres) and, despite their rich production, are constantly threatened by:

- the urban pressure that erodes the agricultural land use;
- the bureaucratic pressure, that requires skills people to be updated in order to extricate themselves within the complex regulations;
- the market competition, and the growing demand for quality by consumers.

So, to support small farms, the County of San Diego has promoted the implementation of specific programs in

tion must reside more than one mile from a supermarket or large grocery.

4. Only for the fourth axis, and particularly on the creation and expansion of blueberries, which is considered a specialty crop industry in California, it is given some quantitative assessment. Since 2005, harvested acreage has increased from 2,000 to 2,700, and production from 9.1 to 16.5 million pounds (USDA NIFA 2014).

addition to the State (San Diego County Farming Program Plan 2009). This Plan, part of the Strategic one, was made with the support of various departments, including that of Agriculture and Planning of the Territory, and has two main goals:

- to promote economically viable farming;
- to promote land use policies and programs recognizing the value of small farms preserving regional lands.[5]

"In California's San Diego County, agriculture is the fifth largest industry sector, contributing significantly to the local economy. In this county, with a population of 3,098,269 and a median farm size of five acres, it is a testament to the skills of local farmers that the farm gate value in San Diego County consistently ranks among the top 10 agricultural counties in the state of California" (SDCFPP, 2009). Then, purchasing local food helps the local economy, helps the farmer, and reduces the environmental damage incurred in industrial agriculture and in transporting food long distance.

3. Food and the City. A geography of discomfort and opportunity in San Diego

In recent years, besides the County, the City of San Diego has been launching several initiatives related to UA. The amendments adopted by the latter in its zoning code in January 2012 enhance the 'zero food miles' approach by introducing two new categories within the General Plan ('Farmers' Markets' and 'Retail Farms'), In January 2012, the City of San Diego (1,3 mln inhabitants) has adopted amendments to its municipal code which enhance the 'zero food miles' approach by simplifying the process for approving farmers' markets on private property[6], making minor adjustments to community garden regulations, and easing restrictions for keeping chickens, goats and bees in single family and multi-family homes[7].

The amendments follow a $50,000 grant awarded to the City to pursue municipal code and general plan amendments supporting urban agriculture with the goal of stunting obesity rates by planning communities in ways that support increased physical activity and access to healthy foods.

Other funds are available thanks to private bodies advocating for health and health equity, and fighting to expand access to affordable, quality health care for underserved communities.

3.1 Projects against the discomfort: the case study of City Heights

A measure of this discomfort is given by the survey realized within the 14 districts of City Heights, a neighborhood of the city marked by pockets of poverty and illegal immigration (SC 2012)[8].

On average, residents in the City Heights study area (Population 90,577; Households 26,944; Hispanic 54%; White 10%; Black 14%; Asian 19%; Other 2%) travel a distance of 0.66 miles to reach one of the seven full service grocers in the whole area, yet in some block groups residents travel a greater distance, nearly double the study area average[9]. About 33 percent of the total population reside in 'critical food access areas' and roughly 24 percent reside in areas considered underserved, many of which demonstrate market potential that could support additional grocery retail development. However, City Heights is largely defined by its prominent topography: settlements sit primarily atop mesas punctuated by impressive canyon systems and creeks and by an average low density.

Whereas a higher density proves a competitive advantage typical to urban markets, low density could enhance a different consumption pattern related to short food supply chains: at a closer look, urban agriculture and urban farming could easily be accommodated in vacant lands, also considering that husbandry complies with previous activities of the numerous immigrant communities in the area: notably several refugee groups from Somalia, Vietnam, Cambodia[10].

In City Heights, an example of urban geography of discomfort, many projects have been conceived or realized consistent with the healthy and cultural food approach by public and private actors. One of this it is the implementation of a high quality

5. Universities (as UC San Diego Extension) and colleges (as San Diego City College) took up the challenge, using the financial and political support of the county. They have developed training programs to allow adults to get a new job position, as well young people that should be directed to a food and environmental awareness *(Farm to School Program*). The focus on training urban farmers is related to the aging of the current farmers, whose average age is 59 years. In San Diego there is a wide variety of supply also offering sustainable urban agriculture workshops, and training programs to educate young and old alike on how to grow fresh, organic produce at home.

6. Under the amendments, retail farms (produce is grown and sold at the same location) are differentiated from daily, weekly and monthly farmers'markets, under distinct rules.

7. Interview of the Authors with N. Bragado and D. Normandin, City of San Diego, on June the 6th 2013.

8. The survey was realized by Social Compact, a Non-Profit Organization inspired by the business sector, and funded by The California Endowment fund, active since 1996. Over the past few years, Social Compact has worked to develop the Grocery Gap analysis, a research methodology that addresses critical questions regarding grocery and food access options in communities nationwide, namely (1) quantifying demand for grocery services and understanding when this demand is not being met, and (2) measuring a community's access to and the availability of grocery services in a neighborhood and what it means to be underserved.

9. The residents in the quoted area are served, on average, with 1.64 sq.ft. of a grocery retail space per person, compared to an industry standard of 3 sq.ft. per person.

10. At present, weekly farmers' markets settled in City Heights are: City Heights Farmers' Market , Sambussas, Pancho Villa's, Green Butterfly Florist. There is also the initiative 'New Roots Community Farm' held by the International Rescue Committee (see below).

market, Latino community oriented. The project was funded by the California FreshWorks, a private-public partnership (PPP) loan fund whose mission is bringing grocery stores and other forms of healthy food retailers to underserved communities. The investment ($ 8,5 mln) impacted positively on job creation with 122 new units since 2012.

Always in the City Heights neighborhood, the *International Rescue Committee* (IRC) – an important international Non-Profit Organization (NPO) working with a peculiar focus on refugee resettlement in the US – gained better awareness of the food-related problems and began organizing meetings with local communities around this issue. Many immigrant families suffered high rates of obesity and other health problems due to the lack of affordable fresh and healthy food.

IRC started a bottom-up process, working with refugee communities, other residents and local groups to tackle food insecurity and malnutrition. They identified a vacant brownfield public lot in Chollas Creek (2.3 acres) and asked the City for permission to farm that land. Because the City did not yet have a policy for urban farming, IRC – together with residents and non-profit advocates – focused on finding solutions by promoting changes in the laws about land use, community gardens, farmers' markets and other grassroots initiatives.

After several years of bureaucratic process, in 2009 the City of San Diego approved the project and released an 'occupancy permit' on the designated vacant plot. As already mentioned, a significant development in this process was the approval of a city ordinance in January 2012 that dramatically streamlined the city's community garden regulations. On Chollas Creek vacant land a community garden was set up, giving the possibility to develop vegetables and fruit for 85 refugee families (about 350 people).

Since many refugees were farmers in their countries of origin, the strategy was less oriented towards technique, and more towards a better understanding of market dynamics, business and marketing.

The *New Roots Community Farm* is the first of several initiatives put in action by IRC under the broader umbrella of the *Food Security and Community Health* (FSCH) Program.

Other initiatives comprise The *New Roots Aqua Farm*, an 'aquaponics system'[11] that employs a closed-loop cycle of tilapia farming with hydroponic vegetable growing. The Aqua Farm is also a small-food-business incubator that gives entrepreneurial residents additional space to grow.

New Roots growers from both the Community and Aqua Farms sell their produce on a weekly basis at the City Heights Farmers' Market. Also within the same program, the City Heights Community and Remedy Garden is located in the heart of City Heights with 16 gardening plots for community residents and a herbal medicinal garden, where two high school garden programs train youth in urban farming and food justice advocacy.

This incremental strategy is to ensure that refugees and residents are able to obtain affordable fresh organic food to feed themselves and their families, and also potentially to introduce them to the food business. Training programs are organized by the IRC, and because the community farm has been certified, they are able sell their surplus at City Heights Farmers Market and to restaurants, making it a potential secondary income for a family. This is especially pertinent to women, who generally are more involved in the process. Some farmers have turned this activity into a business, through a food business incubator located in Pauma Valley, 50 miles into San Diego County.

From a micro point of view, the initiative is proactive in meeting its community needs, primarily in terms of food security and nutrition.

In a 'critical food access area' such as City Heights, farmers not only have land to farm and access to fresh ethnic food, but also technical assistance, credit facilities and training to improve their business knowledge.

Locally grown food from New Roots may allow households to enhance their income and achieve a better diet. Training programs improve business capacity building, and microenterprises are sustained by a number of IRC facilities. Broadening the perspective, *New Roots* has widened its specific impact via a step-by-step process, and now comprises a network of initiatives serving communities' needs, and developing local economies both within the neighborhood, and beyond its urban borders.

Putting together the IRC initiative and other implemented 'healthy' projects, as the creation of the City Heights farmers' market, it is possible to argue about the first emerging outcomes. Specifically related to farmers' market, recent studies and surveys (Lee, 2011) demonstrate that more than 70 percent of respondents changed their eating behaviors since attending the market. Most patrons spent $20-29 on fruits and vegetables each week, notwithstanding the majority of them purchased only less than 25% from the farmer's market, probably due to the fact that it is open once a week. On the other hand, 'New Roots' initiative can be considered a sort of pilot project with a relevant social inclusion value and at the same time a limited impact in terms of economic support for immigrants, refugees and low-income households.

11. The 'aquaponic system' is the merging of two farming technologies: hydroponics and aquaculture. The former is growing plants with their roots without soil in water or in an inert medium (expanded clay aggregate, gravel, perlite, or similar), the latter is fish farming. Aquaponics represents a symbiotic relationship, where the fish fertilize the plants with their waste. The plants use that fertilizer, absorb it and send the water back clean to the fish to re-use.

4. UA for regenerating San Diego: what lessons and opportunities?

Referring to the topics and issues previously discussed, some important reflections come to light.

First of all, the US and specifically California framework shows many topics as diverse as food, land use, health, social inclusion, agriculture, and transport involved in enhancing urban redevelopment processes. Each topic refers to specific goals and various tools that are built and carried out by central and local administrations (State, County, City) to improve the specific situations, in most cases supported by the private sector.

Whereas, although these themes are often entangled in strategic documents – for instance the 'Farming Program Plan' which is one of the topics of San Diego County Strategic Plan – many professionals are asking for to promote the holistic character of the plans, programs or projects aimed at developing a County's territory or a limited area. This character could allow local government to create a real added value with right way.

On this way, recently William Fulton, who has been leading the San Diego city's Planning Department for 2011, is working to bring many single redevelopment programs and projects under the General Plan framework (Fulton, Shigley, 2012).

In this respect, boosting integrated policies to connect problems regarding, for example, 'junk food', obesity, blight areas, ease of mobility, agriculture, and land use is a major goal. In this framework, strategies and actions linking urban and agricultural planning for regenerating social relationships and urban infrastructures in deprived neighborhoods are crucial to address and modify the geography of "food deserts", which concerns mainly urban areas. When tackling these issues, urban administrations are prompted to innovate both their environmental policies improving the access to affordable quality food and their planning tools dealing with environmental preservation and avoiding further land consumption.

These mixed investment sectors necessarily involve the cooperation of many public and private actors in building programs and achieving multi-sectorial goals. In this way, the holistic approach can effectively implement the collaborative models between local government, local communities and various stakeholders.

Second, it comes to light the importance of 'Conservation' policy which is an important topic, but not only referred to the food system. In fact, the various policies and cases study previously discussed are reconnected, even though partly, in this context in which land use (General Plan and Zoning Code) acts as both framework and guide for private sector, specifically farmland owners, farmland trusts and non-profit subjects. The private sector is involved in projecting initiatives, especially in his suburban farmland, aimed at preserving agriculture, promoting inhabitants' quality of life, maintaining identity, creating new food access. Enhancing these actions is usually possible to make use of some tools offered by the General Plan, namely "rights' transfer" and "easements", preventing the risk of overbuilding caused by an excess of residential area demand. Parcels can be made available to young people with the goal to maintain and develop the agriculture in suburban and vacant lands.

For this reason, also training and education are important goals of the public sector.

At the end, comparing these agricultural policies with the European policies, some interesting aspects of California come to light, namely several subjects belonging to the private sector (i.e. trusts and non-profit organizations) and specific tools aimed at preserving urban agriculture. Some of these, for instance the 'rights' transfer', could be analysed in the light of the topics that are currently discussed in Europe, specifically in Italy and in France.

References

Amati, M., Taylor, L. (2010). *From green belts to green infrastructure. Planning Practice and Research*, 25(2): 143–155.

Benedict, M., McMahon, E. (2006). *Green infrastructure: Linking landscapes and communities.* Washington DC, Island Press.

Campbell E. (2013). *A Study of the Effectiveness of Inner London Farmers' Markets at Improving Food Access in Underserved Communities Without a Policy Intervention*, Johns Hopkins University. Available at http://krieger.jhu.edu/dura/wp-content/uploads/sites/2/2013/04/Campbell-Elizabeth-DURA.pdf

CDC (2013), *Centers for Disease Control. Adult Obesity Facts*. Available at http://www.cdc.gov/obesity/data/adult.html

Friends of the Earth (2013). *The economic benefits of farmers' markets*. Available at http://www.foe.co.uk/resource/briefings/farmers_markets.pdf

Fulton W., Shigley P. (2012). *Guide to California Planning*. Solano Press, Point Arena (CA), fourth ed.

Halweil, B. (2002). *Home Grown: The Case for Local Food in a Global Market*, Worldwatch Paper #163. Available at http://www.worldwatch.org/

Helms J., (ed. 1998). *Dictionary of forestry*. Bethesda, MD, Society of American Foresters.

Hynes H. P., Howe G. (2004). *Urban Horticulture in the Contemporary United States: Personal and Community Benefits*. Acta Horticulturae 643: 171-181.

Lee S. (2011). Farmers' Markets as Community-Based Health Interventions. An examination of nutrition-related chronic disease interventions based on a case study in City Heights, California. BA Reseach doc in *Urban Studies and Planning*, University of California, San Diego. Available at http://www.seniorsequence.net/old_version/images/student_files/FINAL_3.pdf

SDCFPP (2009) *San Diego County Farming Program Plan*. Available at http://www.farmlandinfo.org/

SC (2012), *Social Compact. City Heights Grocery Gap*. Available at http://www.socialcompact.org/

Schwab J. (ed 2009). *Planning the urban forest: Ecology, economy, and Community development*. Chicago, APA Planners Press.

Smit, J., Nasr, J., Ratta, A. (1996). *Urban Agriculture: Food, jobs and sustainable cities*. United Nations Development Programme, The Urban Agriculture Network, Inc.

Stone B., Vargo J., Habeeb D. (2012). Managing climate change in cities: Will climate action plans work? *Landscape and Urban Planning,* 107: 263– 271.

SUFC (2010), *Sustainable Urban Forests Coalition. How does the SUFC define urban forests*. Available at http://www.urbanforestcoalition.com/

USDA (2007). *Agriculture Census*. Available at http://www.ers.usda.gov

USDA ERS (2012). *Food Access Research Atlas*. Available at http://www.ers.usda.gov/data-products/food-access-research-atlas.aspx.

USDA NIFA (2014). *Small Farm Program Coordinators*. Available at http://www.nifa.usda.gov/nea/ag_systems/part/smallfarms_part_coordinators.html

Smart city models and energy efficiency related to the metropolization of the city of Reggio Calabria

Celestina Fazia
DArTe, Mediterranea University of Reggio Calabria – Italy.

Keywords: mobility, environment, people, living, governance, economy

Abstract

Smart cities are those well performing cities that create, through structural and technological innovation, the ideal conditions for setting up socio-economic enhancement and energy efficient values, with the aid of renewable energy and smart grid orientated smart sectors. A Smart City, in brief, is a city which combines and harmonizes specifically six characteristics, mobility, environment, people, living, governance, economy, based on the "intelligent" combination of the resources provided by the city itself and by the activities of the self-decisive, independent and aware citizens (in the case of a smart community).

Challenge for the city and the local authorities. However which are the cities eligible for this role? What are the characteristics and the city size?

This paper provides a tour of the possible candidates focusing in particular on the prerequisites, on the spheres involved, on the existing and feasible strategies needed to set up a Smart Project. The second part of the document focuses on the possible application of smart features to the reality of metropolitan cities and specifically to the forthcoming metropolitan city of Reggio Calabria.

Many different ways of being smart, some best practices

According to the "European Smart Cities" Paper compiled good by Vienna University, Smart city identifying and measuring parameters are to date, given the strong technological innovation which is being adopted within cities, the optimization at urban level of the interaction between technological progress and sustainable challenges. The centre of Regional Science of Vienna University of Technologies identifies the essence of the smart city, which is therefore something that goes beyond a digital or high technologicaly advanced city: it is an organic and multidimensional pooling of the physical, economic, intellectual and social wealth of the city. Focusing on human stock highlights the importance citizens play in promoting the growth of the city, the more liveable the city the higher the level of "smartness" (competitiveness, creativity) of its citizens and therefore of the development of the city itself.

Smart cities are among the instruments to attain the Eu2020 goals. Europa 2020 aims at stimulating and harmonizing the action of cities, and the Smart City, being closer at a local level, manages to organize the city according to its strong points, to the motivation of the stakeholders, to the cultural background, to the partnership among governance, enterprises and citizens, to the strong demand for energy consumption reduction. The Smart City initiatives are seen as tools to better tackle specific issues and to set up a community of world interest at a European level.

"Smart Cities" is an initiative promoted by the UE within the framework of the SET-Plan for the reaching of the Agenda 2020 targets, deadline 2050. The objective is to reduce CO2 emissions by 40% within 2020. The UE intends to invite at least 25 cities/ metropolitan areas to take part in pilot projects. Smart Cities is one of the pillars of the Italian digital agenda and the central Government is ready to support it with significant funding. The most significant examples of smart cities are: Singapore- MIT Alliance for Research and Technology (SMART); IBM Smarter City; Global Program "Smarter Cities Challenge" 2012; Amsterdam Smart City; New York Talk Exchange Project; LIVE Singapore; European Smart Cities project; TAPE-Turin action Plan for Energy; Turin Smart City project.

With reference specifically to the concept of Digital City, the most innovative projects are: New York Digital City, Icheon-Korea DIGITAL CITIES Project, Cisco Digital Smart City at the Milan expo 2015.

The many initiatives underway also include the SMARTiP project (led by Manchester City Council), it aims to use open innovation initiatives to help 'smart citizens' co-produce innovative Internet-enabled public services within emerging 'smart' cities.

The aim of this project, is to enable the adoption of open platforms for the co-production of citizen-centric Internet-enabled services in five sites (testing): Cologne, Bologna, Manchester, Ghent, and Oulu. The objective is to enhance the ability of the cities to grow and sustain a 'smart city' ecosystem which can support new opportunities emerging for a dynamic co-production (urban) process resulting in more inclusive,made higher quality and efficient public services which can then be made replicable on a larger scale.

This will focus on a series of pilot projects, covering three thematic areas: Smart environments, Smart mobility and Smart engagement. Bologna Smart City, among the majority of activities has realized the Iperbole Civic Network – Iperbole users community and the portal of the Municipality was set up in January 1995 as a «telematic bridge» between the virtual community and the real city in order to build a «digital information society at local level». It is an operating project employing Internet to open a public doorway to the connectivity and to state a leading role for local Public Administration in the creation of an informatic and knowledge society[1].

How many and which cities

Before identifying the metropolitan city and its requirements, it is essential to focus on the concept of "city" meant as a portion of territory with a high density characterized by an intense and compact development around the existing old city (the wider area surrounding the city is the result of productive and residential expansion in the neighbouring territories). The phenomena of expansion is alarming: in UE and not only (eg in UK) it is necessary to help support cities in becoming smarter. In the UK alone, 7 out of 10 people now live in cities, and the United Nations predicts cities will grow by 60 % by 2050. As they become more complex, an intelligent standardized structure for using and sharing existing data and resources, becomes vital, how to improve performance, reduce risk and achieve sustainable growth.

The UE ITRE Commission for industry, Research and Energy published the document "Mapping Smart Cities in the UE" (Table 1) which provides not only a detailed map of the most successful cities in Europe, but also a detailed analysis of the present situation in terms of a intelligent city. According to the study, smart cities tend to be small in scale, though there are exceptions like a few metropolitan areas (Helsinky). In 2011 the cities with at least a 100.000 inhabitants, or experiencing at least one "Smart City" Project or endowed with characteristics which would enable them to take part in a "Smart City" project were at least 51% of the total. Speaking in terms of geographical distribution the countries with the largest number of Smart Cities are the United Kingdom, Spain and Italy; although the highest percentage are in Italy, Austria, Sweden, Estonia, Denmark, Norway and Slovenia. A large part of the Smart City initiatives have received funding from different sources, namely the government and private enterprises. Quite a few projects have been carried out thanks to the active participation of the public and private sectors and by a shared and strategic governance. Intelligent traffic systems and Smart City neighbourhood units are the initiatives which have attracted the greatest percentage of public funding. Energy, climatic change and resource managing systems receive the greatest quota of shared funding while participation platforms receive less interesting funding.

Table 1 – Overview of success factors for the solutions for some smart cities (by: MAPPING SMART CITIES in the EU, Study, Policy Department-Economic, European Parliament-2014).

City and solutions	Success Factor		
	Vision	People	Process
Copenaghen	+	+	+
Cycling	+	+	+
Integrated public trasportation	+	+	o
Barcelona	o	+	+
Control of lighting zones	+	o	o
Smart parking	+	+	+
Media-tic Building	o	+	-
E-governance	o	+	+
Amsterdam	o	+	+
Climate Street	o	+	+
Ship to grid (Green Economy)	o	o	+
Smart building management syystem (ITO Tower Project)	o	+	+
Healt lab	o	+	+
Helsinki	-	-	+
Open data platform (Helsinki Region Infoshare)	o	+	+

1. http://www.comune.bologna.it/english/

The Helsinki example

The global increase in urbanization brings enormous challenges: the concentration of a large share of the population in urban areas requires new solutions and integrated approaches. Transnational Nations, such as the United Nations and the European Union, to multi-levell of organization, as well as national actors, launched initiatives to promote the development of sustainably organized urban areas.

Amsterdam, Helsinki and Florence are among the cities listed in the "Mapping Smart Cities in the UE"[2] document which seek to identify citizen participating platforms for the development of the ICT cities. The strategic objective of these projects is to develop better public services through "interactive fruition city platforms", namely the Smart City Platform of Amsterdam, or to collect public data for the development of applications, useful data mash-up o new services. The town of Helsinki, in Finland, is seeking a new means to encourage the creation of technological devices, digital services, and citizen oriented applications. The Helsinki project believes in transparency which enables a better feedback from citizens to civil servants. The metropolitan area of Helsinki needs to streamline and reorganize the offer and the fruition of the city given that it is the most highly populated area of the nation. The metropolitan area encompasses Helsinki, Vantaa, Espoo and Kauniainen, and is situated in the southern part of the country, on the shores of the Gulf of Finland. In 2008 it had 1024347 inhabitants, around one fifth of the population over an area of 765 km^2 ,equal to around 0,2% of the total Finnish surface. The Helsinki-Vantaa area which welcomes 18 of the Finnish universities, most of the country's firms and the largest Finnish Airport, has become an urban laboratory for testing all the necessary technologies for improving the life of its citizens. Open data, Living Labs, crowdsourcing and internet networks are four of the topics developed in the projects outlined by the Forum Virium Helsinki's Smart City Project Area. The aim is to develop urban digital services accessible by mobile devices, so as to improve the quality of life and of work. A strategic experiment which integrates everyday life with the surrounding urban environment by 2015. The Forum Virium strategy intends to make Helsinki and its metropolitan region a forerunner at international level for the digital services offered. The operation strives to transform Helsinki and the metropolitan area into fertile ground for investing time and money. A good portion of the Helsinki project refers to ubiquitous technologies, technologies which are fully integrated in the life and daily activities of the people. Real-time traffic data, open public data, active participation of the citizens to paramount changes in the urban setting.

The Forum Virium Helsinki's Smart City Project Area, through totally integrated technologies in objects and daily activities (real-time traffic data, access to public data and e-governance participation, new and versatile services created by individuals and companies) promotes the development of digital urban services which makes living in an urban environment much easier.

The transition from smart city to smart metropolis

Cities and utilities need to find ways to make it easier to deploy innovative products and services. Cities should look for ways to attract capital and create organisational structures which have the apacity to deliver innovative programmes. In all the cases listed, the smart city offers a group of services to reduce the structural gap present in the city, like quality life creating the urban intelligence.

The smart city puts on the market a new instrument of intelligent community management with a hi-density of technology (thanks to the participation of citizen and the application of smart technologies). Smart urban technologies can provide an important contribution to the sustainable development of European cities. The 68% of the EU population lives in urban areas, a proportion that is growing as the urbanisation trend continues in Europe and worldwide. The EU has developed a shared European vision of sustainable urban and territorial development. European cities should be places of advanced sociale Progress and environmental regeneration, as well as places of attraction and engines of economic growth based on a holistic integrated approach in which all aspects of sustainability are taken into account.

Cities have always been places of opportunity and even more so now. Recent estimates say that 80% of global GDP is generated in cities. People are attracted to cities to find jobs, friends, culture and enjoy the excitements of urban life. The current megatrends of rapid urbanisation, climate change and resource depletion need to be acknowledged and understood by cities. Cities are starting to address the challenges of this new urban context.

This underlines that cities are also the sites of tremendous innovation. Cities can be great proving grounds for technologies, providing opportunities for people to invent new things, and opportunities to test and sell them. Cities therefore present an opportunity for suppliers and consumers of smart technologies. Smart technologies could help address some of the challenges of urbanisation by helping to optimise resource consumption and improve services through better management of demand and supply.

2. MAPPING SMART CITIES in the EU, Study, Policy Department-Economic, European Parliament-2014.

Smart factors for the metropolitan city of Reggio Calabria

But what can change if the *smart* city is a *metropolitan* city? The metropolitan phenomenon has not gained ground only in Europe but it has taken root all over Italy. It results not only from the need of wider urban facilities but above all from interrelation and relationships among the different functions and activities within it.

The italian metropolis is concentrated with 36% of Pil, 35% of occupated, 32% of italians and 3% of foreign people. Italian metropolis will be a motor of organisation and strategic planning, like the best european practices, Barcelona, Lion, Munich and Stockolm, able to locate resources, time, subject and methods of implementation of the projects, with a shared vision of development. The metropolitan cities have taken an increasingly important role in global economic geography, this form of supra-municipality government must be an opportunity to modernize the public administration and urban structure.

The approach adopted instead by ABB to build and monitor the smart city model focuses on three thematic areas of particular importance in terms of influence on the level of smartness and, consequently, also on the competitiveness of the urban environment:

Mobility management, because it is obvious the centrality of the choices in the area of mobility for citizens, but equally interesting are the potentials – in terms of impact on the lives ‚smart' cities – related to technological development and innovations in the regulatory/ management of flows and services.

Management of resources, because of the efficiency in the use and sustainability in the generation/ availability of resources are an important measure of the intelligence of an urban system , where the critical issues may prove dramatically .

Quality of life of the city, used to identify potential environmental and social activities that characterize the daily life of individuals in urban areas.

The "Manifesto of the Italian metropolitan cities" being defined by some associations active in ten metropolitan Italian cities, is aimed to affirm that they are the engines of national economies and that, once established, they will be able to achieve any decisive action for the competitiveness of the area, for attraction of investments, for to the creation of productive areas and technological centers, for to best use EU funds[3]. Such policies need to be reformulated in the following points:

- To switch to selected parameters through interactive platforms and data provided by various sources (by service providers and implemented by smart city users, (community) through interactive model that allows you to develop urban dynamics and "questions" of the city according to varied needs.
- To manage and analyze information in real time, to define the optimal solution for the better understanding of how a city works. Improve the management of natural and socio-cultural resources through the sustainable exploitation of resources and factors of regional competitiveness by developing the management skills and innovative interaction (smart planning and smart governance) in strategic sectors (water, buildings, waste, infrastructure services, security and safety ...) that contribute to the construction of the smart community.
- To encourage the rational use of energy for urban activities, therefore parameterize the production, the cycle of sorting and utilization for biogas. Pursue the realization of the theoretical models that see in systems computerization the key to obtain a "resource" energy from waste streams, and to improve the overall environmental quality of the city through the reduction of loads and pressures.

Europe's most pressing challenge is to overcome the economic crisis and thus put itself firmly on the path to sustainable development. What is required is a change in how Europe's economy operates – a change that will release the many strengths Europe can bring to bear in tomorrow's economy of high innovation, knowledge and skills.

Objectives are:

- To introduce a new concept of experience smart and prove its feasibility via a range of technological innovations beyond the existing state of the art, including virtual reality, and animations;
- To establish a research and show-case platform for demonstration, validation, and evaluation of such experiencing, and hence making the researched ideas, and implemented technologies ready for possible commercial exploitation.

This is why Europe (Horizon) 2020 places research, technology and innovation at the forefront of activities designed to help Europe exit the current economic crisis and build smart, sustainable and inclusive growth through the following objectives: Smart mobility, Smart health, Smart education, Cloud computing technologies per smart government, Smart culture e Turismo, Renewable energy e smart grid, Energy Efficiency e low carbon technologies, Smart mobility e last-mile logistic, Sustainable natural resources (waste, water, urban biodiversity).

The appellation smart, has identified the digital city, within a decade then the city socially inclusive, to the city that provides a better quality of life. Smart City equals sustainable city: this is the only factor common to main definitions proposed to date[4].

3. Nicoletta Picchio, *Le città metropolitane, una via per competere*, "Il Sole24ore", 8.2.2014.

4. ABB, Smart Cities in Italia: un'opportunità nello spirito del Rinasci-

Figure 1 – City of Reggio Calabria (Italy).

Different meanings of "smart" the most relevant one related to the case study

The project refers to the characteristics/contents of the metropolitan area and of the metropolitan city as well as to the construction of factors of metropolization for the city of Reggio Calabria through the transfer of good practice: Helsinki. It is fundamental to find new approaches to the construction of Reggio Calabria – a metropolitan city- that should take a leading role in the mediterranean context, develop all the necessary infrastructures, attract immaterial flows and relaunch them in to a network, should:

- Improving the contexts of territorial competitiveness of the smart city by highlighting its flows (flows of relationships, so even-intangible nature, extent, value, the government of the same, the ability to attract investment and capture interest) and favoring local territorial value and that of wide area through the improvement and the efficiency of services.
- To intervene in existing sensitive nodes to submit them at structural controls for all sources of risk (pollution, technological risk, social segregation ...), for a smart city-smart living. Compare the environmental performance of different districts with the human presence in their inside.
- To promote the adoption of new technologies and the integration of traditional participation forms, including the use of simple tools, easy to use, that will influence the process of drafting the policy.
- To support the participation of citizens in decision-making processes, reinforcing and extending the modalities of participation (for a smart community).
- To provide protective measures and risk control by developing a technological infrastructure aimed at the prediction of weather events particularly intense and potentially dangerous.

We need to identify the contribution of being smart, not only

mento per una nuova qualità della vita, Ambrosetti, 2012

with reference to the environmental issues of sustainability and environmental efficiency. The Calabria region is moving in this direction by participating in various initiatives: the project "ACI. SmarT In Moto-" topic area „Smart Education" coordinated with „Smart Culture and Tourism"; the project „Staywell"-topic area „Smart Health „integrated with „Smart government „- which offers research and technological innovation activities on themes „state of the art" of Smart Health, for monitoring the lifestyle, to support the well-being and individual prevention.

How can city and community (of area slower development) meet the energy and climate challenge? What can be gained if different energy services and technologies are combined in a smart way? How do citizens of a metropolitan city benefit from the implementation of energy efficiency measures and renewables? Who needs (through urban governance, multi-level dialogue) to be involved to start the transformation towards smart city and communitiy? Is this transition affordable for Reggio Calabria?

Figure 2 – Landscape of Condofuri (RC), Italy.

Reggio Calabria, recently established metropiltan City, is a city of 190,000 inhabitants. Located in the Straits, currently does not have the economic, social and environmental factors for the advancement to the rank of a metropolitan city. The prevailing residential buildings is low quality (phenomenon of illegal buildings). The area in which action is taken will not be closely tied to the political and administrative borders, but may extend to other areas based on reasons related to functional interdependencies.

There are several ways to be smart, but only one is the common denominator to consider the city, its government[5] and its technologies to be able -through actions aimed at inclusion, innovation and interaction- to promote active citizenship, a smart communities, aimed at creating new sociale, economic and cultural opportunities with paths of

5. Decreto Legge "Ulteriori misure per la crescita del Paese" approved on the October 4, 2012 in Consiglio dei Ministri. It contains an important section (Art. 20) devoted to "intelligent communities".

"smartierization".

The analyses, carried out also on the city of Reggio Calabria, suggest that success factors (upgrading) for metropolitan cities may be identified as follows

- economic factors: from the institutions to the international quality of research and to the market;
- sociale and inclusive factors: availability of good quality accommodation, strong sociale mixity and effective policies of sociale redistribution;
- location factors: position along the axis of a corridor or a network, as a multimodal gateway for specific activities or at the junction of important railway and air transports;
- cultural factors and heritage: importance of well preserved and valued historical heritage, policies for international cultural diffusion, policies for old city and landscape;
- environmental factors: high quality landscapes, hydrogeological security prestigious and preserved environmental sites;
- urban governance, multi-level dialogue, policies of urban marketing, management of urban conflicts and of urban security, funning organization;
- to identify, develop and deploy replicable, balanced and integrated solutions in the energy, transport, and ICT actions through partnerships between municipalities of the metropolitan city and industries related with planning, energy, sociology, economics and all the new technologies and infrastructures that are the core of the functioning of the city.

The key challenges for Reggio Calabria[6] metropolitan smart city are to significantly increase the overall energy efficiency of cities, to better exploit the local resource both in terms of energy supply as well as through the demand side measures. This will imply the use of energy efficiency measures optimising the use of renewables, the sustainability of urban transport and the needed drastic reduction of greenhouse

Figure 3 – City of Reggio Calabria, Railway, Italy.

6. The city of Reggio Calabria is the biggest in the region of Calabria Situated on the toe of Italy is separated from Sicily by the Strait of Messina, the city lies on the slopes of Aspromonte. Reggio Calabria is home to important archaeological museum which details the history of strong Greek ties with the region.

gas emissions in urban areas - within economically acceptable conditions - while ensuring for citizens better life conditions: swifter transport, job creation and as a consequence a higher degree of resilience to climate impacts (e.g. urban heat islands effects).

The policies and the proposals for metropolitan smart city of Reggio Calabria can address the following main unexplored sectors:

Integrated Infrastructures:

- through the integration of physical infrastructures such as core networks, street scenes, lighting, industrial sites etc to create new forms of value through re-use and repurposing. This might also imply the exploitation of synergies between smart grids, broadband infrastructures and in general poly networks;

low energy districts (or nearly zero) through the integration and management of:

- the cost-effective refurbishment of existing buildings without significant disruption for tenants (use of sustainable materials) with a special focus on residential buildings (illegal building);
- the supply of energy with predominant exploitation of local resources (e.g. waste heat, renewables) and the active participation of consumers;
- ICT solutions for the design and overall management of energy/ transport systems;

Sustainable urban mobility through:

- the integration of energy/ fuelling infrastructure with vehicle fleets powered by alternative energy carriers for public and private transport, including logistics and freight-distribution.

The metropolitan city of Reggio Calabria is afferent to the PON Metro.

It is necessary, therefore, through the instruments of urban planning (Figure 4, PSC di Reggio Calabria[7]) and programming:

- Put at the heart of urban regeneration construction of "public city" in which the service functions, service, culture and leisure, infrastructure and public spaces find integration with in the urban residence also ang gives an identity to the suburbs;
- Give priority to networks of sustainable mobility;
- Enter the new polarity in an organic way in the urban seizing of the opportunities of decentralization of functions of excellence that contribute to the formation of new urban centers.

The priorities and actions are:

- Applications in digital innovation for Public Administrations (Urban Agenda for the metropolitan city).
- Interactive Map for Smart Communities, in terms of usage of digital inclusion, online services, participation in the network to the strategic construction of the metropolitan city.
- Improve the „use" of physical and virtual city and its services through the enhancement of the demand of ICT by citizens and community involvement in the creation of the metropolitan city (Partecipation/Construction).

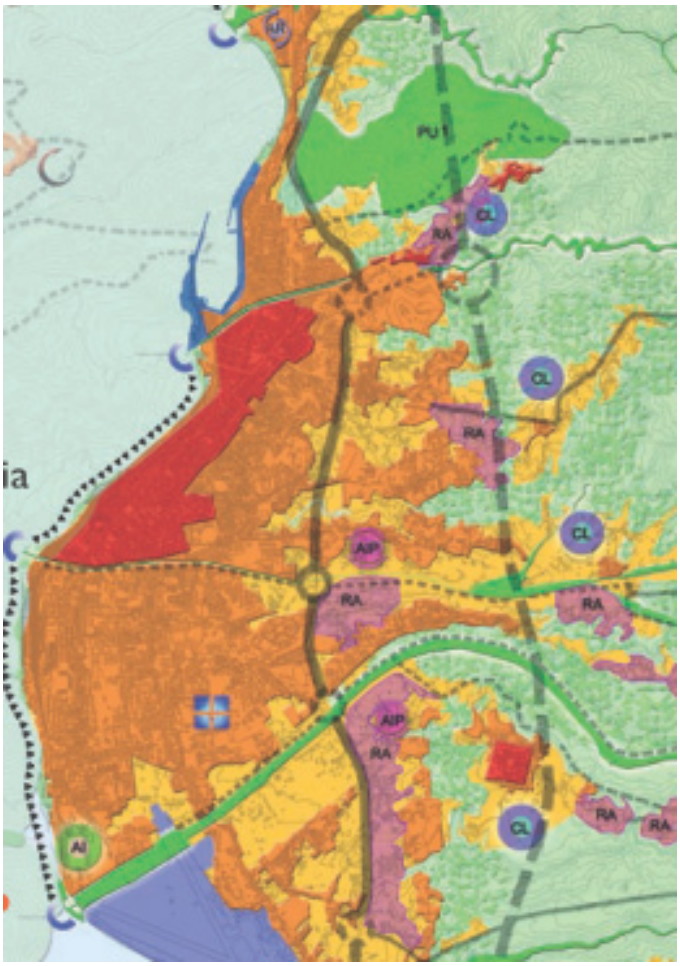


Figure 4 – PSC of Reggio Calabria, Italy.

7. PSC of Reggio Calabria (designers in RTP: Profs. Franco Karrer, Loreto Colombo, Francesca Moraci). The Preliminary Document is prepared and approvated (March 2010) in accordance with the Lur Calabria n. 19 of 2002.

References

ABB, “Smart Cities in Italia: un’opportunità nello spirito del Rinascimento per una nuova qualità della vita”, Ambrosetti, 2012

Alcatel Lucent, “Getting smart about smart cities”, 2012

Campbell T., “Smart cities: Curitiba”, Urban Land, aprile 2007

Caragliu A., Del Bo C., Nijkamp P., “Smart cities in Europe”, Series Research Memoranda 0048, VU University Amsterdam, Faculty of Economics, Business Administration and Econometrics, 2009

Cittalia-Fondazione ANCI Ricerche, “Smart cities nel mondo”, 2012

Decreto Legge “Ulteriori misure per la crescita del Paese” approved on the October 4, 2012 in Consiglio dei Ministri. It contains an important section (Art. 20) devoted to “intelligent communities”, 2012

DigitPA e Dipartimento per la Digitalizzazione della Pubblica Amministrazione e l’Innovazione Tecnologica, “Rapporto E-gov Italia 2010”, 2011

Fazia, C. Palamara D, (a cura di), Dal documento Preliminare, Dp, al Piano Strutturale Comunale, PSC. Le attività di comunicazione del processo di formazione del Piano Strutturale Comunale. Creative Artword, Reggio Calabria, 2011

Fuggetta A., “Com’è smart la città”, www.lavoce.info, marzo 2012

George A., “Britain 2020 – David Cameron’s vision?”, http://aageorge.com/2011/10/09/britain-2020-david-camerons-vision/

Granelli A., “Città intelligenti. Una via italiana alle smart cities”, Sossella Editore, 2012

MAPPING SMART CITIES in the EU, Study, Policy Department-Economic, European Parliament-2014. Parliament-2014.

Mulligan L., “Smart cities and sustainable technology”, 2010

Picchio N., Le città metropolitane, una via per competere, “Il Sole24ore“, 8.2.2014

Rivetti B., “UE e Smart Cities: politiche, attività, eventi e finanziamenti UE” Dipartimento per la Digitalizzazione della PA e l’innovazione tecnologica, 2011

Silvestrini G., “Rinnovabili smart”, in QualEnergia, n. 3, 2012

Van Beurden H., “Smart City Dynamics. Inspiring views from experts across Europe”, HvB Communicatie, 2011.

Sustainable Urban Mobility

Innovative parking strategies through the application of variable pricing techniques. The case of San Francisco

Giulio Maternini, Francesca Ferrari
Department of Civil Engineering, Architecture, Land, Environment and Mathematics (DICATAM) – University of Brescia, Italy

Keywords: variable parking pricing, innovative parking management, on-street and off-street parking, parking occupancy rate

Abstract

The goal of this paper is to propose a first methodological approach for the application of the variable parking pricing techniques to Italian medium-sized cities. After some consideration about the need of re-thinking the parking management systems, the pilot project implemented in San Francisco, CA, known as "SFpark", has been analyzed, basing on the results described in a recent final evaluation report. This project represents the first application of variable rates in specific pilot areas for on-street and off-street parking spaces. Its application aimed mainly to optimize the use of existing parking, reducing time to access the city and to search free parking spaces. Starting from this case study, we highlighted the main steps to be implemented in Italian cities to better use the existing parking supply.

1. The parking issue: a general overview

The car ownership increases the need of parking spaces. Over time, the lack of specific actions taken to manage parking led the community to consider free parking as a vested right, generating high parking demand and reducing turnover (The Institution of Highways & Transportation, 2005; Roli, Roli and Medeghini, 2007; Federal Highway Administration, 2012). This approach can potentially generate an increase of "disturbing" traffic, due to the people in search of free parking spaces (a phenomenon known in the American literature as "cruising for parking"). This expectation has a negative impact on roads level of service and on travel times.

Despite all, parking demand will change in the near future, mainly as a consequence of the decrease of circulating passenger cars, of the economic crisis, as well as of the improvement of public transport and of non-motorized mobility infrastructures.

Therefore, soon the removal of on-street parking lots will emerge as a significant need, especially in the context of the historical city centers. It will allow the increase of high quality urban spaces reserved for pedestrian and bicycle mobility, as well as for street furniture. The reduction of on-street parking will lead cities to realize parking structures, which need to ensure profit and return on investment, in order to attract potential investors and to be economically affordable. An innovative parking spaces management system could be able to satisfy these requirements.

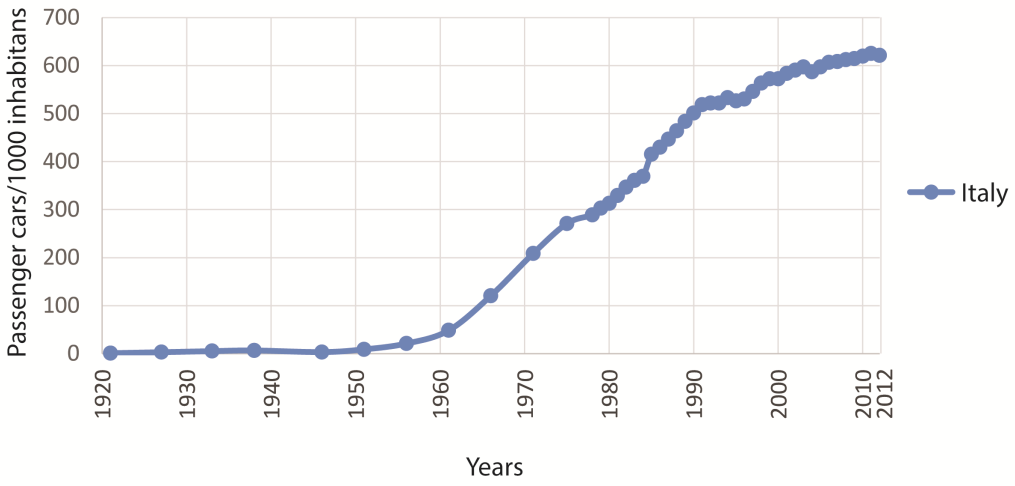


Figure 1 – Italian motorization rate 1921-2012, calculated as ratio between the number of circulating passenger cars (Source: Automobile Club Italia – ACI) and the resident population (Source: National Institute of Statistics – ISTAT).

In order to identify the most appropriate methodology for parking management, we need to consider some boundary

conditions, including for example the availability and the level of service of the existing public transport systems (LPT) and the possibility of implementing the intermodality between private cars and LPT (Simićević et al., 2012).

Several studies (for example, Victoria Transport Policy Institute, 2011; Kodransky and Hermann, 2011) suggested, among the possible activities that can be undertaken to manage both parking demand and supply, the application of innovative pricing policies. The number of applicable actions depends on the goal to be achieved: if the innovative parking pricing policies are part of a more general parking management strategy, they act locally on the parking spaces turnover, in relation to the location and the occupancy rate of the considered spaces. If they are applied in presence of congestion pricing, parking pricing should be well integrated in transportation policies, should be applied to a large area and characterized by different fares (Kittelson et al., 2008, Victoria Transport Policy Institute, 2011; Shoup, 2011; Litman, 2010).

2. Variable pricing in parking management

The introduction of variable parking fares mainly aims at improving the occupancy rate and users turnover management. In literature, the variability of parking fares (Victoria Transport Policy Institute, 2011; Shoup, 2011) is generally related to the parking duration, time and day. There are two innovative ways to determine the variable parking fares:

- performance based pricing: the static variability of parking fares depends on the ratio between available spaces and occupied ones. The parking manager can establish the maximum and minimum value of the desired occupancy rate. These values represent the expected performance of parking spaces and fares are regularly calibrated (for example, monthly updated) basing on collected data of spaces occupancy;
- dynamic pricing: based on the principles of performance-based pricing, the fare calibration is dynamic during the day, following the collected data of occupancy rate. This fare variability needs to be carried out also through the implementation of Intelligent Transport System (ITS) technologies, to collect and elaborate parking data and to inform users in real time.

Generally, the application of parking variable fares requires several parameters, such as:

- fee base value, calibrated on the state of art (if parking spaces have been already set, the rate may equal the existing one or be different, according to the current occupancy rate);
- maximum and minimum percentage of occupied spaces (as a matter of fact, in case of too high fares, parking spaces may be occupied below 50%, while in case of too low prices, they may be occupied more than 90%);
- maximum and minimum fee variation during their calibration;
- fee calibration frequency, which includes the communication of the new fares system to the actual and potential users;
- average parking duration.

3. The case study of San Francisco, California

Among several innovative projects involving management parking supply, the case of San Francisco can be considered a good practice well known in literature. The "SF*park*" project aimed at dynamically managing both on and off-street parking supply, through the fees calibration based on actual parking occupancy rate. The main objectives were the minimization of the time spent in search of free parking, as well as the reduction of time to access the city.

3.1. Project roadmap

In November 2008, the "SF*park*" pilot program application guidance was approved, including the pilot area definition and the parking policies. Furthermore, the San Francisco Municipal Transportation Agency (SFMTA) was commissioned to define fees, demand and supply, both for on and off street parking spaces.

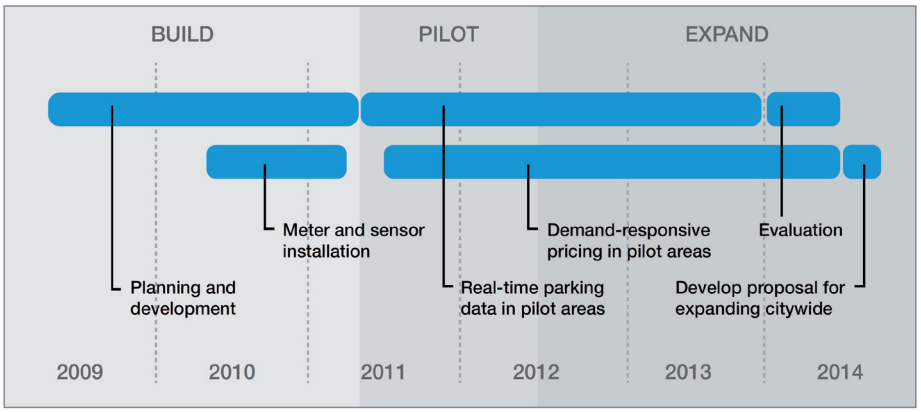


Figure 2 – Summary of the "SFpark" pilot project timeline (Source: San Francisco Municipal Agency, 2011).

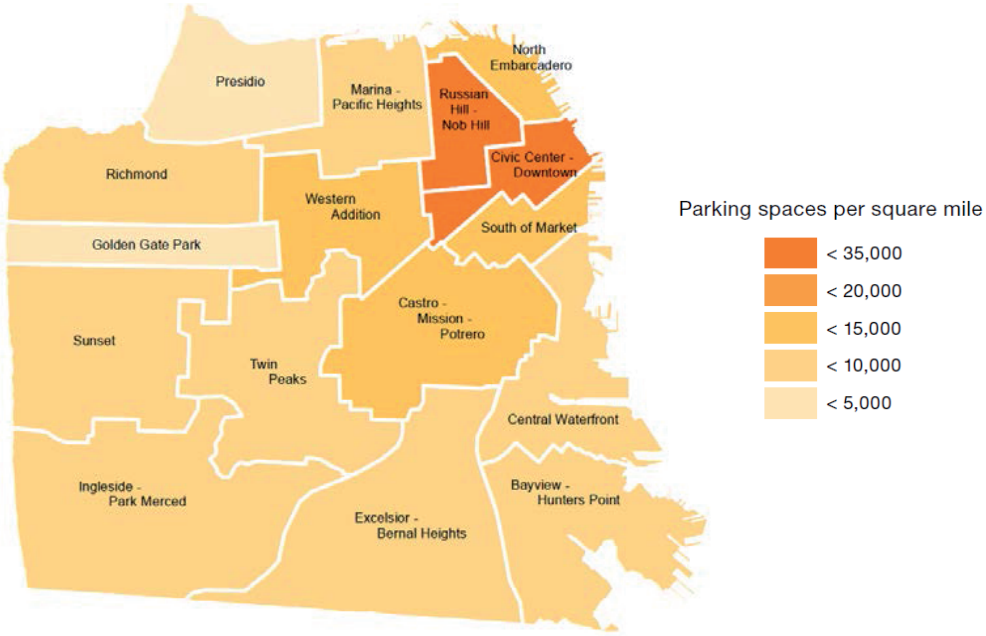


Figure 3 – Publicly-available parking by neighborhood in San Francisco - spaces per square mile (Source: San Francisco Municipal Agency, 2014).

In 2009, the pilot project was developed for seven neighborhood, namely: Marina, Fillmore, Civic Center, Mission, Downtown, South Embarcadero, Fisherman's Wharf. In spring 2010, the required smart park meters and sensors were installed.

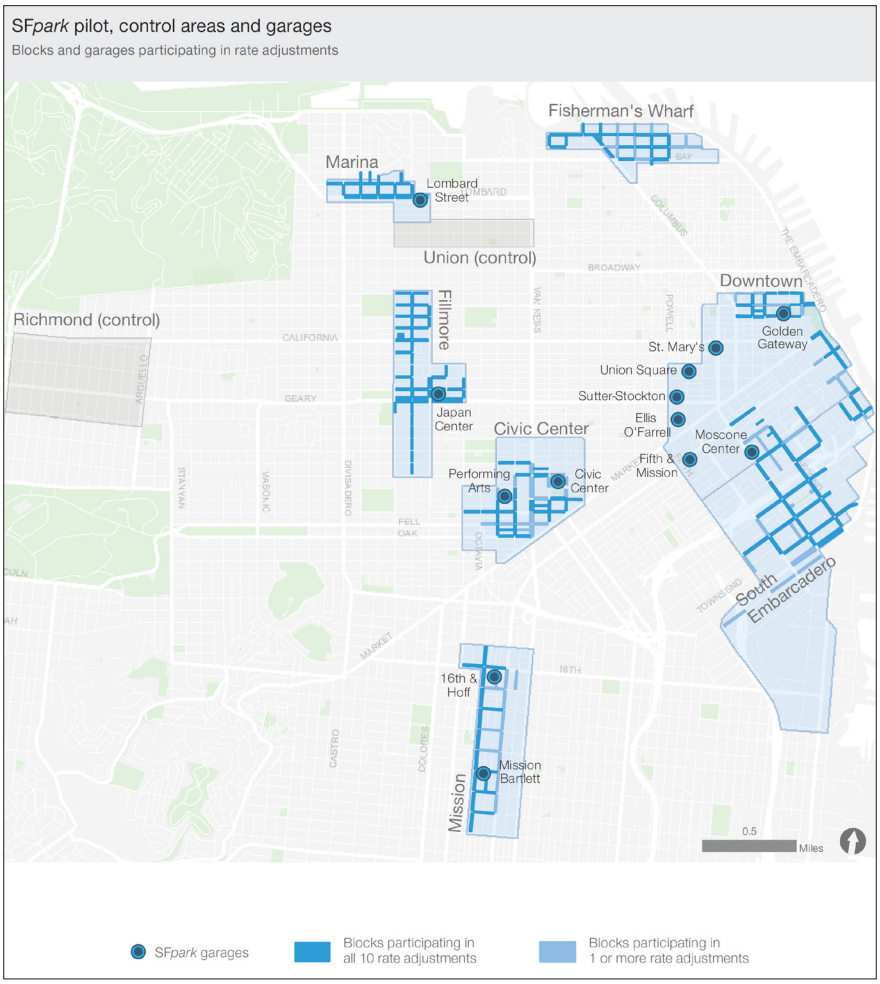


Figure 4 – Pilot and control areas in the "SFpark" project (Source: San Francisco Municipal Agency, 2014).

In April 2011 the "SF*park*" project actually started together with the parking data collection. In August the first park meters calibration was carried out. In this year, also dedicated smartphone applications and "pay by phone" service were launched. In May 2012, the information about parking were also available on "511" phone service. The experimental phase finished in at the end of 2013, sensors were turned off and the evaluation phase started. The first evaluation report was published in August 2011, while the second and last one in June 2014.

3.2. The "SF*park*" project architecture

During the "SF*park*" project, the parking fees gradually and periodically changed (increasing or decreasing) in order to find out the lowest parking price able to get the desired occupancy target, which was set to 60%-80%. Furthermore, the parking duration limits was revised in the pilot areas.
The city renewed also the payment methods, allowing also the use of credit and prepaid cards and of "pay-by-phone" systems. This innovations required to update the existing informative system to give real time information to users about available spaces, preferential routes and parking fees.
The first step consisted in surveying the parking demand, supply and related prices. This phase was useful also to plan the installation of new parking sensors and "smart" park meters. Census data were geo-referenced in GIS environment to make easier their update.
As regards the on-street parking, before the beginning of "SF*park*" project, the hourly fee changed according to the distance between parking lots and the desired destination, as well as to the time and day of the week (distinguishing between working and non-working day). The main actions consisted in dividing the parking fees into five time slots (9-12 or 7-12, 12-15, 15-18 or 15-19) and in their calibration was made as following:

- if the occupancy rate ranged between 80% and 100%, the price increased in the time slot of $ 0,25;
- if the occupancy rate ranged between 60% and 80%, the price was unchanged;
- if the occupancy rate ranged between 30% and 60%, the price decreased in the time slot of $ 0,25;
- if the occupancy rate ranged under 30%, the price decreased in the time slot of $ 0,50.

The periodical update of park meters was carried out by the centralized management system with wireless connection, thanks to the elaboration of the collected data (payment transaction from park meters and occupancy rate from parking sensors). The SFMTA adjusted on-street fees about every eight weeks from August 2011, and hourly rates could not exceed $ 6.00 or go below $ 0.25.
Also for the on-street parking, the parking fees were divided into five time slots (0-9, 9-12, 12-15, 15-18, 18-24) and SFMTA periodically calibrated them as described below:

- if the occupancy rate ranged between 85% and 100%, the price increased in the time slot of $ 0,50;
- if the occupancy rate ranged between 50% and 85%, the price was unchanged;
- if the occupancy rate ranged under 50%, the price decreased in the time slot of $ 0,50.

Alongside variable pricing variable pricing, the pilot project foresaw other initiatives, which indirectly affected peak-hours traffic flows. For example, the price in the peak-hour time slot was calibrated also to stimulate the arrival to the parking spaces in the off-peak hours. Other discounts were available for commuters and for "early birds" (i.e. who arrive at parking before the morning peak hours).

3.3. ITS system

At all the pilot areas, SFMTA installed magnetic sensors in order to monitor on-street parking occupancy: 11700 sensors were installed for about 8000 parking spaces (some spaces needed two sensors). Fees payment within the pilot areas was managed by new smart park meters, replacing the older ones, to allow the payment with credit/debit card and to manage longer parking time limits. Smart park meters are also able to collect payment transactions to update the centralized database. These data were sent by wireless connection, therefore any wired connection was necessary. SFMTA also installed both "single lot" (about 5000 parking spaces) and "multi lot"[1] park meters (covering more than 400 parking space).
As regards off-street parking, the municipal garages were already equipped with access control systems. Furthermore, the payment system was already equipped to allow the use of credit card. SFMTA maintained the existing technology, integrating it with hardware/software and networks able to broadcast the streaming data feed, where necessary.
The "SF*park*" project also included the development of a dedicated website to spread out real time information about the localization of available parking spaces. Furthermore, on the website, documents and reports about results, fees calibration and collected data were periodically published. Furthermore, two smartphone applications were developed replicating website information, as well as adding several static data about suggested itineraries to reach chosen parking spaces. These information were provided in order to reduce the number of vehicles searching of available car parking spaces on the most congested roads.

1. While the "single lot" meter is installed near one specific parking space and allows paying only for its occupation, the "multi lot" one allows paying for a block of spaces, usually for a maximum number of eight.

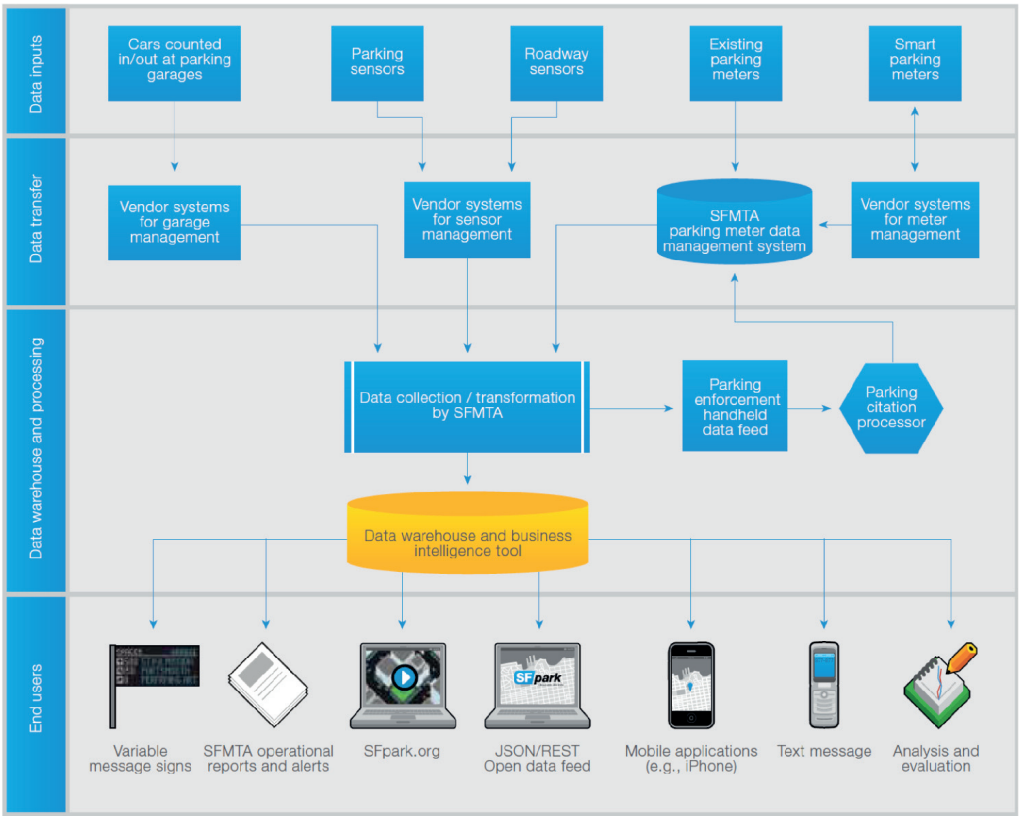


Figure 5 – Architecture of ITS system used in the "SFpark" project (Source: San Francisco Municipal Agency, 2011).

3.4. Project evaluation

The evaluation phase foresaw two independent analysis, one made by the US Department of Transport (USDOT) and other by SFMTA. While USDOT evaluated the urban financed project through the calculation of standard indicators, SFMTA defined two levels of evaluation:

- primary level: the influence of the pilot project on the transport modal choice, as a consequence of the introduction of innovative parking pricing and of the real time information delivery to users;
- secondary level: the possible improvement of public and non-motorized modes of transport due to primary level effect.

SFMTA built up the *ex ante* scenarios through specific parking surveys, while the *ex post* scenario was realized and updated with the following information:

- parking duration and periods of sensor inactivity (on-street parking sensors);
- occupancy rate of motorcycles parking (manual survey *in situ* periodically carried out);
- payment transactions, parking duration, method of payment, paid fees, periods of park meter inactivity (smart park meters);
- hourly use of parking space (off-street public parking);
- parking occupancy of disabled people, its duration and time spent in search of free parking (manual survey *in situ* periodically carried out);
- LPT users (data collected by LPT company);
- traffic flows data at municipal and regional level (surveyed through specific sensors);
- road safety data in pilot areas (given by the municipality);
- exogenous factors, as fuel price, unemployment, weather conditions, etc.

Data collection involved not only the pilot areas, but also some defined "control" areas, where the innovative parking system was not applied. This approach was considered useful to compare the "zero scenario" to "SF*park* scenario". The "before" data are referred to spring 2011, while "after" data to spring 2013.

In June 2014, SFMTA gave the evaluation of the project, showing the effectiveness of demand-response pricing in San Francisco, improving parking availability and utilization. Overall, the parking price decreased for about the 50% of existing parking spaces in the pilot areas.

Furthermore, the project results showed that the amount of time needed to find a free parking space decreased by 43%, compared to a 13% decrease recorded in the control areas.

During the calibration phase, the increase/decrease varied in each area: fares increased more in the Downtown, Marina, Mission neighborhoods and decreased more in the Civic Center, Fisherman's Wharf, and South Embarcadero. In the Fillmore neighborhood fares slightly increased.

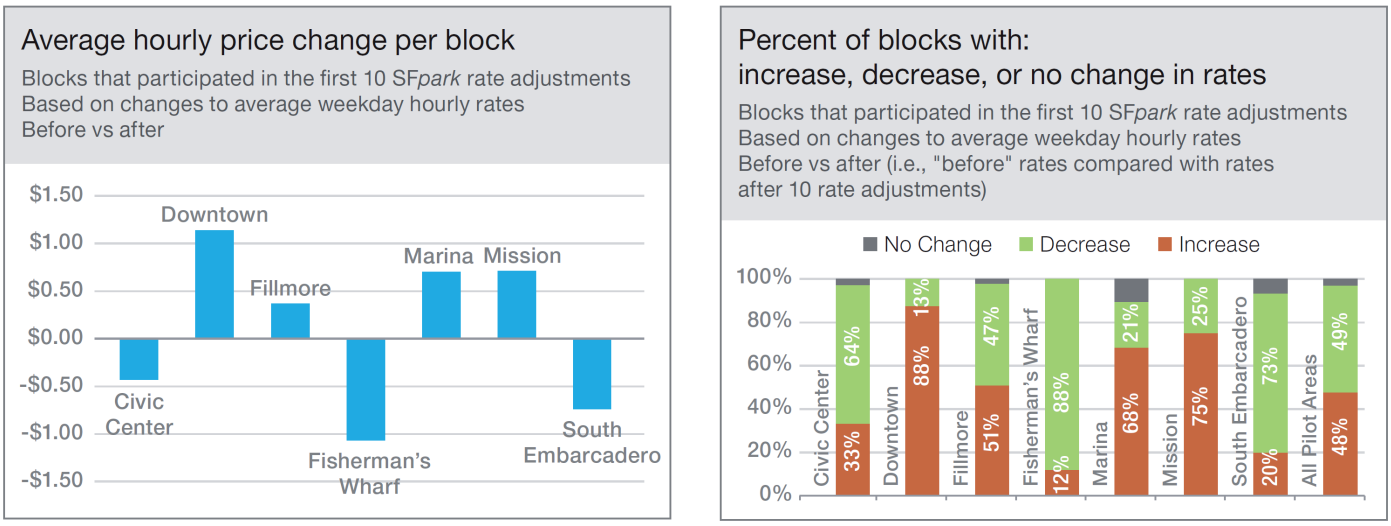


Figure 6 – Summary of pricing variation for on-street parking spaces (Source: San Francisco Municipal Agency, 2014).

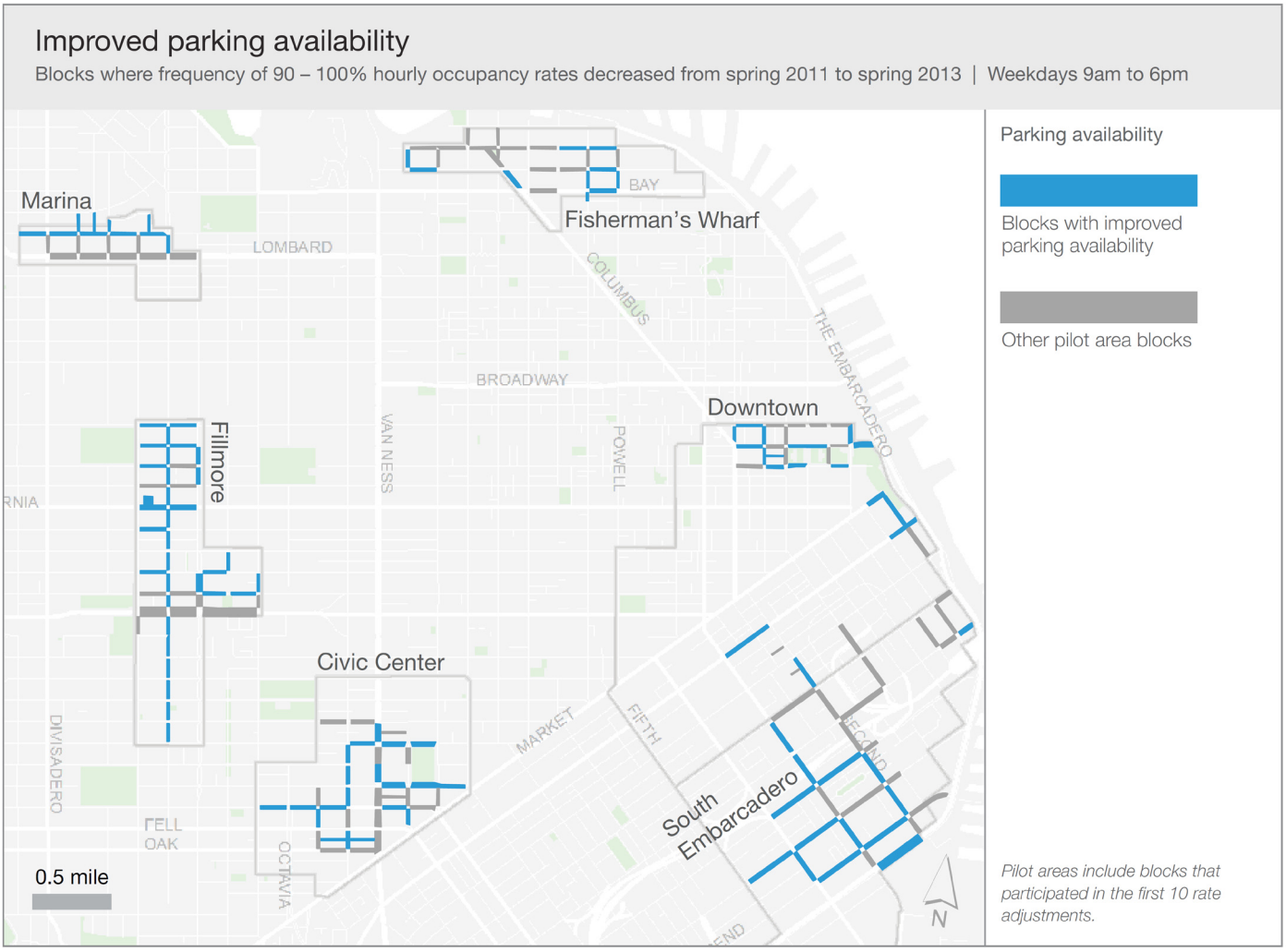


Figure 7 – Parking availability: analysis of variation percentage after "SFpark" implementation (Source: San Francisco Municipal Agency, 2014).

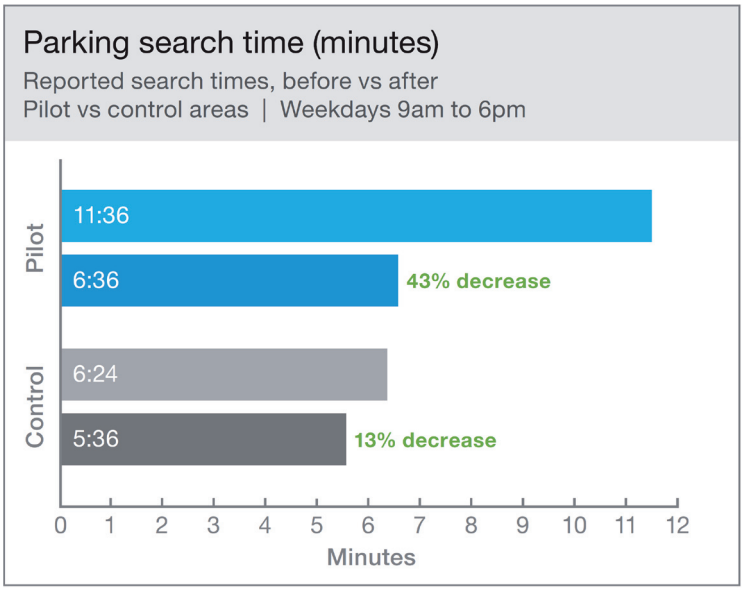


Figure 8 – Parking search time in weekdays: before and after the "SFpark" project implementation (Source: San Francisco Municipal Agency, 2014).

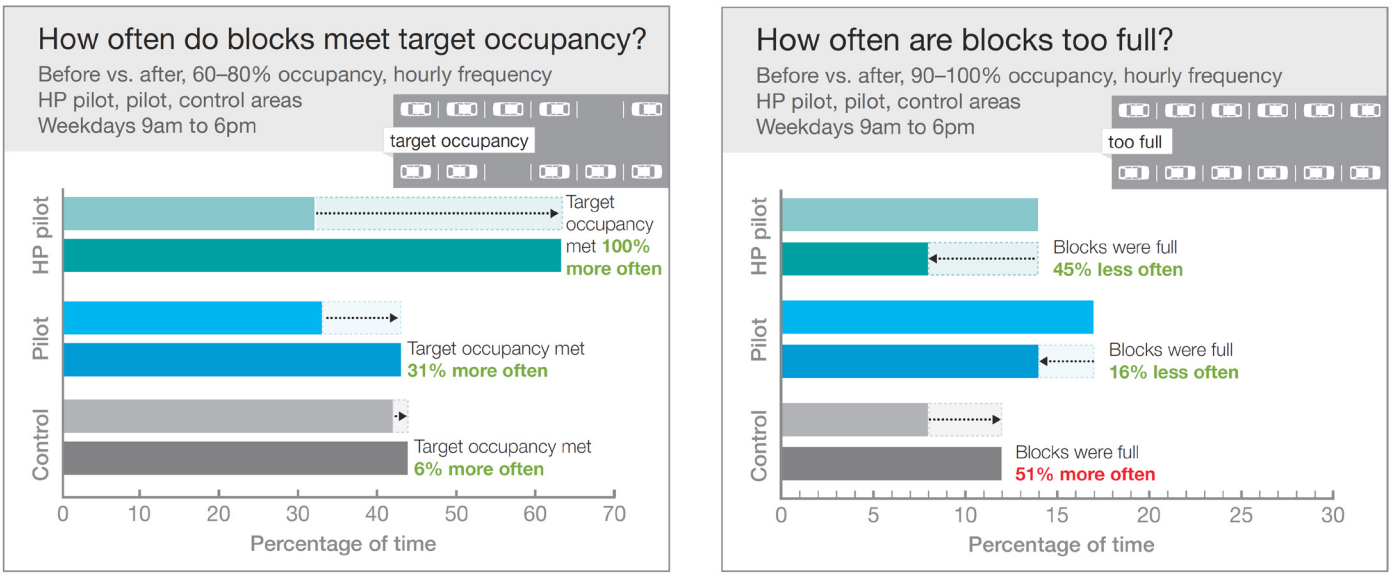


Figure 9 – Summary of parking supply response to actual users demand in the "SFpark" project (Source: San Francisco Municipal Agency, 2014).

The evaluation results showed also that parking pricing could be considered an effective measure for the parking demand management. As SFMTA introduced new park meters in several areas inside and outside of "SF*park*" pilot and control areas in 2011, the parking availability experienced an important improvement, decreasing from 90% to 15% the time of full parking spaces. The natural consequences are the following:

- easiness to find free parking in commercial and mixed-use areas;
- a higher parking turnover;
- increase of the off-street parking use.

Considering the typical underuse of garages in San Francisco, SFMTA tried to increase the use of off-street parking by applying to them lower prices and to reduce the time spent in search of on-street parking, especially for commuters.

Confirming these results (Shoup and Pierce, 2013), the parking elasticity[2] was calculated after the first evaluation period. It was mainly influenced by:

- the localization of the parking spaces: in the pilot areas elasticity was about 0,50 mainly in commercial areas and

2. Usually the elasticity of parking demand is defined as the variation percentage of the use of a specific supply linked with its price changes. The elasticity coefficient represents this kind of variation (J. Simićević, N. Milosavljevi, G. Maletić, S. Kaplanović, 2012). In parking field, the elasticity is calculated as the ratio between the variation percentage of the parking occupancy rate and the variation percentage of parking pricing.

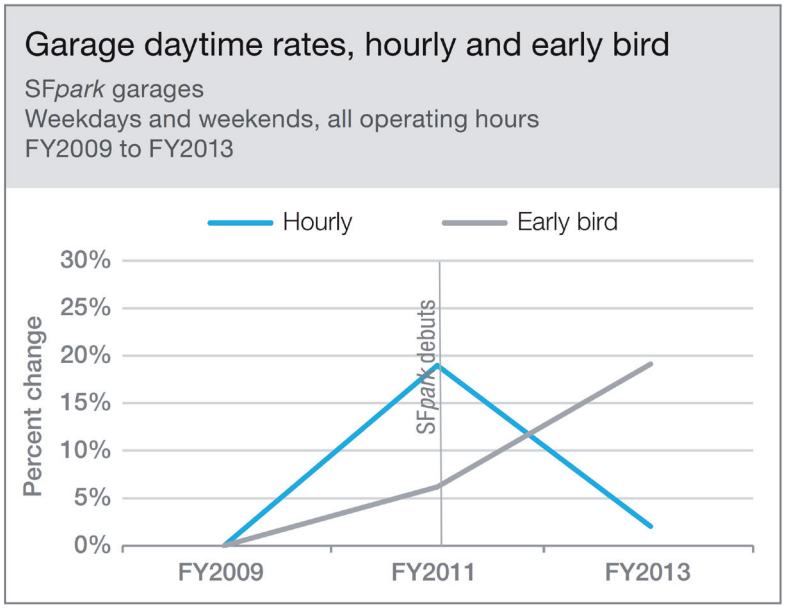


Figure 10 – Garage rates before and after the "SFpark" project implementation (Source: San Francisco Municipal Agency, 2014).

0,21 mainly in residential areas;

- the time of the day: in the morning and in the weekends the parking demand was less elastic than the one registered at noon or in the afternoon;
- the initial price: the elasticity was lower when the initial fares ranged between $ 0,00 and $ 1,00; greater elasticity was detected when fares were already high;
- the amount of price change: greater elasticity was measured after a fee reduction of $ 0,50;
- the amount of fee variation for each specific "block" of parking spaces;
- the specific phase of the pilot project: after the first price calibration, the measured elasticity was limited; it significantly increased after the second fees calibration, while, from the third one on, elasticity reached a stable value. Two factors could justify these results (Shoup and Pierce, 2013): firstly, in August 2011 fees calibration was implemented when "SF*park*" project was not widely known. Secondly, several exogenous factors could affect users' behavior.

As regards traffic flows, SFMTA declared that within pilot areas daily vehicle miles traveled (V.M.T.) decreased, as shown in the following figures.

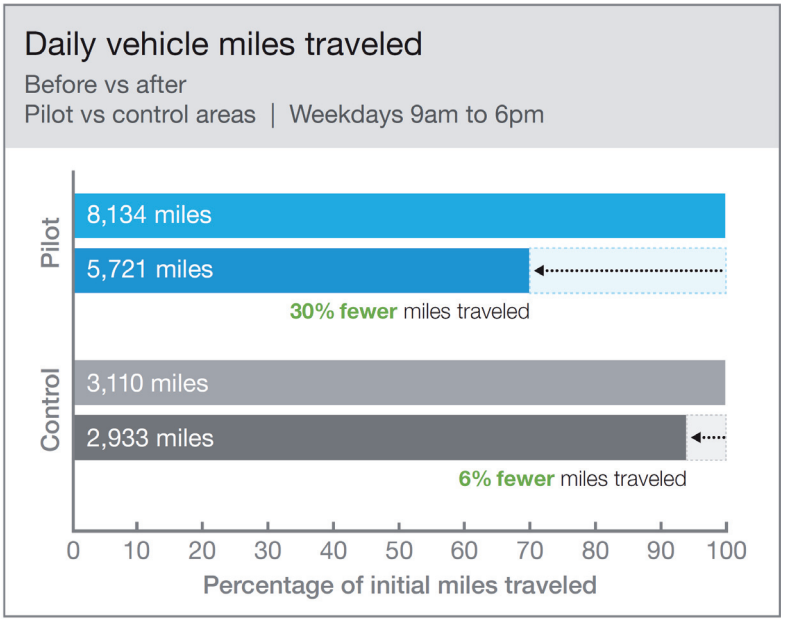


Figure 11 – Vehicle miles traveled (V.M.T.) before and after the "SFpark" project implementation (Source: San Francisco Municipal Agency, 2014).

Traffic data from roadway sensors revealed that areas with improved parking availability experienced a reduction of about 7,7% in traffic flows, while areas where parking availability did not improve or worsened a 4,5% increase in traffic volume was observed. In addition, traffic speed decreased by 6,3% where parking became easily available. SFMTA underlined that traffic flow reduction in pilot areas could not be considered a consequence of a decrease in the local economic activities or of the parking demand, even if parking taxes and sales tax revenues increased. Actually, parking demand and economic activity increased more in these areas than in the control ones.

As regards the payment methods, the results showed that the possibility to use credit cards was really appreciated by actual users. Also the "pay-by-phone" method experienced a continuous growth since its activation.

As regards the implemented ITS systems, SFMTA highlighted the following considerations:

- the electromagnetic interference coming from overhead transit line and other facilities, varied from "block" to "block";
- the sensors battery life was shorter than expected, due to the application of specific software to filter out electromagnetic noise;
- difficulties in coordinating the sensor experimentation with the activities carried out by the San Francisco Department of Public Works, which caused the breaking of several sensors.

4. Re-thinking the parking management in italian medium-sized cities

Taking inspiration from some international good practices, a first methodology was developed to re-think the parking management actions in Italian medium-sized cities. The pursued objectives are:

- to incentivize the occupancy of off-street parking spaces, instead of searching for free on-street parking spaces;
- to meet the ever changing demand of mobility;
- to re-generate urban areas in favor of non-motorized mobility and accessibility to public transport.

The first investigated aspect was the applicability of the variable pricing techniques in Italy from a regulation point of view. According to the Italian current set of laws, it is up to the Municipality to define the public parking fares, both in case of direct and indirect management options[3]. The introduction of a new fare usually requires the approval of a special municipal ordinance, as in San Francisco. The possibility, for the parking manager, to apply different variable fares comply with the existing Italian laws but should be regulated by some "limitations" imposed by the Municipality, for example in terms of minimum/maximum applicable fare, the calibration frequency, the entity of the fare variation and the communication channels and timing to users.

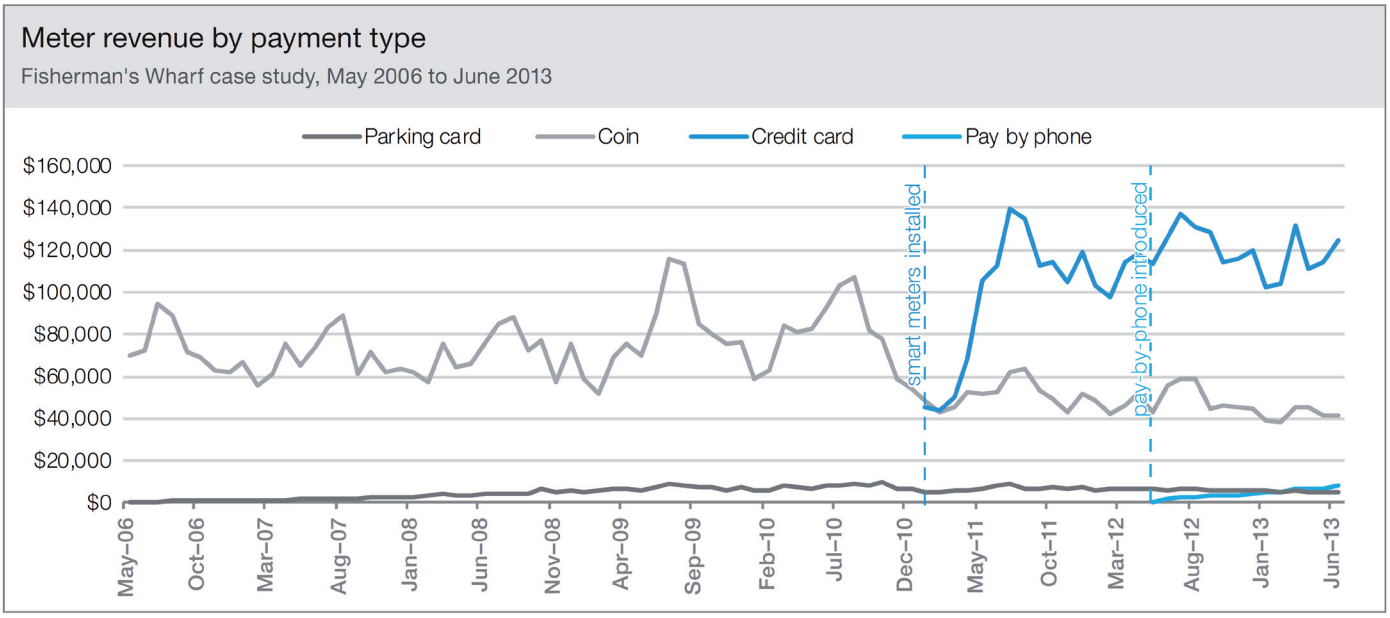


Figure 12 – Trend of different method of payments before and after the "SFpark" project implementation (Source: San Francisco Municipal Agency, 2014).

3. As stated in the Italian Highway Code (Art. 7, D. Lgs. 30 aprile 1992, n.285 "Nuovo codice della strada").

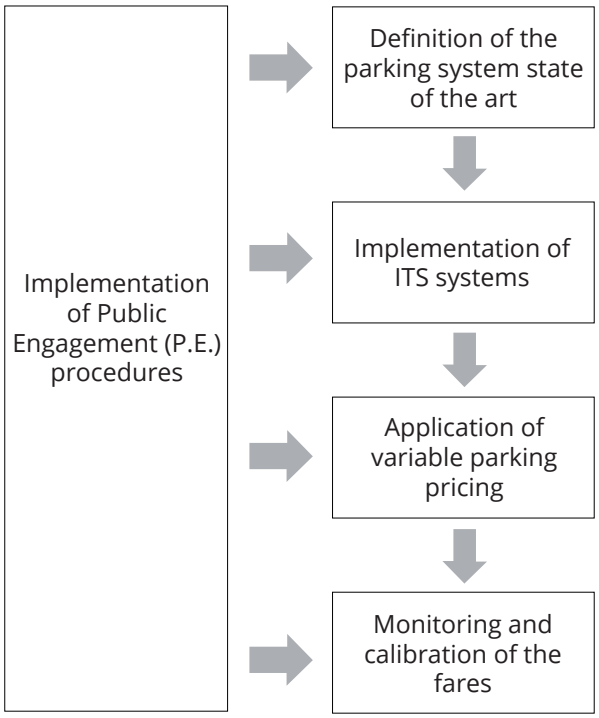


Figure 13 – Methodological proposal for the application of variable parking pricing policies in Italian medium-sized cities. (Source: own elaboration).

The table below highlights the key points, which characterize the proposed methodology.

Table 1 – Methodological proposal for the application of variable parking pricing policies in Italian medium-sized cities (Source: own elaboration).

FIELD	MAIN ACTIVITIES	EXPECTED RESULTS/BENEFITS
Parking spaces state of the art	Surveys on the existing parking supply and demand	Implementation of a parking database (occupancy rate, fees, parking duration, etc.)
	Georeferencing collected data	Implementation of geographical parking database
	Customer care surveys (awareness and acceptance)	Assessment of possible actions
ITS system: state of the art and implementation	Definition of specific characteristics to apply an ITS system (sensors, park meters, connections, *hardware*, *software*, VMP, etc.)	Selection of the most suitable ITS system
	Definition of the responsibilities for the system management and maintenance	More reliability/credibility of the ITS system
Variable pricing for parking management	Definition of the pilot areas where applying variable parking pricing	Evaluation of the project on pilot areas
	Definition of maximum and minimum occupancy rate for on-street and off-street parking	Optimization of the existing parking supply use
	Definition of variable parking fees and their range of calibration	Achievement of the expected performance, reduction of occupancy rate for on-street parking spaces, to favor LPT and non-motorized mobility
	Allocation of revenues from parking fees	Regeneration of urban areas and incentives for non-motorized and LPT mobility
	Organization and implementation of public engagement procedures	Improvement of users' awareness and acceptance about the innovations concerning the parking system and enhancement of the information diffusion
	Monitoring phase (parking data, traffic flows data, parking payment transactions, etc.)	Calibration of the innovative system

As described in the previous table, the first step of the proposed procedure consists in surveying the current parking demand and offer, through the implementation of a parking database. The San Francisco case study highlighted the importance of collecting reliable data in order to obtain a realistic *ex ante* scenario on which basing the following fares

variation. The essential information to be collected are:
- the hourly occupancy rate referred to an entire day and to the peak hour;
- the average parking duration;
- the existence of parking time limitations and fares;
- the traffic flows, distinguishing, if possible, the through from the parking related traffic (including movements to enter/exit the parking and the disturbing traffic).

Data should be collected for the working and non working days, as the kind of users are generally different. In case of cities characterized by the presence of seasonal touristic traffic, the parking demand seasonal variability should also be taken into consideration.

Collected information should be georeferenced, in order to have a more complete and better evaluation of the parking demand/offer. This further geo database implementation allows to consider more context information such as for example:
- the presence of different fares/time limitations in the same parking area;
- the localization of the urban traffic generators;
- the presence of parking spaces reserved for special road users categories;
- the presence of transit stops, their level of service[4];
- the level of service of the pedestrian/cycle paths to access the above mentioned urban traffic generators[5].

As regards the ITS implementation, they are considered a fundamental component in the application of innovative fare systems, such as the variable pricing schemes, especially in relation to the information delivery efficiency and management. It is important to make surveys concerning the existing ITS devices in order to assess their functionality. For each of them, the technical features, the maintenance state and the actual use should be investigated. Such data collection is important to define the architecture of the new ITS system, which should be suitable both for the parking manager and users needs, better exploit the existing devices and avoid incompatibility problems between the system components and the technological network. Finally, it would be necessary to establish the responsibility for the ITS system management and maintenance, in order to assure its efficiency and affordability.

The next step consists in defining the pilot areas and the experimentation phase duration, which depends on the parking demand elasticity respect to the fare variation (Shoup, 2011; Victoria Transport Policy Institute, 2011). The expected parking use performance should be set, adopting for example, the range 60 ÷ 80 %, as suggested by the San Francisco case study and by the available literature. Then the variable parking pricing scheme should be set, starting from the definition of different time slots (a minimum of 3 slots is recommended, according to the park meter functioning time and parking demand variation during the day). See the example of San Francisco in the previous paragraph.

Commuters are particularly sensitive to the parking fares modifications. Alongside the introduction of new fare schemes, in order not to penalize commuters and to discourage the use of individual means of transport, favoring the adoption of alternative modal choices, it is important to reinvest part of the parking revenues to improve the non-motorized accessibility to the urban traffic generators.

The monitoring phase is necessary to calibrate the new parking fare system and to find the most suitable parking fees according the desired parking performances. The monitoring process should be accurately planned, as the data collection timing depends on:
- the adopted fare calibration frequency;
- the available measurement systems.

At the end of the experimentation, the final evaluation phase should consider the following aspects:
- the comparison between the *ex ante* and the *ex post* scenarios collected for the pilot areas;
- the ITS effectiveness, possibly administering customer care surveys;
- the most frequent methods of payment, in order to assess their cost effectiveness;
- the economic/financial sustainability of the investment;
- the users acceptance.

The evaluation phase allows to improve the new parking pricing scheme in the pilot areas, in order to scale it at city level.

Of course, during the whole process, the periodic involvement of the interested stakeholders represents a fundamental aspect to increase as much as possible the success of the initiative, as suggested by the well known public engagement procedures developed at European level[6]

6. Some final considerations

Traditionally the increase of the parking demand was faced by enlarging the existing parking spaces supply. However, in the last few years several cities all over the world have set the goal of reducing private traffic and increasing road safety, especially in metropolitan areas. Now, the recent trend is to act on the existing parking supply optimizing its management. The case study of San Francisco shows that

4. For the calculation of the level of service of the waiting areas it is possible to apply the methodology proposed by Maternini and Foini (eds, 2009).

5. For the calculation of the level of service of the non-motorized itineraries, it is possible to apply the methodology proposed by the Highway Capacity Manual (AASHTO, 2010).

6. For example, it is possible to take as reference the procedures developed in France (the so called "Debat public") or in the United Kingdom.

variable parking pricing could be a good innovative system to better manage the existing parking supply. Starting from the experience gained in this city, it is possible to make a first methodological proposal, to calibrate this innovative parking management system to the Italian medium-sized cities.

Thus, variable parking pricing approach could:

- indirectly reduce the "disturbing traffic" component caused by who is looking for parking: ITS systems could suggest the position of available parking spaces to users and the less congested routes to reach them;
- push the use of specific parking spaces (for example, the those off-street ones);
- manage the occupancy rate of on-street and off-street parking spaces, calibrating fees and optimizing use of parking supply;
- control payments, to reinvest the revenues both for parking management and for the improvement of the non-motorized accessibility to the desired destinations.

The analyzed good practices have also demonstrated that variable pricing in parking management would work better if integrated with traffic management activities, such as, for example, the re-organization of the existing on-street parking, the requalification of the non-motorized users itineraries to access the main urban functions and transit nodes.

References

Federal Highway Administration (2012), *Contemporary Approaches to Parking Pricing: A Primer*, U.S. Department of Transport, Washington DC. http://ops.fhwa.dot.gov/publications/fhwahop12026/fhwahop12026.pdf

AASHTO (2010), *Highway Capacity Manual* 2010

Kittelson & Associate, District Department of Transport (2008), *Parking Management with variable pricing - Guidelines for effective parking management*, Maryland. https://www.mwcog.org/transportation/activities/tlc/pdf/DDOT-report.pdf

Kittelson & Associate, District Department of Transport (2008), *Parking Management with variable pricing - Guidelines for effective parking management*, Maryland. https://www.mwcog.org/transportation/activities/tlc/pdf/DDOT-report.pdf

Kodransky M., Hermann G. (2011), *Europe's parking U-Turn: from accommodation to regulation*, New York. http://www.dcba.ie/wp-content/uploads/2012/04/European_Parking_U-Turn.pdf

Litman T. (2010), *Parking pricing implementation guidelines: how more efficient pricing can help solve parking problems, increase revenues, and achieve other planning objectives*, Victoria Transport Policy Institute. http://www.vtpi.org/parkpricing.pdf

Maternini G., Foini S. (eds) (2014), *Linee guida per la realizzazione delle fermate del trasporto pubblico*, Vol. XIII "Tecniche per la sicurezza in ambito urbano", Egaf, Forlì.

Pierce G., Shoup D. (2013), *Getting the prices right - an evaluation of pricing parking by demand in San Francisco*, Journal of the American Association, Winter 2013, no.1, vol.79, pp. 67-81. http://shoup.bol.ucla.edu/PricingParkingByDemand.pdf

Roli A., Roli M., Medeghini M. (2007), *Parcheggi – Soluzioni per la sosta nelle città italiane*, Dario Flaccovio Editore, Palermo.

San Francisco Municipal Transportation Agency - SFMTA (2011), "*SFpark*" *rate adjustment policy: on-street parking,* San Francisco, California. http://sfpark.org

San Francisco Municipal Transportation Agency - SFMTA (2011), "*SFpark": putting theory into practice - post-launch implementation summary and lessons learned*, San Francisco, California. http://sfpark.org

San Francisco Municipal Transportation Agency - SFMTA (2014), "*SFpark": pilot project evaluation summary – a summary of the SFMTA's evaluation of the "SFpark" pilot project*, San Francisco, California. http://sfpark.org

San Francisco Municipal Transportation Agency - SFMTA (2014), "*SFpark": pilot project evaluation – the SFMTA's evaluation of the benefit of the "SFpark" pilot project*, San Francisco, California. http://sfpark.org

Shoup D. (2011), *The high cost of free parking*, American Planning Association, Planners Press, Chicago

Simićević J., Milosavljevi N., Maletić G., Kaplanović S. (2012), *Defining parking price based on users' attitudes*, Transport Policy, no. 23, pp. 70-78. http://www.sciencedirect.com/science/article/pii/S0967070X12000935

The Institution of Highways & Transportation (2005), *Parking strategy & management*, Media Service Ltd., Essex. http://www.britishparking.co.uk/write/Documents/Library/Parking_Management_and_Strategies-_IHT.pdf

Victoria Transport Policy Institute (2011), *Parking pricing - direct charges for using parking facilities*, Victoria. http://vtpi.org/tdm/tdm26.html

Environmental design

Environmental Design Criteria through Geoindicators for two Mediterranean Coastlands[1]

Renata Valente
Dipartimento di Ingegneria civile, Design, Edilizia, Ambiente (DIcDEA) – Scuola Politecnica e delle Scienze di Base della Seconda Università di Napoli (SUN), Via Roma, 29 – 81031 Aversa (CE), Italy
renata.valente@unina2.it

Leonidas Stamatopoulos
Department of Geology, University of Patras, University campus – 26504 Rio, Patras, Greece
leonstan@upatras.gr

Carlo Donadio
Dipartimento di Scienze della Terra, dell'Ambiente e delle Risorse (DiSTAR) – Università degli Studi di Napoli Federico II, Largo San Marcellino, 10 – 80138 Napoli, Italy
carlo.donadio@unina.it

Keywords: adaptive, coastal geomorphology, hazard, Campania, Italy, Peloponnese, Greece

Abstract

This paper examines some interdisciplinary studies that were carried out along the coasts of the Campania region (southern Italy) and the Peloponnese (Greece). The objective of this research is the definition of environmental design criteria for the Mediterranean coasts, using scientific methods in order to identify critical points and devise appropriate instruments. Initially, physical-geographic and geomorphological coastal systems such as beaches, cliffs and technocoasts were defined. Here the concept of geoindicator was introduced taking into account and interpreting tectonic, lithostratigraphic and geomorphologic elements. The geoarcheological structures are also used as useful parameters for the reconstruction of the evolving landscape. Having defined the methodology used to identify the hazard of coast stretches, the parameters were put in relation with the eco-sustainable landscape recovery techniques. To curtail erosion and hydro-geological instability along the urbanized seafront, geoindicators can be employed in the design of transitional environments in relation to the return of the phenomena at different times. The results indicate how the adaptive approach and the non-imposing solutions contribute to reduction of the anthropogenic impacts and environmental hazards in regions where there is a high hazard risk, and how the safety and stability of the coasts in addition to the quality of the projects can be enhanced.

Introduction

Transitional environments are extremely sensitive to external disturbances, while being conservative at the same time they show the prevailing processes that occurred in the past. Their evolution is closely linked to the combined interaction of physical, biotic and anthropic phenomena, and is governed by non-linear physics: the higher the morphological variability of the coasts the greater the complexity of its evolutionary dynamics.

The anthropic action, particularly over the past 200 years, has contributed to the change of the coastal landscapes, especially the urban ones, through a series of actions involving the river basin and the gulf, which occurred in a short time and in limited spaces. In this sense, man operates as an exogenous agent, stiffening the soil and slowing or inhibiting the leveling action of natural agents.

The interventions on the coasts are for settlement reasons, tourism, or even protection against weather-climatic phenomena, according to traditional criteria based on the rigid opposition to the force of natural elements and intensive exploitation of valuable places having a high market value. In most cases the site is restricted to the site of operation, while transitional environments are precisely those where the dynamics of natural phenomena and their rate of the transformation should be considered. Therefore the entire area where related phenomena occur should be studied. These are also places where it is easier to pinpoint the interdependence of events and the need for a trained understanding of their complexity.

Environmental design refers to these principles, according to historical references in scientific literature, from basic ones such as the work of Ian McHarg, who pointed out how each site is the sum of historical, physical and biological processes that should be accounted for. In fact, the dynamism of these processes is closely related to the action of man, as they influence it and in turn are influenced by such action (McHarg, 1969). Philosophical reference is the holistic approach to understanding, problem solving and critical study, aimed at the solution of more aspects

1. The work is the result of collaboration between the authors; in particular, the paragraphs "Introduction", "Design Criteria" and "Conclusions" were written by Renata Valente, the other paragraphs are edited by all authors. We also thank Anna Chiara Menditto who prepared the maps.

and consideration of the concatenations. (This method, with the disposition "to listen" and study the environmental context, is the prelude to an adaptive attitude.)

Sustainable projects on the coasts are those in which the solution enables evolving configurations to address the natural phenomenon in its different forms over time, rather than block transformations with imposed measures. In order to realize such projects the necessary premise is the environmental analysis conducted in an interdisciplinary manner taking into account all physical aspects, weather-climate change, social, vocational and settlements. Moreover, this complex set of data is to be read in its intrinsic mutual relations to understand the evolutionary trends and refer to them (Johnson and Hill, 2002).

The scenarios studied allow one to distinguish the kind of design to be proposed which can be *imposed*, namely with a rigid structure, generally parallel to the coast, regardless of the topography of the site; *covert*, characterized by soft systems, flexible and recyclable, wood, recycled rubber, with the use of vegetation to control erosion or retrieve dune systems, and *hybrid*, halfway between classical archetypes and the typical solutions of non-urban surroundings (Dern, 1992; Valente, 1999). In several instances alternative configurations include dumps, transverse structures, excavations into the mainland, the shoreline stiffeners with coasts fleshed out. Several can also be the technical choices for the realization of such sets of structures, from elements of reinforced concrete or steel, or defense works composed of modular elements, up to floating modules, submerged barriers, drainage pipes and wells, coasts nourishments, consolidations with bioengineering techniques.

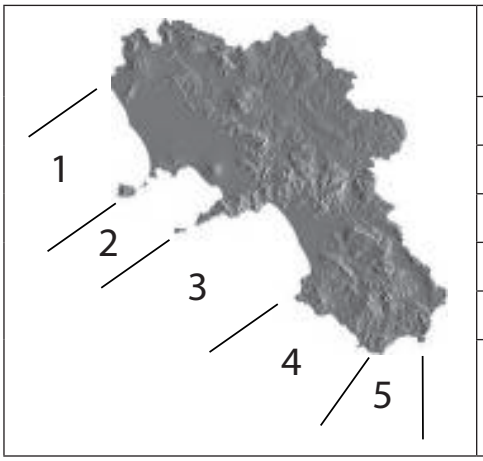
To appropriately select an adequate option reading geomorphological aspects is of greater benefit to subsequent environmental design strategies along the shore. Having defined the classification of stretches of coastline on the case study of Campania region in Italy (Donadio et al., 2014) it is compared with the stretches of the Peloponnese coast in Greece, by iterating the scientific methodology.

The alternation of short hot-arid climatic crises and cold-humid ones related to astronomical causes with cycles ranging from 150-200 years and 10-40 years (Ortolani and Pagliuca, 1994; Mazzarella, 2007), the global sea-level rise, the vertical soil movements at a regional and local scale, all contribute to the retreat of shorelines and coastal risk increase. This phenomenon is intense in many densely urbanized coastal plains, where the effects of accelerated subsidence are recorded. Typical examples of induced feedback by anthropic actions are the coastal defence works, designed to remedy the consequences of environmental changes, natural or induced, which have often amplified this phenomenon or started a new erosion focus. Therefore, these structures are surely resistant, but not resilient. Today Campania's coastal landscapes (Monti et al., 2003) show both different tectonic styles and typical geoindicators of morpho-climatic systems that are no longer active. Starting from the recognition of these issues, this paper develops a methodology for the study of coastal environments in order to propose strategies for adaptive type environmental design, where solutions of an evolving landscape are in harmony with natural transformations (Beck, 2013). This approach therefore starts by studying the physical characteristics of the places and major phenomena in them.

Coastal systems

According to morphological aspects, a *coastal physiographic unit* (CPU) is an area of coastline that borders on the edge the littoral drift along the emerged and submerged beach. Therefore the effects of a construction built on the coast does not extend outside the CPU. The boundaries of the area may not be fixed in time as a result of various events that alter

Table 1 – Coastal Physiographical Units in Campania (Italy) and their extension. The index of the structure I indicates the ratio of the total length of the coastal defences and coastal extension (average value in italics).



n°	Coastal Physiographical Unit	km	*I*
1	Gulf of Gaeta (mouth F. Garigliano-Monte di Procida)	58	0.21
2	Gulf of Napoli (Monte di Procida - P. Campanella)	305	0.38
3	Gulf of Salerno (P. Campanella - P. Licosa)	84.5	0.16
4	Cilento (P. Licosa - C. Palinuro)	112	0.13
5	Gulf of Policastro (P. degli Infreschi - Sapri)	34.5	0.11
		594	*0.20*

the dynamics of the changing coastal physiography. When observation time increases, separate CPUs can join, for example as a result of intense prolonged erosion over time or as exceptional sea storms which determine consistent sediment movements not previously implemented. The identification of the CPU can be based on various physical elements: the physiography of the shoreline, petrographic and textural composition of sediments, marine forecast system and the presence of human activities. Along the Campania coast there are five main PCUs (Table 1), six in the Peloponnese (Table 2), from the Northwest to the Southeast. *Coastal geomorphic units* (CGU) which represent segments of coastline with homogeneous morphotype features and geomorphic processes (De Pippo et al., 2008).

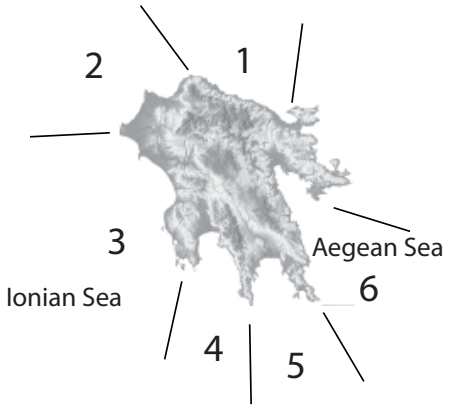
The comparison between the two regions, both at high morphological variability, shows that the length of the Peloponnese is about 49% greater than Campania, although some CPUs partly fall in contiguous regions and therefore the regional administrative perimeters do not coincide with the physiographic ones. This condition frequently means that the impact of the implementation measures along the coast often cause induced consequences in distant sites, too.

Maritime works are of various types: the ratio of the lengths of coastal defences and coastal extensions which provide the structuring I index, whose average value in Campania is four times greater than that of the Peloponnese (Tables 1 and 2).

Beaches

Beaches are stretches consisting of sandy and/or pebbly deposits, with good lateral continuity (Figure 1). The beaches studied are better developed when inland there is a flood plain and estuary. Some are at the foot of the cliffs. The beaches in many cases are still bounded by barrier dunes, but often have relict shapes and some wetlands behind them. The shoreline has a slightly concave or straight shape, with a slight convexity at the mouth of the rivers Volturno and Sele in Campania, Piros and Alfios in the Peloponnese. The sediment supply to beaches from the rivers in both regions has decreased since the 50s for over-mining and construction of river dams.

Table 2 – Coastal Physiographical Units of Peloponnese (Greece) and their extension. The index of the structure I indicates the ratio of the total length of the coastal defences and coastal extension (average value in italics).



n°	Coastal Physiographical Unit	km	*I*
1	Gulf of Korinth (C. Ireo - Rio)	151	0.12
2	Gulf of Patras (Rio - C. Kyllini)	90	0.10
3	Gulf of Kyparissia (C. Kyllini - C. Akritas)	188	0.01
4	Gulf of Messinia (C. Akritas - C. Tenaro)	150	0.03
5	Gulf of Lakonia (C. Tenaro - C. Malea)	152	0.02
6	Gulf of Argolis (C. Malea - C. St. Emilianos)	246	0.02
		977	*0.05*

Coastal geomorphotypes

The Campania coast stretches for 480 km, 256 km of which (60%) are high rocky coasts and 224 km (40%) lower clastic coasts (Monti et al., 2003); among them, 95 km (42%) of shorelines show erosion.

The Peloponnese coast stretches for 977 km, of 637 km of which (65%) are high rocky coasts and 340 km (35%) lower clastic coasts; among them, 110 km (32%) of shorelines show erosion. From the morpho-type point of view we can distinguish three main CPUs: the beaches, the cliffs and the technocoasts.

Cliffs

Cliffs are rocky coastlines with a significant gradient, usually 30% > (Figure 4). At the base there are often pebble beaches or debris cones, due to erosion of the outcropping lithotypes for the wave action and weathering. In Campania stratified carbonatic rocky cliffs on the Sorrento Peninsula and Mt. Bulgheria are found; terrigenous deposits (flysch), in Cilento; volcanic rocks in the Phlegrean Fields, Ischia and Procida islands, Mt. Somma-Vesuvius. The profile of the cliffs is more variable in lava rocks and/or pyroclastics; cliffs with pebble beaches or foot debris cones are widespread in the Phlegrean volcanic district, in the islands, in Sorrento Peninsula and Cilento in Campania. In the North and West Peloponnese the cliffs are modeled mostly in conglomerates, in Korinth, Patras and Kyparissia; secondary in limestones and marls in the South, in Messinia, Lakonia and Argolis, and to C. Vàrdia there are flysch strips.

Figure 1 – The sandy beaches with dunes of Castel Volturno (a) in Campania (photo P. De Stefano, 2006) and C. Araxos in the Peloponnese (b) (photo L. Stamatopoulos, 2012).

Figure 2 –The cliffs with piles of landslide of the promontory of Posillipo in Campania (a) (photo C. Donadio, 2013) and Karavostasi in the Peloponnese (b) (photo L. Stamatopoulos, 2012).

Technocoasts

Technocoasts refers to the artificial, engineered coast. Often they overlap with degraded beaches, where the construction of works or the intense urbanization have made the previous natural environment unrecognizable (Figure 5), as is visible in the areas of Naples, Pozzuoli and Salerno, in Campania, and Korinth, Patras and Xylokastro in the Peloponnese, where it is represented by the *waterfront*. This stems primarily from the high population density along these coastal areas (index of littoral), as well as the difficulty in protecting the coast. The works are distinguished by type, location and size. Along the sandy coastline rigid defense systems were built, sometimes emerging or submerged. Longitudinal adherent defences were built to protect coastal infrastructure where there had previously been a wide dune ridge. Along the rocky coasts direct interventions to curb the phenomena of collapse and overturning were implemented, before or after, to reduce the undermining by the foot swell. The first consist of coatings with rods and nets or walls, barriers, for the latter the works are similar to those of longitudinal protection of beaches. In the technocoasts the following factors can determine critical phenomena: coastal erosion, flooding, storm surges, landslides, seismicity and volcanism, anthropogenic activities and works.

Geoindicators

The methodology of identification of critical areas is based on the use of geoindicators (Hammond et al., 1995; Elliott, 1996). These, according to the IUGS (*International Union of Geological Sciences*), are described as " measures of geological phenomena or processes that occur on the Earth's surface or close to it, which vary significantly in periods of less than 100 years and provide significant information for the assessment of the environment". Within the framework of Environmental Planning Commission (*Commission on Geological Sciences for Environmental Planning* – Cogeoenvironment) of IUGS,

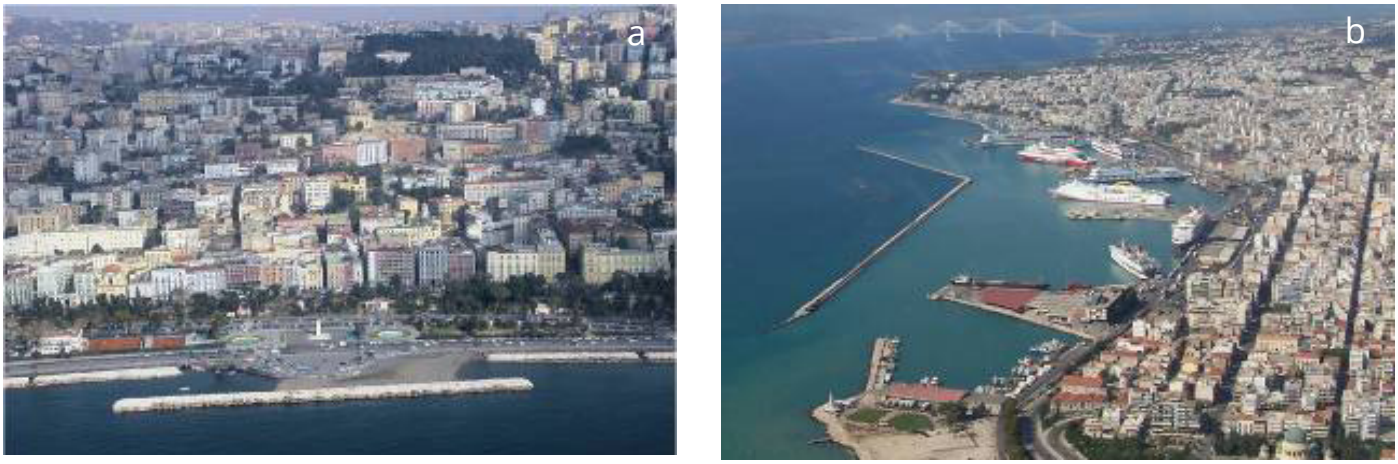


Figure 3 – Engineered coasts (technocoasts) of Naples (a) in Campania (photo P. De Stefano, 2001) and Patras in the Peloponnese.

a multidisciplinary work group (*Geoindicators Working Group*) drew up an list of 27 geoindicators with a global value (Berger and Iams, 1996). This represents a support tool for integrated assessment of natural environments and ecosystems and has a wide variety of applications in coastal risk assessment (Berger, 1997; Bush et al., 1999). This methodological approach provides a good interpretation of parameters upon which the main evolutionary processes depend. Some were chosen among the global geoindicators list by Berger and Iams (1996), considered the most significant in relation to the different and specific geoenvironmental, morphodynamic and man-made caused features. Potential critical phenomena at shorelines resulting from the examination of geomorphological aspects and regional coastal dynamics are related to six major geoindicators: coastal erosion, flooding/river flooding in coastal area, storm surge/*tsunami*, landslides, seismicity/volcanism/bradyseism/subsidence, anthropogenic activities and works.

The values determined for each geoindicator can be attributed to stretches of coastline with physical elements (high, low and artificial coastland) and homogeneous morphodynamic processes. These values must be relative and much as possible, non-qualitative and objective. In this way the allocation of the numeric value is derived by adding together the various active phenomena in that segment, expressed by a score.

The degree of coastline criticality, dependent on each locally significant geoindicator must then be translated into a total value, resulting from the sum of the values of all the indicators considered important at large scale. Mutual influences between geoindicators which are analyzed by interaction matrix (cause/effect) where one distinguishes factors that influence the system (*cause*) and those that are affected (*effect*) by the system. This matrix (Figure 4) is used to quantify the overall criticality by indexing the intensity and the reoccurrence of various factors in each CGU (De Pippo et al., 2008 e 2009).

To quantify the different importance of interactions a semi-

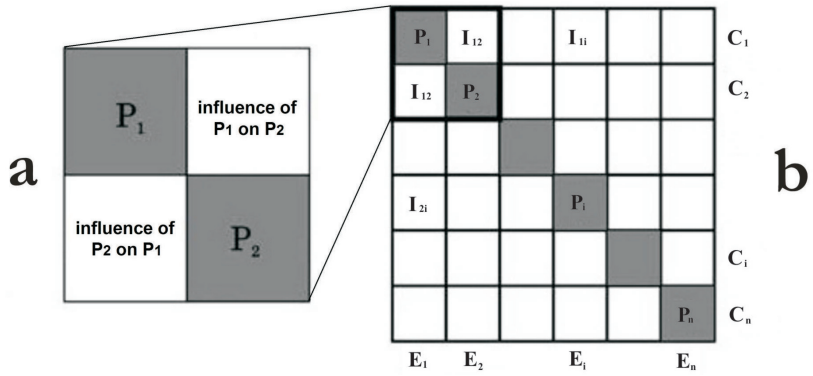


Figure 4 – Descriptive matrix of interactions of hazard. Along the diagonal there are six main geoindicators (gray squares, top to bottom): coastal erosion, floods, storm surges, landslides, seismicity and volcanism, man-made structures. The matrix indicates the influence of parameters on the system (cause of the phenomenon) or of the system on each parameter (effect of the phenomenon) [scheme a]. The cause-and-effect diagram for N parameters [scheme b] shows how the interaction matrix works: I_{12} box represents the influence of P_1 on P_2 (cause); on the contrary, the I_{21} box shows the influence of P_2 on P_1 (effect). The mechanism is repeated for each parameter of the diagonal of the matrix (after De Pippo et al., 2009).

quantitative coding is used that defines the percentage of incidence of each single parameter. For each CGU different levels of criticality factors are taken into account (Ik, from 0 to 4), to multiply individually by the resulting coefficient of the application of the matrix (Xk, from 1 to 6), which is the percentage of incidence that each factor has on GCU. The resulting weighted sum calculates the actual overall degree of criticality (Kt) with the following expression:

$$K_t = \Sigma_{n(1\text{-}6)} \cdot Ik_n \cdot Xk_n \quad (1)$$

The result of weighted summation (1) corresponds to the degree of criticality of the coastal segment varying from *low* L to *extreme* E, expressed in a map (Figures 5 and 6). The passage from the notion of *criticality*, *i.e.* territorial susceptivity of a sector to the onset of destructive phenomena, to that of *hazard*, *i.e.* probability that one or a series of natural events might occur in the future in a certain area, is dictated by the estimated return time (t_r) of events, even of anthropic origin, recognized as possible risk factors. Shorter return times, expressed in years and divided into at least four classes should be considered (Table 3).

The fourth class (D) refers to those natural events whose return

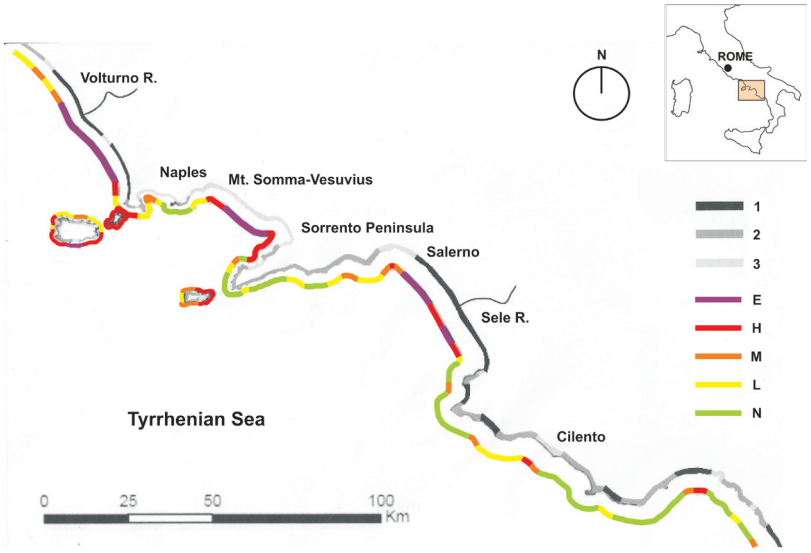


Figure 5 – Campania (Italy): Map of the Coastal Geomorphic Unit: 1, beach; 2, cliff; 3, technocoast and overall hazard along the coasts: E, extreme; H, high; M, average; L, low; N, negligible. The highest values are recorded primarily in the techno-coast UGC and the beach (after Donadio et al., 2014).

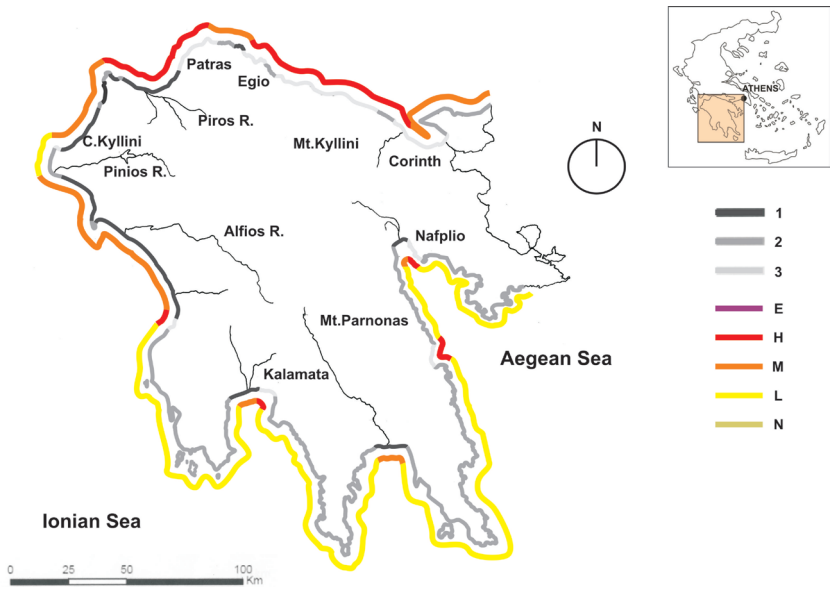


Figure 6 – Peloponnese (Greece): Map of the Coastal Geomorphic Unit: 1, beach; 2, cliff; 3, technocoast and overall hazard along the coasts: E, extreme; H, high; M, average; L, low; N, negligible. The highest values are recorded primarily in the techno-coast UGC and the beach.

periods are not well defined (such as earthquakes, volcanic eruptions, *tsunamis*) or are long compared to the average timing design. Each class is attributed a descending value between 4 (A) and 1 (D). The degree of danger is the product of critical values expressed by the application of interaction (see matrix of Fig. 1) and those of return times (see Tab. 3). The overall hazard, called geomorphological (see Figures 5 and 6), is obtained from the integration between the different hazards for each significant event, with increasing values depending on the criticality and return time (De Pippo et al., 2008 e 2009).

On the basis of the previous methodologies, the study of the Campania and Peloponnese CGUs highlights specific criticalities and hazard in similar locations as follows.

Table 3 – Classes of return time (t_r) in the short term (years) of natural events and/or anthropogenic origin recognized as potential critical coastal factors and its numeric value. The timeline shows the possible overlapping of return times allocated to six geoindicators in each CGU (after Donadio et al., 2014).

class	return time tr (years)	value	time chart
A	0 - 2	4	
B	2,1 - 5	3	
C	5,1 - 10	2	
D	> 10	1	

Campania

Ischia and Procida islands (CPU 1-2)

On Ischia high hazard is registered in technocoasts to the North and West (Ischia Porto, Forio d'Ischia), the hazard is extreme to the South due to exposure to storm surges of II-III quadrant, despite recent nourishments, and is low or negligible in the remaining sections. In Procida the hazard is high everywhere for undermining to the foot of the tuff cliff, erosion of beaches exposed to storms of the IV quadrant and in short sections of technocoast.

Island of Capri and the Sorrento Peninsula (CPU 2)

On Capri high hazard occurs in the northeastern stretch for undermining the foot in the presence of a shallow marine terrace (Pennetta & Lo Russo, 2011); medium-high hazard is registered in the North technocoast and in the cliffs in the South due to landslides. In the remaining areas it is low. On the Sorrento Peninsula the hazard is high and extreme in the technocoasts and cliffs of the northern slopes due to storms especially of the IV quadrant, for undermining the foot and landslides, while low in the southern ones.

Phlegrean and Naples coast (CPU 2)

Tuffaceous paleocliffs, modeled in subaerial environment and then submerged between -10 and -25 m are present in the Neapolitan area (Donadio and Valente, 1995). In the area west of Naples, and between Torregaveta and Castel dell'Ovo, Roman ruins which submerged down to -12 m indicate variations of the coast over the past 2500 years due to bradyseismic causes (De Pippo et al., 2002). Many partially submerged caves, man-made from the Roman Age, are along the tuff cliffs. The terraces are modelled in tuff and lava down to -50 m, while paleosea-notches only in the tuff at -1.8 and -3.7-m (Baia, Posillipo). The hazard is high in technocoasts (maritime works and waterfronts) and medium in pyroclastic cliffs exposed to storms of II-III quadrant, for undermining the foot and landslides.

Vesuvian coast (CPU 2)

The coastal sector at the foot of Mt. Somma-Vesuvius, between Portici and Torre Annunziata, is densely populated. Some Roman ruins at-4.5 m indicate coastal changes due to volcano-tectonic phenomena post-79 AD (De Pippo et al., 1996). In technocoast stretches of beach and cliffs the hazard ranges from extreme to high for exposure to storm surges of II-III quadrant and landslides.

Falerno-domitio and Sele littorals (CPU 1-3)

Beach dune systems of Garigliano, Volturno (falerno-domitio littoral) and Sele rivers show the same morphosedimentary aspects (Pennetta et al., 2011). In both, the dune is transformed by human intervention, while in others it has disappeared to erosion or appears in relict forms. The technocoast and the adjacent beaches are characterized by a high hazard to extreme, even for frequent flooding. The causes are related to the entrapment of sediments in artificial reservoirs and overmining sediment from the riverbed, reducing sediment supply to the sea through river mouths.

Cilento and the Gulf of Policastro (CPU 4-5)

This area is characterized by high and steep carbonatic cliffs and low terrigenous units, alternating with pebble-sandy pocket beaches. The shoreline retreat in recent years has accelerated due to the construction of a dam and a port. The high hazard is registered in the technocoasts and adjacent beaches.

Peloponnese

Gulfs of Korinth and Patras (CPU 1-2)

The Gulf of Korinth is a tectonically active area. Most of the coastal areas between Korinth, Egio and Patras are intensely anthropogenic. Hazard ranges from high in the technocoasts to medium in the beaches at the foot of the little craggy cliffs, exposed to waves of I-II quadrant. Dune-beach systems of Patras and Kyllini show the same morphosedimentary features (Stamatopoulos et al., 2014). The hazard is high for erosion due to storm surges of the III-IV quadrant and local floods.

Gulf of Kyparissia (CPU 3)

In this section the hazard is medium in the beach of the wide bay between C. Katakolo and Kyparissia, eroded by storms of the III quadrant, and at the mouth of Alfios river due to some flood, while high in urban stretches. Low hazard is recorded along the cliffs of Channel of Zakynthos, north of the bay and as far south as C. Akritas, due to some landslides.

Gulf of Messinia, Lakonia and Argolis (CPU 4-5-6)

These three sectors show similar morpholithologic features: the more or less steep cliffs are characterized by numerous pocket beaches. The hazard ranges from low to medium for exposure to storm surges of the II-III quadrant, undermining of the foot swell and a few landslides. High hazard only occurs in the technocoast of Nafplio.

Among the various geoindicators to consider in the morphoevolutionary recent dynamics of Mediterranean high coast one should definitely monitor the present-day sea notches along the cliffs, their morphology and depth, together with geostructural and the lithostratigraphic parameters, the height and steepness of the slope, the facing seabed morphology and the presence of landslide piles. Regarding littoral prisms, besides historical cartographic aspects, the presence of persistent erosion berms should be carefully monitored, due to storms and undermining at the foot of dunes, as well as relations between decrease in beach width, increase of the slope and sediment diameter of threshold of the shoreline (Limber et al., 2008), usually for the beaches examined, around 0.125 mm. In addition, assessment should be made of the conservation status and naturalness of the entire dune ridge and its vegetation succession, morphosedimentary and submerged aspects of bars and seabed down to -10 m depth. In both coastal morphotypes the presence of submerged structures and ruins, how deep they are and how dated are contributing factors to morphoevolution knowledge and vertical movements dynamics (accelerated subsidence, bradyseism) in man-made coasts.

Design Criteria

Considerations so far exposed explain the importance of careful assessment of temporal components of the various degrees of criticality of stretches of coastline. Physical differences and return time of previously classified events allow the setup of a methodology that is based on the dynamics of the place, on the reoccurrence of phenomena and their foreseen intensity in order to determine appropriate project strategies (Beck, 2013).

A first analysis can be carried out on the consequences normally induced by the type of settlement patterns on high rocky or low clastic coasts, as already illustrated with a chart by Valente (1999), analyzing the relation of every modification of the site in the medium term, with the aid of a plan and section. This makes it possible to record the transformations of the sites, landscape and how defense works undergo damage due to these relatively rapid changes. These physical natural and artificial alterations are then overlapped every time by the presented geoindicators that later bond with the forces normally in place. In addition, it is essential to consider further aspects such as the degree of urbanization of the sites under consideration, in addition to the quality of the settlement and the land uses. The hazard rate of the sites is evaluated multiplying criticality by the overall value of the place, in cultural, social, and natural setting terms.

Reflecting on the relationship between hazard and density, it looks like it is actually outside Europe with lower settlement concentrations where areas affected by severe catastrophic natural phenomena such as floods or storm surges could even be abandoned. On the contrary, in Mediterranean Europe and in southern Italy in particular, the concentration of population along the coastline is typically due to the special conditions of the climate and landscape. In these circumstances obviously there is a higher risk of hazard and difficulty in securing safety, control and use in the settlements. So in many cases the higher recursion of events is, paradoxically, to be considered as a safety index, just like the temporal distance between the phenomena tends to give false assurances on how to use certain places. We underline how geomorphologic information about evolving *trends* is noticeably used for environmental design besides using this information for the study of critical conditions and moreover in relation to every possible class of physical changes that could occur.

The methodological approach proposed is to consider the evolutionary process of the site as a matter to be dealt with in order to be in tune with it and avoid destructive events where the natural element takes the upper hand on the landscape created by man. Such an attitude also allows inhabitants and visitors to remember natural phenomena of the site and thus be able to benefit, in a conscious and therefore more responsible way, from an active environmental education.

This approach makes it possible to greatly increase the security of places where the population will be able to recognize the same geo-indicators or at least see the main signs of transformation adjusting human activities to natural dynamics. Examples of the adaptive project strategy proposed here are those where the increase in the level of water or land due to bradyseism or floods are addressed using floating structures that create transitory configurations of the coast in relation to the different levels of water.

In an effort to systematize in a scientific manner possible project alternatives in different conditions, plans of criticalities of the coasts of Campania (Figure 5) and the Peloponnese (Figure 6) have been studied. For morphological conditions and lighter human settlement, the Greek coasts show in general characteristics of lower criticality and greater homogeneity than the characteristics of resilience.

By comparing morphological characteristics, the degree of settlement and referring to previous authors' scientific works, two CGUs, Torre Annunziata-Castellammare di Stabia and Salerno in Campania, comparable to the CGU of Patras and Cape Ireo-Rio on the Peloponnese were chosen. For each CGU tables of the types of appropriate action in relation to the six geo-indicators and relative return time (Tables 4, 5, 6 and 7) were drawn up. This was done by initially using the semi-quantitative values indicated by De Pippo et al. (2008) for the coast of Campania and developed by analogy for the Peloponnese.

Table 4 – Appropriate actions for the CGU Torre Annunziata-Castellammare di Stabia (H, high hazard)

CGU 9: Torre A.-Castel. St., H	*geoindicator*	*return time tr (years)*	*type of action according to the site*
	coastal erosion /prograding	**2,1-5**	settlement withdrawal, RSA
	flooding / river or torrential flooding in the coastal area	**0-2**	settlement withdrawal, raised structures, floating structures, transient uses, spectacle
	significant meteo-marine event	**2,1-5**	settlement withdrawal
	landslide phenomena	**>10**	barring-down, grout, bio-engineering
	seismicity / vulcansims / bradyseism / vertical movement from load and/or compaction	**>10**	anti-seismic structures, alert system
	man-made activities and works	**0-2**	submerged protection, de-structuring margins on the water, removable structures

Table 5 – Appropriate actions for the CGU from Cape Ireo to Rio (H, high hazard)

CGU: Capo Ireo Rio, H	*geoindicator*	*return time tr (years)*	*type of action according to the site*
	coastal erosion /prograding	**2,1 - 5**	dewatering, restoration of hydrological regime / sediment intake
	flooding / river or torrential flooding in the coastal area	**5,1 - 10**	restoration of hydrological regime, permeabilization of soils, settlement withdrawal
	significant meteo-marine event	**2,1 - 5**	buildings withdrawal, dewatering
	landslide phenomena	**> 10**	barring-down, grout, bio-engineering
	seismicity / vulcansims / bradyseism / vertical movement from load and/or compaction	**5,1 - 10**	anti-seismic structures, alert system
	man-made activities and works	**0-2**	submerged protection, de-structuring margins on the water, removable structures

Table 6 – Appropriate actions for the CGU Salerno (H, high hazard)

CGU 21: Salerno, H	*geoindicator*	*return time tr (years)*	*type of action according to the site*
	coastal erosion /prograding	**2,1 - 5**	settlement withdrawal, dewatering, removable structures, recovery of dune systems
	flooding / river or torrential flooding in the coastal area	**5,1 - 10**	settlement withdrawal, raised structures, floating structures, transient uses, alert system
	significant meteo-marine event	**2,1 - 5**	withdrawal, floating structures, alert system, predisposition of escape routes
	landslide phenomena	**> 10**	barring-down, grout, bio-engineering
	seismicity / vulcansims / bradyseism / vertical movement from load and/or compaction	**—**	—
	man-made activities and works	**0-2**	submerged coastal protection, de-structuring margins on the water, respect of protected areas

Table 7 – Appropriate actions for CGU Gulf of Patrasso (H, high hazard)

	geoindicator	*return time tr (years)*	*type of action according to the site*
CGU: Golfo di Patrasso, H	coastal erosion /prograding	**0-2**	dewatering, restoration of water regime/sediment provision, recovery of dune systems
	flooding / river or torrential flooding in the coastal area	**2,1 - 5**	restoration of water regime / sediment provision/ settlement withdrawal /raised structures, floating structure, transient uses /alert systems
	significant meteo-marine event	**2,1 - 5**	submerged protection, de-structuring margins on the water
	landslide phenomena	**> 10**	bio-engineering
	seismicity / vulcansims / bradyseism / vertical movement from load and/or compaction	**> 10**	anti-seismic structures, alert system
	man-made activities and works	**2,1 - 5**	submerged coastal protection, de-structuring margins on the water, bio-engineering

The iteration of this process has enabled us to verify the hypothesis of synoptic framework of sustainable actions for Mediterranean CGUs. Such a framework includes general physical characteristics of high and low coasts and geoindicators present (Table 8). The table shows on top the arrow indicating the greater frequency of the phenomena. At the opposite end of the arrow, which indicates a minor recurrence of events are classified the cases where it is possible to reduce the number of actions but not the degree of attention by the authorities responsible for safety control.

In particular the results obtained show that some phenomena are not dangerous for high coasts some others for the lower ones. Examples include landslides, seismicity, flooding or tsunamis, for high coasts, or landslides for low coasts. While in general the withdrawal from the shore line of settlements is a common denominator, some particular interventions, such as the floating structures, are appropriate within several conditions such as flooding, storm surges or bradyseisms with return times that are not long. It is in these cases that among the suggested strategies there is the spectacularization of some natural phenomena to increase the tourist value of certain places. An example may be the way in which in 1985 William Wenk designed the George Wallace Park in Denver (USA), where in recreational spaces during times of flooding concrete structures become obstacles for flooding, creating scenic and attractive waterfalls.

In the presence of the beaches affected by erosion the following are used: techniques such as the RSA (recovery and stabilization of beaches through the drainage of beaches or dewatering), the choice of transitional destinations, removable and repositionable structures and, in the presence of dune barriers behind, the protection and consolidation of dunes with bioengineering techniques. However, in relation to the comparison with the return times, when immediate results are needed for high frequencies, protection and consolidation of the dunes with vegetation are associated with structures for the interdiction of crosswalks and wooden barriers against sand dispersion.

Characteristics that show the good quality of technical interventions on a beach (Blakemore and Williams, 2008), are the presence of fine and clear sands, low slope and a depth not exceeding 50 m. An overall view of the interested watershed should be taken into account, providing corrective works in the presence of dams (desilting, bypassing and hydroflushing), the increased connectivity with the recovery of the banks and river rapids modeling.

In the presence of cliffs in landslide, in addition to restoring the existing sandy and/or pebble beaches at the foot, rather than massive consolidation works, such as rivets or similar techniques, after appropriate operations of barring-down it is useful to apply grout to gravity, consisting in a mixture of cement and sand made from local rocks in fractures to close them and prevent the infiltration of meteoric and disruptive action of roots of some plant species. In addition, depending on the inclination of the slopes, it is always useful to consider the advantages offered by the use of vegetation in application of bioengineering techniques.

In the case of areas affected by flood phenomena, as well as the prediction of transient uses for floodable areas, structures that can be elevated or floating should be used.

The stretches defined as techno-coast, where man made works prevail, pose the problem of a rigidity that offers resistance but not the resilience to weathering elements. In order to dissipate the energy of the phenomena it is preferable to use submerged barriers and where possible the restructuring of the margins on the water, allowing different configurations and discontinuity.

Table 8 presents the planning of an alert system applicable in many contexts for extreme events aimed at maintaining contact with the population along the coast, in order to give warnings, information and safety guidelines before, during and after high intensity events. Design systems services, communication and information systems should be used as updated useful tools of the environmental design. Replacing the rigid defense structures with intangible elements such as networks and software that manage the timing of the inflow of persons (e.g. in the case of flooding), it is possible to envisage a return to a dynamic transformative nature of many landscapes whose evolutions have been fossilized by man, but may change again and be in harmony with natural processes.

Table 8 – Overview of appropriate actions for Mediterranean CGUs.

		return time tr (years) ← frequency of phenomena							
		A = 0 – 2 years		**B = 2,1 - 5 years**		**C = 5,1 - 10 years**		**D = > 10 years**	
		high coasts	low coasts	high coasts	low coasts	high coasts	low coasts	high coasts	low coasts
Geoindicator category	coastal erosion	*reconstruction of the beach at the foot of the cliff* *protection with submerged barriers*	*settlement withdrawal* *transient uses* *dewatering* *restoration of water regime* *removable structures* *protection and consolidation of dunes with vegetation*	*reconstruction of the beach at the foot of the cliff*	*settlement withdrawal* *dewatering* *restoration of water regime* *removable structures* *protection and consolidation of dunes with vegetation*	*reconstruction of the beach at the foot of the cliff*	*settlement withdrawal* *restoration of water regime* *removable structures* *protection and consolidation of dunes with vegetation*		*settlement withdrawal* *protection and consolidation of dunes with vegetation*
	flooding / river or torrential flooding in the coastal area	—	*settlement withdrawal* *transient uses* *raised or floating structures* *restoration of water regime* *alert and scenic system*	—	*settlement withdrawal* *restoration of water regime* *transient uses* *raised structures* *floating structures* *alert system*	—	*settlement withdrawal* *restoration of water regime* *transient uses* *raised structures* *floating structures* *alert system*	—	*settlement withdrawal* *restoration of water regime* *raised structures* *alert system*
	significant meteo-marine event / *tsunami (D)*	—	*settlement withdrawal* *transient uses* *floating structures* *predisposition of escape routes* *alert system*	—	*settlement withdrawal* *floating structures* *predisposition of escape routes* *alert system* *dewatering* *destructuring of margins on the water* *submerged protection*	—	*settlement withdrawal* *predisposition of escape routes* *alert system*	—	*settlement withdrawal* *alert system*
	landslide phenomena	*barring-down* *grout with local rocks* *prevention from use*	—	*barring-down* *grout with local rocks* *bio-engineering*	—	*barring-down* *grout with local rocks* *bio-engineering*	—	*barring-down* *grout with local rocks* *bio-engineering*	—
	seismicity/ vulcanisms/ bradyseism/ vertical movement from load and/ or compaction	*antiseismic structures*	*antiseismic structures* *floating structures*	*antiseismic structures*	*antiseismic structures* *floating structures*	*antiseismic structures*	*antiseismic structures* *alert system* *floating structures*	*antiseismic structures*	*antiseismic structures* *alert system*
	man-made activities and works	*environmental restrictions*	*submerged protection* *destructuring of margins on the water*	*submerged protection* *destructuring of margins on the water* *bio-engineering*	*submerged protection* *destructuring of margins on the water* *bio-engineering*	*submerged protection* *bio-engineering*	*submerged protection* *destructuring of margins on the water* *bio-engineering*	*submerged protection* *destructuring of margins on the water* *bio-engineering*	*submerged protection* *destructuring of margins on the water* *bio-engineering*

Conclusions

Based on the information provided on recurrences and recursion of the main evolutionary phenomena, the geoindicators prove to be indispensable tools to define the most appropriate strategies of environmental design. The comparison between the two Mediterranean regions with similar physiographic features and settlement supports the objective of systematization of the type of appropriate actions. This can be effective operational planning technical support.
Non-coercive interventions are revealed as the most adaptive along the coastline and need to be suitably calibrated in relation to the return times of active phenomena in the cases under consideration. The schemes presented as a result of the observation of the Peloponnese and Campania Region are useful for the choice of techniques to be adopted for durable works and the energies needed for maintenance, in addition to possible new sustainable ways of using and protecting the sites. The environmental friendliness of the interventions does not only depend on the size or use of the areas but above all on the design strategies and technologies chosen to carry out the works.
These ideas contribute to the construction of innovative methodologies of environmental regeneration that can transform the countries that adopt them as global references for the protection and enhancement of the landscape. It is an effort to be made, in particular in times and areas of crisis, because the economic resource represented by the special quality of the places has the unique characteristic that it cannot be moved. This constitutes a guarantee for those companies who invest in scientific research to assure that what was built/created remains where it was generated and should not be moved in quest of seemingly more competitive conditions.

References

Aiello G., Barra D., De Pippo T., Donadio C., Petrosino C., 2007. *Morphological evolution of volcanic islands near Naples, southern Italy.* Zeit. Geomorph. N. F., 51(2): 165-190.

Beck T., 2013. *Principles of Ecological Landscape Design*. Island Press, Washington, DC. pp.280

Berger A.R., 1997. *Assessing rapid environmental change using geoindicators*. Env. Geol., 321: 36-44.

Berger A.R., Iams W.J., 1996. (Eds.) *Geoindicators: assessing rapid environmental change in earth systems*. A.A. Balkema, Rotterdam, Netherlands. pp.466.

Blakemore F., Williams A., 2008. *British tourists' valuation of a Turkish beach using contingent valuation and travel cost methods*. J. of Coastal Res., 24(6): 1469-1480.

Bush D.M., Neal W.J., Young R.S., Pilkey O.H., 1999. *Utilization of geoindicators for rapid assessment of coastal-hazard risk and mitigation.* Ocean and Coastal Management, 42: 647-670.

De Pippo T., Donadio C. Pennetta M., Terlizzi F., Valente A., 2009. *Application of a method to assess coastal hazard: the cliffs of Sorrento Peninsula and Capri (southern Italy).* In: Violante C. Ed., *Geohazards in rocky coastal areas*, Geological Society of London, Spec. Publ., 322: 189-204.

De Pippo T., Donadio C., Pennetta M., Petrosino C., Terlizzi F., Valente A., 2008. *Coastal hazard assessment and mapping in Northern Campania, Italy.* Geomorphology, 97: 451-466.

De Pippo T., Donadio C., Pennetta M., Terlizzi F., Vecchione C., Vegliante M., 2002. *Seabed morphology and pollution along the Bagnoli coast (Naples, Italy): a hypothesis of environmental restoration.* Marine Ecology, 23: 154-168

Dern J.Q., 1992. *Mar Tierra Paisaje de frontera*, Quaderns d'Arquitectura y Urbanisme. Actar Ed., Barcelona, Spain, 196: 32-41.

Donadio C., Pennetta M., Valente R., 2014. *Geoindicatori della morfodinamica costiera della Campania a criteri di progettazione ambientale*. Studi costieri, 22, pp.16 (in press).

Donadio C., Stamatopoulos L., 2014. *Genesis and evolution of some lagoons in Greece and Italy: preliminary data for a key to geomorphological model interpretation*. Proc. of Regional Symposium on Water, Wastewater and Environment: Traditions and Culture (Kalavrouziotis I.K. & Angelakis A.N. eds.), 22-24 March 2014, IWA, Hellenic Open University, Patras (Greece), 283-296.

Donadio C., Valente R., 1995. *Coast renaturalization at west periphery of Naples: morphologic features and landscape design.* Proc. II Int. Conf. Medit. Coastal Env., MEDCOAST 95, 24-27 october 1995, Özhan E. Ed., 1: 423-437.

Elliott D.E., 1996. *A conceptual framework for geoenvironmental indicators*. In: Berger A.R., Iams W.J. Eds., *Geoindicators: assessing rapid environmental change in earth systems*, A.A. Balkema Ed., Rotterdam, Netherlands. pp. 337-350.

Hammond A., Adriaanse A., Rodenburg E., Bryant D., Woodward R., 1995. *Environmental indicators: a systematic approach to measuring and reporting on environmental policy performance in the context of sustainable development*. Washington, D.C., World Resources Institute. pp. 43.

Johnson B. R., Hill K., 2002. (edited by) *Ecology and Design. Frameworks for Learning.* Island Press, Washington, DC. pp. 501

Limber P.W., Patsch K.B., Griggs G.B., 2008. *Coastal sediment budgets and the littoral cutoff diameter: a grain size threshold for quantifying active sediment inputs*. J. of Coastal Res., 22(2B): 122-133.

Mazzarella A., 2007. *The 60-year solar modulation of global air temperature: the Earth's rotation and atmospheric circulation connection.* Theor. Appl. Climatol. 88, 193-199.

McHarg I. L., 1969. *Design with Nature.* Garden City, New York, American Museum of Natural History, by the Natural History Press. pp. 197.

Monti L., Donadio C., Putignano M.L., Toccaceli R.M., 2003. (a cura di) *Geologia subacquea delle aree marine costiere. Linee guida al rilevamento geologico subacqueo, scala 1:10.000. Progetto CARG Regione Campania*. Regione Campania, Lab. Graf. Legatoria Duminuco Ed., Sapri (SA). pp. 93.

Ortolani F., Pagliuca S., 1994. *Variazioni climatiche e crisi dell'ambiente antropizzato*. Il Quaternario, 7(1): 351-356.

Pennetta M., Corbelli V., Esposito P., Gattullo V., Nappi R., 2011. *Environmental impact of coastal dunes in the area located to the left of the Garigliano river mouth (Campany, Italy).* J. Coastal Res., SI, 61: 421-427.

Pennetta M., Lo Russo E., 2011. *Hazard factors in high rocky coasts of Capri island (Gulf of Naples, Italy).* J. Coastal Res., SI, 61: 428-434.

Stamatopoulos L., Aiello G., Barra D., De Pippo T., Donadio C., Valente A., 2014. Morphological and palaeoenvironmental evolution of the Lagoon of Papas, southwestern Greece, during the Holocene. Ital. J. Geosci., 133(2), 282-293.

Valente R., 1999. *Frontiere tra Mare e Terra. La progettazione ambientale lungo la linea di costa*. Liguori Ed., Napoli. pp. 208.

Towards the Sustainability Assessment: A Case Study of International Indicators and the Trial Assessments of Kashiwa-no-ha Plans in Japan

Masaru Miyawaki
Department of Urban Environment Systems, Faculty of Engineering, Chiba University, Chiba, Japan, miyawaki@tu.chiba-u.ac.jp

Soujanya Tenkayala
Takusho-Kaihatsu Co., Ltd, Chiba, Japan – soujanya13@gmail.com

Keywords: Sustainability, Assessment, Indicator, Sustainable development, Eco City, Smart City

Abstract

Sustainability indicators and their assessment are increasingly recognized as a useful tool for planning and communication of progress in fields such as environment, economy and society in the world. However in Japan, sustainability assessment is neither applied nor mandatory in the planning process. In order to easily evaluate sustainability of the various types of plans, effective indicators must be established. After the comparison of international indicators of 'Sustainable development', 'Eco City' and 'Smart City' in the global context, the integrated indicators are proposed in this paper. The proposed indicators are applied to the trial of the sustainability assessment for the recent urban development of Kashiwa-no-ha, which is a well-known Smart City Project in Japan. Even though the lack of some viewpoints is evident from the sustainability indicators, the sustainability assessment is a useful tool to check and develop plans for Kashiwa-no-ha in the future.

1. Introduction

The impact of human activity on the environment has been long recognized. In recent years, environment friendly urban development has been well debated and seen a surge of activity especially with growing concern towards issues such as global climate change and urbanization. Such various projects are labeled often by self-declared terminologies such as sustainable, eco, smart, intelligent etc., which have a wide range of interpretations. The compounded result of lack of clarity regarding various environment friendly urban development terminologies and lack of universally accepted regulations or assessment frameworks for these terminologies has been labeled as 'Fuzzy planning' (Gert de Roo and Geoff Porter 2007).
Clear and comprehensive environment friendly development terminology and identification of their salient features will disperse fuzziness and aid in selection process of appropriate urban areas for comparative studies.

1-1. Research Objective

This paper examines current trends of indicators seen internationally in sustainability, and attempts to explain these trends through a comparative study between the different terminologies in the international level. The objective of this study is to provide clarity to such terminologies and to try to integrate sustainability indicators and to evaluate some model plans in Japan.

1-2. Research Methodology

A comprehensive study of indicators was conducted to identify origin, widely accepted definition of current terms and their salient features. Similar terms were grouped together based on related themes and sub-themes. The frameworks of each are compared and analyzed to validate their conformance with the identified definition and their indicators. An international comparative analysis of three main frameworks; *'Sustainable development'*, *'Eco City'* and *'Smart City'*, and the integration of their indicators are the unique point of this study and it was conducted to identify their characteristics.
Two case studies were analyzed based on this comparative table to demonstrate the applicability of the study. The indicators of three frameworks were used to assess two plans of the well-known Kashiwa-no-ha project in Chiba Prefecture which is the recent urban development selected as the case study of the applicability in Japan.

1-3. Role and Importance of Indicators

Indicators should be used for the Environmental Assessment or the Sustainability Assessment in the formal procedure but they are yet to be established in every country until now. Indicators are very useful for everyone to quickly check the integral sustainability, and are able to widely ensure

conformance to project plan and introduce the progress of the project. They help to assess strategies and policies enforced, and are used to communicate success of environment friendly developments. Hence, indicators should be continued to research from worldwide comparative studies, required for knowledge sharing purposes.

2. Classification of Terminology

The term sustainability is used in this paper to commonly refer to all projects, which aim to reduce their impact on the environment. Based on the literature study, this paper groups terms with overlapping concepts together and identifies three main types of urban developments in practice today- *sustainable*, *eco* and *smart*. Classification of various terms under the three main types is given in Table 1. The three main terms types of projects are defined as follows.

Table 1 – Classification of Terminologies and Definitions.

Urban Development Types	Sustainable development	Eco city	Smart city
Year	1980's -	1980's -	2000's -
Related terms	Green city, Low carbon, Zero carbon	Bio-Region, Ecological Metropolis, Compact city, Neighbourhood	Digital city, Intelligent city, Innovative city, Smart growth, Smart industry, E-Governance, E-Democracy
Definitions	The most quoted definition is from Our Common Future, also known as the Brundtland Report (United Nations 1987): "**Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs**. It contains within it two key concepts: The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."	"an urban environmental system in which input (of resources) and output (of waste) are minimized" (Register 2002). Ecocity Builders and associates' definition of "ecocity" is conditional upon a healthy relationship of the city's parts and functions, similar to the relationship of organs in living complex organism.	A Smart City is a city well performing in six characteristics- smart economy, smart mobility, smart environment, smart people, smart living, smart governance, built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens. (Centre of Regional Science, Vienna University of Technology 2007)

2-1. Sustainable Development

Sustainable Development is defined, as 'Development that meets needs of the present without compromising ability of future generations to meet their own needs[2]', by United Nations. Sustainable Development is the most developed term with an internationally accepted UN framework. The 3rd edition of this framework (2007) has been used for this comparative study.

2-2. Eco City

Eco City is defined as 'an urban environmental system in which input (of resource) and output (of waste) are minimized', by Ecocity builders and associates. It is a United Nations accredited non-profit organization. Richard Register, the head of this organization is credited with coining of the term 'Eco City'. It is yet to see an internationally accepted framework and indicators list. Ecocity builders and associates work closely with the United Nations. The International Eco City Framework and Standards (IEFS), currently under development by the organization, Ecocity builders, has been taken as the base framework for studying the Eco City developments in this comparative study.

2-3. Smart City

Smart City is the latest term and the fuzziest concept. Unlike the previous terms, there are a large number of governments and private businesses involved in various Smart City projects worldwide. Hence consensus in this case is most difficult. Various definitions were identified as closest to the concept indicated by the term 'Smart City'. From these definitions, 'Smart City' can be summarized as a strategic device to encompass and highlight the growing importance of Information and Communication Technologies in profiling the competitiveness of cities. Additionally it relates to wise management of natural resources through participatory governance. European Union in particular has devoted constant efforts towards growth in the 'Smart Sense', through initiatives such as the 7th Research and Development Framework Program and the Competitiveness and Innovation Program (CIP). The base framework for smart cities which is proposed by the Centre of Regional Science of Vienna University of Technology has been adopted from a European research paper on ranking of European cities. No other indicators list has appeared with more official credibility. Hence their indicators of 'Smart City' are adapted in this paper.

3. Comparative Analysis of the indicators

3-1. Frameworks: An overview

Assessment frameworks form the skeletal grid over which the progress of the environmental friendly urban development takes place. It gives the important areas of focus, referred in this paper as themes and sub-themes, and forms the baseline for achieving the concept objectives. The assessment framework forms the basis for evaluating the measures and plotting the progress achieved towards environment friendliness. It shows where the urban area stands with regards to its performance level under each theme. It also helps pinpoint themes, which need immediate attention and those where good progress has been achieved. It forms a medium to propagate and collaborate with other such efforts.

3-2. Indicators: An overview

Performance of the urban development under each theme for the assessment framework is measured through indicators. Indicators are defined as 'A quantitative or a qualitative measure derived from a series of observed facts, that help determine relative the position (e.g. Urban development) in a given focus area.' Indicators guide and play an important role in making informed decision towards achievement of environment friendliness by:

- Translating technical knowledge into manageable units of information to give a solid basis for decision-making. This aids the process of setting policy priorities and benchmarking or monitoring performance.
- Help measure and plot progress towards goals. When evaluated over a period of time at regular intervals, an indicator can show the direction of change over a period of time.
- Indicators are useful in identifying trends and drawing attention to particular problem areas. They can provide a warning to help reassess areas, which require immediate attention and also to alert in cases of measures not taking there expected course and remedying the situation.

Indicators play an important role in communicating the progress and status of development, which is an important requirement for collaborated efforts towards advanced research for the sustainability of development and the realization.

3-3. Objective of the comparison

The assessment frameworks and indicator systems for each of the three types of environment friendly urban developments are compared to understand the differences between the three approaches with respect to the indicators adopted. Table 2, shows comparative study of frameworks of the three main terminologies. This helps us determine:

- The actual point of focus within each theme of focus (theme). Area of focus may be broad but comparing the sub-themes and the characteristics used helps decipher actual level coverage and gives the difference between the frameworks.
- The validity of the observations made in the previous sections.
- This comparison is also intended to formulate an evaluating methodology to observe and understand existing urban developments, with respect to the suitability of adopted concept terminology.

3-4. Analysis Methodology

The framework for 'Sustainable Development' has been taken as base and placed in its original format, as it is the oldest, well defined and the most widely accepted framework currently in use today. The Eco City framework, which is next in line in terms of evolution, is placed next and the Smart City framework, the latest framework is placed last. The Sustainable Development framework, as it was taken as base, was placed in its original format. The 'Eco City' framework and the 'Smart City' framework have been shifted around to match the related themes and sub-themes on the base framework. Each framework uses slightly different wording to describe related theme. Hence, to make the table easy to read, the themes have been color-coded based on three traditional themes namely- 'social - blue', 'environmental - green' and 'economic - orange'. Two additional groups 'ecological' and 'technological' have been suggested for features unique to eco and smart respectively. These help identify the areas of focus central to each concept.

During the comparison, it was observed that, in the frameworks used to assess the urban developments though same themes were answered, the amount of importance given to themes varied. This was observed in the number of indicators under each theme. This is indicative of importance of a certain theme in the framework and directly corresponds to center of focus of the concept and terminology used to name it.

3-5. Analysis in the table 2

Comparing the three frameworks, gives us a clear understanding of the characteristics and themes central to each framework. From the comparison in table 2, the following observations were made.

Sustainable Development framework is most well defined in terms of the areas of focus and indicators used. Sustainable Development through continued efforts by the United Nations has a good degree of coverage in the three traditional areas - social, economic and environmental. It deals with the basic

minimum standards required for an urban area. It addresses basic issues such as poverty, sanitation, living conditions, climate change, income levels etc. along with themes such as research development. Sustainable Development, the oldest framework has the least number of areas of focus.

The comparison shows the conference of Eco City framework with the Sustainable Development framework. While the basic social, economic and environmental factors are covered, the indicators move on to a more sophisticated level. It overlooks certain subthemes seen in Sustainable Development and can be said to be suited for the measure of the state of a developed urban area. Eco City covers newer areas than Sustainable Development. Ecological factors receive special emphasis in the Eco City framework. These newer areas of focus, introduced from Eco City framework onwards have been labeled as ecological and shaded with purple color. It is also clear that Eco City refers to not just the ecological aspects of the urban area but is concerned with its functioning as an ecosystem. The importance of community building is also seen from the degree of coverage for those particular areas.

However, it is Smart City, which offers the maximum coverage. Existing themes from the Sustainable Development and Eco City are covered and additional themes introduced. Smart City framework shows development in the technological aspect, a necessary essential in this technology intense age. The smart use of resources and knowledge is also clear from the framework and indicators set. A similar transition as seen from Sustainable Development to Eco City framework, can be seen in the indicators in the Smart City framework. Certain older themes have lost their place in the Smart City framework. It places emphasis on taking the urban area to an innovative new level; with increased emphasis on the latest cutting edge research and technology as the means for this step. The new areas of focus, introduced from Smart City framework onwards, have been labeled as technological factors and shaded with grey color.

All three frameworks of Sustainable Development, Eco City and Smart City sufficiently cover the three traditional themes- social, economic and environmental themes. However, certain themes grouped here as ecological and technological are answered only in the newer frameworks. An evolution of environment friendly development trends can be seen in the time line of the frameworks. This evolution pattern is explored with respect to usability as a base framework for evaluating urban developments pursuing environment friendly concept. The Sustainable Development being stage 1, Eco City stage 2 and Smart City stage 3.

After the analyses of three frameworks, their integrated indicators of the Sustainability Assessment are proposed in this paper (Table 2). Evaluation of the case study in Japan was done to understand with the integrated indicators. This also helps in demonstrating the usability of the model for study of environment friendly urban developments.

4. Case Study – Kashiwa-no-ha International Campus Town, Chiba Prefecture, Japan

4-1. Current Situation of Environment Friendly Planning in Japan

Rapid economic growth in the 1960's led to massive waste disposal and pollution related issues. These issues led to awareness and inclination towards, planning of environment friendly urban developments. As early as the 1970's, cities such as Kitakyushu started adopting innovative methods to reverse the negative effects of industrialization. These efforts were mostly localized approaches aimed at immediate mitigation of pressing concerns of the effects of industrialization. A more nationalized effort was seen in 1993, with the eco town project by the central government. Stringent recycling laws by the government also diverted focus into recycling and reuse strategies and led to the development of cutting edge technologies, leading to technology advancement in this area.

Declining population, increase in the aging population, environmental issues, health, crime prevention, disaster prevention and need for economic growth revitalization are some of the problems ailing Japan today. Along with these, due to the diversification in the lifestyle of the people there has been a change in the needs of the residents and users of the urban environment. Recent trends have seen large-scale development of urban developments by private agencies with cutting edge technologies especially in the energy and waste management sectors. With the 2011 March Tohoku earthquake and resulting energy issues, disaster prevention and environment friendly rebuilding of Japanese urban areas has received more focus. The future city initiative, the government's new growth strategy, which was proposed in 2010, received a boost and decisions to quicken the pace towards environment friendly urban development are being made. Most of these strategies were based on the Sustainable Development principles. The Sustainable Development framework stipulated by Architectural Institute of Japan exists, but Eco City and Smart City related projects are yet to see a framework. Currently both are evaluated against the Japanese adaptation of the UN-CSD framework. As is clear in the study so far, Sustainable Development, Eco City and Smart City are concepts with independent areas and unless these are understood and planned accordingly, cannot give the complete picture. Hence, we can say that 'Fuzziness' in sustainability is evident in Japanese urban planning.

4-2. Selection of the Case Study

Operational examples of Smart City in Japan are few and of these, Kashiwa-no-ha was selected for this study following a literature study for the following reasons:

- Long period of application and development of environment friendly initiatives.
- Public – Private – Academic model. Advanced research being conducted in the universities for development in this area.
- A new development, which was conceived as a model city for knowledge transfer and to utilize know-how for local economic benefit and world environment benefit.
- Unique initiatives and maximum areas covered.

Kashiwa-no-ha International campus town is a new town located just 30 km from the capital, Tokyo. It is well connected

Table 2 – Comparison of the international indicators and their integration into the indicators of sustainability assessment in this paper.

Social
Environmental
Economic
Ecological
Technological

SUSTAINABLE DEVELOPMENT			**ECOCITY**			**SMART CITY**			Indicators of the Sustainability Assessment in this paper	
Source: UNITED NATIONS COMMISSION FOR SUSTAINABLE DEVELOPMENT (UN-CSD) - Indicators of sustainable development -3rd edition- © United Nations 2009			**Source:** International Ecocity Frameworks and Standards(IEFS) - © 2011 Ecocity Builders -United nation accredited non-profit organisation			**Source:** Smart Cities- Ranking of European Medium-Sized Cities Vienna, Austria: © Centre of Regional Science, Vienna University of Technology, October 2007				
http://www.un.org/esa/sustdev/natlinfo/indicators/guidelines.pdf			http://www.ecocitybuilders.org/what-we-do/ecocity-standards/			http://www.smart-cities.eu/press-ressources.html				
Theme	**Sub-theme**	**Characteristics**	**Themes**	**Sub-Theme**	**Characteristics**	**Theme**	**Sub-Theme**	**Characteristics**	**Theme**	**Characteristics**
Poverty	Income poverty	Poverty line	Socio Cultural features	Wellbeing	Employment	Smart Living	Social cohesion	Poverty	**Poverty**	Poverty
	Income inequality	Difference in income levels				Smart People	Flexibility	Acquiring new job		Employment
	Sanitation	sanitation facilies			Living standards	Smart Living	housing quality	Living standards		Living standards
	Drinking water	Improved water source	Bio-Geo-Physical conditions	Water	Clean and safe water	Smart Environment	Sustainable resource management	Resource use		Improved water source
	Access to energy	Electricity and modern energy sources		Energy	Clean and renewable energy					Electricity and modern energy sources
	Living conditions	Slum dwellers	Socio Cultural features	Wellbeing	Living standards	Smart Living	housing quality	Living standards		Slum dwellers
			Socio Cultural features	Culture	Cultural activities to facilitate eco literacy and social learning	Smart People	Cosmopolitanism/Open-mindedness	Knowledge about regional affairs		Cultural activities to facilitate eco literacy and social learning
						Smart People	Cosmopolitanism/Open-mindedness	Immigration friendly		Immigration friendly
Governance	Corruption	Bribes paid	Socio Cultural features	Wellbeing	Good governance	Smart Governance	Transparent governance	Corruption and bureacracy	**Governance**	Transparent governance
	Crime	Homicide cases			Safety	Smart Living	Individual safety	Crime		Safety
					Social belonging	Smart People	Participation in public life	Voluantary work, voter turnout		Voluantary work
			Socio Cultural features	Community Capacity and Participation	Community participation in decision making process	Smart Governance	Participation in decision-making	Political activity of inhabitants		Community participation in decision making process
					Organisational support		Public and social services	Day care, quality of schools and other social service facilities		Day care, quality of schools and other social service facilities
Health	Morality	Life expectancy	Socio Cultural features	Wellbeing	Physical and mental health	Smart Living	Health conditions	Life expectancy	**Health**	Life expectancy
	Health care delivery	health care facilities		Community Capacity and Participation	Organisational support : Resources			Health care facilitites, health care personel, quality		health care facilities
	Nutritional status	nutritional status of children	Bio-Geo-Physical conditions	Food	Healthy and accessible					nutritional status of children
	Health status and risks	Tobacco use, Death due to major diseases, suicide	Socio Cultural features	Wellbeing	Physical and mental health	Smart Living	Health conditions	health system		Physical and mental health

Education	Education level	primary education access	Socio Cultural features	Education	Formal and informal education	Smart People	Level of qualification	Qualification levels, language skills	**Education**	primary education access
		life long learning			Lifelong access to education		Affinity to life long learning	Participation percentage		Lifelong access to education
	Literacy	Literacy rate			Formal and informal education		Level of qualification	Qualification levels, language skills		Literacy rate
			Socio Cultural features	Education	Access to information		Level of qualification	Knowledge center, books accessed		Access to information
					Vocational training and social institutions	Smart Living	Education facilities	Access, quality		Vocational training and social institutions
Demo-graphics	Population	Growth rate	Ecological Imperatives	Carrying Capacity	Demographics	Smart People	Social and ethnic plurality	Foreigners, nationals born abroad	**Demo-graphics**	Foreigners, nationals born abroad
	Tourism	Ratio of local residents to tourists	Socio Cultural features	Wellbeing	Time Use: Work, Recreation and leisure time	Smart Living	Touristic attractivity	Leisure time use		Leisure time use
Natural hazards	Vulnerability to natural hazards	population in hazard prone area	Socio Cultural features	Wellbeing	Safety	Smart Living	Individual safety	Personal safety	**Natural hazards**	Personal safety
	Disaster preparedness and response	Human and economic loss								Disaster preparedness and response
						Smart Living	housing quality	Minimal standards		housing strength
Atmosphere	Climate change	Emissions	Bio-Geo-Physical conditions	Air	Condusive to the atmosphere	Smart Environment	Pollution	Pollution rate and effects	**Atmosphere**	Emissions
	Ozone layer depletion	Ozone depleting substances								Ozone depleting substances
	Air quality	Air pollutants			Healthy air for good health					Air pollutants
Land	Land use and status	Land use	Ecological Imperatives	Carrying Capacity	Demand of the settlement on the local ecosystem	Smart Environment	Environmental protection	Nature protection	**Land**	Land use
		Land degradation	Bio-Geo-Physical conditions	Soil	Soil fertility					Land degradation
	Desertification	land affected by desertification			Functions and operations meet their ranges of healthy ecosystem					land affected by desertification
	Agriculture	Fertilizer Use			Fertilizer Use		Attractivity of natural conditions	Green Space share		Fertilizer use
		Organic farming			Organic farming					Organic farming
			Bio-Geo-Physical conditions	Food	Healthy and accessible					Healthy and accessible
Land	Forests	extent and sustainable management	Ecological Imperatives	Ecological integrity	Habitat areas and ecological corridors	Smart Environment	Environmental protection	Nature protection		Ecological integrity
Oceans, seas and coasts	Coastal zone	demand by local settlement and water quality	Bio-Geo-Physical conditions	Water	Healthy water bodies	Smart Environment	Environmental protection	Nature protection	**Oceans, seas and coasts**	demand by local settlement and water quality
	Fisheries	Fish stock			Impact to the local ecosystem					Fish stock
	Marine environment	marine ecosystem protection								marine ecosystem protection
Freshwater	Water quantity	Extent of water resource use	Bio-Geo-Physical conditions	Water	Ratio of water use to recharge rate	Smart Environment	Attractivity of natural conditions	Green Space share	**Freshwater**	Extent of water resource use
	Water quality	quality, pollution, waste treatment			Healthy water bodies		Pollution	Pollution rate and effects		Water quality, pollution, waste treatment
			Bio-Geo-Physical conditions	Water	Local sourcing of water					Local sourcing of water
Bio-diversity	Ecosystem	protected ecosystems and their management	Ecological Imperatives	Ecological integrity	Habitat areas and ecological corridors	Smart Environment	Environmental protection	Nature protection	**Biodiversity**	Habitat areas and ecological corridors
	Species	threat status								
				Biodiversity	Sustains healthy biodiversity of the ecosystems		Attractivity of natural conditions	Green Space share		Green Space share
			Ecological Imperatives	Carrying Capacity	Support ecological integrity					Support ecological integrity

Economic development	Macro-economic performance	Gross domestic product (GDP), Gross Savings, Investment share, Inflation	Socio Cultural features	Economy	Healthy and equitable environment	Smart Economy	Productivity	GDP	**Economic development**	GDP
	Sustainable public finance	Debt Vs Gross National Income (GNI)			credit unions					Sustainable public finance
	Employment	Vulnerability, Labour productivity and costs		Wellbeing	Employment	Smart Economy	Flexibility of labour market	Part timers, rate of unemployment		Employment, Part timers, rate of unemployment
	Information and communication technologies	Internet users								Research and development expenditure, Employment in knowledge intensive sectors, patents held
	Research and development	Research and development expenditure	Socio Cultural features	Economy	Healthy and equitable environment	Smart Economy	Innovative spirit	Research and development expenditure, Employment in knowledge intensive sectors, patents held		
	Tourism	Contribution to GDP			Eco-tourism	Smart Living	Touristic attractivity	Importance of location		Touristic attractivity
			Socio Cultural features	Economy	Green (local) employment	Smart Economy	Enterpreneur-ship	Self-employment rate and new buisnesses		Self-employment rate and new buisnesses
						Smart Economy	International embedded-ness	International passenger and frieght intensity		International passenger and frieght intensity
Global economic partnership	Trade	Export	Socio Cultural features	Economy	Fair trade programs				**Global economic partnership**	Fair trade programs
	External financing	Official development assistance, Foreign Direct Investment (FDI)			Community development corporations					Official development assistance, Foreign Direct Investment (FDI)
						Smart Economy	Economic image & trademarks	Importance as decision making center		Economic image & trademarks, decision making center
Consump-tion and production patterns	Material consumption	Material use	Bio-Geo-Physical conditions	Material Resources	Responsible source/use/ recycling	Smart Environment	Sustainable resource management	Resource use	**Consumption and production patterns**	Responsible source/use/ recycling
	Energy use	Renewable energy		Energy	Clean and renewable energy					Renewable energy
	Waste generation and management	Hazardous waste		Material Resources	Responsible source/use/ recycling		Pollution	Pollution rate and effects		Waste generation and management
	Transportation	Energy use, Passenger and freight	Primary urban design feature	Access by proximity	Transit access	Smart Mobility	Local accessibility	Public transport access and connectivity	**Smart Mobility**	Public transport access and connectivity
			Primary urban design feature	Access by proximity	walkability			Quality		walkability
						Smart Mobility	Availabilty of ICT-infrastructure	Computers and broadband access		Computers and broadband access
							(Inter-)national accessbilty	International connectivity		International connectivity
							Sustainable, innovative and safe transport systems	Green mobility, traffic safety, economical cars		Green mobility, traffic safety, economical cars

by train and superhighway to Tokyo. Many universities and academic research centers also located around this area. As a result, the Kashiwa-no-ha campus town was developed with a strategy to adopt environment friendly policies through ties with universities and other institutions. The development plans were studied from the 90's. The new Kashiwa-no-ha plans were prepared with the cooperation of Chiba Prefecture, City of Kashiwa, the Developer of Mitsui Fudosan Co., Ltd and two Universities of Tokyo and Chiba. The author was a member of these planning process for the environment friendly urban development. The analysis of this paper, with respect to the international indicators integrated from the three methodologies, was conducted for two of main Kashiwa-no-ha plans, as seen in Table 3.

Case Study 1: Kashiwa-no-ha International Campus Town Initiative (2008, modified in 2014).

Case Study 2: Kashiwa-no-ha Smart City project (2011).

4-3. Analysis of Case Study 1: Kashiwa-no-ha International Campus Town Initiative (2008, modified in 2014)

A joint development effort by public–private–academic sectors drafted in 2007 and implemented the Kashiwa-no-ha International Campus Town Initiative from early 2008. In this case study, we see all factors of Sustainable Development answered. Most factors under Eco and Smart methodologies are also met. After the five years of the execution of the plan, their objectives and the contents were modified and more detailed issues were incorporated for the realization of the plan in 2014.

The objectives of Kashiwa-no-ha International Campus Town Initiative are composed of eight ambitious themes (Table 3). The objective 1: 'Sustainable Garden City' leads to environmental projects and certain standards. For the example the existing green fields and their networks will be preserved in the total 40% of the planning area. The developers would be obligated to maintain more than 25% of the green part of their building lots. The aim of reductioning more than 35% of CO_2 by 2030 (which is based on the Kyoto protocol of 2010) is being promoted in all area of City of Kashiwa.

The objective 2: 'Creative and Industrial Spaces' aims to provide for global level industries through the development of an incubation center near the new railway of Tsukuba Express. For the example the 'Plant Factory' of Chiba University is a closed growing system, in which throughout the year a constant production of high quality vegetables can be achieved.

The objectives from 3 to 8 aim to attain their challenges for education, mobility, healthy, area management, urban design, and innovation through the partnerships between public, private and academic sectors.

In this case study, we see most factors of sustainability answered (Table 4). Kashiwa-no-ha has wide walkways for the safe movement of pedestrian traffic and can be hence be argued as a walkable city. Among the unanswered themes-characteristics of immigration friendly is the international theme of poverty. But immigration is very limited as it is highly regulated and controlled by law as a whole in Japan, so the indicator of 'immigration friendly' may be not be applicable in the sustainability of this local plan. Each country is differentunique in its characteristics and in this case, immigration being a subject of national policy, it is difficult to use this parameter to measure the sustainability.

Another unanswered theme is the characteristics of 'support ecological integrity' under the theme of biodiversity. Generally there is a lack of sensitivity for the ecological support in the urban development plan in Japan. Although the plan incorporates green corridors spiteunderof strong pressure of economic activities, there is not indicated any support for the ecological activities. This point would be added in the environmental theme and the educational theme.

The last unanswered themes are characteristics of 'global economic partnership'. The plan is respected for the academic internationality but that is not oriented for the economic one. We don't have any data about the international trade and we should research more about the real relationships between the products of Kashiwa-no-ha and the global market in the next planning phase.

Table 3 – Eight objectives of Kashiwa-no-ha International Campus Town Initiative (2008, modified in 2014).

Objective 1 : Sustainable Garden City
Objective 2 : Creative and Industrial Spaces
Objective 3 : International Spaces for Academic Community and Culture
Objective 4 : Sustainable Mobility System
Objective 5 : Healthy and Kashiwa-no-ha Life Style
Objective 6 : Area Management by the Partnership between Public, Private and Academic Sectors
Objective 7 : High Quality Urban Design
Objective 8 : Innovation Field

Table 4 – Assessment of the Case Study of Kashiwa-no-ha Plans – Answerability with respect to indicators of the three themes of Sustainability.

Theme		Answerability		Plans	
	Social	+	Answered	A	Kashiwanoha International Campus Town Initiative (2008, modified in 2014)
	Environmental	-	Unanswered		
	Economic	NA	Not Applicable	B	Kashiwanoha Smart City Project (2011)

Indicators of the Sustainability Assessment (Social Theme)		A	B	Indicators of the Sustainability Assessment (Environmental Theme)		A	B	Indicators of the Sustainability Assessment (Economic Theme)		A	B
Theme	**Characteristics**	**Answer bility**	**Answer bility**	**Theme**	**Characteristics**	**Answer bility**	**Answer bility**	**Theme**	**Characteristics**	**Answer bility**	**Answer bility**
Poverty	Poverty	+	+	**Atmosphere**	Emissions	+	+	**Economic development**	GDP	NA	NA
	Employment	+	+						Sustainable public finance	+	+
	Living standards	+	+		Ozone depleting substances	NA	NA		Employment, Part timers, rate of unemployment	+	+
	Improved water source	+	+		Air pollutants	+	+				
	Electricity and modern energy sources	+	+						Research and development expenditure, Employment in knowledge intensive sectors, patents held	+	+
	Slum dwellers	+	+	**Land**	Land use	+	+				
	Cultural activities to facilitate eco literacy and social learning	+	+								
	Immigration friendly	-	-		Land degradation	+	+		Touristic attractivity	+	+
Governance	Transparent governance	+	+						Self-employment rate and new buisnesses	+	+
	Safety	+	+		land affected by desertification	+	+		International passenger and frieght intensity	+	+
	Voluantary work	+	+								
	Community participation in decision making process	+	+		Organic farming	+	+	**Global economic partnership**	Fair trade programs	-	-
	Day care, quality of schools and other social service facilities	+	+		Fertilizer use	+	+		Official development assistance, Foreign Direct Investment (FDI)	-	-
Health	Life expectancy	+	+		Healthy and accessible	+	+		Economic image & trademarks	-	-
	Health care facilities	+	+		Ecological integrity	+	-	**Consumption and production patterns**	Responsible source/use/ recycling	+	+
	Nutritional status of children	NA	NA	**Oceans, seas and coasts**	Demand by local settlement and water quality	NA	NA				
	Physical and mental health	+	+		Fish stock	NA	NA		Renewable energy	+	+
Education	Primary education access	+	+		Marine ecosystem protection	NA	NA		Waste generation and management	+	+
	Lifelong access to education	+	+	**Freshwater**	Extent of water resource use	+	+				
	Literacy rate	+	+		Water quality, pollution, waste treatment	+	+	**Smart Mobility**	Public transport access and connectivity	+	+
	Access to information	+	+								
	Vocational training and social institutions	+	-		Local sourcing of water	+	+		Walkability	+	+
Demographics	Foreigners, nationals born abroad	+	+	**Bio-diversity**	Habitat areas and ecological corridors	+	-		Computers and broadband access	+	+
	Leisure time use	+	+		Green Space share	+	+		International connectivity	+	+
Natural hazards	Personal safety	+	+								
	Disaster preparedness and response	+	+		Support ecological integrity	-	-		Green mobility, traffic safety, economical cars	+	+
	Housing strength	+	+								

4-4. Analysis of Case Study 2: Kashiwa-no-ha Smart City project (2011)

Implemented from 2011, it is a joint venture of world leading private companies who have come under the Smart City planning Inc. to build a next generation environmental city. It aims to take advantage of advanced technologies and know-how of these companies, to provide optimal solutions at source. The Kashiwa-no-ha Smart City is being developed as a flagship project to create a model to showcase cities of the future (Figure 2, Figure 3) Especially the Smart City project leads the efficient energy use based on the Area Energy Management System (AEMS, Figure 4). Sustainable building design rich with innovative ideas and technologies will be produced in this area (Figure 5).

This case study project meets most factors of the social theme without the 'immigration friendly' and 'vocational training'. Answerability of the economic theme is same as in the previous case. Many factors of smart technologies have introduced in Kashiwa-no-ha, but there are no points about global market partnerships. Also the characteristics of ecological integrity, ecological corridors and the support of ecological integrity are not fulfilled. The answerability of these points is lesser than the previous case (Table 4). One reason for this lack of answerability can be attributed to the fact that, private companies drive this project. The companies excel in research and technological edge in their respective fields and the project is a showcase of such cutting edge technologies. However, the absence of governing bodies to look at the overall planning such as in the previous case of the International Campus Town Initiative may have led to the decreased answerability in this project.

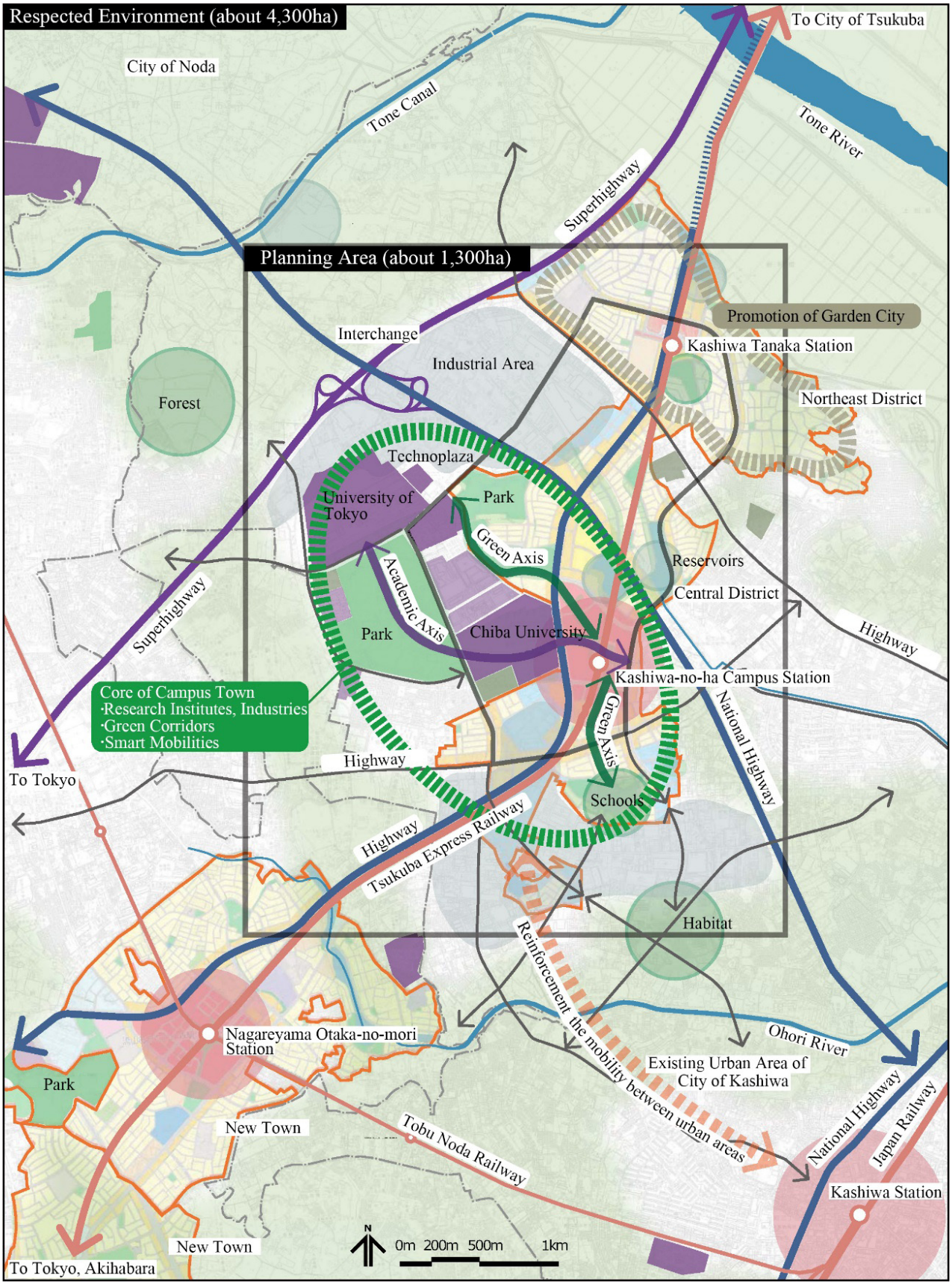


Figure 1 – The planning area of Kashiwa-no-ha International Campus Town Initiative (2008, modified in 2014). The main target of this plan is about 1,300ha of the City of Kashiwa in the respected environment of the intercity surroundings (4,300ha). Credit: Committee of International Campus Town Initiative (Chiba Prefecture, City of Kashiwa, Chiba University, the University of Tokyo, Urban Renaissance Agency, Mitsui Fudosan Co., Ltd).

The project area of the Smart City is now limited in some building lots but it may be spread to surrounding lots including natural preservation area and reservoirs.

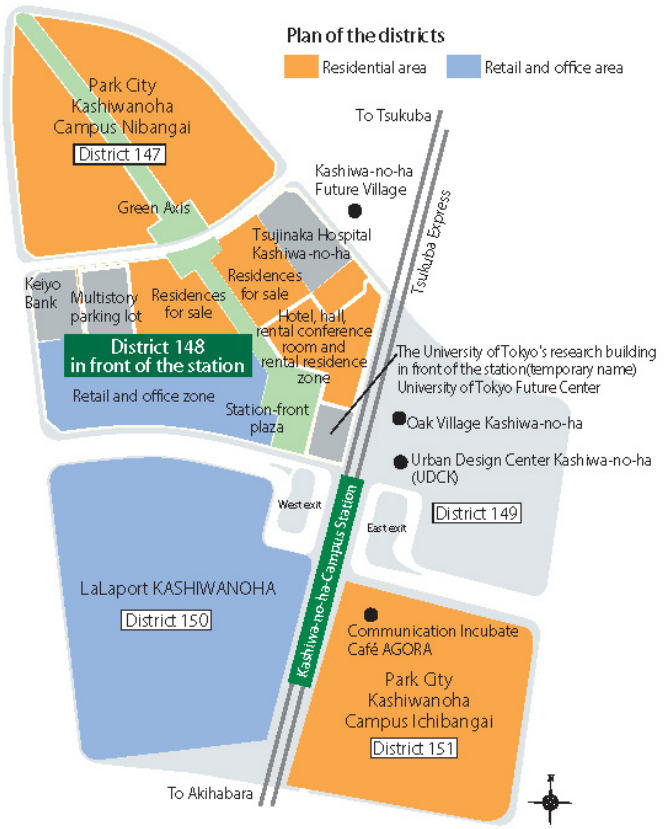


Figure 2 – Project Area of the Kashiwa-no-ha Smart City Project (2011). Credit: Mitsui Fudosan Co., Ltd.

Fig. 3 Perspective of the Kashiwa-no-ha Smart City Project (2011). Credit: Mitsui Fudosan Co., Ltd.

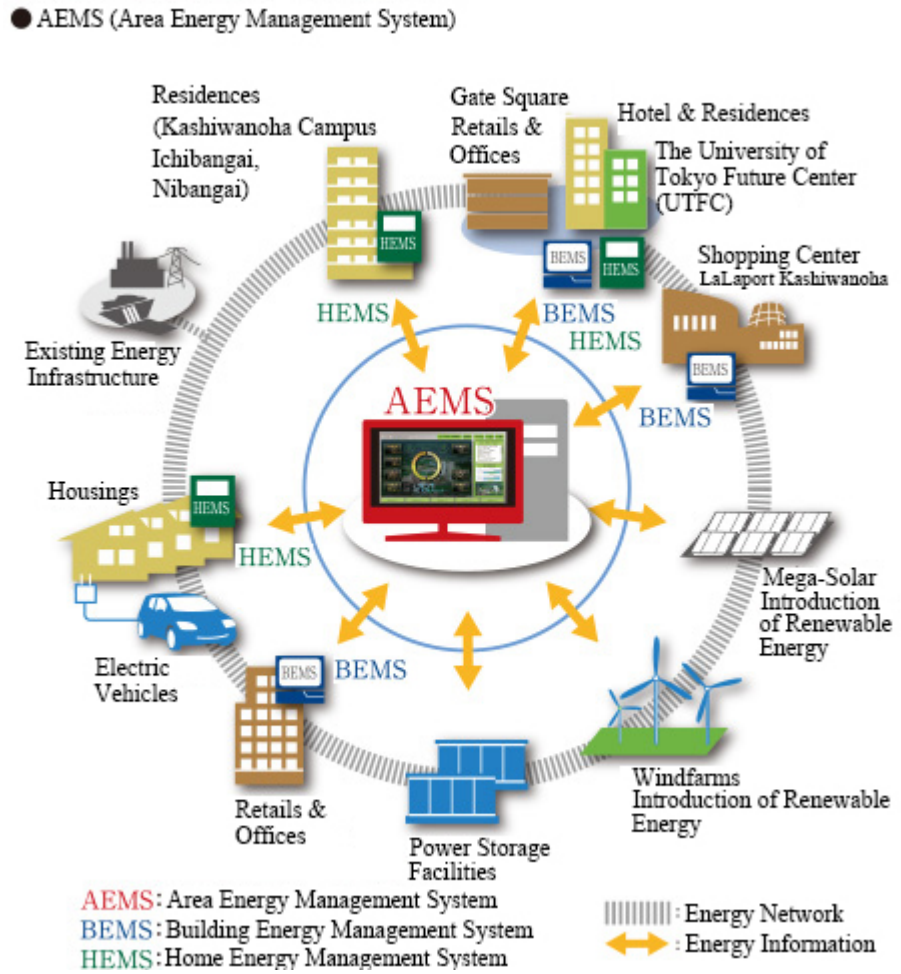


Fig. 4 Concept of Area Energy Management System in Kashiwa-no-ha. Credit: Mitsui Fudosan Co., Ltd.

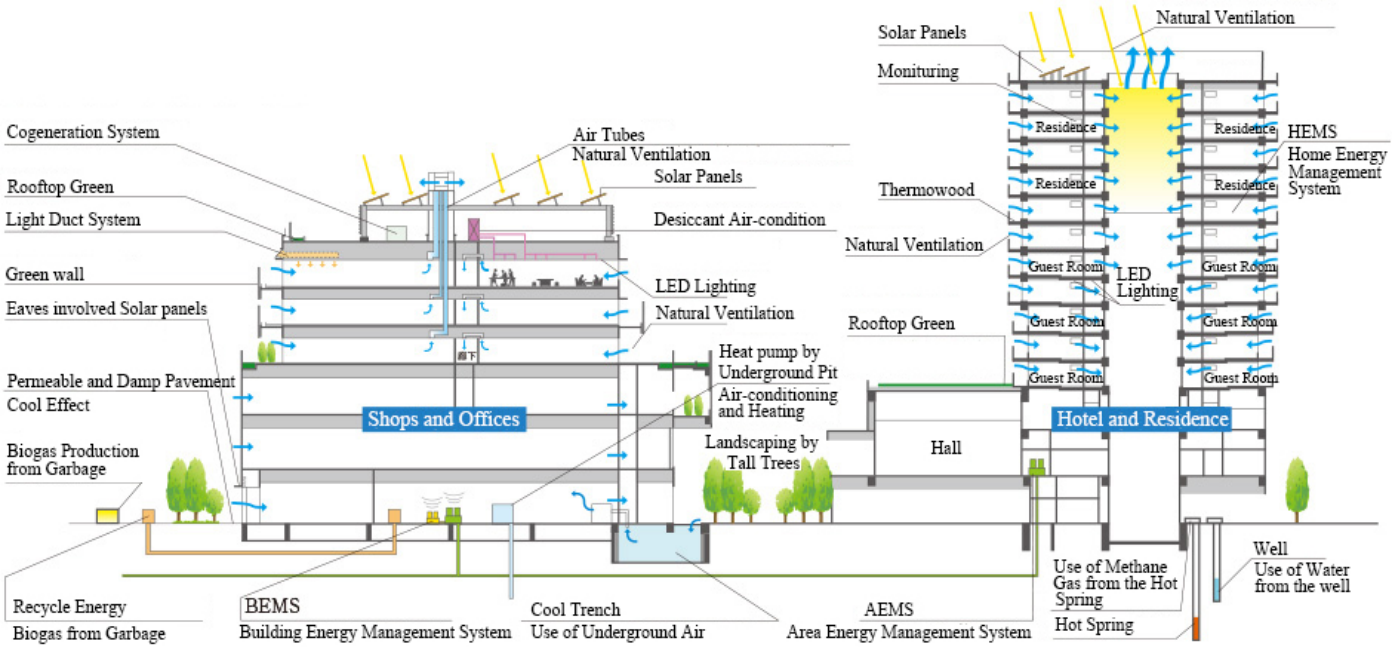


Fig. 5 Sustainable building design in Kashiwa-no-ha (District no.148). Credit: Mitsui Fudosan Co., Ltd.

4-5. Comparison of the Two Case Studies

The comparison of the two case studies was based on the comparison table of the three themes of Sustainability (Table 4). The table was adapted to check answerability of both projects. Based on the results of the answerability evaluation, the areas where the projects cover and the areas they lack have been identified.

From the analysis it is evident that both plans of Kashiwa-no-ha are at Sustainable Development stage with the current development plans. This shows insufficient application of environment friendly urban development terminology as identified in the study. For the next step, the insufficient themes of both plans must be studied.

Between the two plans, most of the urban development themes are covered and this can be said to be to the overall benefit of the development. Overall Kashiwa-no-ha International Campus Town Initiative (2008, modified in 2014) is more comprehensive than the Smart City project (2011). When replicating the Smart City project, care must be taken to ensure the operation by adopting from the comprehensive plan as possible as overall themes.

5. Conclusions

This paper concludes the following five points.

1) Differences between terminologies of Sustainable Development, Eco City and Smart City have been analyzed from their indicators (themes and sub-themes). The basic minimum themes to be covered, so as to be benchmarked under each of the three main methodologies is evident from the analysis (table 2).

2) United Nations, International organization and Vienna University of Technology being responsible for 'Sustainable Development', 'Eco City' and 'Smart City', has resulted in a well-defined framework, which has the potential to be used worldwide. It is clear that, usage of indicators of 'Sustainable Development', 'Eco City' and 'Smart City', along with involvement of government regulatory bodies leads to overall comprehensive plans. It can be concluded that, involvement of government regulatory bodies leads to overall comprehensive plans if the integrated indicators of 'Sustainable Development', 'Eco City' and 'Smart City' would be used for the sustainability assessment before or during the planning.

3) All of the themes in 'Sustainability' are answered in the 'Eco City Framework'. 'Eco City' methodology covers certain new areas previous not seen in the older 'Sustainable Development'. 'Eco City' can therefore be concluded as an evolved form of Sustainable Development. One reason for the 'Eco City Framework' and 'Sustainable Development Framework' overlap could be the close association of the organization at the forefront of development of the two terminologies.

'Smart City' covers new areas previously not seen in either 'Sustainable Development' or 'Eco City', however, it doesn't cover some of the themes found in both 'Sustainable Development' and 'Eco City'. The reason for this may be the independent development of the 'Smart City' concept as against the collaborative efforts seen in 'Sustainable Development' and 'Eco City'.

Recognizing the differences between their terminologies, we tried to integrate their indicators under all themes in 'Sustainability' in this paper.

4) In the case studies at Kashiwa-no-ha, the integrated indicators clearly verify characteristics of the plans. At Kashiwa-no-ha, even though the newer 'International Campus Town Initiative' (2008, modified in 2014) and 'Smart City Project (2011)', fails to cover all themes, it is clear that especially the themes of 'biodiversity' and the characteristics of 'ecological integrity' in the theme of 'land' should be paid more attention while planning. The characteristic of 'immigration friendly' in the theme of 'poverty' maybe not be concerned with the local plans, because it depends on the national policy. The theme of 'global economic partnership' was also unanswered. The themes of globalization should be studied in more detail during the next planning modification.

All indicators of the sustainability assessment of this paper are meaningful and the result could be useful for the future development of planning methodologies at Kashiwa-no-ha.

5) In the current scenario of multiple frameworks, this study proposes to sort the existing scenario, rather than to propose another new framework. This study proposes that the integration of three types of themes (social, environmental and economic themes) can be considered as three stages in the development of environment friendly urban developments. Considering the development time line and convergence of themes in the analysis of frameworks of the three terminologies, the following stages have been proposed – Stage1- Sustainable Development, Stage 2- Eco City and Stage 3 - Smart City. This study proposes that the overlap of the concepts and the integration of their indicators can be taken advantage of to develop overall comprehensive plans. The comparison table of the frameworks is useful as a base framework for evaluating urban developments pursuing environment friendly concepts.

Though, development of frameworks has many variable factors such as; location, culture, local issues, etc., from the frameworks of Sustainable Development, Eco City, Smart City and the case studies at Kashiwa-no-ha Campus Town, we can conclude that mutual co-operation in development of frameworks, at least at regional level, along with government

involvement will ensure proper coverage of all critical themes, consensus and uniform applicability of terminology and their inherent concepts. This study demonstrates a methodology to analyze, evaluate urban development projects, and attain clarity to terminology usage or their corresponding framework. It facilitates comparative studies between differently termed developments, which are critical for identifying successful projects and for the adaptation of these in future projects thus aiding the growth of future environment friendly urban developments.

References

Gert de Roo and Geoff Porter (2007), Fuzzy Planning: The Role of Actors in a Fuzzy Governance Environment, Ashgate Publishing Ltd.

United Nations (1987), Report of the World Commission on Environment and Development: Our Common Future http://www.un-documents.net/wced-ocf.htm

United Nations (2007), 'Indicators of Sustainable Development: Guidelines and Methodologies', the third edition http://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=107&menu=920

Ecocity Builders (2011), 'International Eco City Frameworks and Standards' http://www.ecocitybuilders.org/what-we-do/ecocity-standards/

Ecocity Builders (2011), 'The Eco City Frameworks, Human Settlements in Balance with Nature and Culture'

Giffinger R, Fertner C, Kramar H, Kalasek R, Pichler N & Meijers E, Vienna University of Technology, Centre of Regional Science (2007), 'Smart Cities: Ranking of European Medium-Sized Cities' – http://www.smart-cities.eu/press-ressources.html

Worldwide City Concepts Analysis: Analysis mapping of over 30 city concepts dealing with sustainability issues - Christoph Rat-Fischer and Florian Rapp, European Institute for Energy Research (2012), Germany

The ministry of Economy, Trade and Industry (2007), Eco-Towns projects/Environmental industries in progress, Japan

Chiba Prefecture, City of Kashiwa, the University of Tokyo, Chiba University (2008), The Kashiwa-no-ha International Campus Town Initiative – http://www.pref.chiba.lg.jp/seisaku/keikaku/sougoukikaku/documents/gaiyou.pdf

Committee of International Campus Town Initiative (Chiba Prefecture, City of Kashiwa, Chiba University, the University of Tokyo, Urban Renaissance Agency, Mitsui Fudosan Co., Ltd) (2014), The Kashiwa-no-ha International Campus Town Initiative, http://www.udck.jp/town/CTI2014_web.pdf

Smart City Project (2009), Official website of Smart City Project – http://www.smartcity-planning.co.jp/en/index.html

Mitsui Fudosan Co., Ltd (2011), Kashiwa-no-ha Smart City project, Official website of Kashiwa-no-ha Smart City http://www.kashiwanoha-smartcity.com/en/

Bioclimatic simulation, environmental based urban design and architectural redevelopment in the Mediterranean Area: a didactic approach for the training of future professionals

Fabrizio Tucci, Filippo Calcerano
PDTA Departement, University of Rome La Sapienza – fabrizio.tucci@uniroma1.it – filippo.calcerano@gmail.com

Keywords: Environmental analysis and design, bioclimatic and biophysical feature, urban heat island, urban historical and archaeological tissue, computing fluid dynamics simulation, early design stage, methodology, didactic approach.

Abstract

The study presents a synthesis of the didactic experience called "Bioclimatic simulation, environmental based urban design and architectural redevelopment in the Mediterranean Area", in which, among others, the case study of the Tor Fiscale district in Rome was addressed; the latter deals with the theme of the self-reliant city, of the heat island effect mitigation, and of the energy and environmental efficiency of buildings from passive energy efficiency and smart grid point of view. The learning process tested on students is based on the study and simulation of climate, urban and local microclimate factors, of the utmost importance for the training of future professionals with a strong environmental sensitivity, in addition to the traditional analysis of a typical urban fabric characterized by strong historical, archaeological and environmental features. The microclimate area simulation is used as a decision making support tool aimed at deepening the critical-knowledge on the area and the proper formulation of objectives and strategies through a process characterized by a flexible and adaptive approach with the aid of retroactive feedback. The study sets out the specific biophysical and bioclimatic features to consider when developing objectives and strategies of intervention in a portion of urban tissue. The case study of Tor Fiscale is analysed in its peculiar characteristics of an area substantially closer to the centre of Rome, characterized by a strong presence of archaeological and natural values, together with a context of strong environmental degradation and unauthorized building construction. The paper concludes with assessments developed within the framework of the didactic process, along with a report on the teaching experience for further didactic improvements and three design results directly related to the analysis and the didactic process.

Framework definition and question remarks

In Europe the energy consumption of the building sector accounts for about 40% of the overall demand for energy; buildings consume 40% of the incoming material into the economy and generate approximately 40-50% of the greenhouse gases produced (Ardente et al. 2011). Cities host now more than 50% of the world population (UN 2012) and although they take up less than 3% of the earth's surface, they consume 75% of the total energy produced and produce 80% of all greenhouse gas emissions (Brown 2001) (European Commission 2010). The European Directive 2010/31 has already set ambitious targets for reducing energy consumption for the building industry and a central role for the achievement of these objectives will increasingly be carried out also by the evolution and development of the city not as a sum of individual buildings but as a system of interrelated energy flows as much as possible self-reliant, that is tending to prefer the local production of services, goods and energy according to the well-being of the community (Shuman 2000). A further articulation of this principle applied to energy requires the consideration of geography and natural resources both as a mean to meet the energy demands of the city (Grewal and Grewal 2013) and as a mean to transfer the principle of the energy efficiency of buildings to the energy efficiency of the urban fabric through its passive behaviour, as the latter is capable of significantly reducing energy consumption of the buildings within it at the source (Yang et al. 2012). The urban climate is strongly influenced by natural and anthropogenic factors dependent on the density and the heat storage capacity of the built fabric, the presence of mineralized or green surfaces and pollutant emissions. The heat balance of a city is very different from that of a suburban area and the phenomenon is called the "heat island" effect. The urban heat island is the best example of increased energy consumption of a city due to anthropogenic-induced changes in microclimate and local climate (Gartland 2008, Grimm et al. 2008). The triggering factors related to the effect of urban canyon, the decrease in convective exchanges data from the wind and pollution, are summarized in the table below (D'Olimpio 2008, RUROS 2004).

Studies show that mitigation of the heat island can produce savings in energy consumption for summer cooling between 20 and 30% (de la Flor and Domínguez 2004, Akbari, Pomerantz, and Taha 2001).

Factor	Cause
Increase in absorbed solar radiation (shortwave) and increased heat storage	**Morphological:** the urban geometry develops a greater sun exposed surface compared to a flat surface and determines multiple reflections of radiation (canyon effect). **Constructive:** the high heat capacity and low albedo of construction materials increases the heat storage capacity of the urban fabric modifying the thermal balance.
Decreased thermal radiation loss (long wave)	**Morphological:** the urban canyons (related to a low sky view factor) cause a decrease of the radiative exchange with the sky (heat sink) and an increase in radiative exchanges between the buildings themselves. **Anthropogenic:** the pollution reduces the energy dissipation capacity of the system to the sky (the greenhouse effect)
Increased radiative flux from the sky	**Anthropogenic:** the pollutants discharged into the layers of urban atmospheres that have absorbed direct solar radiation, increases the thermal radiation emitted from the air (increased greenhouse effect)
Decreased evapotranspiration of soil	**Constructive:** the high rate of impermeable mineralized soil surfaces at the expense of green permeable soil and the decrease of evapotranspiration from plant species heavily decreases the cooling properties of urban tissue.
Decrease in convective heat dissipation	**Morphology:** The roughness of the urban fabric decreases the air velocity and thus the capacity of the winds to disperse by convection heat loads in excess.
Increase of anthropogenic heat radiation	**Anthropogenic:** the thermal conditioning of buildings, transport and manufacturing processes help to increase the thermal balance of the city.

The support of manuals and rules of thumb, that are still the prevailing approach and often cause misleading results, is not enough for a bioclimatic design methodology that in addition to managing the highest number of phenomena involved in urban design is also able to mitigate the heat island effect. The support of computational simulations capable of treating the complex interactions between heat exchanges, air flows and evapotranspiration as a system of related optimizable items, and not as the sum of a number of elements designed and optimized separately for subsystems, is needed (Hensen 2004). This approach, down to an appropriate scale of depth, goes beyond the given climate statistics to the study of the urban microclimate. It is important simulations are involved in the decision-making process from the early design stage, and not relegated, as it normally happens, to the final stages when they have a very limited impact on the final result (Lechner 2009, Reiser et al. 2008, De Wilde, Augenbroe, and Malkawi 2014). Unfortunately, the designer that generally manages the early stages of the project is rarely a simulation expert capable of determining the appropriate simulation for the decision support required. Overcoming the above mentioned obstacle in the application of simulation tools in professional practice is one of the objectives of the educational approach described here. An analysis approach must always be supported by simulations, used as decision making support tools (Morbitzer 2003), that lead to a better formulation of objectives and strategic guidelines for the design of urban transformation. The training of future professionals with a strong environmental sensibility and a basic understanding of building and urban environmental simulation process, capable to go beyond these limits, should start in university, through courses with a strong emphasis on the application of simulation tools and their harmonization within the design process.

Definition of the methodological approach

After the definition of the framework the didactic scheme for urban microclimate design approach is presented through 6 steps of progressive analysis:

In step 1 students are asked to briefly develop individual concepts based on the first impressions arising from the area survey and from the dossier provided by the course. This step is ice-breaking and helps students to become familiar with the complexity of the area and the multitude of linked factors.

In step 2 students are divided into seminars, each of which is assigned a particular in-depth topic of the district. Within each seminar students are divided into groups of 2-3 people and are asked to start their group analysis on the area according to the scheme proposed by the course. From this point onwards, the students inside groups will continue to work together until the development of the final work for the examination. The data collected allows the students to comprehend the dynamics of the environment in general and define the climate type and the general strategy of reference (in this case, with distinct approaches in summer and winter), with particular attention given to the thermal range above a certain threshold (14 ° C in the case of Rome) that allows for an optimal use of cooling mechanisms based on thermal inertia of urban materials. Subsequently the students are asked to analyze the biophysical factors of the area (step 3), hydrological basin and geomorphologic condition paying particular attention to the characteristics of the vegetation species. These factors are analyzed both from a botanical point of view and in terms of design with a focus on factors such as:

- stress resistance to the wind;
- permeability to the wind;
- permeability to solar radiation and *habitus* (evergreen or deciduous);

- characteristics of the root system for integration into a built contexts;
- resistance and adaptability to the climate of reference.

In step 4, four bioclimatic factors are thus analyzed. The sunshine is analyzed in its critical summer and winter condition both in relation to the public space (localized heat island effects or perennial shadow areas), and in relation to the solar exposure of the built fabric (analyzing the potential use of passive strategies and systems of active energy production from renewable sources). The analysis of the urban microclimate is further detailed in step 5 by adding to the effects of solar radiation, wind flow around buildings, steam and heat exchange between soil and surfaces, heat exchanges and water vapour of vegetation and climate, thanks to the CFD freeware software ENVI-MET (Bruse 2010). The software is used to verify the information resulting from step 4 and obtain additional information on the prevailing winds in the urban fabric – an important element for a suitable design of external environmental comfort and natural ventilation in buildings - on the hygrothermal and radiant conditions relative to the albedo of urban materials, vegetation and of any water bodies. With step 6 an outline of bioclimatic factors is added to the traditional analysis on the functions and uses of the area, the infrastructure and character and identity of places, to produce five guidelines for urban planning and buildings design which are later developed in the examination papers.

Step	Analysis	Design	Tools
1	Concept works on first impressions arising from the area	Analysis and development of the material provided to the students from the course	Dossier of the area, on site survey
2	Climatic data and definition of the climate (solar radiation, temperature and temperature range, humidity, prevailing winds)	Selection of the general strategy based on the type of climate	Statistical data
3	Biophysical analysis	Hydrographic survey, geomorphology and vegetation analysis from a botanical and design point of view	Thematic maps
4	Bioclimatic analysis: sunshine	Identification of critical areas from the point of view of the excess of sunshine in summer or of perennial shade in winter, analysis of the radiative flux on the surfaces of buildings	Sunshine simulations of a three-dimensional reconstruction of the urban fabric
5	Bioclimatic analysis: ventilation and urban microclimate	Identification of issues resulting from a problematic interaction of morphological construction elements and plants	Computational fluid dynamics (CFD) simulation of the microclimate behaviour
6	Analysis outline and development of strategy	Summary of information derived from previous analysis in integration of urban planning traditional analysis subsystems	Data post-processing and critical synthesis of analysis

Case study of Tor Fiscale: area description

Rome is one of the largest and most ancient cities in Europe, characterized by a very complex landscape generated from a hilly volcanic area crossed by the river *Tevere* and its smaller affluent. The area of about 130 hectares is characterized by 5.4% of historical or archaeological urban fabric, 27.6% of modern urban fabric, 31.7% of green areas and agricultural protected areas and 3.4% of industrial productive urban fabric. The resident population is of 2,640,000 inhabitants.

The *Tor Fiscale* district is about 1.34 square kilometres wide with a population of 2,234 inhabitants and a density of 2.4 inhabitants per square km, that is far below the average of the surrounding areas of the city, which is around 17.75 people per square kilometre (U.O. Statistica Roma Capitale 2013). The area is connected to the rest of the urban fabric only by a corridor to the Northeast. The North western margin consists of the archaeological park of *Tombe di via Latina* to the east the district is divided from the rest of the city by two ancient aqueducts and a railway. The aqueduct of Claudius dating back to 38-47 AD belongs to the Roman period, while the aqueduct of *Felice* built in 1585 is from the Renaissance period. The railway runs through the Regional Park of *Appia Antica* that also acts as a margin for the district to the south and west, crossed by the road *Appia Nuova* which links the centre of Rome with the Southern periphery. The district is crossed by the *via Latina* of the Roman period (fourth century BC), an ancient road 4 meters wide which was the oldest infrastructure of connection with the south of Italy; the path

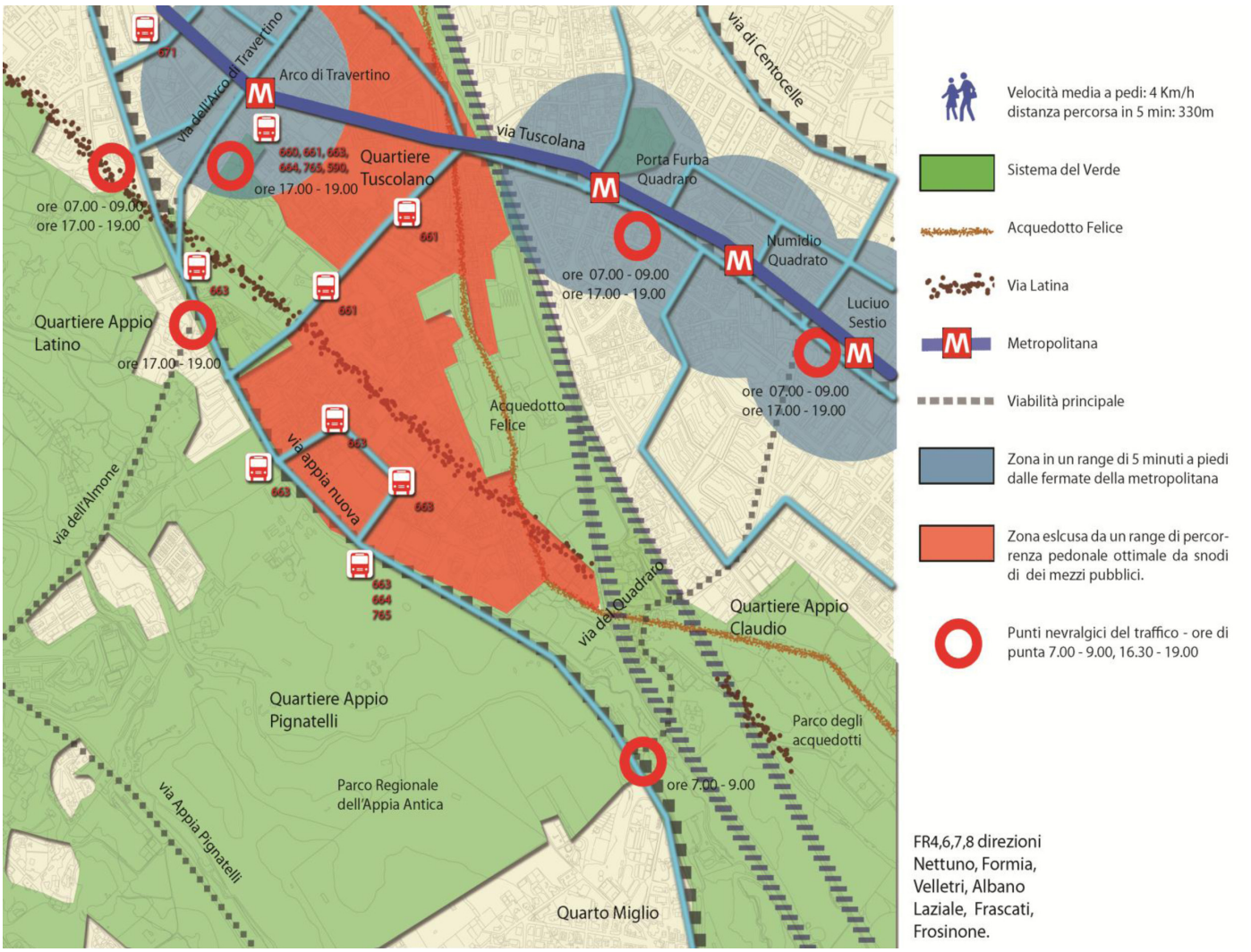
is still visible in the archaeological park, while it's covered with unauthorized buildings within the district. Finally, at the intersection between the two aqueducts stands the *Torre del Fiscale*, a surveillance tower of the medieval period (XIII cent.) that gives the name to de district. The tower is 30 meters high with a square base built of tuff blocks. The urban fabric has developed spontaneously from a series of historic farmhouses with a strong acceleration during the second world war, which catalyzed the population fleeing from the *San Lorenzo* district under bombardment. The people took refuge in the shacks close to the Roman aqueducts. The existing built fabric is mainly residential with a low to medium density without an adequate supply of services and public transport connecting this area to the rest of the city (despite the relative proximity of a underground station). The area close to the *Via Appia* (Southwest) and aqueducts (Northeast) is still characterized by unauthorized settlements both residential and productive. A lot of urban laws insist on the area, mainly with hydrological and archaeological constraints, and recently the "Integrated Program for the redevelopment of the city to be restored" (PRINT) has been activated; the latter is characterized by a good degree of flexibility and a particular focus on the environmental and archaeological features of the district.

Climatic analysis

In terms of climate Rome can be assimilated to the category of sub-coastal climate that includes hilly areas and low mountains of Lazio. The average maximum summer temperature is of 30,4 °C while the average minimum winter temperature is of 2,6°C; the daily thermal range of the area is greater than 14 °C (suitable for the use of the thermal inertia in passive strategies), the annual rainfall is around 876 mm with limited rainfall in June, July and August. The average relative humidity during the year is 72.9%. The prevailing winter winds come from the North-East, while the prevailing summer winds come from South-West, both with an intensity of 4,4 m/s according to the meteorological stations of the nearby *Ciampino* and *Roma Urbe* Airports.

Biophysical analysis

As in most European cities, in the *Tor Fiscale* district there is a single network for waste-water management. This configuration of the network of waste-water along with the population growth and the unauthorized urbanization has generated a great deal of pressure on water resources. Over



time this pressure caused an effect of urban stream syndrome (Willuweit and O'Sullivan 2013, Grimm et al. 2008, Walsh et al. 2005) and therefore an increase in groundwater pollution and a loss of biodiversity of which we have clear evidence at the river *Almone* flowing nearby within the Regional Park. At geomorphologic level the East margin, with its aqueducts and railway, is raised above the central urbanized area and the rest of the Regional Park of Appia Antica. The vegetation is characterized by the presence of riparian forests on the floodplains, turkey oak hilly Tyrrhenian deciduous forest and sub-Mediterranean middle Italy turkey oak.

Bioclimatic analysis: sunshine

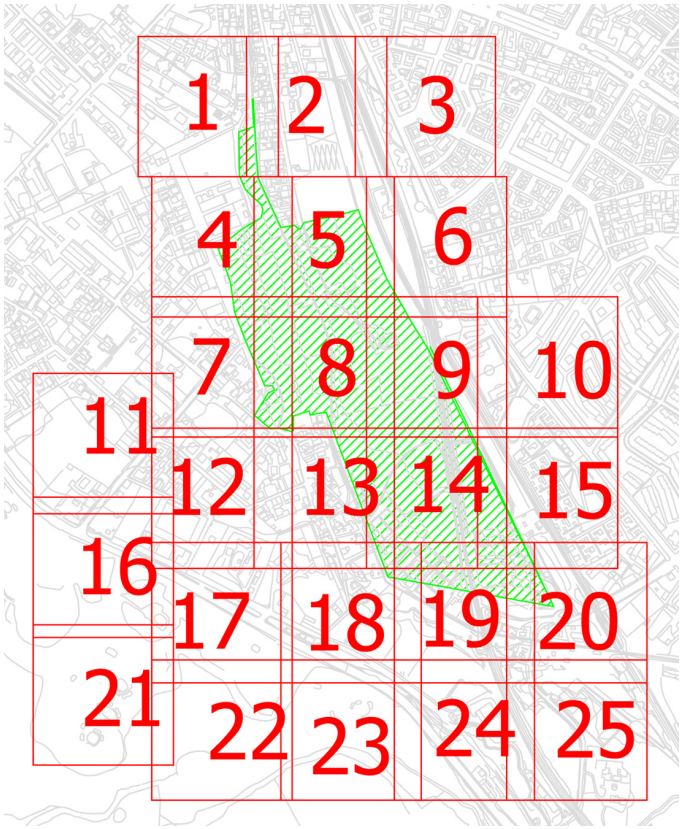
The urban fabric has been reconstructed in two three-dimensional models with different foliage of deciduous plant species between summer and winter, with a simulation software and the use of satellite imagery and an on-site surveys. The analysis did not reveal any particular critical situation in winter because of low construction density. In summer, the shading of the area depends exclusively on tall tree plant species, which are present in the parks but almost absent in the portions of urban fabric under study, resulting in the generation of numerous local heat islands.

Bioclimatic analysis: ventilation and urban microclimate

To simulate the microclimate behaviour of the area, given its size and the computational capabilities of the software, it was necessary to divide the area into quadrants, partially overlapped to limit quadrants boundary discontinuities typical of a CFD simulation (as shown in the picture on the right). For each quadrant, summer and winter simulations were carried out and their results were graphically reconstructed in thematic maps of the performance of the prevailing winds, relative humidity and temperature of the area (table on the next page).

The temperature analysis confirms the presence of heat island effect in the unauthorized urban fabric, with rates of relative humidity lower than the surrounding green areas. The prevailing winds in summer, due to the district roughness, never reach the levels observed at the meteorological station

of Ciampino, and stand at around 2.6 m/s in summer and 3.6 m/s in winter at eye level. The most critical areas were then subject to further investigations.



Decision support tool and processing strategies

Design strategies are then identified and adapted to positively influence the urban microclimate in terms of buildings energy consumption and comfort of outdoor spaces, through a retroactive feedback process. The design strategies modify sunshine loads on the area, shield winter prevailing winds and direct summer prevailing winds towards existing or new buildings in order to use natural ventilation systems. These strategies are analyzed running simulations on *post operam* models with different morphology of vegetation and albedo of surfaces. A set of objectives for the environmental and energy optimization of the neighbourhood is developed, supplementing the current planning instrument in force. The new objectives that foster a new and environmentally conscious design approach to the urban fabric are divided into five main categories:

Microclimate And Environmental Comfort

Objectives: landscape and environment valorisation; improvement of urban comfort; reduction of heat island effect; reduction of noise and air pollution resulting from the Via Appia.
Strategies: densification of evergreen plant species to shield winter prevailing winds; densification of deciduous vegetation on identified Southwest Northeast channels to strengthen wind flow (wind canyon effect) to be exploited for passive cooling of the heat islands while cleaning the air from the smog particles in suspension; use of water masses for summer wind cooling purposes; creation of a filter space between the road *Appia Nuova* and the rest of the neighbourhood, by means of earth movements, to mitigate noise and air pollution; reduction of mineralized surfaces with low albedo and gradual replacement with high albedo surfaces, or green surfaces.

Vegetation And Urban Ecosystem

Objectives: reconnection between the two edges of the regional park and the archaeological park of *Tombe* di via Latina through ecological corridors; promotion of biodiversity.
Strategies: creation of a hierarchical network of different types of vegetation integrated with microclimate optimization objectives, giving priority to indigenous species to foster the continuity of the Regional Park.

Water

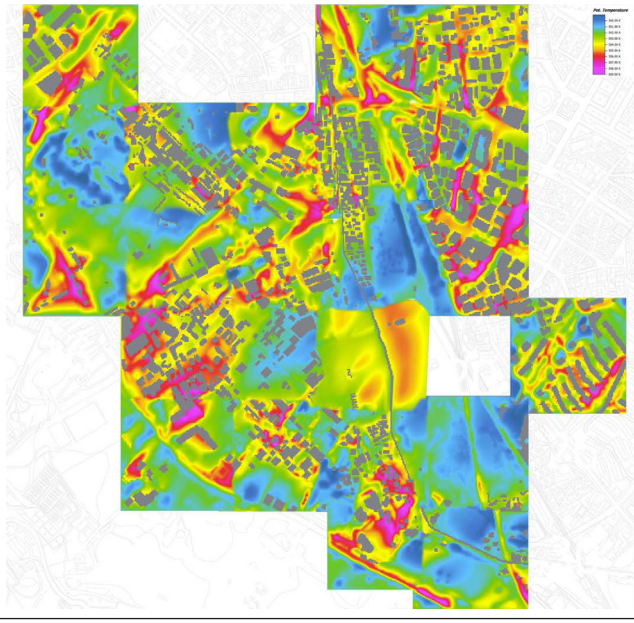
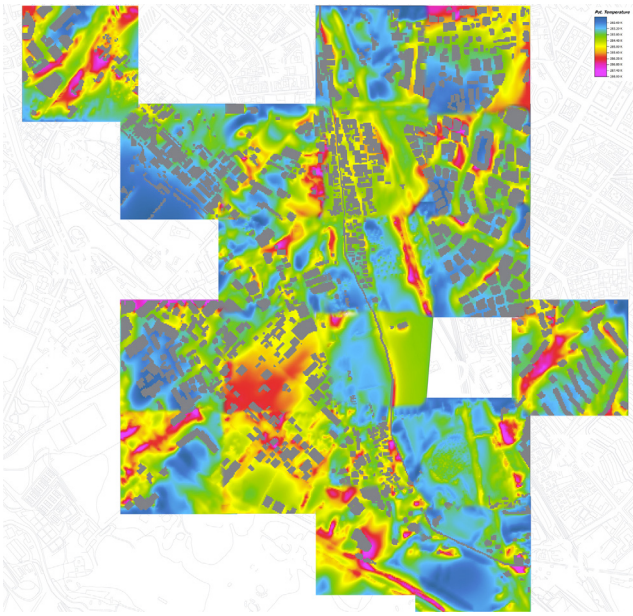
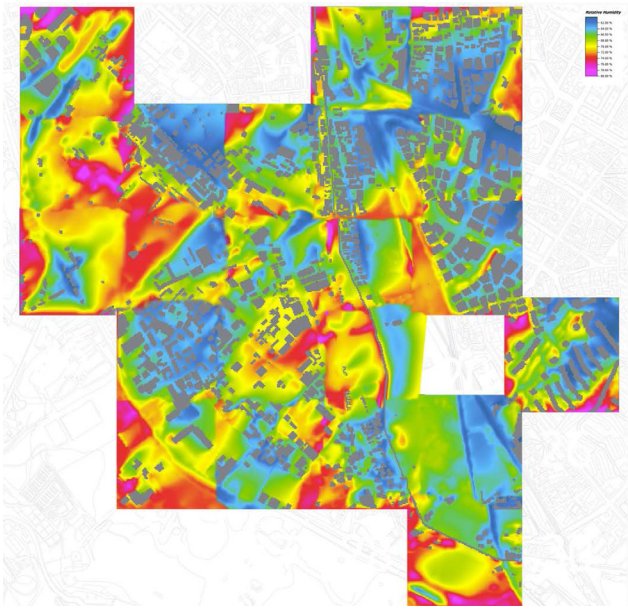
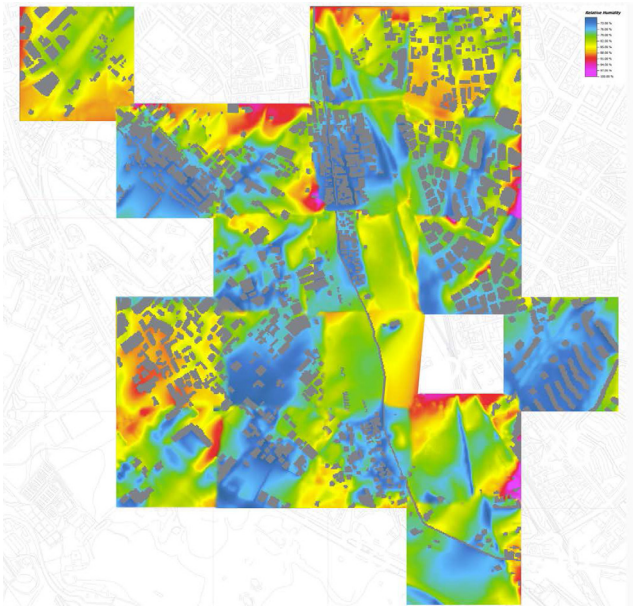
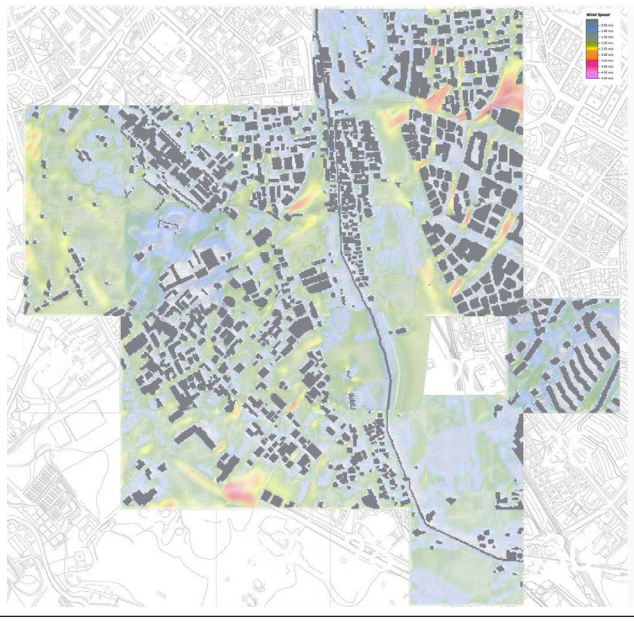
Objectives: achievement of the principle of hydrological invariance of urban fabric transformation and mitigation of urban stream syndrome.
Strategies: protection of the drainage basin through specific management of first rainfall water and redirection of rainfall into the ground through an increased number of permeable surfaces and rain gardens; in new buildings introduction of grey and black waste-water management using constructed wetlands for herbal purification; rational use of water to reduce drinkable water consumption by encouraging the use of storm water collection systems for irrigation of green areas.

Energy and Light

Objectives: reduction of energy consumption and production of energy from renewable sources; integration of production processes to meet the energy demands of the residential sector.
Strategies: reduction of energy consumption in buildings by optimizing the summer passive behaviour of the urban microclimate; use of natural ventilation strategies to redesign the flow of summer prevailing winds and strengthen their intensity; installation of photovoltaic panels on public surfaces; use of the waste energy from the productive sector to meet the energy requirements of the residential sector; use of low consumption artificial urban lighting.

Infrastructures

Objectives: rationalization of private vehicular traffic flows and strengthening of sustainable mobility.

	SUMMER	WINTER
Temperature		
Relative humidity		
Prevailing wind		

Strategies: reorganization of the road network in accordance with the demolitions to be carried out on the ancient path of Via Latina; reduction of private car traffic using traffic calming areas; increase of connections with the underground station through neighbourhood electric shuttle; creation of exchange nodes to access the regional and archaeological parks; strengthening of public links with the city's public transport network within these nodes.

Functions And Uses

Objectives: reorganization of the urban fabric based on the ancient Via Latina road and aqueducts; reconnection of *Tor Fiscale* with the route of the *Via Latina* in the archaeological park; creation of a network of spaces and public services based on the route of the *Via Latina*, with demolition and relocation of the unauthorized buildings.

Strategies: demolition of unauthorized buildings constructed on the ancient route of *Via Latina* and injection of primary functions in the district; creation of a hierarchical network between the functional nodes/green nodes, archaeological park and public transport, enhancing the "green island" character that is already present, albeit latent, in the current configuration of the district.

Conclusions

The introduction of the environmental subsystem analyzed in its biophysical and bioclimatic factors, introduced in a didactic experience with students coming to be professionals has led to an enrichment of their specific skills, also determined by learning a software capable of simulating the energy and microclimatic behaviour of the city.

In terms of direct consequences on the breakdown of teaching hours, the addition of the above-mentioned content produced the following changes:

- removal of 15% of the original course hours reserved to lectures, in favour of specific lectures, which resulted in the need to of synthesize aspects of the original lecture series;
- removal of 20% of the course hours originally reserved to consultations on projects, in favour of specific consultations on simulations and interactive lectures in which the class is asked to comment on the results of the simulations;
- introduction of a specific figure among the teaching assistants, with the role of coordinator of the simulation aspects for the entire course and the specific task of supervising the work of individual students;

For the students this entry led to:

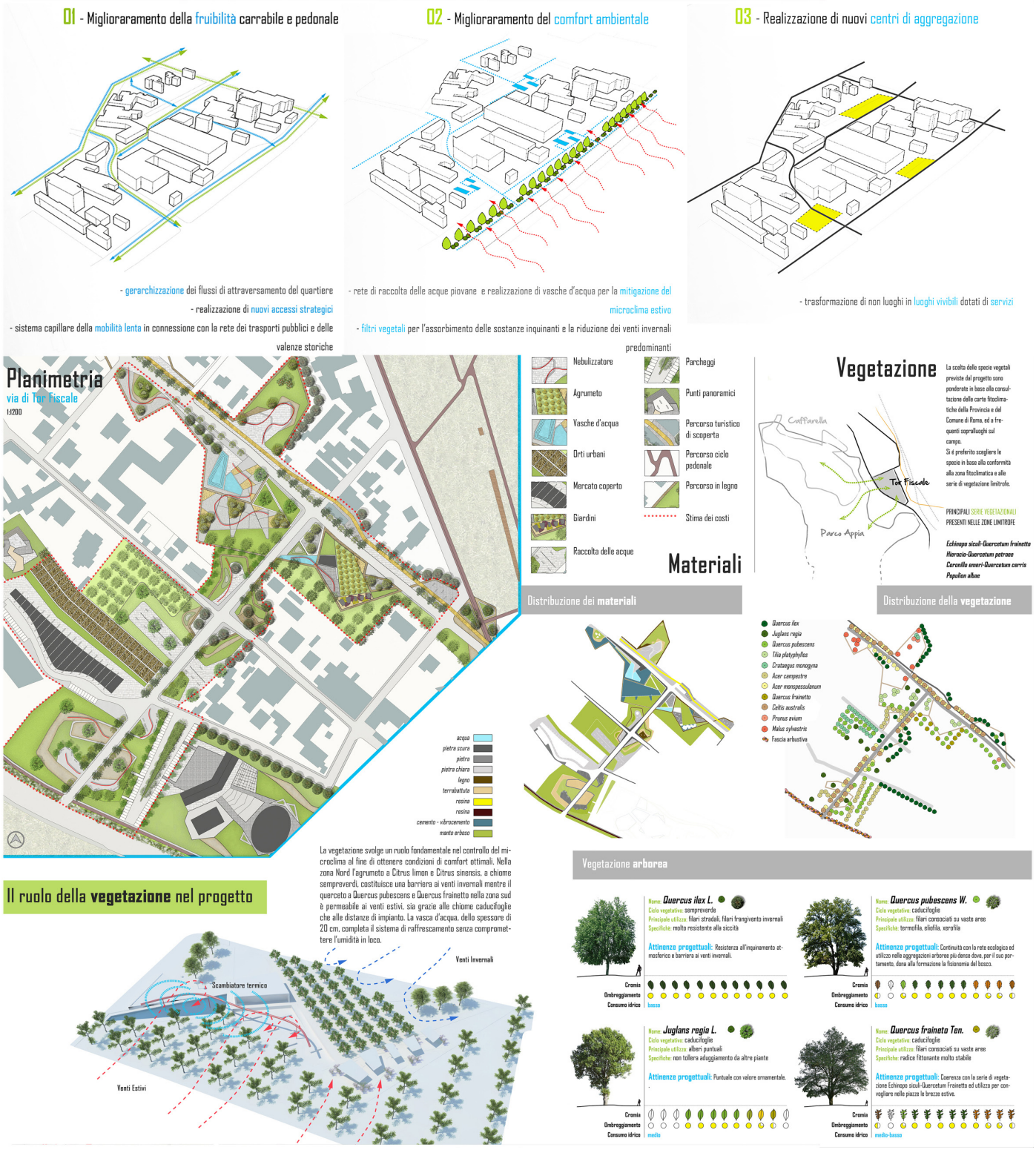
- the improvement of the environmental sensitivity that is no longer based on manuals and theoretical knowledge but on the actual possibility of testing in reality (albeit virtual) their project proposals;
- the ability to quantify the improvements in terms of microclimate conditions with *post-operam* simulations compared with *ante-operam* simulations, a factor that sparked in some working groups a positive competitive spirit in the pursuit of the better bioclimatic design of the area with a great improvement in the final works.

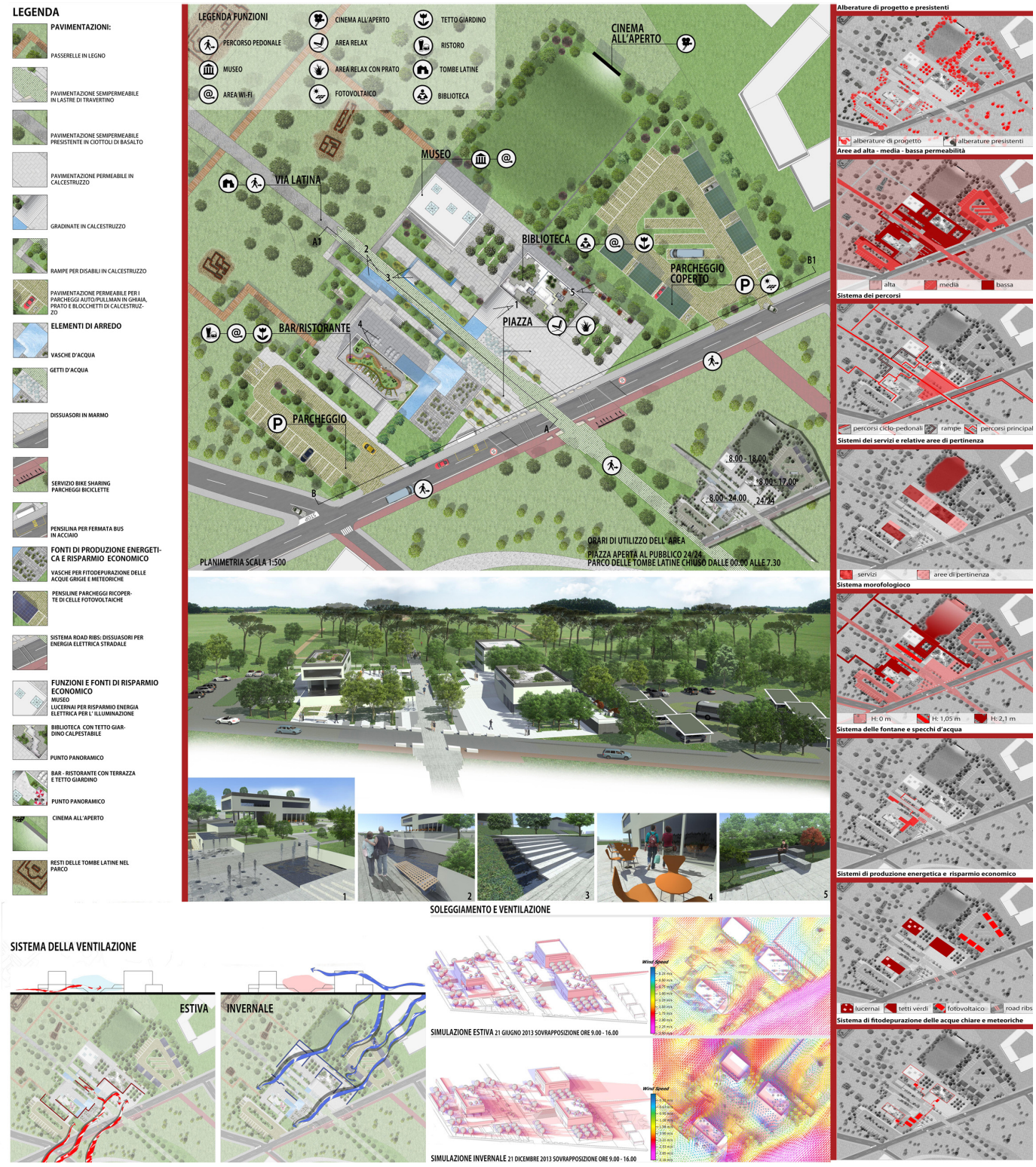
Overall, this type of educational organization, despite an increased use of human resources and the need for greater coordination of teachers, has produced a very positive response in students: there was an increased participation compared to the traditional course in the development of the design theme and in the production of final works for the exam, which reached high standards despite despite the vastness of implicated design factors.

Design Results

The three following images represent some of the results of the didactic process.

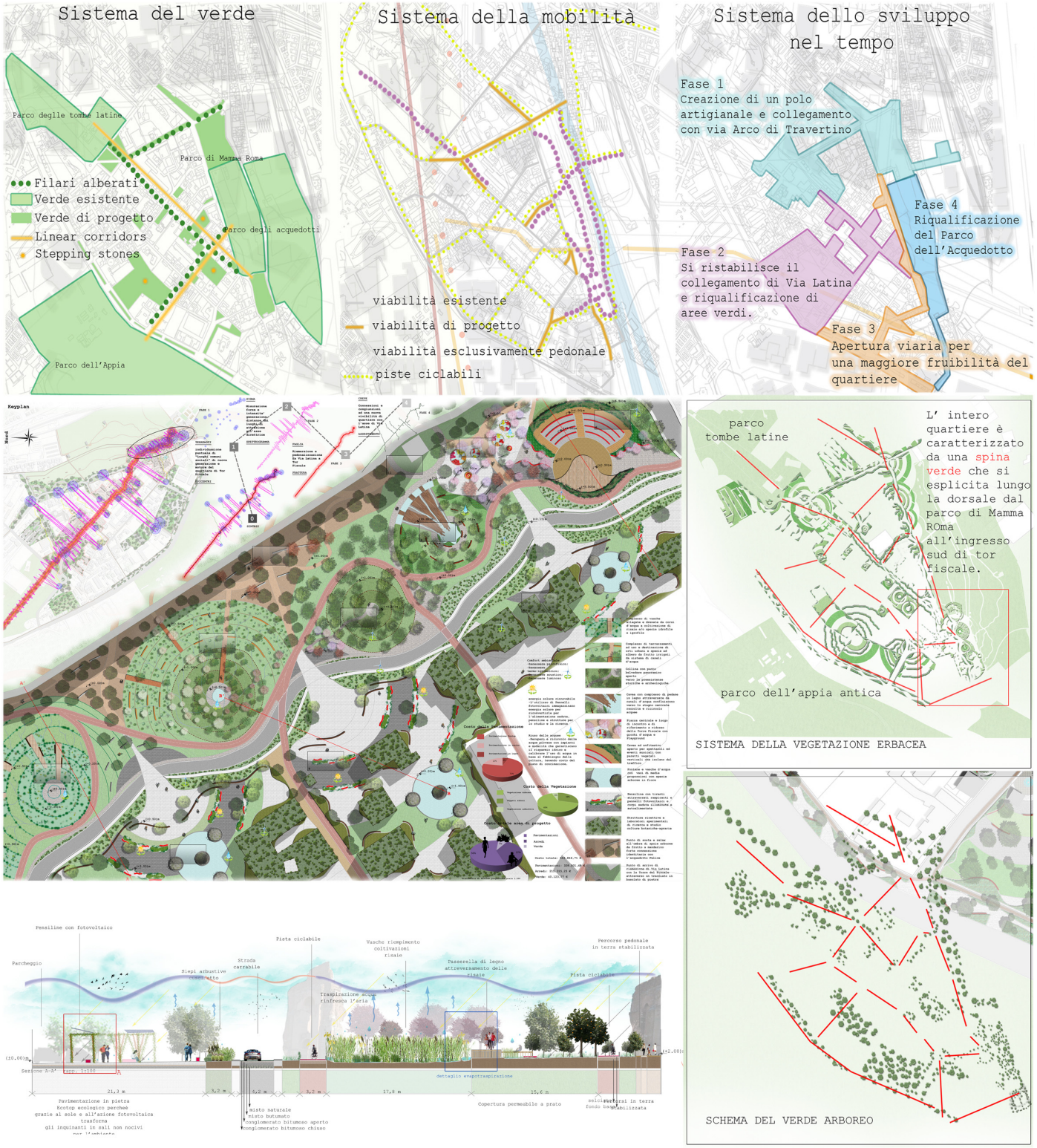
1. Entrance to the district and its relationship with via *Appia Nuova* (Di Cosimo and Conti, 2014).
In this design approach the theme of the entrance to the neighbourhood and the filter space between the road *Appia Nuova* and the urban fabric is solved through native vegetation design, which combined with an appropriate selection of materials based on urban albedo and inclusion of water surfaces, improves urban outdoor comfort in summer while shielding at the same time the urban fabric from the winter prevailing winds.





2. Relationship between the archaeological park of *Tombe di Via Latina* and the ancient underground route of the *Via Latina* (Danielli and Iacomini, 2014).

This design approach addresses the, currently non-existent, relationship, between the archaeological park of *Tombe di via Latina* and the ancient route of the *Via Latina* with a series of demolitions along the axis and the creation of a service area to the park that is also open to the rest of the neighbourhood. The diagrams on the right represent a schematic overview of the issues involved: pre-existing vegetation, permeability of the areas, the path system, system services, and related areas of relevance, morphological system, the system of fountains and ponds, systems for the production of energy from renewable sources and energy saving, system of constructed wetland, gray water and rainwater, along with a schematic time line of the intended use of the area. Sun path and microclimate simulations of the area contribute to the verification and tuning of the design process.



3. Reconnection of the green system with *Torre del Fiscale* (Giannetti et al. 2014).

The plan, that is supported by conceptual schemes, describes a design approach based on reconnection of the two green edges that surround the area, through a series of green punctual injections, linked by the thread of the ecological network and enriched by the pre-existing archaeological architecture, to return *Torre del Fiscale* to its role as landscape landmark, as the Southeast entrance to the city of Rome.

References

Research work and experimentation of the results on didactic experience: *Bioclimatic simulation, environmental based urban design and architectural redevelopment in the Mediterranean area: urban redevelopment of Tor Fiscale district in Rome*, 2013-2014. Research group: Prof. Arch. Fabrizio Tucci (Principal Investigator and coordinator), Arch. PhD student Filippo Calcerano, Arch. PhD Carlotta Cecchini, Arch. PhD student Mary Fiorentino, Land Arch. PhD. Student Filippo Iacomini, Arch. PhD student Rosanna Morleo, Land Arch. Francesca Romano, Dr. Marco Gaudioso, Dr. Luca Porretta, Dr. Cinzia Salvatori.

Akbari, H, M Pomerantz, and H Taha. 2001. "Cool Surfaces and Shade Trees to Reduce Energy Use and Improve Air Quality in Urban Areas." *Solar Energy* 70 (3). Urban Environment: 295–310. doi:10.1016/S0038-092X(00)00089-X.

Ardente, Fulvio, Marco Beccali, Maurizio Cellura, and Marina Mistretta. 2011. "Energy and Environmental Benefits in Public Buildings as a Result of Retrofit Actions." *Renewable and Sustainable Energy Reviews* 15 (1): 460–70. doi:10.1016/j.rser.2010.09.022.

Brown, Lester R. 2001. *Eco-Economy*. 1st edition. New York: W. W. Norton & Company.

Bruse, Michael. 2010. *Envi-Met* (version 3.1). University of Mainz.

Calcerano, Filippo, and Carlotta Cecchini. 2014. "Mediterrean Building Refurbishment: Thermal Mass and Natural Ventilation Simulated Control." *Proceedings of 5th German-Austrian IBPSA Conference BAUSIM 2014 "Human Centered Buildings" 22-24 September 2014*, 8.

De la Flor, Francisco Sánchez, and Servando Alvarez Domínguez. 2004. "Modelling Microclimate in Urban Environments and Assessing Its Influence on the Performance of Surrounding Buildings." *Energy and Buildings* 36 (5). EPIC-3rd European Conference on Energy Performance and Indoor Climate in Buildings: 403–13. doi:10.1016/j.enbuild.2004.01.050.

De Wilde, P. J., G. Augenbroe, and A. Malkawi. 2014. "A Workbench for Structured Design Analysis Dialogues."

European Commission. 2010. "POLIS, Solar Urban Planning - Manual of Best Practices, Intelligent Energy Performance."

Gartland, Lisa. 2008. *Heat Islands: Understanding and Mitigating Heat in Urban Areas*. Earthscan.

Grewal, Parbir S., and Parwinder S. Grewal. 2013. "Can Cities Become Self-Reliant in Energy? A Technological Scenario Analysis for Cleveland, Ohio." *Cities* 31 (April): 404–11. doi:10.1016/j.cities.2012.05.015.

Grimm, Nancy B., Stanley H. Faeth, Nancy E. Golubiewski, Charles L. Redman, Jianguo Wu, Xuemei Bai, and John M. Briggs. 2008. "Global Change and the Ecology of Cities." *Science* 319 (5864): 756–60. doi:10.1126/science.1150195.

Hensen, J.L.M. 2004. "Towards More Effective Use of Building Performance Simulation in Design." *In Leeuwen, J.P. van & Timmermans, H.J.P. (Eds.). Proceedings of the 7th International Conference on Design & Decision Support Systems in Architecture and Urban Planning, 2-5 July. Eindhoven: Eindhoven University of Technology.*

Lechner, Norbert. 2009. *Heating, Cooling, Lighting: Sustainable Design Methods for Architects*. Hoboken, N.J.: John Wiley & Sons.

Morbitzer, C. 2003. "Towards the Integration of Simulation in the Building Design Process". Strathclyde: PHD thesis, Energy System Research Unit, University of Strathcylde.

Reiser, Claudius, Ruth David, Markus Faigl, and Oliver Baumann. 2008. "Accounting for Primay Energy New Code Requires Dynamic Simulation." *Proceedings of Building Simulation 2008: 3rd Conference of International Building Performance Simulation Association, Berkley, California, July 30, August 1*.

RUROS. 2004. *Progettare Gli Spazi Aperti Nell'ambiente Urbano: Un Approccio Bioclimatico*. C.R.E.S.

Shuman, Michael. 2000. *Going Local: Creating Self-Reliant Communities in a Global Age*. 1 edition. New York: Routledge.

Tucci, Fabrizio (2007). Progettazione architettonica, la sfida del risparmio energetico. In Il Sole 24 Ore - Edilizia e Territorio - Commenti e Norme, n. 10, 12-17 marzo 2007.

Tucci, Fabrizio (2010). Technologies for natural cooling in the experimentation of eco efficient housing in the Mediterranean.

In: Santamouris M. (Ed.), Cooling the cities: the absolute Priority. Passive & low Energy Cooling for the Built Environment. Conference proceedings. 3rd International Conference Palenc. 29 sept.-1 oct. 2010 Greece. Heliotrop Edition, Grecia.

Tucci, Fabrizio (2011). Efficienza ecologica ed energetica in Architettura. / Environmental and Energy Efficiency in Architecture. Firenze: Alinea Editrice.

Tucci, Fabrizio (2012). Atlante dei Sistemi tecnologici per l'Architettura bioclimatica. Ventilazione naturale negli Edifici / Atlas of technological Systems for bioclimatic Architecture. Natural Building Ventilation. Firenze: Alinea Editrice.

Tucci, Fabrizio, and Filippo Calcerano. 2013. "Tecnologie Sostenibili in Convegno a Roma. Emergenza Energetica E Dissesti Climatici: Le Sfide Del Progetto Contemporaneo." *Modulo* 385: 514–16.

Tucci, Fabrizio, and Filippo Calcerano. 2013. "Environmental and Bioclimatic Urban Redevelopment: Case Study of the Ancient Mura Latine Area in Rome." *World Academy of Science Engineering and Technology Issue 79 July 2013 Oslo*, 1581–88.

UN. 2012. "United Nations, Department of Economic and Social Affairs, Population Division: World Urbanization Prospects, the 2011 Revision." New York.

Walsh, Christopher J., Allison H. Roy, Jack W. Feminella, Peter D. Cottingham, Peter M. Groffman, and Raymond P. Morgan. 2005. "The Urban Stream Syndrome: Current Knowledge and the Search for a Cure." *Journal of the North American Benthological Society* 24 (3): 706. doi:10.1899/0887-3593(2005)024\[0706:TUSSCK\]2.0.CO;2.

Willuweit, Lars, and John J. O'Sullivan. 2013. "A Decision Support Tool for Sustainable Planning of Urban Water Systems: Presenting the Dynamic Urban Water Simulation Model." *Water Research* 47 (20). Urban Water Management to Increase Sustainability of Cities: 7206–20. doi:10.1016/j.watres.2013.09.060.

Yang, Xiaoshan, Lihua Zhao, Michael Bruse, and Qinglin Meng. 2012. "An Integrated Simulation Method for Building Energy Performance Assessment in Urban Environments." *Energy and Buildings* 54 (November): 243–51. doi:10.1016/j.enbuild.2012.07.042.

Design result and graphic contribution of: [1] Di Cosimo, F., and Conti, R.; [2] Danielli, F., Iacomini, G.; [3] Giannetti, E., Di Curzio, M., Attardi, G., *Environmental Design Laboratory* on the theme: "Environmental and bioclimatic simulation based urban redevelopment of Tor Fiscale district in Rome", Sapienza University of Rome, 2014.

Building Technologies

Parametric planning for the restoration and rehabilitation of architectural heritage

Saverio D'Auria
Department of Civil Engineering, University of Salerno, Via Giovanni Paolo II, Fisciano (Salerno), Italy – sdauria@unisa.it

Emanuela De Feo
Department of Architecture and Industrial Design, Second University of Naples, Via San Lorenzo, Aversa (Caserta), Italy
emanuela.defeo@unina2.it

Giacomo Di Ruocco
Department of Civil Engineering, University of Salerno, Via Giovanni Paolo II, Fisciano (Salerno), Italy – gdiruocco@unisa.it

Keywords: BIM Surveying, laser-scanning, cost-benefit analysis, parametric modeling, cultural heritage

Abstract

Over the last decade, economic, financial and social issues have undermined the construction industry, leading to a worldwide crisis. Restoration and energetic rehabilitation have become increasingly more common within the construction industry. Notwithstanding the fact that it has a significant architectural heritage, Italy has proven not to be ready to face demanding projects regarding the rehabilitation of historical buildings. Therefore, numerous construction companies have missed out an important source of income and have left EU Structural and Investment Funds untouched. The reasons for these Italian problems include: the lack of long term programming; shortage of quality control systems as well as the lack of team work.

The aim of this paper is to show that the use of BIM – Building Information Modeling – can solve many of the aforementioned problems connected to rehabilitation projects. In fact, the efficiency and benefits of this kind of approach towards the analysis, management and planning of rehabilitation projects have proven to be significant. In order to prove the efficiency of the BIM, a study was carried out to compare the cost-benefits of both a standard as well as a BIM survey when surveying a historical building. With the aim of this research in mind, the team decided to survey the castle of Francolise, in the province of Caserta.

The aim of this article is not to show how BIM surveys work, but rather the actual efficiency of the BIM survey when used to survey historical buildings. Before starting the analysis, it is important to underline that protocols – which could define the usage of the BIM for existing buildings – have yet to be created.

Foreword

The European Union has promulgated a public procurement directive, expressly requiring the modernization of public contract regulations. The document, asks the 28 Member States of the European Union to use BIM for public contracts and design contests founded by the EU: *"...for work contracts and design contests, Member States may require the use of specific electronic tools such as of building information electronic modeling tools or similar..."*.

If on the one hand, many countries around the world (such as Finland, UK, Germany, Korea, Japan, etc.)use BIM as a standard surveying tool, with it having now become a keyword in the construction business, along with the words *Mobile, Field and Lean;* on the other, regulations for the use of BIM have yet to be issued in Italy. The lack of any form of BIM regulations has not affected Italian businesses, due to the fact that BIM surveying is not as widely used as standard surveying. However, in order to allow Italian companies to operate in the rest of Europe and extra-European territories, issuing regulations is a necessary step.

The role of BIM in architectural rehabilitation

Architectural rehabilitation aims to rehabilitate an existing building while keeping its intrinsic and extrinsic properties intact[1].

Although they are subject to the norms UNI 10838-10914/1-11150 (1-2-3-4) and 11151, rehabilitation processes require a revision of the technical instruments and regulations. In order to do so, every different case requires an analysis in order to rehabilitate the building taking into account its unique features. Moreover, rehabilitation projects also require a careful management, planning and programming.

A rehabilitation project in addition to respecting issued norms, also aims to preserve the characterizing features of the building. Over recent years, software such as BIM have helped construction companies to reduce the duration of projects, while also saving both time and work.

Building Information Modeling allows users to: firstly shape, inspect and check the parameters of a certain 3D model which matches the real life building; secondly, carry out a structural analysis, produce accurate data and drastically reduce planning issues; finally, reduce the risks connected to unforeseeable factors by simplifying any managing procedures.

1. De Joanna P., *Il recupero edilizio nelle aree protette. Norme e strumenti di programmazione, progettazione ed esecuzione*, Franco Angeli Editore, Milano 2010.

Introduction to BIM for integrated planning

Nowadays building processes are fragmentary and based on paper documentation, which contains all the project information (technical, contractual and administrative). Due to the use of paper documents, mistakes, omissions and miscommunications are still quite common and can lead to problems in the client-supplier relationship such as: delays, unplanned costs, lawsuits.
Building Information Modeling is a solution to many of these problems. Firstly, it does not require paper made documentation; secondly it allows to generate, modify and manage digitally the 3D model of a certain building; finally, it carries out a unique, implementable, up to date 3D model, which can eventually help prevent data loss, misunderstanding and redundancy.
This result can be achieved by creating shared BIM, a digital representation of the physical and functional characteristics of a real building[2].The3D model is made up of three-dimensional objects such as doors, walls, windows, stairs, roofs; the building's mechanical, physical and logistical features; elements within the building are connected by associative rules.
Parametric integrated planning is widely used for projects relating to new constructions, but its use for existing buildings is difficult and still being studied. If on the one hand, the use of BIM is helpful in new projects which deal with modern factories and contemporary building complexes because of their standardized features, on the other, the unique technological, geometrical and physical characteristics of pre-existing building's make the use of BIM more difficult. This obstacle can be overcome by using integrated and parametrical planning along with laser-scanner data. It is therefore possible to create a three-dimensional point cloud. The point cloud can be then modified and updated and the elements which do not match the modern standardized components within the BIM library can be added.

Parametrical planning for architectural heritage: BIM surveying

To validate the hypothesis, the team objective was to show the benefits and advantages of using BIM software. In order to do so, the Castle of Francolise was chosen as a case study, and the study group decided to carry out a cost-benefit analysis between the two different kinds of survey: the direct and the BIM survey. Some variables were analyzed using the two methods in order to compare them and define which method would prove to be more convenient in terms of costs, quality and precision.
However, this paper does not focus on surveying operations, which have been considered irrelevant elements.

The medieval castle of Francolise

The castle of Francolise is a medieval building in the city of Francolise, Caserta, southern Italy (Figure 1) and was built during the second half of the XIII century.
It is made up of four floors connected by two stairs, with a total surface of 1450 square meters. Although the second floor preserves the original materials, laminar wood has been applied for safety reasons to the other three.

The direct survey

Thedirectsurveywasconductedusingstandardinstrumentation: tape measures, spirit levels and plumb bombs. The angles and edges were matched with measure points, which resulted in many triangular shaped schemes. Furthermore, the vertexes – which were not possible to define during the measurements – were found with a trilateration process.
This survey was completed in four days deploying two different work teams: one made up of three people who measured the inner walls; whereas the other, made up of two people, measured the outer walls. 48 sketches were produced.
The data collected was digitalized using AutoCAD. One team member was able to draw four sections and four facades taking into account technical drawing standards. This phase was finished in eight working days (Figure 3).

The BIM Survey

The BIM survey is quite different from the direct one. An important difference is the way the team members operate in a 3D space: not only did they use horizontal reference points, but they also took sloping position measurements. The points found were then put into a x, y, z coordinate system.
The BIM survey gave different results compared to the standard one, notably regarding the speed, which was extremely higher than the traditional survey. When surveying the inner area, the work team used a "Faro Focus 3D" laser scanner, which took 84 pictures per scan, with a resolution of 2Mpx, thanks to a CCD sensor. The laser has a 120 meter range, 122.000 points per second speed, and finally an

2. Osello, A. *Il futuro del disegno con il BIM per ingegneri e architetti*, Dario Flaccovio Editore, Palermo, 2012, p. 35.

Figure 1 – The main facade of the castle.

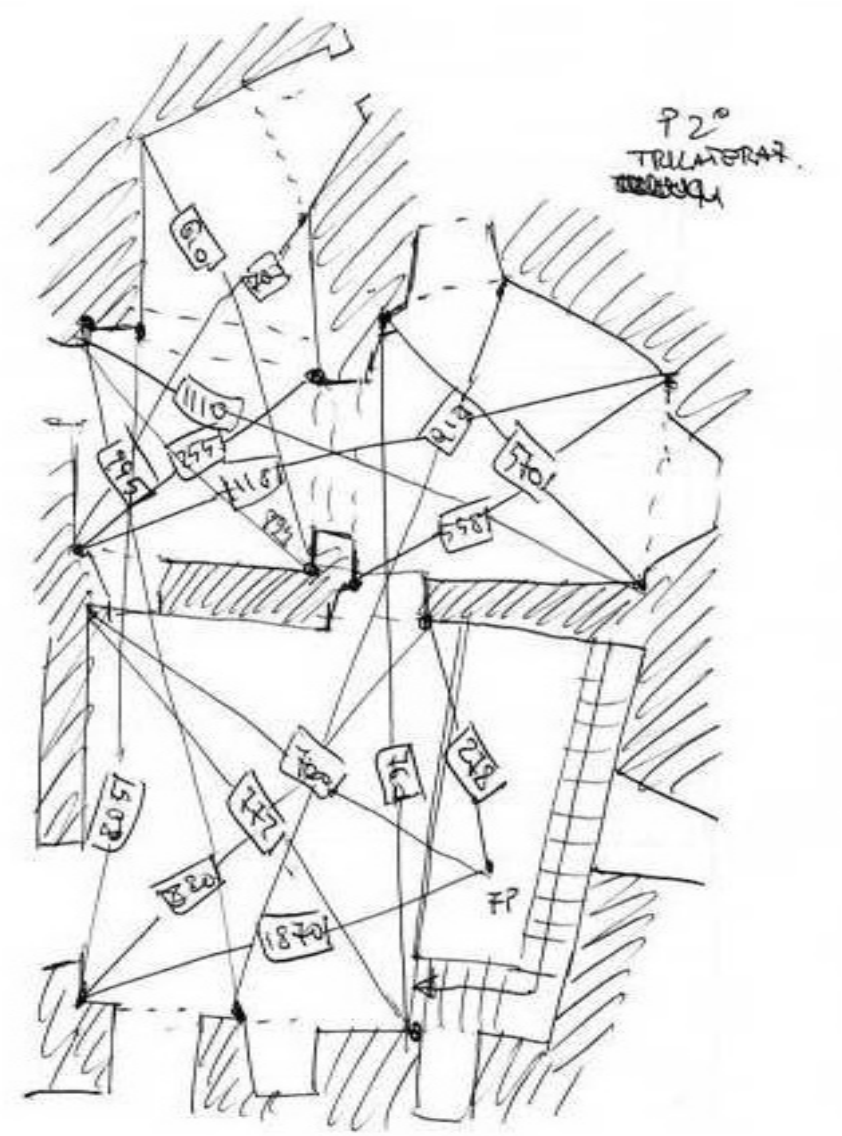


Figure 2 – One of the 48 sketches produced.

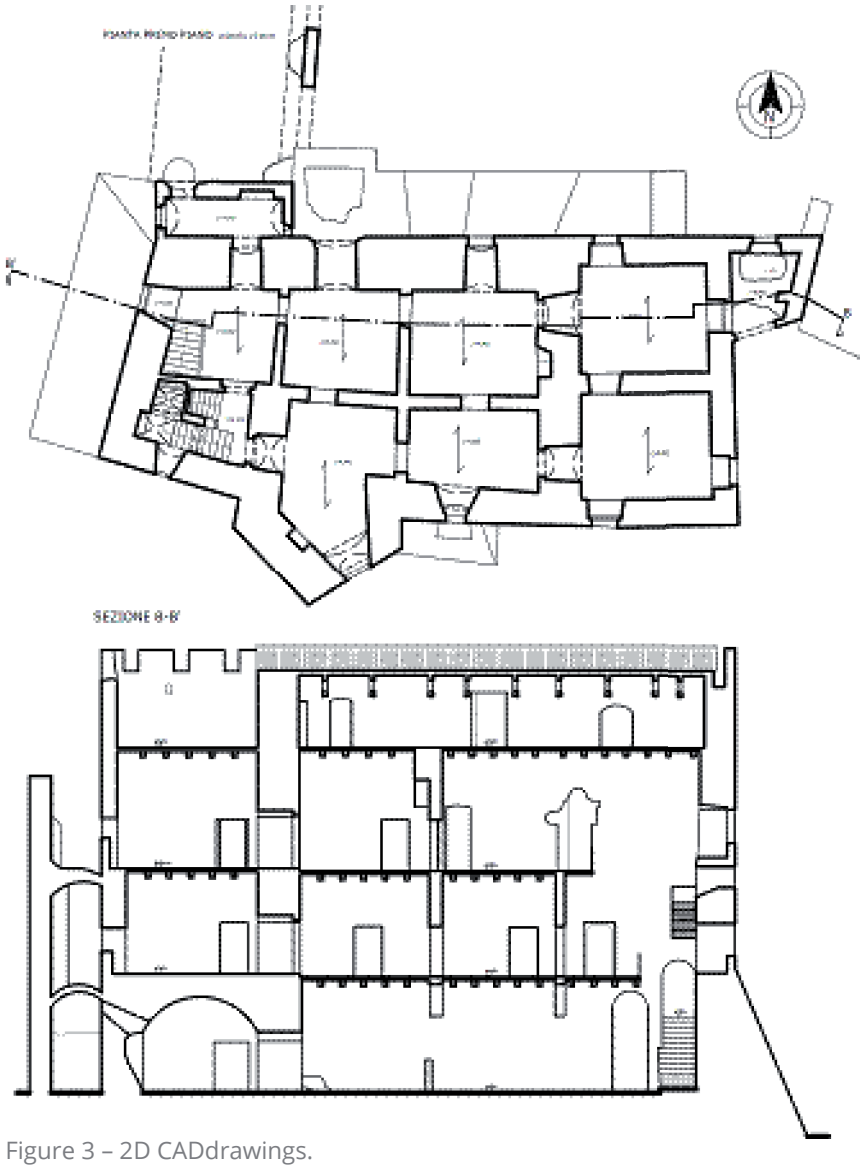


Figure 3 – 2D CADdrawings.

average error of 2 millimeters for 25 meters.
Due to the proximity of the objects to the laser, the resolution was set to 1/16; 4xqualityfor the inner spaces; scan duration: 2 minutes and 23 seconds; whereas for the outer spaces, the resolution was set to 1/8; quality 4x; scan duration 3 minutes and 44 seconds. (Table 1) A total of 36 scans - 29 for the inner spaces and 7 for the outer spaces (Figure 4) - was made by one team member in one working day.

The following phase was the most laborious and demanding. By using the homologous points present in the common areas, the scans taken were aligned to one another using the Faro Scene 5.1 software. This process was heavily simplified using software recognized targets. Furthermore, in order to prevent the hardware from overworking, the point cloud was decimated by deleting any unnecessary information. This task was completed in one working day by one team member.

Table 1 – Laser-scanner settings.

	Outer spaces	**Inner spaces**
Resolution	1/8	1/16
	1 pt. every 12 mm from 10 m	1 pt. every 24 mm from 10 m
Quality	4X	4X
Speed (pt./sec.)	122.000	122.000
Duration (sec.)	224	143
Number of scans	7	29

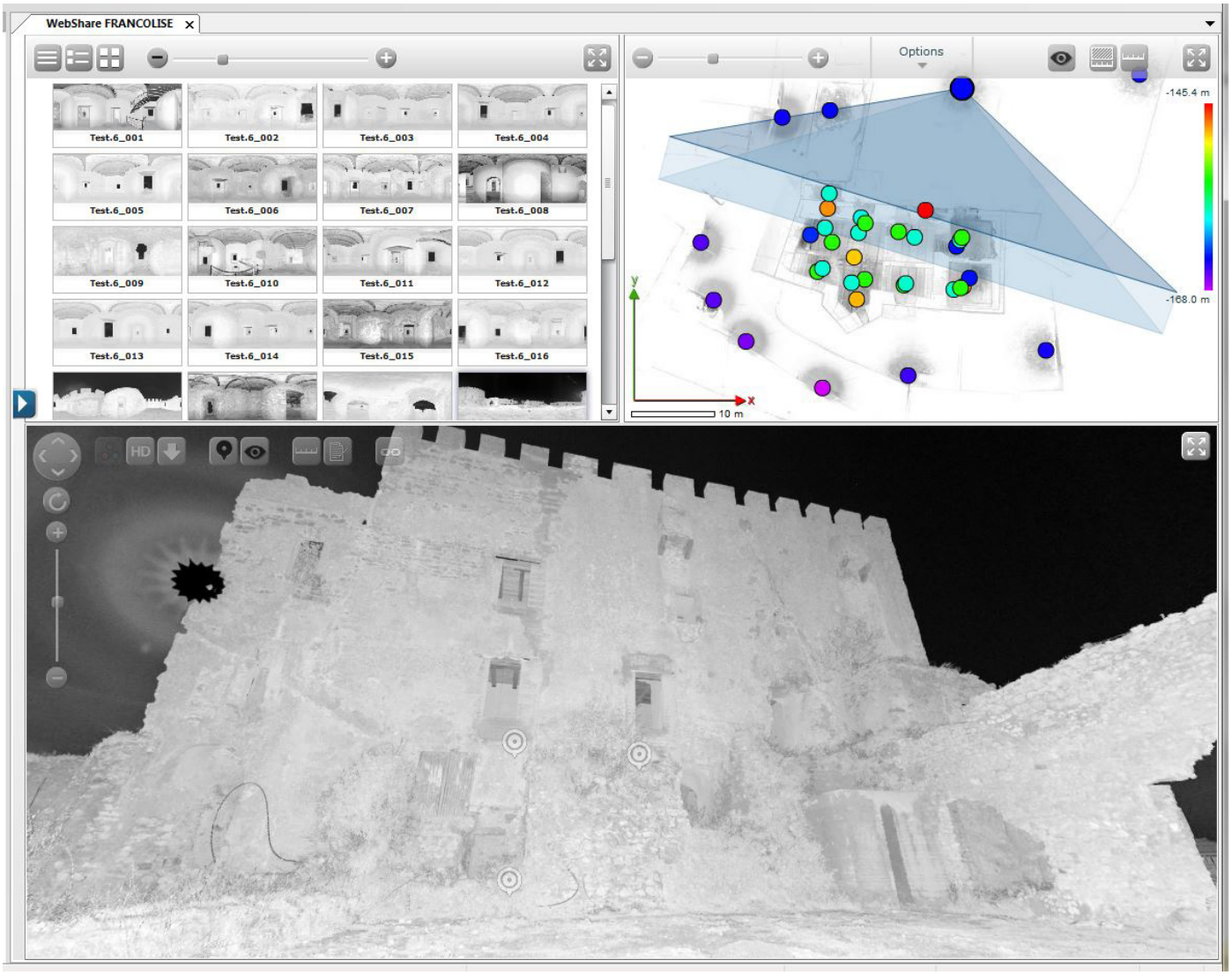


Figure 4 – Overview map with scan positions.

The point cloud model generated (Figure 6), along with representing the real building, is a database that eases the restoration plan. In fact, thanks to the IT model, users can both inspect and modify the different elements of the 3D building model, minimizing the chances of making mistakes. Furthermore, the model can also be metrically, geometrically and colorimetrically interrogated.

The BIM model of the castle was drawn with a parametrical modeling. It is not relevant to describe the data elaboration step by step. The software used for the model elaboration was Revit Architecture 2013. After setting the castle position coordinates, the point cloud was opened (Figure 7) and the levels defined (Figure 8).The graphical output properties and castle editable features (density, resistance, tensile strength) were then assigned.

If on the one hand, the objects found in the software library can be applied in the case of a new building modeling, on the other, in the case of pre-existing buildings such as the Castle of Francolise, the uniqueness of the elements of the castle did not permit the use of library objects. For example, the outer walls of the castle do not present the same shape in the different diagrams.

In order to make this issue irrelevant, after having taken the point cloud as a guide to the drawing, the outer walls were volumetrically modeled and the thermal and mechanical properties appointed (Figures 9 and 10).

Regarding floors, the process was more laborious because corresponding BIM elements were created to match the castle floors: for example, BIM models were created for plywood and concrete reinforced floors and the mechanical and energetic features were assigned to different components.

Editing the floors and modeling the castle was laborious. If on the one hand, in order to edit the floor, the team created BIM elements for each type of floor (plywood/concrete), assigning to each floor specific mechanical and energetic features; on the other, although allowing the team to set different parameters for the castle structure itself (such as thermal conductivity, porosity, etc.), due to the fact that the whole castle is made

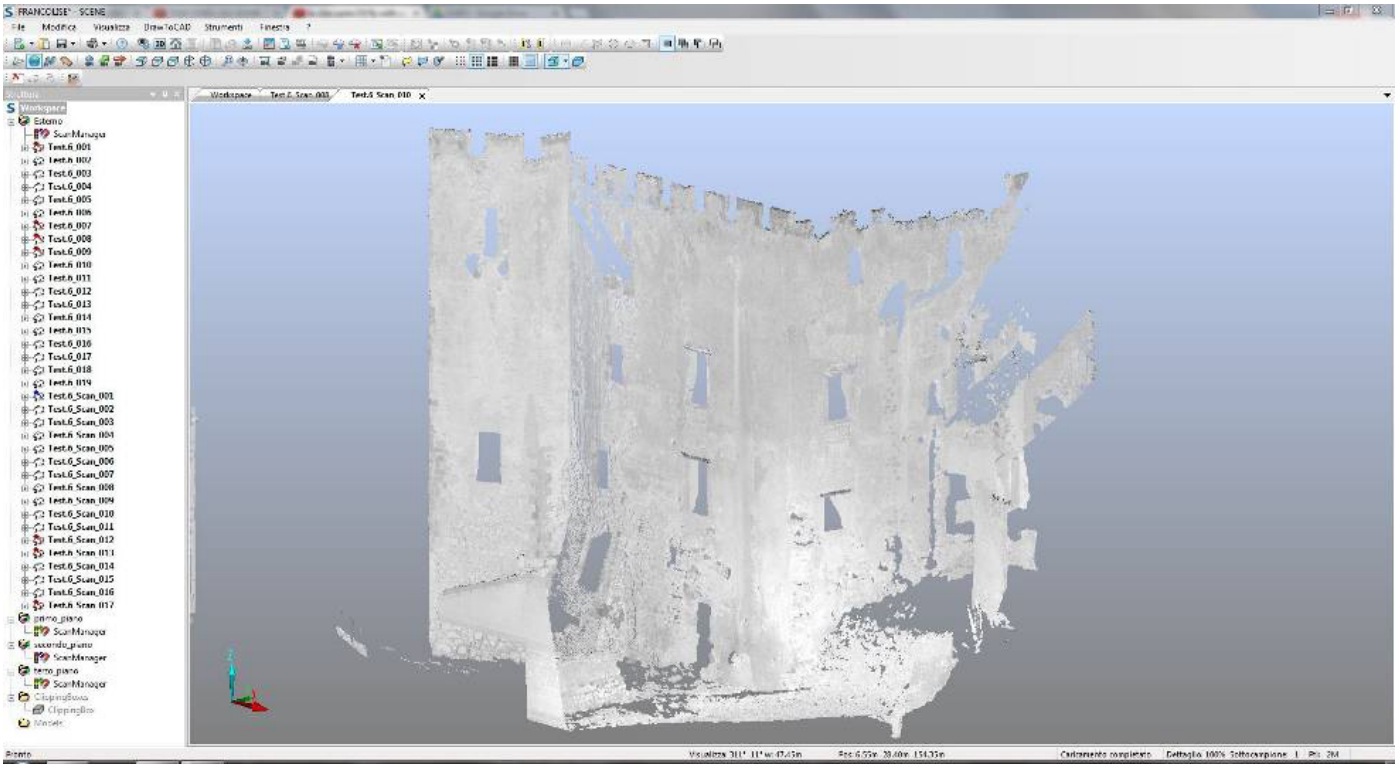


Figure 5 – One of the point clouds of the castle.

Figure 6 – The 3D model of Castle of Francolise.

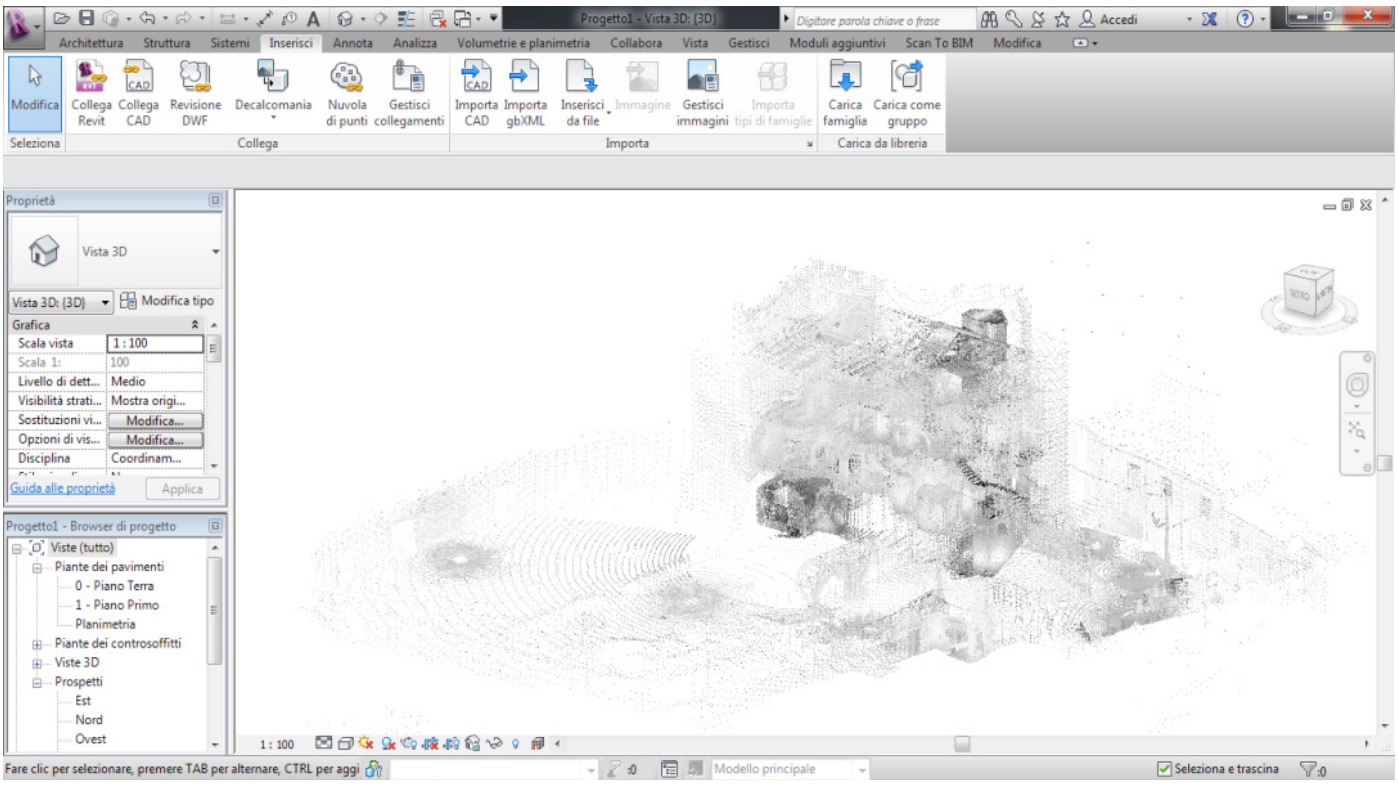


Figure 7 – The point cloud model used in Revit Architecture 2013.

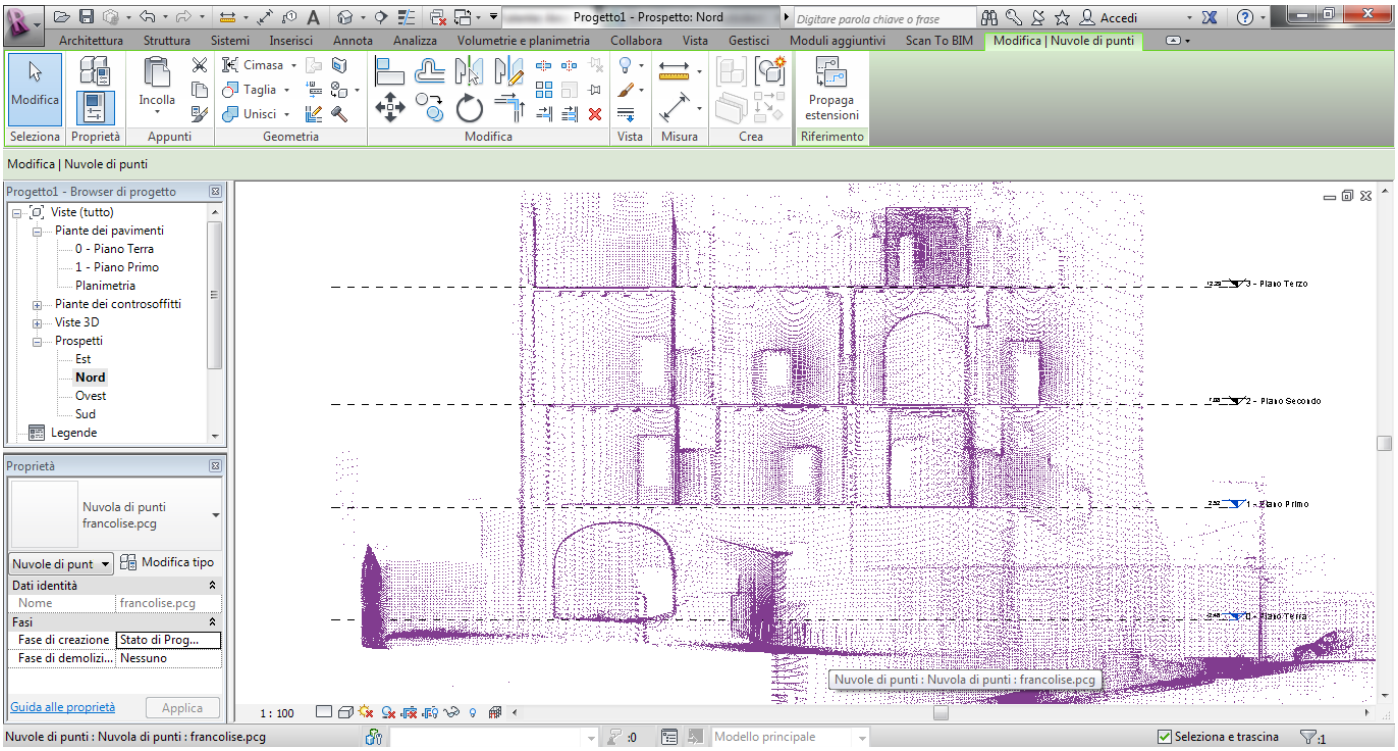


Figure 8 – Marking of the different levels on the point cloud.

up of load-bearing walls, the software only allowed to set the general limestone and tuff mechanical characteristics, the reason being that Revit was created for steel and reinforced concrete structures. Therefore, the BIM model could not be immediately analyzed. However, it was possible to transfer the 3D model into a calculation software that would prevent the user from creating another 3D model.

Overall, the castle of Francolise BIM model (Figure 11) was realized by one team member in six working days. The first observable benefit is the possibility to obtain a variety of 2D graphics in just a few seconds.

Furthermore, it was possible to automatically draw up tabs

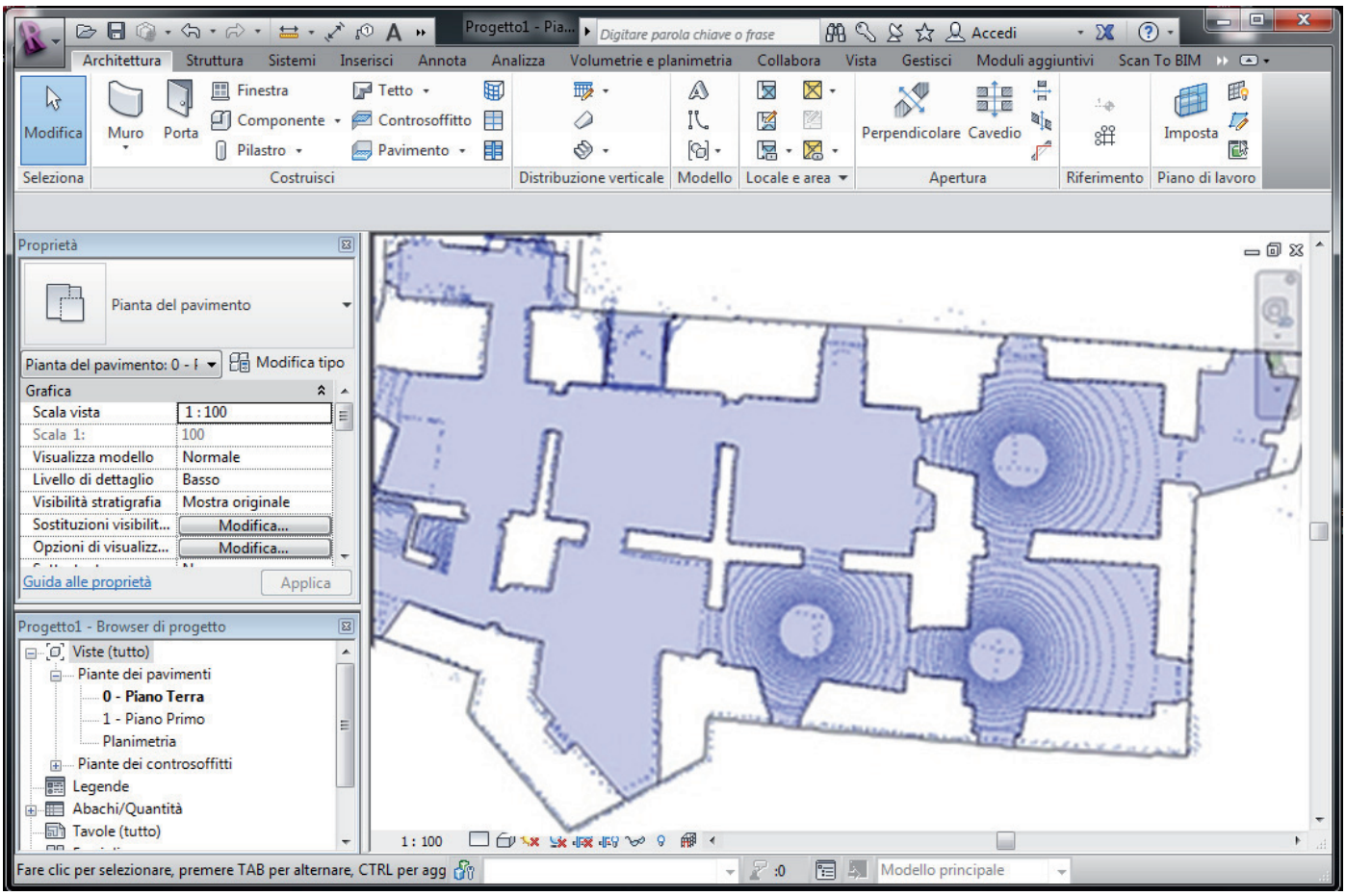


Figure 9 – Modeling of the walls.

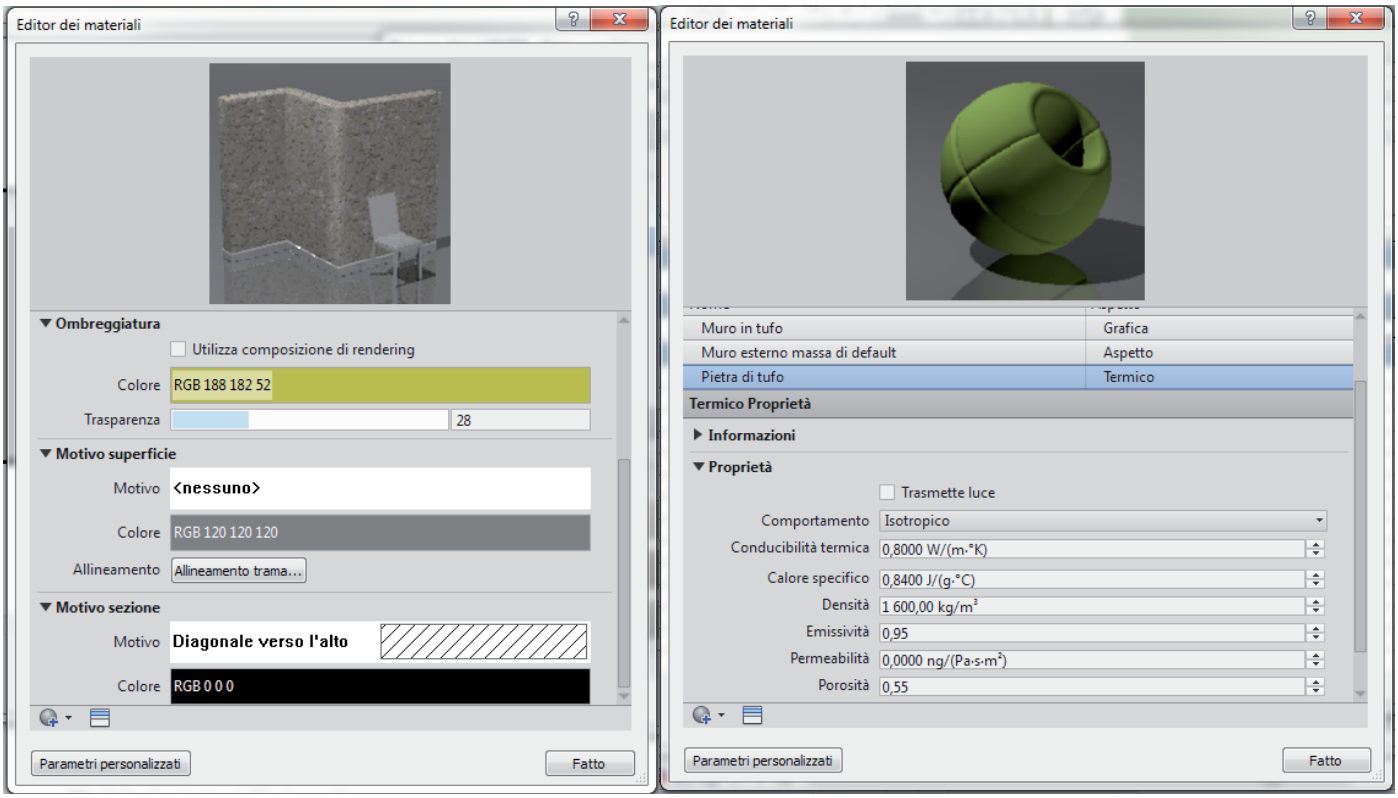


Figure 10 – Setting of the thermal and graphical features.

and charts concerning surfaces, quality of materials, exc. Moreover the model can be implemented and modified anytime, and can give different output, for example about the energy cost and its impact.

Analysis, comparison and results

The case described highlighted some interesting aspects. The data elaboration time between the BIM Surveying and the direct one is significant. A major role in this case was played by the "Focus Faro 3D". In fact, whereas the traditional survey required the employment of five team members who completed the job in four working days (20 men-days), the BIM laser-scanner survey was completed within just one day. The result is astonishing, with a man-day saving ratio of 95%.
The following metrical data elaboration produced different results concerning the quality and quantity of the information. If on the one hand, the traditional process due to a restrict number of 2D infographic models which were also subject to discretization, only allowed a limited number of drawings and sections to be created; on the other, the BIM surveying, after a preliminary processing phase gave a 3D model which is not comparable to the results that the 2D graphics produced: for example, the 3D models gives the user a faster analysis.
The direct survey final phase was finished in eight working days. It gave the team four diagrams, four sections, and four perspective drawings. Whereas the creation of point clouds using BIM surveying took one working day. The final result is significant also in this case: time reduced by 87% .
If on the one hand, the direct survey had now come to an end, the BIM Survey was still being carried on. The 3D point cloud helped create a BIM model which was completed within six working days. Differently from what happens with a standard survey, in this case it only took few steps for the team to get 2D graphs such as diagrams, sections and perspective drawings. Furthermore, tabs and charts relating to the main aspects of the building, such as surfaces, quality of materials, exc. were rapidly drawn when needed. Finally, the model was automatically implemented and modified, responding to every single change made, for instance about the energy cost and its impact.

Conclusions

The parametrical planning study carried out and the application of BIM surveying to architectural heritage have led to several observations. The castle of Francolise laser-scanner surveying and the following parametrical modeling, proved that the objective of this research paper – which is included in a series of studies concerning the energetic and technological requalification – is correct.
In fact, it is possible to apply the BIM methods to both architectural heritage as well as pre-existing buildings. Although requiring implementations and tests, the BIM

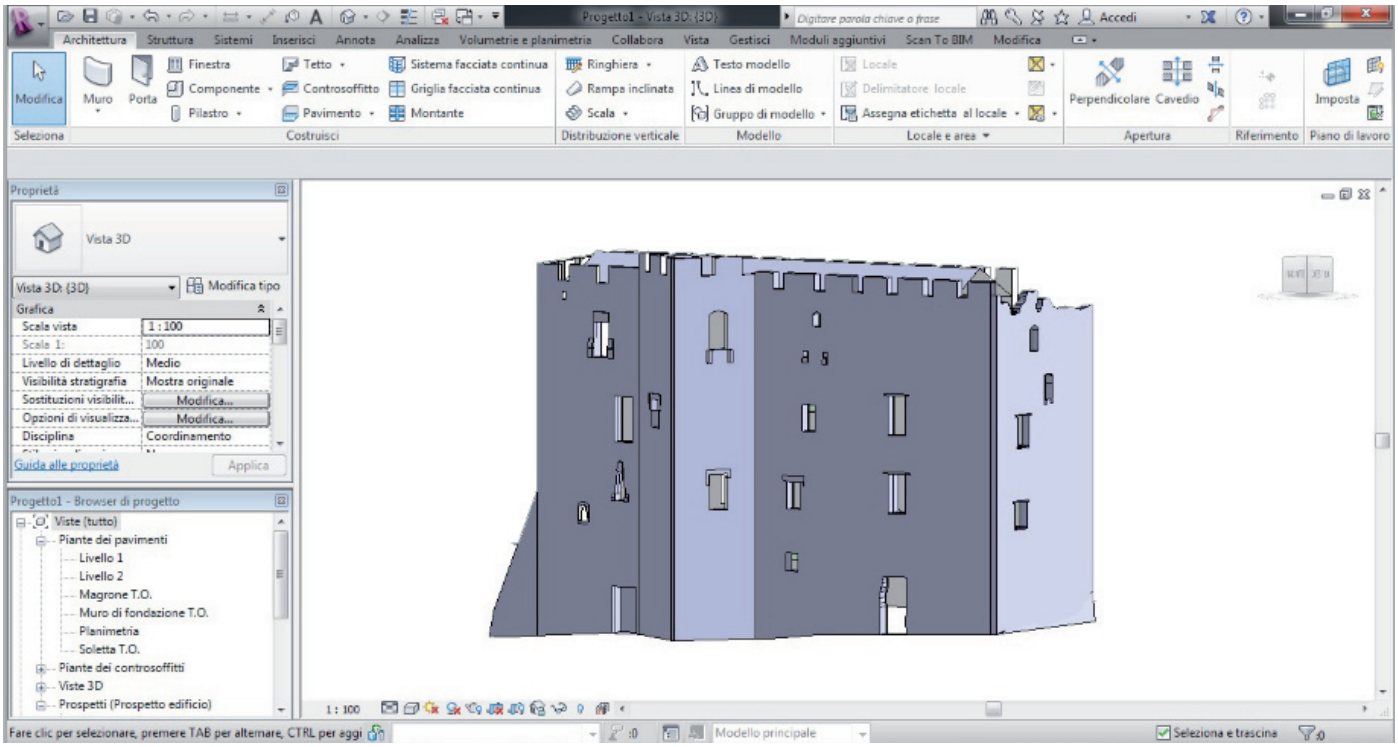


Figure 11 – The bim model of the Castle of Francolise...

method gives users an evident number of advantages both for the construction of new buildings as well as for the rehabilitation of pre-existing ones.

In order to support this thesis, the team carried out a comparison between the application of BIM Surveying and direct surveying. The BIM method proved to better than the traditional one in terms of the productivity and quality of the work.

A further observation concerns the economic aspects of the traditional and BIM surveys. The costs linked to traditional surveys are only made up ofqualified technicians fees.

On the other hand, BIM survey costs are higher due to the technological equipment (laser-scanner) needed and employment of specialized technicians who can elaborate and model point clouds. On the other hand, the BIM Survey reduces the man-days factor by 70% compared to the traditional survey. On the whole, the BIM method is more convenient: it reduces costs by 20%.

The quantity of information obtainable from the output of the final products of the compared methods is another important factor. The traditional survey only produces a limited number of 2D CAD elaborates, whereas the BIM Survey produces a3D building information model. It consists of a real building infographic prototype. This model brings many benefits to its users, who can easily obtain an unlimited number of connected diagrams, sections and perspective drawings; charts regarding materials; tabs regarding material specifics; characterization of constitutive elements; etc..

Although bringing many implementations, there are some limits connected to the parametrical planning of architectural heritage. Although the Castle of Francolise modeling was not complicated due to the absence of ornamental elements, and the number of irregular elements within the castle structure was not relevant; in this case, the team was able to inspect a different building, characterized by particularly complex features - such as a church or acourtyard –where there would be many more issues.

Altogether, in order to improve the BIM of architectural and structural elements (capitals; gates; pilasters; cornices; etc.), online libraries have to be implemented by creating different groups of elements whose lengths, widths and physical-mechanical properties could be freely edited, according to the users' needs.

It has been shown that when applied to architectural heritage, the BIM Survey could become an important tool for local administrations. Administrators along with experienced technicians could create a "cultural heritage smart catalogue" connected to historical buildings within territories under their jurisdiction.

This architectural heritage smart cataloguing - which would consist of a database containing BIM models of buildings in need of renovation - would simplify issuing design contests, minimizing risks of interference and failures. The current organization has, in fact, proven to be inefficient: local administrations are not able to spend at least half of the ESIF (European Structural and Investment Funds)received from the European Union.

Acknowledgements

The software and hardware equipment employed for the research within the case study of the Caste of Francolise have been provided by Lab. Model of Department of Civil Engineering of University of Salerno.

References

Azhar, S. *Building Information Modeling (BIM): Trends, Benefits, Risks and Challenges for the AEC Industry*, Leadership and Management in Engineering, American Society of Civil Engineers Library, Reston, Virginia, 2011.

Ahmad, A.; Demian, P.; Price, A. *BIM implementation plans: A comparative analysis*, in: Smith, S. *Proceedings of 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, 2012.

Barba, S.; Fiorillo, F.; Corder, P. O.; D'Auria, S.; De Feo, E *An application for cultural heritage in erasmus placement. Surveys and 3D cataloging archaeological finds in Mérida (Spain)*, in: *4th International Workshop "3D-ARCH'2011", 3D Virtual Reconstruction and Visualization of Complex Architectures*, Trento, 2-4 marzo 2011.

Cappochin, S.; Maistri, D.; Torre, A. *Efficienza energetica in architettura. Metodo BIM (Building Information Modeling) e metodo CasaClima per la progettazione di edifici a basso fabbisogno energetico*, Gruppo24Ore, Milano, 2011.

D'Auria, S. *Metodologie e strumenti per la progettazione: il BIM*, in: Di Ruocco G., D'Auria S., Falcone I., Nivelli M., SabainiGama M. (a cura di), *Lezioni di Architettura*, CUES Edizioni, Salerno, 2012.

D'Auria, S.; Barbato, D. *Standardisation of the design processusing BIM software*, in: Gambardella, C. (a cura di), *Le Vie dei Mercanti. Heritage Architecture Landesign*, Atti del XI Forum Internazionale di Studi Le vie dei Mercanti, 13-15 Giugno 2013, Aversa-Capri, Italia, La scuola di Pitagora editrice, Napoli, 2013.

De Joanna P., *Il recupero edilizio nelle aree protette. Norme e strumenti di programmazione, progettazione ed esecuzione*, Franco Angeli Editore, Milano, 2010.

Eastman, C.; Teicholz, P.; Sacks, R.; Liston, K. *BIM handbook. A guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors*, John Wiley & Sons, Hoboken, New Jersey, 2008.

Gallaher, M.; O'Connor, A.; Dettbarn, J.; Gilday, L. *Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry*, National Institute of Standards and Technology, Building and Fire Research Laboratory, Gaithersburg, Maryland, 2004.

Gleason, D. *Laser Scanning for an Integrated BIM*, Lake Constance 5D-Conference 2013, 28-29 ottobre, Constanza, Trimble Navigation, 2013.

Lo Turco, M. *Il BIM tra rilievo e progetto: l'utilizzo delle scansioni al laser scanner in ambiente parametrico*, BIM Academy, 2013, http://www.bimacademy.it/2013/11/il-bim-tra-rilievo-e-progetto-lutilizzo-delle-scansioni-al-laser-scanner-in-ambiente-parametrico

Randall, T. *Client Guide to 3D Scanning -and- Data Capture*, UK BIM Task Group, Londra, 2013.

Turner, B. *Building a few million points. Leveraging high definition laser scanning for BIM*, in: *Structural Engineering Structural & Design*, zweigwhite, Fayetteville, Arkansas, febbraio 2011.

Materials Engineering

Recent advances in the field of nanoporous materials for energy and environmental applications

Domenico Caputo, Nicola Gargiulo, Paolo Aprea
Dipartimento di Ingegneria Chimica, dei Materiali e della Produzione Industriale, Università di Napoli Federico II, P.le V. Tecchio 80, 80125 Napoli

Keywords: Nanoporous materials, Zeolites, Mesoporous silicas, Metal-organic frameworks, Environmental protection

Abstract

Advances in nanoscale science and engineering are providing unprecedented opportunities to develop more efficient and cost-effective materials and technologies for environmentally friendly processes.

Zeolites and related materials, such as functionalised mesoporous silicas and the more recent metal-organic frameworks (MOFs), represent a class of nanoporous materials characterised by very interesting and useful adsorption and/or ion exchange properties.

A brief overview on present and perspective utilizations of these materials in environmentally friendly processes, including solar and thermal energy storage, methane and hydrogen storage and CO2 capture, is here presented.

1. Introduction

The continued deterioration of environmental issues - from energy to water crisis, from climate change to deforestation - is a clear demonstration that the current model of development, based on an irrational exploitation of resources, a boundless energy consumption, an overproduction waste and pollution, is bringing humanity to a level never seen of environmental degradation and depletion of available natural resources.

Many of these problems can be connected precisely with the production of energy, whose currently adopted processes generate pollutant emissions that affect the whole geosphere, and particularly the atmosphere.

In this scenario, the scientific and technological research plays a critical role both through the exploitation of alternative energy sources with low environmental impact and the development of methods for the reduction of polluting emissions.

An important contribution in this area is provided by the science and technology of materials, especially through the synthesis of new materials. Among them, materials characterized by porous nanoscale structure (nanoporous materials) appear to be of enormous interest.

An important class of nanoporous materials is represented by zeolites and related materials, including the mesoporous silicas and the most recent hybrid materials based on a metal-organic structure (MOF, Metal-Organic Frameworks).

The porous structure results in a high specific surface area that, associated with the presence of chemically active sites, leading to the typical catalytic, adsorption and, in the case of zeolites, ion exchange properties.

There are many actual and potential applications of these materials in the field of energy and environment protection, some of which are described below.

2. Zeolites

Zeolites are, from a chemical point of view, hydrated aluminosilicates of alkaline and alkaline earth metals.

whose structure is constituted by a three-dimensional network of AlO_4^{5-} e SiO_4^{4-} tetrahedra linked through the sharing of oxygen atoms.

The spatial arrangement of these tetrahedra generates a network of cavities and interconnected channels having a diameter generally less than nanometer (nm, 1 nm = 10^{-9} m), the volume of which constitutes from 20% to 50% of the total volume of the zeolite crystals (Breck, 1974).

Under normal conditions, these cavities are occupied by water molecules and metal cations which, not being an integral part of the rigid aluminosilicate framework, can be, respectively, removed or exchanged without affecting the stability of the structure itself.

This justifies the extraordinary properties (adsorption, catalysis, and ion exchange) that characterize zeolites, both natural and synthetic, and on which are based on major industrial applications (Colella, 2002; Caputo and Pepe, 2007).

3. Ordered mesoporous silicas

In recent decades there have been many efforts for the synthesis of porous materials with pore sizes greater than those typically present in zeolitic structures (Davis, 2001). In 1992, researchers at Mobil Company have introduced a highly innovative synthesis technique, based on the possibility to use a supramolecular template constituted by surfactant micelles from which, by the following removal of the micelles, a porous solid is obtained (Kresge *et al.*, 1992; Beck *et al.*, 1992; Zhao

et al., 1998). By this technique, a class of mesoporous silica-based molecular sieves, called M41S, was produced: such materials (among which the most known terms are MCM-41, MCM-48 and SBA-15) show pore diameters between 15 and 100 Å. The development of these materials having well-defined, adaptable pore sizes, and functionalizable inner surface areas, has generated great interest in the chemical and petrochemical sector, due to their potential applications as catalysts and molecular sieves (Kresge *et al.*, 1992; Beck *et al.*, 1992). Recent progress in the techniques of internal functionalization of mesopores (Pasqua *et al.*, 2003; Gargiulo *et al.*, 2007; Gargiulo *et al.*, 2012) open new horizons for their use as adsorbents in gas separation processes.

4. Metal-organic frameworks (MOF)

Over the past decade considerable attention was paid to the definition of new approaches for the rational design and synthesis of zeolite-like materials with specific structures and functions. In this regard, the hybrid materials known as metal-organic frameworks (MOFs) can be considered the latest development of porous crystalline materials. Their structure is composed of individual units or small clusters of metal oxides joint by linking organic molecules (linkers) through strong covalent bonds. The final result consists in a framework similar to that of microporous zeolites (Li *et al.*, 1999). For this reason, MOFs are often labeled as "organic zeolites". The wide range of compounds useful as reagents for their synthesis allowed the production of numerous structures with specific surface area much higher (over 6000 m^2 / g) than what is usually detectable for active carbon and zeolitic materials. This characteristic, together with the detailed control of the size and chemical functionality of the pores, provides great freedom to design the structure more suited to a specific application.

5. Some application examples in the field of energy and environmental protection

5.1. Storage of solar and thermal energy

The sun, as a source of clean, free and renewable energy, is getting more and more attention among researchers.
However, the intensity of the solar radiation is subject to unavoidable fluctuations, due to the alternation of night and day, seasons and weather conditions, which in turn affect the efficiency of solar powered devices. The possibility to store the solar energy for a later use would represent a smart way to solve these problems.
Conventional methods to store thermal energy consist in varying the temperature of a suitable "reservoir device", or producing a phase change (usually solid-to-liquid or liquid-to-gas) of a fluid or also inducing an endothermic chemical reaction between two or more substances, but all these techniques involve some disadvantages, which practically limit the widespread availability of such technologies, and point out the importance of setting up alternative methods.
A method which use an adsorption-desorption cycle can be an interesting alternative. Generally speaking, the adsorption is the reversible process by which a solid (adsorbent) captures a liquid or a vapor (adsorbate) onto its surface. Being adsorption exothermic in nature, desorption is endothermic. It is so possible in principle to develop a device which allow to store energy by desorbing a fluid phase from an adsorbent substance, and to recover the same amount of energy simply by contacting again the adsorbent with the fluid. A critical aspect in the design of such a device would be the choice of the best adsorbent-adsorbate couple.
A common feature of many porous materials, such as zeolites, is the high affinity towards water molecules: zeolites are usually used as desiccants materials. Being the water adsorption a highly exothermic process, it is possible to store thermal energy using a cycle similar to that depicted in Figure 1, in which the thermal energy is: a) stored by heating the adsorbent (desorption step); b) used by contacting the anhydrous zeolite with water vapor (adsorption step).
This method would allow to store a higher energy density with respect than the conventional ones previously mentioned. Moreover, as far as the zeolite is held anhydrous, there is no loss of stored energy, allowing to virtually save it to infinity.

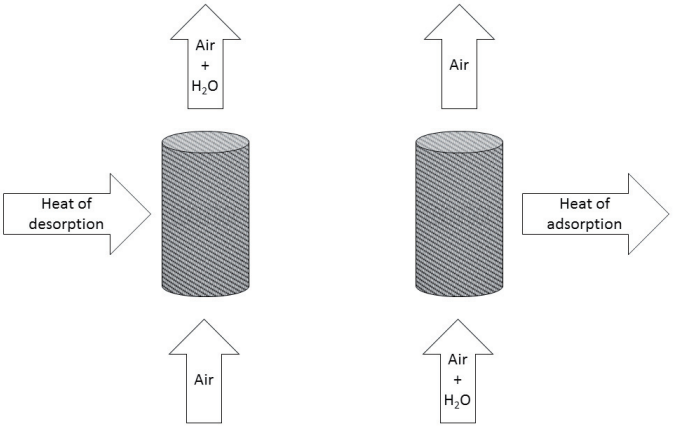


Figure 1 – Energy storage and reuse via a water vapor desorption-adsorption cycle.

Zeolitic materials are already used in "open heat pump" adsorption based devices, which are employed to store the thermal energy produced by conventional sources (Sizmann, 1989; Nan *et al.*, 1994; Hauer, 2002). These systems can

assure high storage capacity, and can perform either heating or cooling tasks. In Munich, German (Hauer, 2002), devices are currently operating which combine a thermochemical energy storage system with a cogeneration module in order to recycle waste heat thus reduce the polluting emissions.

Solar thermal plants employing zeolitic materials can reach efficiency higher than 50% on average, much more than those of photovoltaic plants (12-15%). As an example, Vaillant recently put on the market a hot water heating system named Zeotherm, based on a zeolitic fixed bed and a solar energy heater (Vaillant Group, 2014).

This device basically consists of a condensation boiler and a zeolite bed under vacuum (see fig. 2 scheme). Its working cycle is composed by two steps:

I) Adsorption. It takes place in the lower part of the heating pump, where the water vapor in the vacuum reservoir is evaporated by the heat coming from the solar collector and carried to the zeolite bed, where is adsorbed and produces heat;

II) Desorption. It takes place in the zeolite bed, which is heated up by a burner, and frees the water vapor which is carried to the lower part of the heat pump where condenses, producing heat again.

This system can reach a per year efficiency higher than:

- 30% with respect to a conventional boiler
- 20% with respect to a modern boiler
- 10% with respect to a traditional boiler coupled with a solar energy system.

It also reduces the CO_2 emissions of about 30% at the same time.

Hauer and Fisher (2011) also proposed, in collaboration with Bosh Siemens Hausgeräte GmbH (BSH), a dishwasher which uses zeolites.

During a conventional dishwasher routine (fig. 3 – left), the water is heated twice: for the washing process (at about 50°C) and for the drying process (at about 60°C), which consists of the evaporation of the water from the dishes and its condensation on the dishwasher floor.

The dishwasher proposed by Hauer, recently put on the market, warms up and dries an air flow by means of adsorption on a zeolite bed in order to dry the dishes, and warms up the washing water by condensating the vapor desorbed from the same bed. In this way it is possible to perform just one heating instead of two, and, at the same

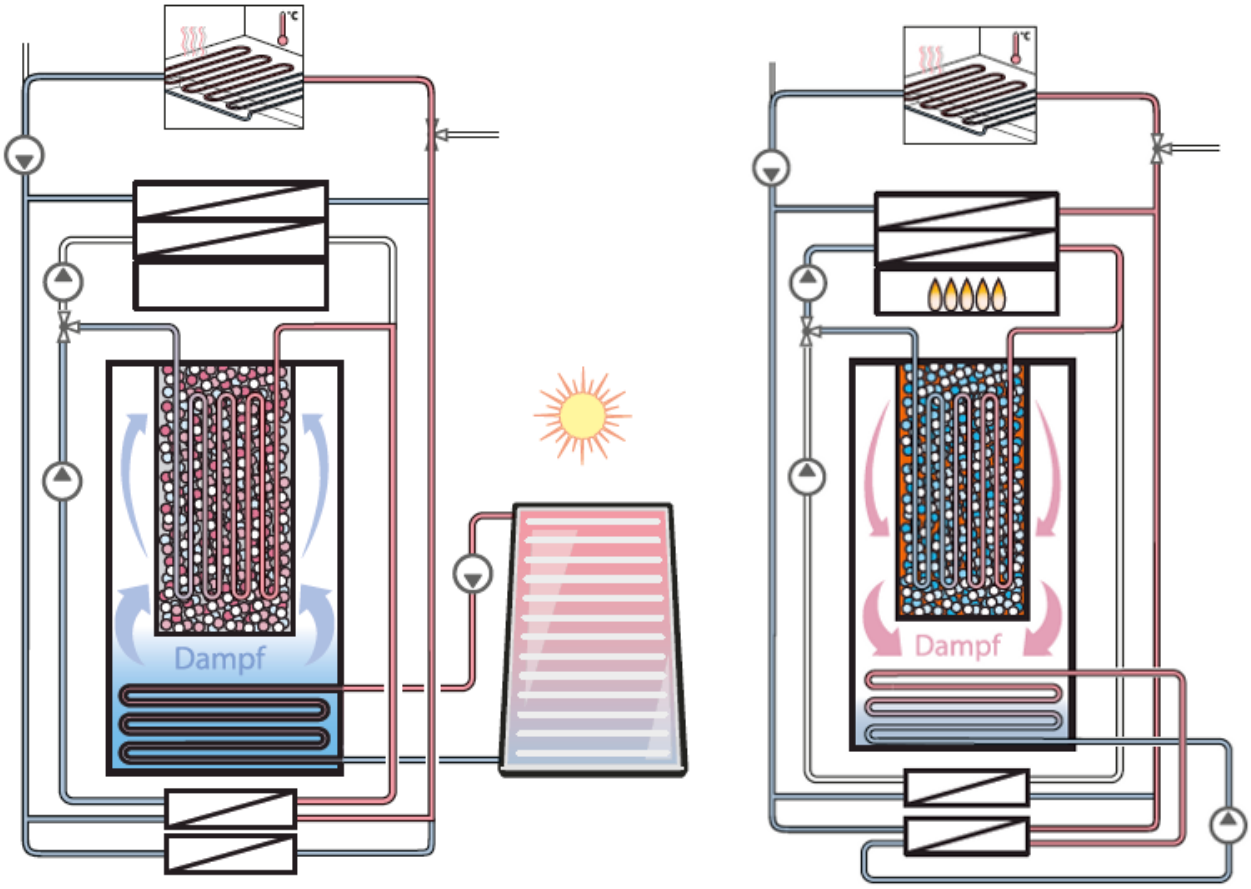


Figure 2 – Adsorption (left) and desorption (right) step in the Zeotherm appliace (Vaillant Group, 2014).

time, to reduce the power consumption of about the 25% with respect to a conventional appliance. In fat, during the washing process (Figure 3 – right), an electrical resistance at 250°C warms up an air flow which runs through the zeolitic bed and promote the water desorption. Such water vapor saturated flow, coming from the bed, is carried to a condenser where the vapor, becoming liquid, frees its latent heat and warms up the washing water. After the washing, the humid water coming from the dishes is carried to the zeolitic bed, still warm: the adsoption process dries and further warms the air flow, which can be used to dries the dishes in turn.

5.2. Storage of hydrogen and methane

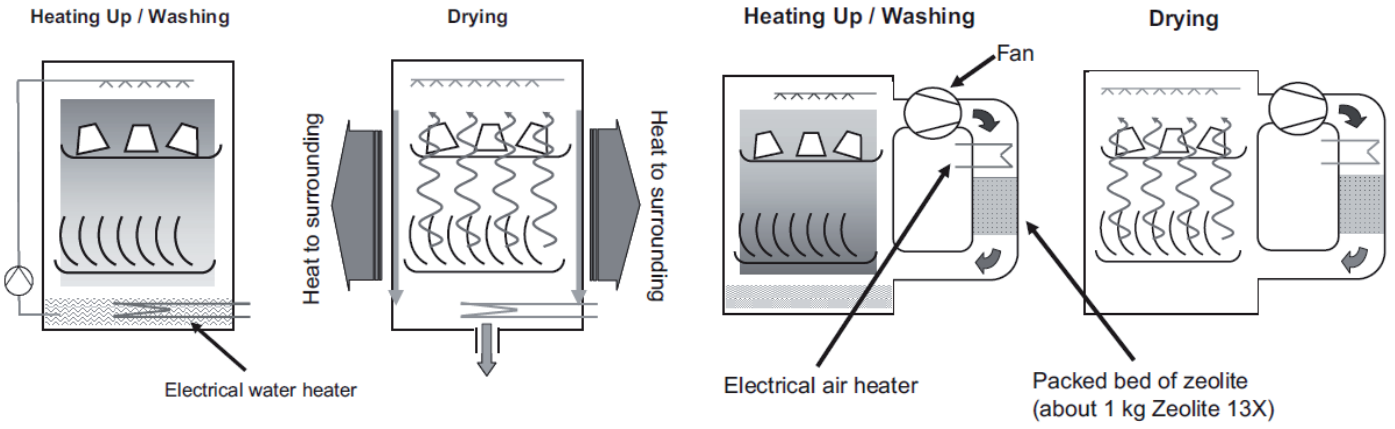


Figure 3 – Operation schema of a traditional dishwasher (left) and an integrated adsorption module dishwasher (right) (Hauer and Fisher, 2011).

It is well-known how many governments around the world declared the hydrogen economy as a target for future energy needs. In this respect, it seems that MOFs possess, or are close to own, hydrogen storage capacities high enough to significantly increase the performance of tanks operating at ambient temperature for automotive applications. On board hydrogen storage is the main problem to be overcome for a concrete perspective of use of fuel cells in the transport field. In the United States, in order to stimulate research in this area, the Department of Energy (DoE) set certain specifications that an effective storage system must have (Satyapal *et al.*, 2007; U.S. Department of Energy, 2014), including: (a) storage capacity; (b) working temperatures and pressures; (c) time for refueling / recharging. For these parameters, DoE set values to be considered as milestones to be achieved by 2010 and 2015, and a final target value. For example, as regards the storage capacity, the reviewed target values are 0.045, 0.055 and 0.075 kg of H2/Kg storage system (tank), respectively (U.S. Department of Energy, 2014).

The on-board storage systems so far considered for the creation of prototypes (Felderhoff *et al.*, 2007) envisaged the use of tanks containing (i) gaseous and high pressure-compressed hydrogen, (ii) liquid hydrogen at very low temperatures, (iii) solid-state hydrogen in the form of hydrides. None of them, however, fulfills all the criteria set by DoE, especially in terms of storage capacity, working temperatures and pressures, and costs (Thomas, 2007). One of the alternative methods to those described above, with excellent future prospectives, envisages hydrogen storage by adsorption in porous materials. The different types of adsorbent materials investigated so far (activated carbon, nanotubes, zeolites, etc..) showed very fast hydrogen adsorption / desorption kinetics, but storage capacities still very far from the targets set by DoE (Felderhoff *et al.*, 2007).

Metal-organic framework (MOFs) seem the most promising adsorbents, instead. Recently, the structure named MOF-210, consisting of [Zn4O (CO2) 6)] units connected by organic bridges, shoewd a BET specific surface area of 6240 m2 / g and a hydrogen adsorption capacity at 80 bar and 77 K equal to 0,086 kg H_2/Kg (Hirscher, 2011). Further imrpovements could be achieved by varying the chemical nature of both the metal and the organic linker. While waiting for hydrogen to become the next generation energy carrier, the use of nanoporous materials as adsorbents was also proposed for the on board storage of natural gas. The compressed natural gas (CNG) - powered vehicles entered the mass market several years ago. The tanks currently used contain compressed gas at about 200 atm, but the directions given by DoE to reduce the risk of explosions envisage a final target pressure of max 35 atm at near-ambient temperatures, with a minimum target for the storage capacity equal to 180 volumes (STP) / tank volume. MOFs seem to be most promising adsorbents also for methane storage. Very recently, a new metal-organic phase, called PCN-14, has been developed, showing a specific surface area of 2176 m2 / g and a methane adsorption capacity of 220 v (STP) / v at 35 bar and 290 K (Ma and Zhou,

2010), which is above the minimum target set by DoE. The high production cost is still one of the major limitations for the real world applications of MOFs.

5.3. CO_2 capture

Nanoporous materials can be also employed in the separation of gaseous mixtures, thanks to their peculiar properties of selective adsorption and molecular sieving. In particular, investigations about the use of such materials in the removal of toxic or environmentally hazardous gases mainly focused on CO_2 capture and separation. As particularly regards zeolites, through the appropriate choice of framework, Si / Al ratio and extra-framework cation content, it is possible, in certain cases, to tune the adsorption properties in order to achieve the selectivity required for a particular separation. 13X zeolite, characterized by a relatively high surface basicity, proved to be a very suitable adsorbent for CO_2 capture by means of Pressure Swing Adsorption (PSA) processes (Siriwardane *et al.*, 2001).

Despite the wide use of zeolites for CO_2 capture, in the last two decades, considerable efforts have been made in improving separation processes based on the adsorption of this gas and, more specifically, in the selection of new high-performance adsorbents, as the development of such materials is the key for improving the aforementioned processes. Recently, technological solutions based on the use of functionalized mesostructured silicas have been extensively studied, particularly focusing attention on the so-called "molecular baskets", characterized by the use of polyethylenimine as functionalizing agent (Gargiulo *et al.*, 2007; Gargiulo *et al.*, 2012). These materials, however, have a marked tendency to reach the saturation capacity already at very low values of CO_2 partial pressure, and seem, therefore, particularly suitable only for separation processes in which the complete removal of CO_2 justifies the use of pressures in the order of magnitude of 10^{-6} bar for the regeneration of the adsorbent. Very recently, several materials belonging to the class of metal-organic frameworks (MOFs) have proved to be good candidates for improving the performance of adsorption-based CO2 capture processes. In particular, the copper 1,3,5-benzenetricarboxylate, mostly known to the scientific community by the acronym Cu-BTC, was compared in detail with a more traditional adsorbent, such as 13X zeolite. Selectivity level being the same, Cu-BTC showed a higher adsorption capacity at room temperature and developed less heat of adsorption during the process when compared to 13X zeolite: both these features are crucial for the improvement of fixed bed adsorption processes (Aprea *et al.*, 2010).

6. Conclusions

The results obtained so far in the application of nanoporous materials as adsorbents in the energy-environmental field appear to be very promising, especially with regard to metal-organic frameworks (MOFs). The ability to obtain new synthetic structures and the possibility to introduce chemical modifications in order to modulate the characteristics of the material to make it suitable for specific uses continue to stimulate research in this area. In particular, in the next few years, the attention will be focused on some parameters such as the volume of nanopores available to the adsorbate molecules and the adsorbent/adsorbate affinity, which seem to be more crucial than others for future developments in this field.

References

Aprea, P., D. Caputo, N. Gargiulo, F. Iucolano, and F. Pepe. "Modeling carbon dioxide adsorption on microporous substrates: comparison between Cu–BTC metal organic framework and 13X zeolitic molecular sieve." *Journal of Chemical & Engineering Data* 55 (2010): 3655-61.

Beck, J. S., J. C. Vartuli, W. J. Roth, M. E. Leonowicz, C. T. Kresge, K. T. Schmitt, C. T-W. Chu, D. H. Olson, E. W. Sheppard, S. B. McCullen, J. B. Higgins, and J. L. Schlenker, "A new family of mesoporous molecular sieves prepared with liquid crystal templates." *Journal of the American Chemical Society* 114 (1992): 10834-43.

Breck, D. W. *Zeolite Molecular Sieves: Structure, Chemistry and Use*. New York: John Wiley, 1974.

Caputo, D., and F. Pepe. "Experiments and data processing of ion exchange equilibria involving Italian natural zeolites: a review." *Microporous and Mesoporous Materials* 105 (2007): 222–31.

Colella, C. "Applications of Natural Zeolites." In *Handbook of Porous Solids*, edited by F. Schüth, K. S. W. Sing and J. Weitkamp, 1156-1189. Weinheim: Wiley-VCH, 2002.

Davis, M. E. "Evolution of extra-large pore materials." *Studies in Surface Science and Catalysis* 135 (2001): 29-36.

Felderhoff, M., C. Weidenthaler, R. von Helmolt, and U. Eberle. "Hydrogen storage: the remaining scientific and technological challenges." *Physical Chemistry Chemical Physics* 9 (2007): 2643-53.

Gargiulo, N., D. Caputo, and C. Colella. "Preparation and characterization of polyethylenimine-modified mesoporous silicas as CO_2 sorbents." *Studies in Surface Science and Catalysis* 170B (2007): 1938-43.

Gargiulo, N., F. Pepe, and D. Caputo. "Modeling carbon dioxide adsorption on polyethylenimine-functionalized TUD-1 mesoporous silica." *Journal of Colloid and Interface Science* 367 (2012): 348-54.

Hauer, A. "Thermal Energy Storage with Zeolite for Heating and. Cooling Applications." Paper presented at the 3rd Workshop of Annex 17 ECES IA/IEA, Tokyo, Japan, October 1-2, 2002.

Hauer, A., and F. Fischer. "Open Adsorption System for an Energy Efficient Dishwasher." *Chemie Ingenieur Technik* 83 (2011): 61–6.

Hirscher, M. "Hydrogen Storage by Cryoadsorption in Ultrahigh-Porosity Metal–Organic Frameworks." *Angewandte Chemie International Edition* 50 (2011): 581-2.

Kresge, C. T., M. E. Leonowicz, W. J. Roth, J. C. Vartuli, and J. S. Beck. "Ordered mesoporous molecular sieves synthesized by a liquid-crystal template mechanism." *Nature* 359 (1992): 710-2.

Li, H., M. Eddaoudi, M O'Keeffe, and O.M. Yaghi. "Design and synthesis of an exceptionally stable and highly porous metal-organic framework." *Nature* 402 (1999): 276–9.

Ma, S., and H. C. Zhou. "Gas storage in porous metal–organic frameworks for clean energy applications." *Chemical Communications* 46 (2010): 44–53.

Nan, L., G. Best, and C. C. De Carvalho Neto, eds., *Food and Agriculture Organization of the United Nations*. Rome: FAO, 1994.

Pasqua L., F. Testa, R. Aiello, G. Madeo, and J. B. Nagy. "Surface properties of mesoporous silicate and alumino-silicate modified by reaction with benzoyl chloride." *Physical Chemistry Chemical Physics* 5 (2003): 640-5.

Satyapal, S., J. Petrovic, C. Read, G. Thomas, and G. Ordaz. "The U.S. Department of Energy's National Hydrogen Storage Project: Progress towards meeting hydrogen-powered vehicle requirements." *Catalysis Today* 120 (2007): 246-56.

Siriwardane, R. V., M. S. Shen, E. P. Fisher, and J. A. Poston. "Adsorption of CO_2 on Molecular Sieves and Activated Carbon." *Energy & Fuels* 15 (2001): 279-84.

Sizmann, R. "Speicherung thermischer Energie-Eine Übersicht." Technical report presented at the BMFT Satusseminar "Thermische Energiespeicherung", Stuttgart, Germany, 1989.

Thomas, K. M. "Hydrogen adsorption and storage on porous materials." *Catalysis Today* 120 (2007): 389-98.

U.S. Department of Energy. "'Grand challenge' for basic and applied research in hydrogen storage." Accessed July 9, 2014, http://energy.gov/eere/fuelcells/grand-challenge-basic-and-applied-research-hydrogen-storage-solicitation.

U.S. Department of Energy. "Target for on-board hydrogen storage systems: Current R&D focus is on 2015 targets with potential to meet ultimate targets." Accessed July 10, 2014, http://www1.eere.energy.gov/hydrogenandfuelcells/storage/current_technology.html.

Vaillant Group. "Neubauten in Wien-Aspern mit Vaillant Zeolith Gas-Wärmepumpe zeoTHERM." Accessed July 9, 2014, http://www.vaillant.at/Presse/Presse-Information/Waermepumpen/article/zeotherm-aspern.html.

Zhao, D., Q. Huo, J. Feng, B. F. Chmelka, and G. D. Stucky. "Nonionic Triblock and Star Diblock Copolymer and Oligomeric Surfactant Syntheses of Highly Ordered, Hydrothermally Stable, Mesoporous Silica Structures." *Journal of the American Chemical Society* 120 (1998): 6024-36.

Durability and mechanical properties of nanocomposite fiber reinforced concrete

Bartolomeo Coppola, Paola Scarfato, Loredana Incarnato, Luciano Di Maio
Department of Industrial Engineering, University of Salerno, Fisciano (SA), Italy
ldimaio@unisa.it

Abstract

In this study we investigated the influence of polypropylene/organoclay fibers on durability and mechanical behaviour of concrete. Pure polypropylene fibers and polypropylene nanocomposite fibers of two different lengths (20 and 60 mm) have been mixed in concrete at two volume fractions (0.1% and 0.3%). Nanoclay addition increases fibers elastic modulus (about 27%) reducing ductility. Workability of concrete is greatly influenced by fibers length and volume fraction: increasing these two values workability decreases. Fibers are not influent on compressive and flexural strength while post-cracking toughness is increased. Nanocomposite fibers have a better pull-out strength due to a better friction during slipping, but this doesn't ensure a better adhesion. Water absorption, freeze/thaw cycles and the sulfate attack test demonstrate that concrete durability increases with the volume of the fiber fraction.

1. Introduction

Durability of structures is an important issue for construction industry but also for maintenance costs. Shrinkage of concrete represents a serious concern for structures durability due to concrete low tensile strength and thus cementitious materials are subjected to cracking during their life. One crack control method widely accepted by researchers, is the use of randomly distributed fibers, particularly fine synthetic fibers with a volume fraction below 0.5%. The composite material made of concrete and short fibers is named fiber-reinforced concrete (FRC). Several authors investigated the influence of fibers, and particularly of PP fibers, on durability and transport properties of concrete structures, particularly on permeability (Kakooei et al., 2012). Polypropylene is one of the most widely used synthetic polymers as it is easy to process, cheaper, has excellent chemical resistance and is stronger than other synthetic polymers. The addition of nanoclay as reinforcement in the PP matrix can further enhance the physical properties of synthetic fibers. Nevertheless, studies on PP/clay nanocomposite fibers are so far limited. Richardson et al. (2012) reported that polypropylene fibers effect is to reduce water absorption and increase freeze/thaw resistance, having an increase of material durability. Their researches show that fibers inclusion could increase void system, offering an alternative way to improve void content. As in any fiber reinforced composite, fiber-matrix bond in FRC is extremely important. Mechanical behaviour of fiber reinforced composites is greatly governed by adhesion that allows stress transmission between matrix and fibers. To increase FRCs toughness or energy absorption, fiber slip has to be avoided. Fiber matrix bond is investigated by pull-out tests that are able to describe fiber/matrix interface, changing test parameters, i.e. fiber inclining angle, embedded length, specimen geometry etc. (Kim et al., 2008; Bartos, 1981; Singh et al., 2004). Deterioration processes of concrete structures are due to several causes: corrosion of the reinforcement, sulfate attack, frost action and alkali aggregate reactions. Sulfate attack depends on environmental and exposure conditions, representing an important issue affecting concrete durability. Neville's review (2004) about sulfate attack point out the differences between the mere occurrence of chemical reactions of sulfates with hydrated cement paste and the damage or deterioration of concrete. Jianming et al. (2013) investigated durability of concrete exposed to sulfate attack and wetting/drying cycles assessing that these could increase structures deterioration. Concrete transport parameters are influenced by water content of the test specimens. The measurement of transport properties is sensitive to the test procedure and attention to preconditioning of the test specimens is necessary (RILEM TC 116, 1999). The aim of this paper is to study the influence of different fibers on concrete behavior. Particularly the research interest lies in the lack of studies on the addition of polypropylene nanocomposite fibers in cementitious composites.

2. Materials and methods

Concrete was prepared using a CEM IV/A 32.5 R (ITALCEMENTI S.p.A.) and natural aggregates deriving from limestone crushing. Characteristics of aggregates are listed in Table 1.

Two different fibers were used: pure polypropylene and nanoclay reinforced polypropylene. Both types have been produced in the laboratory of Polymer Technology of the Department of Industrial Engineering of University of Salerno. Fibers have been produced by a twin screw extruder (COLLIN ZK 25, L/D = 32) using a feeder for polypropylene granules (MOPLEN V79S) and a feeder for the commercial layered organoclay powder (DELLITE 43B). Polypropylene and nanoclay blend comes out from the extruder at the molten state, is cooled into water and wound by a winder (COLLIN TECH-LINE BAW 130 T). This extrusion process produces a filament that after has been cut in short fibers at two different lengths: 20 and 60 mm. Fibers morphology is described in Table 2.

Mechanical properties of fibers have been determined by a tensile test, according to ASTM C 1557-03. The test was carried out at two cross-head speed (10 and 50 mm/min) using a universal testing machine with a load cell of 1 kN. Gauge length is 40 mm.

Concrete production was made by a concrete mixer: cement and aggregates are mixed for 10 minutes, than water is gradually introduced to have a homogeneous mixture (UNI EN 206-1, 2014). Concrete mix composition is indicated in Table 3.

Throughout the work will be used the FRC classification listed in Table 4.

Concrete workability has been evaluated by slump test. Workability is synonymous of consistency, i.e. the facility of concrete to flow. The test was carried out using a mold known as a slump cone or Abrams cone (UNI EN 12350-2, 2009).

Table 1 – Characteristics of aggregates.

Aggregate	Diameter [mm]	Water absorption [%]	Density [g/cm³]	Chloride content [%]
Sand	0 - 4	0.9 ± 0.1	2.68	0.01 ± 0.02
Fine	4 - 8	0.2 ± 0.1	2.70	0.01 ± 0.02
Coarse	8 – 20	0.5 ± 0.1	2.71	0.01 ± 0.02

Table 2 – Description of different fibers.

Fiber designation	Material	Cross section	Length [mm]	$\Phi_{average}$ [mm]
PP20	pure polypropylene	circular	20	1.05
PP60	pure polypropylene	circular	60	
PPNC20	polypropylene nanocomposite	circular	20	1.20
PPNC60	polypropylene nanocomposite	circular	60	

Table 3 – Concrete mix composition.

Component	Dosage [kg/m³]
Cement CEM IV/A 32.5 R	434
Sand (0-4 mm)	594
Fine aggregate (4-8 mm)	443
Coarse aggregate (8-20 mm)	333
Water	217
Water/cement ratio	50 %

Table 4 – FRC classification.

Concrete designation	Fibers length [mm]	Fibers material	Fibers volume fraction [%]
Reference	-	-	-
FRC_PP20A	20	PP	0.1
FRC_PPNC20A	20	PP NC	0.1
FRC_PP60A	60	PP	0.1
FRC_PPNC60A	60	PP NC	0.1
FRC_PP20B	20	PP	0.3
FRC_PPNC20B	20	PP NC	0.3
FRC_PP60B	60	PP	0.3
FRC_PPNC60B	60	PP NC	0.3

Mechanical properties of FRCs have been determined by flexion and compression tests at 28 days. For determining flexural strength two beams 15x15x60 cm for each mix were tested, according to UNI EN 12390-5. Notched specimens (45 mm on the lower edge) were used. For the four point bending test, flexural strength is given by the equation:

$$f_{cf} = \frac{F \cdot L}{d_1 \cdot d_2^2} \quad \text{(eq. 1)}$$

where f_{cf} is the flexural strength, F is the maximum load, l is the distance between the supporting rollers, d_1 and d_2 are the lateral dimensions of the specimen (Figure 1).

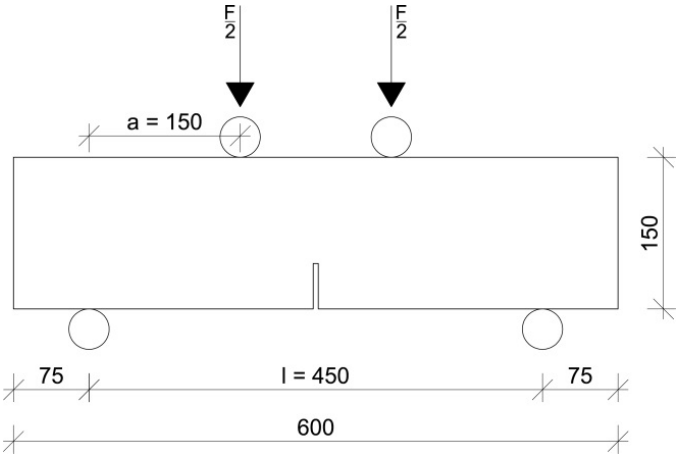


Figure 1 – Four-point bending test scheme.

Compressive test was carried out on three cubic specimens (15x15x15 cm) for each mix, according to UNI EN 12390-3. Load was applied by incremental increments, between 0.2 and 1.0 N/mm²s, until failure is reached. The maximum compressive load is registered and used for determining the compressive strength:

$$f_c = \frac{F}{A_C} \quad \text{(eq. 2)}$$

where f_c is the compressive strength, F is the maximum load at failure and A_c is the cross-sectional area of the specimen on which the compressive force acts.

Durability of FRC was investigated by water absorption test, sulfate attack and freeze/thaw cycles, on prismatic specimens (7.50x7.50x15 cm) after 28 days curing. Rate of absorption, i.e. sorptivity, of water by FRC was evaluated according to UNI 9526. Specimens were dried inside an oven until constant mass is reached, after have been cooled at environmental temperature and then the weight was measured (M_0). Specimens were placed on supports at the bottom of a pan, filled of tap water so that the water level is 5 ± 1 mm. Water level was maintained constant during all the tests. Immediately after that the lower face on the specimen was immersed the timing started. The mass has been recorded after 1, 5, 10, 20, 60, 120, 240, 300 minutes and 24, 48 and 72 hours (M_i). The absorption I_i (eq. 3), at the time t_i, is the change in mass divided by the cross-sectional area of the test specimen (A):

$$I_i = \frac{(M_i - M_0)}{A} \quad \text{(eq. 3)}$$

The sorptivity coefficient S_i is calculated as follows:

$$S_i = \frac{I_i}{\sqrt{t_i}} \quad \text{(eq. 4)}$$

Water absorption for total immersion has been evaluated according to ASTM C 642-97. Specimens were totally immersed in water until the constant mass is achieved (mass variation less than 0.1% in 24 hours), M_1. Water absorption percentage (Ab) is evaluated as a percentage of the mass of the dry specimen M_0:

$$A_b = \frac{M_1 - M_0}{M_0} \cdot 100 \quad \text{(eq. 5)}$$

Standard ASTM C 88-05 defines a test method for testing aggregates, to estimate their soundness when subjected to weathering action in concrete or other application. FRC samples were cyclically immersed in a saturated solution of sodium sulfate (Sodium Sulfate Anhydrous, Na_2SO_4, provided by J.T. Baker) then dried in oven. Solution was prepared into a beaker on a hot plate magnetic stirrer device at a temperature between 100 and 110 °C. Before its use, the solution was maintained at room temperature for 48 hours, covering the beaker to avoid evaporation. Three samples for each mix were tested: specimens are immersed in the solution for 16 hours then are left on a desk for drain. After are dried in oven at 110 ± 5 °C for 8 hours, cured at room temperature and weighed, then immersed again in the solution. Nine cycles were performed.

Durability at freeze/thaw cycles was assessed according to UNI 7087. Three specimens for each mix were used: two are subjected to alternate freeze/thaw cycles and one is the reference sample. This specimen is immersed in tap water at 20 ± 2 °C during the testing period. Extent of deterioration is evaluated by the durability factor (eq. 7) that is the ratio between relative dynamic modulus of elasticity at the N cycle

and the same property measured on the reference specimen. After 28 days curing the specimens are thermally stabilized in water at 5 ± 2 °C for 3 hours. Each cycle has two phases: cooling and maintaining at the lower limit of the cycle; warm-up and maintaining at the upper limit of the cycle. During the first phase specimens were kept in the freezer at -20 ± 2 °C for 2 h ± 10 min. After are placed in water at 5 ± 2 °C for at least 15 minutes then weighed. Generally a concrete is considered resistant at freeze/thaw cycles if after 300 cycles the relative dynamic modulus of elasticity is at least 80 % of the initial one. FRCs were submitted to 15 freezing/thawing cycles. The relative dynamic modulus of elasticity is measured by ultrasonic pulse method. Ultrasonic pulse velocity, V, and dynamic modulus of elasticity, E_d, are related by eq. 6:

$$E_d = \rho V^2 \frac{(1+\upsilon)(1-2\upsilon)}{(1-\upsilon)} \quad \text{(eq. 6)}$$

where ρ is concrete density and υ dynamic Poisson's ratio (υ = 0.2).
Durability factor is given by:

$$DF = \frac{E_n}{E_i} \times 100 \times \frac{n}{300} \quad \text{(eq. 7)}$$

where n are the cycles performed, E_n and E_i are dynamic modulus of elasticity of the samples undergone to freeze/thaw cycles and reference, respectively.

3. Results and discussion

3.1 Fibers tensile test

Elastic modulus, stress at yielding and tensile strength of fibers were determined by tensile tests and values are reported in Table 5.

Table 5 – Mechanical properties of fibers.

Fiber	E [MPa]	σ_y [MPa]	σ_b [MPa]	ε_b [%]
PP	785 ± 55	8 ± 2	22 ± 3	1500
PPNC	914 ± 9	11 ± 2	27 ± 2	1279 ± 83

Nanoclay addition leads to an increase of elastic modulus and tensile strength of 16% and 23% respectively. Nanocomposite fibers are slightly stiffer than pure polypropylene ones but are less ductile. Strain at failure of nanocomposite fibers is lower (-16%) than the maximum strain allowed at polypropylene fibers. Due to the limit of the testing machine, tensile tests for polypropylene fibers was arrested at a strain of 1500 % corresponding to an elongation of 600 mm.

3.2 Workability of fresh concrete

Workability of concrete was measured in terms of slump. Slump values of the different mixes are listed in Table 6. Increasing fibers volume fraction slump decreases, but a slightly higher viscosity is registered for the mixes with longer fibers. With same volume fraction, fiber having longer length reduces workability of concrete of a higher percentage. Fibers can form a network structure in concrete, which restrain mixture from segregation and flow. Slump classes are S3 and S4, so concrete is classified as fluid. Polypropylene and Nanocoomposite fibers have the same effect on concrete rheological behaviour.

Table 6 – Slump values of tested concretes.

Mix	Slump [mm]	Slump variation [%]	Slump class
Reference	200	-	S4
FRC_PPNC20A	160	-20	S4
FRC_PPNC20B	150	-25	S3
FRC_PPNC60A	150	-25	S3
FRC_PPNC60B	140	-30	S3
FRC_PP20A	165	-18	S4
FRC_PP20B	155	-23	S3
FRC_PP60A	145	-28	S3
FRC_PP60B	140	-30	S3

3.3 Test on hardened concrete

Compressive strength was obtained by eq. 2. As stated by several authors, fibers addition is not effective on compressive strength and variation of compressive strength is very negligible. Variation of compressive strength over unreinforced reference mix is very low, varying between -7.06 % and +11.42 % for FRC_PP20B and FRC_PPNC20A, respectively.

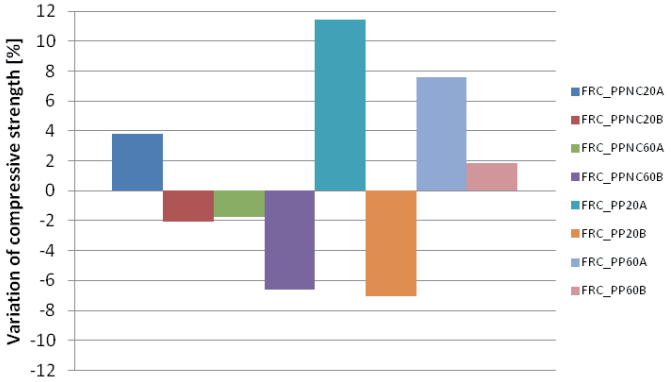


Figure 2 – Variation of compressive strength over reference mix.

Observing specimens after compressive test is clear the different failure mechanism: specimens without fibers show the so-called "hourglass" shape (Figure 3a) due to shear forces generated by friction at the interface with the plates of the press, which prevent the cross expansion of the specimen (Poisson's effect). Specimens containing fibers have a different rupture because fibers act as confinement (Figure 3b).

Values of flexural strength are reported in Table 7.
Four-point bending tests report a low variation of flexural strength. Fibers are effective in the post-cracking behaviour for the increase in toughness: load-deflection curves show an elastic behaviour until the peak is reached and cracking is achieved. Post-cracking behaviour is strain-softening and the residual stress increases increasing fibers volume fraction and fibers length (Figure 4 and Figure 5).

Figure 3 – a) Specimen without fibers; b) specimen with fibers.

Table 7 – Flexural strength of concrete at 28 days.

Mix	Flexural Strength [N/mm²]
Reference	1.54
FRC_PPNC20A	1.62
FRC_PPNC20B	1.67
FRC_PPNC60A	1.25
FRC_PPNC60B	1.45
FRC_PP20A	1.17
FRC_PP20B	1.48
FRC_PP60A	1.60
FRC_PP60B	1.47

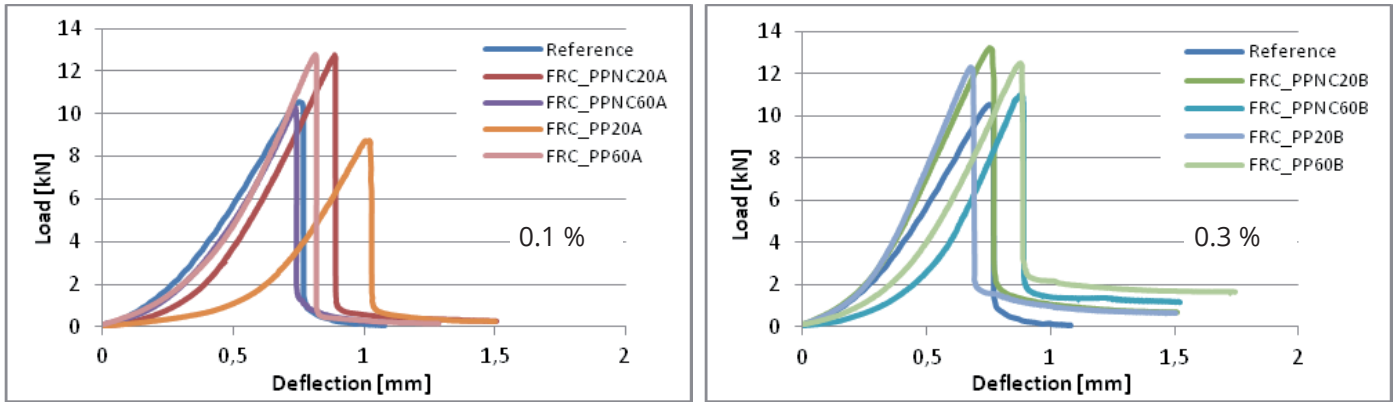


Figure 4 – Load-deflection curves, a) 0.1% fibers volume fraction; b) 0.3% fibers volume fraction.

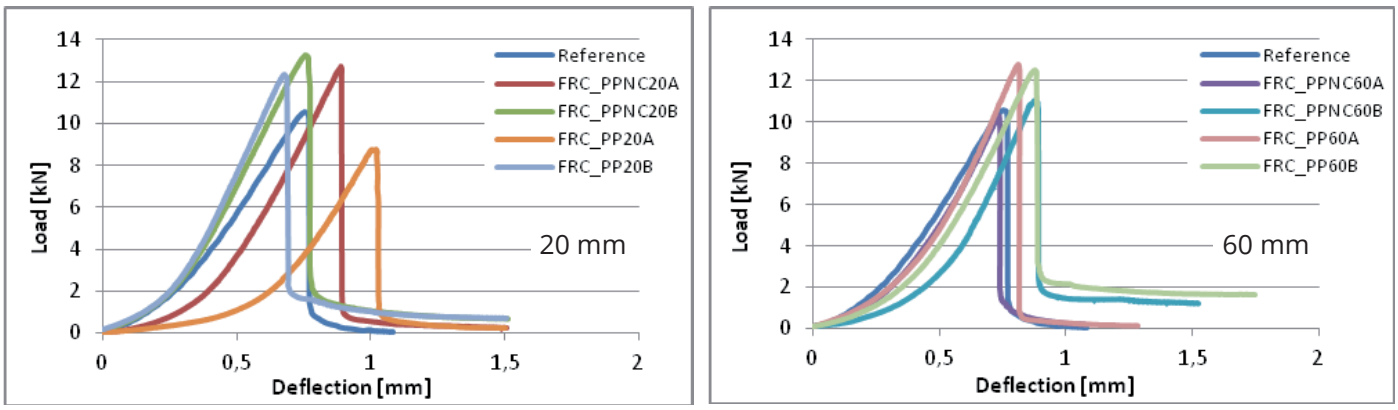


Figure 5 – Load-deflection curves, a) fibers 20 mm long; b) fibers 60 mm long.

Considering the same fibers volume fraction (Figure 4) and the same fibers length (Figure 5), we have the higher toughness increase for FRC_PP60B and FRC_PPNC60B, respectively. These mixes contain longer fibers (60 mm) and higher fibers volume fraction (0.3%). Thus, post-cracking behaviour is influenced by fibers volume fraction and length. Fibers could bridge fracture faces and delay specimens failure, showing residual stress after crack openings. An important parameter for toughness increase is the amount of fibers present in the notch (Figure 6).

Concrete water absorption was calculated by eq. 5 and the percentage of absorbed water versus time is reported in Figure 7. Reference sample presents the higher absorption rate, 6.64%. FRCs show a lower percentage of absorbed water rather than the reference mix, varying between -70% and -75% for FRC_

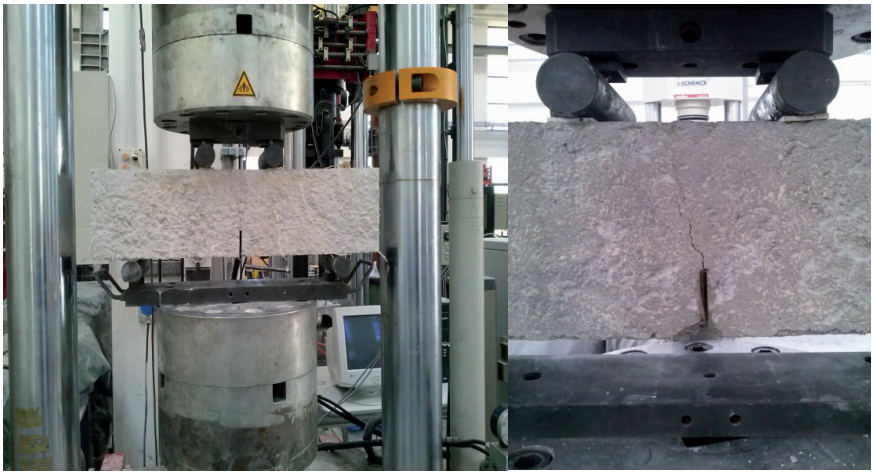


Figure 6 – Four-point bending test, notched specimen.

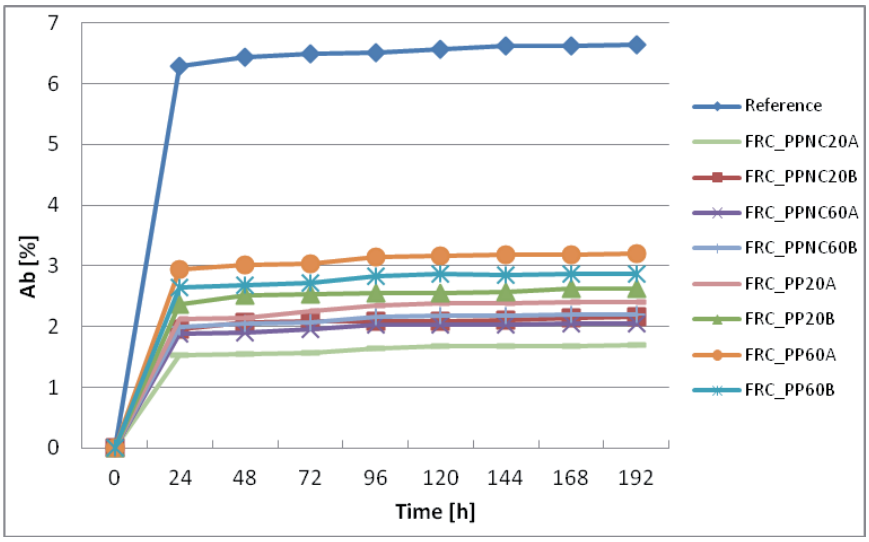


Figure 7 – Absorbed water percentage vs time

PP60A and FRC_PPNC20A respectively. Curves show a similar behaviour for the different mix: during the first 24 hours concrete absorbs the higher percentage of water and after 4 days tend to plateau. The presence of fibers leads to a lower water absorption rate and the best behaviour is registered for mix FRC_PPNC20A which contains nanocomposite fibers of 20 mm at the lower volume fraction (0.1%). Increasing fibers length and volume fraction a slightly greater percentage of water is absorbed (Figure 8 and Figure 9).

FRCs containing nanocomposite fibers absorb a slightly lower water amount compared to FRCs containing polypropylene fibers. Figure 9b shows that FRCs reinforced with longer fibers absorb more water than FRCs containing shorter fibers (Figure 9a). Thus, FRCs water absorption increases increasing fibers length and volume fraction.

Capillary water absortpion test is a further evidence of this phenomena. FRCs absorb less water, presenting clearly lower values of absorbed water per surface unit ratio, I_i (Figure 10).

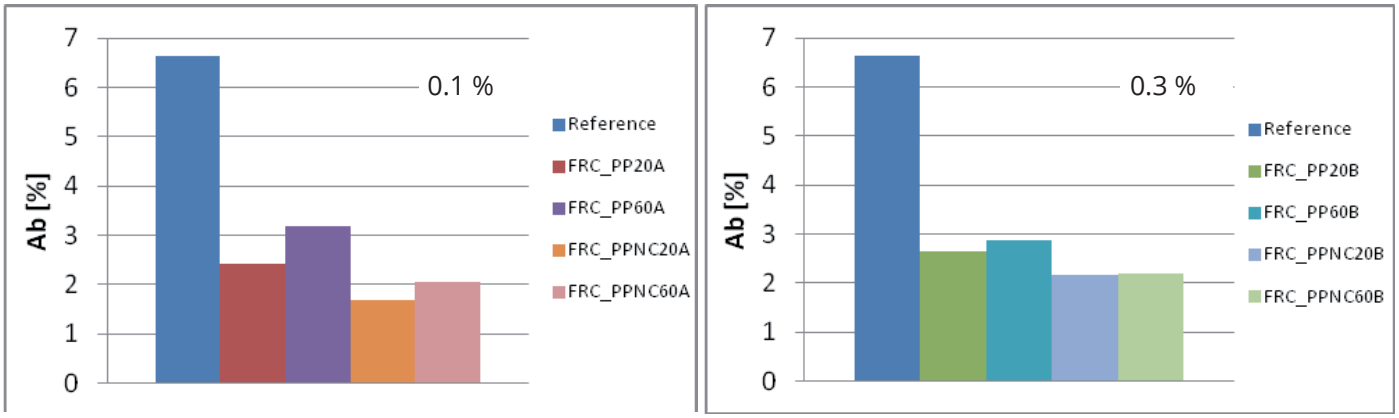


Figure 8 – Absorbed water percentage, a) 0.1% fibers volume fraction; b) 0.3% fibers volume fraction.

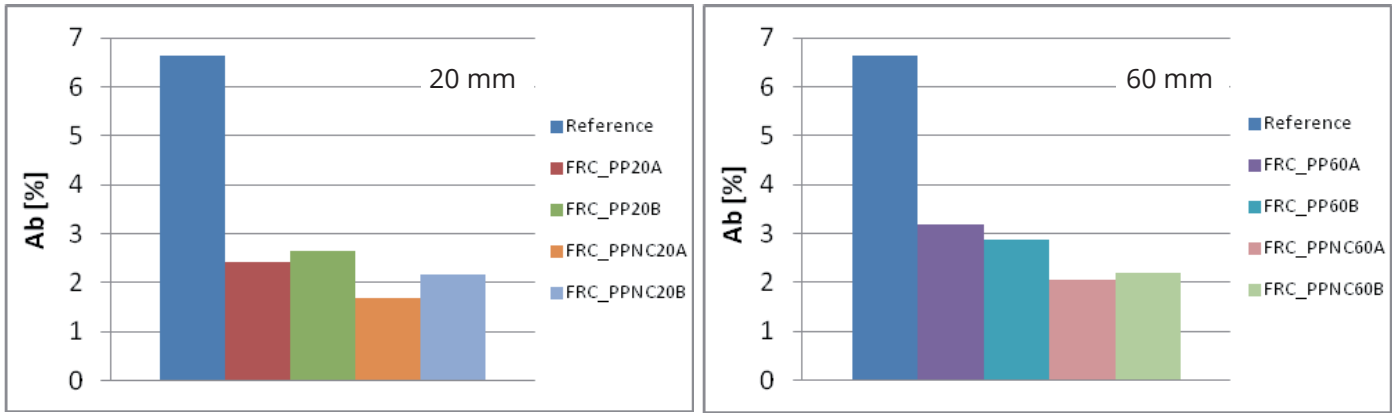


Figure 9 – Absorbed water percentage, a) fibers 20 mm long; b) fibers 60 mm long.

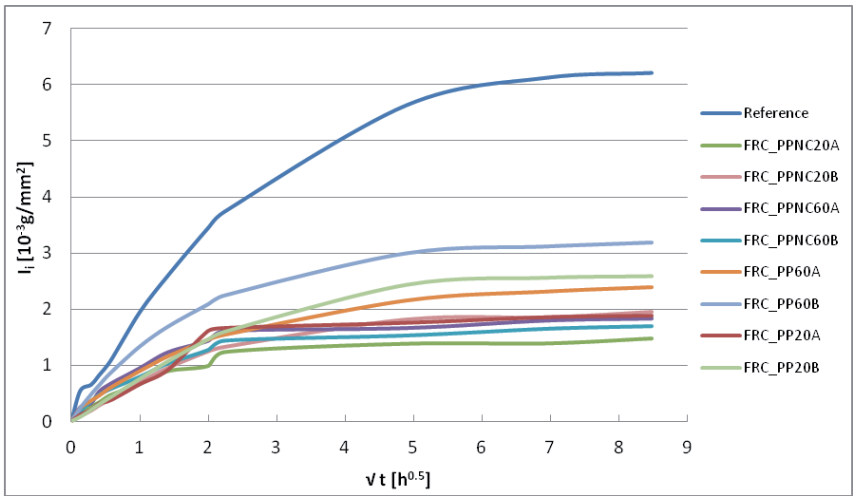


Figure 10 – Absorbed water per surface unit vs square root of time.

At the end of the test capillary rise has been measured (Figure 11). Fibers addition clearly leads to a decrease of absorbed water. Capillary rise of unreinforced reference mix is 50 mm while for FRCs it ranges between 31.50 mm and 15.10 mm for FRC_PP60B and FRC_PPNC20A, respectively. It is generally observed that FRCs reinforced with nanocomposite fibers have a lower capillary rise and increasing fiber length also to increase by increasing the capillary pores in concrete. The presence of fibers changes pores structure: fibers length, diameter and volume fraction are important parameters governing this aspect.

Sulfate attack has been evaluated by specimens weight loss over cycles number (Figure 12). For all the specimens was registered an increase of weight after the first cycle, due to the absorption of sulfate solution. Weight starts to decrease after the fourth cycle when expansive action of ettringite causes particles loss.

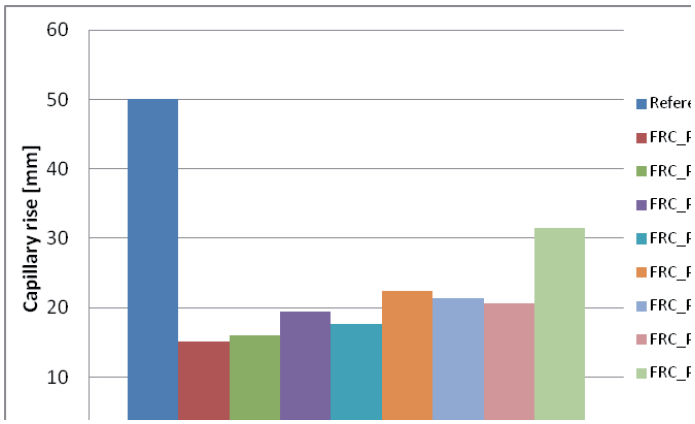


Figure 11 – Capillary rise at the end of the test.

Table 8 – Sorptivity coefficient [10^{-3} g/mm^{2}h$^{0.5}$].

Mix	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}
Reference	4.19	2.25	2.01	1.88	1.94	1.83	1.72	1.66	1.15	0.88	0.73
FRC_PP20A	0.89	0.71	0.77	0.65	0.66	0.65	0.81	0.74	0.36	0.26	0.22
FRC_PP20B	0.60	0.69	0.74	0.74	0.75	0.75	0.73	0.71	0.49	0.36	0.30
FRC_PP60A	1.78	1.26	1.11	1.04	0.89	0.81	0.72	0.68	0.43	0.33	0.28
FRC_PP60B	1.81	1.65	1.57	1.49	1.33	1.19	1.04	1.00	0.61	0.44	0.37
FRC_PPNC20A	1.04	0.90	0.83	0.81	0.66	0.63	0.49	0.55	0.28	0.20	0.17
FRC_PPNC20B	0.69	0.659	0.69	0.69	0.69	0.67	0.62	0.59	0.37	0.26	0.22
FRC_PPNC60A	1.93	1.11	1.30	1.16	0.94	0.87	0.71	0.72	0.34	0.25	0.21
FRC_PPNC60B	1.36	1.24	1.16	1.00	0.79	0.73	0.63	0.64	0.31	0.23	0.20

capillary rise increases.

Sorptivity coefficient, S_i, has been calculated by eq. 4 and results are listed in Table 8. Sorptivity coefficient is expected

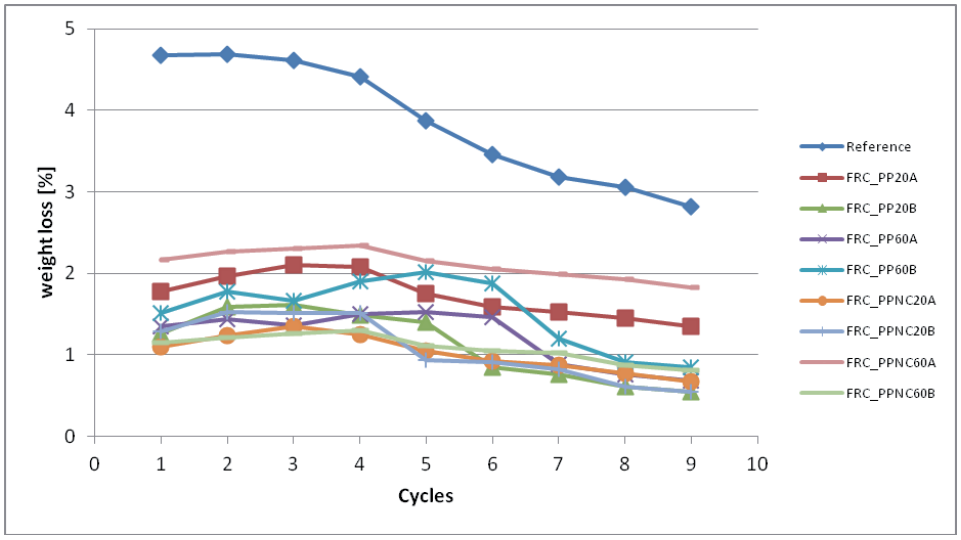


Figure 12 – Weight loss during sulfate attack cycles.

Samples are not completely destroyed after the last cycle. Reference samples show a higher mass variation after the third cycle while FRCs curves rise until the fourth cycle and then slightly decreasing. Again fibers volume fraction and fibers length are fundamental parameters: increasing fibers volume fraction weight loss decreases.

Durability factor is a parameter to assess freeze/thaw cycles resistance of concrete. Due to the low number of cycles performed in this study, is considered only the variation of durability factor over reference mix (Figure 13 and Figure 14).

The greater increase of durability factor is registered for FRCs containing the higher fibers volume fraction (Figure 13b and Figure 14). Fibers length is effectiveness at lower fibers volume fraction: FRCs with shorter fibers have higher durability factor (Figure 13a). Thus, for freeze/thaw resistance the most important parameter is the fibers volume fraction while fibers length influence plays a role at lower fibers volume fraction.

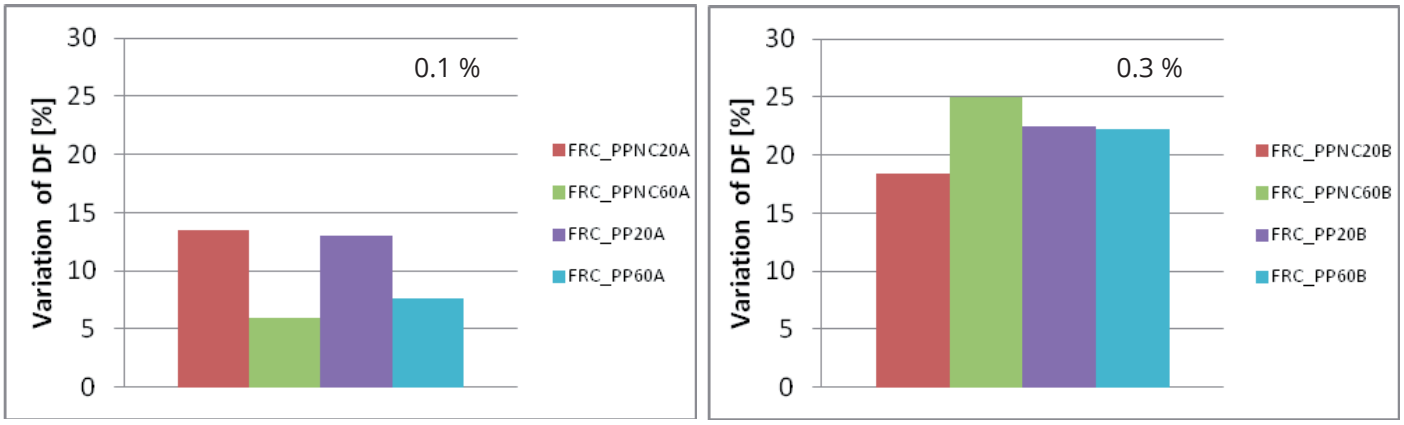


Figure 13 – Variation of durability factor over reference mix, a) 0.1% fibers volume fraction; b) 0.3% fibers volume fraction.

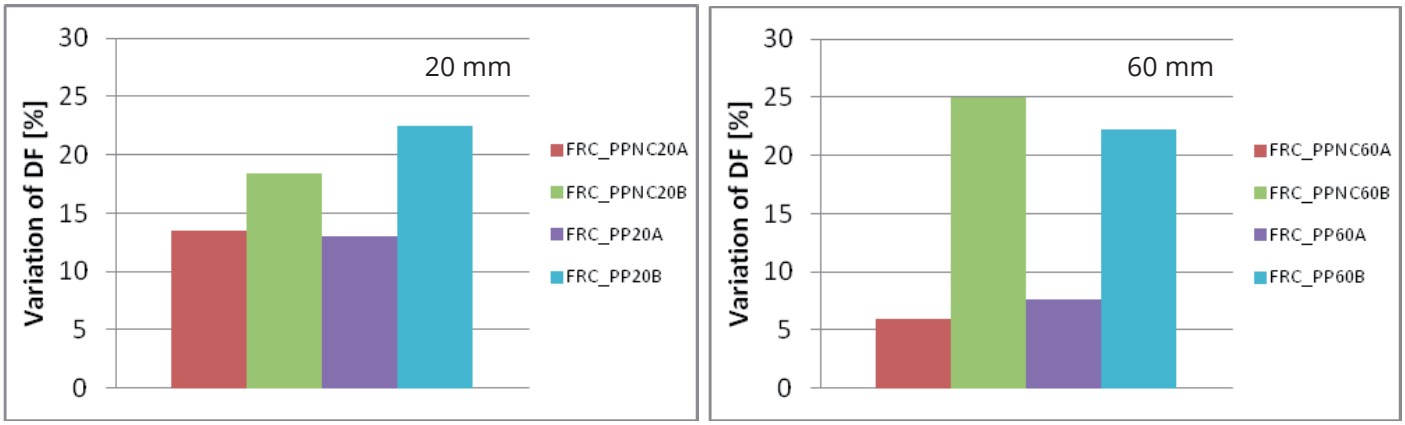


Figure 14 – Variation of durability factor over reference mix, a) 20 mm length fibers; b) 60 mm length fibers.

4. Conclusions

In the present work the influence of Nanocomposite fibers on FRCs was investigated. Nanoclay addition increases elastic modulus and tensile strength compared to pure PP fibers. Nanocomposite fibers are slightly stiffer than pure PP ones but are less ductile.

Increasing fibers volume fraction workability of concrete decreases and considering the same volume fraction, longer fibers reduces workability of concrete of a higher percentage.

Compressive and flexural strength of FRCs are not influenced by fibers addition while post-cracking behaviour is affected by fibers volume fraction and length. Fibers could bridge cracks and delay specimens failure, increasing toughness.

Fibers modify transport properties: the presence of fibers leads to a lower amount of absorbed water. The best behaviour is registered for FRCs containing few and shorter fibers. Increasing fibers length and volume fraction a slightly greater percentage of water is absorbed.

FRCs show a better durability compared to unreinforced concrete. FRCs exposed to sulfate attack show a lower weight variation during cycles, in this case the volume fraction represents an important parameter: increasing the volume fraction the weight loss decreases. Regard freeze/thaw resistance, the greater increase of durability factor is registered for FRCs containing the higher fibers volume fraction. Fibers length is effectiveness at lower fibers volume fraction.

Thus, nanoclay addition plays an important role on fibers properties but slightly differences are registered on FRCs containing nanocomposite fibers compared to pure PP fibers.

References

ASTM C 88-05, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate, 2013.

ASTM C 642-13, Standard Test Method for Density, Absorption, and Voids in Hardened Concrete, 2013.

ASTM C 1557-03, Standard Test Method for Tensile Strength and Young's Modulus of Fibers, 2013.

Bartos, P. "Review paper: bond in fibre reinforced cements and concretes," International Journal of Cement composites and Lightweight concrete, no. 3, 3 (1981): 159-177.

Jianming, G., Zhenxin, Y., Luguang, S., Tingxiu, W. and W. Sun. "Durability of concrete exposed to sulfate attack under flexural loading and drying–wetting cycles," *Construction and Building Materials,* no. 39, (2013): 33-38.

Kakooei, S., Hazizan, Md A., Morteza, J. and J. Rouhi. "The effects of polypropylene fibers on the properties of reinforced concrete structures," *Construction and Building Materials,* no. 27, (2012): 73-77.

Kim, J-HJ, Park, C-G, Lee, S-W, Lee, S-W and J-P Won. "Effects of the geometry of recycled PET fiber reinforcement on shrinkage cracking of cement-based composites," *Composites Part B: Engineering,* no. 39, 3 (2008): 442-450.

Neville, A. "The confused world of sulfate attack on concrete," *Cement and Concrete Research*, no. 34, (2004): 1275-1296.

Richardson, A.E., Coventry, K.A. and S. Wilkinson. "Freeze/thaw durability of concrete with synthetic fibre additions," Cold Regions Science and Technology, no. 83-84, (2012): 49-56.

RILEM TC 116-PCD. "Permeability of concrete as a criterion of its durability. Concrete durability— an approach towards performance testing," Materials and Structures, no. 32, (1999): 163-173.

Singh, S., Shukla, A. and R. Brown. "Pullout behaviour of polypropylene fibers from cementitious matrix," Cement and Concrete Research, no. 34, (2004): 1919–1925.

UNI EN 206-1, Concrete: Specification, performance, production and conformity, 2014.

UNI 7087, Concrete: Determination of the resistance to the degrade due to freeze-thaw cycles, 2002.

UNI 9526, Concrete: Determination of water absorption by capillarity, 1989.

UNI EN 12350-2, Testing fresh concrete. Slump-test, 2009.

UNI EN 12390-3, Testing hardened concrete. Compressive strength of test specimens, 2009.

UNI EN 12390-5, Testing hardened concrete. Flexural strength of test specimens, 2009.

Book Reviews

BOOK REVIEWS

EcoMasterplanning

Ken Yeang, John Wiley and Sons Ltd, 2009

ISBN 978-0-470-69729-0

Climate change has become a serious global threat due to our misuse of the planet.

The uncontrolled use of natural resources, the accelerated melting of the polar ice caps, the consequent rise in sea level and the callous destruction of the world's forests, are revealed in an almost daily barrage of reports and statistics.

How can we intervene? What can architects do?

Some of the answers can be found in the Ken Yeang's book: EcoMasterplanning.

The book talks about the biointegration of built environment with natural systems. It differs from conventional planning, in that it is premised upon the protection and enhancement of existing ecosystems.

EcoMasterplanning presents an innovative approach to masterplanning, based on the ecological concept of physical planning as an environmentally benign and seamless biointegration of four infrastructures that are categorised by the author as:

- grey infrastructure or engineering infrastructure: includes all the large urban engineering systems necessary for the support and functioning of any human urban development, including roads, drains, electricity, telecommunications, street lighting and solid waste disposal which should not be the usual conventional engineering system but sustainable systems;
- blue infrastructure or the water management system: sustainable drainage scheme for the management of surface water runoffs, ensuring the management of the conservation of water within the built environment and its context;
- red infrastructure or human infrastructure: includes the built forms, enclosures, recreation spaces and the pedestrian networks as well as governmental, social and economic system;
- green infrastructure or eco-infrastructure: fundamental to the ecomasterplan because it serves to sustain clean air and water, to create a greater habitat for sharing resources among species, to provide channels for species movement and interaction, as well as a wider range of other development opportunities for flora and fauna.

The book was published by John Wiley and Sons in April 2009. In a highly visually driven format, it is organized with foreword, introduction and over 20 case studies from around the world including 3 in Europe, 1 in North America, 3 in Oceania and 13 in Asia.

EcoMasterplanning points towards a better future for planning.

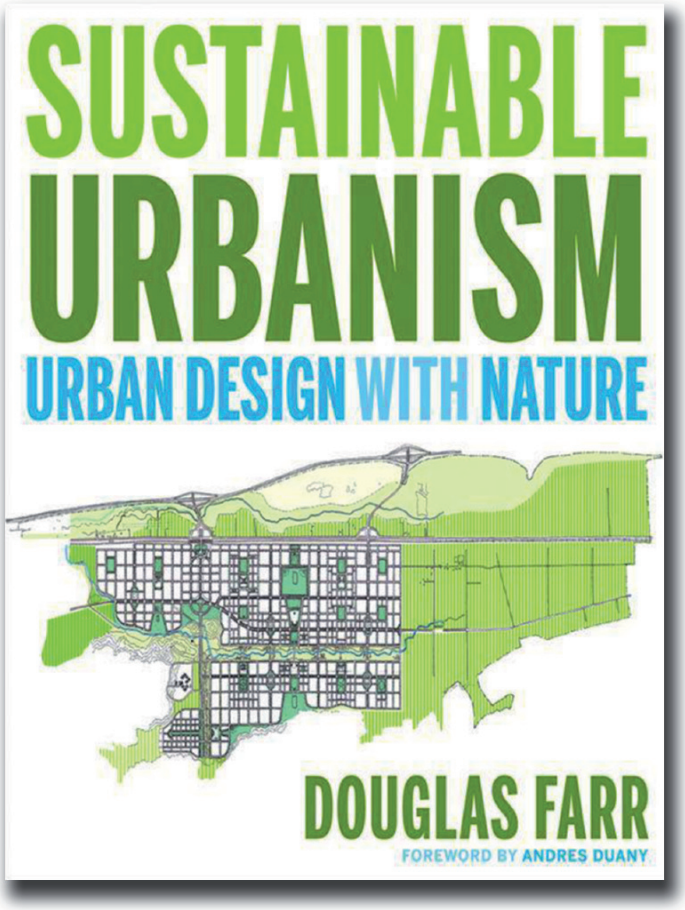
It recognises that the essence of an appropriate response resides in a deep understanding of the role and responsibilities of the masterplanner towards adopting an affirmative ecological approach to planning design.

Luigi Macchia
PhD Student
Department of Civil Engineering, Design, Building and Environment
Polytechnic and Basic Sciences School
Second University of Naples

Sustainable Urbanism: Urban design with nature.

Douglas Farr, John Wiley and Sons Ltd, 2008

ISBN: 978-0-471-77751-9



Mankind is becoming increasingly urbanized: there will be five and a half billion people by 2025; worldwide, one in two people now lives in areas highly populated. Just this fact to argue that environmental sustainability is an urban issue, the challenge is the search for a new urbanity. This is why the battle for sustainable development, for a healthier one, just and stable, from the point of view of the environment, is to fight, to a large extent in the cities.

The western economic model, which was asserted with the industrial revolution, produces a great alteration of ecosystems and a large-scale environmental change. The revision of the classical economistic finalization of the dynamics of transformation requires the search for new settlement patterns. In this cultural background, the book provides a comprehensive introduction to sustainable urbanism. Written by Douglas Farr, the chair of the **L**eadership in **E**nergy and **E**nvironmental **D**esign for **N**eighborhood **D**evelopment (**LEED-ND**) initiative, and by worthy American experts on sustainable urban design, who are involved with both the Congress for the New Urbanism and the US Green Building Council, Sustainable Urbanism: Urban Design with Nature is an urgent call to action and a comprehensive introduction to sustainable urbanism.

The book, published by John Wiley & Sons Inc. in the 2008, is organized into four parts, eleven chapters plus a preface.

The first part: The case for sustainable urbanism, is divided in two chapters: The built environment: where we are today and Sustainable urbanism: where we need to go. This part functions essentially as an outline for courses in planning, architecture, engineering, environmental studies, and interdisciplinary sustainable development that could be used to train development professionals, public officials, and municipal staff on the emerging practice of sustainable urbanism. It narrates and quantifies the magnitude of the problem, provides a history of pioneering reforms, makes the compelling case for sustainable urbanism, and outlines an agenda of strategic reforms leading to the dominance of sustainable urbanism.

The second part: Implementing sustainable urbanism, is organized in two chapters: Leadership and communications and the Process and tools for implementing sustainable urbanism. It is designed to serve as an operating system to coordinate the work of discrete individuals to achieve magnified benefits. The process section describes the detailed steps needed to implement sustainable urbanism through individual planning and development projects. It also provides templates for selecting qualified design professionals, project types, and development teams.

The third part: Emerging thresholds of sustainable urbanism is articulated in five chapters. It features nearly thirty emerging thresholds of sustainable urbanism. The thresholds can be used as benchmarks for designers to use as performance targets on projects, particularly useful in conjunction with the LEED for Neighborhood Development standard, or to provide the foundation for developing even more robust standards. The standards span five comprehensive areas of concern: density, sustainable corridors, neighborhoods, biophilia, and high-performance buildings and infrastructure. Together

these constitute some of the most challenging opportunities for design integration in sustainable urbanism.

- *Density.* Sustainable urbanism is not achievable at low densities below 7-8 dwelling units per acre (DU/A). The sites should be dense enough to set the place walkable and provide the place with public traffic system. For these reasons, sustainable urbanism requires minimum development densities roughly four times higher than an average U.S. development density of two DU/A.
- *Sustainable corridors* are building blocks of sustainable regions. The main parametres of such a corridor are its density and land use mix. To achieve a well-based density and to free people from automobile dependence, a minimum of 7 DU/A is required. For even better service and modes, a density of 15 DU/A for trolley transfer and 22 DU/A for light trail system are necessary. The corridor land use mix should achieve a 1:1 job-housing balance. Transit corridors are the backbone of sustainable urbanism, linking neighborhoods together with districts and other regional destinations;
- *Biophilia* (Human access to nature) concerns in detail biotopes, stormwater systems, locally grown food and local waste management;
- *High-Performance Buildings and Infrastructure*. In this chapter, the impact of urban planning on building energy usage is shown. Building orientation and massing (which is the work of an urban planner) have significant influence on the energy used by the unit, even before any energy efficiency measures are incorporated into the design. From a planner's perspective the results are obvious: reducing surface-to-volume ratio as much as possible and reducing south-facing glass that receives direct sunlight. The term *high-performance infrastructure* refers to core best practices improving the performance of the entire roadway system. This design includes street and sidewalk, underground utilities, stormwater infrastructure, landscapes, and streetscape elements.

The fourth part: Case Studies in Sustainable Urbanism is organized in two chapters: Lessons Learned from Sustainable Urbanism and State of the Art in Unbuilt Sustainable Urbanism. It documents a diverse and mature worldwide movement of visionary neighborhood-scale projects, both those already built and those yet to be built, that take a sustainable urbanistic approach.

Summarizing, the essays written by Farr and others delve into such issues as: increasing sustainability through density, integrating transportation and land use, building up sustainable neighborhoods, including housing, car-free areas, locally-owned stores, walkable neighborhoods, and universal accessibility. It may be an answer to many questions referring to how places should grow, how people should get from one place to another and how people could live in a more sustainable way. The text provides a clear direction for urban designers, urban planners, and architects to design cities and developments that are sustainable and reduce environmental harms. The book includes a wide background on sustainability, case studies of exemplars of sustainable urban design and standards for sustainable urbanism. In particular the last one seems to be an important contribution to urban planning techniques to plan and design new types of human settlements.

Salvatore Losco
Assistant Professor in Urban and Regional Planning
Department of Civil Engineering, Design, Building and Environment
Polytechnic and Basic Sciences School
Second University of Naples

CSEJ
City Safety Energy
Journal

Le Penseur Publishing

CSE JOURNAL | CITY SAFETY ENERGY
ISSN 2283-8767
40002
9 772283 876009
Price € 30,00