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

The cover image is Rue de Rivoli - an emblematic street of Paris connecting Bastille to Concorde – that since May 2020 has been reserved for bicycles and pedestrians, Paris, France, Saturday, Nov. 6, 2021.

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Evergreen Section

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The city as a complex system in structural crisis

Rocco Papa [a], Rosaria Battarra [b], Romano Fistola [c], Carmela Gargiulo [d]*

[a] Department of Civil, Architectural and Environmental Engineering (DICEA), University of Naples Federico II, Italy
e-mail: rpapa@unina.it
ORCID: http://orcid.org/0000-0003-3355-1418

[b] Institute for Studies on the Mediterranean, National Research Council, Naples, Italy
e-mail: rosaria.battarra@ismed.cnr.it
ORCID: https://orcid.org/0000-0003-4607-6329

[c] Department of Engineering, University of Sannio, Benevento, Italy
e-mail: rfistola@unisannio
ORCID: https://orcid.org/0000-0001-6758-7510

[d] Department of Civil, Architectural and Environmental Engineering (DICEA), University of Naples Federico II, Italy
e-mail: gargiulo@unina.it
ORCID: http://orcid.org/0000-0001-6481-0908
* Corresponding author

Evergreen section

This work was published in Italian in 1995 with the title "La città come sistema complesso in crisi strutturale" as a contribution in the volume Bertuglia, S.C., Fuccella, R. & Sartorio, G. (eds), "La città come sistema complesso in crisi strutturale: strumenti e tecniche per il governo metropolitano", Giuffrè, Milano.
The book is included in the Studi Urbanistici series published by Fondazione Aldo Della Rocca and it can be consulted, in its original version, at the following address: https://www.fondazionedellarocca.it/
The authors thank the President Gian Aldo Della Rocca for having authorized the publication of the research in English. The paper in this new section of TeMA Journal, Evergreen, is the literal English translation (only some tables have been deleted from the original text). This section aims at drawing the attention of the international scientific community to papers that, despite the passing of time, still present elements of significative scientific interest – insights, anticipations and reflections – enough to deserve careful read back.

Abstract

The paper aims to be a contribution to the resolution of the deep crisis that has been affecting the current urban realities, facing the problem in all of its aspects, such as those of scientific and methodological approach and operating procedures.

Keywords

Complexity theory; Government of urban system; Multivariate statistical analysis.

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1. Introduction

This work aims to be a contribution to the resolution of the deep crisis that has been affecting the current urban realities, facing the problem in all of its aspects, such as those of scientific and methodological approach and operating procedures. In other terms, the awareness of the priority of the "city problem" on a national and international scale makes it necessary, not only the re-examination of the procedures by which urban phenomena have been faced until today, but also and firstly the "way of seeing" the city, and therefore the philosophy of approach to the urban issue.

The working group that carried on this research is convinced that to the increased complexity of the urban problem must correspond an adequate methodology of analysis and intervention, which makes use of appropriate techniques and tools, also through the intake of new technologies.

If attention is focused on the "government" of the city, urban planning and land use planning must be seen and considered, primarily, as organizational sciences. For this reason, it is necessary that the urban government is addressed at eliminating the negative externalities resulting from the increasing urban entropy and macroscopically visible in the current process of urban and metropolitan transformation.

Against this background, this paper is configured as an attempt of redesigning the approach to urban systems, oriented to the improvement and optimization of the planning, management, control and governance abilities of the transformations that affect metropolitan areas.

In this way, the strategies for governing the complexity of the "urban system" are individualized. The assumption of these strategies is the concept of urban system that not only includes the city and its complex becoming, but also the complexity of the system of decision-makers who define the desired states of the city and the complexity of the decision-making systems. The premises that refer to the whole work are related to the "paradigm of the complexity" that seems to offer the greatest scientific guarantees of reference and relation to frame, in a scientifical way, the metropolitan phenomenon.

The logic adopted in this study is the systemic-procedural one which allows to figure out the city both as a "physical phenomenon" (its form, its streets, its buildings) and as a "functional phenomenon" (the relationships existing between its elements and the laws regulating these relationships).

The focal point of this work is represented by the part related to the government of the city, where some tools are proposed, such as innovative techniques and procedures as essential elements to relaunch a new and effective policy of planning and governance of the territory. Eventually, it is reported a first application of the methodology described on a sample area: the Neapolitan conurbation.

In extreme synthesis, this work proposes three distinct lines of action to face and solve the current crisis of the city. The first one aims to updating, the reading techniques and cognitive tools of the urban phenomenon in the light of the possibilities that science and technology make available.

The second one must have as its target the redefinition of the "interpretative paradigms" of the urban phenomenon. Suffice it to say to the Copernican revolution that takes place looking at the city no longer as a machine but as a complex non-deterministic system.

The overriding objective of the third line of action must be the definition of new instruments and renewed techniques of city governance. And this is due, not only to the updating of reading and analysis techniques, but also to the new interpretative models of the city. As a matter of fact, if the urban system is connoted by its complexity, it will be necessary that the tools and techniques of governance of this complexity are no longer static projection tools (the current regulatory plans) or cumbersome and very slow techniques of formal and bureaucratic control but conform to the dynamism and variety of the 21st century city.

The work, conceived and developed in a unified action by the research team, for the necessary scientific attributions among the authors can be divided as follows: the second paragraph was drawn up by Carmela Gargiulo, the third paragraph by Rocco Papa, the fourth and the fifth paragraph by Romano Fistola and the sixth paragraph by Rosaria Battarra.

2. The city as a dynamically complex system

2.1 The 21st century city: the challenge of complexity

The concept of system and, particularly, of complex system has been pervading for some years all the scientific disciplines to the point of involving a "revolution of thought".

The methodological and operational approaches that each discipline has reworked on the basis of the new scientific thought have, in turn, produced re-orientations, in many cases even radical. At the bases of the new "vision" of the world and in general of the natural and social phenomena, there is a consideration that today may appear simple and natural, but which is the result of continuous revisions and readjustments in philosophical and scientific speculation.

The concept of "object" is replaced by the concept of "system", i.e., the Aristotelian model in which the object is composed of only two parts "form/substance" and the Cartesian model, in which the object is reducible and decomposable, have been overcome to reach the concept of system understood as a "complex unit".

The system is a set of elements and relations between the elements that define its organization. If, however, a system such as a set is composed of several elements, the rules of composition won't be simply additive as in the case of a set, but relational.

In this regard, a system can be conceived as the product of the interrelations/interactions among the elements that constitute it, of the internal organization, of the conditions, of the conditionings, of the constraints of the environment of which it is part.

The variables that define the complexity of a system, can be identified in the number and quality of the component elements, in the type and in the degree of the relationships among the elements, in the number of hierarchical levels of the relationship structure (the organization).

In one of them the systemic concept simultaneously expresses unity and multiplicity, totality, diversity, organization and complexity.

However, there are still other considerations, directly dependent on the concept of complexity, on which philosophy, theoretical physics, but also disciplines such as ecology, economics and sociology, invite to confront themselves.

In this respect, it should be emphasized that the difficulty and in many cases the impossibility of interpreting the phenomena of reality and predicting their evolution over time have undermined the conception according to which it is possible to predict, with certainty, the future evolution of a system through the knowledge of its initial state.

The theory we are referring to is the deterministic one developed by Laplace in 1776; it is based on the second law of dynamics: F = ma which, for a long time, was considered a recipe for predicting the future. If the F forces, acting on an assigned mass m are known, also the acceleration a will be known. Starting from here it follows that if the position and velocity of an object can be known and measured at a given instant, they can be determined under any condition.

The scientific research of the twentieth century has questioned Laplace's determinism following a surprising discovery: deterministic systems, also very simple in their organization and consisting of a few elements, can manifest an uncertain behavior. Such randomness is an intrinsic quality of the system itself and does not depend on the type or quantity of information available.

The first to intuit the existence of randomness was the mathematician French Henri Poincaré (1908), who observed that fortuitous phenomena can occur in a system; the very small variation that they cause on the system in the present has enormous repercussions in the future.

"A very small cause that escapes our attention determines a considerable effect that we cannot fail to see, and so we say that the effect is due to chance. If we knew exactly the laws of nature and the situation of the universe in its initial state, we could predict exactly the situation of the same universe at a later time. But even

if it happened that the natural laws no longer had any secret for us, even then we could know the initial situation only approximately. If this allowed us to predict the next situation with the same approximation, we would not need more and we would have to say that the phenomenon was predicted, that it is governed by laws. But this is not always the case; it may happen that small differences in the initial conditions produce very large ones in the final phenomena. A small mistake in the former produces a huge error in the latter. Prediction becomes impossible and there is a fortuitous phenomenon".

This kind of randomness was given the name of "chaos" in later times.

One of the principles on which chaos theory is based is the principle of indetermination by Heisenberg, according to which "the exactness, by which classical concepts can be judiciously applied to the description of nature, is limited by the so-called relations of indeterminacy".

This principle, which has become a fundamental principle of quantum mechanics, provides a good explanation of some random phenomena at a very small atomic scale.

On a larger scale, the reasons for unpredictability must be sought in other fields; for example, in the random motion of fluids. In reality, it is not necessary to appeal to such complicated and indeterminate systems because the random behavior also occurs in very simple systems.

In general, it can be said that chaotic systems are very sensitive to small actions at every point of their becoming. In this sense, the degree of indeterminacy that a chaotic system can achieve is extremely high. In addition, any phenomenon, even very small, can very quickly reach macroscopic proportions. In other words, in the presence of chaos any prediction is destined to reach a huge inaccuracy.

The conceptual framework of reference for the study of chaos can be traced back to the theory of dynamical systems (Gargiulo & Papa, 1993). The definition of a dynamic system is given by the essential information about the system (the characteristics) and by the laws and criteria of evolution of the state over time (the dynamics). The space of existence of evolution is called the space of states or space of phases (Fig.1); such a space is a purely conceptual abstraction whose coordinates are the components of the state.

Of course, the coordinates of the phase space change with the context; for example, for a mechanical system they could be identified in position and speed, for an ecological system in the populations of the various species.

Even if it is recognized that the behavior of chaotic dynamical systems is unpredictable, the space of states can be useful to represent such behavior in geometric form.

With regard to the representation of chaos, it can be said that fractals represent the geometry of chaos.

The spatial correspondence between chaos and fractals is not accidental; as a matter of fact, an analogy between fractal geometry and chaos consists in the fact that in both fields the most recent discoveries have occurred as a result of scientific advances that have questioned the traditional view of mathematics. Fractals represent above all a language of geometry; they are expressed not by primary forms (straight line, circle, etc.) but through algorithms, i.e., through sets of mathematical procedures (Fig.2). These algorithms are then translated into geometric shapes by means of a computer.

At the current state of knowledge, therefore, chaos theory does not allow to give a solution to the problem of predicting the evolution of systems also because there are still many unknowns about the actual role and meaning of chaos. One measure for chaos is entropy.

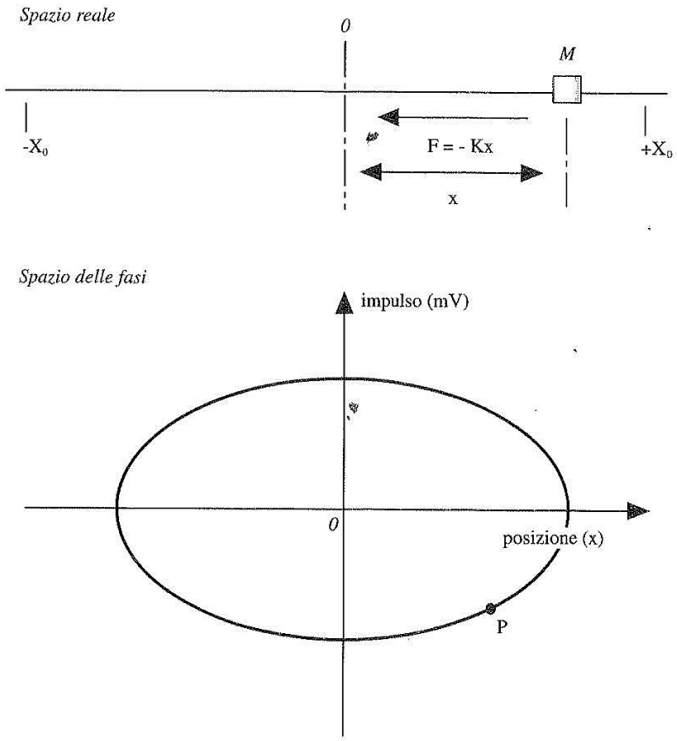


Fig.1 The representation of real space and phase space (source: Vidal and Roux, 1981)

The concept of phase space can be illustrated quite simply in the case of the harmonic oscillator. The classical image of this oscillator consists of a body M of mass m moving along a straight line Ox constantly subject to a direct booster force towards an equilibrium position assumed as the origin. The intensity of this force is directly proportional to the distance OM = x. Under these conditions, the body M oscillates on one side and the other of O with a maximum elongation XO. At each instant t the state of the oscillator is completely defined by only two variables: the instantaneous x(t) position and velocity v(t) of the M body. Consequently, the corresponding phase space is a plane with the position and pulse coordinates: each state of the oscillator is associated with a point P of this plane. If the oscillator is at rest in the equilibrium position O, its state will be represented by the origin point of the coordinate system, since x = 0 and mv = 0. If the body oscillates freely from one side of O to the other, the representative point P will move in the plane generating a trajectory in the phase space. The trajectory shows that it is an ellipse with centre in the origin, as long as the oscillator is isolated and there is no friction. Thus a curve, i.e., a geometric entity, can provide a complete description of the oscillator's motion. The use of such a representation is of decisive interest when the system studied or its dynamics are relatively complex.

The concept of entropy follows from the second law of thermodynamics; every time energy is transformed from one state into another, the available energy is reduced in favour of the unavailable energy. As Rifkin (1982) explains, the transformation of energy requires you to "pay a price". This cost is represented by a loss of energy available to perform work of a certain type in the future. The term that describes this fact is entropy. An increase in entropy, therefore means a decrease in available energy.

When energy and matter become unavailable, we come to the greatest possible disorder and therefore chaos. The second law of thermodynamics refers both to energy and to the order and above all to the organization of systems; in this respect this principle applied to a physical system is defined as a statistical principle of energy degradation, disorder of the constituent elements and therefore of disorganization.

Thus, the centrality of organization as an intrinsic quality of complex systems strongly emerges.

Organization means the form, distribution and intensity of the relationships between the components that a complex unit or system produces. Ultimately, the ability to organize is one of the fundamental properties of a system and can be expressed as the transformation of relational interactions into an organization.

The organization thus becomes the constituent property of a system.

The variety and multiplicity of existing systems makes it possible to build a hierarchy and categorization of systems.

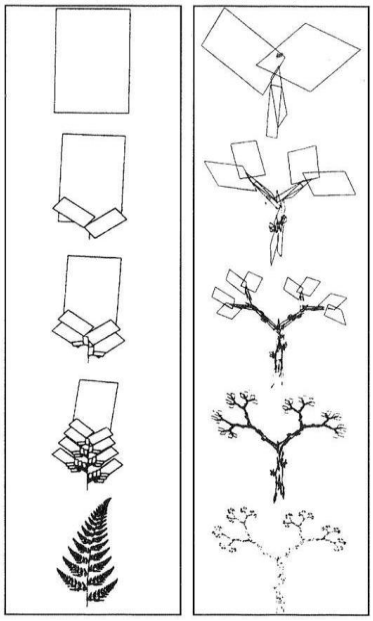


Fig.2 The generation of fractal images (source: Jurgens, Peitgen and Saupe, 1990)

Simple examples of fractal images can be generated from the feedback ring of the photocopier machine; such images depend only on your copying program. The initial rectangle is transformed by a program that halves the size of an image and copies it three times until a fern fractal (left) or fractal tree (right) is obtained. A few numbers defining the copying rules are enough to specify an image that would require hundreds of thousands of numbers to be described with traditional methods.

Five different figures of organization are thus identified:

- system;
- subsystem;
- supersystem;
- ecosystem;
- metasystem.

if system is meant as that autonomous system in relation to what is external to it; a subsystem is a system subordinate to a system of which it is a part; for supersystem, a system that controls other systems that are not included in this; by ecosystem, the systemic set of which interrelations and interactions constitute the environment of the systems that are part of it and finally for Meta system, the system that results from the interrelationships that transform and come to understand two previously independent systems (Morin, 1983). The determination of the hierarchical level of a system depends, substantially, on the choices, selections and decisions of the observer, by whom the very conceptualization of a system ultimately depends.

In other terms, in the definition of a system there are always, at the base, decisions and choices of a subject, who operates within the polysystemic selections in relation to its own purposes, the available tools and in relation to the cultural and social context.

It should be emphasized that the chaos theory produces degrees of complexity even within the scientific method of verifying a theory; until now, the method of verifying a theory has consisted in making predictions and, subsequently, comparing them with experimental data. For chaotic systems, the circumstance of the impossibility of predictions means that the verification of a theory becomes difficult and full of pitfalls, which refers to statistical and geometric properties rather than detailed and punctual predictions.

Among the infinite systems in which physical reality can be articulated there is the city, which is attributable to a dynamic system of high complexity.

As mentioned before, giving such a definition of the city means affirming, firstly, that the city is attributable to a set of components related to each other (system) and, moreover, that the future evolution of the city-

system is not linearly predictable on the basis of the knowledge of the initial conditions and that the processes of the system are not manageable and controllable through deterministic tools.
The degree of complexity reached by the city and, in particular, by the metropolitan conurbations is such that, at present, the decision-makers and administrators are unable to provide a compatible and adequate solution to the management and government problems that a system such as that urban poses as it is also subjected to the processes of maximization of entropy.
Until a few decades ago the city managed to develop while maintaining harmony and compatibility between its parts; today the occurrence, on the urban structure, of extremely variable and changing events, difficult to trace back to only one cause, but almost always the result of causes that are difficult to read and the inability to control and manage these phenomena, also due to the inadequacy of the adopted procedures and the means available, is determining unbearable conditions of hardship and congestion.
It is also worth to add the contribution of the introduction of new technologies that, involving all levels and sectors of associated life, produce effects whose peculiar characteristics are both of a cumulative type and of an effusive type (Gargiulo, 1990).
Such characteristics, encouraging the acceleration of the growth process of the sectors that they invest, generate new progress and new knowledge. Thanks to these characteristics so distinctly self-propelling, the ability to affirm and spread technological progress goes beyond the narrow limits of productive economic activities, for which, in most cases, it finds inspiration and stimulus, coming to profoundly affect the social, political and of course territorial aspects.
From the above, it can be understood how the multiplicity, the multiformity and the variety of existing relationships, in a word the complexity, within the society-city system requires adequate methods of reading and analysis and innovative control and management tools and techniques.
In this perspective, the role of the "paradigm of complexity" in the resolution of urban and metropolitan problems becomes the challenge on which to focus for 21st century city. Through this paradigm of the 21st century city will be the city where, through the right interpretation (reading and analysis) of the complex phenomena that are affecting the city, it is necessary to define procedures, techniques and adequate tools to restore well-being, livability and quality of life to the users of the 21st century city.

2.2 The city as a system with a strong complexity

The enormous growth of the city and its high degree of hardship, the uneasiness of its users and the degradation that is not only physical, but also and above all social, are phenomena that have undergone an increasing acceleration over the last decades.
It is interesting in this regard to recall how, already at the end of the 30s, Mumford (1938), taking up a well-known diagram by Geddes, would have prophesied the end of the metropolis if the trends towards uncontrolled urbanization had continued.
This interpretative key, actually, rather widespread, which provided for a "global urbanization" of the city and therefore its inevitable decline has been, partially, contradicted by the slowdown in the growth of the city in the last decade, so that, assuming as an interpretative key that of the "cycles of urban life", it has been affirmed by many parties that the large cities of the industrialized world are going through a phase of deurbanization or counter-urbanization that manifests itself precisely with phenomena such as the arrest if not even the loss of population (Martinotti, 1990).
Once again the image that this interpretation of urban growth gives us is that of "urban crisis" and "death of the city" even if this seems to be in clear contradiction with the phenomena of congestion, pollution, hardship but also, at the same time, with the strong, creative and innovative prospective — what has been defined as city effect (Conti & Spriano, 1989) — which seem to characterize some of the great cities of the West.

The speed of the processes of transformation that characterize the metropolis, the coexistence of apparently contradictory phenomena, the ever-increasing diffusion of the products of technology that – to recall only one of the effects induced on the "urban shape" by telematics and computer science – modify the localization logics of activities and contribute to make it increasingly difficult to read and interpret urban phenomena (Papa, 1993).

In the world of scientific research, the affirmation that the city as a "system" defined by the elements (the different activities and functions) and by the interactions and relationships between its multiple components (communications and channels) that are expressed on its territory and that produce, with different intensities and methods effects difficult to detect on all parts of the city, has been shared for a long time. (Me Loughlin, 1973).

Starting from this "position", accepted and shared by those who study and are interested in the city as a whole, various methodological and operational approaches have been developed.

There is no doubt that, at least in the initial approach, the study of urban phenomena causes many situations of discomfort caused both by the difficulty of univocally adopting one of the approaches developed, and by the complexity of the phenomena that manifest themselves in the city.

Among the scientific paradigms currently available to interpret the variety and interdependence of urban phenomena, the paradigm of complexity seems to offer the greatest guarantees of relevance and relationship.

The city can be interpreted not only as a "physical phenomenon" (its shape, its streets, its building) but also as a "functional phenomenon" (the relationships that exist between its components and the laws that regulate these relations, and therefore the life itself and the development of the city) (Papa, 1992).

In relation to this reading, the scientific approach of reference for the study of a metropolitan system is the systemic-processual one oriented to the definition of the reciprocal influences between the elements of the system and between the system and its components.

This approach can be traced back to the theory of catastrophes by Thom and to the philosophy of heterogeneity by Morin that considers the city system as a structure whose state is continuously modified by the contribution of energy (stresses) that it receives from the outside and that consumes incessantly. Its equilibrium state is only apparent since, actually, it turns out to be stationary or dynamically stable; the city, i.e., is a system characterized by an inextricable complementarity between "disordered phenomena" and "organizing phenomena", which self-regulate a subsequent state of equilibrium.

To govern such a system, it is necessary in the first instance, to know its whole structure; it is necessary to know what the parts of the system are and how they interact; in other words, to know the elements and laws that regulate its integration, without which (elements, laws and integration) one could not even think of a system.

In actual fact, the essential characteristic that allows the existence of any generic system is what Edgar Morin (1983) defines as "organizational antagonism". Every organizational interrelationship presupposes the existence and play of attractions, affinities, possibilities of connections or communications among the elements. But the preservation of differences presupposes in the same way the existence of forces of exclusion, repulsion, dissociation, without which everything would be confused and no system would be conceivable.

In other terms, every system and, above all, the urban system, produces internally both antagonism and complementarity; to govern a system it is therefore necessary to know the rules (if there are any) with which antagonisms and complementarities are organized.

Before Morin, also von Bertalanffy (1968) had stated that every totality is based on the competition between its elements and presupposes the struggle between its parts. We cannot speak, therefore, about a system without presupposing the idea of antagonism; but such an idea carries as an implicit and direct consequence the potential disorganization or disorder. As a matter of fact, the moment when the system goes into crisis,

disorder spreads. The system goes into crisis when differences turn into oppositions and complementarities into antagonisms.

In other words, it is necessary to know the elements of a metropolitan system and the laws that rule its mutual relations to identify the several dysfunctions and the various internal anomalies.

To better clarify the terms of the issue, it is appropriate to briefly recall the type of approach, we are proposing to be adopt: the systemic-functional conception of the city.

This conception leads directly to the general theory of systems, which, applied to the urban phenomenon, allows the construction of a model of investigation useful for the interpretation and decoding of urban complexity. In this respect, at the reading and analysis of the city-system it is necessary to combine the characteristics of the individual parts of a system with the characteristics of the entire system, trying to find the interrelationship that links the single parts to the whole and vice versa.

The circuit on which the passage from the parts to the whole is triggered and from this back to the parts is of a polyrelational type as the elements must be in their characters, in the relationships in which they take part, in the entire organization in which they exist and ultimately in that particular "culture medium" in which they are inserted (that particular system); vice versa the system must be defined in its distinctive features, in the relationships existing between its elements and in its relations with each of its elements. Continuing down this scientific approach and from the observation of the urban system, it can be said that the city and in particular a metropolitan area is certainly a dynamically complex system.

On the basis of the considerations expressed above and from the theory of dynamical systems it is deduced that the evolution of the city cannot be linearly predicted on the basis of current conditions (Bertuglia & La Bella, 1991). Saying, therefore, that a city is a dynamically complex system means to say that this system is defined, in addition to its own characteristics, by laws and criteria of evolution of the state that change over time.

The dynamic complexity that characterizes the city depends essentially on three main variables:

- the levels of hierarchy;
- the type and quality of the relationship;
- the number of elements.

The various levels of hierarchy allow us to read the urban structure according to various points of view. From the functional-antagonistic point of view, for example, there is a hierarchy within the city that can be traced back to the centre/periphery antagonism.

The type and quality of the possible relationship paths refer to the interconnection between the various elements of the system and depend on the ability to know the effects that each action performed even on a single part of the system can generate on one or more different parts and on the other relationships.

A function of complexity can be expressed as follows:

$$C = f(l_g, r_t, e_n)$$

where l_g= hierarchical levels

r_t= types and quality of relationships

e_n= number of elements.

The invariants of urban complexity that distinguishes the modern city and, above all, that of technologically advanced countries can be traced back to particular phenomena that spread with increasing intensity and that mark the difference between the organization of the current city and that of the city of the past. These phenomena refer specifically to three conditions connoting the current city:

- concentration;
- specialization;
- integration.

The first condition refers to the high physical concentration of urban and metropolitan activities. The second one refers to the increasing specialization of urban and metropolitan activities that can also be read as a direct consequence of the high concentration. The first two conditions require, consequently, the strong functional integration between activities and groups of activities.

The concentration, specialization and integration of activities produce such synergies in the urban and metropolitan system as to connoting the city as the place of complexity because complex is the system of relationships and activities and, therefore, the organization of the city.

A first response, in a methodological key, to the growing and dynamic urban complexity must be oriented mainly towards three methodological objectives:

- redefining the cognitive paradigms of urban phenomena;
- reconfiguring the techniques and methods of interpreting these phenomena;
- adapt the instruments and techniques of governance to the variety and complexity of the systems to be governed.

In an operational key, the considerations carried out push to define the levels of "treatability" of the system to be controlled and to adapt the availability and degree of sophistication of the control tools at these levels; secondly, to adapt the reading and knowledge of the urban system to the levels of operation of the instruments of government and thirdly to diversify the instruments of government at the level of the complexity of the system to be governed.

In the definition of this new and articulated methodological context of reference, a role that is certainly not marginal is played by the potential that the use of new technologies can develop, both in an instrumental key in terms of aids to knowledge, interpretation, and control of the urban system, but also in terms of rebalancing factor in defining the territorial structures and hierarchies of the next future (Beguinot, 1989).

In the perspective oriented to the "refinement" of the interpretative paradigms of the urban reality in view of the adaptation to the growing complexity, it is necessary to articulate the city in a plurality of subsystems constituting the "city-system".

Favoring the definition of the city as the maximum expression of the community to configure and organize the space, that is, considering the physical-formal characteristics of the city, the physical subsystem (the stone city) is defined; if the city is understood as the place of the maximum functional and relational concentration, that is, if urban activities and the relationships between them are taken into account, the functional subsystem (the city of relationships) will be defined; if, finally, the city is defined as a "semantic space", i.e., the way in which the inhabitants perceive and live their own habitat is preferred, the perceptive-semantic subsystem (the city of experience) will be defined.

Three subsystems that refer to three cities, therefore: a "city of stone" which constitutes the physical city, a "city of relationship" which constitutes the functional city and a "city of man" as a synthesis of the psycho-perceptive relationship between man and his own habitat. The three cities (Beguinot & Cardarelli, 1992) have always "coexisted" in the same space and at the same time. If the first constitutes the premise and the condition for the life of the second, the latter animates the first one that otherwise would be reduced to a useless succession of full and empty ili deprived of life, the third one is finally the image of the city that everyone has within himself, the result of the complex and changing relationship that is established between the individual, stone city and relationship city.

The factors affecting the development or obsolescence of each of the three cities are profoundly different; that is the reason why only in periods of great stability, the city, in its wholeness, experienced periods of prosperity and harmony; vice versa, in periods of great transformation — social, political, economic and cultural — the city experienced seasons of profound crisis, even structural, which even questioned its existence.

Assuming this key of interpretation, as it is defined in more detail in the following, the development or the current crisis of the city can be interpreted as the greater or lesser adaptability of the physical city to the

functional city, thus guaranteeing the complex system of relationships, increasingly numerous, to express itself without this intensification of exchanges translating into an increase in entropy, with effects of chaos and congestion that are difficult to control.

The current city, for its complexity and for the continuous transformation of the man-city relationship, needs the recovery of the correct use of space that is constantly altered to try to adapt to the multiplicity of functions and activities that the modern city must perform.

In other words, it could be said that in periods of great and rapid transformations, such as the current one, characterized by the growing introduction of new technologies that make possible ways and times of communication very different from the past, the stone city, which has a greater inertia to change than the city of relationships, cannot keep up with the functional city.

The different speeds of evolution of the three cities are therefore among the causes of its crisis and the discomfort of its inhabitants: in the modern city the stone city not only does not favor the life of the functional city, but even constitutes one of the major obstacles to its correct development; man is no longer able to recognize the city and above all to know himself within it.

To overcome this situation, it is necessary to relaunch a policy of transformation of our cities to adapt them to the changed needs of the community through operations of great cultural scope, before technical-operational. But to do this it is essential to develop a new and different philosophy of approach to the city, the one, proposed here, which refers to the theory of dynamical and complex systems. With the support of this it is necessary to analyze the urban and metropolitan problems in the light of the changes taking place triggered by social, economic but above all technical-scientific progress, which new technologies direct and feed.

The condition of chaos that seems to be a constant of the modern city naturally affects all "the three cities in the city".

In the city of stone, the demands for performance become more and more intense and sophisticated, as required by post-industrial society.

In the city of relationships, the number and intensity of relationships increase incessantly to the point of making it impossible the comprehension of its complexity. To try to solve this situation that, over time, becomes increasingly unsustainable, it is necessary and urgent to develop new techniques and new tools for urban and metropolitan government, management and control.

In the lived city the references and connotations of the cities of the past have been lost: the loss of historical memory, the lack of traditional references valid for the entire community, the jumble of ways of doing, living and transforming the city creates growing uncertainty and insecurity in the urban population.

In an attempt to govern the growing complexity, due to the changes taking place in the city system and the speed with which they are proposed, it is necessary to adopt techniques and tools that must refer to the correct use of new technologies, to the processes of neofunctionalization of the main urban functions, to the careful management of non-renewable resources.

2.3 The crisis of the city as a crisis of complexity

The multiple definitions of the city that have followed one another over time have always highlighted its central role in the processes of development of the territory. The “city as the maximum intensification of human intervention in space” (CRESME, 1991), the city as the highest concentration of functions and activities, the city as a "vital nucleus", a territorial reference pole, capable of activating flows of goods, people and information and expression of a strong creative and innovative potential (Conti & Spriano, 1990).

Nevertheless, the transformations and phenomena that characterize metropolitan areas have profoundly questioned the very principles of the city, so much so that numerous scholars of various disciplines agree in diagnosing the "crisis" of the major urban systems in the world.

In this respect, it seems appropriate drawing attention to the dual meaning that the expression "crisis of the city" is assigned by scholars and researchers of urban phenomena.
As a matter of fact, if someone means by crisis of the city the obsolescence of the urban and metropolitan settlement form (the cities as a concentration of activities) for the negative externalities that it proposes with growing rhythms, someone else will mean by urban crisis the instability of the city as an organized system that cannot find a compatible rationalization of activities and functions.
According to the writers, if there are different forms and contents of the crisis of the city of this end of the millennium, the causes will be identified univocally in the crisis of the idea of the city as an organized system that fails in giving suitable answers to the different requests of its users. If the growing complexity seems to be configured as the greatest entropic agent of the urban organization, it must be solved through techniques, tools and models of government capable of recomposing the diversification and specialization of the city.
There are numerous interpretative schemes developed trying to identify the reasons for the crisis of cities, as a way of organizing collective life, and to predict metropolitan dynamics in order to propose adequate intervention policies.
Some scholars relate the phenomena of reduction of the urban population, the increase in unemployment, the replacement of functions within the historic centers — characteristic of a phase of metropolitan decline with the deep economic crisis that affected the mature territorial systems during the 70s.
This crisis, that hit the large industry of the mature sectors (think for example of the crisis in the steel sector and its repercussions on centers such as Liverpool, Birmingham and Manchester), profoundly questions the rules of growth of the Fordist metropolis dictated by the needs of the large, mechanized factory (Camagni & Gibelli, 1992). But since the beginning of the 80s, industrial activities have been replaced by activities related to services, information, the development of information technology, the so-called tertiary sector that reached its maximum development, in terms of employees, during these years.
In this perspective, the crisis of the city can be interpreted as a "transition crisis". In the transition from the industrial society to the "information society" the city becomes more and more a space of flows; the loss of the traditional functions that had determined the growth of the city — which has as a tangible sign the presence of large "voids" in the urban fabrics has as a reflection, at first, the loss of identity of the city itself, triggering processes of degradation of large peripheral bands.
In other words, it could be said that the contradictory phenomena that characterize the great Western cities can be attributed to the simultaneous presence of two "models" of cities, the result of different economic systems that determine different criteria for the spatial location of activities. On one hand, the Fordist metropolis characterized by high building densities, functional obsolescence and infrastructure networks, the growth of the suburbs, a low environmental quality that now shows the tangible signs of its "collapse"; on the other hand, the "meta-industrial" metropolis characterized by non-polluting high-tech productions, a high offer of qualified services, a greater functional heterogeneity, a high environmental quality, which still, in most cases, has not managed to establish itself.
Another interpretation of metropolitan decline refers to the five principles of economic and spatial organization of the city: the principle of agglomeration (or synergy); the principle of accessibility (or spatial competition); the principle of interaction (or demand for mobility); the principle of hierarchy (or the order of cities); the principle of competitiveness (or export base) (Camagni, 1991).
Many of the problems that today affect cities can be related to the crisis of these principles (Bellotti & Cario, 1991). As a matter of fact, the high cost of land, on one hand, and the problems related to congestion such as traffic, degradation, pollution, do not make it more "convenient" to locate activities within the city, deeply questioning the principle of agglomeration. In this context, accessibility within cities is becoming less and less competitive, as is the location of those productive functions that qualify and specialize the role of the city. The only principle that still applies is that of the external competitiveness of cities, since despite everything they

still represent the places where they are present to a greater extent and higher quality, technical progress and innovative capabilities.

The crisis of the city as an organized structure refers to the growing hardship of the cities, to the discomfort of its users, to the degradation, which is not only physical but also and above all social — just to mention some of the macroscopic effects of this crisis — which seem to have become the structural invariants that characterize big cities.

What clearly emerges is that, beyond the interpretative models that are adopted today we are witnessing the "collapse" of the city, the jamming of the mechanism of operation, determined by the affirmation of complex phenomena that make it necessary to refine the techniques of analysis and knowledge, but above all of the tools and techniques of government of metropolitan areas.

An advance in this sense can be represented by the systemic analytical approach that starts from the affirmation of the city as a place of complexity. By adopting this interpretative model, most of the phenomena that have recently established themselves in modern metropolises can be explained, what we could define as the structural components of the crisis which are:

- congestion;
- environmental degradation;
- forced mobility;
- urban insecurity;
- ungovernability.

The reasons for these effects are not easily identifiable and the use of the systemic approach may be useful for this purpose. This, as we have seen, makes it possible to break down the city system into three subsystems: the stone city – namely the physical city –; the city of relations – that is, the functional city –; the psycho-perceptual city – i.e., the city of man.

Among the reasons that have greater relevance in determining the collapse of urban systems is the different speed of evolution of these three subsystems. Actually, while the ways of working, of using one's free time, of enjoying the different urban functions rapidly evolve, while the way of "using" and living the city changes, the physical spaces and the canals (the stone city) are transforming very slowly. The crisis of the city, in this perspective, can be interpreted as the poor adaptation of the stone city to the city of relationships.

The inertia to the change of the physical system depends on the characteristics of the urban system such as the history of the city, the physical amplitude, the demographic dynamics; but also some generalizable factors such as the scarce availability of economic resources destined for large urban transformations or the decision-making inability that slows down any attempt to adapt the physical city, as well as the lack of a guiding idea that can coagulate different forces on a strong project of rebirth and revitalization of the city.

On the other hand, the functional city, as a result of the evolution of ways of life, also induced by new technologies, is rapidly transformed. Cultural models and production processes are changing, indeed, the amount of information available is increasing and a new way of man to relate to the outside world is defining. At the same time, the city of man is no longer the "closed" urban space of the medieval city, nor the "urban field" of the city of 900, thus becoming a "metropolitan field". The expansion of the city like wildfire breaks the dialectical link between city and non-city, between center and context; the symbolic value and the semantic structure of the city are lost and man is no longer able to carve out "islands of meaning" that give him the perception of his habitat.

In other words, the city of relationships finds an obstacle to its rapid evolution in the rigidity of the physical system; man, in a society of increasing complexity, cannot recognize the city and above all to recognize himself within it.

Actually, if the different speed of evolution of the three subsystems can be identified among the main reasons for the crisis, the one that allows to explain, in a systemic perspective, the complexity of the phenomena in

progress, it will be possible to identify a series of "metacauses" resulting, most of the time, of incorrect models of development of the city.

Consider, for example, the adoption of the "additive policy" that not only favored the expansion of the city "like wildfire", but contributed to the rapid obsolescence of the existing building heritage.

By adopting this model of development, in fact, every free space within the urban centres was occupied and when this was no longer possible, the city grew in the outermost bands, giving rise to the "monstrous" suburbs, real pockets of social and urban degradation.

The incorrect distribution of functions (localized irrationality) within the city has perhaps produced even more serious consequences. The lack of control over the locations and intensity of use of the functions resulted in the strong inhomogeneity, in terms of functional potential, of the various parts that make up the city. Suffice it to recall, for example, the phenomenon of functional specialization of historic centres, which in many Italian cities have become the privileged seat of tertiary activities.

In this way it has affected the functional articulation of the cities obtaining "pieces of the city" that do not have autonomy, because contrary to the consolidated city they are characterized by monofunctionality (think for example of the urban suburbs that have become the dormitory neighborhoods for the social groups expelled from the historic centers; but also to the central districts intended for offices, used in a differentiated way at different times of the day).

In addition, the concentration, specialization of the activities and the increasing number of relationships between them, produce increasing levels of demand for displacement within urban areas. This is in particular that share of mobility that we can define as "forced", that is, not freely chosen, but rather determined by the bad organization of the "city system".

Once again, as the demand for mobility increased, it was decided to find a solution by adopting an additive logic, that is, by creating new channels and infrastructures, rather than operating upstream with interventions aimed at "governing" the demand for displacement, acting above all on the distribution of functions, which were mentioned above.

This consideration brings back to the central question, to the "knot" from which one cannot ignore if one intends to address the issue of the revitalization of metropolitan areas, that is, the poor capacity for government and control of the metropolitan system.

To the "challenge of complexity" that pose, as we have seen, urban and metropolitan systems, it is increasingly necessary to give answers in terms of timely and correct decision-making capacity on the part of the institutions.

This will result in "producing decisions" for the selection of those services and those "strategic" activities able to specialize the city by assigning them a role within the "networks of cities" that now go beyond national borders. It is known, in fact, how large cities are now in competition with each other and in this sense the efficiency of the metropolitan government is also measured in relation to the policies activated to address functional obsolescence, enhancing the culture and vocations of specific realities.

But it will also be necessary to restore value to the planning activity of the public decision-maker, identifying procedures, tools and techniques able to guide all the phases of the process of choice and implementation of interventions: from that of promotion, to design, implementation and management.

The plan, according to this philosophy of approach, is no longer conceived as the design of the expanding city, which rigidly divides the territory into homogeneous areas, but rather one or more instruments of government through which to define the urban and metropolitan functions to be developed, the permissible intensities of use, the priority interventions to be activated, the role of operators (whether public or private), etc.

3. City government as a government of complexity

In this section of the work, the issue of city government as the government of complex, dynamic systems in structural crisis has been faced.

In the previous pages we have tried to define the scientific and cultural context in which the research path that is intended to develop in this study moves and the reasons for the deep crisis of the city as a place of maximum concentration of human activities, the objective of the following pages is instead to develop a proposal for a method that, using the assumptions of scientific nature and exploring the reasons for the urban crisis, allows to define tools and operational techniques for the government of the city and the metropolis of the next century. In other terms, having formulated the type of approach that is intended to be followed in solving the problem - describing in consistently rigorous terms the premises and scientific references - and identified the structural reasons for the decline of the city as a privileged place for human life, in this section it is intended to apply to the city and to the metropolis the cognitive paradigm that refers to the theory of systems and consider the city and the metropolitan conurbations as complex units that therefore must be read, analyzed, planned and managed with the techniques and means of control and governance of complex systems. What are the objectives to be pursued in defining a method of governing a complex system (the city) whose active subjects (the inhabitants) must freely participate in decisions on the trajectories of the system? The city, for its complexity and for the transformation of the man-city relationship, must recover within itself the correct use of space that has been deteriorating to keep up with the countless functions that the modern city is required to perform.

Cities of stone, cities of relationships and cities as a space of sense must find a renewed balance that allows man to live in the best possible (environmental) conditions, those that his work and his intelligence allow him and that today find an unsurmountable obstacle in the ways of thinking, living and managing the contemporary city. It is necessary going back to a correct use of the city that finds its natural premise in the reuse of space after having properly recovered it. To recover and reuse the urban space it is necessary to abandon the culture of addition and make a different culture one's own: the culture of the government of transformations that aims to make optimal use of what is there and that today appears chaotic and deficient only because it is insufficiently organized.

Therefore, an objective seems to be indubitable: the city government must be oriented to the recovery and therefore to the reuse of the city, but in the course of recent urban history the recovery interventions, meant as an attempt to regain the city to man and to give it the lost values of liveability back, have generated operations that have profoundly affected the physical dimension neglecting the intervention on the functional and relational structure of the same.

It is possible, in support of this thesis, to identify in the recent history of the city a succession of rehabilitation interventions ranging from nineteenth-century gutting, dear to Hausman, to the subsequent turn-of-the-century thinning, to the restoration and urban restructuring operations, to reach the most recent recovery operations for reuse. In this evolution it is possible to observe how in the early stages the intervention was operated directly and exclusively on the physical city and how, with the passage of time, we are getting closer and closer to the idea of intervening also on a functional and relational level (recovery for reuse) that defines ways and intensity of use inside the city. Each of these interventions had as its objective the attempt to give a respond to the renewed needs and to the growing needs of the urban population.

These last few years - characterized by a growing crisis of the cities such as identity crisis, role crisis, but above all crisis of complexity and therefore of maximization of entropy - have seen, especially in the cities of our country, a widespread stagnation in the interventions on the city.

It is necessary to relaunch a policy of government of cities and metropolitan areas to adapt them to the changed needs of the community through operations of great cultural breath, before being technical-operational. To do this it is essential to develop a new and different philosophy of approach to the city that

analyses the problems in the light of the changes taking place triggered by social, economic but above all technical-scientific progress, which new technologies seem to direct and feed.
Man, therefore, transforms, uses and perceives the city depending on whether he places himself with respect to it as an actor, as a user or as an interpreter of change.
To bring the growing complexity of urban problems back to the dimension of man and his ability to solve them, we must necessarily proceed to a simplification of complexity.
The tools to pursue this goal must refer to the correct use of new technologies, to processes of re-functionalization of the main urban functions, to a careful management of non-renewable resources.
To define the policies of revitalization of the contemporary city, which must necessarily move from the intent of simplifying problems and reducing complexity, we must consider the new changes taking place in the city system and the speed through which they are proposed.
Speed could therefore be configured as the element that more than others contributes to the degradation of collective life and urban life in particular: speed of evolution of phenomena - economic and cultural - and therefore social change in a broad sense, but also physical speed of movement of people, things and information, speed of transfer of ideas and cultures, speed of learning and training of the new generations and therefore instantaneity and spatial indifference as a product of the replacement of spatial proximity with computer proximity.
Technological innovation and the new way of communicating that it allows us, and above all will allow us, can be a sure prerequisite for a different way of being and thinking and therefore of living in the city. In this way the relational city seems to expand without boundaries beyond the physical city allowing everyone to get in touch with the rest of the world without moving his body and it is to this city that the task of responding to our work needs will be entrusted.
A collective effort is needed that leads to the definition of an overall plan that combines the use of information with the correct use of space aiming at the revitalization of the city, a project that defines the ways and intensities of immaterial relationships and configures the recovery, oriented to reuse, of the spaces of the physical system.
Eventually, if the common goal is a city in which the functional space is dilated to the maximum to allow all the necessary exchanges and relationships and the physical space regains the harmony and certainty of the city of man, then everyone will be called to the maximum effort, cultural before technical, to realize the 21st century city.
To do this it is necessary to adapt not only the cultural models with which we look at the city but also the tools and techniques for its control. The city can no longer be considered as a mechanism, the city is something much more articulated, varied and diverse, in a word complex, and to manage such complexity it is necessary to radically review the ways, tools and procedures of city management.
The city, therefore, is not a machine, it is thus not a deterministic system in which, given the starting conditions, it is possible to define, with certainty and reliability, not only the future states but also the times in which these states will be realized. Instead, it presents itself as a complex non-deterministic system in which the desired states (intentions) are known but it is not possible to define with certainty possible paths to reach them keeping in mind only the starting conditions. In other words, once known the initial conditions and the laws of relationship between the individual phenomena, if in a closed system temperature pressure it is possible to define the value of the temperature of a gas as the pressure changes, in the city but also in an infinitely less articulated and complex system won't be possible to deterministically link a cause to an effect but these are linked by three distinct phenomena of relationship. In fact, a deterministic causality can be identified: every time a cause A is produced, a B effect necessarily follows; a probabilistic causality: every time a cause A is produced there is a definite probability that the effect B will occur, and finally a correlation between cause

and effect: the event (cause) A is significantly combined with the event (effect) B but it is not possible to define any reliable link between the two phenomena.

The city, therefore, as a place of complexity where the variety of the system itself (the city) are added two elements of extreme interest that however contribute decisively to expand the vastness of the problem. This refers to the complexity of the decision-making system (who decides and what they can decide on) and the complexity of the decision-making mechanisms (hierarchical decision trees, timing, responsibility, interests, etc.). The first circumstance constitutes an indispensable attribute of economic and social organizations oriented to the plurality of powers and their mutual control, - the second is closely connected to the first and grows due to the complexity of the system to be controlled and the degree of interconnection with other systems. Given the possible strategies to govern the complexity of the urban system, whether with the expression urban system we mean to define not only the city and its complex becoming, but also the complexity of the system of decision-makers who define the compatible states of the city and the tools to achieve them and the complexity of the decision-making systems that obviously refer not only to the public decision-maker but also to all those social subjects who contribute, with their choices, to define, in a decisive way, one or more future states of the city.

Upon a thorough analysis, three distinct lines of action can be identified.

The first one must be oriented to update, in the light of the possibilities that science and technology make available, the reading techniques and the cognitive tools of the urban phenomenon.

The second one must have as its objective the redefinition of the interpretative paradigms of the urban phenomenon. Just think of the Copernican revolution that takes place if we look at the city no longer as a machine but as a complex non-deterministic system.

The third line of action must have as its priority objective the definition of new instruments and renewed techniques of city governance. And this is due not only to the updating of reading and analysis techniques but also to the new interpretative models of the city. As a matter of fact, if the urban system is connoted by its complexity, it is necessary that the tools and techniques of governance of this complexity are no longer static projection tools (the regulatory plans provided for by urban planning legislation) or cumbersome and very slow formal and bureaucratic control techniques (the technique of the municipal building permit applies to all) but adapt - for quality of content, speed of procedure and control capability - to the dynamism and variety of the city. In addition, if deterministic phenomena follow the most probable trend, i.e., they develop in the direction that has the highest possibility of occurring, complex systems, as subjected to actions to achieve one or more desired states, must necessarily follow an unlikely trend.

Finally, from the entropic aspect, it should be emphasized that deterministic systems as subject to predominantly spontaneous evolutions proceed in the direction of an increase in entropy, while complex non-deterministic systems as they are subjected to non-spontaneous but voluntary evolutions necessarily produce anti-entropic phenomena.

In this direction, a decisive contribution can come from the analysis of the techniques developed in cybernetics that precisely studies the management of voluntary actions.

In a technique related to the management of voluntary actions, unlike what happens in deterministic systems in which known the causes agents can theoretically be defined the future of the system itself, it is known what you want (the state or future states) and it is a matter of forcing the system in the direction of the desired state, but to do this it is necessary to prepare the causes so that the phenomena that intervene take place in the convergent way towards the desired result.

In a procedure for the management of voluntary actions, some connoting features can be distinguished, which must therefore constitute a constant reference in the development of a new and effective model of city management. The elements of greatest interest are:

- a continuous adaptation of the causes and therefore of the conditions of the system to the current situation in relation to the objectives set;
- a continuous comparison between result and intention to govern the processes of change, preparing the causes so that they direct the system in the desired direction;
- the conveyance of massive information flows between the various elements of the system as the main anti-anthropogenic factor;
- the preparation of an adequate number of control variables which, due to their characteristics and number, can be considered compatible with the quantities to be controlled.

Beyond the necessarily schematic and therefore not immediately understandable formulation, at a second reading, the principles listed above are nothing more than the rules of behaviour that every thinking being follows when facing any vital action.

In all vital actions, in fact, from the simplest to the most complex, it is possible to recognize a continuous comparison of the result with the intentions according to a cyclic scheme in which the partial result achieved is continuously reported (information flows) to the intention, compared (through control variables) with it and based on the measured deviations a subsequent action strategy is defined.

This feedback procedure (return of the response) constitutes an essential requirement of cybernetic logic, just as the fluid that circulates in the return cycle is the information, whether it consists of orders given by the centre (government actions) or data returned from the exit to make the comparison of the result with the intention. Information is precisely the anti-anthropogenic agent that distinguishes cybernetic phenomena from deterministic phenomena, in fact it allows you to choose an action rather than another not on the basis of its greater probability but on the basis of the preferential function that the intention has attributed to it.

From the comparison between the current instrumentation and the necessary models of city government as a system (subjected to voluntary actions), some of the nodes that reduce, in the current phase, the management of the city to a substantial immobility that accelerates the crisis and is among the causes of urban decline are highlighted. In fact, the profound inadequacy of the current instrumentation for the cybernetic control of a complex system (which is precisely the city) emerges, and this due to the absolute prevalence of the static action of forecasting (urban plans) of the future compared to the dynamic activity of government (step by step) of the constantly evolving system.

Therefore, the city must be read, analysed, managed and governed as a dynamically complex system using the techniques and tools that scientific research and new technologies make available to actors and especially to urban decision-makers. The city system, however, can be articulated in a plurality of subsystems because there are several sub-cities that, sharing spatially and temporally the same experience, contribute to forming the city. In the previous paragraphs it was proposed an articulation of the city in three subsystems, for each of them it is necessary to develop a method of analysis, an instrument of intervention and a model of government. They may be traced back to:

- a stone city that represents the physical subsystem, a sort of urban hardware consisting of everything that is matter, from houses to parks, from sewers to streets;
- a city of relationships that represents the relational subsystem, the software of the city, everything that is immaterial and that makes a set of houses and things a living and vital city;
- a city of experience that, one for each user of the city, represents how each inhabitant sees, lives and feels the city.

For each one of these cities, referring to a cybernetic approach of control and regulation of voluntary actions, all the cycles of actions aimed at governing urban transformations have been defined - exhaustively. With reference to the physical city, according to the scheme shown below, morphological reading actions have been identified for the knowledge phase, meaning by morphological reading the study of the shape of the stone city and its numerical and cartographic formalization organized in geographic information systems (GIS). For

the functional city, a relational reading is necessary, whose essential elements are constituted by the current and potential uses of individual urban spaces, the intensity of use of areas and spaces, their geographical distribution, the degree of relationship and synergy that each activity establishes with all other urban activities.
For the city of experience, reading must be of a psycho-perceptive type in which, through sample surveys, it can emerge which image the city returns to its inhabitants according to various indicators such as the degree of education, the level of income, the professional condition, etc..

System	Reading actions	Intervention Tools	Governance Models
Physicist	Morphological	Project	Control
Functional	Relational	Programs	Regulation
Psycho perceptual	Perceptual	Strategies	Recommendation

Tab.1 Systems, reading actions, intervention tools and governance models

In the same way, for the physical city, that is, for houses and things, it is necessary governing through projects, i.e., defining some physical hypotheses of transformation of the city that refer to real design ideas in which the decision-maker can evaluate the quality of the transformed shape and its level of visual impact on the pre-existing reality.
For the functional city, the intervention tool must be a program of transformations of the intended uses and intensities of use within the city and the metropolitan area. A flexible tool, divided into temporally and spatially defined actions, to be updated - step by step and in a cyclical process - to take into account the transformations that each action produces on existing activities and on their degree of interrelationship with present and future activities.
For the perceptual city, the intervention tool must be configured in the definition of a strategy for transforming the city/citizen relationship oriented to the preservation of positive and shared aspects and to the elimination of the negative externalities that a transformation without evaluations under the psycho-perceptual aspect can procure.
These intervention tools must correspond, for each sub-system, as many (technical) models of governance that, enhancing the potential of the intervention instrumentation, guarantee quality of results and certainty of objectives. The model of government of the physical city must consist of a continuous and direct action that directs, regulates and verifies all the activities of physical transformation of the city. In other words, a rigorous and continuous control activity must be carried out, such as to guarantee maximum compliance with the hypotheses of programmed physical transformation.
The model of government of the functional city must be an action aimed at keeping within established limits the values of certain quantities (intended use, intensity of use and degree of interrelationship) in line with the pre-established and constantly updated programs; ultimately, an action of regulation of functional transformations must be carried out which, without opposing the complexity and minimize the entropy of the entire urban system.
Finally, the psycho-perceptual city needs address actions that, safeguarding the existing perceptual heritage, can guide the transformations, physical and functional, to guarantee continuity in change and quality in transformation.
Ultimately, the 21st century city and metropolis must be governed with techniques and models that, referring to the management tools of complex systems, are varied, flexible and diversified.

4. Innovative processes for metropolitan government

The vastness of the issues linked to the planning and management of metropolitan conurbations has triggered, for some years, the development of renewal processes, both in the scientific and technical-regulatory fields. As regards the regulatory aspects, a sure innovative orientation in the processes of managing the metropolitan object can be found in the approval of the italian law n.142/90 on the "Regulation of Local Autonomies". This legislation, including the new institution of the metropolitan city, seemed to provide a definitive answer, also in operational terms, to the declared inability of the municipal and provincial administrations (traditionally organized according to widely outdated models) to address and govern effectively and organically the development of the territory. The law proposes an innovative approach to the problems of the territory based on considerations such as the strong polarizations of population flows, the sudden expansion of many smaller urban centers, the proliferation and concentration of functions, the uncontrolled development of the phenomenon of the conurbation, etc. and feels the need for a new territorial and administrative way that interprets the changed dimension of the phenomena. The law perceives and answers to this need by providing for the establishment of a new territorial institution that follows, from a constitutional point of view, the provincial institution. The metropolitan area, as defined by the law n.142/90, is made up of a main city (the urban pole) and several municipalities that have economic and cultural relationships and interactions with it, concerning activities and essential services of associated life, as well as territorial affinities.

Following this assumption, the areas including the municipalities of Turin, Milan, Venice, Genoa, Bologna, Florence, Rome, Bari and Naples, and neighboring municipalities have been indicated as metropolitan areas, leaving the special statute regions of Sicily and Sardinia the task of identifying the boundaries of the respective new metropolitan areas. There have been many studies, debates and proposals (developed in particular from the middle of the seventies up to now), on the criteria for identifying the boundaries of national and international metropolitan areas; the fact is that although the law indicates precise methods and regulations for the identification and territorial delimitation almost none of the administrations of the municipalities mentioned has moved in this way. The reasons for such inaction can be sought on one hand, in the unavailability of operational tools suitable for the purpose for the local governments and on the other hand in a *laissez faire* attitude of the central government culminating in the enactment of law n. 436/93 which converts into "possibility" the obligation of delimitation of the metropolitan area (Fistola, 1988) as mentioned in art. 17 of law n.142/90.

Furthermore, in the fourth paragraph of the same article it is possible to find one of the principles of greatest interest, for the purposes of this study. This article establishes that in the metropolitan area the territory of a province with the name of metropolitan city is identified. On this identification between the new metropolitan city and the province and on the re-aggregation of the territories cut out in the delimitation of the new areas, it is of particular interest to mention some points of the law which states: "*… each provincial precincts must correspond to the area that includes most of the social, economic and cultural relations of the resident population; each provincial territory must have the minimum requirements of size, demographic entity and productive activities that can favor a serious planning of balanced development; the entire territory of each municipality must be part of a single province (concretely, in the creation of the metropolitan area, the peripheral municipalities must be fully aggregated or completely separated); as a rule, the minimum limit of 200.000 inhabitants per province must be respected; the establishment of provincial offices of the state administrations and other public bodies in the new provinces is not necessarily required; the pre-existing provinces must guarantee the new ones adequate operational tools and financial resources".* In addition, as regards the actions of territorial modification, merger and establishment of municipalities, the following is states:

"*… It is first of all necessary listening to the opinion of the populations concerned, in the forms provided for by the regional law; new municipalities with a population of less than 10.000 inhabitants or whose constitution*

entails, as a consequence, that the population of other municipalities falls below this threshold can't be established; regional law for the establishment of new municipalities by merging contiguous municipalities ensures adequate ways of participation and decentralization of services to the communities; special state contributions are expected in the event that municipalities with a population of less than 5.000 inhabitants participate in the merger ".

Many of the innovative contents of the law, which finally seems to support a new model of approach to the socio-economic-territorial problems of local autonomies, concern the functions attributed to the metropolitan city and the ways of providing services to the local community.

It is possible to state that the metropolitan city is established, according to the mentioned law, as a sort of hybrid entity deriving from the union between the single municipality-city and the authority in charge for managing a larger territory similar to the province.

In this way, the metropolitan city is assigned both functions of previous provincial competence, and functions normally entrusted to individual municipalities, if they have a predominantly supra-municipal character and must therefore be carried out in a coordinated and/or joint form within the area.

In particular, as regards the provincial dimension, shall we say, to the metropolitan city are assigned the functions relating to the following issues:

a. protection of the territory, wardship and enhancement of the environment and disaster prevention (sector in which, in certain cases, any state intervention must still be envisaged);
b. protection and enhancement of water and energy resources;
c. enhancement of cultural heritage;
d. traffic and transport;
e. protection of flora and fauna, parks and natural areas;
f. hunting and fishing in inland areas;
f. hunting and fishing in inland waters;
g. waste disposal at the provincial level, detection, regulation and control of wastewater discharges and atmospheric and noise emissions;
h. public health and hygiene services and prophylaxis;
i. secondary education and vocational training, school buildings within the limits assigned by state or regional laws;
l. data collection and processing;
m. technical-administrative assistance for local authorities.

With more details to the urban planning it will be said that it is a task of the metropolitan city to adopt a Territorial Coordination Plan which, while taking in account the different competences of the municipalities, points out the general guidelines of the territorial structure and in particular foresee: the different destinations of the metropolitan territory according to the prevailing vocation of its parts, the general location of the main infrastructures, the structure and development of the main communication lines, the intervention for soil consolidation and water management as well as areas in which it is appropriate to establish parks or nature reserves.

It will be seen below how this approach is very close to that which, in the context of the tuning of metropolitan government techniques, defines the specific tasks of the metropolitan decision-maker called to provide the macro-functional guidelines of the territorial system, based on the planning formulations. As far as the municipal dimension is concerned, it is possible to state that the metropolitan city must be attributed all those functions, of previous municipal competence, which highlight a specific peculiarity of supra-municipal interest and it is therefore appropriate, for reasons of territorial economy, extend to the entire metropolitan area.

They are:

a. territorial planning of the metropolitan area;
b. mobility, traffic management and transport;
c. protection and enhancement of cultural heritage and the environment and of natural areas;
d. soil defence, hydrogeological protection, protection of water resources, waste disposal;
e. collection and distribution of water and energy sources;
f. services for economic development and large commercial distribution;
g. wide-area services in the health, education and vocational training sectors and other urban services.

From the above, it would seem that there is an overlap of competences, for the two dimensions mentioned, in almost all the subjects listed. This eventuality of confluence of the exercise of the same functions by two different bodies, acquires particular interest as regards the areas of territorial planning and traffic. In this regard, the law seems to define two scales of intervention: a territorial dimension, which identifies the location, in specific municipal areas, of infrastructures and equipment of interest and supra-municipal users and falling within a planning strategy of the entire metropolitan area (the provision of the large inter-municipal road network is of specific relevance to this scale), and a local scale (of municipal competence) to which the metropolitan city is called upon to control building activity and to prepare the implementation tools envisaged in the general regulatory plan, the competence of which would seem to remain on the line between the two dimensions. Another topic to take in account is related to the relationship between the activities of metropolitan cities and the central administration. This connection was sanctioned with the institution of the Minister (without finance) for problems in urban areas at the same time as the creation of the Department for Urban Areas, which is assigned the task of fulfilling the requirements regarding the cognitive and planning phase for legislative, administrative and financial related to the upgrading and construction of infrastructures and services in urban and metropolitan areas.

As regards the activities of the Department, of specific interest in this study, these include:

- the check and control over the legislation concerning the layout and management of urban areas;
- the coordination of administrative action for the implementation of related initiatives;
- the study and implementation, by the central state administration, of programs for the solution of specific problems in the aforementioned areas, as well as the obligations relating to state activities related to the management of urban and metropolitan areas and the connection between local authorities, administrations and public institutions, including economic ones, operating in the aforementioned areas.

To carry out these activities, the following are envisaged:

- the introduction of information technology and the establishment of a study and planning office (which should carry out studies on high-voltage housing areas, research and programming);
- the setting up of an office for the coordination of interventions, for their verification and for the formulation of programs and program agreements;
- the establishment of an office for the technical implementation and supervision of these agreements.

From this list there is finally a change of reference models in the administrative and regulatory planning activities. It is to be hoped that the administrations of the new metropolitan cities inspire their interventions to planned choices with the same rigor that should inspire the organs of the Department and it is desirable that between this and the metropolitan administrations a climate of mutual cooperation is created, both in the planning stage and the implementation of the intervention programs to the needs of which the creation of the new type of local authority is due. As will be more understandable later on, some of the generating principles of the normative instrument described have been functionally interpreted and transposed into the proposed governance process and techniques. This analogy will allow a more rapid development and a more concrete possibility of implementation of the tools developed in the functional planning stage.

5. Innovative tools for metropolitan management

The crisis of the current urban and metropolitan systems, with reference to what has been stated on the different evolutionary speed between physical and functional systems, can be traced back to two strictly interrelated phenomena that have characterized the national urban history of the last sixty years: physical diffusion and functional proliferation.

By physical diffusion we mean that process started in the period between the two wars (where the Italian economy was still essentially agricultural), progressively invested in the urban agglomerations of our country, causing an uncontrolled expansion. The ultimate expression of this process, which had its maximum acceleration in the fifties and sixties, are the metropolitan conurbations, extensive swathes of territory pervaded by building volumes without solution of continuity, in which the original settlements, all free space disappeared giving rise to high settlement densities. The cause of this diffusion must historically be sought in the urban location of some highly polarizing functions, in particular the productive ones, the mercantile ones and the administrative-managerial ones which attracted, from the rural areas, massive quantities of population, for which it was necessary to prepare suitable living spaces. The concentration of the population in specific areas, where these functions were located, soon led to the emergence of collective needs which were answered by creating new urban service functions. This mechanism, which iterated more and more rapidly, especially in the transition period from industrial to post-industrial society, can be referred to as functional proliferation. It is possible to represent the development of the phenomenon of urban growth (Fig. 3), relative to the processes described by placing, in a Cartesian diagram, the physical expansion and the functional proliferation on the two reference axes and tracing the curve that, during the social evolution has linked the two processes. It will be possible to see how, in the current post-industrial phase, the curve undergoes a sharp surge towards the top, thus highlighting the current trend towards functional complexification of metropolitan contexts.

This phenomenon has led to the formation of the current metropolitan systems characterized, as mentioned, by a high relational complexity.

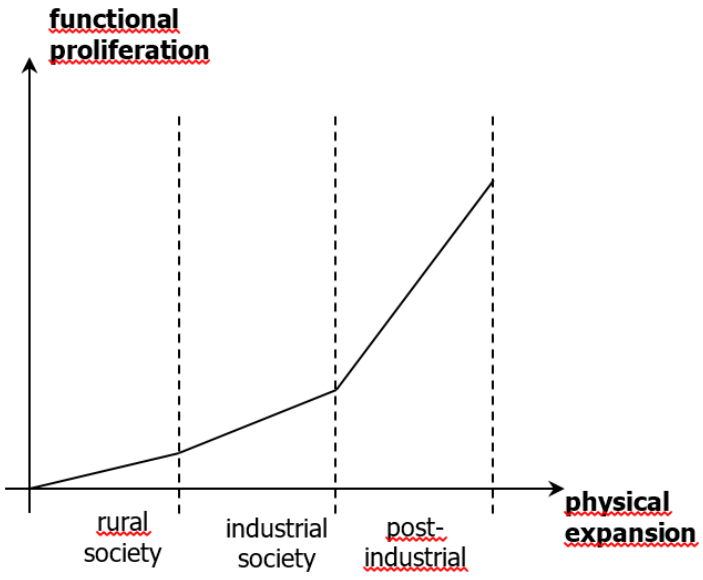


Fig.3 The phenomenon of urban growth. The figure shows the diagram of the hypothesized relationship between functional proliferation and physical expansion in the different phases of corporate evolution

Above described, which finds a further representation in the triangular scheme (Fig.4) (in which the events placed at the vertices are concatenated cyclically), can be useful to understand the transition from the urban to the metropolitan dimension, in particular from a functional point of view.

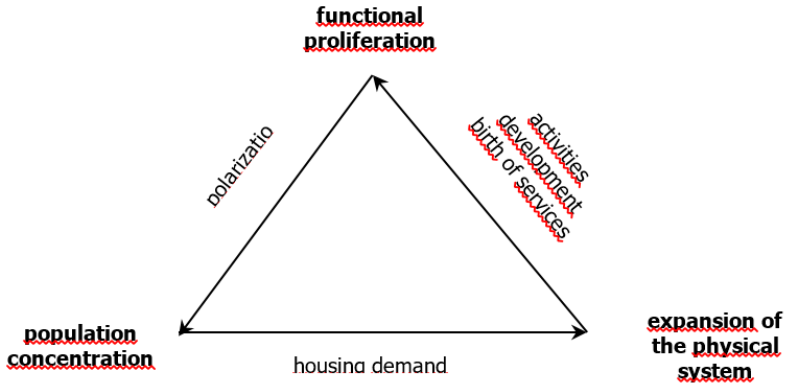


Fig.4 The triangle of urban growth. The diagram illustrates the physical/functional evolution of the city by describing this process with the circuitry along the sides and vertices of the triangle, representative of specific generative phenomena

It is possible to say that each complete circuit on the triangle has added a further stage in the process of physical/functional evolution of the city. Currently some of the Italian metropolitan areas are probably going through the last phase of possible development of the two phenomena mentioned at the beginning.

As far as the physical system is concerned, there is no one who does not see the conditions of degradation and marginality in which many of the metropolitan fabrics of our country currently find themselves. Considering the urban phenomenon, in its spatial three-dimensionality, it is possible to note that the physical expansion, having now consumed any free surface (in the xy plane), has begun to search for new possibilities of expansion according to the z dimension, thus generating new urban districts whose containers grow enormously in height, abruptly standing out (moreover with enormous visual impact) from the pre-existing fabric.

From the functional point of view, the proliferation of urban functions and their overlap in the metropolitan system have led to the current ungovernability and structural crisis of almost all large metropolitan areas.

The basic problem lies in the fact that attempts have always been made to control the (spatial and functional) development of the city, intervening almost exclusively on the physical system. In particular, it was considered of being able to govern urban evolution only through physical planning, but the current "crisis of the plan" highlights the erroneousness of this assumption. As has been shown, however, the urban phenomenon, partly limited in physical expansion by the unavailability of free areas, increasingly entrusts its evolution to the functional component. With the conquest by the city of the metropolitan dimension, the urban plan, unsuitable for correctly managing the functional transformation, has progressively lost any type of potential control of the urban phenomenon and has limited itself, in many cases, to sanctioning the expansion of building areas, beyond any real possibility of address and real control. It should also be noted the inadequacy of the regulatory instruments (prior to those provided for by law n.142/90 on the reorganization of local autonomies) adopted in the physical planning, unsuitable for the governance of complex territorial phenomena and moreover often ignored both by individuals and, as unfortunately happened in particular in the south of Italy, by entire regional communities. If the urban generation process is depicted, previously represented according to the triangular scheme, as a succession of linearly concatenated events (Fig.5), we will observe how urban planning intervenes only on the last phase of the generative process, thus failing in operating any control over the functional process. Therefore, the need for tools capable of interpreting complexity, of using it for the analysis of phenomena and consequently being able to appropriately orient functional proliferation, is becoming more and more acute.

As has been shown, the problem must be faced by elevating complexity to a science, approaching the urban phenomenon in an innovative way by considering the city as a dynamic system. It is necessary to develop tools that, relating to the metropolitan phenomenon in its entirety and adopting the systemic logic, allow it to be controlled, regulated and directed, essentially: the government.

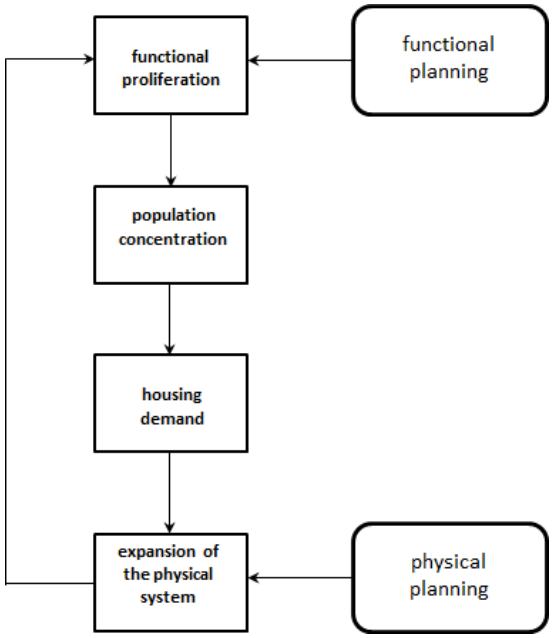


Fig.5 The urban generation process. The figure describes the intervention of functional planning on the first stage of the urban generation process

5.1. The strategic planning

Considering that currently the transformation of the city occurs by single steps (i.e. through the modification of individual built areas) it is necessary that this set of physical transformations take place in a functional planning framework that organizes and rationalizes the various actions and contains appropriate procedures for regulating the metropolitan system.

In this way, it is possible to state that the government must be implemented through a policy action, a management plan, rather than a regulatory one, which could be defined as a "plan-process"; in essence, a tool completely different from traditional plans, oriented to the forecasting of the structure of specific territorial realities, which takes the form of a definition of strategies. In this perspective, it is possible to suppose that the governance of metropolitan phenomena takes place, so to speak, at two different levels: a general level, in which all the actions of functional direction and management of the metropolitan system as a whole are defined and a level which could be defined as local, and limited in scope, to which all the operational modification actions of the space component are implemented, capable of helping to direct the system towards the strategic objective identified at the first level.

It will therefore be possible to distinguish a strategic or first-level planning which identifies the effective instrument of governance in the plan-process, and a physical planning that limits its scope of intervention to portions of anthropized territory of the metropolitan area and directly and constantly controls it the modifications following the functional directives developed at the level of strategic planning.

In order to build a conceptual scheme of the process (Fig. 6) it is possible to state that three different levels are identified:

- the level of the decision;
- the level of strategic planning (regulation);
- the level of physical planning (control).

The decision level is the one at which the Metropolitan Decision Maker (MDM) belongs, he is a manager (technical / political) of the city who defines the guidelines and policies to be implemented in the metropolitan area.

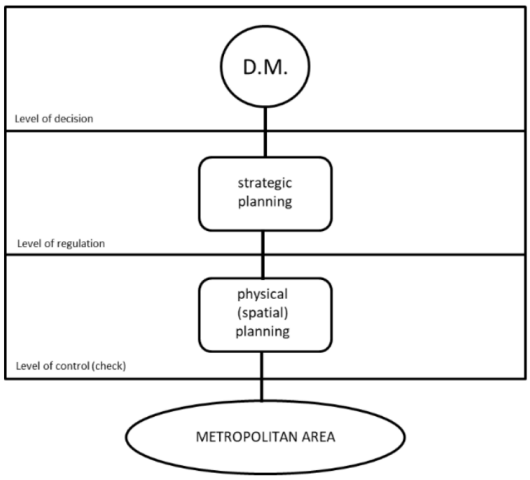


Fig. 6 The levels of metropolitan government. In the figure, the governance actions are located at different levels populated by regulatory control procedures

Strategic planning is located at the immediately lower level, fundamental for the political decision-maker, who receives the indispensable support for his decision-making activity from the activity of this level. At the third level there is the physical planning that governs the specific interventions and governs the evolution of the physical system through the control of the modification activity in the different areas in which the metropolitan territory is divided. It is then noted (Fig.7) how each element at the different levels receives an input and emits an output for the element of the next level.

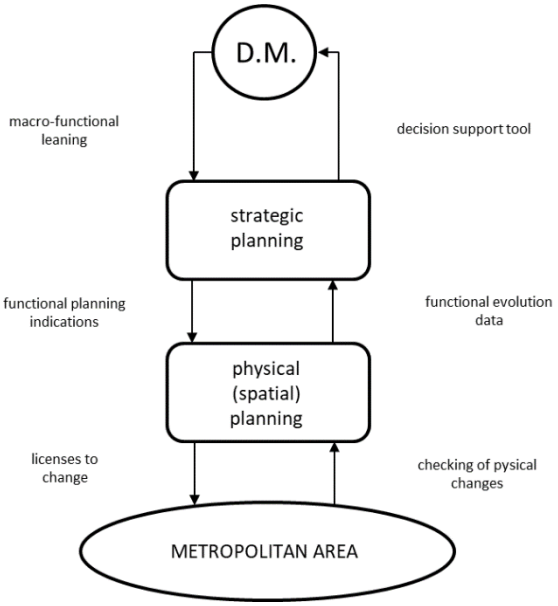


Fig.7 The management of the metropolitan area: flows. The figure highlights the input/output flows that connect the different levels and allow the definition of the government actions of the metropolitan area

As a matter of fact, the metropolitan decision maker receives support to the decision from strategic planning (input) and expresses a functional address decision (output) for the system. Strategic planning receives, from the physical planning level, the characteristics of the evolution trend of the metropolitan system (input) and defines functional strategies (output); finally, local level planning checks the metropolitan system, controlling its physical modifications (inputs), and defines the functional (evolutionary) patterns that it transmits to the higher level. At the same time, it authorizes (output) the transformations of the physical environments and of the single spatial elements only whether conceived and implemented in the direction of the functional choices defined by strategic planning. The whole procedure is therefore configured as a cyclical process of monitoring

and continuous direction of the metropolitan system; every new functional proliferation, which can give rise to phenomena of concentration and congestion, is promptly detected, properly managed and made compatible with the system as a whole, before it can generate functional complexification phenomena.

By examining in detail, the functions of each level, it will be said that the task of the metropolitan decision-maker is to predict, on the basis of the functional guidelines defined in the strategic planning and also referring to the community economic policies and international metropolitan management, indicating the major metropolitan infrastructural development lines, the structure of the communications network, the distribution of activities on the territory and their intensity.

The tasks of strategic planning can be summarized as follow:

- definition of the boundaries of the metropolitan area;
- delimitation of the sub-metropolitan areas or spheres of intervention;
- formulation of functional strategies for the macro-scale;
- verification of functional compatibility.

The process of defining the boundaries of the metropolitan area is probably the most complex operation for the strategic planner who, in this activity, will have to make use of the most recent qualitative/quantitative analysis techniques capable of synchronously analyzing the various phenomena active in the territory and of the most recent computational and IT tools that technological innovation makes available today to scholars and operators. It could be hypothesized (in the perfect development of the process) a sort of delimitation dynamic, flexible, temporally changeable, which could include (or exclude) in following moments, areas of territory previously excluded from the perimeter. This dynamic possibility could also constitute a thrust and solicitation element for the activation of self-centered development processes of the individual municipalities.

The tracing of the boundary of the sub-metropolitan areas will also be implemented through techniques capable of detecting the spatial and functional unity of a given metropolitan area (district / municipality), which can be configured, also from a social and administrative point of view, as a defined unit.

The step of formulating functional strategies is divided into two actions:

- the analysis of the system (reading);
- the development of the intervention strategy.

Referring to the operational descriptions relating to the second action, it will be said that the reading phase concerns the activities within the metropolitan system.

The steps to be carried out in this phase are:

- identification of land use;
- analysis of the distribution of urban activities;
- measurement of the intensity of land use;
- check of the degree or relationship (and or interaction).

The first two points are performed through operations of localization analysis and recognition with the aid of pure cartographic supports and/or computer representation tools (digital maps, computerized aerial photogrammetry, remote sensing, etc.).

For detecting the intensity of a certain activity in a place, reference will be made to measurement parameters of the intensity of use of the individual containers. This intensity can be measured through parameters such as the volume of the container, the covered area, the maximum height, the land area, etc. and compound indices such as land density. Through these parameters it is possible to build appropriate indicators that can describe the intensity of an activity on a site. Finally, the degree of relationship and interrelation between activities must be detected differently depending on the activity under study. Some significant parameters could be the number of users / hour of a given service or the number of outgoing and / or incoming telephone calls, etc.. To the physical planning, that performs its activity in a local area, it is assigned a triple task:

- governing and guiding the individual interventions of physical modification in the various metropolitan districts of competence;
- monitoring the functional transformations and evolutions;
- verifying the compatibility between content and container.

The first one is carried out, as already mentioned, through the authorization for the transformation of a space and upon a submission of a project which is not in opposition with the general functional approach; the second and third are developed through the direct survey of the district structure, both through alphanumeric data and indicators, and through info-telematic cognitive tools. All data concerning the functional system must however be collected (as will be seen in detail below) by specific departments and sent to the strategic planning level. In order to better define these tasks, it seems useful describing the operational structure and mentioning the operating modes of the system, which will be further explored in the presentation of the case-study.

5.2. The action phases

The strategic planning will have to be based on cybernetic control processes of the metropolitan system, using the other statistical techniques of multivariate analysis. Summarizing the different phases, it is possible to say that having detected the functional structure of the territory (not yet as metropolitan), the best development trajectories are identified in order to individuate "guiding factors", to be considered as indicators of metropolitan capacity and useful to describe the functional state of the system.

For the definition of these factors, please refer to the next section; however, it is possible to say that these criteria are used by means of specific variables, detected on the territory, able to describe the values (distribution, intensity) of the activities, to which it was mentioned above. The definition of the main factors allows to start the functional management process of the metropolitan system of which the physical limits are identified. Subsequently, the strategic planning, processing the information coming from the lower physical level, defines the system strategies that inform the support tool for the metropolitan decision-maker who simultaneously provides the macro-functionalities. These are encapsulated in the plan-process that stipulates the directives for the possible physical modification of the individual metropolitan districts. At this point the process enters a steady state phase and starts its cyclical path of: monitoring the effects induced by the functional guidelines, controlling the trend of the reference variables and possible recalibration of the functional development trajectories.

We will now try to describe the operational actions that allow the process to work properly and in particular the techniques for setting up the Decision Support Tool (DST).

The process is articulated in five steps (Fig.8):

- detection;
- collection and archiving;
- processing and updating;
- checking and amending the trajectories;
- definition of development.

It has already been highlighted that one of the tasks of physical planning, placed at the third level of the metropolitan management process, consists in monitoring the physical/functional transformations of the metropolitan system and we have mentioned the variables that allow the setting of the main factors. These variables are constantly monitored throughout the metropolitan area, through what could be imagined as a network of sensors represented by specific detection units such as the planning offices of the individual districts, the administrations of entities and service companies and trade union organizations, research centers, etc.. A database is set up at each of these sensors in which all the data concerning the variables in question are collected and appropriately filed. In this sense, it would be appropriate encouraging the creation of shared

databases (which can be accessed by multiple organizations), as the current trend seems to show, which will greatly facilitate the transfer of data. The detection and collection network finds its confluence point in the strategic planning office, where a Metropolitan Database (MDB) is located to which the data of the peripheral offices are transferred. The MDB provides for the storage and continuous updating of the values of the reference variables. The updated variables are then processed, with the methods of factor analysis, mentioned above, through a sort of expert system that will be defined as the Metropolitan Management System (MMS). The MMS verifies whether the functional trajectories follow the expected trends and provides for any redirections by inserting new functional strategies in the SSD.

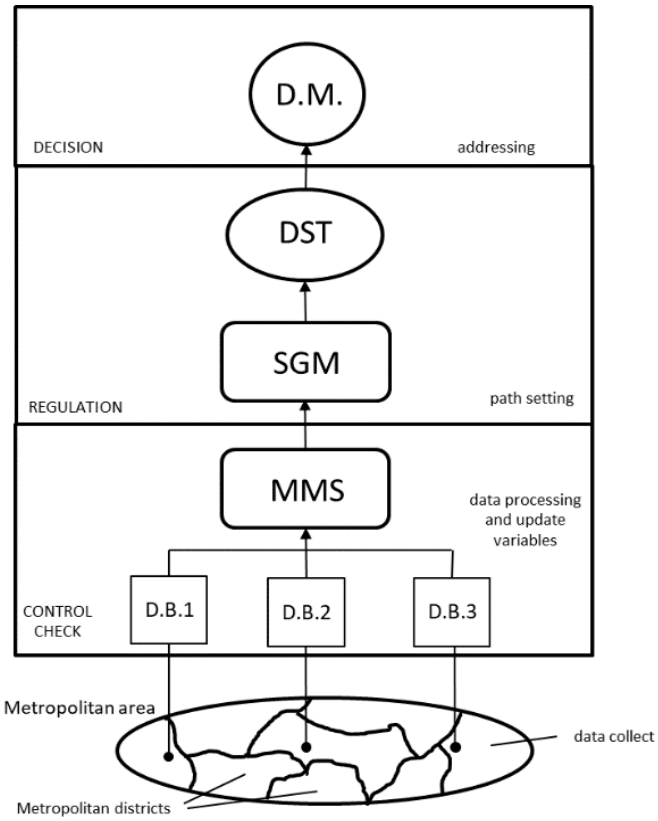


Fig.8 The decision support. Scheme of the operational process for defining the decision support tool according to the levels of government

In conclusion, it seems possible to formulate some considerations.

From the description of the process and of the operational moments it is clear that the functional control of the system is almost total and, in this sense, the link between strategic (or functional) planning and physical planning is positively understood; the latter recovers, in this structure, a role of real control of the modifications of the space system. Functional proliferation is suitably oriented to favor the socio-economic development of the metropolitan system, and governed to prevent its entropic complexification. In this way, the metropolitan decision-maker will finally be able to base his decisions on a support tool that cyclically checks the effect on the system and inhibits, through regulation, its negative effects. Eventually, it should be noted how, in this organization, the processes and products of technological innovation will provide a decisive aid for the definition of metropolitan governance tools. Also in this case, the smart adoption of the innovation and the definition of new tools and techniques for managing the metropolitan phenomenon, can lead to new ways of living the city and to the recovery of values of livability which seem irremediably lost in the current megalopolitan post-industrial dimension (Gottmann, 1961).

6. An experimental application: the government of the metropolitan area of Naples

This last section describes the application of the methodological hypotheses illustrated in the previous paragraphs aiming at defining new and more effective tools and techniques for governing cities and metropolitan areas.

The aim is to develop a decision-support tool for the governance of Italian metropolitan areas, taking into account current legislation and in particular Law 142/90 on local autonomies which established the 'metropolitan city' (AA.VV., 1991a; AA.VV., 1991b; Beguinot, 1993; Bertuglia & Occelli, 1991; Cesec, 1991; Marchese, 1989). This part does not present procedures that have already been tested and are certainly applicable, but it is a first attempt to formalize the methodology developed. The operational procedure developed is aimed at achieving three results: delimiting the metropolitan area of Naples; defining the functional planning areas; elaborating the strategic projects of the area. The procedure is divided into three steps: i) identification and collection of the variables (state indicators) to analyze the study area; ii) processing of the variables with multivariate statistical analysis techniques (principal component method, factor analysis, cluster analysis, etc.); iii) interpretation of the outputs and their formalization into decision support tools.

6.1 The database definition

The definition of the database, which constituted the first phase of the research, concerns an area comprising 136 municipalities in Campania. For each of these municipalities, 60 quantitative indicators (state variables) were defined. The data were obtained by consulting official statistics or from the main bodies that supply goods and services to the Campania territorial system.

Among the data needed to carry out an experimental research on an urban area, intense correlations between variables are frequently possible to find; for this reason an in-depth analysis was carried out. In this way, all the indicators that, characterized by strong correlations with other variables, would not have provided significant information were eliminated. With this objective, the correlation matrix relative to the 60 original variables was calculated; this matrix (60 x 60), as expected, presented, in 32 cases, values of correlation coefficients close to unity.

Having identified the subsets of variables that were strongly correlated with each other, we moved on to the definition of the variables with a strong information content with respect to the research objectives. Finally, the 32 indicators which, being strongly correlated with others, did not bring significant increases in information to the data system were eliminated. The data matrix, in this last phase, took on the final size of 136 x 28, namely:

- 136 rows, relating to the municipalities of the area comprising the whole province of Naples and part of that of Caserta and Salerno, in a hypothesis of a 'wide' metropolitan area (AA.VV., 1991a);
- 28 columns, relating to the number of variables describing the regional urban system.

The variables examined were divided into ten groups (Tab.2) and particularly:

- structure and characteristics of the population;
- communication input-output;
- mobility;
- energy consumption;
- household consumption and income;
- economic operators;
- gross domestic product;
- bank branches;
- employees in industry;

- distance from Naples.

The first group collects variables such as: population and population variation in the period 71/81 and 81/89 as well as the natural balance and the social balance.

The source for the retrieval of these data is ISTAT. For the second group of variables, which provide information on communications (telephone calls and television subscribers), SEAT-SARIN[1] data for the year 1987 were used.

The same source was used for the data on mobility, number of economic operators and bank branches. The seven variables of the group "energy consumption" are distinguished in relation to power. These data have been provided by ENEL[2] and refer to 1987. All the variables related to the group "household consumption and income" have been taken from the 1987 SOMEA Atlas (SOMEA, 1987).

Group	**Variables**	**File name**
Population structure and characteristics	Resident inhabitants 1987	POPOLAZ87
	Population variant 71/81	VAR1AZ71/81
	Population variant 81/89	VARJAZ81/89
	Rate of natural increase	SALDO NAT
	Rate of social increase	SALDO SOC
Communication input-output	Phone calls for business customers	SCATTI AFF
	Phone calls for private customers	SCATTI PRI
	TV subscribers	ABB TEL
Mobility	Vehicles on circulation	AUTO CIRC
Energy consumption	Private lighting total billed power	EL D TOT
	Public lighting total billed power	EL IL TOT
	Private lighting billed power over 3kw	EL IND m3KW
	Lighting on premises other than dwellings up to 30 kw per rated power	EL IND 30K
	Lighting on premises other than dwellings from 30 to 500 kw per rated power	EL IND 500
	Lighting on premises other than dwellings over 500 kw per rated power	EL IND m500
	Details of total agricultural use by billed power	ELAGRI TOT
Household consumption and income	Per capita consumption	CONS PC
	Level 1 per capita consumption	CONS LIVI
	Level 4 per capita consumption	CONS LIV4
	Per capita income	RED DISP
	Income Total	RED TOT
	Level 1 consumption	AUTOCONS L1
	Level 4 consumption	AUTOCONS L4
Economic operators	Economic operators	OPER ECON
Gross Domestic Product	Gross Domestic Product	PIL
Bank branches	Bank branches	SPORT BAN
Employees in industry	Employees in industry	IND TER IN
Distance from Naples	Distance from Naples	DIST NAPOL

Tab.2 The 28 selected variables

1 SEAT-SARIN was a company that managed the "yellow pages", a list of companies classified by product category, which contained the address and telephone numbers for each of them.

2 ENEL is the National Body for Electricity, a public body that until 1999, the year of the liberalization of the market, was the only company for the production, transformation, transmission and distribution of electricity in Italy.

6.2 The calculation procedure

The principal components method provides three main types of output:

- the principal components, i.e. the factorial axes intersecting the cloud of objects (the municipalities) along the principal axes of inertia;
- the coordinates of the characters (the variables) and the coordinates of the objects (the municipalities) on the set of axes defined by the principal components.

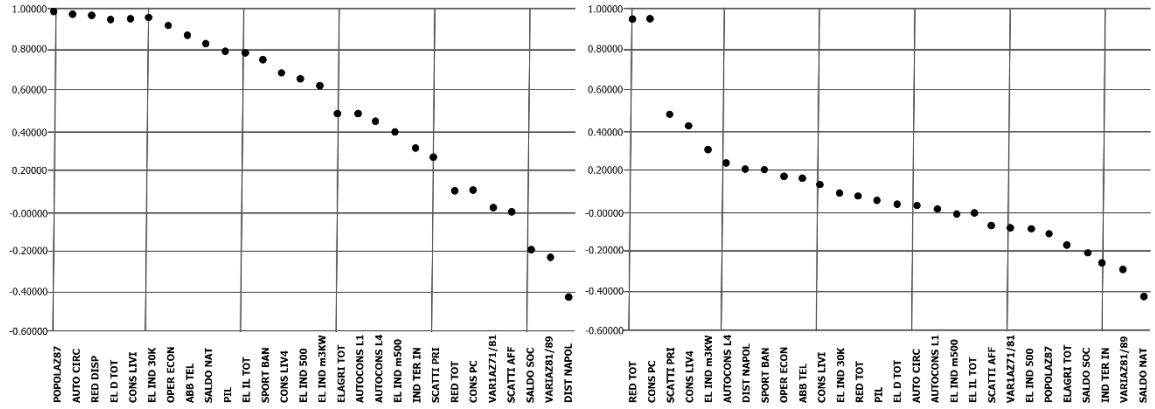
The vector of eigenvalues divided by the number of objects (the municipalities) gives the shares of variance explained by each component of the system (Luongo, 1981).

In this paper, the system under consideration has proved to be quite structured, not only because the first three components explain a high percentage (82%) of the entire variance of the system, but also because the first component alone explains almost 61% of the total variance.

In the light of these initial results, the first five main components have been taken into account for the subsequent phase of analysis. In fact, the first component explains 60.6% of the total variance, the second one 13.3%, the third one 8.3%, the fourth one 4.9% and the fifth one 3.9%, for an overall total of 90.6%.

In this type of procedure, a value of explained variance of just over 90% can be considered as an optimal threshold. The first component, which explains about 61% of the variance, can be defined as the "metropolitanism index". It is a component that prevails over the others. In particular, by analysing the correlation ratios, it can be deduced that most of the variables (25) are positively correlated with the first component; the remaining ones (3) show an inverse correlation. The first component is significantly influenced by the number of inhabitants, by the number of cars on the road and by the total disposable income; immediately following are the consumption of electricity for private use, the per capita consumption for retail trade, the economic operators and the number of television subscribers. The social balance, the variation in population from 1981 to 1989 and the distance from Naples are negatively correlated with this component (Fig.9a).

The second component, which explains about 13% of the total variance, can be synthetically defined as the "index of economic well-being". This component depends primarily on the values of per capita income and per capita consumption, and is inversely correlated with the consumption of electricity for agricultural purposes and with the social balance (Fig.9b).



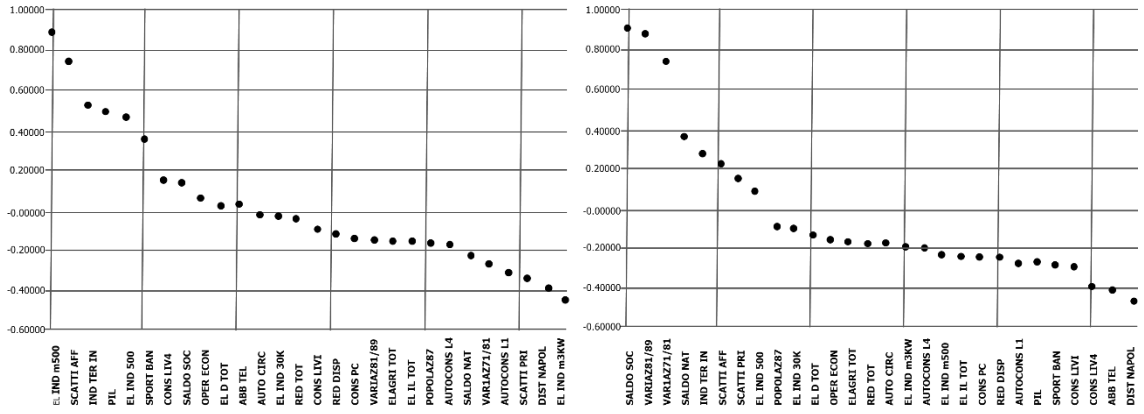
(a) (b)

Fig.9 Sorting of the first (a) and second (b) component

The diagrams show what part of the area is highly characterised by income and consumption variables.

The third component, which explains about 8% of the total variance, is called "industrial production index". In fact, the most relevant variables are electricity consumption for industrial use, i.e. telephone calls for business

customers and industrial employees. The variables measuring positive elements (industrial productivity, high number of employees, gross domestic product) are placed at the opposite side of the scale (Fig. 10a).
The fourth component, which explains about 5% of the total variance, is called the 'internal migration index'. This component is mainly influenced by the social balance, the variation of the population between 1981 and 1989 and the natural balance. The social balance and the natural balance positively influence the component, along with the variation of the population (Fig. 10b).
The fifth component which explains 3.5% of the total variance is called the "index of (rich) self-sufficiency on a tourist basis". The variables that have the greatest weight on this component are level 4 self-consumption (luxury goods), distance from Naples and level 1 self-consumption (Fig. 11). This shows that, although with a low incidence, the municipalities included in the study area have tourism as one of their main characteristics.



(a) (b)

Fig.10 Sorting of the third (a) and fourth (b) component

5.3 Interpretation of results

An element of great importance provided by the principal components method is the value of the coordinates that each municipality assumes on the axial system of factors.

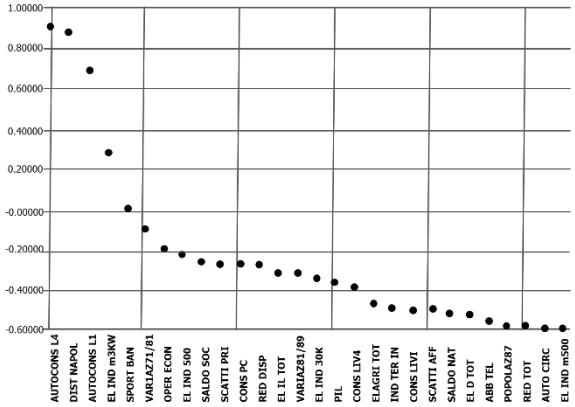
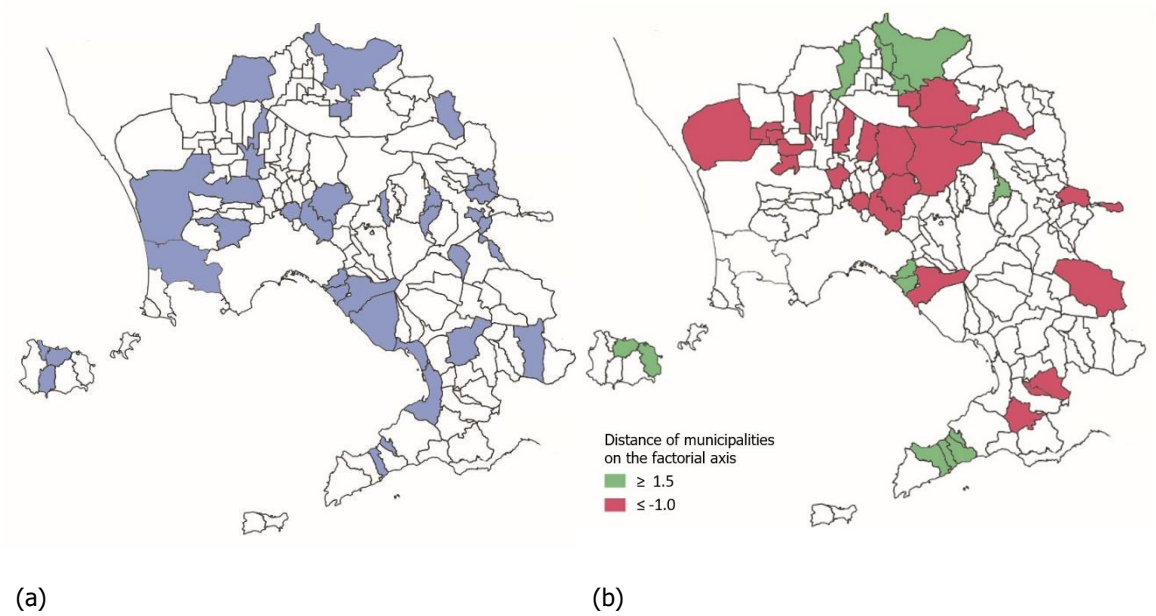


Fig.11 Sorting of the fifth component

By analysing the order in which the objects (the municipalities) are arranged on the first component (metropolitan index), it can be seen that the municipality of Torre del Greco is in first place; then come, in order of increasing distance, Portici, Pozzuoli, Caserta, Casoria, Castellammare di Stabia, San Giorgio a Cremano and Ercolano, up to the municipalities that close the series: Lacco Ameno, Liveri, Riardo, San Marco Evangelista and San Vitaliano (Fig. 12a). The values of the coordinates of the objects are included in a reduced

interval, and this demonstrates a flattening of the metropolitan index of the municipalities included in the study area. The municipalities of the Province of Naples that have values of the factor greater than 1 are distributed in a crown around the regional capital. These municipalities have very high values of the resident population and few qualifying functions that are, instead, located exclusively in Naples. In fact, these municipalities have been used as areas for residential developments to meet the inexhaustible demand for new housing determined by the great concentration of tertiary and industrial activities in Naples.

As regards the values that the coordinates of the objects (the municipalities) take on the second component (well-being index), it emerges that among the municipalities examined, the richest are those of Caserta, San Sebastiano al Vesuvio, Portici, Sorrento and Piano di Sorrento. From this point of view, the group of municipalities that most gravitate around Naples are those at the bottom of the ranking and in the worst position as regards the second component linked to income and consumption (Fig. 12b).



(a) (b)

Fig.12 (a) Metropolitan index and (b) Economic well-being index

The figure shows that for the metropolitan index, the municipalities that present factor values >1 are those that are distributed around Naples, which are those that present factor values <1 for the economic well-being index, further confirming the conditions of socioeconomic hardship that characterise them.

The analysis of the coordinates of the municipalities on the third component (industrial production index) confirms the results of the analysis of the trend of the first component. First of all, it can be noticed that in the distribution of the municipalities on this axis, the first places are located: Pomigliano d'Arco, Caserta, San Marco Evangelista, Marcianise, Caivano and Casoria.

These municipalities, located along the Naples-Caserta axis, represent the strong points of productive-industrial activity in the entire region. On the other hand, Afragola, Marano di Napoli, San Giorgio a Cremano, Torre del Greco and Portici are at the bottom of the list (Fig.13a).

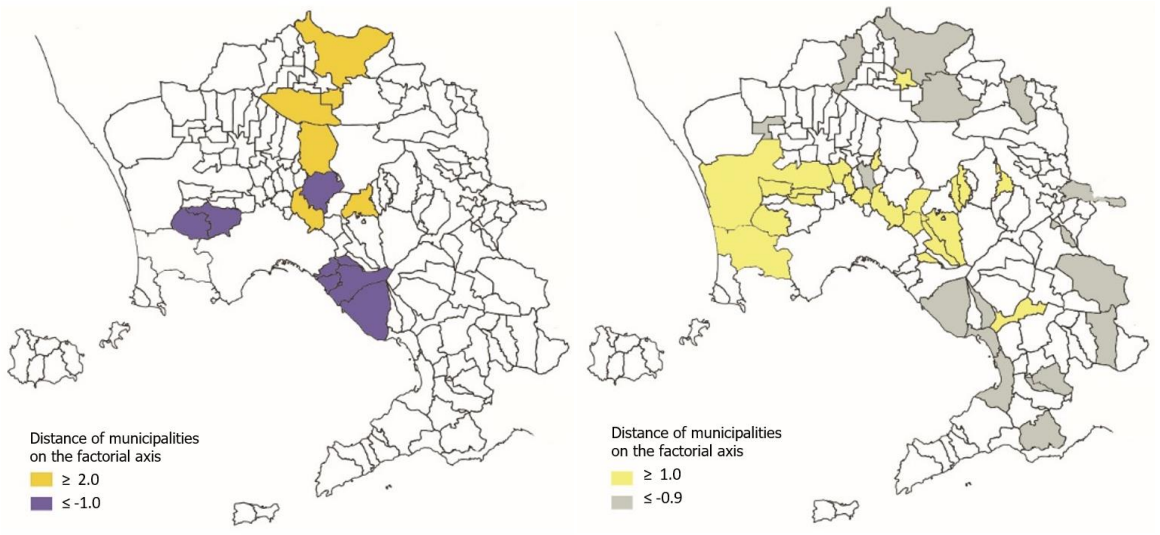
For the fourth component (internal migration index), the municipalities of Quarto, Giugliano in Campania, Villaricca, Volla, Qualiano, Casalnuovo di Napoli, San Nicola La Strada, etc. are at the top of the list. These municipalities constitute the "residential reservoirs" to respond to a demand for new housing that Naples cannot satisfy (Fig.13b).

In the ranking of the fifth component (index of tourist self-sufficiency) the first places are occupied by municipalities that are the strong points of the regional tourist system: Ischia, Forio, Sorrento, Serrara Fontana, San Cipriano, Pozzuoli, etc. (Fig.14).

Confirming this indication, the indicator with the greatest weight is represented by consumption within the municipality for luxury goods, i.e. everything that encourages tourism.

The outputs of the proposed method are an initial attempt to define operational decision-support tools for defining new instruments and techniques for governing metropolitan conurbations.

The articulation of the territory in relation to the 5 indices – metropolitan index, economic well-being, industrialisation, immigration and self-sufficiency on a tourist basis - constitute an indispensable tool, not only for the delimitation of the boundaries of the metropolitan area, but also for the identification of functional strategic planning areas.



(a) (b)

Fig.13 (a) Industrial production index and (b) Internal migration index

The figure shows that for the Index of Industrial Production, the municipalities located along the Naples-Caserta axis represent the strong points of the industrial system in the Naples metropolitan area, while for the Index of Tourist Self-sufficiency, the municipalities with factor values > 1 are those that constitute the "reservoirs" for a demand for new accommodation.

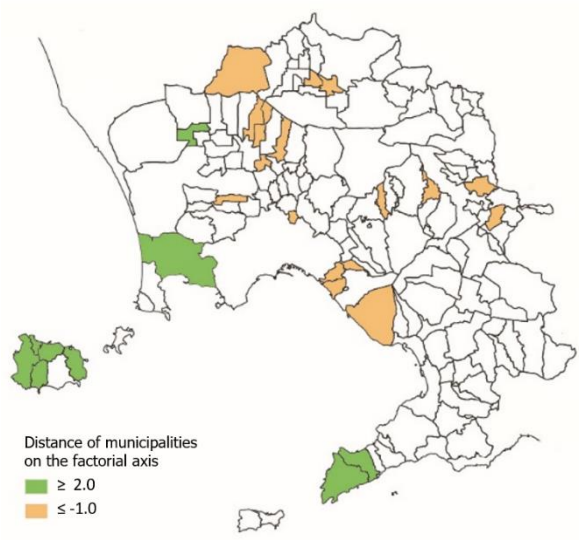


Fig.14 Self-sufficiency on a tourist basis Index

The figure shows that the municipalities in which the value of the factor is equal to 2 are Forio, Ischia, Sorrento, etc. which represent the strengths of the regional tourism system.

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Author's profile

Rocco Papa

Emeritus of Land Use Planning at the University of Naples Federico II. Editor-in-Chief of the Scientific Journal TeMA - Land Use, Mobility and Environment since 2007. Director of the Department of Urban and Regional Planning (DiPiST) of the University Federico II of Naples, from 1999 to 2005. Vice-Mayor of the Municipality of Naples, from 2001 to 2006. City Councilor for Livability (appointed to Town Planning and Historical Centre) for the Naples Municipality, from 1997 to 2006. Research activity, carried out continuously since 1974, has developed according to the following four main lines: the study of the interactions between urban and mobility systems; the management and governance of metropolitan areas; the safeguard of environmental quality in highly urbanized areas; the experimentation of new protocols for urban planning tools

connected with the updating of techniques, methods and models of analyses, interpretation, planning and governance of territory. As City Councilor for Livability (appointed to Town Planning and Historical Centre) for the Naples Municipality he has developed in detail the following projects: the approval and implementation of the new Master Plan of Naples, the restoration and requalification of the "Real Albergo dei Poveri" and of the "SS. Trinità delle Monache", the implementation of the Line 1 and Line 6 of the Metropolitan Railway. He is the author of more than 180 publications.

Rosaria Battarra

Architect, researcher of the National Research Council since 1998. He also carries out his activity at the Department of Civil, Construction and Environmental Engineering of the University of Naples Federico II, developing research on the redevelopment of the existing city and on the tools for implementing urban policies. More recently, the research interest has turned to the issues of governance of the metropolitan city, in light of the increasingly widespread diffusion of the "smart city" paradigm. She has been an adjunct professor at the Polytechnic and Basic Sciences School since 2001. From 2007 to 2014 she was in charge of the Urban Planning and Enhancement Department of the Urban Transformation Society Bagnolifutura spa. Author of over 50 publications.

Carmela Gargiulo

Full professor of Urban Planning Techniques at the University of Naples Federico II. Since 1987 she has been involved in studies on the management of urban and territorial transformations. Since 2004, she has been Member of the Researcher Doctorate in Hydraulic, Transport and Territorial Systems Engineering of the University of Naples Federico II. Her research interests focus on the processes of urban requalification, on relationships between urban transformations and mobility, and on the estate exploitation produced by urban transformations. On these issues she has coordinated many research groups as scientific manager of operational units or as principal investigator of competitive projects. As scientific manager of the Dicea-University of Naples Federico II operative unit: "Impacts of mobility policies on urban transformability, environment and real estate market" from 2011 to 2013, as part of the PRIN project; Cariplo Foundation project "MOBILAGE. Mobility and aging: support networks for daily life and welfare at the neighbourhood level "2018-2020; ERASMUS + Key Action2: Project "Development of a Master Program in the Management of Industrial Entrepreneurship for Transition Countries" (MIETC), with European and Asian partners 2020-2022. As Principal Investigator of the Smart Energy Master Project for territorial energy management funded by PON 04A2_00120 R&C Axis II, from 2012 to 2015. Author of over 150 publications.

Romano Fistola

Associate Professor at the Department of Engineering of the University of Sannio. Master Science with honors at the Faculty of Architecture, University of Naples Federico II. He was fellow and temporary researcher at the Institute of Planning and Land Management of the National Research Council of Italy (MISM) and has been of the contractor University of Naples Federico II University of Pavia, adjunct professor at the University of Naples Federico II. He was permanent researcher at the Institute of Planning and Land Management of the National Research Council of Italy (Naples) from 1996 to 2003 and member of the Scientific TIP of the institute. Since 2004 he is researcher (ICAR/20 scientific field) at the University of Sannio, Department of Engineering. He was a visiting researcher at the Center for Urban and Regional Development Studies (CURDS) University of Newcastle upon Tyne (UK) under the direction of prof. J.B. Goddard and served as lecturer at the Bartlett School of Architecture, Building, Environmental Design and Planning, Faculty of the Built Environment at University College London and at the European Masters (MSc): "Regional Policies and Development in Europe", University of Graz. In 2005 he was elected member of the Board of the Italian Regional Science (AISR), in which role he was reelected until 2010. Since 2004 he holds the course "Technology Planning" at the Faculty of Engineering, University of Sannio and teaches in the integrated course of "integrated town planning and transport". He teaches "Geographical Information Science" at the PhD in Civil Engineering, Faculty of Engineering, University of Naples "Federico II". He collaborated at several researches in the field of urban and regional planning, financed by CNR and by the MIUR. He collaborated with the Department of Town and Country Planning of the University of Naples "Federico II". He is currently member of the National Institute of Urban Planning and designated as the auditor of the INU Campania.