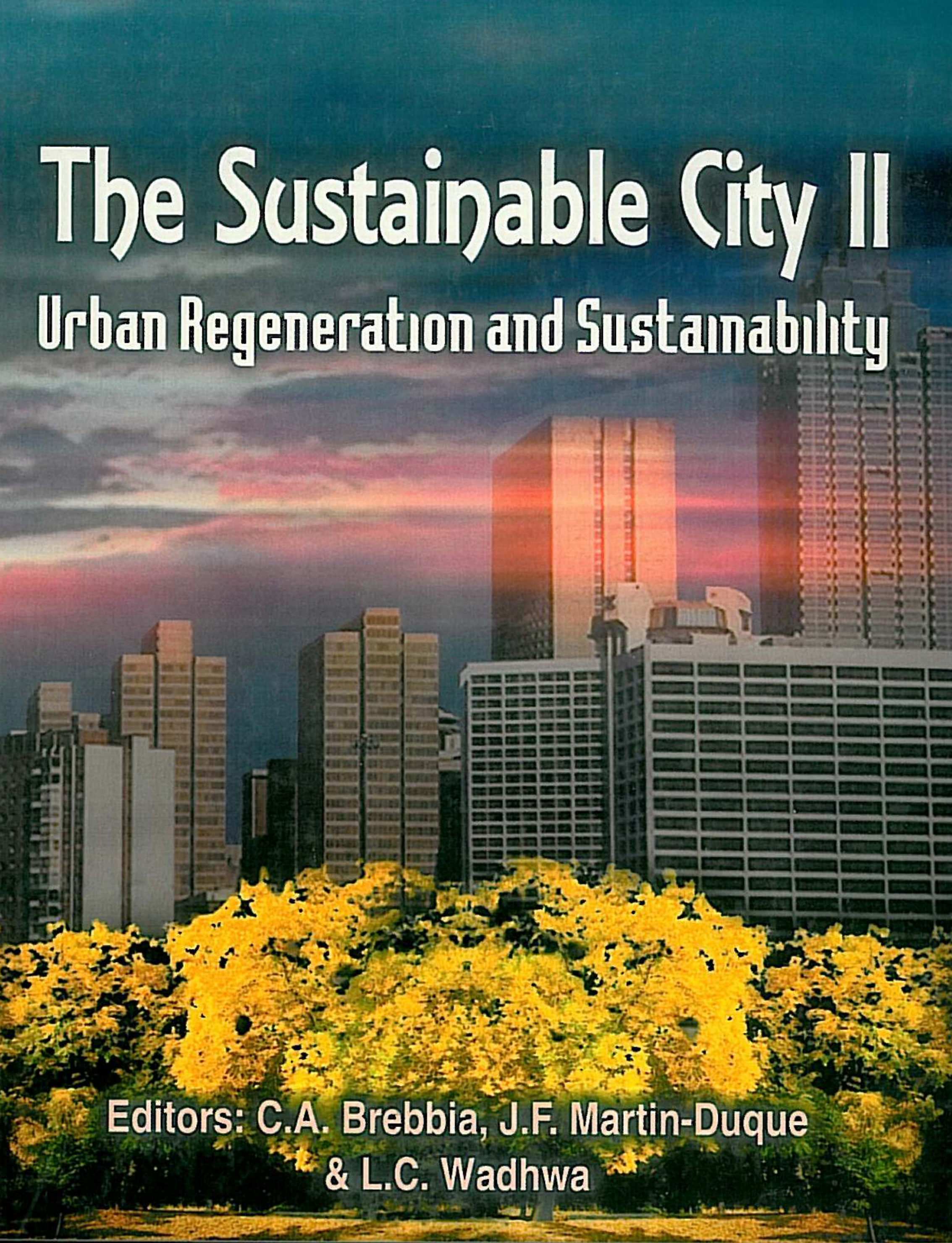
The Sustainable City II

Urban Regeneration and Sustainability



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Self-organization as a resource for a sustainable city planning

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Abstract

A city can be studied as a complex system. The no-linear interactions between its structural elements, the multiplicity of decision makers and times-scales, its structure based on many levels of organization, its openings to the outside, its irreversible dynamics, are features peculiar to a complex system. Some definitions of natural sciences, from the theory of dissipative structures to the concept of adaptive complex systems, could be extended to the idea of city.

Actual processes of globalization, of technological progress, of spatial organization by networks, make uncertain the object-city. Its territory looks like dematerialized.

It's more and more difficult to define an urban system and the validity of its boundaries. It's often dubious even its being a system because of the lack of integration between its parts (sub systems).

The indiscriminate aggrandisement of towns, the excesses of functional zoning that separate urban activities, the deficiency of communicability, are diseconomies to race against. The efficiency of organism-city increases according to levels of integration between its parts and between itself and the outside.

What especially we take care is evaluating the city's capability of self-organization, investigating how external actions can suggest this kind of adaptive processes, how efficiently we can direct them toward a structural shape.

It strongly emerges the necessity of defining a sustainable model of city development, a kind of projected heterorganization, that means improving cooperations between planning acts from the top and self-organization processes from the bottom. Complexity and multidimensionality are not a defect to delete

but a resource to improve by program tools, that are those of management and handling during the time, and not those of timeless deterministic planning.
Taking into account Prigogine's dissipative structures, we try to analyze the sustainable city in terms of entropy's flows and entropy's productions.

1 Introduction

Actual disciplines and sciences of territory have great limits. The common approach is that of analytical reductionism; it usually studies the constitutive elements of a system as they were isolated each other. Its numerous applications are based on the illusion of respecting a reassuring formalism and a methodological rigour. Reality is different. Reductionism causes a methodological mistake that is really based on arbitrary assumptions (postulates) and, in fact, empty of any rigour. Arbitrarily splitting the whole system into many parts makes difficult the comprehension of its behaviour because of the loose of information. On the contrary, a holistic approach pays attention to the scheme of interactions between the elements and it introduces a new visual "gestalt", a new vision.

City is a social system and it shows (no linear) interactions between its own constitutive elements. The urban dynamics follow unintuitive behaviours, evolving toward unexpected and surprising directions. In front of environmental perturbations, a city is able to endow itself spontaneously with a space-time structure, coherent and tidy, based on the scheme of interactions between the constitutive elements.

A medieval city is an example of spontaneous configuration of a settlement that is apparently casual because of its irregularities. Different historical cities have different configurations; each one has its own urban shape, materials and building techniques. In spite of these irregular shapes and reciprocal diversities, there are clear regularities and similarities especially concerning to the relations with the external environment and to the internal interactions. We are referring, for example, to the narrow and tortuous streets that follow the morphology of territory, protecting from wind and weather, and that are more defensible against enemy's invasions; to the introversion inside boundary walls and around the square that is a place of aggregation, of changes, of meetings; to the church and the public palace as expressions of power, and sometimes buildings and towers where noble families live. The medieval city's shape, even if is really spontaneous and no planned, meets anyway real requirements. Actual city has similar properties, but many variables and more complex behaviours hinder clear analysis of it.

2 Territorial systems and adaptive complex systems

The isomorphism between cities (territorial systems) and complex systems, that we are going to analyze, will be useful to comprehend and modify urban dynamics.

The paradigm of complexity shows an opportunity to cooperate with, to define new ways and aims for applications in city planning.

The theory of dissipative structures by Ilya Prigogine let us introduce concepts as system's historical dimension, "the arrow of time", irreversibility, order, information and city's evolution in terms of self-organization and co-evolution of many urban actors. Studying city's evolution in terms of information learning, we can better understand its creative power, its complex behaviour, its manner of adapting to environmental dynamics and to suggestions coming from the outside.

2.1 No linear actions

A system can be defined as a set of interacting elements.

Von Bertalanffy [1] gave a definition of interaction saying that all the constitutive elements are connected by interactions so that the behaviour of an element, respecting a relationship, will be different respecting another one.

Complexity of systems and their going toward self-organization is based on no-linearity of interactions between their constitutive elements. It means there are feedbacks. A feedback is negative when it "contains" and guarantees stability. A positive feedback, on the contrary, "reinforces" and suggests destabilised effects (instead of dumping little perturbations, as the negative feedback does, it amplifies them more and more). Positive feedbacks cause the effects of a local action are no-limited to its nearest environment. No-linearity, even if it acts on a microscopic level, that is the level of the interactions between the elements, gives to the system properties of order and organization in a macroscopic scale. Really, this is a feature of all systems, even the simple ones, because it depends on the interacting between constitutive elements that are not isolated. However, in complex systems, no-linearity can reinforce a local action to generate a chain of effects extended to all the system. This phenomenon is normally known as "the butterfly effect".

So, it is no-linearity, with its amplified effect, that causes the growing of unintuitive behaviours, impossible to deduce by an analysis of separated constitutive elements. That is because the whole is different from the addition of its parts. The features of the whole, if compared with those of constitutive elements, are new and emerging.

2.2 Organization

Single units of a complex system develop reciprocal relationships by interacting each other and they self-organize by exchanging information. This organization is an additional information value that is not visible just observing single parts.

Organization of a system is the configuration of the interactions between its elements.

In a complex system, organization is not imposed by external subjects or defined project instructions but it emerges spontaneously. The system chooses its organization on its own, among many possible alternatives.

The single constitutive elements of a system do not decide consciously which kind of organization to take on. "Single elements do not bring ordering codices" [2]. It does not exist an ordering project inside the system that is known and followed by the elements. "Organization emerges on a macroscopic space-time scale, that is many times bigger of microscopic interactions between the elements" [3]. Single components do not need an overall order. Their behaviour is individualistic and ruled by the law of "the slightest resistance". Each element looks for the greatest benefit by the slightest expenditure of energy. However, each element is not isolated and free because of its being a constitutive part of a system, but it interacts and communicates with other elements. "Communicating means that its behaviour modifies probability of behavioural act of the other subjects" [4].

It emerges a process of continuous reciprocal adaptation between the parts of the system; each one acts and reacts according to the actions and reactions of the other parts. This process does not stop until it gets to an organization that guarantees a harmonious, and no-conflicting, interaction between the elements, according to the suggestions coming from the external environment [5].
"A no-linear system controls and dominates its complexity by using organization as a tool" [6].

So, a complex system chooses the best configuration of interactions. This is an unconscious choice. Organization emerges spontaneously because of the concerted, competitive and cooperative actions of constitutive elements, each one pursuing its own aim.

Atoms go toward a slightest energy state constituting chemical links and ordering themselves into molecules. Organisms continuously adapt each other by their co-evolution processes and constituting an ecosystem. These are examples where groups of agents, looking for their own consistence and reciprocal adapting, can transcend themselves and acquire collective properties, that do not exist individually, like the life and the thought [5].

2.3 Open systems

So, at least, we have to underline a system chooses the organization that optimises the interactions between the elements according to the suggestions coming from outside. Ilya Prigogine speaks about dissipative structures saying they are thermodynamic systems open to energy and matter and they self-organize toward higher levels of complexity. Prigogine means, in a no-equilibrium state, they are able to became ordered structures (like space shapes or time rhythms) by absorbing qualified energy from the environment, neg-entropy, and producing entropy to the environment, that is a energy decrease (a energy leak).

The organization spontaneously adopted by a complex system, depends on the perturbations coming from its external environment. So, its configuration is not static but dynamic: it does not stay immutable but it modifies itself each time the external conditions change and make it far from an equilibrium state.

Complex systems are adaptive ones because they modify their organization trying to gain the best advantage from environment's changing. Self-organization could be considered as a sort of evolution by whom the system tries to adapt itself to the environment. This adaptation happens by two processes: prevision and feedback. This is what happens in biological evolution. The organization chosen by a system at once is the one that harmonizes the interactions between the elements according to the suggestions coming from the environment. Self-organization is a sort of unconscious prevision. The system explores many kinds of possible organizations. The choose of a kind depends on the feedbacks from the environment. It is a sort of selection. If the organization is able, the system conserves it until next environmental changing, that is the selection delivers those fluctuations that make the organization to change.

Selection works in a macroscopic level while fluctuations develop in a microscopic one. So, we deduce, "no-linearity amplifies not only from local to global levels, but even, on the inverse, from global to local" [7].

At the end, for self-organising there are two conditions: no-linearity and opening, that is external actions coming from the environment have to make the system far from an equilibrium state.

"While the system is in a equilibrium state, it is perfectly homogeneous and no ordered structures emerge. A cubic centimetre of water, in ambient temperature, is characterised by the disorder motion of its molecules, that is a "motion by thermal agitation"; if it is put under the whether of a winter storm, it self-organize in a snowflake with its peculiar dendritic structure" [8].

2.4 Bifurcations and fluctuations

In a self-organising process, the choice is among many organization shapes, qualifiedly different. The evolutive trend of a system could be described by a diagram of bifurcations with many branches. The choice of a branch, in front of a bifurcation point, depends on small local fluctuations that constantly exist on the level of interactions between the constitutive elements. These fluctuations are consequences of the law of "slightest resistance": each element always modify its interactions with the others, looking for the most advantageous. The amplification of fluctuations, caused by no-linearity, makes grow macroscopic relationship and ordered structures. Prigogine speaks about this growing of space configurations and time rhythms in dissipative structures, calling it "order by fluctuations" [9]. A microscopic fluctuation is amplified until it pervades all the system, on a macroscopic level, creating an ordered structure sustained by energy lost. "We can imagine dissipative structures are giant fluctuations maintained by flows of energy and matter" [9].

We said fluctuations can be amplified only by external perturbations. If a system is in a equilibrium state, it means negative feedbacks prevail over the positive ones and they deaden fluctuations. If perturbations make the system in no-equilibrium state, it means the positive feedbacks prevail and amplify fluctuations making grow a new order structure. The system becomes sensible to

its own fluctuations and activities. So, it is a no-equilibrium state that reveals the power of no-linearity.
"Surprises of complexity, caused by no-linearity, not always happens, but only in no-equilibrium conditions" [8].

2.5 Historical dimension

Bifurcations give to the system a historical dimension, that means the system's state, in a instant, includes the choices previously taken.

The biological organisms are structures capable to remember (to take memory) the past organizations adopted during their evolution. The changes with the environment generally irreversible. "The meaning of the state of a system, in a certain instant, includes its own previous path (its history) and the contemporaneous structure takes inside the memory of previous bifurcations" [10].

In front of a bifurcation point, fluctuations decide which branch to follow.
Between two bifurcation points, the system is anchored to the branch where it stays by deterministic laws that keep it from changing its actual organization. The past bifurcation decided its actual state.

2.6 Information

Now, we would like to understand better "those processes that select the structures rising (emerging) from the turbulent ocean of fluctuations" [9]. In front of bifurcation points, the system looses its natural adaptation. A sort of selection (prevision and feedback) guarantees a new organization emerges among many possible ones, suitable to the new environmental conditions.

Using the metaphors of evolution and learning, we say the system learns to know its environment by analysing perturbations. Prigogine finds an analogy between self-organization and learning. A complex open system receives a continuous flow of energy and matter from the outside. This neg-entropic flow could be described as a flow of information about the external environment. The system finds some regularities, builds a scheme that describes the environment and, finally, lays down its behaviour. Each time the environment or the information's flow changes, the system finds new regularities and builds a new scheme. Interacting with the environment, the system receives information from the outside and learns how to behave according to it. This feature of adapting and learning is the main property that distinguishes complex systems from chaotics [5]. No-linearity is a feature of both complex and chaotic systems. In chaotic systems, no-linearity amplifies fluctuations never stopping and never making the system stabilize on a organization finally suitable to its environment. A complex system can became chaotic if its environment changes too much or too fast: the information flow becames chaotic and the system can no more find regularities, "learn" its environment and self-organize.

Two different systems interacting with the same environment recognize different kinds of resources, that are neg-entropy sources. The environment is so rich of resources as the system is able to recognize and metabolize them.

Self-organization is the progressive recognising of new neg-entropy sources from environment: is the adopting of levels of organization capable to find and use certain resources of the environment. Each time the environment changes, some neg-entropy sources disappear and new sources emerge. The system can be unable to recognize them immediately. Self-organization is a learning unconscious process that takes place by recognizing new resources. If the flow coming from the environment is made only by news, the system can be unable to self-organize. It is a system in a totally new environment, a fish outside the water; it will adopt a chaotic behaviour. If the flow is made only by confirms, the system will never evolve.

Meaning entropy of a system as the measure of its disorder level and neg-entropy from environment as pragmatic information, self-organization is the process by whom the system learns to recognize, not only the environment in general, but the energy's sources from the environment.

2.7 Entropy's flows and entropy's productions

The metaphor of learning is able to describe the behaviour of a complex system, from a thermodynamic point of view, by using the analogy of concepts like (neg)entropy, (dis)order and information. Entropy is the measure of the level of disorder inside a system.

According to Prigogine, the variations of entropy are distinguished in variations of entropy caused by entropy's production inside a system and variations of entropy caused by the entropy's flows from and to the outside. Some processes are kinds of relationships or reactions between under-systems that happens inside the system, without any external cooperation, as it was isolated. The total variation of entropy is an addition of this variation by inside production and variation by changes with the outside. In a isolated system, entropy increases until a maximum value (second thermodynamic law) and the system goes toward a thermal death. An open system, on the contrary, receives neg-entropy's flows and lays positive entropy to the outside.

The system can decrees its internal entropy, that means it increases its order inside. It needs a neg-entropy's flow to win the entropy's production inside and maintains itself far from an equilibrium state, that is a state with maximum value of entropy.

So, a system evolves toward a steady state, where entropy is constant and has minimum values.

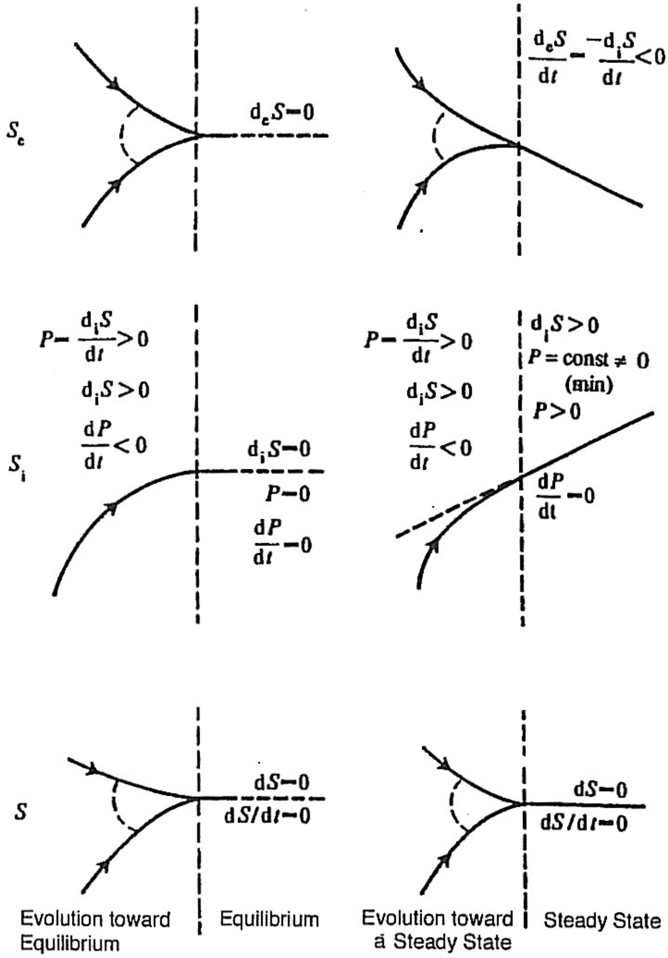

Figure 1: Entropy's variations in four different cases

3 Complexity of city

We think the isomorphism between city (territorial system) and complex system, has an important meaning. Some of the features described above are peculiar of the system city and can help to understand the urban dynamics. City is structured on many levels of organization, it has a multiplicity of times-scales, there are many decision makers and factors of choice, it happens unforeseen events and surprises. Multiplicity is easy to understand just thinking that it is possible to describe a city in many different ways and it is impossible to define at ones a urban system or its boundaries.

City has shaded boundaries, softer and softer outlines: the lifestyle of city moves to no-urban areas too because of the expansion of services, the increasing of transports, and the migration of people toward suburban areas. Processes of technological innovation and decentralization, as well as new media, communication tools and economy globalising processes, make certain activities no more anchored to an urban location. They make grow the freedom of moving of financial capitals, wares, information and people.

In contemporaneous cities we observe new kinds of production, often based on "soft" energies and technologies. "Soft" is, for example, the energy for electronics and informatics, and is the new scientific though based on complexity of nature and self-organization and no more on absolute certainties of mathematics and geometry.

Even the new action's policy has to be "soft" and based on reforms and research programs, instead of imposing definitive solutions.

The research looks for adaptive development models that use evolutive and dynamic natural shapes and not intensive energies and deterministic laws.

So, we strongly suggest "soft" models of city planning and policies of reformism and experimentalism. The new aesthetics and coherences have to develop on "soft" energies and to improve the integration between the planned environment and the spontaneous, natural, self-ruled behaviours.

3.1 Integration places

Edgar Morin says the "method of complexity" re-actuates the relationship between disconnections and fractures; it works to comprehend the multidimensionality and never forget the integrating whole (the totality).

The processes of space integration that take place in a city are potential indicators of the satisfaction of no-linearity and opening, necessary to each kind of self-organization. Each economic and social action, made by urban actors, has its own space-time dimension. Actions interact each other. These interactions have their own space-time dimension too. So, these systems are not isolated but they reciprocally interact and create networks of relations. When these relationships become physical, they often superpose each other, they overlap. Multi-specific physical spaces come up where many systems and actors interact. The city shape depends on these processes of interaction and on those processes of relationship between city (or its certain local systems) and other local systems. Referring to the metaphor of information, the set of these relations is the "cognitive domain" of a city: when this domain is big, it means that the city belongs to a global system of cities and has a bigger internal flexibility that is its capability to change its organization according to external perturbations.

The indiscriminate growing of city, the limits of functional zoning in separating activities, the lack of communicability are diseconomies to fight against. Efficiency of city organism is directly proportional to the level of integration between its parts and between the outside and itself. The new sustainable model of development has to leave the mentality of growth and start the way of functional integration, suggesting self-organization processes based on multidimensionality of city as a point of strength, against the functional zoning of the obsolete rational city planning.

The city is a system of micro-structures, services and relations. It is articulated into relational intensive spaces where overlap places of residences, production, market, free time, research. The "soft" city planning has to develop "soft" programs about urban functions but even the projects have to go towards very clear ideas of city. We mean, while many hypothesis and open configurations are explored anyway the theorist model of the city has to be quite clear.

3.2 Conclusion

Every organism can grow and modify during the time, but a transformation is not only a scale jumping, a geometrical increase of its dimensions. An intensive reordering of the organism has to follow each dimensional transformation.

Self-organization is a kind of learning and the city is no more able to learn, that is to adapt itself to the external suggestions. We have to teach it how to recognize these suggestions, transforming them from news to confirms [4].

The planning project has to drive spontaneous processes, fighting against the lost of communicability caused by a too fast growth. The project has to find and select a peculiar principle of order.

We have to simulate spontaneous processes of urban self-organization and find efficient actions to direct them toward a certain direction. The project will direct and lay the urban transformation on the metropolitan scale; if it proposes a clear, close and defined shape, the plain will pay its lost of flexibility. On the contrary, its capability to act, , doesn't work if it is too open.

The project is similar to the picture taken by a photographer as a sort of manner able to show a clear view of a city but even very flexible and open to many kinds of interpretations. It results an approximation, nearer to a landscape view than to an objective view, that works like a suggestion for the continuous research of alternative spaces.

The project is more than a way to impose or propose possible future shapes but it is a "cognitive look" over the city, a permanent research and experimentation to look for the sense of the places and find new items of development. It's a kind of "investigative strategy" by the production of shapes, suggestions and images.

This suggestions about urban systems introduce an ambitious research program even if still far from a coherent formalization. The new aim is to look at no-planned adapting processes no more as obstacles to remove but as opportunities to exploit.

In general we hope for a change from the trend of control to that of interaction's play.

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The Sustainable City II
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