A New Paradigm for Deep Sustainability: Biourbanism

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Abstract

Biourbanism introduces new conceptual and planning models for a new kind of city, valuing social and economical regeneration of the built environment through developing and healthy communities. Thus, it combines technical aspects, such as zero-emission, energy efficiency, information technology, etc. and the promotion of social sustainability and human well being. In effect, this new paradigm endorses principles of geometrical coherence, Biophilic design, BioArchitecture, Biomimesis, etc. in practices of design and also new urban policies and, especially Biopolitics to promote urban revitalization by ensuring that man-made changes do not have harmful effects to humans. Green city standards start inside the designs of each building and continue either in unbuilt spaces surrounding buildings or inside complex infrastructural networks, connecting buildings and people.
The proposed presentation should illustrate how new exciting developments, such as fractals, complexity theory, evolutionary biology and artificial intelligence are interrelated and constantly stimulate interaction between human beings and the surrounding environment. New Biophilic solutions in designs of buildings have been proved as attractive opportunities for new markets of housing. Thus, some new infrastructural projects start embracing Biophilic advanced solutions which finally aim at energy efficiency and optimal performance. As parallel activity we can now see emerging new innovative monitoring systems of building health not only in small scale, but also in large scale buildings, such as rail stations, for example, and commercial centres or even sometimes entire educational complexes integrated to new infrastructural projects. Some important case studies are going to be presented; they have been analyzed and evaluated by Biourbanism and Biophilia principles and applied methods of design.

Keywords: Biourbanism; Biophilic designs; urban design; urban web; green city; human health

1.0   INTRODUCTION

1.1   Biourbanism as organization

The first definition of the term "Biourbanism" was given in 2010 by the philosopher and

psychologist Stefano Serafini (ISB), the bio-statistician and expert in complexity theory

Alessandro Giuliani (Italian NIH), the architects Antonio Caperna and Alessia Cerqua (Roma Tre University), and the mathematician and urban theorist Nikos A. Salingaros (University of Texas at San Antonio) (www.biourbanism.org/biourbanism-definition/, 01/07/2013). Since 2011 the International Society of Biourbanism (ISB) has been established, as an interdisciplinary community of scholars, aiming at giving a new epistemological frame to urban studies. Today the Society has members in Europe (Italy, UK, The Netherlands, Spain, Belgium, Norway, Sweden, Greece), in Australia, Russia, and USA. The ISB publishes a bi-annual peer-reviewed journal, the Journal of Biourbanism (JBU) (www.journalofbiourbanism.org, 01/07/2013). Recently the ISB has shown activity in both professional practice and education, such as service design for urban and social change by implementing Biourbanism principles in the Artena, Segni SEED and LEPUS projects in Italy and in higher education at various levels in Università Tre (Rome, Italy), University of Sant' Antonio (Texas, USA) and University of Derby (Derbyshire, United Kingdom).

1.2   Definition of Biourbanism and related theories

Biourbanism considers the city as a living organism; it studies it within the frame of Integrated Systems Sciences and the last advancements of Life Sciences, such as:

- **Laws of form** and Self-organization in evolution;

- **Epigenetics**

- **Systems Biology**

- **Constructal Law,** as it has been introduced by Adrian Bejan, affirming that, *"Design is a universal phenomenon in nature. It is physics. It happens naturally when something is flowing and it is free to morph. Design unites the animate with the inanimate"* (Bejan & Lorente, 2013, p3).

In this paper, the author wishes to concentrate more on the first and last points as stated above. As it was recognized by the Manifesto of Biourbanism, which is now published in the official

web site, *"**Biourbanism** focuses on the urban organism, considering it as a hyper complex system, according to its internal and external dynamics and their mutual interactions."* (Caperna, 2010, http://www.biourbanism.org/p2p-urbanism/, 01/07/2013). This paper will discuss issues related to cities as urban organisms and, especially cases of self-organised societies and urban design and planning.

Biourbanism regards the urban fabric as being composed of several interconnected layers of energetic structure, which influence each other in a non-linear manner primarily. The interaction between two or more interfaces of these layers evolves into new properties, which are not always conventional, apart from a dynamic analysis of the connected whole by non-linear coupling of the interfaces, which connect certain layers. Thus, it is obvious that, evolution and creation of new boundaries/interfaces follows laws related to fractal growth, as we see further in section 2.1. In brief, **Biourbanism** recognizes **optimal forms** defined at different scales (from the purely physiological up to the ecological levels) which, through morphogenetic processes, secure an optimum of systemic efficiency for the quality of life of the people living in cities. Designs, which do not follow these laws, as mentioned in the previous paragraph, may produce anti-natural and hostile environments, which do not fit into human beings' evolution, and thus, fail to enhance life by any means (Tracada & Caperna, 2012). Biourbanism is based on key underpinning theories and practices, such as exemplary scientific paradigm shifts, New Life sciences (as biological origins of architecture and urbanism), Peer to Peer Urbanism (as an innovative way of conceiving, constructing and also regenerating the city). For example, Morphogenetic Design Processes, based on authentic recognition of optimal forms at different scales, are able to guarantee optimal systemic efficiency.

Hence, Morphogenetic designs can guarantee high standard quality of life. (Caperna, 2011, http://www.journalofbiourbanism.org/2012/caperna/, 01/07/2013). Since several years, even before getting involved with Biourbanism, the author of this paper has carried out research on

urban fabric of cities, which have been developing in very remote times. Research findings (Tracada, 2008) proved that, patterns of energetic lines, such as preferential paths, flowing and exploding in very ancient landscapes, had kept quite intact their evolving energy for many centuries and, perhaps they performed as generators of further expansion and development until recent and current times. These lines have always behaved as fractal everlasting emergences and have managed to influence and inform human behaviors and life in cities. We have witnessed fractility to be transferred from geographical flow shapes to energetic flows of human acts, as it is shown in the following diagram. From a core centre or an important nodal point, we see an explosion of lines, which create spaces and, as a result, **Ch-òros** (in Ancient Greek, it means spatial expansion of human activity between boundaries, not necessarily linear though). From the edges/interfaces, a new line moves and acts as a piercing/penetrating element towards the surrounding natural and artificial environments and expands as new activity of human flow and again. In fact, **act** means everlasting movement and behaviour of both human beings and artificially created pathlines under human footsteps and performances/urban rituals. **Act** originates from Ancient Greek **Ak-is**, formed by the Ancient Arian root **Ak** or **Ac**, plus **–is** and it means **piercing item**, such as a sword, for example.

<div align="center">

Act

↑

Ak(c)-is

↑

Ak-

↑

Edge, boundary & rule

↑

Line pointing+piercing+penetrating into space

↑

Explosion of cosmic lines = Space/Ch-òros

↑

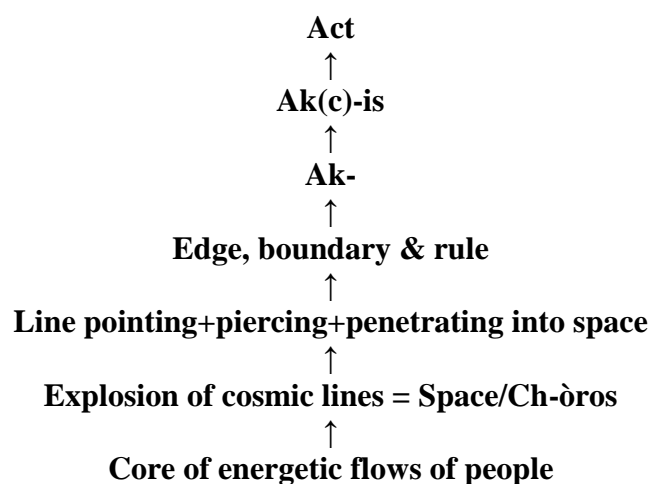**Core of energetic flows of people**

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Figure 1 – The author's own diagram inserted in materials taught to students at Level 6 and 7 in Higher Education and related to history and theory of architecture and Urbanism.

Patterns of energetic lines are so important to the development of cities, because they include all

their inhabitants' intentions and attitudes towards built and unbuilt environment. Healthy intentions and attitudes can always guarantee healthy societies and continuous growth. By the way, when an unexpected and sudden alteration happens (not according to the citizens' plans), we may be able to go back and investigate on previous patterns to find out links to enable us to make adjustments and necessary repairs of all structures and infrastructures inside badly affected areas. For example, the author had the opportunity to attend and follow instructions and teaching materials given by Christopher Alexander during particular seminars, when she pursued studies in the Faculty of Architecture in Florence in late 1970s. Through his pattern language, Christopher Alexander (Coppola Pignatelli et al. 1977) offers a diagnostic method of investigation on the growth of urban fabric, which is defined by active pathlines and human activities along them. At the same time human unconscious inherited behaviors and traffic flows may still delineate areas of previously very stable and healthy areas, which apparently have gone in decline and presently show an unhealthy urban fabric; new opportunities may arise in them to be used by communities once more and according to new public demand, perhaps with some further help from experts.

Pathlines of human energetic flow accomplish form crosses and powerful nodal areas, which make fractal connections easier and systematic rather than random. New activities usually create more pressure at peripheral nodal points, which are able to unfold to another new fractal border expansion of new paths capable to generate more buildings and spaces to be available for further public deployment. In fact, with his fourth principle of the pattern language, Alexander affirms that, in any project and any new build a common set of previously existing urban design codes will be embossed; this set is defined by patterns that, they have been adopted and accepted largely by a local community (Coppola Pignatelli et al. 1977, p16). Furthermore with his sixth principle, Alexander insists that, the efficiency of new interventions will be safeguarded eventually by an annual diagnosis that will show in detail which areas are still alive and which

ones are inert ('dead'), no matter what the moment of life could be inside a certain community. Although Alexander accepts the fact of areas being dead, the author of this paper (Tracada, 2008) should like to suggest that, useful seeds of the past can always re-appear as rejuvenating elements for new urban interventions at any time, whatever alterations may have occurred. Other authors, who further analyzed critically Christopher Alexander's work, like Nikos Salingaros, for example, also affirmed that, unmistakably 2D information shown by a plan could not be so relevant for people who would try to distinguish and receive information from complex 3D surroundings and vertically rising surfaces created by architecture (Salingaros, 1999). In a sense, architecture acts as *"extension of the human mind to the environment"* (Salingaros, 1999, p29). Therefore, we can construct or draw and even model 3D structures in order to connect people with them by being mindful to their immediate surroundings. If the human mind does not detect any connections, the next tendency is to flee that unfamiliar environment. People define their living space by becoming aware of the particular existence of solid margins through their emotions as well as through physical contact and through the senses. As we should show in section 2.2, a fine fractal emergence is able to define an ideal outer border between urban space and green or simply open areas. Therefore, urban space should be considered more complex scientifically than the formal geometry of a plan proposed by architects and urban planners today. This may prove that sciences can contribute more than ever through diagnosis of healthy cells ready to generate growth or regenerate badly affected fabric of modern cities.

2.0   FRACTAL CITIES

2.1   Geography of fractals in the natural and built environment

Urban space is often related to information theory, as its use is in agreement with information context, which initiates from surfaces rising from the ground; this information can be perceived as logic signal and also be accepted by human beings, navigating through it, by means of pedestrian and often preferential pathlines (urban navigation indicators). Successful spaces

should offer noticeable hints from local structural emergences; standing and seating signals, for example, may determine the most advantageous pedestrian paths and nodal points associated with them. Hence, human life in cities emerges during connectivity via geometrical continuity of grids and fractals, via path connectivity among highly active nodes, via exchange/movement of people and, finally via exchange of information (networks).

Nowadays some vital elements in urban fabric have been often concealed for reasons of style preferences. Classical theories and geometries, real patterns of social life, as **bios** (=active life in Greek) have been replaced by modern minimalist rectangular grids and very compact blocks of buildings. Recent theories, such as New Urbanism and Biourbanism, affirm that *"cities risk becoming unstable and deprived of healthy social interactions."* (Tracada & Caperna, 2012). Several authors, like Christopher Alexander, believe that there is still time to go back and explore spaces, patterns and linguistics in the built environment, in such a resourceful way that, again social and historical patterns of **bios** should enable us to reinstate preferential paths of communication, respecting everyday life activities. The paper discusses issues related to insistent and long lived flows of people moving along unrestrained pathlines, which become important references for urban sprawl.

To a certain extent we discover often how powerful certain pathlines could be within processes and performances of complex systems of everlasting interweaving amid architectural emergences and natural landscapes. Lines perform infinite complex acts to create environment and, that complexity often coincides with developments following laws of fractal growth. Biourbanism investigates upon internal and external dynamics of these complex systems in order to propose feasible solutions of new built and/or regenerated environment; Biourbanism recognizes the existence of layers and interfaces and can predict analysis and synthesis of systems to accomplish service design, for example, as we see in section 3.0 which refers to specific recent case studies and projects.

As a professional in urban design, the author had the opportunity to carry research, for example, on maps and developments of masterplans of several villages, towns and cities in Tuscany. By studying developments of geographical expansion, it was obvious that, fractal growth was always present at all phases. Either because of defense purposes or because of mere spreading out, historically all towns and cities have followed fractility in structure, as we can see in Figure 2 below. The medieval walls had acted as boundaries showing clearly fractal expansion of pathlines, which became again generators of new 3D interfaces by stopping just in front of new walls before proceeding and re-exploding further towards new areas (and so on).
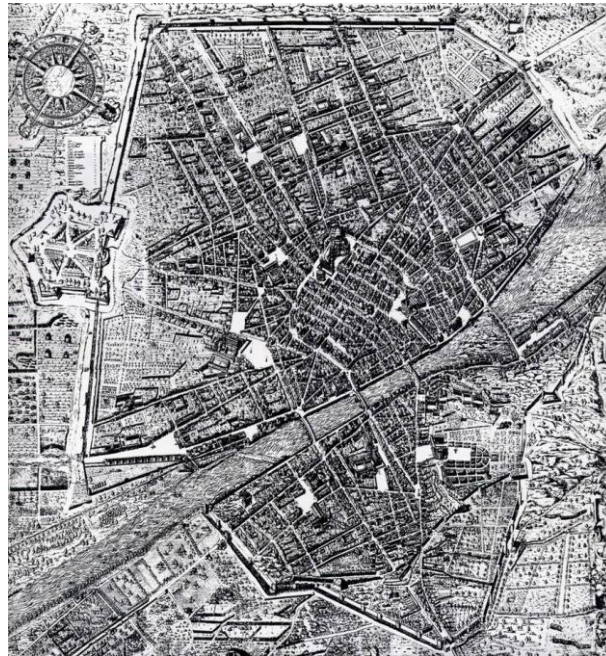
Figure 2 – Stefano Buonsignori's map of Florence (1585), Property of the Museum *Firenze Com'Era*, Florence, Italy.

Pathways crossing landscapes stay alive as long as acting/moving/performing bodies work together to accomplish either rituals of everyday life or unique spiritual parades and social gatherings. Still today the lines that cross both ancient and modern landscapes linger as powerful elements to order further human interactions and urban growth. Hence, lines defined by geometrical conventions often perform as germinating elements that are strictly controlled by human performances. These powerful indicators of life and bios are capable to act in synchrony

to encourage further generation of natural and manmade environments. The long emotional and/or spiritual existence of these pathways still influences human beings' emotions and motivates them to perform rational and harmonious walks. The preservation and re-discovery of such lines could offer us the most advantageous solutions to urban design and planning in such a decisive way that, we could not be wrong as designers and planners to integrate especially important infrastructures at the most vital nodal points of ever-growing fractal expansions of human energetic flows.

2.2   Fractal interfaces: underpinning theories of urban continuity and integration

According to Mathematics and Physics, fractal is a structure that shows complexity at any magnification; there is more 3D complexity into a fractal than plane sterile surfaces joining at angles. According to some author (Salingaros 2005), continuous straight-line or plane boundaries and edges dividing one region from another are an exception rather than a rule in living cities. As Salingaros suggests (2005), successful urban interfaces should be either similar to a **permeable membrane** with holes to make allowances for trading off or a **folded curtain** with edging that looks like a tortuous waterway on a flat map.

The expansion of a city starts practically from buildings and stops at buildings from which, again energetic lines expand as pathlines to show pedestrian and urban users' real intentions with urban spaces. According to Nikos Salingaros (Salingaros, 1999), we may be able to design and generate successful urban space of any kind by using three fundamental axioms. These axioms oblige us to create urban space, which should be delimited by surfaces offering to citizens' clear information. This visual field of spatial information, which is also associated to the laws of optics according to the same author, unmistakably establishes the web of paths and nodes of human traffic. The axioms also dictate clear separation between pedestrian space, which should be protected from car traffic and hazards. Thus, the urban space which is designed by using these axioms *"feels emotionally nourishing"* (Salingaros, 1999, p. 30). The three urban space

axioms should have an immediate influence to the arrangement of communal space and buildings; they can offer general rules and information on shaping the façades of buildings, but not on design. This happens because, by defining urban spaces and dimensions, we are not able automatically to be restricted to use only specific designs; a variety of different designs can be present, for example, around a piazza, but the shapes of façades may be similar. The axioms operate at a more essential level than extensive design choices. Salingaros affirms that *"plans, patterns, symmetry, axes, are only of secondary importance relative to the fundamental processes that generate urban space. This lends support for the irregularity of successful urban spaces"* (Salingaros, 1999, p. 31) and, he also suggests that, contemporary urban planners should not focus so much on formal geometries of urban spaces, because people do not prefer to use them at all or they scarcely use them for very short time.

By returning to Bejan and Lorente's very recent review on **Constructal Law** (Bejan &Lorente, 2013) in relation to design, we also find that any kind of design, including urban design appears as a universal phenomenon in nature and responds to laws of physics. For example, if we say that design **flows**, this becomes factual, when we observe maps presenting free flow of rivers in estuaries. This process happens physically when something is flowing and it is free to be formed. The inorganic world dictates organic flowing, as a manifestation of organic informal shaping of landscapes; cities should imitate these processes in order to integrate the build into the unbuilt natural environment, instead of imposing authoritarian formal grids in urban spaces. According to the same authors, design processes are not static; design is a dynamic and ever changing phenomenon, but differs according to proposals of optimality. For example, some principles on optimal design that they relate to urban spaces and arrangements affirm that *"Minimum travel time is used in urban design, traffic, and transportation"* [or] *"minimum effort and cost is a core idea in social dynamics and animal design"* [or] *"maximum profit and utility is used in economics."* (Bejan & Lorente, 2013, p.2). If we integrate human pedestrian flows in

the discussion, we may have to think differently about urban spaces; all these statements could be true, if only we could offer urban design as a fluid and human-orientated experience which considers human emotions and behaviors. This can be achieved by coupling of fractal forces, as we see in section 4.0.

In Constructal law, designers accept that designs are **tree-shaped** (Bejan & Lorente, 2013), so that they could be expressed through conduction, fluid flow and convection processes; this law can be considered as statement mainly and does not use words such as tree or complexity, etc. Flow configurations in nature can derive from Constructal law *"analytically or numerically, approximately or more accurately, blindly (random search) or using strategy (shortcuts)"* (Bejan & Lorente, 2013, p. 3). The researchers mentioned here had treated several designs in detail and especially **tree-shaped architectures**; they treated them *"as fundamental problems of access to flow: volume to point, area to point, line to point, and the respective reverse flow directions"* (Bejan & Lorente, 2013, p. 3).
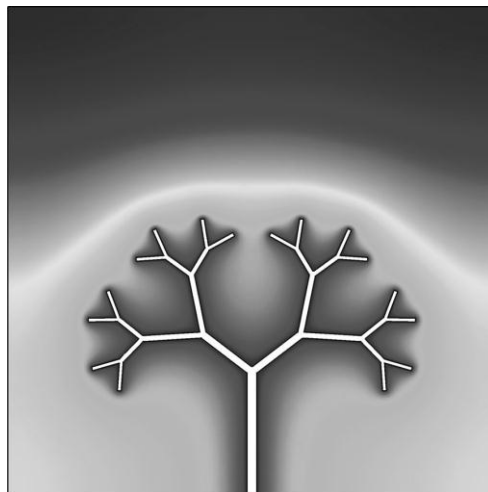

Figure 3 – Tree-shaped architectures: *"Constructal invasion of a conducting tree into a conducting body"* **(Bejan & Lorente, 2013, p. 3).**

As shown in Figure 3, the theoretical discovery of trees stems examines, how one point (source, etc.) connects with an infinity of points (volume, area, line) and thus, it expresses fractal

geometry. According to the same authors, *"the reality of the continuum requires a study of the interstitial spaces between the tree links"* (Bejan & Lorente, 2013, p. 3). The interstices can only be immersed in invisible and disorganized flow, whereas the tree links serve as conduits of the visible streams.

The researchers (Bejan & Lorente, 2013) discovered that the tree-shaped architecture is the arrangement of imperfection over the available flow space; that means pathlines and pedestrian routes should flow in the same way inside urban space and landscape. The same authors say that, *"it is the architecture for access into and out of the flow space, which is finite"* (Bejan & Lorente, 2013, p. 3).   In fact we can see this evidently in fractal coupling of forces in section 4.1.

3.0 CASE STUDIES AND ONGOING PROJECTS BY THE INTERNATIONAL SOCIETY OF BIOURBANISM

3.1 Artena Village, Province of Rome, Italy

The International Society of Biourbanism (ISB) has been involved into some projects related to **service design** for urban and social change by implementing Biourbanism issues (Artena Project, Segni SEED and LEPUS Project).

The Artena Project started in 2012 after discussions took place in 2012 between the Municipality of Artena and funding members of ISB. The medieval 'borgo' (=village) of Artena has been formed by optimal primordial structure of fractal growth upon a steep hill situated in the Province of Rome.

In the map in Figure 4, we can easily distinguish the characteristics of Constructal invasion of architecture (buildings) into and out of low space, as Bejan and Lorente suggested and as explained in section 2.1. Fluid and human orientated design is also clear throughout and thus, it respects and favours positive human emotions and behaviours. Especially the young generation

of the inhabitants of Artena love their village and want to stay and be productive and creative at the same time; they were helped by members of ISB and scholars in Neuroergonomics Summerschool organised in July 2012 by ISB to understand that, their community could be proved to be successful and sustainable only if they could revive local productivity in commerce and the arts. They have now managed to produce their own beer in a local brewery with local and special ingredients, which is now exported to other cities and perhaps countries soon (dissemination of information via internet helped a great deal). Inhabitants are very enthusiastic in the results and have also participated in other initiatives, such as photographic competitions and support to the specialist Neuroergonomics Summerschool by ISB, running for the second time in July 2013 (with active participation of the author of this paper, too).
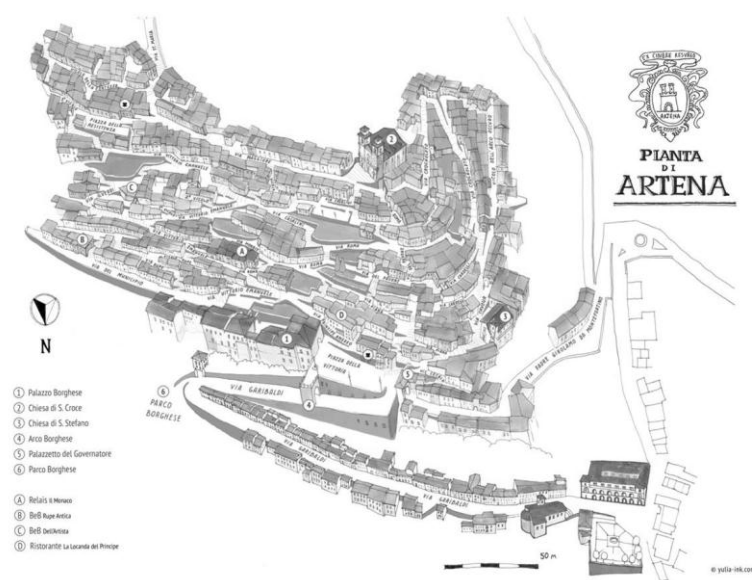
Figure 4 – Artena village structure: flow space is evident into available pathways (©yulia-link.com)

3.2 Professional training and sustainable education in Biourbanism

During the workshops of Neuroergonomics of urban space (Artena Summerschool), the scholars have the opportunity to study Mimesis and Environment, Design and Neurological Patterns, Algorithmic Sustainable Design (cutting-edge mathematical techniques for a

Biophilic architectural and urban design), Body Consciousness and Neuroergonomics Space Analysis and Practice drawing. Many more initiatives are going to take place in 2013 and 2014; a discussion between ISB and the University of Derby started some year ago. Currently the author is considering the creation of a specialist collaborative postgraduate course between the University and ISB. This course could offer the opportunity to scholars to further develop ideas and projects under the supervision of international experts in related sciences, like Prof. Nikos Salingaros, Dr. Antonio Caperna and Dr. Serafini. The author is also Editor in Chief of the Journal of Biourbanism, which has attracted the attention of many international experts in Sciences and Urbanism and started a discussion also between researchers and the general public (participation projects, such as the ex-bus depot ATAC in Rome in 2012.
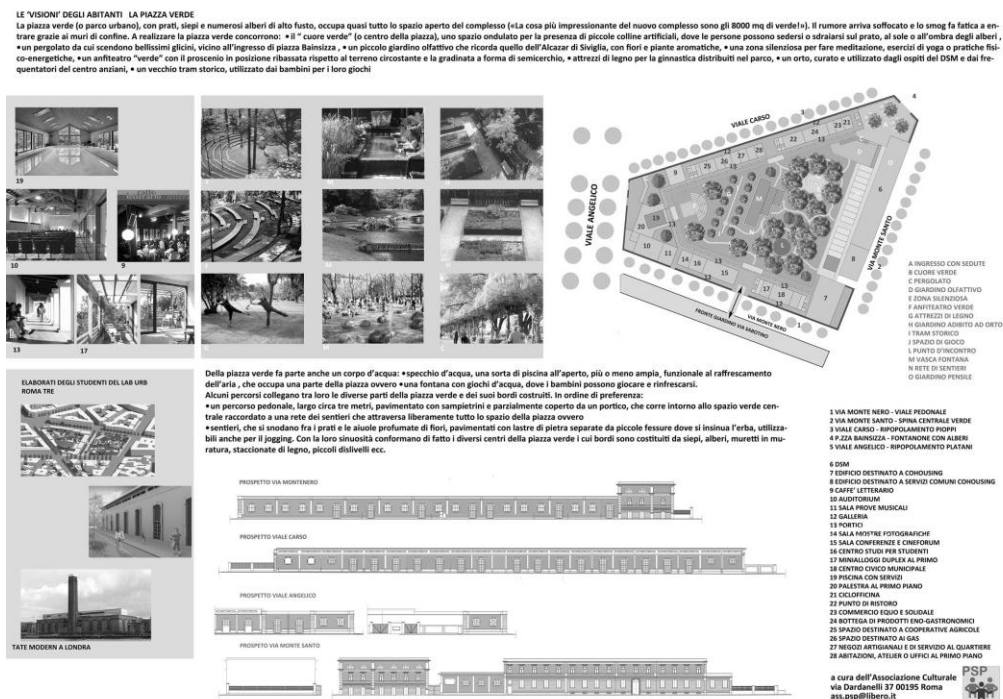

Figure 5 – ATAC depot regeneration area in Rome participation project - analysis

The project in Figure 5 was included and presented recently on 1st June 2012 by Dr. Stefano Serafini and Eleni Tracada in the workshop *Biophilic Design. Theory and practice*, in Environmental Design Research Association (EDRA) Conference, Providence44, USA.

4.0   DISCUSSION

4.1   Effects of fractal urbanism (design and planning)

As some authors (Batty & Xie, 1999) have confirmed, currently we may be able to develop *"coherent and consistent dynamics of urban evolution which is built around the current fascination with the highly decentralized complex systems whose operation is at the local level, and which generates urban forms which are consistent with the fractal patterns that have been widely observed for cities"* (Batty & Xie, 1999, p. 110). Batty & Xie's ambition is to prove fractal theory's consistency by measuring urban transition during post industrial revolution era; their intention "to think about the future evolution of urban form in the context of the shift from cities based on energy and industry to those based on information and services" (Batty & Xie, 1999, p. 111) may be of major interest nowadays during a world wide financial crisis. The authors wish to investigate on the emergence of **world cities** and **edge cities,** as two features of this ongoing change; they accept the incidence of dynamic theories on fractal expansion, which has the aptitude to make some sense during this phase of evolution through expansion of communication systems in cities.

4.2   Coupling forces of fractility

Many authors affirm that specific patterns are more favorable than others in the formation of cities; most of them (Alexander et al, 1977; Batty & Xie, 1999; Salingaros, 2005) suggest that complex mathematical patterns form precise urban modules; a module is formed by strongly coupled elements on the same scale. It is also imposed a critical diversity of different coupled elements; *"different modules couple via their boundary elements"*, as Salingaros (Salingaros, 2005, p. 87) affirms by defining distinct rules for geometrical urban coherence of human connections in cities. Components of urban fabric may be contrasting, but they have to coexist harmoniously. By coupling urban elements at the smallest scales, we are able to create very strong fractal links in urban fabric, as seen in Figure 6 and, most Biophilic designs, as the case

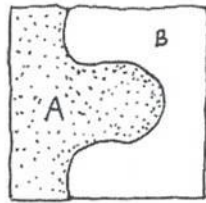study in section 3.2, follow mainly this rule.
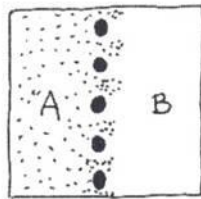

Fig. 3 Geometric coupling through interpenetration.
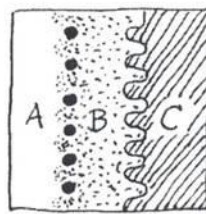

Fig. 4 Geometric coupling through permeability.

Fig. 5 Inductive coupling via a common third element.

Figure 6 – The nature of strong links: colonnades, rows of houses, shops with gaps for cross-paths (Salingaros, 2005, p. 91)

The same author also insists that, urban coherence is based upon stable modularization and urban modules are formed by connective forces; *"a module is any group of nodes (units) with a large number of internal connections…connections between internal nodes must be stronger than external connections"* (Salingaros, 2005, pp. 121-122). This is proved in the case of the village of Artena, as seen in section 3.1 and see also Figure 7 below.
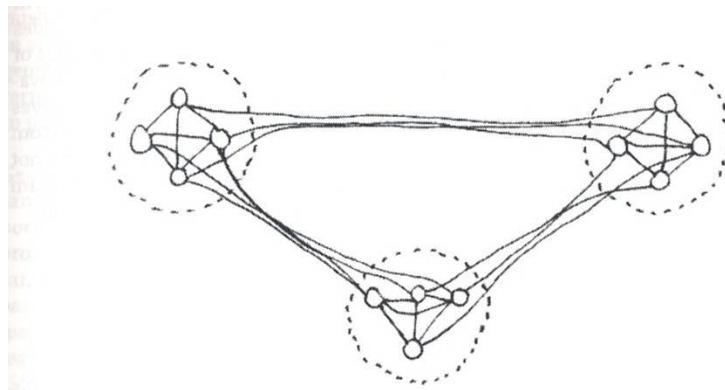
Fig. 3 Modules internalize connections between their constituent nodes.
Three modules connect themselves via organizable forces.

Figure 7 – Part of the urban web, which shows modules connected between them

(Salingaros, 2005, p. 123)

5.0   CONCLUSIONS

As we saw in this paper Biourbanism is a composite new urbanism discipline which has attracted a lot of attention by scholars and practitioners nowadays.

- Biourbanism presents links with many sciences to set its theories;

- It is thought that, new models of urban design and planning are clearly based upon human orientated designs;

- Biourbanism enhances harmonious growth of urban fabric by offering help to local communities actively participating in urban development

- Biourbanism offers new alternatives to plan urban modules from small scale of modules to larger conurbations.

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