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Journal of Biourbanism (JBU) is a peer-reviewed international online journal of architecture, planning, and built environment studies. The journal aims at establishing a bridge between theory and practice in the fields of architectural, design research, and urban planning and built environment and social studies. It reports on the latest researches and innovative approaches for creating responsive environments, with special emphasis on human aspects as a central issue of urban study and architecture.

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Editorial

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As an Editor of the Journal of Biourbanism, I am pleased to announce that, for this issue some distinguished authors have also submitted their work to be peer reviewed and eventually be published alongside with PhD scholars work. It is an honour for us in Biourbanism to get so much response to our calls for papers from both established researchers and new inquisitive young specialists. The discourse and debate, which, I am sure, will emerge will not only help experts, but also communities interested directly in the future of the cities they live and work. Thus, in this current issue, the authors' contributions were carefully peer reviewed to initiate again a new series of fruitful discussions and enable scholars communicate their ideas in progress and/or developing theories and practices on advanced sustainable methods of architectural and/or infrastructural design in order to achieve high standards in urban design and planning simultaneously.

Prof. Nikos Salingaros' paper gave me the opportunity to discuss with him on a topic which is very dear to me personally as a scholar and to my postgraduate students as well; that is the topic on fractal dimensions having even healing power on human bodies and minds. In his important paper with the title *Fractal Art and Architecture reduce Physiological Stress*, Prof. Salingaros proves that human beings respond in a very positive way to fractals, as these appear and appeal to human perception in a variety of their manifestations. Prof. Salingaros has based his discussion not only on his own scientific evidence and experience, but also on other authors and scientists' findings, especially during the last few decades of rapid technological developments in digitalisation in arts and architecture. As a result of his valuable research, the author affirms that, euphoria is the result of sensational experiences of human beings in direct contact with fractal landscapes; whereas stress can be sensed when minimalist environments are completely sterile of fractal geometries and patterns. In the last couple of years, I had the opportunity personally to carry out several short workshops/projects with my students and tested Prof. Salingaros' ideas and formulas on *Thermodynamics* of the built environment; we have managed to get very significant findings and we hope to carry on this direction in order to develop useful tools to be easily used in proposed and scientifically and sustainably planned either new districts of cities or areas of regeneration. With his article, in this current issue, Prof. Salingaros offers us the chance to see how from a real biophilic environment and by transforming it into abstract design, we risk getting people extremely stressed rather than happily excited. Then, my students and I shall be eager to use his suggestions on fractal dimensions and see how especially fractal gaskets can create comfortable architectural 3D spaces, not necessarily flat decorative horizontal or perpendicular surfaces. Nevertheless, this article can really give us a lot of elements to play with, test and enjoy.

In their *Ecological Design for Dynamic Systems: Landscape Architecture's Conjunction with Complexity Theory*, Prof. Robert Mugerauer and Prof. Kuei-Hsien Liao also affirm that, ecological design is directly linked to self-organising organisms, ecosystems and cities; this is the kind of design to help us resolve current social and economic problems. According to these two authors the ecosystems' self-organizing capacity should be maintained unaltered and uninterrupted in such a manner that, damaged ecosystems dynamics should be continuously preserved and restored within an operational new paradigm of complexity theory. The importance of this paper again is that, the authors have used examples of hydrologic flow regime and flooding to test scientifically ecological designs; the authors talk about complexity theory by explaining resilience, adaptation, plasticity and related concepts and also discuss in detail the impact of this theory to ecology and design. This is a valuable paper, highlighting that, design work which is based upon complexity theory does not only follow universal formula or set of rules by incorporating the critical variables of initial historical conditions, but also encompasses pre-existing landscape properties and life cycles in never-ending interactive processes of growth, decline, new assembly and dissipation.

Then, we find again with pleasure another interesting paper by Joseph Akinlabi Fadamiro, Joseph Adeniran Adedeji, and Rasaki Aderemi Ibrahim on *Indigenous urban open spaces as public infrastructures for sustainable cultural system in Ilawe-Ekiti, Nigeria*. These authors discuss about urban open spaces in relationship to public infrastructure and indigenous value-system in cities in Nigeria; they debate on the fast loss of indigenous public open spaces and their negative effects in urbanisation. The research and study as a whole focuses mainly on how these important spaces could be sustainably safeguarded. The scholars seem to be extremely keen to support an incessant protection of these important cultural spaces, which again shows that landscapes and cityscapes should be always considered as valuable manifestation of harmonious continuation of human life in any part of the globe.

I should like also to mention the fact that, four papers included in this issue have been especially peer reviewed and selected by Editor's choice after having been submitted to be presented and included in the Water Efficiency (Watef) Conference 2013, with the title *Innovation through Cooperation*; this conference was organised by the University of Brighton, UK and took place in Oxford from 25th to 27th March 2013. I am a member of the Waterwise/Watef Network established in 2011 and I was especially invited by Dr. Kemi Adeyeye, Watef Network Coordinator, in the Conference Scientific Committee; I had the opportunity to take part in blind peer review processes and finally select the papers included in this current issue, as follows:

- In their paper *Towards in integrated approach to measuring and monitoring water in domestic building*, Dexter Robinson, Jonathan Gates, Simon Walters and Kemi Adeyeye discuss why the impact of human activity on the natural environment is so damaging by only considering water consumption in dwellings nowadays. The authors propose that it is necessary to monitor simply, cheaply and accurately, water use factors which can be used to inform customised water efficiency strategies in a building. Thus, the authors investigate on water technology performances and water efficiency in contemporary dwellings; they also refer to climate change and human behaviours to be adequately adapted to this in order to preserve efficient supplies of water, our most precious natural element to preserve human life on this planet.

- Ifte Choudhury and Farzana Sultana, in their *Rainwater Harvesting for Domestic Consumption in Bangladesh*, explain to us why water supplies have suffered in Bangladesh by industrial and human effect pollution; the authors explore the possibility of rainwater harvesting for domestic consumption in urban areas and propose guidelines to compute storage requirements. Their guidelines may also form a useful tool/model for rain harvesting in cities in Bangladesh in desperate need of water supplies.

- In his *Supply and Demand of Potable Water in Australia and the United Kingdom. How climate change can affect the distribution of potable water supply,* Lee Callaghan focuses on the increasing impact on water utility companies and their customers to conserve water in both countries; the author compares and addresses common and non-common issues and discusses mainly public perception on water conservation.

- In their *The use of the water element in the energetics of Micro-urban development in Slovak Republic and Taiwan R.O.C.*, Stefan Tkac and Zuzana Vranayova discuss issues related to unregulated growth and energy consumption in some small city districts; they propose new multi-purpose hydro types to fit micro-urban demands and preserve both water and energy production methods used via efficient power grid circles in cities. This is an interesting article which considers both water and electricity uses according to specific planned urban systems in micro and macro scales.

And finally, we have got an interesting and perhaps fairly controversial article by Dr. Thomas Mical, who talks about *Soft Infrastructures for a Neo-Metabolism.* We may say that the author attempts to explain, according to his own understanding and analysis, how Biourbanism encompasses *Soft natural systems thinking*, or at least, how close Biourbanism could be with an interplay of systems, intersecting architecture, infrastructure, and landscape urbanism. I am sure that this paper will trigger a sparkling debate between scholars. But, having been teaching in the department of the Built Environment for several years, I feel that, this is the time to talk about hard infrastructures in cities and how these could fit in urban design and planning today without obstruction to ordinary human life in cities. However, I believe that, architecture, civil engineering and urbanism should cooperate in order to establish new regulations, which would allow for self-organisation of communities and would guarantee fractal harmonious developments in social-economical and urban growth simultaneously.

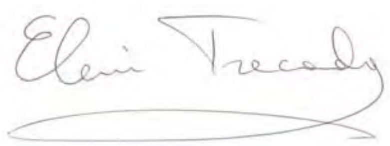
It has been a great pleasure to act as Editor in Chief of this issue as well and once again I should like to thank all the authors who have taken the time and effort to produce the aforementioned published papers. I should also like to thank all authors who submitted papers, but did not get the opportunity to be published this time, because of major corrections asked by peer reviewers. I am looking forward to receiving these resubmissions for our next issue and having them published. Our scientific committee and the executive team of the International Society of Biourbanism will decide soon about deadlines of submission for the next issue of our Journal of Biourbanism. Please, keep an eye constantly on our web site, in which you will also find more materials published or announcements on the progress of specific important publications pertinent to our past, current and future activities.

I am always convinced that all issues raised by the papers included in this current issue will create a fruitful and interesting discussion, which can be always produce new articles and perhaps a full conference on Biourbanism soon. All our members of our committees and, especially our scientific committee, encourage research developments in the discipline and philosophy of Biourbanism worldwide by constantly organising events, symposia and specialist workshops / summer schools. Thus, I should encourage all readers and scholars to participate in additional discussions and contribute actively by writing their thoughts and findings in more papers to be submitted in the near future.

I shall add that this year has been a very challenging and exciting one for the staff of the International Society of Biourbanism, who participated in conferences in U.S.A. and Europe, and worked hard on research, teaching, and dissemination. This, together with the decision of publishing some selected contributions to the Watef conference, delayed the editing of the present issue nr. 2 of 2012 to 2013.

Thank you for considering our continuous efforts.

My best wishes to all of you.



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Part A – Peer-reviewed papers

Fractal Art and Architecture Reduce Physiological Stress

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ABSTRACT

Human beings are apparently tuned to prefer an environment that has the self-similar properties of a fractal. Furthermore, as different types of fractals are characterized by what is known as their "fractal dimension" D , we respond best to "mid-range" fractals where D is between 1.3 and 1.5. In such fractal environments, our body automatically dampens its response to stress induced by intensive tasks and reaction to external forces. This implies that particular fractal environments are healing, or at least buffer us from life's stresses. The remarkable fact is that this response is independent of what the fractal designs around us actually look like: they can be either representational or abstract. Altogether, we have here the beginnings of a new way of interpreting how the visual environment affects our health.

Key words: fractals, biophilic design, healing environment, stress, ornament, cognitive resonance.

INTRODUCTION

The term "fractal" refers to "broken"; that is, fractal designs are not geometrically smooth or pure, but are defined by components on a hierarchy of different scales. Fractals can be either built with accumulated accretions (patterns of ordered heterogeneity, spikes, granulations, "hairiness"), or instead have gaps or holes (perforations, sieves, hierarchically-ordered spacings). In either case, fractal structures depart from smoothness and uniformity by breaking geometrical linearity. Their name, however, tends to emphasize the "jaggedness" aspect that is characteristic of only one group of fractals. Fractals could be curved: a cauliflower is composed of superimposed whorls of ever-decreasing sizes, so there is nothing "jagged" here.

A key property of fractals is their self-similarity, where a similar structure is apparent at increasing (or decreasing) magnifications. Each perfect fractal can be magnified repeatedly by a specific scaling ratio, and will appear the same every time. Among the few natural fractals that are obviously and remarkably self-similar are cauliflowers and the mammalian lung. In a mathematical fractal, scaling similarity shows for any number of successive magnifications while for natural fractals, the basic structure eventually changes: for example, successively magnifying the bronchial tree of a mammalian lung eventually gets down to the cellular level, which shows no branching structure (West, Deering 1995; West, Goldberger 1987). Many natural fractals such as plants and other biological structures tend to be only statistically self-similar. In that case, a magnified portion of the fractal will resemble but not be identical to the original.

Architects are increasingly interested in fractal patterns and shapes, and are beginning to use them in their designs. Applications tend to be restricted to fractal building plans and fractal decoration on façades. The fractal forms that have been built recently, however, contrast strikingly with traditional fractal architectural expressions such as the Gothic form language (Joye 2007). Even so, this trend moves away from the uncompromisingly "pure" forms favored by twentieth-century modernism, which insisted upon simple and empty geometrical shapes such as squares, rectangles, or regular curves such as semicircles or parabolas. Elementary pure solids and fractals represent opposite ends of the design spectrum: the former express reductionist design, while the latter express ordered complexity that is a result of mixing a hierarchy of linked scales. There is no reason why contemporary architects should not use fractals in their designs, but those should be more than just motifs.

We are commonly exposed to both natural and artificial fractals in our everyday experience. It turns out that much, if not all of natural structure is fractal. Natural forms exhibit complex geometrical structure on a hierarchy of scales, from the large to the small, going down to the microscopic scale. Artificial fractals have always been produced as part of traditional artifacts and buildings (Goldberger 1996). Computer-generated fractals are now common in our everyday environment because of our pervasive digital technology. They are generated by recursive algorithms, which create substructure on a frame on increasingly smaller scales, or build up a complex whole by progressively adding contributions that create the whole out of smaller components.

I am interested here in knowing how the human perception system responds to fractals. We can begin with the conjecture by Ary Goldberger (1996) that our mind somehow has an intrinsically fractal structure, and therefore more readily accepts fractal information (Mikiten *et al.* 2000). As a consequence of this anatomical trait — and this point is crucial to architecture and design — we tend to imagine fractal forms as the most "natural". While this hypothesis is not yet proven, it does contradict the often-made claim by modernist architects that humans have a predilection for crude geometric forms. Indeed, it implies quite the opposite. Let us consider the experimental evidence on exactly what type of form makes human beings feel more comfortable, which should resolve this issue. Before doing so, it helps to remember that the modernist architects' assertion favoring abstract geometric preferences predates this latest scientific evidence by many decades, but the architecture community never went back to re-examine the original claims.

EXCITEMENT VERSUS STRESS

This paper argues that fractal images reduce stress in the workplace and living environment, and digs deeper into results that certain fractals are better than others in accomplishing this task. Experimental evidence suggests that there is an optimal fractal dimension required to reduce stress, and that being exposed to plain non-fractal shapes increases a person's stress levels. These results explain why we naturally prefer fractal images in our environment, and consequently, why humankind has produced intrinsically fractal traditional art, artifacts, and architecture. We know that we enjoy the complex patterns of woodland scenes, which are shown to be fractal. Going beyond simple enjoyment, people consider exposure to natural scenery to be restorative: it is good for our health.

In architecture, the stark modernist interiors that came of age with Adolf Loos and later with the Bauhaus have been very unsuccessful in eliciting the type of universal and visceral attraction and sense of comfort that more traditional interior environments accomplish, as witnessed by what the majority of the population chooses as their living interiors. People like to bring objects such as photographs, plants, dolls, and *objets d'art* into their living space and workplace. This practice has been condemned by a rather narrow design élite that continues to support the old minimalist design ideology against overwhelming evidence of what makes people most comfortable.

The research that provides a scientific basis for these general societal preferences would suggest that plain, empty shapes have no place in architecture; at least in architecture that has to be used by human beings (industrial buildings being a separate case altogether). Is it then the purpose of architecture to reduce stress? This is an open question that raises important issues, as some contemporary architects make it a point to induce stress in the user. Here it is necessary to distinguish between excitement that has a positive physiological effect, and stress that has the opposite negative effect on the human organism. Positive excitement is elicited by euphoria; the emotion of love; inspiration through traditional art, music, and dance; religious ecstasy; transcendental and mystical experience; sexual attraction, etc., whereas stress from negative excitement comes from physical threats (the fight-or-flight response); war; panic situations; horror and intensely violent real-world experiences and films; and prolonged exposure to environmental conditions or pollutants that wear a person out. Both groups of environmental factors disturb homeostasis (an equilibrium condition in the body), yet one is nourishing while the other is harmful (Selye 1974).

I believe that architecture that is adapted to human physiology is nourishing because it generates positive feelings through positive cognitive response to symmetries and fractal structures (Salingaros 2003). An artificial environment with those measurable qualities provides a better quality of life (Salingaros 2012). By contrast, stressful environments with the opposite characteristics induce anxiety and depressive behavior, and ultimately pathology in their users and residents.

PHYSIOLOGICAL RESPONSE TO FRACTALS

Visual perception studies reveal human preferences for fractal landscapes and structures. I review material here from Richard Taylor and James Wise (Taylor 2006; Wise, Rosenberg 1986; Wise, Taylor 2002). They found that people feel more comfortable with fractal images showing nature, over non-fractal images such as non-fractal abstract art. The first point to emphasize is that those research studies used physiological measures and did not depend upon responses giving the subject's preference, because that could be, and usually is, influenced by learned biases. Instead, the body's automatic responses were rated by measuring skin conductance. It is known in the medical profession that raised skin conductance (electro-dermal response) correlates very well with increased bodily stress. Therefore, the skin conductance will peak in a stress-inducing environment, and will be reduced in a low-stress environment.

The results from a 1986 study carried out by NASA (Wise, Rosenberg 1986) strongly indicated that persons respond positively to natural scenes (either real scenes, or visual images of them), whereas they respond negatively to non-fractal abstract shapes. Subjects had to perform three types of challenging mental tasks: arithmetic, logical problem solving, and creative thinking while exposed to four different 1m x 2m images. Ordinarily, such tasks induce a degree of physiological stress, so that it was possible to measure the effect of the image on the body state while performing these tasks. The skin conduction measurements in the three different environments were compared with the same tasks performed in a control setting, which featured a pure white panel of the same dimensions. The results are as follows: the abstract non-fractal artwork *increased* the stress by 13% as compared to the control situation, whereas the two natural scenes *decreased* the stress by 3% and 44% as compared to the control (Taylor 2006).

A second interesting point emerges from further analyzing the data. The two natural scenes used in this experiment had a markedly different effect on reducing stress in the subject. The first image, showing a dense forest scene (top of Figure 1), lowered the stress somewhat, but the second image, showing a savannah landscape of isolated trees (middle of Figure 1), lowered stress considerably. The researchers concluded that, for some unexplained reason, persons react far more positively to a specific type of natural scenery. It's not just a question of having more nature, because the forest scene has a higher density of plants. This finding is nevertheless consistent with the biophilia hypothesis (Kellert *et al.* 2008), where humans feel most comfortable in environments that reproduce the mathematical qualities of ancestral human evolutionary environments. It is believed that we evolved in a savannah rather than in a forest. Thus a savannah landscape should (and does) provide the most positive response. The difference in the two natural scenes is one of fractal dimension (a mathematical measure of the fractal's internal scaling, which is described below) hence it is possible to pinpoint with some accuracy our innate biophilic fractal preferences.

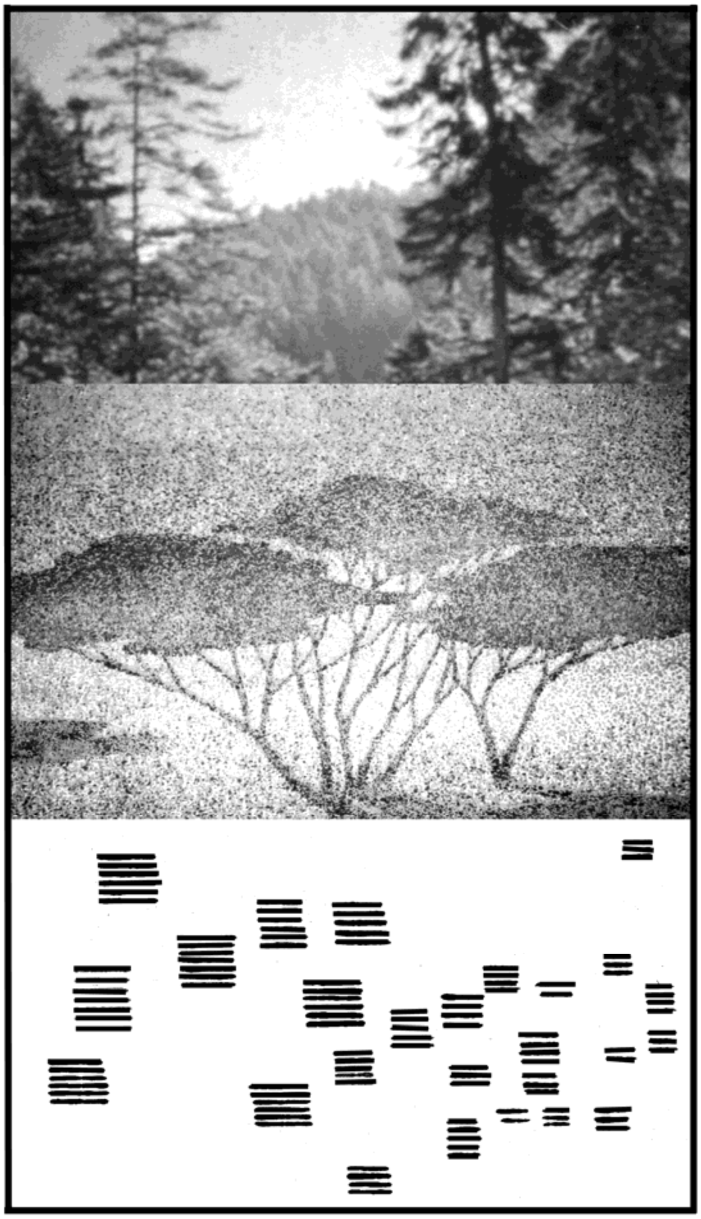

Figure 1. A photograph of a forest (top), an artistic rendition of a landscape (middle), painted lines (bottom). © Richard P. Taylor, used with permission.

There is yet a third result that comes out of these experiments. The forest scene used in the results referred to above is a photograph. It happened that the savannah landscape scene is not a photograph, but a rather stylized drawing of a savannah landscape. This reveals that our response is triggered by fractal properties much more than by an accurate representation. As such, the importance of the scenes in creating their physiological response relies squarely upon their mathematical content, and not in some intrinsic or mysterious vitalistic qualities of the natural scenes themselves. This result makes possible a remarkable simplification of what is at first a very puzzling effect.

In this interpretation of what is responsible for the physiological effects of fractals on human beings, I agree with my former student Yannick Joye, who attributes the mechanism to the mathematical and not the biological content of the environment (Joye 2007). Only this assumption explains why we respond in a positive manner to artificial fractals and, coincidentally, why humankind has produced fractal designs on artifacts and buildings for millennia (Goldberger 1996).

ANOTHER INTERPRETATION OF THE STRESS REDUCTION EFFECT

I wish to present an alternative interpretation using the same data reviewed above and draw a new conclusion. By taking the savannah landscape scene — our presumed ancestral evolutionary environment — as a fixed baseline, we can list the increasing stress conditions caused by the different experimental environments. I will use the control situation (plain white panel) as just another of the elements, giving it equal importance.

(*i*) Savannah landscape: minimal environmental stress
(*ii*) Dense forest scene: slight increase of environmental stress
(*iii*) Minimalist colorless environment: significant increase of stress
(*iv*) Abstract non-fractal design: further increase of stress

Ordering the experimental environments in this way demonstrates clearly that minimalist design is neither preferred, nor particularly good for us as far as dampening our physiological response to stress. It increases stress over our innate baseline fractal preference. When we abandon minimalism in design and create complex but non-fractal artificial environments, we actually increase our stress ever further. I'm aware that this is a disconcerting statement to designers, artists, and architects, yet it is supported by incontrovertible experimental data.

Working with Judith Heerwagen for the Herman Miller Furniture Company, Wise did a later variant of his original NASA experiment (Heerwagen, Wise 2000). In this case, cognitive measures were used. The study used standard workstation cubicles of three different varieties, identical except for the pattern on the fabric covering their visible surface. One variety had a digital image of a savannah landscape, another variety was plain grey, and the other variety was covered with a geometrical pattern. Subjects sat in these workstations for half a day while performing a series of creative problem-solving tasks. A positive correlation was found between the scores on creative problem-solving tests and the natural-image workstation. Please note that since the work is proprietary, few details are available for publication.

WE NOTICE FRACTAL EDGES AND CONTOURS

It is instructive to explain how the fractal dimensions are computed for the images shown in Figure 1, above. In general, the eye forms a two-dimensional image of a three-dimensional complex of objects. Ordinarily, it focuses attention on contrasting edges in this image: a definite line, outline, border, edge where two contrasting regions meet, etc. We know that the eye scans an image by following its regions of highest contrast, called the "scan path" (Salingaros 2003; Yarbus 1967). Impressions of scenes are therefore determined for us by the fractal character (or not) of dominant contrasting lines within them, called fractal contours. For buildings, these dominant lines could be the roofline or skyline, borders, edges, articulated or otherwise ornamental lines, etc. The fractal dimension *D* (explained below) is then computed for these dominant lines, with the numbers expected to lie between 1 and 2.

Figure 2. A fractal edge defined by the repeating patterns of the Borobodur Temple, Java. © Richard P. Taylor, used with permission.

These experiments with fractals confirm that the presence of dominant lines in our environment affects our physiological state: this effect, though subconscious, is significant. Furthermore, the effect is beneficial when such environments have a fractal property, and specifically, when they correspond to a "mid-range" fractal. People have been creating fractal art and architecture since the beginnings of humankind and civilization, which is verified by undertaking a survey of traditional art, artefacts, and architectural ornamentation produced ever since the first humans (Eglash 1999; Washburn and Crowe 1988). This enormous effort, concomitant with the rise of humanity and culture, may now be interpreted as the natural attempt to create stress-reducing environments using sensory feedback. This conjecture explains a great deal of anthropology and history, until we come to the 20th Century, when Art and Architecture began to diverge drastically from traditional models.

THE FRACTAL DIMENSION

Allow me to provide some background on what the fractal dimension *D* represents. A smooth line (either straight or curved) has $D = 1$, whereas an area fills in a two-dimensional region and has $D = 2$. However, an infinitely crinkled, meandering, and convoluted line will fill a little into its adjoining area and will have *D* somewhere between 1 and 2. An example of this type of fractal line is the von Koch Snowflake, with $D = 1.26$ (which is amply documented on the World-Wide Web). A mathematical object that has dimension approximately halfway between a line and an area, i.e. that has fractal dimension around 1.5, is called a "mid-range" fractal. The more convoluted and meandering a fractal line, the closer its fractal dimension will approach 2, at which point it ceases to be a line because it fills in all the area.

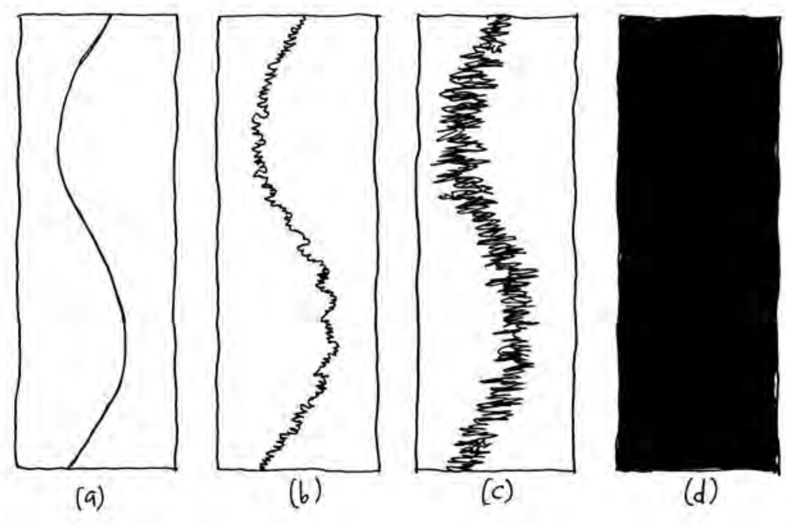

Figure 3. Fractal lines of increasing dimension, until they become an area: (a) D = 1 (not fractal), (b) D = 1.2, (c) D = 1.7, (d) D = 2 (not fractal). Actually, these are drawings and not accurate fractals. Figures by Nikos Salingaros.

We can also arrive at a "mid-range" fractal in quite a different manner. Starting from a filled-in plane with $D = 2$ we begin to punch holes into it, perforating it with smaller and smaller holes. If we do this in a regular hierarchical manner, we are reducing its dimension and eventually create a "mid-range" fractal with D somewhere between 1 and 2. But this object arises in a very different manner from a crinkly line: it is a sieve and did not begin as a line at all, yet it could have comparable fractal dimension to a fractal line. The triangular Sierpinski gasket, with $D = 1.58$, is an example of such a fractal (again, see the World-Wide Web for a description).

Let us go back to the visuals used in the NASA experiment. Each of the straight parallel lines grouped in sets of three to seven (bottom of Figure 1) has dimension $D = 1$, and is not fractal. The lines being grouped together may form a visually interesting pattern, but do not contribute to any fractal structure. The groups themselves are arranged randomly without any type of scaling symmetry that might generate a fractal.

TAYLOR'S ANALYSIS BASED UPON THE FRACTAL DIMENSION OF DOMINANT LINES

An analysis by Taylor using a great variety of fractal lines having different fractal dimension D reveals that human beings do indeed have a preference for a specific type of fractal (Taylor 2006). It turns out that we have a stress-reducing experience with D around 1.4, i.e. for a specific "mid-range" fractal. These measurements are very approximate, yet they serve to establish a clear peak for human physiological response to fractal lines observed in scenery.

This finding helps to explain the curious and unexpected result of the original NASA experiment (Wise, Rosenberg 1986; Wise, Taylor 2002). The forest scene (top of Figure 1), which turned out to have a mildly positive effect, has dominant lines with fractal dimension $D = 1.6$, whereas the savannah landscape scene (middle of Figure 1), with a strongly positive effect, has lines with fractal dimension $D = 1.4$. According to this and other experiments, human beings do have an enhanced response to fractal images characterized by lines with fractal dimension nearer a preferred value of $D = 1.4$. Therefore, it should be no surprise that the subjects in the above experiment responded better to the savannah landscape scene.

Further distinct experiments by Taylor and his associates reveal a preferred value for the fractal dimension of edge lines with $D = 1.3$ (Hagerhall *et al.* 2008). Subject responses were evaluated this time by using Quantitative Electroencephalography (qEEG) to measure the alpha waves of cerebral cortical activity. Fractal edges having four mid-range fractal dimensions from $D = 1.1$ to 1.7 were generated by computer. (The figures were supposed to mimic fractal horizons that resemble the silhouette of the Borobodur temple shown in Figure 2, but are not nearly as attractive). By measuring the intensity of the alpha waves in the subjects, a peak preference for $D = 1.3$ was detected from among the different figures they were exposed to. Since high alpha-wave activity is known to be associated with a relaxed state, this finding is consistent with the hypothesis that such fractal edges are the most restorative and relaxing (Hagerhall *et al.* 2008).

A SQUARE GASKET AND THE RELAXING EFFECTS OF NEEDLEWORK

I will now construct a square fractal gasket, a variant of the triangular Sierpinski gasket, and compute its fractal dimension. This exercise shows that, starting from an area, one can construct a "mid-range" fractal that is no different from a fractal line. We begin with a filled-in square of side L, and divide it into 9 smaller squares with sides $L/3$ (Figure 4). Repeat this procedure with each of the newly-defined squares, which eventually leads to the more line-like pattern shown below in its third iteration (Figure 5).

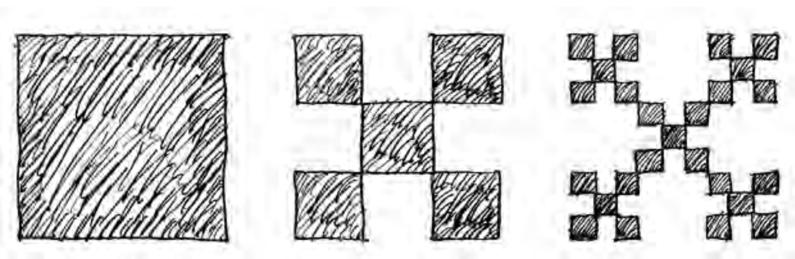

Figure 4. Construction of a square fractal gasket with scaling factor equal to 3, by successively removing smaller squares to create a symmetrical pattern. Figure by Nikos Salingaros.

Let me describe the iterative procedure that produces the entries shown in figure 4, above. The original filled-in square (on the left in Figure 4) is taken as the zeroth iteration: nothing has been done yet. The first iteration (in the middle of Figure 4) cuts the original black square to leave five smaller black squares each of side $L/3$. The second iteration (on the right of Figure 4) further cuts the five smaller squares into twenty-five even smaller black squares, each of side $L/9$. In general, the side x_i of each square in the i-th iteration is as follows: $x_0 = L$, $x_i = L/3^i$. The number N_i of non-empty squares (their multiplicity) at each iteration is: $N_0 = 1$, $N_i = 5^i$. From these values, we compute the fractal dimension as $D = -\Delta \ln(N_i) / \Delta \ln(x_i) = \ln 5/\ln 3 = 1.46$. (I refer the reader to standard descriptions for how this formula arises).

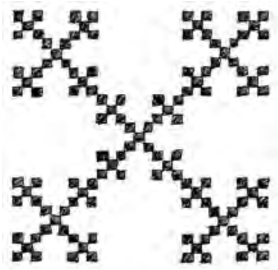

Figure 5. Third iteration of the fractal gasket. At this stage, it resembles a fractal line, and is remarkably similar to traditional crochet needlework and cross-stitch embroidery patterns. Figure by Nikos Salingaros.

Without getting into mathematical details, the fractal dimension depends upon both the fractal's scaling ratio and the geometrical denseness/sparseness of the design. Elsewhere (Salingaros, West 1999), I compute the fractal dimensions of the two best-known mathematical fractals in a plane: the von Koch snowflake (D = 1.26), and the triangular Sierpinski gasket (D = 1.58). The method for obtaining these results is outlined there.

Though evidence is mostly anecdotal, folklore tells us that stitching and creating crochet patterns such as the fractal with mid-range dimension shown in Figure 5 helps to relax a person. Indeed, for centuries before we had television and home entertainment, women did exactly that. Needlework has traditionally been identified as a particularly relaxing activity that calms the nerves, though it doesn't tell us anything about the effects of particular patterns. The American Home Sewing, Craft Association (AHSCA) commissioned a study by psychologist Robert H. Reiner, who reported that women who sew experienced significantly lower blood pressure, a drop in heart rate, and lowered perspiration rate (Reiner 1995); unfortunately, details of this experiment are not available.

ORNAMENT AND TRADITIONAL ART GENERATE A HEALING ENVIRONMENT

A basic confusion has been encouraged in our times, by a culture that copies superficial visual traits without attempting to understand the underlying reason for the forms. This practice has led to a false understanding of what traditional artifacts and ornament represent. Many learned writers state that ornament is "imitative of nature", but this is a backhanded compliment. And it is misleading. Traditional Art, and ornament in particular, are nothing less than human mental creativity expressed in the most direct and immediate manner. Ornament is simply the first step in the generation of innovative structure towards coherently complex forms. Almost every other positive human achievement points in the same direction, and arises from the same creative process that generates organized complexity.

The incredible mathematical sophistication of traditional material culture is simply not seen in our times, because design professionals tend to be obsessed with either "pure" forms or with the quest for innovation at all costs. The extremely rich traditions of fractal design in urbanism, architecture, and artifacts worldwide are simply dismissed as "not modern"; misinterpreted as an inability of those outside a narrow 20^{th} century artistic and intellectual élite to create exact industrial forms (Eglash 1999). The excuse typically given is that such objects are "not utilitarian". But nothing could be further from the truth: these are the eminently practical tools for creating a healing artificial environment. People wiser than us in these matters figured out that surrounding themselves with fractal objects provides an antidote to life's daily stresses (Figure 6).

When we confront the industrial products of the past several decades, we can hardly find a fractal. The popular interpretation for this paucity is that an anti-fractal aesthetic was necessary to reflect the needs of the machine age. But this is pure propaganda based on ideology. Late nineteenth-century and early twentieth-century industrial utilitarian designs and objects were in fact fractal, just like earlier traditional ones. Early industrial furniture and household objects and utensils were designed to also give nourishing feedback from their everyday use. The later radical simplification of forms was an ideological imposition by the Bauhaus and its successors: ever since the 1920s, people tend to judge a "modern" object by whether it conforms to this peculiar and intolerant aesthetic, not because it employs the latest technology.

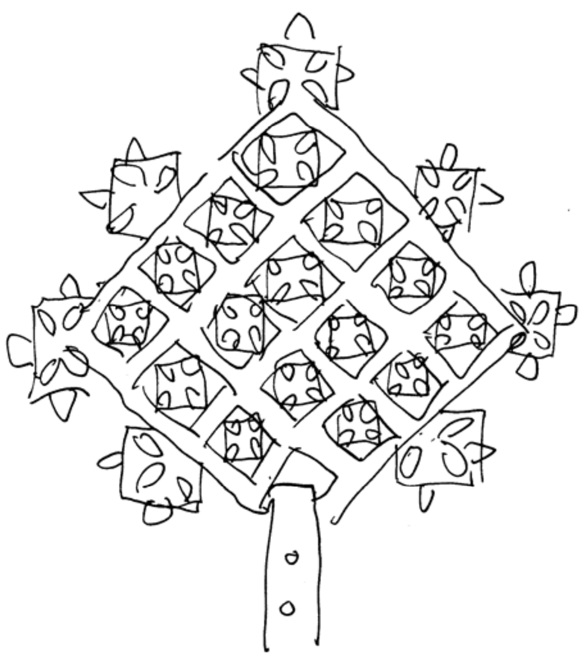

Figure 6. Ethiopian silver cross is an obvious fractal. Figure by Nikos Salingaros.

Taylor startled the Art world by proving that the paintings of Jackson Pollock are fractal (Taylor 2006; Taylor *et al.* 2011). Here we have an example of totally abstract art that is nevertheless fractal. The conjecture is that this is the reason why people find it attractive. Taylor's claim aroused excitement, with some researchers questioning whether the scaling in Jackson Pollock's paintings obeys a consistent scaling ratio, or if it extends to a sufficient number of scales for a true fractal (Jones-Smith, Mathur 2006). Taylor's rebuttal settled the issue (Taylor *et al.* 2006) and a number of groups subsequently performed their own fractal analysis on Pollock's paintings. This discussion encourages art historians to look at paintings and traditional products of material culture from a new, fractal perspective. Fractal art does not necessarily have to copy natural forms directly: what fractal art copies is the generative process that nature follows.

An important question raised by the discussion on Pollock is: "*how many orders of magnification are required for a self-similar visual to appear fractal?*" It turns out that the eye can perceive fractal structures with just a few multiples of scaling. For example, the design shown in Figure 5 has only three iterations yet we respond to it as a fractal. Its scaling factor equals 3, thus two consecutive magnifications equal 9x, or approximately one order of magnitude (10x), at which one still sees the cross pattern (middle of Figure 4). At three consecutive magnifications 27x, we lose the pattern and get a square (left of Figure 4). Taylor finds that a design which is statistically self-similar at between one and two orders of magnitude (i.e., from 10x to 100x) works as a fractal.

A related but distinct question is how many orders of scaling are necessary in architecture. This time the answer is not so simple, because the user's eye perceives extremely fine detail in the materials. If a fractal structure or design is not hierarchically anchored onto the smallest scales, then any large-scale fractal will seem detached. That is, it will appear fractal but as something superimposed on the structure (and cognitively detached from it) rather than an integral part of it. Architects designing abstract fractals today don't include the number of iterations that take advantage of the stress-reducing effects. Contrast this with the fractal quality of traditional and vernacular architectural languages, right up to and including Art Nouveau and Art Deco, which do indeed connect to the materials.

FRACTAL TUNING AND SEVEN CLUES TO COGNITIVE RESONANCE

Goldberger, Joye, Taylor, Wise, and I (and other researchers in this field) agree on one fundamental point: there appears to be a certain resonance between our cognitive apparatus and environments that possess fractal properties. Furthermore, not all fractals elicit the same degree of positive emotion leading to physiological stress reduction, but specifically mid-range fractals with fractal dimension around $D = 1.4$. Human beings seem naturally attuned to a visual signal of fractal character and particular fractal dimension. The brain is constantly computing characteristics of our environment, evaluating features that are essential for our survival, so this resonance has deep meaning. Lacking a satisfactory explanation for why our body is built in this way, we have only clues as to the underlying mechanism. I list some of them below

First clue: from the structure of the mind. The mammalian body, and especially the brain, is organized according to fractal morphology. The brain is a structured system of hierarchically-organized anatomical modules existing on distinct levels of scale. Measurements of magnetic resonance images (MRI) of the human brain confirm its essentially fractal anatomy (Kiselev *et al.* 2003). Evidence from associative memory points to a parallel between thought processes and the brain's fractal physical structure (Mikiten *et al.* 2000). Going further, Mikiten, Yu, and I conjectured that signal reception works like tuning a radio to a specific type of signal, which is consistent with the notion of resonance of our mind with fractals of a specific fractal dimension. Functional magnetic resonance imaging (fMRI) and magneto-encephalography (MEG) studies of the human brain reveal both spatial and temporal synchronizations among different regions of the active brain. Significantly, space and time measures in the brain separately show fractal patterning (Pincus 2009).

Second clue: from fractal antennas. In a recent technological development, the discovery of fractal resonators in microelectronics by Nathan Cohen (Cohen 2005) opens up the exciting possibilities of studying a parallel mechanism in electronic hardware. Antennas built using fractal geometry have been found to significantly outperform linear antennas. Indeed, a fractal antenna built on the design of Figure 5 proves to be extremely efficient in geographical locations with weak signal, where ordinary antennas cannot function properly. Advantages of fractal antennas include significant reduction in size without loss of receiving ability; and extremely wide bandwidth compared to linear antennas, which obviates the need for an additional tuning unit. That is, fractal antennas are able to capture different frequencies without either geometrical or electronic tuning. Conjecturing by analogy, fractal physiological structures that make up our body could somehow resonate with fractal structures in the external environment.

Third clue: from dynamic fractals in human physiology. So far in this discussion we have considered geometrical objects containing different scales. The same phenomenon exists in time, where fractals in the temporal dimension contain signals of different duration. The electrocardiogram (ECG) time-series of the human heart has fractal properties (West, Deering 1995). The dynamics of the human heart contain many frequencies that describe the variability of the basic rate at 70 beats per minute, which in a healthy heart goes up and down from 50 to 110 in a temporal pattern with fractal components. In a remarkable observation, pathologies of the heart are associated with a departure from a fractal spectrum, when the electrocardiogram becomes more linear, or when the distinct temporal scales decouple. That signals the onset of a heart attack. The West-Goldberger hypothesis states: "*a decrease in healthy variability of a physiological system is manifest in a decreasing fractal dimension*" (West, Goldberger 1987). These results on dynamic physiological processes suggest similar patterns occurring on spatial scales, which we already know.

Fourth clue: from the Savannah hypothesis. Several researchers, each starting from a different direction of reasoning, come to a similar conclusion about the influence of our presumed ancestral environment. The mid-range fractal dimension of a savannah landscape provides survival advantages such as effortless conveyance of basic structural information (Joye 2007; Kellert *et al.* 2008). Environments with higher fractal dimension, such as forest, can hide predators and thus present more danger, whereas environments with much lower fractal dimension are both too open and too exposed to offer protection and sources of food. If we are indeed tuned to this particular fractal environment because of our evolution, then we should respond with increased stress in environments with fractal dimension very different from a Savannah: those with considerably less or considerably more than the mid-range value around $D = 1.5$.

Fifth clue: from eye motions. Taylor and his associates propose an explanation for fractal resonance derived from measurements made on eye motions while scanning a picture. The eye executes a search procedure all over a visual in what is called “saccadic” motion consisting of many jumps of different length. The path itself is not regular, but follows regions of highest contrast (Yarbus 1967). Other than picking out the regions of maximal contrast, the irregular motions correspond to a stochastic fractal called a “Lévy flight” (Taylor *et al.* 2011). Taylor computed the fractal dimension of the Lévy flights of the eye while tracking fractal scenes of different fractal dimension. Interestingly, the fractal dimension of the eye path pattern did not change: it was fixed at $D = 1.5$. Therefore, it seems that the eye uses its own intrinsically fractal scanning procedure, which is unaffected by the fractal dimension of what is being scanned. It follows that cognitive resonance should occur for any line that has fractal dimension around 1.5.

Sixth clue: from sharks foraging for food. Animals looking for food tend to execute a stochastic search (random directions and path lengths) that resembles a Lévy flight, where a local region is searched thoroughly, and then the animal moves some distance away and searches that new location. Not only has the shark been observed to forage in this way, but also the albatross. The straight lengths of the movements combine many short paths, several paths of intermediate size, and a few paths of longer length. This is the characteristic inverse-power scale distribution in fractals. Taylor conjectures that this efficient Lévy flight foraging search pattern applies just as well to the eye motions in seeking out information from a visual in the most efficient manner (Taylor *et al.* 2011). The stochastic Lévy fractal eye motions when scanning a scene therefore come from an evolutionary adaptation to mathematics, and are not a characteristic peculiar to the eye’s anatomy, thus supporting the fifth clue.

Seventh clue: from artwork that reduces stress. An enormous amount of art produced throughout human history needs to be evaluated for fractal properties, and, if it is indeed fractal, its fractal dimension should be measured. In a 1993 survey, Vitaly Komar and Alexander Melamid claimed that landscape paintings containing water, people, and animals were the most universally preferred by persons from all continents (Dutton 2009). Note that the presence of water in a scene lowers the fractal dimension of contours to that of a “mid-range” fractal. The publication of this survey caused uproar in the world of fine art, since realistic landscapes have long been considered “kitsch”, and thus taboo. Yet interior designers and environmental psychologists know something, because dentist offices’ waiting rooms contain precisely such visuals (along with photos of cute puppies): an application of biophilia to lower the stress of anxious patients.

While medical researchers increasingly appreciate the health benefits of fractal environments, there is diversity of opinion as to the optimal fractal dimension. Some researchers investigating this topic disagree with choosing the mid-range fractals as the ones preferred by the human perception system. Alexandra Forsythe and collaborators, while supporting the healing value of fractal surroundings, propose that the preferred fractal dimension is much higher, between 1.6 and 1.9 (Forsythe *et al.* 2010). As evidence, they present the fractal dimension of well-known paintings, such as Botticelli’s “The Birth of Venus” $D = 1.86$, Monet's "Water Lilies" D = 1.78, and van Gogh's "Sunflowers" D = 1.76. Elsewhere, Ali Lavine computed Hokusai's "Great Wave off Kanagawa" to have D = 1.73 (Lavine 2009). These numbers, if independently confirmed, would of course require reconciliation with the experimental data given by Taylor and others.

I offer my own two points of caution in way of explanation. First, in this paper we are most interested in paintings that are known to lower stress in the viewer. A work of art may be famous and well-liked but not necessarily have restorative properties. Indeed, it may appeal precisely because it induces excitement. Hokusai's wave is certainly fractal, but may not be good at damping environmental stress. From the distinction between stress-inducing versus nourishing kinds of excitement, we can tolerate a short exposure to a challenging and provocative artwork, but an environment with those characteristics is probably going to have adverse physiological effects on our organism because of chronic stress. Second, it is notoriously difficult to measure the fractal dimension of a picture using the box-counting method (Gonzato *et al.* 2000). If one is not careful, the result given by commonly-used software could be off by 50% or more when measuring genuine fractals. Worse still, one could actually get a value for the fractal dimension of a non-fractal visual, which is a nonsensical result. We need to be cautious about the reported numbers for fractal dimensions of artworks, and wait for more data.

CONCLUSION

The work summarized here addresses how fractal visuals influence human beings during the performance of stressful mental work. Beneficial, restorative environments dampen the inevitable rise in physiological stress while performing a necessary task requiring concentration. The opposite, those environments that actually boost the stress levels of normal mental concentration, should be considered harmful to our health in the long term. Despite the voluminous literature on learning and workplace environments, the effect of fractal scenes on reducing stress has not yet assumed the central importance it deserves. Instead, we continue to see the same stress-raising environments reproduced in new offices, work environments, and schools of all types. Apologists for continuing such typologies insist on a largely mythical industrial efficiency, stylistic "honesty", inviolability of the principles of modernist design, etc.

We could, on the other hand, use recent scientific results such as the work reported here to drastically re-design learning and working environments. There exist sufficient preliminary results to do this. It is surprising from a scientific point of view, but expected, considering the inertia of the design establishment, that direct research on how people are affected by the fractal qualities of their environment is still only of marginal interest. One would think that this ought to be a central topic for investigation, to which society should devote major effort and funding. Too much of what is taken for granted, but which is shown to be wrong by experiments, relies upon personal opinion. But when individuals are asked what they like, they invariably give back what they are taught as the prevailing opinion, thus perpetuating opinions that obscure facts. It is time for us to correct this deficit of information on the design of the built environment.

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Ecological Design for Dynamic Systems: Landscape Architecture's Conjunction with Complexity Theory

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ABSTRACT

Ecological design adequate to help resolve current social-environmental problems will have to engage organisms, ecosystems, and cities as far-from-equilibrium, open, self-organizing systems. Because these systems are inherently dynamic, with elements co-constituting one another, the goal of ecological design should not be a specific condition or end state. Rather, the entire network of processes, especially the positive feedback loops from which a given system's self-organizing capacity emerges, needs to be maintained. Thus, the task of fully ecological design is to avoid interrupting or impairing a system's ability to maintain or transform itself; or, as is increasingly necessary, enhancing or helping restore damaged ecosystem dynamics. Thankfully, landscape architecture and allied design disciplines and practices are developing greater capacity to facilitate dynamic adaptive processes—substantially contributing to a transition from a first to a second phase of ecological design that operationalizes the new paradigm of complexity theory. In order to continue the transformation we need to make explicit and integrate the fundamental dimensions of this shift and the implications for design. To present a clear description and analysis that also emphasizes the actual physical changes that make an ecological difference the essay uses examples concerning hydrologic flow regime and flooding.

Keywords: ecological design, complexity theory, dynamic systems, self-organization, adaptive processes, hydrologic flow regime, flooding.

INTRODUCTION

Ecological design adequate to help resolve current social-environmental problems will have to be able to engage organisms, ecosystems, and cities as the dynamic, far from equilibrium, open, self-organizing systems that they are. Thankfully, the capacity to facilitate the dynamic adaptive processes through which systems maintain or transform themselves is growing within landscape architecture and allied design disciplines and practices. This positive development is substantially due to their participation in the transition that is well underway from a first phase of ecological design to the second, in which the new paradigm of complexity theory will hold sway. In order to continue the transformation to a fully ecological design we next need to make fully explicit and integrate the fundamental dimensions of this change, and especially the unique contribution of landscape architecture. As a starting point, the current situation is clearly seen in a snapshot of three developments presented within the last year and (fourth) their background:

1. An increasing number of designs and projects achieve the necessary ecological goals (but are not fully theorized): for example, "The Resilient River": Turenscape, Beijing, Team Leader and "Streamline," Stoss Landscape Urbanism, Boston, Team Leader in the reprogramming of the Mississippi River waterfront (*Landscape Architecture Magazine* 2011, 36-44)

2. In treating best practices some recent works helpfully bridge conventional ecological and engineering ideas and new concepts such as resilience (but do not attempt or accomplish the needed deeper theorization within complexity): for example, Donald Watson and Michele Adams' (2010).

3. Presentations are beginning to transfer ideas from resilience and urban ecology to urban design (but require more detailed empirical development and theory): for example, sessions on Refocusing Ecological Urban Design in Waterfront Projects at the Resilience, Innovation, and Sustainability Conference held in Phoenix in March, 2011 (Roderick, Wilson, Rottle, 2011).

4. A series of projects and reflections have situated design within the transition to non-equilibrium ecological theory and identified the importance of complexity thinking but have not gone on to elaborate the critical concepts or their full consequences: for example, Johnson and Hill's *Ecology and Design* (2005).

As a next step in articulating second-phase ecological design, this essay examines the stages of understanding "resilience," "adaptation," "plasticity," and related concepts, draws out their implications for practice and unfolds the underlying, more comprehensive complexity theory. Though our remarks in large part apply to environmental design in general, we will focus on landscape architecture, urban design, and civil engineering in order to present a clearer description and analysis and to appreciate the earlier stages of the transformation. We use examples that mainly deal with hydrologic flow regime and flooding to emphasize the actual physical changes that make an ecological difference.

For heuristic purposes we can distinguish first from second phase ecological design. This is not to imply a simplistic historical account, since indeed there are multiple iterations of systems theory as it has developed from the early work by Ludwig com Bertalanffy (1968), Oden (1953), and cybernetics by Watson and Adams.[1] Yet, while many other systems approaches have been implemented in areas ranging from engineering to organization studies, there indeed was a notable shift in emphasis with the ecological design initiated by Ian McHarg and others in the 1970s and continuing today in the work of many landscape architects such as Anne Winston Spirn and Fritz Steiner. Additionally, there is substantial evidence that another distinctive pulse occurred with the work of Prigogine and others such that a disjunctive line of systems thinking emerged—a discontinuous bifurcation in the terms of complexity theory. From the perspective of the theory and practice situated along this new trajectory, and as documented by Science and Technology Studies (STS), a paradigm shift has occurred: already well-recognized in domains such as ecology, resource management, sustainability, and other social-natural sciences, we are only recently recognizing that it is operative in landscape architecture and (more broadly) in ecological design.[2] Thus, the major point of this essay is not to focus on the historical evolution of the new paradigm, but, after acknowledging its importance in many areas of science and professional practice, to explicitly theorize it in relation to landscape architecture, ecological design, and engineering (and also to elaborate the implications for what is built). The focus, then, will be only on the two ecological approaches that have transformed design.

In the first phase of ecological design – which we could say roughly runs from Ian McHarg's *Design with Nature* (1969) to the first few years of the new millennium – it became apparent that design could not remain only functional or aesthetic, but needed to be ecological. This ecological design strives to make ecology the basis for design or to integrate ecological principles into design. At the heart of prevailing ecological design discourse and theory is the conviction that designers need to minimize destructive impacts to the environment and cultivate ecologically sound forms in order to ensure long-term survival of all species (Van der Ryn and Cohen 1996, 18). As a result, there has been sustained attention to new modes of integrated design, to interdisciplinary cooperation with ecology and other life sciences, and to the goals of conservation, preservation, and finally restoration. A substantial advance has been made beyond the long-dominant mode of design of the modern era, which laboured under the old dualisms in which the designer was taken to be the creative, controlling subject and the environment to be mere raw material to be manipulated, all with the intention of satisfying anthropocentric values such as were identified with aesthetic, functional, or profitable-commoditized objects.

[1] Watson and Adams begin their chapter 12 by saying that "Design for resilience is an emerging paradigm for the design profession" (257) and go on to describe its basic characteristics and best practice responses the coverage is quite general. Critically, though in a positively pluralistic approach, they consider it only as a new strategy to be *added* to those already in use: "Strategies of resilient design of coastal communities meet all best practice standards of flood-resistant design and represent the next criteria. The first four [traditional] criteria represent a first line of defense and typically are required of property owners undertaking new or substantially improved construction projects." (199). Here is a well-intended and pragmatic case of remaining within first-phase ecological design rather than moving to the second-phase — which requires internalizing the radical changes involved and helping work out the dramatic reformulation of previous understandings and practices that the shift to complexity theory's non-equilibrium dynamics involves.

[2] On the technicalities of paradigm shifts in general and the transition to non-linear complexity there is good coverage in the Science and Technology Studies (STS) literature, such as Stengers 1997; Taylor 2005; Latour 1987.

THE IMPACT OF COMPLEXITY THEORY

The accomplishment of the first phase of ecological design remains important, indeed needs to be incorporated and continued though transformed. To put it in the simplest way, the reasons for the unavoidable transition to the second phase of ecological design lie in the development and appreciation of complexity theory and the associated phenomena. The early work of Grégoire Nicolas and Ilya Prigogine already described how, for example, "our climatic system is a case of far from thermodynamic equilibrium" which displays and can be described in terms of "nonequilibrium, positive feedback loops, transition phenomena, and evolution" that characterize nonlinear dynamical complex behaviour among the many elements involved and that finally form the basis for emergent behaviour (1989, 36-40, 226-228). Over the next two decades other scientists successfully applied the view to describe processes of the open, self-organizing biosphere, including organisms' development and evolution (Kaufman 2000, 21, 188-194).

Ecology and Design, an important collection of essays by leading figures in environmental design and planning edited by Bart Johnson and Kristina Hill, witnesses the point of transition between first- and second-phase ecological design, where the latter is recognized as the new region opened by the larger paradigm shift to complexity theory (2005, 1, 3, 6). Most of the essays operate on the older side: for instance, Anne Whiston Spirn elaborates first-phase ecological ideas as she explores the generative metaphor of the garden seed (2005, 29-49). On the other side, second-phase ecological design appears as some of the essays mention the new non-equilibrium theory of ecology, which is congruent with complexity thinking. However, these concepts are not developed there. For example, in their chapter ("Ecology's new paradigm: what does it offer designers and planners?"), H. Ronald Pulliam and Bart Johnson (2005, 51-89) discuss a shift from an equilibrium point of view to a disequilibrium one where history matters, ecosystems as open systems as opposed to closed ones, and then-recent developments proceeding from the old view; yet they do not elaborate the dramatic implications of work by Prigogine or other natural scientists.[3] More problematically, in other works even where there is talk about and acceptance of the new ecological paradigm, professional practices intending "sustainability" too often remain solidly entrenched in the old paradigm, whereas what is actually built (and how) needs to be substantially changed.

We are faced, then, with kind of questions nicely posed by Steven A. Moore as editor of the recent *Pragmatic Sustainability: Theoretical and Practical Tools (2010)*: "The systems approach to ecological planning advocated by Steiner, as introduced by McHarg in the 1970s, has much in common with the 'complexity theory' proposed… If the 'planning' of complex adaptive systems requires constant and continual effort, what are the implications for the production of 'city plans'?" (211). or, "the concept of CAS [Complex Adaptive Systems] suggests that we should engage in 'dynamic process-oriented' designs (likened to a recipe) rather than static outcome-oriented designs (likened to a blueprint). How will such a proposal influence the worlds of architecture and engineering in which blueprints drawn at a distance from the site and time of construction hope to control the outcome in every detail?" (64). This

[3] An important early argument to begin the shift is made by Stuart Cowan, who has a doctorate in complexity theory; still, though briefly considering turbulence and flooding, the landmark *Ecological Design* that he did with Sim van der Ryn (1996) focuses on the broad implications, biodiversity, and the bio-regional scale rather than specific designs and physical changes.

essay pursues the same questions more broadly cast — "What are the implications of complexity theory for a fully ecological design?"

DESIGN ALIGNS WITH COMPLEXITY

Given their innate, substantial pre-alignment to complexity theory's fundamental features, it is puzzling that the design disciplines and professions, though employing the ideas here and there and generally recognizing that cities are ecosystems, have not been in the avant-garde delineating the new paradigm.[4] When engaging in design activity, a designer/design team proceeds through iterations in which all the elements (e.g., design concept, functional objectives, designed physical forms) mutually modify one another: in each cycle all the major identifiable elements are included and brought into a coherent pattern, in the course of which further problems, inconsistencies, and alternative possibilities come forward. These "results" could not be anticipated or fully predicted. That is, the design process and the design work (the "final design" for the designers) in a project are both emergent phenomenon. Design work also is dramatically site- and case-specific such that each project is unique, not allowing the use of any universal formula or set of rules, thus already incorporating the critical variables of initial conditions, contingency, and history which are so prominent in complex self-organization and dissipative phenomena. Landscape design, especially, not only takes into account the existing site contexts (such as the hydrological, geological, historical, and cultural), but also considers plants' and landforms' inherent changes and interactions with other elements that occur during their life cycles. Such design always has worked with the open, dynamic interactive processes of growth and decline, of assembly and dissipation.

Design's processes and trajectory can better be brought together with complexity theory's resources if we make explicit the dimensions of the paradigm shift and the implications and opportunities it has for design (specifically for landscape architecture and urban design) and engineering that directly deal with dynamic, far-from-equilibrium environmental processes. Table 1 lays out the main differences among the views of modern design, first-phase ecological design, and second-phase ecological design. Note, however, this does not display a simplistic, divisive range: no more than anyone would propose that organic holism began with McHarg, it is neither as if no one used complexity theory before the second phase of ecological design, nor that the second phase no longer appreciates organic wholes. Rather the point is to identify alternative paradigms and to discuss the current change that is well underway but that nonetheless needs to be discussed and brought fully—pushed—to the next stage. Thus, not all the terms listed for second-phase ecological design are part of our present design vocabulary; one of our intentions is to begin to become fluent in their meanings and application.

[4] The urban ecology literature consistently connects complexity and sustainability of the built environment but does not include design, especially as a matter of actual physical change. As to design, despite promising titles, even the best such as Alexiou, Johnson, and Zamenopoulos (2010) link design and complexity research but focus on systems analysis and modeling from a dominantly mathematical and engineering approach; the exception, Leonard Bachman's essay, "Embracing complexity in building design," that does conceptualize and historically locate aspects of complexity in relation to the built environment remains abstract, not treating actual physical changes. Even among the books within "sustainable design," for the most part neither is substantial complexity content delivered nor are there explicit design outcomes. Positive exceptions include Yang (2006); Hensel, Menges, and Weinstock (2010).

	Modern Design	First-Phase Ecological Design	Second-Phase Ecological Design
Guiding Image	Mechanistic	Organic Whole	Complexity
Environment seen as	Fixed/Stable, Predictable	Close to Equilibrium, Growth as Development of Potential	Far-from Equilibrium, Fully Dynamic, Open Processes
	Raw Material	Inherently Valuable	Emergent
Goal/Values:	Anthropocentric: Control, Aesthetics, Social-Economic Function	Humans & Nature Balanced Potential Fulfilled	Organism ←→ Environment Co-constituting Natural and Human Systems
	Development Conservation Preservation ———	——— Conservation Preservation Restoration	——— Resilience (proper) ——— ———
Action & Design are thought and practiced as	Adaptation by Control (via technology)	Adaptation by Cooperation (technology is Suspect)	Adaptation by Acceptance (modulating feedbacks to maintain system dynamics)
	Engineering (linear)	Design (linear)	Design←→Engineering (both are non-linear. and interactive)
	Free to Change Regimes (Stability Domains) as We Wish	Should keep in "Natural" Regime	Plasticity within & across Regimes
	Universal	Regional-Local	Heterogeneous, at Every Scale

Table 1. Comparison of Paradigms

RESILIENCE AS A GOAL FOR ECOLOGICAL DESIGN

The first phase of ecological design has been genuinely holistic, seeing healthy, un-impacted ecosystems or environments as important to support human systems. The underlying idea is that an organic whole, comprised of parts each of which individually and all together act as an integrated system, grow so as to fulfil their potential which finally is realized in a stable climax condition. This ideal image identifies the ecological well-being of a landscape with its aesthetic and functional maturity. Correspondingly, not only new designs, but projects aiming at *preservation* and *conservation* have a clear measure: the goal of design is to achieve or maintain such ideal "end states." Even the notorious question of "what state" of an ecosystem should be intended in restoration is subsumed within the idea of a fixed "kind." The goal would be to restore a mature stable tall grass prairie or an alpine lake district. But, ecological design based on such an image operates on the premise of an outdated ecological theory of equilibrium, ignoring the dynamic, open nature of environmental systems.

In contrast, complexity theory emphasizes that organisms and ecosystems (as well as cities) are open systems, far from equilibrium. The nature of these systems is inherently dynamic with contingent constituents mutually informing one another, thus indicating that the goal of ecological design should not be a specific condition or end state (such as their mature unity). Rather, the entire network of processes, especially the complex of feedback loops, is what needs to be maintained, as spelled out in theories of self-organization for the entire environment or particularly by autopoiesis for the living organisms. The minimal task of design in the second phase of ecological design, then, is to avoid interrupting or impairing a system's ability to maintain itself. Given our current environmental problems ecological design increasingly has the even harder task of enhancing or helping restore the ecosystem dynamic.

Image 1. The continuous dynamism, rather than stability, that marks ecosystems is apparent in an old growth rain forest. Olympic Peninsula, Washington.

Image 2. Complex processes and cycles over time are played out in the meandering of rivers. River South Esk, Angus, Scotland.

Whereas the received modern view in the West (and by extension much of the planet) is that humans are the masters of nature and can do as we will (thus changing ecological regimes entirely, as attempted in the desert around Las Vegas and Dubai or in the drained and filled-in wetlands of Florida), the first phase of ecological design recognizes the importance of individual ecosystems. Here the design is intended to make built forms and human uses appropriate to and supportive of a specific sense of place and identity as desired by humans, based on images of what stable, mature ecosystems ideally should be. When the system in question deviates from the preferred steady state, this norm of maintaining a system as it "should be" prompts designers to restore the system to that condition as quickly as possible. Confusingly, in the engineering field (Wang and Blackmore 2009) and some ecological literature (Pimm 1984), the speed at which a system can return to its "normal" state is also discussed as an issue of system resilience. In his now-authoritative definitions sorting out conflicting usages, Holling identifies this older equilibrium-based viewpoint as "engineering resilience" to distinguish it from the newer "ecological resilience" that acknowledges changes and variances as an inherent part of the system dynamics (1996). We want to further clarify the categories by pointing out that because it operates within the same tradition of using linear thinking and the concept of uni-directional causality to understand what are taken to be closed, near-equilibrium phenomena that self-organize into steady states, first-phase ecological design actually shares the same means and goal as engineering. In this essay, then, first-phase ecological design and engineering resilience are treated as being the same, and are differentiated from second-phase design's "ecological resilience" proper.

Image 3. Attempts to master nature drive much of our built environment.
Dubai.

In light of the appreciation of the non-linear and open character of dissipative flows described by complexity theory, exemplarily holistic and stable place identity as perceived in the first phase doesn’t actually exist, particularly when the ecosystems are viewed in a much larger timeframe. Because ecosystems are dynamic, they could not be maintained in a fixed condition nor perhaps even be recovered when lost. Since organisms and their environments are dynamically co-constitutive, the sense of place and the identity of an ecosystem would be a pattern that emerges over the course of historical process, shifting across stages in life trajectories and continuous transformations of communities of persons, non-human organisms, and non-living elements that together organize and maintain themselves as life-worlds (Umwelts) or bio-cultural regions (Mugerauer 2011).

As noted, second-phase thinking already is operative in many environmental disciplines and practices. A good example of the critique of first-phase approaches occurs in McDaniel and Lanham’s position on sustainable development:

> The agents in these CAS [Complex Adaptive Systems] … are diverse, interact non-linearly, self-organize, contribute to the development of emergent properties, and co-evolve with their environments over time. Rather than striving for system balance, or equilibrium, complexity science informs us that systems can operate more effectively at points far from equilibrium. Campbell’s model of sustainable development, which emphasizes the achievement of balance, seems to imply that sustainability is the desired outcome of a single-level, closed system. However, [we] view the systems in which sustainable development is sought as open systems both affecting and being affected by their environment. (2010, 52)

Thus, while the second phase of ecological design does not at all reject the approach and goal of the first phase, which is to make our built environment more sustainable, it recognizes “the dynamic nature of the landscapes on which sustainability is typically sought” (McDaniel and Lanham 2010, 51), and thus, in the terms of this essay, that an ecological system is much more variable than hitherto appreciated and may in fact have multiple possible states. Individual system elements are surprisingly plastic and their interactions are complex. Therefore the same system can display different behaviours over time. Such a system would have a wide range of regime, within which its elements change, sometimes in long periodic cycles, sometimes unpredictably. A system may also reach a point at which it jumps across a threshold—without smooth linear change— to another regime altogether, where system elements and their internal interactions are altered, resulting in dramatically different sets of system behaviours. For example, depending on the long-term outcome and the interpretation, a lake's shift from clear to murky (a flip from an oligotrophic regime with low phosphorus, low algae, and rooted aquatic plants to an eutrophic regime with high phosphorus and high algae) might be an irreversible flip between two distinct trophic states or only a transition among two phases of a single state with a wide range, where slowly over a long cycle the system might self-organize to alternate between the phases.

Image 4. Dominated Eutrophic Regime. China.

Image 5. Clear Water Oligotrophic Regime. Step-Lakes, Washington.

Therefore, ecological resilience proper is the amount of perturbation that can be absorbed before the system shifts to another behaviour regime (granted that the empirical identification and theoretical definition of regime is not always as clear as when what had been a grass-dominated savannah becomes shrub- or tree-dominated, or a tropical forest becomes grassland). But, in light of complexity theory's understanding of far-from-equilibrium, open phenomena, even when applying the idea of ecological resilience as the ability of a system to persist through external shocks, there is no a priori or abstract way to assert whether the goal for a particular system should be its persisting without moving into a different regime with new behaviours or (for multi-equilibrium systems) its crossing a threshold to another of its stable states (Holling 1973). Further, we need public debate and policy concerning when ecological design should strive to maintain or restore system resilience, so it could stabilize in a regime that is desirable for human beings or when we need to take into account scenarios where the system encounters an external shock inducing a irreversible regime shift such that humans need to adapt by accepting the changed condition.

In principle, then, there can be neither a single specific paradigmatic image of what second-phase ecological design should accomplish and look like, nor of what resilience would concretely entail. The issue is not one of some universalizable structure or appearance, much less "aesthetics" or style; rather, the issue concerns the resilience of each particular historically evolved system with which a design is dealing uniquely. This is not at all what we are used to perceiving or enacting. To reiterate, we traditionally have taken a given environment to be stable, and then have either attempted to keep it the same by controlling what seemed to disturb it – fire in a forest, flooding in a river valley – or by deliberately making the changes necessary to produce a different environment that we prefer – a fertile agricultural region out of California's central valley, achieved by dams, canalized rivers, and irrigation systems. To recognize and accommodate the wide range of phenomena within a watershed as long-term complexity events and conclude that we should "let them be" is another matter. The variation and historical contingency of the flow of water, the rise and fall of rivers and tributaries, the shifting shoreline as banks are undercut, the varying course when the river migrates, and the changing pattern of floodplains in time and space, all would have to be incorporated into a design even when we are dealing with a small waterfront park or engaging in river restoration works.

ADAPTATION

The question is how we would actually design in the second ecological phase. Again, this is not to call for some totally unheard-of mode of design. It simply makes explicit the parameters brought forward by complexity theory and recognizes that the work generated out of design process is in fact not pre-formed, but emergent. By calling out and gathering together already successful approaches and projects and by adding more examples here to give "systematic" coverage of the major dimensions, we hope to articulate and encourage the needed but unpredictable design for complexity.

Many of the examples that follow are intended to indicate how we might translate the recent reemphasis on "adaptation" that has been occurring in climate change discussion to more fully accomplish the parallel shift from the dominant modern design approach through the first phase of ecological design to the second. In a most basic sense, ecological design is about how we adapt our practices and projects to the historical unfolding of organic-environment relationships. Whereas dominant views have contended that adaptation is a matter of either yielding to or conquering external deterministic forces, second-phase ecological design attempts to respond to our surroundings by finding strategies to resonate with and modulate the given situation which, in fact, is already constituted by multi-directional physical-bio-cultural interactions. In the scientific-technological era where the environment is taken as fixed and nature is separated from culture, according to neo-Darwinian ideas "adaptation" normally refers to the need to adapt to the unavoidable, fixed external environment, where failure to do so leads to death. Or, with the complementary tradition of attempting to dominate nature, in cases where we have the means we often use our technology to simply change the environment so it matches our habits and needs, at least temporarily – an approach which is the cause of much of today's environmental crisis. In both modes, we take nature to be predictable, and then deal with environmental variance by either limiting change as much as possible or bending it to our will. This is "adaptation by control."

In contrast, in first-phase ecological design, we adapt by trying to understand what the whole, healthy environment would be like and to identify disturbances needing mitigation so as to allow the system's self-organizing processes to be restored. We correct either our behaviour or intrusive, harmful phenomena that block healthy growth and stability. Here, design resonates with natural ecology in the attempt to achieve well-being – "adaptation by cooperation."[5] The evidence that climate change will involve increasingly extreme events together with the shift toward a more eco-centric view that turns away from trying to exercise power in order to control the world has led to a renewed interest in developing strategies to maximize our adaptive capacity. The first steps have been to recover the heritage of successful work (White 1964) and to develop more sophisticated strategies for proactive adaptation rather than mitigation after the fact (*Global Environmental Change* 2008). But this entails a different understanding of adaptation since in processes already underway, and in fact never starting from scratch, the organisms of an ecosystem simultaneously respond to facets of their environment and also help shape their surrounding worlds, thus providing changed habitats for succeeding generations of their offspring and for the other organisms in the system (Mugerauer 2011). In processes of open development where organisms and their environments co-constitute each other, the task is not to investigate what we can do to maintain or recover a specific wholeness, but to actually enter into the unfolding dynamic processes to help bring forth a new set of interactions, that is, "adaptation by acceptance." It accepts – even if not always embracing – the long-term, large-scale dynamic that is and will be operative, then adjusts the feedbacks "in process," so that changed interactions of particular living and non-living elements simultaneously modify the character of the system. Hence the degree of adaptability of an element or system is the degree of ease with which it adjusts physically in response to changing conditions, including abrupt external disturbance and slow internal dynamics.

The differences between modern, first-phase, and second-phase ecological design are striking. Modern design non-ecologically and technologically attempts to control environments, for example, by armouring and canalizing rivers in order to direct and maintain water flow at levels desired for agricultural or commercial uses. First-phase ecological design holds that if changes are necessary to fulfil human demand, they should be done with less negative environmental impact: the required engineering, for example, should use "ecologically-friendly materials." In contrast, second-phase ecological design considers an entirely different approach to such problems. The greatest difference of the second-phase ecological design would appear in adaptations that defer to the sovereignty of the overall dynamic, as the Dutch have in ceding dominance to the sea and the river by dramatically changing both their philosophy of human-environment relationships and their practices (Doevendans and Schram 2007). On a large scale this appears in the flood management approach of "room for the river"

[5] Though it is beyond our scope here, the requirement that ecological design adequately operate within, and even become a co-determining element of complex systems opens further challenges. The fundamental principle that all elements of an ecological system need to be engaged both in their heterogeneous particularity and in their tangled structural couplings not only requires considering the diversity of other-than-human life but, importantly, inclusionary social practices and collaboration among too-often-unconnected diverse professional and resident groups (Ernstson 2008). Here increased democratic participation in policy decisions and management practices aligns with the ethical obligation to provide at least adequate, if not equal, access to resources. In terms of our examples, by utilizing complexity theory to integrate the local or even neighborhood-scale with the watershed, we can develop ecological designs for industrial or post-industrial areas that are responsive to both distressed riverfront sites and populations (Kibel 2007).

(*Ruimte voor de Rivier*) (de Groot and de Groot 2009; van Stokkom et al. 205). It can be noted that there are precedents for second-phase design within our own heritage, as with the Hegemann and Peets, and then Olmsted Firm's design for the city of Kohler, Wisconsin (1913), which allowed for the Sheboygan River's annual spring flooding by designing Ravine Park so as to leave the flood plain alone yet, though landscaping, provide for its use as a grassy-banked amphitheatre in the summer and fall months.

Image 6. Armouring is a paradigmatic mode of attempting to control rivers with non-ecological technology. Taiwan.

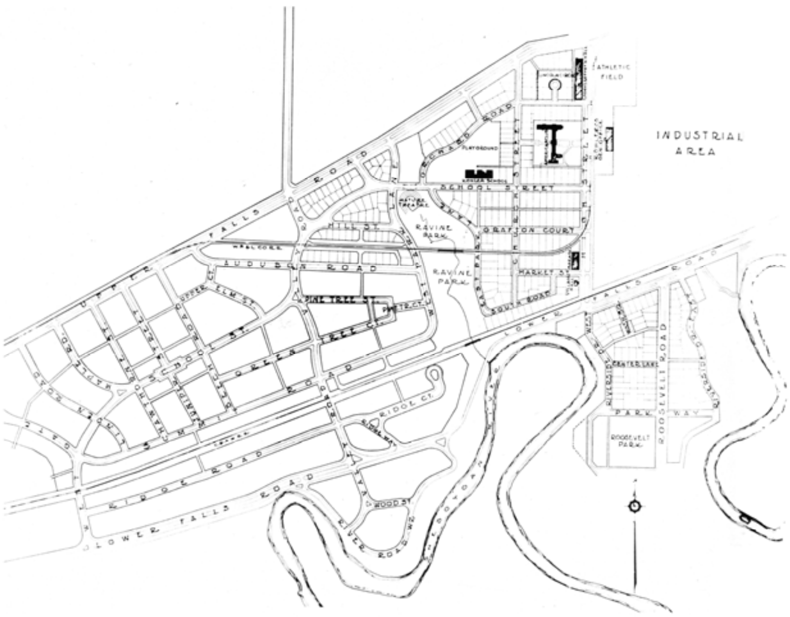

Image 7. Second-phase ecological design has precedents within our heritage as with Ravine Park which left the flood plain alone. Kohler, Wisconsin, 1913.

Since the difference between first- and second-phase ecological design is not fundamentally one of appearance, but of mode of integrating into a system's dynamics, the distinctive adaptations of the second-phase may not be fully apparent. Some of the latter are a matter of implementing short-term strategies that pick up and refine the approaches of first-phase ecology, but extend them by recognizing and accommodating extremes occurring within the range of one regime, as San Francisco has done by retrofitting skyscrapers with sophisticated, computer-controlled flexible foundations to change their structural coupling with seismic activities. Or, fixed elements may be used to modify the course of events as adaptations by second-phase ecological design (and differ from first-phase approaches) with the fuller understanding that new built environmental features modify the organic and non-living systems, initiating new feedback loops whose changes in turn impact the overall dynamic, continuing along in further cycles. The change from creosote pilings and bulkheads to concrete and steel along shorelines is an example: in Puget Sound "the replacement promotes the growth of polychaetes, mussels, and anemones, a diversity which in turn is important with regard to food web relationships with fish species," the result of which further modulates the local ecosystem and thus the environmental cycles from then on (Wilson 2009, 83, 211, 299; Roderick, Wilson, Rottle 2011). In contrast, though devices such as the Thames Barrier, the Netherlands' Oosterschelde Storm Surge Barrier, and Venice's MOSE Tide Barrier do not close off the flow of water they nonetheless are instances of traditional engineering. While movable upwards, they are permanent underwater structures resting on the sea- (or river-) bed, whose size, materials, and placement will induce changes in morphology, current flow, chemistry, and ecology thus setting off fresh sub-cycles in the local environment. Yet complexity is not operationally incorporated: the diversity of interactive elements and their feedback loops are neither modelled in the engineering studies nor used to generate a norm in practice (Pirazzoli and Umgiesser 2006; Rinaldo et al. 2008).

Given that any ecological design requires engineering and construction in order to be actualized (as is well treated in work such as Watson and Adams' *Design for Flooding* cited earlier), in the emerging second-phase a new relationship with a new kind of engineering is required. In fact, non-linear engineering already operates where thermal convection is a critical factor, for example in fluid dynamics (as in the circulation of the atmosphere and oceans) and where turbulence is a major concern (as in pipelines, or by extension in traffic flow), which is one reason this essay uses so many hydrological examples (Nicolis and Prigogine, 1989; Prigogine and Herman 1971). As noted, the change in engineering in relation to ecological design may not be visually apparent: the difference between second-phase and earlier approaches and built projects is not a matter of size, movability, or a particular material or form. Rather what matters is the way linear and non-linear thinking deal with far-from equilibrium, open ecological phenomena. The former brackets them off, while second-phase ecological design recognizes and responds to them – indeed in two primary modes, emphasizing complexity and ecology.

Design and engineering can focus on the complexity of environmental processes by accepting and engaging the operative dynamics. A well-known example (in relation to the striking change in the Netherlands' world-view mentioned above) is the "amphibious houses" that would rise and fall with the water level in Maasbommel, an idea now further developed and at least imaginatively applied to entire cities (Watson and Adams 2010, 244-248). Another, less apparent case occurs in Köln where temporary baffles can be placed atop the walls along the bank of the Rhine in the event of flooding – a technique important not because of its movable format, but, because it results from conscious attention to the overall complex hydrological, pollution, and hard built environmental systems' feedback loops operative at both normal water levels and during flooding.

Image 8. Amphibious houses are one of the ways the Netherlands now accepts and responds to the dynamics of ecological complexity and climate change.

Image 9. Mobile wall spill barriers can be used to accommodate the complex environmental feedback loops operative at both normal water levels and during flooding. Köln, Germany

Or, in light of the acceptance of complexity, there can be a direct emphasis on ecology since design and engineering are in a better position to protect and even improve ecosystems. How such positive environmental changes are concretely built can be clearly seen in the changes made to the Isar River in Munich where the river is recently allowed to run more freely between the levees to create more complex habitat environments.

Image 10. Second-phase ecological design can restore the resilience of urban rivers as has been done with the Isar. Munich, Germany.

Similarly, as mentioned at the beginning of this essay, in projects treating the Mississippi River waterfront Turenscape's "The Resilient River" proposes acting incrementally in four phases over 50 years, patiently relocating industry and creating wider green corridors; Stoss Landscape Urbanism's "Streamline" approach, recognizing "that a river is actually a complex, braided landscape of ever changing channels," would move first to reclaim the river, extending the "social or civic floodplain" through strategies involving new parkland, forested fingers, and newly located green industry (*Landscape Architecture Magazine*, 2011, 40, 44). Another example is the way urban water runoff is mitigated so as to deal with the full range of ecological functions in the watershed in Seattle, Washington.

Image 11. Bio-swales provide a way to protect, even improve, ecological function in urban watershed systems. Seattle, Washington.

PLASTICITY

To consider the larger scale of the regional bio-cultural landscape (for example, a watershed), second-phase ecological designs are dealing with two sorts of challenges. First, can our built environment be designed in a way to maximize resilience that is to accommodate the environmental variance within a regime of the ecosystem or, where there are multiple possible states, can it operate across thresholds to entirely different regimes? Second, in terms of the human community, can it help us suffer less when an inevitable disruptive regime shift occurs; can it help an ecosystem move out of an undesirable regime where ecosystem services are degraded? Here the plasticity, operative not only generally in the ecosystems themselves, but in all the components and scales or even in multiple regimes, comes to the fore because it is one of the major factors that make adaptation possible in the first place. Just as biological growth, development, and evolution are possible because the same molecules can become different sorts of cells and the same sorts of cells can become different organs (Harold 2001; Gunderson 2003), ecological design depends on enacting flexible built elements — such as hydrological infrastructure — as well as policy and management practices that are able to respond differentially to the heterogeneous world.

Another way in which second-phase ecological design and new engineering are operating together is found where material science is exploring “the potential to extend design processes from the development and fabrication of a single static artefact or building to families of variant forms that can respond to varying conditions,” for instance in the “computational generation of responsive architectural ‘skins’ and for adaptive intelligent environmental systems for buildings” that are interactive with material and energy flows (Hensel 1997, 11, 19, 64, 69; Ball 1997). To continue our hydrological examples, since it is harder to change a major urban area already prone to flooding than it is to plan future settlements away from flood plains, flexible design could be used to retrofit existing buildings. For example, supporting elements could be treated as pilotis, the fixed ground floor walls replaced with raisable ones, and only easily portable furnishings utilized on that ground floor, so that as farmers once routinely did during spring floods, belongings and activities could be moved upward until the water recedes. Or, more innovatively, new materials might be developed that function just as well in multiple regimes, dry or flooded. Imagine a sponge-material stiff enough to function well as a wall when dry, but with the possible alternate state of absorbing and holding water.

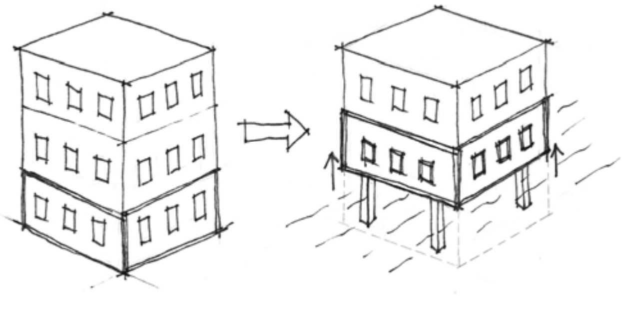

Image 12. Plasticity for multiple ecological regimes can be accomplished through new design and engineering. A variable ground floor could be provided by building with pilotis and raisable walls.

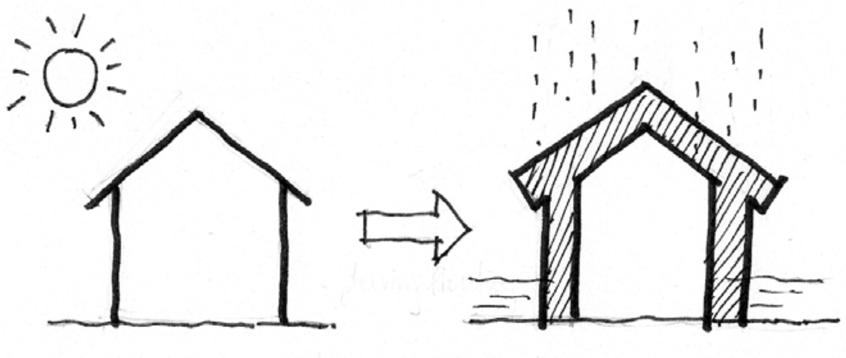

Image 13. Ecological design and new material science could allow a building to have alternate positive states. Consider a sponge-walled house that functions well when either dry or wet.

CONCLUSION

Scientific, political, and design developments all align in one trajectory. By fully engaging with complexity theory, no matter what the scale, the second phase of ecological design can better understand the open, dynamic systems that constitute our world and thus become capable of more appropriately and effectively participating in the organism-environment co-generation always underway – especially by designing and implementing actual physical changes that maximize the plasticity and adaptation critical to the emergence of resilience.

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Indigenous Urban Open Spaces as Public Infrastructures for Sustainable Cultural System in Ilawe-Ekiti, Nigeria

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ABSTRACT

The fast extinction of indigenous public open spaces in contemporary cities is one of the negative consequences of urbanisation. Since the physical environment is symbolically encoded, this development not only represents loss of infrastructural quality of cities but implies a change of value-system between the indigenous and the modern styles. Among the few conservation of the indigenous public open spaces and their value-system in Yoruba urbanization is Ilawe-Ekiti, Nigeria. This study therefore evaluates the value-system of some selected organized public open spaces in the city. The aim was to determine their significance towards formulation of sustainability framework. The primary data for the study was obtained through historical method, field survey and physical observation for multiple evidences as required of scientific enquiries. Qualitative results show that the spaces are material evidences of high indigenous value-systems in urban context. The study concludes with recommendations on the sustainable conservation of the spaces.

Keywords: urban open spaces, public infrastructure, indigenous value-system, cities, recreation.

INTRODUCTION

The significance of public open spaces in indigenous settlements has long been recognised (Okolo and Okolie, 2009). In particular, indigenous markets and town squares are major components in the urban morphology of the Yoruba nation of South Western Nigeria. These open spaces are not only parts of the urban grain but they determine the overall form of the urban pattern as major infrastructures. More importantly, traditional urban open spaces are historical documents of the cultural value-system of the people. They are cultural products of power, identity and belief semiotically encoded in the built environment (Low, 2000, Fadamiro and Adedeji, 2012). They are urban voids of quite public ownership that appears less structured to the human eye for place of relaxation, of stimulus release, in contrast to the intense and meaning-loaded communications encountered in the remainder of the city for outdoor assembly (Lynch, 1990). Unfortunately, the tide of the urbanisation process has not only swept away these symbolic icons, but has also eroded their inherent much-cherished cultural value-system. Post-industrial transformation of cities (Giseke, 2005) has destroyed the "heterogeneous complexity" – spatial, structural, and cultural – that provides a common denominator for human settlements. The social cohesion of indigenous societies was influenced by these open spaces. According to Amin (2008), "a city's streets, parks, squares, and other shared spaces have been seen as symbols of collective well-being and possibility, expressions of achievement and aspiration by urban leaders and visionaries, sites of public encounter and formation of civic culture, and significant spaces of political deliberation and agonistic struggle." "When public spaces are successful, they will increase opportunities to participate in communal activity. As these experiences are repeated, public spaces become vessels to carry positive communal meanings" (Carr et al, 1993). Therefore, "within the urban canon, to assert that only a weak link might exist between public space and civic culture or democratic politics, is a lot less acceptable" (Amin, 2008).

This "strangulation" of the public facet of enviable indigenous city life engenders withdrawal, individualism, non-communal dwelling pattern, nucleated lifestyle and a new social value-system. Unfortunately too, there is no replacement of these lost spaces with the acclaimed "modern" community infrastructure equivalents. The general trend of this development in the name of modernisation is disturbing. According to Abdulkarim (2004), "most Nigerian cities show inadequate consideration or even total neglect for landscape and open space development in the preparation of land use plan."

Despite this description of the state of public open spaces in Nigerian cities, there are few exceptions. In particular, indigenous public open spaces that still exist in urban context in few Nigerian cities, especially in the Yoruba land, are preservations of their archetypes. Among these few cities is Ilawe-Ekiti. The city has organised public open spaces of indigenous value-systems that should be studied towards enhancing their sustainable maintenance. The aim of this study therefore is to determine the significance of these public open spaces towards formulation of sustainability framework.

ILAWE-EKITI: AN OVERVIEW

Ilawe-Ekiti is a Yoruba town in Ekiti State, Nigeria, whose geographic coordinates are 7° 35' 60 N and 5° 5' 60 E. The town existed before colonial influences in Nigeria, but was not much favoured by colonial developmental forces. This may be responsible in part for the survival of the indigenous public open space systems of the town, which have been swept away in majority of Yoruba urban centres by the so-called modernised style of urbanism. Ilawe-Ekiti is one of the fastest growing residential neighbourhoods and has the largest population in the Ekiti South-West Local Government. It is the seat of the local government secretariat and a low-density neighbourhood of low income earners. The majority of the families in the town depends on farming while a few others are employed in civil service. The town has many educational institutions and moderate literacy status. Its morphology is much similar to a typical Yoruba urban centre with the King's palace and market being central and surrounded by residential quarters administered by lower traditional chiefs. The communal lifestyle typical of Yoruba towns is prevalent in the town. Consequently, the majority of the residential quarters are provided with organised public open spaces for communal gathering and cultural functions. The spaces are representative of the indigenous chieftaincy value-systems of the town which make them suitable for the study. This has sustained the indigenous public open space system of the town as major infrastructures which are not common in Yoruba towns of the present modernism.

METHODOLOGY

The study was carried out through historical investigation, field survey and physical observation of the six organised public open spaces in the town. It evaluated and described the physical structure, accessibility, patronage, ownership, uses, management, and maintenance of the spaces. The spaces are Eku Oja Aaye Cultural Centre in Aaye, Imodagbo Cultural Centre in Okepa, Orosun Adin Recreation Centre in Adin, Idi-Ogun Yaya Recreation Centre, Imo Erebe Recreation Centre in Oke Emo, Idi Agba Recreation Centre in Okebedo.

RESULTS AND DISCUSSION

Eku Oja Aaye Cultural Centre, Aaye Quarter

Description and Significance

Eku Oja Aaye is located along Iloro Sreet, Aaye Quarter of the town. It is known to be the origin of the quarter and it is surrounded with clusters of dwellings. The total gross floor area was formerly about 800 m^2 and presently about 1500 m^2 after its reconstruction, as Aaye Community Hall. The Centre is associated with some notable shrines. These include Omoweere, which is believed to be the god of children that is responsible for giving children to the infertile and Esi, which is worshiped for longevity of life.

Other features of Eku Oja Aaye Cultural Centre are: Ori Awo, a raised earth above the ground; Igi Odan, a big tropical rainforest tree, which is forbidden for children to climb; Eye Aaye, a pillar, on which Olojaaye, Elemikan and Elejofi chieftaincy titles are installed; a pavilion, constructed with sandcrete blocks, plastered and covered with corrugated roofing sheets.

Uses and Management
The significance of Eku Oja Aaye Cultural Centre transcends the Aaye Quarter of Ilawe-Ekiti. Olofin festival is a notable festival for the town and takes place at the centre. The priests of Olofin, Alaworo, on the way to Olofin Forest for rituals usually entertain audiences with dancing at the centre during the yearly Olofin Festival. In addition, political rallies, statutory registration of voters, population census and community meetings usually are held at the centre.

Eku Ooja Aaye is sponsored as a community self-help scheme. Members of the community contribute to finance the development of the space, while the Egbe Eyeweere (age group) are appointed to maintain the cleanness of the space excluding the Ori Awo as a taboo. While the space can harbour intruders, who are security threats to the community, the taboo limits the overall cleanness of the place. The open nature and occasional use of the space also presents maintenance challenges to the community.

Imodagbo Cultural Centre, Okepa

Description and Significance
This is an organised open space with tiered row of seats for about 160 people with approximately 1100 m^2 space on rock under a big rainforest tree (Plate 1). The spot of Imodagbo Cultural Centre is claimed to be the origin of *Okepa* Community of Ilawe-Ekiti. The notable features in the centre include *Obanifon* House also called Esi Omo which is a shed where Chief *Ejigbo*, the priest carries out rituals to the god (*Obanifon)* believed to be the representative of Olofin god. Esi Omo is a strategic point at the centre where barren women worships to appeal for children and healing of the sick. Oju Ogun and Itawa are other shrines at the centre for the worship of god of iron and praise respectively.

Uses and Management
Imodagbo Cultural Centre serves the purpose of maintaining societal norms in the town, so that stealing and other social vices are confessed there to avoid negative repercussions. Also, Ilawe Festival, termed *Olofin*, normally starts in the morning at this centre and ends there at night every July or August of the year. Installation and coronation of important chiefs are held at the centre. These include *Odofin, Onipa, Elejofi, Saruku, Elegiri, Oisa, Ekuara* and *Ajero*. The centre serves recreational purposes for playing Ayo and Draft Games.
The centre is managed by Okepa community members through donations from members. Through these donations the centre has been renovated three times in 1980, 1993 and 1994. Despite the importance of the centre, it harbours nocturnal activities, lacks adequate materials for recreational activities and is often dirty because of its occasional use and therefore not attractive.

Orosun Adin Recreation Centre, Adin Quarters

Description and Significance
According to legend, Orosun Adin Recreation Centre (Plate 2) has existed for over 300 years. Consequently the centre was used to name the quarter. The centre was constructed as tiered rows of concrete seats on a hilly natural stone in 1965. The centre is landscaped with trees and enriched with natural stones and it has no artificial roof covering.

Uses and Management
The centre serves as meeting point for the whole *Adin* Community for relaxation by old people throughout the periods of the day, especially in the evenings. Young people are disallowed from using the centre in the morning and during working hours. To further enhance the usefulness of the centre, a market stall was built there by Ekiti South West Local Government in 2006. In contrast to other centres discoursed earlier, Orosun Adin Recreation Centre is occasionally used for non-indigenous religious activities in addition to rituals. It is also used for chieftaincy coronation programmes, festivals, community discussions, national population census, and immunisation of children. It is a community self-help project and the presence of the market stall enhances cleanliness of the centre by the market women. On the negative aspect, the centre has been a place of constant conflict, gossiping, quarrelling and other social vices.

Idi-Ogun Yaya Recreation Centre, Okebedo Quarters

Description and Significance
Idi-Ogun Yaya Recreation Centre (Plate 3) was founded on a rock outcrop as a pavilion that is presently covered with corrugated zinc roofing sheets. Though the age of the centre could not be ascertained, it was however confirmed that the centre is as old as Okebedo Quarters.

Uses and Management
The centre is mainly used for relaxation in the evenings by members of the community after returning from work. Funding for maintenance of the centre is usually carried out by members of the community. Its present status has high aesthetic value.

Imo Erebe Recreation Centre, Oke Emo

Description and Significance
Imo Erebe Recreation Centre, Oke Emo is known as the origin of Ilawe-Ekiti town according to legend. It was founded by Chief Elero, who migrated from Ile-Ife. Imo Erebe represents the ruling compound in the entire town. Therefore, the paramount ruler, the King of Ilawe-Ekiti is usually installed at the centre, including chieftaincy titles as Elemo, Ausi, and Elero. It is a community centre consisting of series of tiered seats made of concrete and covers a space of about 1200 m^2. Recently, new facilities including Events Hall, restaurant, bar and lock-up shop are being constructed at the centre.

Uses and Management
Imo Erebe Recreation Centre is used for playing activities during leisure times by community members. It also serves as a meeting point for the entire community for corporate prayers, national registration of voters, the king's coronation, and immunisation of children. Draft and ayo olopon are the games, usually available free of charge, and offered as recreational activities at the centre. There is no provision of maintenance staff for the centre. This hinders good management of the centre in addition to the low finance enjoyed by the centre from contributions by community members.

Idi Agba Recreation Centre, Okebedo

Description and Significance
Idi Agba Recreation Centre, Okebedo (Plate 4) has existed for over 300 years according to legend. It covers a relatively small area of about 42 m2. It is historically associated with the origin of the community and used for the annual sacrifices and traditional festival called *Oro Kereje*. The centre has series of stepped concrete seats with a big rainforest tree at its centre which provides shade.

Uses and Management
In view of the core location of the centre in the town, it is commonly used by the old people who inhabit the community houses and prefer to stay outdoors at the centre to overcome the loneliness of their indoor apartments. Therefore, the centre has been a place for reflection, jokes, discussions, debates and observations in addition to relaxation, refreshing, restoration and fellowship. In fact, it was described as great outdoor living room and as an open house. Young people are disallowed from using the centre during normal working hours to discourage laziness. Female members of the community are also disallowed from using the centre as a traditional practice.

RECOMMENDATION AND CONCLUSION

The study revealed that the indigenous public open spaces in towns and cities can still be retained in modern context. This has been demonstrated in Ilawe-Ekiti, the study area. They are embodiments of traditional value-systems that enhance communal living in the age of individualism and “civilisation”. They are symbols of healthy communal living standards and sustain the indigenous value-systems of communities and human settlements. The study reaffirmed the semiotic resemblance between the culture of a people and their built environment (Adedeji and Amole, 2010).

The sustenance of the studied public open spaces over decades through community self-help endowment funds and the preservation of the community’s indigenous value-systems through the upholding of taboos, as control mechanisms, indicate a high level of effectiveness of traditional administrative mechanisms. The study therefore suggests that value-systems can be influenced by space-systems and public open space patterns in particular to dictate the tune of citizens’ participation in communal activities. Though these all-important part of well-envisioned urban settlement, patterns have been eroded in most modern cities. In the towns and cities, where they are still maintained, especially in Yoruba land of South Western Nigeria, they should be financed by the government and non-governmental agencies towards their rehabilitation, restoration and conservation. This will enhance the preparation of robust maintenance schedules that will lead to more vibrant and viable use of the open spaces.

These recommendations become necessary in view of the significance of the public open spaces for human physical, psychological and spiritual well-being and the structural framework of a city. They are infrastructures whose significance cannot be negotiated in the pursue of healthy urban centres.

Figure 1. Showing *Imodagbo* Cultural Centre, *Okepa*, Ilawe-Ekiti, Nigeria. Source: Authors' fieldwork, 2011.

Figure 2. Showing *Orosun Adin* Recreation Centre, *Adin* Quarters, Ilawe-Ekiti, Nigeria. Source: Authors' fieldwork, 2011.

Figure 3. Showing *Idi-Ogun Yaya* Recreation Centre, *Okebode* Quarters Ilawe-Ekiti, Nigeria
Source: Authors' fieldwork, 2011.

Figure 4. Showing *Idi Agba* Recreation Centre, *Okebode* Ilawe-Ekiti, Nigeria.
Source: Authors' fieldwork, 2011.

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Soft Infrastructures for a Neo-Metabolism

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ABSTRACT

Designers' universal impulse to naturalization deals today with reframing new approaches towards soft vs. hard biourban structures. Operative infrastructures generate organic creative futures, and oppose informal, serendipitous, innovative, and risky soft systems urbanism to hard design determinism. The emergency of a Biourbanism soft systems approach contrasts several Metabolist principles and practices, especially those favouring hard infrastructural platforms as fixed systemic cores and conduits. Biourbanism – a conceptual process of creative assemblage generating soft infrastructures – think of the hard-soft and risk-innovation couples, as ecologies. In this way, Biourbanism flourishes between multiple forces, modernities, and ecologies, by retrofitting urban situations where hard infrastructures are incomplete, ruined, or even lacking. It can integrate hardware, software, freeware, and wetware creatively through a thinking design of landscape, architecture, and urbanism, that has to operate also methodologically on multidisciplinary networks, and that can be called neo-Metabolism. Among its unconventional potentialities there are biourban acupuncture, nomadism, multi-effect linkages, biopolitical tactics.

Finally, Biourbanism has a revolutionary capacity within the biopolitical issues of identity and control, as soft systems can still bind and cage; and this challenges with responsibility its idealism and optimism.

Keywords: Biourbanism, neo-Metabolism, ecologies, architecture, soft infrastructure, Soft Natural Systems, informal urbanism, risk, biopolitics.

The persistent allure of the biological imperative for designers is a potentiality in pulsation over time. The potentiality of this recurring organic impulse has already structured mimetic and analogous processes in architecture and urbanism, going back to before early modern and modern design. Architecture, as a fascinating built record of this organic affinity cast in stone, tracks how understandings of natural systems have generated naturalized forms of buildings and spaces. Today we certainly have more precise cognitive (and computational) tools available to clarify this potentiality, a potentiality to situate and interlace a diversified range of design processes and protocols. Thinking the organic, and its transfer from thought into material form, is the most ancient of naturalization processes, traces of which persist today even in those building types and urban morphologies whose organic sources can be obscure. The attraction and imperative to work towards naturalization – of transferring thought into natural form, especially in the modernist reification of systems thinking and positivist organization, repeatedly framed nature as system – where architecture (and its urban context) performed as a system of recording *and* system of production – tracking from the observed to the imaginative projection, as a production of new typologies and topologies have settled as our "second nature." The fluctuating allure of the organic, and architecture's role as imperfect recording-production device of this allure, has given rise to our multiple forms of modernity. The experience of this resonance between nature and artifice (both evident within organic designs) appears also as an inexhaustible source for future design speculation.

To speculate through the organic impulse is to seek new conceptual territories, new linkages and connections, and new systems of dynamic equilibrium. Systems thinking itself has diversified into fascinating protocols and procedures, all of which can be used as cognitive and design tools. This speculative research proposes a series of thought experiments organized through conceptual and spatial correspondences operating under the banner of "Soft Natural Systems." This variant of systems thinking, where the processes are seen as mutable and fluctuating, stages a possible rethinking of a second nature for the design disciplines – one proposed here to intersect architecture, infrastructure, and landscape urbanism.

This intersection, as a dynamic interplay of systems, means looking specifically at the proliferation of soft natural systems, but using all sorts of hard thinking to do this. We should include a focus on the softer aspects of systems thinking, and the grounding of these soft opportunities within the logic of the informal, organic, emergent, and mutable conditions present in Systems Ecology and recent design discourse. The intertwining of these multiple soft modes are intended to animate certain potentialities to create associations, resonances, and conceptual transfers and transformers regarding soft systems operating in the city, as a type of Biourbanism. There is a fascinating potential to rethink urbanism away from infrastructural planning and turn towards reflection and speculation on the necessary values of identifying "soft natural systems" at play in the spaces and experiences of architectural and urban spaces. The "soft" aspect of ecologies, playing upon the puns of soft systems, soft machines, as well as software – as an example, see (Bhatia, Sheppard 2012) – would be phenomena that tend towards processes "becoming" but never arriving at static completion. This characterization of the soft is often excluded from determinism or design, though the soft edges or conditions are just as necessary as the hard (fixed, determinate) elements of order.

Those elements which resonate with our sensations are the soft attributes deserving attention – in the built landscape this includes the pliable, flexible, and agile process-oriented growths and patterns that run through our senses and experiences of the surface of the world, and how the movements of ideas, pressures, and materials is structured by conduits, habits, cultural parameters, and other softer infrastructures. These soft qualities are being nominated and propositionally interlaced within the current thinking of systems ecology, so that we can recognize the inseparability of soft configurations pressuring the harder determinate qualities. These reciprocal hard systems are schematically more like fixed ideas or geo-philosophical characteristic attributes which persist across time, "hardening" as parts of the unyielding built second nature of the urban landscape.

The historical pulsation of organic design is made new by the introduction of new types and methods of spatial-intellectual analysis of natural systems, which under these new formations can yield new operative parameters, shifts of values, and new design solutions (such as using diversified forms of soft systems as generators and transformers, as soft systems already operating outside singular discrete objects) within this conceptual territory of imagined (future) second nature of the architectural ecologies of the city. This conceptual territory can yield diverse models and hybrids of natural processes as refreshed design imperatives, allowing us specifically to consider the growth of cities as a form of growth from a diversified mapping or projection from multiple modes of infrastructure – which proposes architecture and urbanism as components of soft naturalizing systems. This would require us to reframe and rethink our new approaches towards a range of life-supporting infrastructures, from *hard* to *soft*. It is the ambition of this mode of thought that drives the search for more agile schemas of the infrastructure-territory coupling as manifold, complex, flexible, and intensive.

Hard vs. soft infrastructure is a distinction between the permanence and determinism of the network, loosely following the hardware/software distinction of the cybernetic era (Brugmans 2010; Shannon, Smets 2010). In terms of infrastructure, deliberated and partially under rational guidance, in the softer edges of Systems Ecology, we can narrow and characterize the hard/soft distinction along this intensive qualitative distinction.

There are categories of hard and soft infrastructures along economic lines, defined by the World Bank and other organizations, but the design distinctions are more effusive. For example, if we consider the new focus on soft infrastructure in urban growth in India, even the software sector is only partially physical and hardened. Soft infrastructure is "institutional support mechanism for exchange of goods and services, regulated and accessible financial markets, legal institutions and support services… soft infrastructure contains elements of social and cultural life…" (Brugmans 2010, pp. 96-97). In most attempts to enumerate soft infrastructures, we get into the edges of traditional design, and soft infrastructures will include references to cultural necessities, invisible or virtual environments and relations, even cultures of trust. Widely considered, any perceived necessities that are not locked into a specific piece of concrete can be interpreted as potentially soft, and as systems potentially organic. When infrastructures are needed to perform in a new way, or to meet new needs, as movement and communications systems, when they need to flexibly intertwine though a physical-social territory, they can be conceived and made soft – but only because this softness-flexibility is a basis for resiliency in the face of fast change (see, for example, One Lab's program examining water porosity at http://www.terreform.org/farm_details.html).

Now these emergent soft infrastructures – whether they are indeed made of soft materials, or nearly invisible shifting relations, or activated informal chance opportunities – in many cities can and do supplement prior existing hard infrastructures, and can modify the hard models and structures and habits over time, often delivering responsive immediacy and re-structuring future malleability. The premise of multiple modernities as infrastructural thought – as systematizing, totalizing, and hardening – when reconfigured conceptually to follow compelling aspects of soft natures and soft systems, can lead to new thought structures of possible relations in the general schema, and new tactics of connectivity and assemblage in the particular.

Soft infrastructures, as a category of mental and physical processes of construction, can improve, or tense, or subvert, or obscure prior hard infrastructures, as in the extreme case of the range of expressions of informal architecture and informal urban structures (often spilling from the fault lines of hard infrastructure). Informal urbanism can be read from this vantage point as the cause and effect of a subtle type of alternative informal distribution network, emerging form necessity but reactive to the current infrastructure. If we think beyond the regulated industrial conventions of water, utilities, and transport infrastructure to the widest possible range of possible human rights, commodities, and experiences, we can imagine these two working as activators of infrastructural presence. Soft infrastructures can conceptually deliver new and influential conveyances coming to us (especially in urbanism) through the expanded notion of operative soft infrastructures as organic generators of organic creative futures. And as these possibilities become displaced from centralized sites and made mobile through imposed or discovered conduits, we can seek their manifestation and optimization in soft infrastructures that can be formed organically – formations including assemblages, prostheses, inflections, detours, feedback loops, phase states, all sorts of varieties of new propositional configurations, and even as systems of deliverance or future urban mutations (Koolhaas, 2000).

Hard infrastructures can distribute and stabilize flows, but soft infrastructures, being messy, can generate new and transient growth patterns, including emergent or liminal aspects of landscape into urbanism, even to the level of generating new sensations to promoting lifestyles – all possibilities distributed through space as the dream of organic hybrid interactivity, fluctuating pressures, including a necessity of new forms of resilience involving emerging systems. The multiplicity of means for moving people or objects exceeds the hard infrastructural tracks for this, as does the multiplicity of ways you could send time-sensitive information between those two locations using a variety of soft systems. Like the recognition of the rise of informal urbanism, thoroughly analyzed by (Hernández, Kellett, Allen 2012), and the specific fascinating case of the informal spatial logic of the necessary transient inhabitation of street markets (and the covert exchange economies supporting them), soft infrastructures can be invented from necessity, not the optimization that drives harder operations. The messiness of soft systems is the flexibility and impermanence and mutability that can be their long-term advantage over determinate hard infrastructures. Soft infrastructures as a potentiality can always come to fill the gaps and absences of design determinism.

Necessity breeds innovation, but desire breeds success, and it is an invisible economy of desire that animates these informal networks, that gets them flowing. In the current ethos of scarcity, innovation and desire can still be used to push and propose new types of soft infrastructures. It should still be possible, and is increasingly necessary, to think of how soft infrastructures can be used to form and connect improbable relations and exchanges, so that ultimately soft infrastructures become the mechanism for replacing the culture of (ecological) crisis with a culture of (innovation) risk. Risk has been the impulse that can initiate the processes to deterritorialize and dissolve "wicked problems" – or problems of inoperable complexity, to be overcome through emergent strategies (Cutler 2009) – and risk has been the secret impulse driving much visionary design and many magnificent technologies. In a sensed culture of crisis (such as current water security conflicts and food security tensions) risk-aversion solidifies and makes harder these "wicked problems," and it is therefore crucial that the flexibility of soft infrastructures as organic design principles be conceptually grounded in a culture of innovation-risk.

Incidentally, it should be obvious that the vice of gambling or other types of rampant speculation, such as in financial markets, is inherently "risky," but riskiness is not the intellectual design capacity of the creative culture of innovation-risk nominated here. Note also that creative risk is not specifically a calculated risk, so this nominated *ethos* demands a more detailed analysis of risk in design culture.

Increasing forces and pressures structure a culture of risk and innovation, creating turbulence and change as palpable forces in the fabric of the growing city. This turbulence urbanistically sites and locates risk as the potentiality of innovation, creating a risk-innovation coupling still present today, and conceptually co-located in the soft systems described here. Ulrich Beck, in his *Risk Society: Towards a New Modernity* has proposed ideas of "risk society" and "reflexive modernity" in media-formation, hence in a media ecologies, one of the larger soft infrastructures running parallel or submerged through uncertain territories of the perception of buildings and spaces of the city. The role of the soft circulation of image-ideas through nearly invisible / indiscernible layers of the city, some pulsating, some receding, hard and soft, visible and invisible, are in constant interaction (and competition). The culture of risk persists as a promise of technological acceleration, and consequences of embedded ecologies are a new Metabolism, a neo-Metabolism interspersed and interacting in the spatial logic of the city. The emergency of a soft systems approach under the proposition of Biourbanism of today is in many ways the inversion of some key elements of the earlier hardened Metabolist principles and practices, especially those favouring hard infrastructural platforms as fixed systemic cores and conduits. The absence of diverse speciation of modules and capsules with these structural armatures (armatures promising a limited range of flexibility) today seems to lack the diversity and fluidity of organic urban architectural propositions. In the hard built ecologies (and cool sci-fi media ecologies) of that initial Japanese avant-garde Metabolist wave, we have a geological precursor – traces of Metabolism (and Brutalism) still rise in cities today. From the postwar Metabolist fantasy of an organic biosphere superimposed into the emergent city, to the contemporary emergent nested ecologies forming the city as a second nature, we have seen an intellectual tipping point crossed from hard infrastructures to soft infrastructures. The Biourbanism of today is still emerging from the conceptual and computational tools for designing and thinking the hard-soft, risk-innovation couples as situated ecologies. In this way, the Bioarchitecture and Biourbanism flourish between multiple forces, multiple modernities, and multiple ecologies.

To focus these claims, let us consider under what conditions this tipping point can be crossed, or more precisely let us ask how can hard infrastructure go soft? The cities of Beirut and Delhi have incomplete highways, truncated incremental hard infrastructural conduits that cast an enigmatic presence in the cityscape. These present the opportunity for the introduction of new ecologies of thought and new presences of landscape – from sports to urban farming, but also informal street markets and other opportunities for soft infrastructure to graft upon the ruins of the hard, including reinventing new territories in the ruins of the past. Informal and resilient soft infrastructures will rarely achieve the staged mono-functional image of the natural of the well-known NY Highline competition, but differentiated urban second natures are themselves a significant design project and promise in neo-Metabolism. The case against hard infrastructures is a case against their rigidity: for example, obsolete aqueducts, abandoned buildings, industrial brownfields, failed railways… all of these once hard infrastructural devices have devolved over time. Design choices to interact with manifest hard infrastructures are choices of determining the naturalization of second natures to come, and in these projections we know the city will continue to entangle multiple modernities as multiple ecologies: building ecologies, media ecologies, urban ecologies, intellectual ecologies, and hundreds of others. Consider here the insights of Felix Guattari, in his influential *The Three Ecologies*, and its viable application to those aspects of urban architecture and their entangled ecologies. Consider the potentiality of ecologies of thought, of media, of building, and how innovation and risk grows from the dynamic punctuated equilibrium of urban soft systems, we need to understand.

> "By means of these transversal tools, subjectivity is able to install itself simultaneously in the realms of the environment, in the major social and institutional assemblages, and symmetrically in the landscapes and fantasies of the most intimate spheres of the individual. The reconquest of a degree of creative autonomy in one particular domain encourages conquests in other domains…" (Guattari 2000, p. 69)

It is here that Biourbanism's revolutionary disposition begins to emerge as a conceptual process of creative assemblage, in all its manifestations, experiments, and culture of risk (itself perhaps the most generative soft infrastructure).

It may be clear that only some of these infrastructures or ecologies lie within the architect's competencies and/or (softer) expansive circle of influence, but the necessary assembly of expertise can be formed beyond individual circles of influence, so that risk and desire can form a design network that itself becomes a design economy, a relay between nodes of information, capital, risk, will, and expertise. Consider some sci-fi 1990s protocols that would allow for an expanded field of infrastructural states to be considered for design: the correlations of hardware, software, freeware, and wetware (Rucker 2010). These categories (neither absolute nor finite), must be reconsidered as categories of landscape infrastructure (as forms of socialized technologies) and can also be applied metaphorically to infrastructural thought as models of procedural operations, as scales of operations, as tactical solutions to mesh or fuse incomplete spatial entities. For example, the answer to the question of how can the urban distribution of necessities such as food or education be designed would use these multiple infrastructures elucidated by using multiple ecologies – in this example as interconnected hard, soft, and wet procedures that intersect at multiple locations to determine an emergent fine grain reality for a district or territory, as a soft urbanism.

If we can rethink infrastructures as operating under a greater range of softness that simply economical, and if we can think and design soft infrastructures as supplementing, deflecting, and reordering relations and pressures interactively with other forms of infra/structures, so as to increase their agility in conditions of risk, we should also seek to integrate them into multiple intellectual contexts simultaneously. We could also rethink soft infrastructures as the distributive spores of hybrid generative ecologies. Architecture and urbanism already exist as simultaneous reciprocal ecologies, in light of the influential terms of Guattari's categories: mental, social, and environmental. Even more, this late modernist triangulation of ecological criteria applied to thinking and designing as soft infrastructural speculation would lead to an integrative intensification of thought and knowing of the second nature that enfolds urban settings:

> "More than ever today, nature has become inseparable from culture; and if we are to understand the interactions between ecosystems, the mechanosphere, and the social and individual universes of reference, we have to learn to think 'transversally'." (Guattari 1989, p. 135)

The variant organic design sensibilities, when used to distill variant types of soft infrastructures, will benefit from tactical operations and fluid procedural and process-oriented forms of emergence: grafts often fail, but responsive transitory patterns can be modeled and made to grow. Design not of objects but of pressures, flows, and accumulation (of bodies, of goods, of ideas) can be territorialized by situating desires in these three ecologies. The movements of soft infrastructures can include scales of transience, tipping points, nomadology and temporary occupations, fugue states, liminal and interstitial spaces, spatial alterity, emergent multiplicities, and robust identities. These impermanent and unstable characteristics indicate the key to invention that innovates lies in the risk culture (contra crisis culture), and we propose that thinking though multiple ecologies can generate performative soft infrastructures for the development of a Biourbanist integration of systemic multiplicities.

Three significant historical projects would support this turn to Soft Natural Systems, while simultaneously modeling them into spatial locations of processes and risk: Frederick Law Olmstead's 19th c. Boston Emerald Necklace as an urban ecology and proto-landscape urbanism; Kenzo Tange's 1960s Tokyo Superstructures as a revolutionary metabolism growing out of hard infrastructures; and the risk-innovation example of OMA's unbuilt 1980s Paris competition for Park Villette, an urban landscape that is a cinematic factory of the subconscious, relay of desires through a lattice of hybrid gardens. Further reading on these projects have been offered by (Beveridge, Rocheleau 1998; Poole 2000; Vidler 2000; Weller 2006; Lin 2010; Koolhaas, Obrist 2011). In Olmstead, we find the urban landscape project surviving today, a mark of its cultural and economic value, but also an original solution to linking pockets of green space into the growing hardscapes of modern Boston.

In Tange's project for Tokyo Bay, we can locate the growth of concrete-Brutalist forms into systems of relations determined by extreme articulation of tectonic joints, individuals tied into collective structures, and ambitious movement systems offered floating above the Tokyo Bay, creating an urban second nature that is both historical and modern, organic and industrial, structured and evolving, so purely Metabolist. The design vitalism of the original Metabolist movement in 1970's Japan (Tange, Kikutake, Kurokawa) was in partial response to the pulsation of organic oceanic biopolitics as mythical ideal, an imaginary marine ecology enmeshed within densification and systems design of increasing Tokyo urbanism.

In OMA's project, we see the tight modernized discipline and order of cinematic strips of landscape, each with distinct characters and textures arrayed in attenuated individuated plots of urban gardens, duplicating a memory of the Dutch non-perspectival agricultural landscape. In the original model, the landscapes of the Netherlands have always been engineered – water is the hidden ordering system of the submerged hydraulic engineering infrastructure that generated much of the Dutch soil. The reference to non-perspectival views recalls the argument of Alpers (1983), where layered landscape painting of the Low Countries is contrasted with the Italian linear perspective model. The risk of all three involves scaling or transposing the proper place of nature, landscape, infrastructure, and city into other positions or relations, with intent and for effect. The design innovation of all three is the originality of the bold moves, and the challenge to conventions and expectations created by the genesis of the new form the unrealized potentiality of the existing and the real. In all three, the originality came out of a design that articulated the three ecologies of hard and soft-infrastructures, not as a value-add feature, but as the genesis of the world-vision that radiates out into the real world from the imaginary manipulations of the everyday.

The intertwined modal ecologies in soft infrastructures follow the trajectory of these (and many others) precedents into a new metabolism, here proposed as a type of thought process spanning (or scanning) landscape + architecture + urbanism, called *neo-Metabolism*. This neo-Metabolism would be the sophisticated and responsive accruing movements between the hardware, software, freeware, and wetware aspects of the hard-soft infrastructural couple. This neo-Metabolism is an applied theory, retrofitting the prior theory of metabolism (as organic impulse driving infrastructural-technological daring) into the landscape urbanism and hard and soft infrastructures of the immediate near future. The neo-Metabolist city is a multiplicity of scales of ecologies (built ecology, media ecology, and others) increasingly nuanced and influenced by slow and often invisible effects, delivered quietly by these networked potentialities. Note also that even values and ideas can also initiate soft infrastructures, like justice or safety distributed into terrains and topographies. Along with lifestyle improvements, the biological initiatives in the mechanosphere of architectural thinking that has led to built ecologies capable of scrubbing and cleaning the air and the ground, of engineering self-repair, of sensing and responsive buildings and structures (tangible and intangible).

These operations can and should be developed in play with the emergence of soft infrastructures, so that their conceptual flexibility can be integrates with the experiential demands of pleasure, delight, sensuousness. Even alterity and unexpected encounters could be part of their bearing capacity and subject positioning, not an either-or, but a both-and with engineered services. This compelling experiential supplement to determinist thought would also benefit from another level of softening, specifically a play on the "infra" of infrastructure – like infra-disciplinary practices (thinking linkages at the expanding margins of professions), or the infra-thin animate surface within and around acts of infrastructure. The infra-disciplinary was a notion proposed by Jane Rendell following our keynote speeches at the Networked (In)visibilities conference at ETH Zürich in November 2011. The infra-thin is the confounding principle of minimal difference in artist Marcel Duchamp's theories of the 1920s-1930s.

Along with unconventional problem-oriented design discourse/s, soft infrastructures as neo-Metabolist potentialities can emerge from rethinking scales to include micro-interventions, soft infrastructures for urban acupuncture (massive change from minimal intervention), all sorts of lateral coding and re-coding (even misrecognition) from local conditions, migration as neo-Metabolist form and theory, all leading to new landscape infrastructures as part of a larger constellation of risk. These unusual operations will reposition non-objective soft infrastructures as transformers for releasing permutations and producing multiple effects. And as it is said, the difference between having an idea and having a good idea is that the good idea solves multiple problems simultaneously (producing wonder and delight).

Another way to look at soft infrastructures, loosely defined, would be to read the adaptive and informal networks and connections of commodities, services, values, and information in their entirety as a soft grid or scaffolding for the biopolitical order. Biopolitics, after Foucault, is a sovereign move from absolute power to a soft extension of other forms of power over subjectivity, more like the multiplicity of ecology (Foucault 2002, pp. 326-348). In the recent theories biopolitics is read as more pervasive and invisible – Hardt and Negri clarify biopolitical production as "the production of social life itself, in which economic, the political, and the cultural increasingly overlap and invest one another." (Hardt, Negri 2000, xiii)

In biopolitics everything social can be engineered; biopolitics after industrialization falls under the order of "cognitive capitalism" where informatics-production relations lock individual subjectivity, and the social spaces of those subjectivities, to hardening infrastructures and hardened territories. The Soft Natural Systems and the soft infrastructures of Biourbanism are also disciplinary practices that call upon designers to make hard decisions about bodies and identities. In this manner, the optimism or idealism of Biourbanism, its vitalism or revolutionary capacity, needs to be situated in the larger (lingering) question of identity and control, which establish the hardness for risk to spring from. Specifically, soft systems can still bind and cage, and so they can be seen to perform as a mode of biopolitics.

The bio- of biopolitics refers to the method of soft systems and hard systems within control space, implemented through the body, through the hard and soft landscapes, through the organic impulse and analogues of life. It is important to understand soft landscape infrastructures as devices that will also operate as political devices; they can never maintain indifferent positions. The cognitive subject in the hypermodern landscape is forever enmeshed in the modern-industrial and modern-media conditioning of biopolitics, caught in multiple ecologies, formed and reflected in them, provided and controlled by them. In this landscape of hard abstractions and rigid boundaries of inclusion and exclusion, the potentiality of soft infrastructures to open up flexible and porous urbanism is here a nominated line of flight through optimized organizational space, which is the emergence formation of this neo-Metabolist design attitude. The range of hypermodern, automatic, and ultrathin landscapes emerging in place of given nature today are no longer mediating the image of conditioned nature (the remnant of the natural we have left in the city) but mediating the processes of conditioned nature that can best inform these scale transitions, which for design is a question of creating scales of organization as soft systems, for resilience and sustainability. All of these stresses inform a needed type of architectural intelligence, a form of multiple ecologies brought to bear upon the "transversal" emergence of the subject that neo-Metabolist biopolitical tactics require.

In place of a conclusion to this speculation, consider how these select concepts above have been assembled together give a flexible theoretical framework whose operational flexibility. This specified neo-Metabolism vision is centered on the potentiality of conceptually expanded and spatially expansive soft infrastructures – as spores and tendrils for new models and procedures of artificial second natures that should lead to intensive urban growths, raising the intensively of life into the foreground of design principles and methods. By retrofitting urban theories of the prior heroic Metabolism to produce design innovation-risk utilizing aspects of hardware, software, freeware, and wetware, the older organic impulse can become desirable layered and distributed ecologies, uncoiling across the urban landscape, and with concentration and sensitivity this can lead to a greater liberation of subjectivity under biopolitics – where spatial subjectivity is here proposed as a type of "intensive science" for emergent Biourbanism, one that cultivates a multiplicity of ecological operations as a process of softening - in increasingly informal, indeterminate, and transitive urban territories. The intensive is used precisely here to name the architectural intelligence of reconciliation of these soft natural systems of the *biopolis*. De Landa initially proposed the intensive as this correspondence, in a process well known to designers:

> "We may expand the meaning of the term 'intensive' to include the properties of assemblages, or more exactly, of the processes which give rise to them. An assembly process may be said to be characterized by intensive properties when it articulates *heterogeneous* elements as such… More generally, the interactions which organisms have with the organic and inorganic components of an ecosystem are typically of the intensive kind (in the enlarged sense), an ecosystem itself being a complex assemblage of a large number of heterogeneous components: diverse reproductive communities of animals, plants and micro-organisms, a geographical site characterized by diverse topographical and geological features, and the ever diverse and changing weather patterns." (de Landa 2005, p. 64)

Throughout the city there are micro-intensities waiting to be recognized, adapted, incorporated, and brought into resonance and relation with other micro-intensities. These can drive emergence, risk, and form tipping points as some will rise into nascent networks and soft infrastructures, waiting to be wired into informal urban ecologies. The possibility of new soft infrastructures within this proposed neo-Metabolism attitude would not only develop from the intensive science of informal spatial-network genesis and mutation, but should also serve to operate imaginatively as a model for intertwining new types of thinking, specifically a thinking through multiple ecologies, to modify and adjust the biopolitics of existing (hardened) urban order, and to nominate soft infrastructures as a powerful risk-apparatus for liberating unknown natures.

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Part B – Papers selected from

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Towards an integrated approach to measuring and monitoring water in domestic building

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ABSTRACT

Efficient water consumption has gained increasing priority in the move towards reducing the impact of human activity on the natural environment. A significant amount of the water abstracted from the natural environment is consumed directly in human activities such as washing and cleaning. Although, it is possible to estimate the amount of water supplied to fixtures such as taps and showers from manufacturer data, it is often difficult to monitor simply, cheaply and accurately, water use factors which can be used to inform customised water efficiency strategies in a building.

The aim of this study is to provide a literature review that explores and critically appraises the currently available data collection/instrumentation tools and techniques as a start to find a simplified yet integrated solution for measuring and monitoring the various dimensions e.g. physical, social, that inform and influence water use in domestic buildings.

Keywords: water consumption, water use, measuring and monitoring, water technology performance, water efficiency.

INTRODUCTION

Governments now recognise that climate change and its consequences need to be addressed by changing people's behaviour and every day practices. Technological fixes alone are not enough (Uzzell 2008). The daily household carbon emissions associated with water use in the home equates to 2.2 kg CO_{2e} (EA 2008). In terms of the emissions associated with the 'use' phase of water in the supply-use-treatment cycle, 16% can be attributed to system losses, dishwasher use 17%, washing machines use 11%, hot water (gas) 46% and the remaining 11% is attributed to utility companies (EA 2008). Installing water meters is expected to produce a 10-15% reduction in water use, implementing water reuse systems such as grey or rainwater harvesting may yield water use reductions in the range of 30-40% (EA 2008). Studies conducted in the UK and US report that on average, applying water efficient designs and products leads to 15% less water use, 10-11% less energy use and 11-12% reduction in operating costs (McGrahill 2009; Darby 2006 etc.). Smart metering has a wide-ranging success (and failure) rate of 0–20 per cent for reasons that are often unclear or unspecified (Challis 2004; Darby 2010). While many evaluations of feedback programmes have been conducted, they are based on the same fundamental assumptions; namely that when provided with the 'right' information about the costs and benefits of consumption, individuals will make rational and autonomous choices that result in more efficient resource use (Strengers 2011). Most evaluations have therefore focused on the presentation, format and type of feedback provided and the demand reductions or load shifting achieved (Challis 2004; Darby 2006). Consequently, they recommend ways to improve the quality, quantity and presentation of feedback in ways that better engage and inform householders.

Whilst there is no shortage of studies on water consumption in buildings, current evidence on point-of-use consumption is limited, primarily due to the fact that only 40% of UK housing is metered (OFWAT, 2010). There is very few case examples of point-source demand studies which attempts to identify where waste occurs. Of these studies, the findings from the Anglian 100 study are the most recognised as a source of evidence for water consumption in existing homes. Commissioned by Anglian water, the study provides data from existing homes collected from 1992 – 2008. Other studies have since been commissioned by water companies e.g. Wessex Water as part of tariff trial exercises and the data from these studies are gradually being released into the public domain.

Findings from previous research (Anglian 100 study, Clarke et al. 2009, a wide range of MTP reports 2008, Waylen et al. 2007, Chambers et al. 2005 etc), demonstrate disparity in the available evidence and further demonstrate the gaps in the understanding of micro-component water use, and how micro-component use differs between different households. Summary statistics on water use that is based on arithmetic means as the 'average' is heavily skewed by high water users, suggesting that most households are already using less water than 'average'. This has implications on the effectiveness of water efficiency messages; if households perceive that they are already doing enough and they don't need to change.

Water efficiency is just as much concerned with consumer behaviour as it is with the efficiency of fittings e.g. the flow rates for taps, and flush-levels for toilets (DEFRA & CLG 2007). Social factors such as occupancy numbers and demographics, age of inhabitants, occupation of inhabitants, personal habits, perceptions and attitudes, lifestyle and values of the water user influence how water is consumed in a building. Clarke & Brown (2006) argued that public water use awareness campaigns are often unsuccessful in bringing about a significant change in behaviour due to the fact that such campaigns fail to understand the factors that influence people's water use, what drives them to change or embrace new technology. Water efficiency strategies in buildings should therefore aim to understand what people care about, and preserve the things they consider important (Larson 2010).

The aim of this paper it to provide a literature review of available water use measurement devices as a first step in establishing a data collection methodology to inform the design and implementation of water efficiency interventions in domestic buildings.

DESIGN REQUIREMENTS

Domestic properties provide a useful environment for water efficiency research to be undertaken. This is because they have common physical features such as fittings and fixtures along with regular layouts, and a near constant user group. The complexity with designing water efficiency interventions for existing buildings is the fact that households are different and consumption patterns and behaviour differ accordingly. Therefore, a one-size-fits-all strategy for water efficiency in homes has a high risk of failure. Retrofitting water efficiency interventions therefore requires knowledge and understanding of the common as well as different variables that inform or influence water consumption practices in domestic buildings.

Creating, or co-creating this knowledge and understanding require information generated from real data-sets, not generic or generalised data. To this end, data collection to inform water efficiency interventions should collect various dimensions of information; physical, operational, economic, social etc. Often, studies focus on one or perhaps two dimensions only. This paper is the first in a series of studies. It reviews current technologies for collecting physical water consumption data at the end use, as the first step to developing a robust multi-dimensional methodology for water efficiency interventions.

WATER MEASUREMENT TECHNOLOGIES

The water measurement instrumentation and data collection tools fall under three main categories; mechanical, pressure based and electronic sensors.

Mechanical meters

Mechanical meters measure flow mechanically through positive displacement, demonstrated in Figure 1. Positive displacement is the relocation or movement of an object (e.g. a mechanical part in a meter) by another object (e.g. a liquid), which can then be measured or timed. A basic analogy of this would be holding a bucket at the end of a tap and timing how long it takes to fill the bucket thus determining the flow rate (Figiola, 2005).

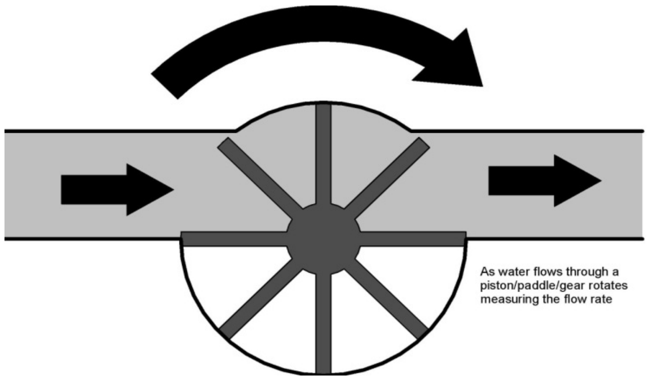

Figure 1. Mechanical meter example

In the mechanical meters examined in this research, the systems consist of various positive displacement systems which are forced to rotate due to the flow of water. The flow rate is determined as the known volume of the cavity per revolution of the system. Examples of mechanical meters include:

- **Piston/rotary/oval meter:** Whilst the system has multiple names the principle is the same within each technology. In this mechanical system, the water flows through an oval section with an off centre rotation which the water displacement rotates. The rate of rotation can be used to determine the rate of flow (Hill 1995).

- **Paddle wheel meter:** A paddle wheel meter works using similar principles to that of a paddle boat, except that the principle is reversed in the paddle wheel meter. On the paddle boat, the rotation of the paddle as it is driven displaces the boat. In the paddle wheel motor, the displacement of the water drives the paddle and the rate of rotation can be used to determine the flow rate (Hanson 1998). An optical flow rate meter (Figure 2) below is based on this principle. They have a turbine built into them that spins when there is water flow in the pipe work and an LED is directed onto a receiver. Each time the turbine spins it blocks the light beam and reduces the output signal of the meter. This output needs to be fed into a pulse converter, which counts the pulses and sends them to a datalogger. The number of pulses can then be converted into flow rate.

Figure 2. Optical flow rate meter

- **Helical gear:** A helical gear is similar to that of all the mechanical systems explored so far in that the rate of rotation is used to determine the flow rate. However, the nature of the helical gear is that the system can be used 'in line'. This means that the system can be installed within a pipe. The helical screw principle uses two counter rotating helical gears; the gears are forced to rotate as the water flows through the system (Pereira, 2009).

Pressure based meters

Pressure based meters rely on Bernoulli's principle of fluid dynamics. This principle states that a change in speed of a fluid simultaneously changes the pressure or the fluids potential energy (Muncaster, 1993). A Pressure based system consists of various differential pressure flow meters. The difference in pressure within a secondary system is used to determine the flow rate of the fluid, shown in Figure 3.

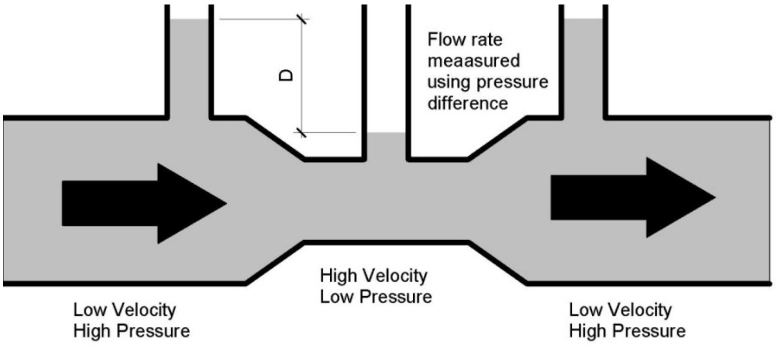

Figure 3. Pressure meter example.

Examples include:

- **Venturi meter:** This meter utilises the Venturi effect, which states that a reduction in fluid pressure occurs when a fluid flows through a constricted section of a pipe. A Venturi meter consists of a flow restrictor which has two pressure taps one at the input and one at the smallest section of the meter. The pressure difference between the two pressure taps are used to determine the flow rate (Soltys, 2011).

- **Pitot tube:** A pitot tube consists of a tube pointing directly into the flow of a fluid. The moving fluid is brought to rest, as there is no outlet. The resultant rest (stagnation) pressure of the fluid is then applied within Bernoulli's equation of fluid dynamics to calculate resultant flow (Muncaster, 1993).

Electronic sensors

Modern innovations in the measurement of flow rate allow for variations in the pressure, temperature and characteristics of the fluid to be documented. These sensors are often electronic and feature various sensors to allow measurements to be taken; compared to mechanical meters, often non-intrusively, shown in Figure 4.

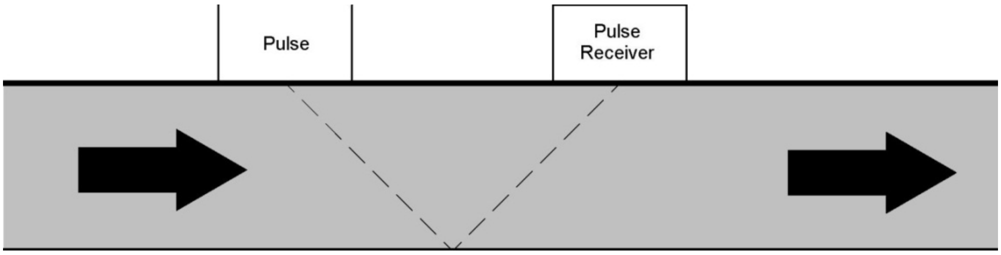

Figure 4. Electronic meter example.

Examples include:

- **Magnetic flow meters:** A magnetic flow meter generates a magnetic field through the metering pipe which generates a potential difference in magnetic field. The potential difference is then sensed by electrodes and used to calculate the flow rate (Hoffman, 2003).

- **Ultrasonic meters:** Ultrasonic flow meters measure the difference in transit time of ultrasonic pulses (see Figure 5). Ultrasonic sensors are clamped onto the outside of the pipe and the pipe material, diameter, thickness and the type of liquid being measured is entered into the receiving unit. The time difference is considered to be the velocity of the fluid along the ultrasonic beam hence deriving the flow rate (Lynnworth 1989).

Figure 5. Katronic KATFlow 220 ultrasonic flow rate meter.

- **Coriolis mass meters:** Coriolis meters use the Coriolis Effect to measure the mass flow rather than volume flow. It is considered that when the mass flows through the meter, the tube twists slightly, as the arms rotate; the flow rate can be measured from the deflection observed (Flecken, 1988).

The advantages and disadvantages of the aforementioned measurement techniques are summarised in the table below.

Mater Type	**Advantages**	**Disadvantages**	**Suitability**
Piston Meter	Accuracy Can measure low flow rates Fast response to flow rate change Straight pipe runs not needed	Intrusive Not suitable for use in turbid water Maintenance Corrosion can be an issue	Non turbid water with good access Low flow rates Where flexibility is needed in terms of location
Paddle wheel meter	Can be connected to a datalogger Relatively cheap Can be installed horizontally or vertically Can run of mains or batteries Straight pipe runs not needed	Data acquisition system needed Optical flow rate meters Not suitable for use in turbid water Intrusive Hard water may reduce working life	Non turbid water Where flow rate readings need to be taken and recorded automatically Good access Where flexibility is needed in terms of location Where difficult to connect to the mains power
Helical gear	Accuracy Can be used with low flow rates Straight pipe runs not needed Corrosion can be an issue	Intrusive Not suitable for use in turbid water Maintenance	Non turbid water with good access Low flow rate measurements Where flexibility is needed in terms of location
Venturi meter	Accuracy Can be used in dirty water	Intrusive Complexity May increase water use Flow rate restriction High cost Occupies considerable space	Turbid or non turbid water with good access Cost not an issue No space restrictions
Pitot tube	Accuracy No moving parts	Intrusive Can be complex May increase water use Flow rate restriction Need straight pipe run	Non turbid water with good access
Magnetic flow meters	Non intrusive Can be used in dirty water No moving parts No pressure drop Can be attached to a datalogger	Conducting fluid needed Electrodes can corrode	Multiple measurements at several outlets Turbid or non turbid water Restricted access Automated collection and storage of data needed
Ultrasonic meters	Non intrusive Possible to measure temperature and heat flow Some systems have an in built datalogger Measurement of fluid flow rates of a wide variety of viscosities Low flow rate measurements	High cost Correct placement of sensors needed Some not suitable for use with dirty water	Where temperature as well as flow rate measurements are needed Automatic data collection and storage needed Restricted access Non turbid water
Coriolis mass meters	Accurate Non intrusive Flow rate not disrupted Density, mass flow rate and flow rate measurement Can measure low flow rates Low maintenance Can be used with dirty water	More expensive than magnetic flow rate meters magnetic flow rate meters	Where multiple parameters need to be measured Dirty or clean water

Table 1. Look up table of advantages and disadvantages of available water measurement.

USEFULNESS AND APPLICABILITY

The decision to use any of the aforementioned technologies will depend on what factors need to be measured, where and when.

Other key considerations include:

- Number of water fittings
- Number of users
- User participation
- Physical space around the pipes
- Effect on the water supply
- Water characteristics
- Frequency of access to systems
- Flow range
- How the data is going to be collected

The water measurement instrumentation and data collection tools reviewed are governed by the constraints of the systems. This section reviews each system in terms of usefulness and applicability for measuring and monitoring water use in domestic buildings.

Mechanical systems provide an accurate way of measuring the water flowing through a pipe. They form the basis of many industry standard methods for measuring the flow of liquid.

However it should be noted that mechanical measurement is often intrusive, relies on the principle of positive displacement, and requires a superb capillary seal separating incoming fluid. The mechanical parts are subject to friction and wear, which may reduce accuracy and require maintenance, which would not be suitable for buildings where access is in-frequent.

Furthermore, these systems sit in line with the water flow and therefore require particle free flows. This suggests that the technologies may not be suitable for waste pipes where particles are likely to build up and affect the results or potentially cause a blockage.

Pressure based systems also provide an accurate but more complex way of measuring water flow but the technologies are not without limitations. All the systems rely on a pressure differential or the measurement of stagnated pressure. This requires the flow of the water to be restricted, which could potentially alter the results of any research as the reduction in water pressure may lead to higher water consumption or frustrate the water user e.g. during showering. Likewise, any particles in the flow will disrupt the accuracy of the meter and potentially stop the flow, if the particles were of sufficient size.

Electronic sensors offer flexibility and the easier option to measure more than one outlet per time. However, it should be noted that whilst these are potentially more accurate, the complexity of the systems and associated calibration can be reflected in the cost of the meters. Compared to mechanical systems, electronic sensors can be easier to install and use. However, these can be expensive and the proximity of sensors to one another may cause errors in data sets. Nonetheless, they do not have mechanical parts that require maintenance. They can be installed in a non-intrusive manner and require little engagement from the user.

Many electronic systems can also be connected to the same data logger, aiding integrated data collection and ease of analysis.

CONCLUSION

There is still limited research on point of use water consumption in the UK and this is essential in understanding how water is used, where and when. This data is vital for determining the effectiveness of water saving devises and any water demand management initiatives.

Due to the complexity and characteristics of domestic properties, and the variability of data from a quantitative amount of water efficiency studies, it is clear that a generic domestic water end use model would not accurately reflect the complex nature of water use. It is therefore argued that it is essential to explore an integrated methodology for measuring and monitoring water use particularly in domestic buildings.

A critical review has been carried out on currently available measurement techniques and is the first step towards this objective. Further areas of research have been identified as follows:

- Appraisal of electronic flow measurement devices
- A study into the potential participation of users with automatic user recognition systems.
- Developing a tool for integrating water consumption and use data.

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Rainwater Harvesting for Domestic Consumption in Bangladesh

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ABSTRACT

Bangladesh has continuously evolving problem with water supplies, not adequate to meet even the minimum requirements for potable water. Surface water is being incessantly contaminated by both industrial and human pollutions; rapidly increasing demands due to population explosion results in withdrawal of ground water at a faster rate than it is replenished by recharge. This problem can easily be mitigated through rainwater harvesting, taking advantage of high quantities of rainfall in the country. This study explores the possibility of rainwater harvesting for domestic consumption in urban areas of Bangladesh and proposes some guidelines to compute storage requirements. Based on these guidelines, computation methods for determining the quantities of rainwater available for collection in different urban regions of Bangladesh and adequacy of those quantities for residential consumption have been determined. These tools can be used for (1) determining the quantities of rainwater required for domestic consumption in urban areas of Bangladesh and (2) size of cisterns for storage of the rainwater.

Key words: Bangladesh, computation of water requirements, rainwater harvesting.

INTRODUCTION

Problem Statement

Rainwater harvesting involves the collection, storage, and use of precipitation. The term is derived from a more general connotation of water harvesting that denotes the collection, storage, and use of water mainly for the purpose of irrigation (Woods, Choudhury, 1992). Nowadays the term generally comprises the collection of run-off on micro-catchment principles, such as roofs.

The purpose of this study is to assess a sustainable rainwater harvesting solution for multistoried residential apartments in Dhaka, Bangladesh through an extensive review of the literature and collection and analysis of secondary data. The objectives of the study were as follows:

- Identify and analyze the rainwater harvesting methods of Bangladesh,
- Analyze the significance of rainwater harvesting in the urban residential areas of Bangladesh,
- Develop a solution for rainwater harvesting solution for a typical multistoried residential apartment in Dhaka, Bangladesh, and
- Utilize programming and visualization to assess the efficacy of the solution.

Historical Background of Rainwater Harvesting

Rainwater harvesting is a common practice in the countries and areas where the annual precipitation is high and pure drinking and usable water is scarce. All over the world, economical condition has prompted the low-income groups to harvest the rainwater for household and essential uses. Several countries of the world in different regions have showed the popularity of this method. Originated almost 5000 years ago in Iraq, rainwater harvesting is practiced throughout the Middle East, the Indian subcontinent, Mexico, Africa, as well as in Australia and United States. Demand of water both from surface and underground sources continually increases with the increase in world population, leading to a consequence of crisis of water supply in different regions. Among other available alternative sources for water supply, rainwater harvesting has become the most economical solution for the water crisis (Boers, Ben-Asher, 1982).

Rainwater Harvesting in Bangladesh

Bangladesh used the surface water as the principal source for drinking water up to the recent past. But nowadays, withdrawal of groundwater has become norm. One of the major problems with groundwater is arsenic contamination. Almost 50 percent of the country suffers from this contamination (Rahman et al., 2003).

Being a tropical country, Bangladesh receives heavy rainfall during the rainy season with mean annual rainfall of about 100 inches (Wikipedia, 2012). This amount makes rainwater harvesting an obvious solution for the country.

The ever-increasing population in Dhaka, the capital of Bangladesh, is putting increased load on underground aquifers. Dhaka receives an annual rainfall of about 100 inches which can easily be an answer to the vertical recharge for the aquifers (Kabir, Faisal, 1999). Rainwater harvesting has also the promise of facilitating the consumers with some additional benefits such as reduction in the scale of seasonal flooding and water logging.

Rooftops in buildings may be designed to collect rainwater solving the challenging issues of minimizing the storage cost and management. If the system is incorporated in the design and construction process of buildings, cost of such a system could be very minimal (Thomas, 1998).

RAINWATER HARVESTING TECHNOLOGY

Catchment Surfaces

Rainwater harvesting is totally based on the availability of water from precipitation. It has to be intercepted first in order to make it available for consumption. The quantity of water that can be harvested depends on the amount of rainfall and the size of the catchment area. Some of the methods of interception include the use of the roof, courtyard, and ground catchments.

Use of roof is the most commonly developed practice for rainwater harvesting. Under satisfactory conditions, roof runoff can supplement or even replace the conventional supply system.

Separation of Sediments

When rainwater is collected from roof, the first consignment of water contains dust, debris, bird droppings, or other sediments. This should be separated from the supply before it is stored. Simple, automatic systems are available for diverting this water (called first flush diverter) that can be easily installed with a rainwater catchment system (see Figure 1).

Storage of Rainwater

Quantity runoff from a catchment area is dependent upon the amount of precipitation. Since it is intermittent in nature, storage must be an integral part of a rainwater harvesting system. Storage facilities can either be below or above ground depending on site conditions and other factors. The cistern or tank selected should be completely covered in order to prevent health hazards and loss of water due to evaporation.

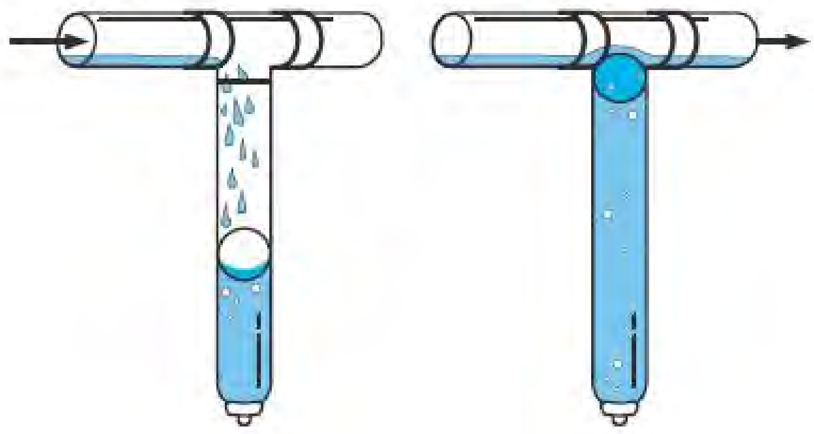

Figure 1. First flush device.

METHODOLOGY

In order to provide a rationale for adopting rainwater harvesting systems for Bangladesh, it was necessary to find out (1) the extent of treatment required to make the water potable and (2) overall savings, if any, to the consumers when they switch either partially or completely to supply from this source.

Data Collection and Analysis for Treatment of Rainwater

One of the major costs involved in water supply is treatment. Before installation of a rainwater harvesting system, one should find out the extent of treatment that would be required for this type of supply water. It was, therefore, decided to find out the quality of harvested rainwater and the levels of its contamination.

Test reports of rainwater from the following countries were collected from secondary sources:

- China (Hao et al., 2006)
- Brazil (Piranha et al., 2006)
- USA (Kilmas, 2006)
- Palestine (Al-Ghuraiza, Enshassi, 2006)
- Portugal (Stigter et al., 2006)
- India (Sarin, 2005)
- Nigeria (Adeniyi, Olabanji, 2005)

The data was then analyzed, comparing it to existing EPA standards (Environmental Protection Agency, 2011). A one-sample t-test was conducted to analyze the data. Variables tested were pH value, total coliform content, total dissolved solids, and minerals such as chloride, iron, nitrate, sodium, and sulfate.

Findings

The analysis of the data, reported in Table 2, strongly suggests that except for the amount of total coliform, chemical composition of rainwater is within the safe range to be used as potable water. It is therefore only logical to conclude that treatment of rainwater for domestic consumption in Bangladesh would not be expensive compared to the cost of treatment for groundwater. Only major treatment would be the removal of total coliform. Comparing different purification methods currently used, several options such as distillation using solar energy, deionization, reverse osmosis, and chlorination. Considering the cost, availability and effectiveness of the various, chlorination seemed to be the most appropriate method for this purpose.

Variable	Mean value	EPA standard	p-value (p<=0.05)	Findings
pH value	6.50	6.50-8.50	0.996	Not significantly different than the EPA standard
Total coliform	805 ppm	5 ppm	0.023	Significantly higher than the EPA standard
Total Dissolved Solids	48.70 ppm	500 ppm	<0.000	Significantly lower than the EPA standard
Chloride	15.128 ppm	250 ppm	<0.000	Significantly lower than the EPA standard
Iron	0.19 ppm	0.30 ppm	0.362	Not significantly different than the EPA standard
Nitrate	4.70 ppm	10 ppm	0.330	Not significantly different than the EPA standard
Sodium	4.05 ppm	200 ppm	<0.000	Significantly lower than the EPA standard
Sulfate	19.14 ppm	250 ppm	<0.000	Significantly lower than the EPA standard

Table 2. Comparison of rainwater quality against EPA standards.

COST BENEFIT ANALYSIS OF RAINWATER HARVESTING IN BANGLADESH

Domestic water requirement

Daily water consumption was calculated by developing a program for the purpose, using Java Script (see Figure 2). It was based on following variables:

- Total number of residents in an apartment
- Daily per capita use of different plumbing fixtures such as lavatories, showers, water closets, etc.

Water Calculator	
Required Data Entry	
Number of People In Residence	5
Indoor Water Use	
Bathroom Water Use	
Daily Showers in the Residence	5
Average Shower Time in Minutes	5
Shower Head Flow Rate (3.8 std. 1.6 res.)	1.6
Total Weekly Baths in Residence	0
WC Water Use	
Average Number of Flushes Daily Per Person	4
Gallons Per Flush (5 std. 1.6 res.)	1.6
Faucet Water Use	
Average Number of Times Each Person Uses Faucet Daily	5
How Many Minutes Each Use	.5
Dishwashing Water Use	
How Many Times Are Dishes Washed by Hand Daily	1
How Many Minutes Each Use	5
How Many Dishwasher Loads Each Week	0
Gallons Per Dishwasher Load	0

Figure 2. Water consumption calculator

Based on the data for water demand by different fixtures, it was calculated that per capita water consumption in an urban area in Bangladesh is 25 gallons per day. The daily consumption of water for a family of 5 living in an apartment would be 125 gallons.

It was now critical to figure out whether adequate quantity of rainwater is available round the year to meet the demands of all the residents of a typical apartment complex in Dhaka, Bangladesh (see Figure 3). Usually such a complex consists of 10 to 20 apartments with a total number residents ranging from 50 to 100.

Projects concerning collection of rainwater using roof as the catchment area can be initiated from the available rainfall data. Mean annual rainfall in Dhaka is about 100 inches. The volume of rainwater collected every day and consequently used for consumption was found out using the following algorithm for different catchment areas and annual fall:

Water available in gallons = (62.4 lbs. per cft. /12inches per ft. /8.33 lbs. per cft.)*annual rainfall in inches*catchment area area*runoff coefficient (1)

A runoff coefficient of 0.9 has been used for the catchment area surface. Table 3 shows quantities of water available for domestic consumption. Assuming a conservative estimate of a rainfall of 80 inches and a catchment area of 9,000 sft., the total quantity of water available would be about 400,000 gallons.

Catchment Area in sft.	Annual Rainfall in Inches					
	50	60	70	80	90	100
6000	168547	202257	235966	269676	303385	337095
7000	196639	235966	275294	314622	353950	393277
8000	224730	269676	314622	359568	404514	449460
9000	252821	303385	353950	404514	455078	505642
10000	280912	337095	393277	449460	505642	561825
11000	309004	370804	432605	494406	556206	618007

Table 3. Annual gallons of water available from catchment surface

It was now necessary to find out whether the available quantity of water would be adequate to meet the daily demands of the residents of a typical apartment complex. The following algorithm was used for the purpose:

Persons served = Water available in gallons per year/ (daily per capita consumption*days in a year) (2)

Table 4 shows the number of persons served at the rate of 25 gallons per person per day at different quantities of rainfall. Assuming a conservative estimate of a rainfall of 80 inches and a catchment area of 8,000 sft., the total number of people served by the water available would be 45.

Catchment Area in sft.	Annual Rainfall in Inches					
	50	60	70	80	90	100
6000	50	60	70	80	90	100
7000	21	25	29	34	38	42
8000	24	29	34	39	44	49
9000	28	34	39	45	50	56
10000	31	38	44	50	57	63
11000	35	42	49	56	63	70

Table 4. Number of persons served by available water from rainfall

Cost Savings from the Use of Rainwater

It is apparent from the above findings that there would a considerable reduction in the use of water from conventional supply systems by factor of 0.5625 if rainwater harvesting is introduced. If the total number of residents in an apartment complex is 80, then it appears that more than 50 percent of the domestic water needs can be met by rainwater harvesting. Since this water is available almost for free, except for the nominal cost of some basic treatments, the cost of water would be reduced to more than half, if rainwater harvesting systems were installed. Considering the present cost of municipal supply water in Dhaka, Table 5 summarizes the savings of a family of five when dependence on conventional supply is reduced:

Cost of municipal supply per 1000 gallons	$0.50	Cost of rainwater	0
Water consumption (in gallons) per year for a family of five	1500	Percentage reduction of municipal supply	56.25%*
Water cost per year for a family of five	$750.00	Reduction in water cost for a family of five	$421.88

*Assuming a total population of 80 in the apartment complex

Table 5. Cost benefits of rainwater harvesting.

PROPOSED RAINWATER HARVESTING SYSTEM

Components

The proposed rainwater harvesting system for an apartment complex in Dhaka, Bangladesh consists of:

- Roof catchment
- Gutters and downpipes
- First flush device
- Filter chamber
- Chlorination chamber
- Dechlorinator
- Cistern
- Water pump and supply pipes

Sizing of Storage Cistern

One of the major elements in the system is rainwater storage cistern. Since most of the apartment complexes in Dhaka are multistoried using raft foundation below, the space enclosed by the foundation wall can be utilized as a cistern without much additional cost.

The size of rainwater storage cistern was determined for a typical apartment complex in Dhaka, Bangladesh, with a roof area of 9,000 sft. The variables used to figure out the size were:

Monthly water consumption (MC): It is the total quantity of water requirement. It was based on daily per capita consumption in gallons.

Critical rainfall (CRF): It is the minimum quantity of rainfall per month in inches required to meet monthly water consumption requirement only from rainfall. It was calculated to be 18 inches.

Monthly factor of insufficiency (MFI): This is a ratio of the difference between monthly rainfall and critical rainfall to critical rainfall. When the monthly rainfall is equal to or higher than critical rainfall, the factor is zero. Table 6 shows all the monthly factors of insufficiency.

Rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0	1	2	8	10	18	20	23	10	5	2	0
Critical	18	18	18	18	18	18	18	18	18	18	18	18
MFI	1.00	0.94	0.89	0.56	0.44	0.00	0.00	0.00	0.44	0.72	0.89	1.00

Table 6. Monthly factor of insufficiency.

Yearly factor of insufficiency (YFI): It is the sum of monthly factors of insufficiency.

Total monthly supply (TS): It is the required quantity of rainwater required to meet monthly consumption, without any shortfall in month of the year. It is based on the yearly factor of insufficiency.

Leakage factor (LF): It is factor that accounts for water loss due leakage through cistern walls. For a concrete surface, the factor is 0.01.

Storage factor (SF): It is a ratio of water consumption from rainwater to total quantity of water requirement for consumption. For a typical apartment complex in Dhaka, Bangladesh the factor is calculated to be 0.5625.

Storage capacity (V_{gal}): It is the capacity of a cistern to store rainwater, measured in gallons. . It was calculated using the following algorithm:

$$V_{gal} = MC*TS*(1+LF)*SF \quad (3)$$

Storage volume (V_{cft}): It is the size of the storage cistern in cubic feet. It was calculated using the following algorithm:

$$V_{cft} = V_{gal} * 8.33/62.4 \quad (4)$$

A computer program using visual basic language was developed to calculate the actual capacity of such a cistern for a typical apartment complex. After entering data for all the steps identified for storage sizing, it was found that the space available in the basement (created by the below grade raft foundation) for a typical apartment complex in Dhaka was adequate for a rainwater storage cistern.

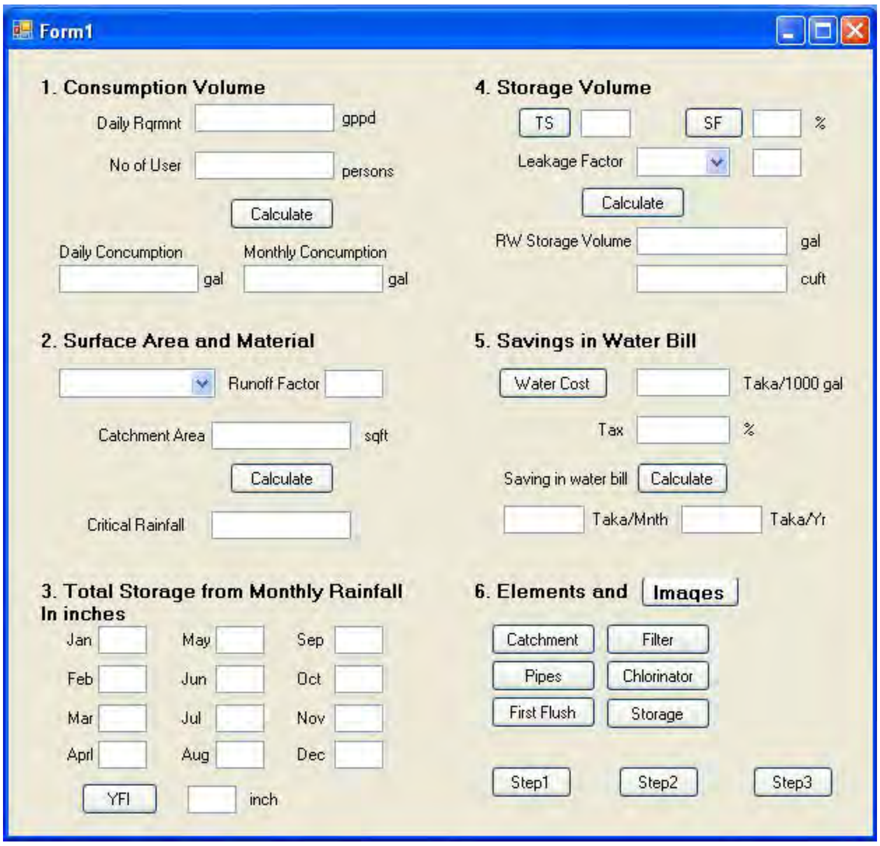

Figure 4. Cistern size calculator.

SUMMARY AND CONCLUSIONS

The rainwater harvesting system that has been developed for a typical apartment complex in Dhaka, Bangladesh is composed of the standard components for such a system, adjusted to local requirements. A 3D model has been developed for the solution to make it easily comprehensible to the users. This model, along with the computer programs, forms the guidelines for design and installation of the system.

The solution developed and expressed in programming and visualization can be a comprehensive and effective tool for learning and designing rainwater harvesting solution both for the user and for the professionals in the building industry of Bangladesh. Under the guidelines, using the local water demand and rainfall, a rainwater harvesting method can be designed even for a different location. The water conservation calculation in monetary terms will provide the owners, builders, as well as the users with the freedom to choose the option that suits most.

Further research can be done on the creation of animation with more details. The local bodies can use this research as a guideline to calculate the possible amount of supply water conserved by the rainwater harvesting as well as the decrease in load on the ground water to advocate this method to be included in housing policy. The results can be an effective teaching tool in the fields of sustainable construction, water conservation, and green building where alternative technologies such as rainwater harvesting are gradually getting serious attention.

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Supply and Demand of Potable Water in Australia and the United Kingdom. How climate change can affect the distribution of potable water supply

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ABSTRACT

This paper focuses on the increasing impact on water utility companies and the general public to conserve water in both Australia and the United Kingdom. The paper addresses the issues that, both countries face, relating to climate change and its effect on the supply and demand of potable water. Consideration has been taken into account the ways in which water utility companies in both countries deal with providing a potable water supply in drought conditions.

Whilst the ways in which each country deals with climate change and its effect on supply and demand requirements for potable water were similar, an underlining feature did distinguish itself throughout, mainly relating to both the government and public's perception to water conservation in each country.

Keywords: climate change, drought contingency, potable water, public perception, water conservation.

PUBLIC EDUCATION

Within the UK, water companies are under a general obligation to promote efficient use of water amongst their customers under the Water Industry Act 1991, although they have little genuine incentive to do so. Many water companies in the UK do offer free or subsidised water-saving products such as cistern displacement devices, "DIY" water audit packs and water butts, alongside water-saving tips. In addition, free or subsidised repair of leakage in supply pipes is generally available.

In the UK in 2010, the Select Committee on Science and Technology (the "Select Committee") detailed the following to the House of Commons (United Kingdom Select Committee on Science and Technology Water Report for the House of Commons 2012)

> "It has become increasingly clear during our inquiry that what is normally known as 'water efficiency' has an absolutely central role to play if demand and supply are to be balanced in an environmentally sustainable way in the face of a growing population, a shrinking average household size and the pressures resulting from climate change."

The Select Committee noted that the work of water companies in this area is relatively small-scale and piecemeal. In contrast, the proactive and innovative approach of some of the Australian water companies such as Yarra Valley Water and Sydney Water is notable. The former is developing new schemes, such as the Ecosaver retrofit programme, whereby banks would offer discounts on loans to the public on the condition that the saving be spent on water efficient devices. Accordingly, the consumer would pay the same amount overall and no subsidies would be needed. Sydney Water, meanwhile, has retrofitted 300,000 properties with water efficient devices, charging a heavily subsidised price of A$22 per household or waiving the charge for certain low income groups. This has resulted in an average annual saving of 20,900 litres per household, equating to approximately 12 percent of average indoor water use in Sydney. It is important that Ofwat should look favourably upon such initiatives as and when they are proposed by the water companies. However, irrespective of these initiatives, there will be a continuing need for other bodies to promote the efficient use of water—not least because of consumers' suspicion of water companies' motives in encouraging them to curb consumer wastage. As Christine Sefton argued, "I think it would be useful for water companies not to be the sole promoters of water efficiency information because people find that quite confusing. Why would someone selling you something ask you to use less of it? They are deeply suspicious of that"(United Kingdom Select Committee on Science and Technology Water Report for the House of Commons 2012). That perception is not supported in Australia.

An interesting observation from the select committee report is the low number of UK households that are fitted with a water meter; currently it is 28%(Ofwat, *Tariff structure and charges: 2009-10)* the metering of domestic supplies potentially curbs excessive water consumption where other methods of waste prevention are unavailable and has significant cost saving benefits for end consumers. Ofwat calculates that the typical customer who switches to a meter can save 5-10% on their bill after the installation of a meter.

In Australia, all recipients of a potable water supply require the installation of an approved water meter (known as the main water meter) to measure the volume of water supplied through each property service pipe to a parcel of land. In addition to this, additional water meters (known as sub or check meters) are required to measure the volume of water supplied to certain types of "dwellings/occupancies" located within that parcel of land, i.e. units or flats, as well as possibly measuring water for certain purposes within a property i.e. water used for irrigation. All installations must adhere to the guidelines set out in AS / NZS3500 and the National Plumbing and Drainage Code and Water Services Association of Australia (WSAA).

In addition to the recommendations set out by the select committee, it was suggested that water meters be installed in households throughout the UK. However, there were concerns regarding the implementation of meters by the water bodies and the fact the end consumer may feel that because they are being charged by a precise consumption rate, the discretion of the amount of water used should be left to the consumer, regardless of water usage restrictions imposed by a third party.

An Australian consumer's use of water is subject to tariffs and excess water charges, whereby some water is available at a low unit price and additional water at progressively higher prices. This means that the water needed for essentials are provided at a relatively low price but there is a cost deterrent for excessive water use.

However, within the UK, it remains difficult for companies to get permission to impose universal metering, both because the circumstances for this to be achieved appear to be very tightly drawn (United Kingdom Select Committee on Science and Technology Water Report for the House of Commons 2012) and because the Secretary of State has a significant measure of discretion. The EA suggested said that the regulations should be changed "to make it easier for water companies to meter all customers in areas" (Demand for water management review Environmental Agency 2012) The Select Committee recommended that higher-performance water efficient fittings and appliances be utilised, in order to increase their appeal to consumers and developers alike. Another important issue is the way in which consumers use water efficient fittings and appliances. This reiterates the importance of a widespread educational campaign, assisting consumers to become more familiar with water efficient devices. Clear instructions should also be provided with such devices.

A related issue is the attitude of developers towards installing water efficient devices in new homes. Developers typically argue that water efficiency is not a selling point for a home – not least because water bills form such a low proportion of most consumers' household expenditure. Worse still, water efficiency can actually deter home-buyers because of consumers' desire for power showers and other luxurious devices. In any event, as John Slaughter, Director of External Affairs at the Home Builders Federation noted: water efficiency comes "fairly low down the list" of priorities (United Kingdom Select Committee on Science and Technology Water Report for the House of Commons 2012) Thus, even if water efficient fittings do not cost any more than regular devices, developers are unlikely to install them unless they are either compelled by regulations or tempted by incentives.

In line with the success of the EU energy rating scheme (United Kingdom Select Committee on Science and Technology Water Report for the House of Commons 2012) water rating schemes to provide consumers with better information on the water efficiency performance of fittings and appliances would offer great benefits to the UK population. An efficiency labelling scheme can heighten public awareness of water efficiency and could also influence manufacturers to develop increasingly water efficient devices.

In Australia, the Water Efficiency Labelling and Standards (WELS) programme stipulates that all water-using appliances and fittings carry a "star" rating indicating their comparative water efficiency alongside an estimate of their water consumption (United Kingdom Select Committee on Science and Technology Water Report for the House of Commons 2012) However, it should be noted that the Australian scheme is mandatory; any scheme in the UK would have to be voluntary unless it was agreed at the EU level.

GOVERNMENT INCENTIVES

In Australia, all state governments offer a range of rebates to the public and business to conserve water and assist in living greener so to speak.

The rebates linked to water conservation vary from state to state. However, in general, certain financial rebates, to a fixed value, are offered to the general public if water saving devices are installed by a licensed plumber or electrician, as appropriate. Each state also offers, for a fixed price, a licensed electrician and plumber to visit households and perform a home energy and water audit. Whilst the practices of rebates schemes are present in the UK, they are not widely used by the public or supported by the various government bodies.

The Greater London Authority commissioned a study on behalf of the London Climate Change Partnership (LCCP) in 2010. The main focus of the study was to look at developing economic incentive schemes to promote retrofitting of the London housing stock to adapt to the impact of climate change. One of its key findings was that incentives were necessary to make this happen as 'cost represents one of the most significant barriers to adaptation for householders'.

Whilst the government scheme may not yet be in effect, both Thames and Southern Water do offer water saving devices to end consumers, although there is no regulation governing installation, i.e. whether installation must be by a qualified professional.

DROUGHT CONTINGENCY PLANS

The Australian Drought and Climate Change Committee states that a drought is an extended period of months or years when a region notes a deficiency in its water supply whether surface or underground water . Generally, this occurs when a region receives consistently below average precipitation. It can have a substantial impact on the ecosystem and agriculture of the affected region. Although droughts can persist for several years, even a short, intense drought can cause significant damage and harm to the local economy.

The Environmental Agency in the UK informs water utility companies that, water companies in England and Wales are required to prepare and maintain drought plans under Sections 39B and 39C of the Water Industry Act 1991, as amended by the Water Act 2003. Water companies submitted statutory drought plans for the first time in 2006. Every water undertaker, including smaller water companies and new appointees and variations, must produce a drought plan under the above legislation.

The Water Industry Act 1991 defines a drought plan as ‘a plan for how the water undertaker will continue, during a period of drought, to discharge its duties to supply adequate quantities of wholesome water, with as little recourse as reasonably possible to drought orders or drought permits’. A drought plan should set out the short-term operational steps a company will take before, during and after a drought. These plans are not strategic and should focus on a company’s actions if a drought was to occur under present circumstances.

In 2011, the Environmental Agency drought guidelines set for water companies were updated to include such events as the environmental impact droughts have, drought orders/permits and the new temporary water use restrictions that were introduced by the Floods and Water Management Act 2010. As a result, all companies responsible for potable water delivery were forced to revise their plans to implement these guidelines.

At a drought conference in Melbourne Australia in early 2012, Professor Martin Thomas, from the University of Canberra Australia, gave a compelling insight into how England was faced with drought conditions and how there is often a misconception by most Australians regarding the English weather patterns.

He said that that whilst most Australians had an image of wet and windy England, droughts in the UK are quite common and occur every 5 to 10 years. The main difference between droughts in the UK and Australia is the time period, which both countries define as drought conditions. In the UK, a drought is classified as a period of 4 weeks during which the rainfall in the period is a third or less than the average. Whereas in Australia, droughts are normally defined as a period of up to 3 months during which rainfall or water availability is at the lowest 10 percentile. Professor Thomas also noted that Australian drought conditions are at times, life changing to many people who experience the severity of them. The Australian government understood the social impact severe droughts were having on individuals and families, particularly in rural areas. Accordingly, Government Assistance is provided which includes income support payments for farmers and small businesses, advice and training grants and assistance to exit farming, and direct assistance for farm hands and irrigators. These measures also helped with social pressures facing families across rural and regional Australia.

There currently is no such programme that exists in the UK, although it should be noted that the conditions and circumstances in Australia are vastly different.

The main argument Professor Thomas made was the British public’s attitude towards the use of water. On average, each person living in the UK uses 170 litres of water per day, the highest consumption per person in the Northern Hemisphere. Australians are used to living in harsh climate conditions and, as a result, water conservation has become a way of life.

Both Thames and Southern Water’s Drought plans look at control measures to enable the ever-increasing demand when levels of supply may stagnate. They also detail, where necessary, water restrictions, which may be imposed should supply levels decrease further.

Australian Water Supply Authorities have a duty, under the Water Management Act 2000 (the "Act") to maintain a sufficient supply of water for the community particularly in time of water shortage. Under the Act, end consumers whose annual use is greater than 6,000 kl are required to prepare and implement a drought contingency plan to their potable supplier.

Each contingency plan should demonstrate ways in which the consumer aims to implement water saving strategies.

NON-TRADITIONAL METHODS OF POTABLE WATER DELIVERY

With collective burdens being placed on water resources, the concept of advantageous use of treated wastewater has rapidly become an imperative for water agencies around the world. Water reclamation, recycling and reuse are now recognised as key components of water and wastewater management. Along with the technology advances in wastewater treatment, the opportunities for water reuse have never been greater. The benefits of using recycled water include protection of water resources, prevention of coastal pollution, recovery of nutrients for agriculture, augmentation of river flow, savings in wastewater treatment, enhancing groundwater recharge, and sustainability of water resource management.

Whilst there is merit in using reclaimed or non-traditional water methods, the concept should not be treated as a stop gap measure to elevate the supply and demand pressure most water utility companies face. As noted above, public education in conjunction with water conservation measures should still be adhered too.

In 2009, The Australian Bureau of Statistics reported that the national water consumption rates were considered to be unsustainable, with about a quarter of Australia's surface water management areas either approaching or exceeding sustainable extraction limits.

The development of water reuse schemes in Australia has been generally slow in comparison to some other countries. It is only in the past few years that, the Australian water agencies have begun to shift their focus of water management to a total water cycle approach. This has led to the development of strategies to reduce the overall amount of wastewater discharged to the ocean and rivers.

Some of the driving factors behind the introduction of water reuse in Australia are summarised as follows:

- Drought and prediction of possible further droughts from climate change;
- Meeting the needs of a growing population;
- Demand from the general community to have greener water strategies and water conservation;
- Increased urbanisation of Australia's towns and cities;
- Increased industrial and agricultural needs;
- To allow conservation of higher quality water for suitable uses;
- Heightened awareness of the potential benefits of using recycled water in the agricultural industry;
- More advanced wastewater treatment processes; and

- Reforms from the Coalition of Australian Governments (COAG) which has pushed government departments to seek further research on the public health and environmental risks of water recycling.
- Some of the types of non-traditional methods of potable delivery are:
- Indirect Potable Use;
- Desalination;
- Rainwater tanks/harvesting; and
- Dual reticulation.

Indirect Potable Use

Direct potable reuse is when purified recycled water is added directly to the potable or drinking water supply. In-direct potable reuse is where the purified recycled water is pumped into an underground aquifer or a dam first. It then mixes with the water that is already there and the mixed water is pumped out and treated for the potable drinking water supply.

Desalination

Desalination is the removal of salt and impurities from groundwater or seawater to produce fresh drinking water. This process of desalination by distillation heats the incoming sea water, leaving the salt and impurities behind, and condensing fresh water from the vapour, or steam. Seawater is pumped into the desalination plant from the ocean and passes through two levels of initial filtration (reverse osmosis) to remove most of the large and small particles and impurities. The filtered seawater then enters the reverse osmosis plant. The water is then forced under pressure through special membranes that act like microscopic strainers. The pores in the membranes are so tiny that bacteria, viruses and other impurities – and the salt – are left behind as fresh water flows through. Around 40% of the water that goes through the desalination process comes out as fresh drinking water. The other 60% is pumped back into the ocean. As it is more salty than normal seawater, special diffusers ensure it mixes quickly and thoroughly back into the sea. This reintegration is closely monitored to make sure the marine environment is not harmed in any way.

Rainwater Harvesting

Rainwater harvesting is the accumulating and storing of rainwater for reuse before it reaches the ground water aquifer.

Dual reticulation

Dual reticulation is a water supply scheme comprising of two separate main supplies to the consumer: one potable drinking water and the other non-drinking recycled water.

COSTS AND ENVIRONMENTAL IMPACT

Non-traditional supply methods, particularly indirect potable reuse are generally considered more expensive than traditional methods, mostly due to the high energy input required to operate advanced water treatment processes such as microfiltration and reverse osmosis. Costs associated with desalination plant can be significant due to the high amounts of energy required to remove the salt from the water.

As desalination becomes more widespread, its environmental impacts, including the design of intake and discharge structures, are coming under increased scrutiny. Some of the damage can be mitigated. For example, reducing the intake velocity enables most fish species and other mobile marine life to swim away from the intake system, though small animals, such as plankton or fish larvae, may still get caught in the intake screens or sucked into the plant.

A bigger problem may be the leftover brine, which typically contains twice as much salt as seawater and is discharged back into the ocean. So far little scientific information exists about its long-term effects.

A separate problem may be that some metals or chemicals leach into the brine. Thermal-desalination plants are prone to corrosion, and may shed traces of heavy metals, such as copper, into the waste stream. Reverse-osmosis plants, for their part, use chemicals during the pre-treatment and cleaning of the membranes, some of which may end up in the brine. Modern plants, however, remove most of the chemicals from the water before it is discharged. In addition, new approaches to pre-treatment may reduce or eliminate the need for some chemicals.

The economic cost of supplying recycled water in many cases exceeds the cost of traditional water supplies, and also a number of alternative augmentation options. In particular, the economic costs and benefits of water supply augmentation options must be assessed in each individual circumstance. This may result in an increase of cost of water supply with the consequence of an upward pressure on water prices or through unnecessary tax revenue to cover the additional cost.

Whilst alternate methods of potable water delivery appear on the outset to be expensive, the whole life costs for such projects will not be fully known until such time as their social, economic and environmental impact can be fully assessed.

PUBLIC PERCEPTION (THE YUK FACTOR)

Arguably the greatest overall risk facing water companies is the social acceptance of recycled water consumption and any affects associated with human health. Public perceptions of health risks have a negative impact on community acceptance of recycled water. Recycling schemes such as indirect potable reuse and third pipe projects are largely dependent on community support and suffer fatally from any concerns associated health. Within Australia, examples for general community acceptance for indirect potable reuse across suggest that successful implementation of indirect potable reuse require Government agencies and water providers to build trust and confidence within the community over time.

The "yuk" factor or disgust in psychological terms, as a barrier to water reuse has been cited in the literature since the beginning of public attitudes studies towards reuse back in the 1970s. However, no studies have been conducted to examine how this factor exerts its influence on people's perceptions of water reuse.

A study undertaken by Melbourne Water in 2003 concluded that on many occasions it was reported that the general community openly acknowledged there was a psychological barrier when it came to using recycled water. This psychological barrier appears to be the disgust emotion derived from the thought of using recycled water.

Indirect Potable Reuse in Toowoomba – The 'Water Futures Toowoomba' initiative proposed indirect potable reuse of recycled water to secure local water supplies, but was rejected by a referendum. The proposal also envisaged long-term community consultation over several years, involving key stakeholders, experts and community leaders. However, in response to vocal community objection, the then Parliamentary Secretary for Water announced that federal funding for the project was conditional to the holding of a referendum within six months. The subsequent referendum was rejected as a result of an active scare campaign which was introduced.

The majority of people's perception towards the use of recycled water is of somewhat apprehensive. This is largely due to the nature of where the water has been prior to delivery. If climate change continues to affect water supply, then such schemes, such as indirect potable use will become widespread, thus requiring potable water providers to conduct more research and interaction with the wider community to demonstrate the safe practicalities of consumption.

In 2011, the first of three meetings entitled 'Engineering the future of water', organised by the Engineering the Future alliance, six speakers from academia, industry and agriculture looked into public attitudes to local water recycling, presenting real life examples of water use in the UK and globally . The belief there is an endless supply of clean fresh water and an apparent squeamishness about recycled water are serious barriers to better use of the vital resource in UK homes and businesses.

Professor Paul Jeffrey of Cranfield University said there was a deep rooted reluctance in the UK to use reused or recycled 'grey' water in homes and businesses – not suitable for drinking but good for flushing toilets and watering plants. He said: "If you look at the amount of waste water we reuse, it's almost negligible. If water reuse is to make a more significant contribution, we've got a lot of work to do and a key component of that work is making sure that public attitudes to recycling are appropriately understood. We know there's an instinctive resistance to recycling – often called the 'yuk factor'. But we also know that the source, the use and the tightness of the reuse cycle are important determinants of public attitudes. People don't seem to mind using their own grey water but they don't like using their neighbours' grey water."

The other major issue identified by the six panelists was the popular public perception that there is a surplus of available water because it rains a lot in the UK. However, Jenny Bashford, from the National Farmers Union warned that after three dry winters, one more could lead to an acute water shortage in 2012. She pointed to the need to think about how to make the best use of our blue (rivers, lakes and aquifers) water, green (soil moisture) water and grey (recycled) water. In addition, Stephen Kay of Cambridge Water said the UK public needed a 'burning platform' – such as a severe drought – before attitudes would change. He said that only when the public turn on their taps and nothing comes out will they be convinced that reusing and recycling water would be the way forward – the reason why countries such as Australia and Israel are so advanced in their reuse schemes.

The Toowoomba City Council stated that their experience has been that public perception about the safety of "untested" non-traditional drinking water sources (particularly recycled water) is a greater barrier to acceptance than operating cost. Experience has also shown that the public is generally more accepting of non-traditional sources as a choice of "last resort" during times of water scarcity. During times of plentiful traditional water sources, acceptance reduces. However, with increasing public knowledge and demonstration of the safety and reliability of non-traditional sources and the associated technology, acceptance will increase, particularly where population growth and/or climate change/variability puts increasing pressure on traditional sources

CONCLUSION AND RECOMMENDATIONS

The way in which we have lived in the past has had a detrimental effect on the way in which we live in the future. Our dependencies on fossil fuel have led to serious implications with our climate and the extremities our climate can produce. Government leaders, as well as, leading environmental regulators have seen a need to change the way in which we live which has led to laws being introduced to tackle the increasing threat caused by global warming and greenhouse gas emissions. Governments around the world have indicated the need and willingness to address the globes climate changing problems. With the event of fossil fuel supplies dwindling to the point of extinction, the need to start utilizing renewable energy sources and non-traditional potable water delivery will become more important than ever before.

The comparisons between the countries water practices are quite evident; both countries suffer from the effects of global warming and climate change. Both have reliance on fossils fuels to deliver energy sources. As a result, both countries have signed international treaties to minimise their fossil fuel consumption.

Whilst El Niño has an effect only to Australian climate condition, financially, the effects can be found with UK import prices. The UK imports a vast array of commodities, particularly from parts of Asia and the eastern parts of North America. If these regions are under the severe effects of El Niño, countries importing the commodities from these regions may face price inflations as a result. So, there are comparisons of El Niño effects for both Countries.

Climates for both countries are immensely unalike, with the exception of Tasmania. Australia has many arid regions where temperatures can be quite extreme. The UK has many regions where the opposite end of that extreme can be found. Populations and land mass are again of a dissimilar proportion. Australia is roughly 35 times the size of the UK. The UK is approx 242,000 square kilometres, NSW alone is 800,000 square kilometres. The UK has a population of around 63 million people and size, whereas Australia has a population of 22 million. Rainfall for both countries depending on El Niño can be very similar; last year there was a difference of 150mm for the average yearly total.

Both countries have water regulations and numerous government acts which oversee the delivery of potable water for human consumption. Both Australia and UK source and treat their water in a comparable fashion. The two countries have drought contingency measures in place, and water companies in both countries look at non-traditional methods like Desalination, to deliver a potable water supply. Likewise there is an apparent lack of acceptance for non-traditional methods of potable water delivery by the greater public.

The main area of any dissimilarity from the research gathered is based around the water conservation techniques of both countries and government incentives that may be on offer to the consumer.

The Australian government offers more incentives to household and industry than that of its UK counterpart. Australia also has stricter laws in place and a national body to deliver these. Whilst the UK also have laws for water use in place, there can often be times where inter regional differences of opinions can be present. Water conservation is very much a part of Australian lifestyle, current climate conditions dictate this, though it would appear that any conservation methods to be adopted by the consumer have not been fully apprehended here in the UK.

It would be recommended that the UK government accept the conclusions reached by the select committee in water conservation in 2010, they concluded that, it has become increasingly clear during our inquiry that, what is normally known as “water efficiency” has an absolutely central role to play, if demand and supply are to be balanced in an environmentally sustainable way in the face of a growing population, a shrinking average household size and the pressures resulting from climate change.

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The use of the water element in the energetics of Micro-urban development in Slovak Republic and Taiwan R.O.C.

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ABSTRACT

The unregulated development of micro-urban areas is underestimated in both cases, so are the energy issues bound with them. The proposed urban idea consists of energy resource decentralisation by means of a detailed focus on micro-urban development through the combination of accurate hydro distribution systems for direct energy production in a place of consumption as a part of the autarchic micro-urban grids arranged in "efficiency electric power grid circles" calculated by loses in wiring. This urban energy model binds micro-urban structures in one solid network and at the same time creates local smart energy communities built up on each individual dwelling unit that can produce energy for itself from renewable resources locally available and support the local micro-urban public grid or even support the nearest city public grid. Proposed new multi-purpose small hydro type is one of the preliminary small scale systems that could be precisely tailored to micro-urban demands and partially support the proposed urban model.

Keywords: energy, micro hydro, water turbine, renewable resources, water management.

INTRODUCTION

There are various scales on how the concept of energy independence should be researched. Most of the recent research proposals that consider energy issues of the human dwellings are mainly dealing with it at a macro-urban scale, which is the centre of many questions from different sectors including the energy one as well. This work represents recent results from a bilateral research project, dealing with investigation and comparison of the hydro-potential within the micro-urban structures in Slovak Republic and Taiwan R.O.C. The effort in this paper is to show the possible use of hydro-potential on a micro-urban scale as one of the major presumptions for creating autonomous micro-urban structures, with their own internal grid. The energy-urban model from the *Fig. 1* shows centralised energy efficiency distribution circles calculated by the losses in wiring, which also shows how the proposed model could create far more symbiotic energy coexistence between the city schemes surrounded by micro-urban regions and ensure coherent sustainable integration of surrounded micro-urban structures, as the city grows instead of an unpleasant urban sprawl. Furthermore, the idea that considers a suitable use of the hydraulic energy, supported by the various applications of a new model of multipurpose micro-urban turbine proposal, as a practical part of this research in possible conglomeration with other renewable energy resources, is presented.

SIMILARITIES IN GEOMORPHOLOGY

Slovakia with its 49 035 km^2 area is 428 km (from East to West) wide and 195 km at max. – 79 km at min. (from North to South), is a landlocked country surrounded by Austria, Hungaria, Ukraine, Poland and Czech Republic. The village Krahule, near by the mining town Kremnica, is one of the several places, which claimed to be the geographical centre of Europe (*48°44′N 18°56′E*). Slovakia's capital Bratislava is located *48°08′38″S 17°06′35″V* near by the western border with Austria. On the contrary the second largest city Košice *48°43′12″S 21°15′29″V* is located on the eastern part of the republic. Eight municipalities accommodate the 5,397,036 inhabitants from which almost 60% are living in the 138 cities and the rest live in 2883 towns and villages. The country's landscape rises from the Southern lowlands: Podunajská nížina (the largest and most fertile agricultural land covers 4,3 km^2 with forests covering 44,3% of the landscape) lowland 10 000 km^2), Záhorská nížina and Vychodoslovenská nížina to the Northern mountain circle (Western Carpathian Mountains). Overall the relief of the Slovak Republic is predominantly mountainous (more than 40% of landscape could be located between the heights of 300 and 700 meters above the sea level and approximately 40% have a 300 meters height), where mountains cover 60% of the landscape. The highest peak is Gerlachovsky štít (2 655m) located in High Tatra Mountains in which also the highest dwelling Štrbské Pleso (1 350m) is located; on the other hand the lowest point in the country is only 94 meters high in Streda nad Bodrogom. Mountains in Slovak Republic are mostly part of Alpine Orogenic phase from the late Mesozoic and Cenozoic eras, although some mountains like Štiavnické vrchy, Vtáčnik, Poľana, Vihorlat or Slanské vrchy are a vestige of volcanic activity. Slovakia has 9 national parks and 35 landscape parks (protected areas). The mountain region is rich with 1,200 cave systems, most of which have unique natural decoration constituted by stalactites. There are also abundant mineral and thermal underground springs with various characteristics in many cases used during rehabilitation or per oral healing processes. The major Slovakian rivers are: Dunaj, 153 km long (mostly creating a natural border with Hungary; the largest middle-European river and the only river with water traffic),Váh, 406 km (the longest river in Slovakia,), Tisa, Hron and Nitra. Water reservoirs consist of many natural, but also artificial lakes, which were built between 16th and 18th centuries (unique system of mining lakes called *tajchy*) and during 20th century for energetic and flood prevention purposes. (Liptovská Mara – 360mil. m^3, Oravská priehrada – 346mil. m^3 and Zemplínska šírava – 334mil. m^3). Many of the natural lakes have a glacial origin and most of them are tarns located in the mountain region of High Tatras. The largest tarn is Veľké Hincovo Pleso with an area of 20,08ha and depth of 53m. Lakes could be found also within the mountains of volcanic origin; the largest is Morské oko, which lies within an area of 13ha and a depth of 26m located on the Vihorlat Mountains. The climate in Slovak Republic is continental (temperature varies from -20 to 37^{o}C) with mild summer and low winter temperatures. Temperature depends on the landscape heights. On the mountains the temperature drops 0,5^{o}C in average per each 100m of height. The western landscape is influenced by the Atlantic Ocean climate, while the eastern side of the country experiences inland conditions. Average low lands' temperatures are 9^o to10^{o}C, while in the mountainous region, temperature oscillates between -3,7 to 0^{o}C only. The south gets the maximum amount of sunlight of approximately 2,000 hours of sunlight annually, while the north-western region gets only 1600 hours. The average annual precipitation rate is 743mm (65% of rainwater evaporates and 35% runs into the rivers), while snow precipitation varies each year and, some winters do not really bring snow in lowlands. Slovakia suffers from various climatic extreme conditions, such as annual floods, droughts, storms with strong wind impact; occasionally blizzards and local minor earthquakes occur too. Taiwan (臺灣), also called Formosa by Portuguese, with its 36,192 km^2 area, is 394 km long from North to South and 195 km max. to 144 km min. from West to East; it is an island country, separated from the coast of China by a 180 kilometres wide Taiwan Strait. Taiwan is surrounded by South China Sea, Philippine Sea and Eastern China Sea; all of them are part of the Pacific Ocean. Its capital is Taipei (台北) at *25°02′N 121°38′E* and is located in the Northern part of the island. Together with New Taipei City and Keelung, it creates one of the largest agglomerations, which accommodates over 6 million people). On the contrary the second largest city Kaohsiung (高雄) at *22°38′N 120°16′E* is located on the Southern part of the country. Five special municipalities, three provincial cities and 12 counties accommodate the 23,239,268 inhabitants with a population density of 641 km^2, which makes Taiwan the 16th most densely populated area in the world. 99.6% of the population live in Taiwan mainland island, the rest 0.4% live on offshore islands (Penghu (Pescadores), Kinmen (Quemoy), Matsu). 70% of the whole population lives in 220 cities and the rest live in towns and villages. The height of the country landscape rises from the East lowlands, Chianan Plains (the home of most of the population of Taiwan) to the Western mountain line (Taitung Coastal Mountain Range (=Hai-an Shan-mo), Central Mountain Range (=Chung-yang Shanmo), Snow Mountain Range (=Hsue-shan Shan-mo), Jade Mountain Range (=Yu-shan Shanmo), and Ali Mountain Range (=Ali-shan Shan-mo). The overall relief of Taiwan R.O.C. is predominantly mountainous (30% of the landscape is created by mountains and 30% hills and plateaus ranging from 100 – 1,000 metres; the rest of landscape (40%) is formed by plains) where mountains cover 70% of the landscape. The highest peak is Jade Mountain (Yu-shan), 3,952m. high (the highest peak of the Tropic of Cancer) located in Jade Mountain Range (Yu-shan Shan-mo) that makes Taiwan the 4th highest island. Mountains in Taiwan are a result of tectonic movements (collisions) of the Eurasian Plate and the Philippine Sea Plate (during late Palaeozoic era) leaving a series of terrains, mostly old island arcs; the suture zones that occur between various terrains result into many earthquakes that happen in Taiwan. Thus, the Eastern Coastal Range of Taiwan is a vestige of volcanic activity of Luzon Volcanic Arch. Taiwan has 8 national parks and 13 national scenic areas. Cave systems are mostly made by sea water; the most famous is Bashian Cave. Taiwan has abundant mineral and thermal underground springs with various characteristics, in many cases used as hot spring resorts. Zhuoshui River, the longest Taiwanese river, is 186 km long. Water reservoirs consist of more than 10 natural lakes, but also artificial ones were built for recreation, energy, irrigation and retention (drinking water and flood control) purposes: Shimen Reservoir – 309 million m3, Sun Moon Lake – the largest body of water in Taiwan – 7.93 km^2 and 27 m deep located 748 m above the sea level). Climate in Taiwan R.O.C. is divided by the Tropic of Cancer (23.5° N) running through the middle section of Taiwan; it divides the island into two climates, the tropical monsoon climate in the south and subtropical monsoon climate in the north.

Geomorphologic similarities	
Slovak Republic	Taiwan R.O.C.
Long high mountains line along the whole country (mountainous character prevailed) Western Carpathian mountains	Long high mountains line along the whole country (mountainous character prevailed) Central Mountains
National Parks, protected reservations, location of forests and water reservoirs	National Parks, protected reservations, location of forests and water reservoirs
Large artificial water reservoirs	Large artificial water reservoirs
Location of the major cities (around railway and highway – main traffic corridor – in the mountain because lowlands path not properly developed for strategic historical reasons)	Location of the major cities (around, HSR, railway and highway - main traffic corridor – located on the coast line and lowlands)
Location of the capital and the second biggest city (opposite side of the country – if turned in 90 degrees clockwise even the same structure as Taiwan)	Location of the capital and the second biggest city (opposite side of the country – if turned in 90 degrees anticlockwise even the same structure as Slovak Republic)
Large hydro-potential in micro-urban scale (small water sources e.g. village rivers as a flood regulation, local drinking water reservoirs for energy purposes)	Large hydro-potential in micro-urban scale (small water sources e.g. village irrigation channels, local rivers and streams as a flood regulation, local drinking water reservoirs and energetic purposes)

Table 1. Basic Geomorphologic Similarities in Taiwan R.O.C. and Slovak Republic.

Average temperature is 22^{o}C, however the temperature varies from -5 to 38^{o} C with hot and humid summers (June to October and heavy rain falls and South – East typhoons) and winter seasons (October to March monsoon season), snow appears only on the top of the high mountains. Whole landscape is influenced by the Pacific Ocean. Average low lands temperature is 12 to 17^{o}C, whilst high mountain region temperature is only -5 to 4,5^{o}C. Taiwan has got approximately 1644 hours of sunlight annually. Average annual precipitation rate is 4,000 mm (usual humidity is 80%); Taiwan suffers from various climatic extremes like regular monsoons and typhoons, floods, droughts, storms with strong wind impact and major and minor earthquakes.

SIMILARITIES IN GEOMORPHOLOGY

The Slovak Republic and Taiwan R.O.C. have both similarities in geomorphologic landscape structures and urban divisions that create notable energy potential premises. Large population difference makes also a good prognosis study potential. Currently Taiwan imports over 99% (large.stanford.edu, 10/12/2010; Chen et al, 2010) and Slovakia almost 90% (www.economy.gov.sk, 01/11/2012) of energy consumables annually. Sustainable development is a priority factor in the European Union as well as in Taiwan R.O.C. So far Taiwan has successfully applied coastal wind turbines and is actively engaged in solar power as an additional energy source.

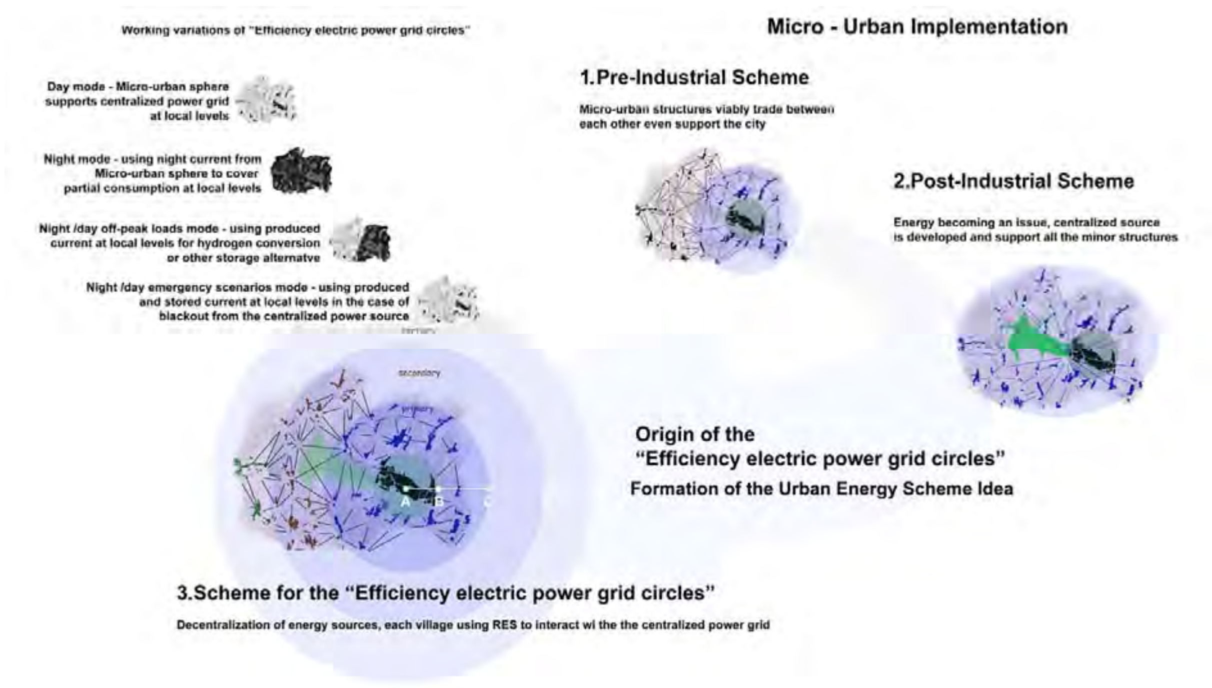

Figure 1. Origin of the "Efficiency electric power grid circles".

Water power plants are used in large scale, facing possible earthquakes and typhoon failures (Charlwood et al, 2000), but this solution covers only 6% (www.nationmaster.com, 15/01/2013) of the energy from renewable resources in contrast to 16% (www.nationmaster.com, 15/01/2013) of the Slovak Republic rate. In Taiwan the development of small scale hydro-power plants for local farmers apply water from irrigation canals or reservoirs, thus becoming more interesting, as for example, the Hsikou hydro power plant project (www.google.sk, 20/02/2013) located in Tainan in South-Western Taiwan, which is owned by Farmland Irrigation Associations. The Slovak Republic lacks wind power, but there is a great potential in geothermal and biomass energy. Solar and hydro energy are both currently donated by government programs for development; hydro-energy in Taiwan is mainly managed by the government TPC (Taiwan Power Company) (info.taipower.com.tw, 20/02/2013). In Slovakia, although the Italian energy giant ENEL group (www.seas.sk, 15/02/2013) covers most of the energy, the market is more open to individuals (37 private companies).

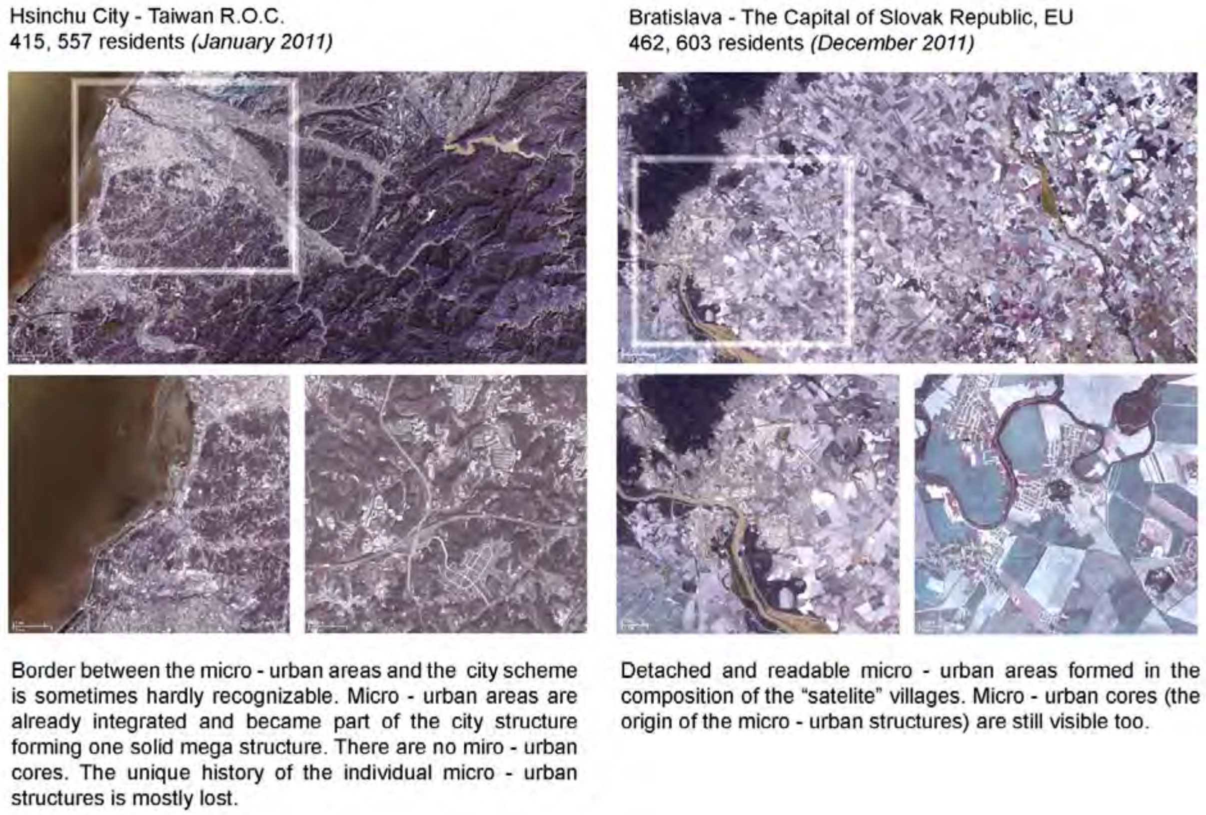

Figure 2. Selected examples for differences in micro-urbanism for both study areas.

Most of Taiwan's hydro-power projects need revitalisation as they were built in the 70s – 80s or even during the Japanese occupation period and, if it comes to small modern hydro-power plants, Taiwan is still in the learning phase (www.youtube.com, 20/11/2012). Small scale hydro-power-plants are seen to be economically viable, easily manageable; they resist natural disasters in a wider scale and can boost local businesses in farmlands across the country. Since the water supplies for irrigation systems are relatively stable, so is the production of energy which is different from the volatile wind or solar energy. Small scale hydro-power-plants also resist natural disasters as well. As a matter of fact, Taiwan's Water Resource Agency in Economic Revitalisation Policy – Project to Expand Investment in Public Works (eng.wra.gov.tw, 25/11/2012) promotes repairs, improvements and research in irrigation systems. Information about the private sector non-impact locations for small scale hydro-power plants are provided, too. On the other hand, Slovak Republic promotes small scale hydro-power plants. In 2011, the Regulatory Office for Network Industries (ÚRSO) issued a final decision for 30 hydro-electric power plants. 200 small hydro-power-plant projects also approved the new concept of using hydro energy potential from Slovakian rivers. From 09/02/2011 and until 2030 (www.minzp.sk, 25/09/2012) a new program will provide for the development of more than 368 new small hydro-power plants with 160 MW and 797 GWh of annual energy production. Private companies and local public initiatives in Slovak Republic are developing projects for the revitalisation of historical small scale hydropower plants like the one in the village Lubochna, for instance. In Slovakia hydro energy has a long tradition; there were more than 1000 small hydro-power plants listed in the inventory of water works from 1930 onwards. Currently the number of small hydro-power plants is around 180 and rising: all plants are in active service, most of them managed by individual owners.

URBAN IDEAS FOR IMPLEMENTATION

Efficiency electric power grid circles - scheme proposal

In this work, the City is introduced as the macro-urban unit that historically evolves, either under some regulations or at irregular intervals. As the city is constantly growing, its general consumption is growing, too. In the urban scheme of Slovak Republic, the city macro-urban structures surrounded by micro-urban structures creating a micro-urban region *(Fig. 2 right)* could be clearly observed. Many citizens are moving in dwellings around the city, as they can reach it at any time they need, while at the same time, they also maintain their private space; life in micro–urban structures starts to expand rapidly. On the other hand, the Taiwanese merged micro-urban and macro-urban schemes *(Fig. 2 left)* do not give the people chances for choices and, thus, many people are moving into already densely populated cities. If it comes to any kind of change in urbanism, it is always easier to implement new ideas in small groups rather than moving huge masses or changing a system that people are used to for many years. The case of Slovak Republic is quite the same as that one in Taiwan before the Japanese occupation era. During and after that era, cities grew unnaturally fast, mostly without clear urban attention. Nowadays, it is hard to track back the micro-urban centres or villages surrounding mega urban structures, which became a major issue in energy distribution. Black outs are common issues in larger cities of some regions. Dealing with micro-urban development in smaller communities usually at town or village levels is not unusual, such as, for example, Feldheim, in Germany, a 100% energy self-efficient village, (www.huffingtonpost.com, 21/02/2013) or GEN – Global eco-village network (www.gen-europe.org, 21/02/2013) are amongst of the most pioneering eco-village projects showing feasibility globally. Each village is a historical settlement and uses some local energy resources.

In the 21st century, research focused on micro-urban energy resources *(Fig. 4)* should be embedded in the strategic plan for each village, as it could support many future developments and mainly their possible autonomous management. Making the community involved and understanding the technology used, it could be the key for success in all sustainable models. The way on how to reach the energy self-efficient community might be feasible by introducing tailor-made multimode technology for basic everyday personal use. The fact is that, almost all the systems for renewable energy conversions are already of general awareness. As a matter of fact, some systems, such as photovoltaics or micro-hydro are already commercially available in quite a large scale. The price of personal scale renewable systems, which will be commercially available, could be another convincing factor. The key might be a distribution system between a centralised source, owned by the city or government and local power plants owned by individuals in micro-urban structures. As the city grows, the centralised energy regulation has become more difficult. But, is the city the only urban unit that it is involved? Pre-industrial revolution models show cities, which are supplied by chains

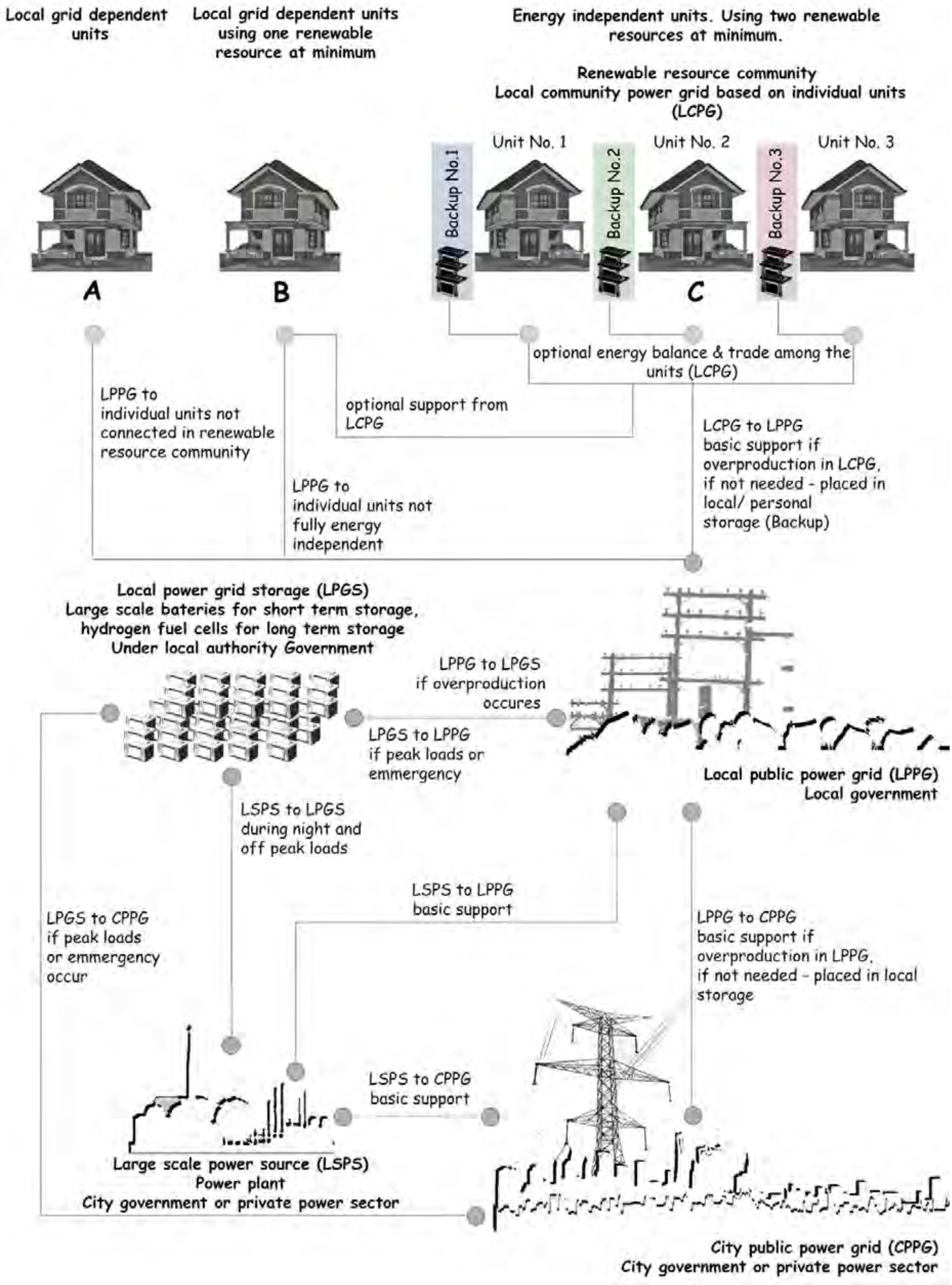

Figure 3. Distribution within the "Efficiency electric power grid circles", between the city and satellite villages.

of villages. Today this model could be feasible as well, but the traded goods will be energy in the terms of energy supplies. According to *Fig.s 1 & 3*, as far as macro-urban scale impact is concerned, these micro-urban structures/villages consist of micro-urban units, mostly individual dwellings, which could create the LCPG - *Local Community Power Grid.* In the case of energy overproduction in the LCPG, direct support of the city supply, energy storage for later use or emergency scenarios, like local black outs, might be covered. According to *Fig. 1,* villages surrounding the city are called satellite villages. These satellite villages form circles with radiuses equal to efficient distribution distances in low voltage wiring, which is calculated by the energy losses in wires and usually represents 10% (Kolcun et all, 2013)

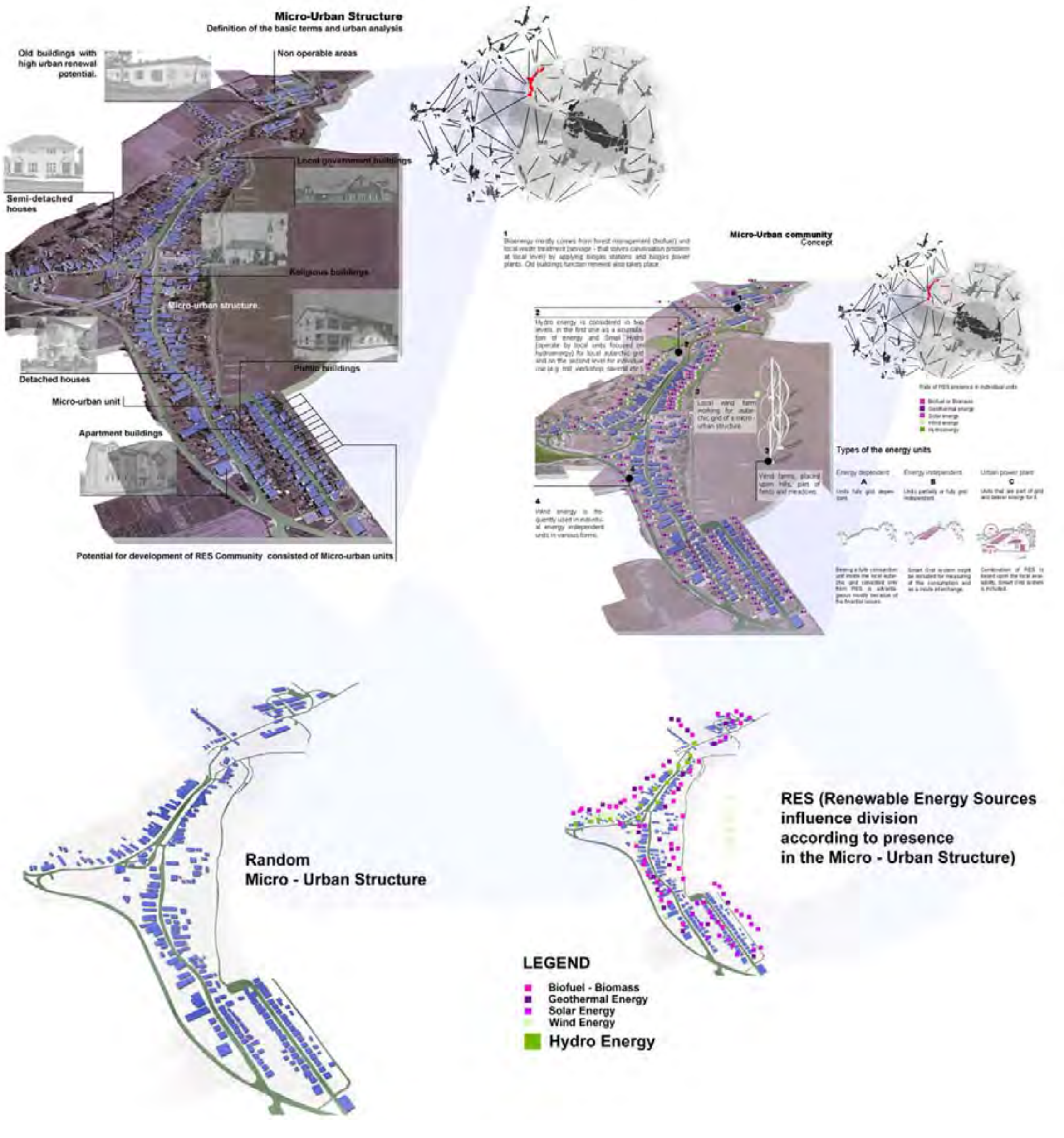

Figure 4. Preliminary study of micro-urban units' division and the concept for RES in the micro-urban structure.

from the overall energy distribution. Each circle produces energy for itself and trade energy among the villages on the same level. Additionally in case of energy overproduction, the primary circle usually includes largest villages and is the closest to the city centre. So, it plays the role of a direct city grid support ("opposite grid flow") with the lowest losses in wiring in emergency scenarios or off-peak, secondary, tertiary, etc. support; these villages play the role of backup and support for themselves and the primary ones as well. All villages play the role of energy storages by short batteries or long term period hydrogen power cells. Assuming that villages promote micro-urban renewable policy, as pictured in *Fig. 3*, individuals will be able to create micro-power stations from their house by producing home energy from available renewable resources and for their personal use or even under regulated development support LCPG from which, energy will be distributed into the next village or directly into the CPPG - *City Public Power Grid*. This community inclusion, due to individuals, may also contribute to boost the micro-urban trade and economy. Even the high voltage wiring could change into low voltage as the distance shortens.

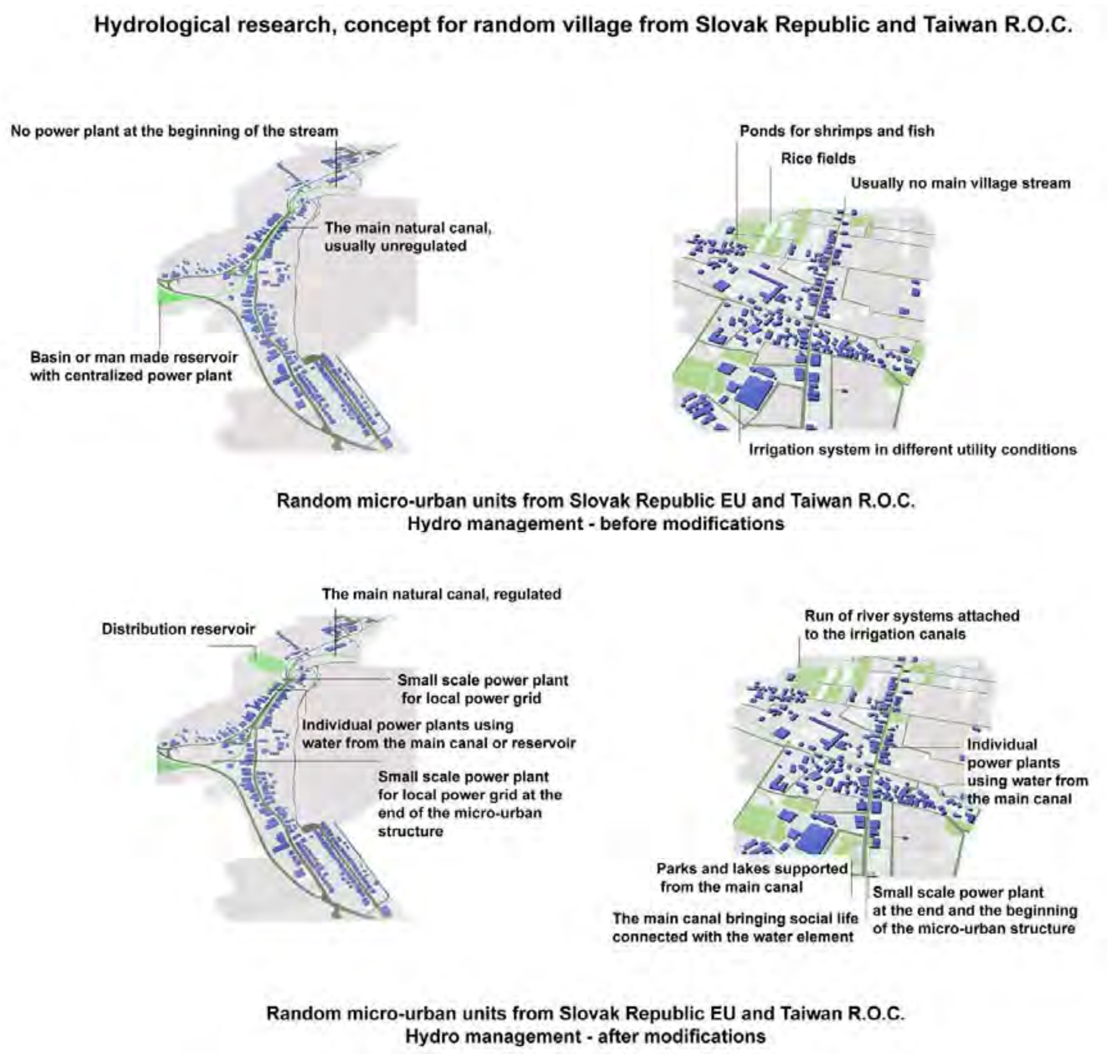

Figure 5. Hydrological research: concept for random village from Slovak Republic and Taiwan R.O.C.

MICRO-URBAN MULTIPURPOSE TURBINE

Current stage of research and development

The experimental micro-urban multipurpose turbine is successor of the 'UFO' micro-urban multipurpose turbine (Tkác et al, 2012) that was originally designed for gas mode. Lately it was adapted to water medium focused on high heads and small flow volumes as well as runoff river systems, due to larger application range in most of the micro-urban structures located on planes.

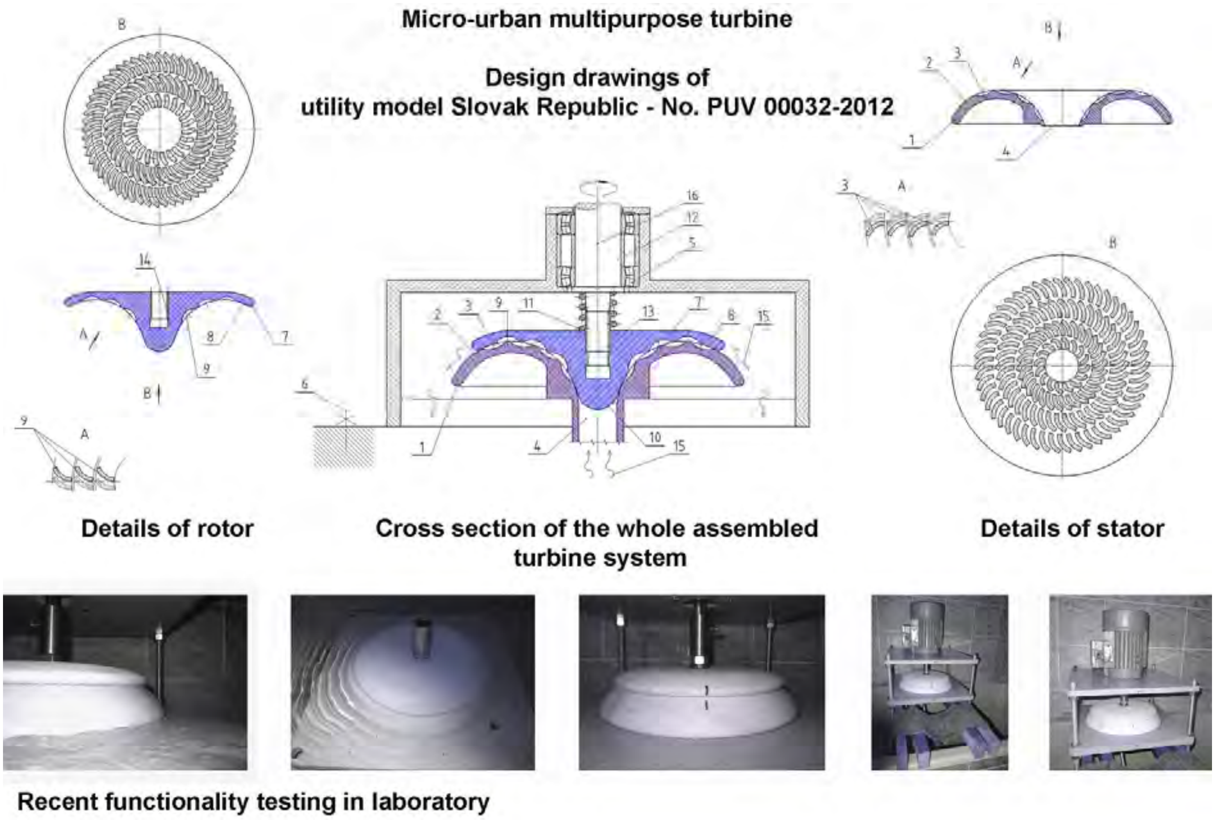

Figure 6. Design drawings of the micro-urban multipurpose turbine and pictures from recent functionality testing. (Legend: 1- Stator, 2 – semi-torus surface, 3 – stator canals in anticlockwise direction, 4 – inflow opening, 5 – bearings, 6 – surface, 7 – rotor, 8 – partial torus curve, 9 – rotor canals in clockwise direction, 10 – self stabilizing cone, 11 – buffer spring, 12 – shaft, 13 – shaft-to-rotor connection, 14 – opening for shaft-to-rotor connection, 15 – inflow and outflow of the working medium, 16 – axis of rotation).

Further ongoing laboratory works on functionality research with improved demonstration model at a scale of 1:2 as shown in *Fig. 6,* are in progress and, results and procedure are shown in *Table 2*. Laboratory research showed that, the turbine could be a possible match for the needs of micro-urban canals, reservoirs or irrigation systems. However, the precise urban and hydrological research on these fields, as in *Fig. 5.*, must be done first. In addition to gas and water mode, hot pressurised steam and saline water mode is thought for future research, too, because the commercial model requires it. It is expected that, within two years, this device could be applied in real micro-urban conditions, mostly as part of urban renewal projects, at least for selected recently and non operable structures, which are located within a large villages and in both study areas.

CONCLUSION

Research involved countries that possess remarkable similarities in hydro-potential connected with geomorphology, still waiting to be used. This potential is hidden also within the chains of small scale hydro-power plants owned by individuals. Application of the urban model presented above would mean decentralisation of small energetic sources that might remarkably influence balanced development in economy, employment. And, last, but not least, it could affect the self-efficiency energy policy of both countries at the same time, as it could increase considerably general awareness of current and future renewable energy significance.

Turbine Functionality Tests				
Type of test	**Applied test medium (value)**	**Equipment**	**Defects**	**Results**
Surface tests of stator and rotor no shaft, only behaviour of the medium in the canals was tested				
Gas mode	Compressed air (0,9 MPa)	Air compressor	Not applicable	Test positive
Water mode	Pressurized water (0,3 MPa)	Water pump	Not applicable	Test positive
Stator to Rotor configuration testing, no shaft applied				
Gas mode	Compressed air (0,9 MPa)	Air compressor	Not applicable	Test positive
Water mode	Pressurized water (0,3 MPa)	Water pump	vibrations detected	Test negative
Whole configuration without dynamo (short shaft (10cm), long shaft(20m))				
Gas mode	Compressed air (0,9 MPa)	Air compressor	Not applicable	Test positive
Water mode	Pressurized water (0,3 MPa)	Water pump	high vibrations detected	Test negative
Water mode	Pressurized water (0,3 MPa)	Water pump	low vibrations detected	Test negative
Whole configuration without dynamo and buffer spring short shaft (10cm) applied				
Gas mode	Compressed air (0,9 MPa)	Air compressor	Not applicable	Test positive
Water mode	Pressurized water (0,3 MPa)	Water pump	vibrations detected	Test negative
Whole configuration with 750 W dynamo included				
Gas mode	Compressed air (0,9 MPa)	Air compressor	Not applicable	Test positive
Water mode	Pressurized water (0,3 MPa)	Water pump	Not applicable	Test positive

Note: produced energy was not measured during the feasibility tests as the applied dynamo only plays the role of shaft fixation that also helped to remove undesirable vibrations in water mode.

Table 2. Stages of procedure and results of the basic turbine experiments

One of the most important objectives in energy planning could be the use of suitable devices in micro-hydro power plants or directly in the micro-urban units in order to obtain the most feasible efficiency. However, basic water turbine principles do not vary; they only improve with time. The proposed different design approach to water turbine development in this paper demonstrates that, there are still undiscovered ways of water energy conversion, which are worth to be researched, especially as part of sustainability in remote areas with unique genius loci environment to be preserved for the future generations.

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BOOK REVIEWS

BIOURBAN ACUPUNCTURE

Marco Casagrande, *Biourban Acupuncture. Treasure Hill of Taipei to Artena*, Rome: International Society of Biourbanism 2013

Review by Angelo Abbate

Science fiction has always confronted artificial and natural reality. Most of it has envisioned a future that is going to corner and minimize nature, echoing social and philosophical treatises, art, and a diffuse anxiety about mature capitalism, with visions of inhuman cities, robots-like men, and life downgraded to slavery by an impersonal power system.

Perhaps that is not just fiction anymore, the leap into a paradoxical parallel-world having happened already, and we unknowingly living in it – living into the "second generation cities", as Marco Casagrande says. These cities are ruled by intangible, unreal, and not-human purposes, and grow by systematically destroying those natural geometric patterns and sub-codes that scholars like Christopher Alexander, Nikos Salingaros, Stephen Kellert, and others working in the fields of Evidence Based Design and Biourbanism, are pointing out.

As human beings seem to be educated to feed destruction, exploitation, pollution, and waste of their own habitat, they are dehumanizing themselves.

The metropolis of Taipei, as many Italian dull suburbs, is no exception to this trend. The ones who live and work in accordance with life, such as urban nomads or indigenous communities, are a threat to the system. It wants to "save them from themselves", checking and adjusting their activities.

Marco Casagrande offers a way out, a therapy for the sickness of our cities, a path to achieve what he calls the Third Generation City.

Cities, to be the fall of the machine, where "the ruin" is the reality produced by nature, that reclaims the artefact. Cities where the nature force takes the initiative, affects the design of industrial society, and becomes co- architect.

The treatment is described by Casagrande as "biourban acupuncture", reviving the traditional Chinese medicine practice on city scale, in order to trigger purifying and healing processes in the urban organism

Marco mentions several "needles" of Biourbanism. All of them aim at establishing a contact between the urban collective consciousness and the vital systems of nature. Illegal community gardens in Taipei, and weed growing from cracks in the concrete, are examples of similar needles. Nature can restore wholeness from a single point or node – even the wholeness of our human condition.

IMPERFECT HEALTH - THE MEDICALIZATION OF ARCHITECTURE

Giovanna Borasi & Mirko Zardini (eds.), *Imperfect Health. The medicalisation of architecture,* Canadian Centre for architecture: Lars Müller Publishers 2013

Review by Eleni Tracada

This is a captivating collection of chapters/papers edited by Giovanna Borasi and Mirko Zardini who offer us a valuable and well-structured overview on a variety of architectural and urban solutions, currently aiming at reassuring human beings that, their well-being in contemporary cities depends mainly on a metaphor becoming reality; that is "the city as a body consisting of variously functional organs" (p. 17). Therefore, the human bodies' physical and biological and even socio-cultural functioning depends on how we can offer today a series of positive solutions to urban problems by avoiding super "sterilisation" processes.

Most metaphors in cities today strive for the "green" regeneration of the urban body, whereas the authors of the critical writings and projects in this book have attempted a comprehensive survey to find and evaluate links between healthy architecture and urban fabric and the natural environment (although the latter has been systematically damaged up to the point to become a heavily poisonous and deteriorating ecosystem. Thus, editors and authors argue that, by immersing ourselves in "green architecture/nature" we can offer a cure to modern cities today. But, this is a paradox, if we consider that, plants and animals can also spread deadly diseases at any time; we are constricted to inhale toxic landscapes in cities, as one of the authors argues in their project.

Today architects and urbanists try to create "therapeutic architecture" by introducing therapeutic functions in both the built environment and surrounding urban landscapes. According to the authors, for example, "placebo architecture" and "trees in the city" do not only contribute to the ecosystem's well-being, but above all to the social ecosystem's stabilisation and "sanitation". Instead of providing inhabitants of cities with drugs, surgery and specialist treatments, the response should be the development of prompt strategies and campaigns in response to environmental and health concerns, such "globesity", swelling of buildings and cities because of rising standards of living and over consumption of goods in need of increasing surface of houses which is merely dedicated to storage and, often waste materials. In response to this problem, we see that, Waste Treatment Plants, such as that of Copenhagen, become clear case studies/examples of the potential innate in architecture and landscape design: an incinerator becoming a public park, where people can exercise on skiing slopes surrounding it. The city's inhabitants can enjoy themselves and "burn calories" through social interaction.

However all authors argue that, we have now surpass the so-called "medicalization of our society"; we do not need any more a medical framework or medical intervention, but, instead, architecture and urbanism should apply a "demedicalization process"; the paradigm shift for architecture and urbanism "will be from the idea of ***cure*** to the idea of ***care*** **–** in the process of taking care of our bodies and our environments" (p. 36). Most of the authors, if not all, strive on ideas and practices relevant to Biourbanism principles; they cover areas, such as urban design, sustainable environments and communities, investigation of old and new theories in architecture and interdisciplinary connections of architecture with arts and design.

The book refers to an exhibition of concepts and projects and it is presented with modern graphics and wonderfully effective illustrations throughout. The editors and authors come from a broad and varied background of disciplines, such as architectural theories and practices, urbanism and even preventive medicine. Giovanna Borasi, Curator of Contemporary Architecture at the Canadian Centre for Architecture since 2005, is an architect and editor. Mirko Zardini, Director and Chief Curator of the Canadian Centre for Architecture since 2005 as well, is an architect and theorist. Both curators are heavily involved with research in urbanism and architecture since several years; they have published very important articles and books.

PARTICIPATION AND ICT – FOR A [VIABLE AND] LIVING CITY

Antonio Caperna, Alessandro Giangrande, Paolo Mirabelli & Elena Mortola (2013) ***Partecipazione e ICT. Per una città vivibile*, Rome: Gangemi editore**

Review by Eleni Tracada

The main purpose to select and connect together these chapters, papers and case studies is to link the concept of participatory urban and architectural designs to human oriented design processes, during which participants and citizens play a main role, no matter which rules and regulations have been followed and/or adopted. The book mainly supports recent developments in theories and practices and with brief and sound support from Prof. Elena Mortola on providing indexes of available materials and secondary sources to help scholars understand especially the importance of co-existence of both natural and built environments in New Urbanism and Urban Renaissance theories and practices, which mainly marked the second half of the 20th century.

In this book, although it is available to Italian speaking and reading scholars at the moment, some chapters are so vital to make us understand how Urbanism developed in Italy and how long it was until urban laws and regulations could start affecting community participatory projects. For instance, in his Integrazione delle pratiche di partecipazione nei processsi di pianificazione sostenibile (=Integration of participatory practices in the processes of sustainable urban planning), Alessandro Giangrande points us correctly to the political trends in Italy, in which precarietà (=precariousness) in employment and posts in institutions and public offices has been always a main issue; citizens have been influenced in such a way that they often reject community coordination in order to act as individual and selfish job hunters. The author of this chapter promotes literature in favour of Town Planning Laws, advocating a new paradigm of Strategic Choices (also explained in detail with very relevant information in Appendix B). To my opinion appendices A, B, and C are very important for this book; it might have been useful to see them following this chapter as one main chapter of case studies. These case studies could have been strong advocates of chapters, such as, for instance, Antonio Caperna's Urbanistica Peer-to-Peer (=p2p Urbanism).

Antonio Caperna in his abovementioned chapter makes a detailed overview on the importance of open sources, such as free software availability in order to guarantee free distribution of materials, integrity of authorship, non-discriminatory applications, open free licencing of software, licencing which is not affecting the integrity of all co-operating IT programmes. The author explains with clarity the models of peer-to-peer design processes and makes reference to pioneer professionals and authors involved, like Michel Bauwens. In his discussion on topology, Caperna explains how effectively distribution networks function to help communities to be self-organised through collective intelligence efforts. The author explains that, current economic crisis could only suggest that, teaching in the schools of architecture should be re-designed in order to favour professional changes, which may help swiftly global communities to exchange useful data on either new urban developments or regeneration projects. The author especially affirms that, human beings should have the right to choose in which environment they want to live (p. 69) and peer-to-peer practices can only guarantee such a selection. It is also good to see some thoughts and recommendations for the future at the end of this chapter.

And I wish to conclude with some comments on the final article of this book, written by Antonio Caperna and Stefano Serafini on Biourbanistica come nuovo modello epistemologico (=Biourbanism as epistemological model). This is a well-structured chapter which includes all the information in brief that you need to understand Biourbanism's aim and objectives. According to the authors epistemological reform in Urbanism was indispensable, as we can see in its developments, good or bad, especially in the second half of the 20th century and in the first decade of the 21st century. The authors explain with clarity why professionals and societies should adopt Biophilic architecture and design, which are the main benefits which are historically passed from antiquity to modernity; they also discuss about various scales of Biophilia and justly conclude that, today many authors and professionals could promote different shapes and forms for cities, far away from some disturbing current tumour sprawl models.

Antonio Caperna is an architect and PhD in Urban Sustainable design; he is President of the International Society of Biourbanism. Stefano Serafini is a philosopher and Director of Studies in Biourbanism. Alessandro Giangrande has a long career as a University teacher and also directed TIPUS laboratory in the Department of Urban Studies in University Tre Rome. Paolo Mirabelli, another author in this book, works for the Institute of Construction Technology, in Milan. And last, but, not least, Prof. Elena Mortola has a very long career in CAAD between the two Universities of Rome, La Sapienza and Tre.

GREEN DESIGN, FOR A GOOD LIVING

Alison G. Kwok, Walter T. Grondzik, *The Green Studio Handbook. Environmental Strategies for Schematic Design*, 2nd edition, New York: Architectural Press, 2011.

Review by Angelica Fortuzzi

Alison G. Kwok, AIA, architect and professor of architecture at the University of Oregon, she taught in architecture programs in California, Hawaii, Hong Kong, Japan, and New York. Walter T. Grondzik, PE, is an architectural engineer and a professor of architecture at Ball

State University. He has taught in architecture and architectural engineering programs in Florida, Oklahoma, Oregon, and Saudi Arabia.

The Biourbanism approach emphasises the need of harmonic solutions in the design of spaces, to make our environments and buildings sensibly better, since, according to what Stephen Kellert writes about biophilic principles “human brain responds functionally to sensory patterns and cues emanating from natural environment”. A good architecture really makes the difference for the total well-being of our body and mind. Spaces with natural light and ventilation and other environmental features result in improved mental and physical performance, lowering the stress. Therefore, a good and responsible use and implementation of natural resources, knowing of the natural resource savings strategies, regarding energy, water and material resources, are fundamental elements to design and an effective high-performing architecture, which is friendly for the environment and human life.

Kwok and Grondzik stress the role of the book, thought as a reference guide to green design, not as a checklist. A source of inspiration for architects and students in university design studio or seminar courses.

The authors provide tools for the preliminary sizing of green strategies, to choose the most appropriate. An introduction focuses on the issues of the design process and integrated design. Then, a relevant part of the book describes the forty-two selected green design strategies, identifying the following main topics: Envelope, Lighting, Heating, Cooling, Energy Production, Water and Waste.

Each strategy is analysed with brief descriptions of principles and concepts, approaches, with key architectural issues, implementation considerations, design procedure, examples and drawings. A reference is provided for further information to the international standards, rating systems, guidelines, and Internet sources.

Furthermore, the Case Studies chapters provide a diversity of geographic locations, climates, building types and green strategies with a roadmap to quickly understand the main differences. A glossary of terms and buildings gives a useful aid at the end of the book.

websites: www.greenstudiohandbook.org/
www.routledge.com/books/details/9780080890524/

BEYOND THE WHITE PAPER BORDERS

Vibhavari Jani, *Diversity in Design: Perspectives from the Non-Western World*, New York: Farichild, 2010

Review by Stefano Serafini

In his wonderful masterpiece *The Nature of Order*, Christopher Alexander refers often to Eastern architecture traditions and schools, both ancient and contemporary, e.g. indicating in Geoffrey Bawa one of the leading masters of a life-enhancing architecture (“the soul of our future architecture”, vol. 2nd, p. 141). Nevertheless, Alexander is long far from any form of "orientalism", as defined by Edward Said in his classic work dated back to 1978. Alexander's research is, on the contrary, devoted to grasping the blossom of human creativity, regardless of its external cultural forms, and the gorgeous iconographic display of his volumes shows it abundantly. He calls "life" the quality of design that is keen to every people as human being. This shouldn't be confused with the search for a "global" or "universal" design, or, differently said, with a neo-colonialist view over the world through design. "Life" will always have a particular cultural feature. Particularity is the very fabric of alive things, and trying to reduce it to a common formula would mean destroying it – that is in fact what Enlightenment did, according to the analysis of Horkheimer and Adorno (*Dialectic of Enlightenment*, 1944). Not by chance, Alexander stresses that any good design process should unfold step by step, from the real, particular, and individual situation the designer has to deal with.

In her beautifully illustrated work, Vibhavari Jani, a scholar researching on special-purposed interior design for wounded people, an artist, and professor of architecture at Kansas State University, exhibits a similar attitude. Despite of the impression one may receive from the title of the book, her work is about all but romantic aesthetics and orientalism.

First, the book addresses a serious cultural lag in Western architecture academia, that lacks expertise in Asian, African, and Middle-eastern design trends, perspectives, and traditions. Jani refers especially to the civilizations that don't belong to the Greco-Judaic-Christian horizon. Asian issue is probably the most relevant, due to the role that countries like China and India, with their 2.5 billion people, are playing already on the world stage, both in economics and culture. Of course, not all the "non-Western" world has been studied throughout the book. Research has been limited to India, China, Turkey, Egypt, UAE, Algeria and Nigeria, as these Countries are representative of outstanding and influencing architectural traditions.

Second, Author shows the need for being able to epistemologically shifting from a cultural system of values to another, in order to understand how different civilizations are actually shaping the present and the future, and how differently they shed light on architecture and its problems. Design should be learned and taught from different perspectives, and this means one should take care of the context, understanding the geography, the anthropology, and the history of a place before working on it – thus getting rid of otherwise unavoidable bias.

Third, Jani advocates the possibility of picking up different worldviews operatively in modern design (it's relevant her attention to Vaastu Shastra), in order to learn solutions for future from the past, and find inspirations for new paths.

The book has won the 2012 Interior Design Educators Council Best Book/Media Award, because of the challenge it posed to most architectural and interior design university programs, that are still Eurocentric. This is a book for making Western education younger, able to go beyond its old borders, and ready to understand a wider 21st century world.

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