

TOWARDS A MORE RESILIENT BUILT ENVIRONMENT

Sietze A. Meijer, MSc.¹, dr. Marcel R.M. Crul¹
dr. ir Arjan van Timmeren²

¹Delft University of Technology, Faculty of Industrial Design
Delft, The Netherlands
Landbergstraat 15, 2628 CE Delft, The Netherlands,
s.a.meijer@tudelft.nl, +31 152783795

²Delft University of Technology, Faculty of Architecture and Building Sciences
Delft, The Netherlands

Abstract

Over time, humankind's lifestyle became increasingly dependent on finite resources. It follows that such a system is unable to sustain itself indefinitely. Several studies show that in the near future the climate may radically change and oil production will peak. Changes in the natural environment will possibly be so overwhelming that man has to radically change its response to environmental changes and thus its lifestyle.

To cope with consequences of climate change the current efforts toward sustainability are likely not to suffice. An approach towards resilience is another way to deal with risks associated with climate change. Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change, so as to retain essentially the same function, structure, identity and feedbacks.

A resilience approach offers a strategy to reduce dependence on finite sources. Thus, basing society on the resilience principle, by result society adheres to commonly accepted definitions of a sustainable society.

The built environment can be regarded as the physical representation of society. Likewise the built environment influences society. Since society is not resilient enough, neither can be the built environment. It follows that when society becomes more resilient, this will affect the built environment in a positive way and vice versa.

This paper outlines the theoretical framework for a resilience approach to the built environment, resulting in a more sustainable built environment than at present. This is done by discussing relevant literature and synthesizing concepts from the fields of ecology, sociology, sustainability and urban design.

Keywords

resilience, built environment, climate change consequences, adaptive capacity

1. Introduction

Depending on the scenario, oil production has either already peaked or will do so soon (de Almeida and Silva 2009). Were it not for the Western society's addiction to energy and product consumption, this would in itself not be problematic. However, humankind faces the challenge to find alternative ways of providing for its energy and consumption needs (de Almeida and Silva 2009). Currently a widely perceived trend is to 'become sustainable' or develop sustainably (Parris and Kates 2003). However, this proves to be difficult however, since both the definition of 'sustainability' and 'sustainable development' and the road to transition are far from agreed upon (Brown, Hanson et al. 1987; Johnston, Everard et al. 2007). Moreover, being sustainable does not necessarily prove to alleviate consequences of previous unsustainable behavior and practices. Sustainability in its many elaborations deals primarily with the prevention of future impact on the environment and less so, if at all, with adapting to the consequences of changes in the environment. This paper argues that the current trend of addressing to environmental impacts and reducing its effects does not suffice in preparing the built environment in dealing with the known and unknown climate changes and their effects. Therefore a different approach is suggested. Originating from ecology, resilience has been used to describe the state of ecological systems. It is defined by Holling (Holling 1973) as:

'...a measure of the persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables.'

When adhering to this principle, it follows that one will deal with the situation as it is and may become. While the situation as it is can be assessed and analyzed, future prospects become more uncertain with increasing time spans. A 'resilience approach' offers a way to deal with this uncertainty. Therefore it can be an effective tool. Although resilience can be regarded as an attribute from a system, resilience itself has attributes that determine the level of resilience a system has. It includes adaptive capacity, self-organization, constructive

feedback loops and nurturing diversity. These attributes, when present in sufficient quality and quantity, can guarantee the ability to deal with uncertainty up to a certain level. In this paper it is argued that adaptive capacity is the basis for resilience. Furthermore it argues that the adaptive capacity is mainly determined by social structures. When increasing the ability of the social structure vis-à-vis dealing with uncertainty, the overall resilience is believed to increase. When talking about resilience it is imperative that it is made clear what is resilient to what. When talking about the built environment it is necessary to define what the built environment is and moreover, what aspect of the built environment is being dealt with. This will be the focus of the following sections.

2 Built environment

The threat of global consumer behavior has its dire effect on the built environment. Menoni says that 'It would [...] appear that with socio-economic progress, the built environment becomes increasingly vulnerable as settlements become more reliant on their increasingly extended supply lines, [...] and vital distribution networks of water, power, gas and telecommunication systems.' (Menoni 2001). Here Menoni does not only refer to the addiction of human society to energy and consumption, but also to the dangers this encompasses. From Alberti and Marzluff (Alberti and Marzluff 2004) we gather that "The environmental changes associated with urbanization have been significant during the last century and are expected to continue through the next several decades. Urban development fragments, isolates, and degrades natural habitats (Marzluff, 2001), simplifies and homogenizes species composition (Blair, 2001), disrupts hydrological systems (Arnold and Gibbons, 1996; Booth and Jackson, 1997), and modifies energy flow and nutrient cycling (McDonnell and Pickett, 1990; Medley et al., 1995). Urbanized area accounts for only for \pm 1-6 percent of the total earth surface (Meyer and Turner, 1992), but cities appropriate a large share of earth's carrying capacity in terms of resource input and waste sinks (Rees, 1996).' (Alberti and Marzluff 2004). Many other studies say that increasing the compactness of cities improves the sustainability of the built environment (Jabareen 2006) and that the form of urbanization has a great impact on sustainability (McDonald 2008). This shows that it is important to deal with the environmental impact of the built environment, specifically urban areas. Dealing with the environmental impact of the built environment involves several levels. Firstly, material, energy and water use can be limited by careful design. This however does only lead to less consumption but does not lead to increased ability of the built environment being able to cope with consequences of climate change. Examples are difficulties with handling of excess water, the urban heat island effect, more extreme summer and winter temperatures etcetera. What do we mean by the built environment? We derive our definition

of the built environment from Rapoport, who constructs the built environment based on four levels ranging from abstract to concrete; 1) the organization of space, time, meaning and communication, 2) the system of setting, 3) the cultural landscape, and 4) the fixed, semi-fixed and non-fixed element (Rapoport 2005). Following is a description of what these four levels mean.

1) The organization of space, time, meaning, and communication

When talking about the built environment, one tends to focus on 'space', excluding other aspects. Time concerns an aspect in which human activities are organized in such way, that it plays as important a role as space does. Meaning is attributed to activities and 'function'. It is equally important, since it is a critical element in desires, evaluation and preferences of environments, and many of its characteristics.

2) System of setting

A setting comprises a milieu, which defines a situation within which ongoing and predictable behavior occurs. Boundaries of settings vary with culture. Rules apply in a setting and are specific for this setting and situation. Settings are not spaces. One space may contain several settings simultaneously or consecutively through time.

3) The cultural landscape

The concept of cultural landscape comes from cultural geography. It refers to the results of interaction between human behavior and the 'primeval' landscape over time. When primeval landscape becomes cultural is a matter of debate. Strictly speaking the hunter/gatherers in the jungle of the Amazon changed the landscape considerably through their activities. Cultural landscapes all have a certain degree of modification in common. An important aspect of this modification is that the cultural landscape is not designed as a whole. It has evolved through millions of independent decisions made by individuals. Small parts of course can be designed in the traditional sense. Yet cultural landscapes have distinct characters. This is a result of the fact that these aforementioned decisions are made based on cultural schemata.

4) Fixed, semi-fixed, and non-fixed elements

The most concrete conceptualization of the environment is it as a composition of fixed, semi-fixed, and non-fixed elements. Fixed elements are infrastructure, buildings, etc. They change slowly over time and infrequently. Semi-fixed elements are the 'furnishings' of the

environment, both interior and exterior. Examples are streetlights, benches, trees, etc. Indoors it means chairs, tables, ornaments, decoration etc. Non-fixed elements are animals and humans, their behavior and attributes like vehicles, hairstyle, clothing, etcetera. It includes social interaction, communication, systems of rules. In settings cues are given through all elements present, most importantly through the semi- and non-fixed elements. The latter becomes important when one or more of the other elements do not provide adequate cues.

With these four levels, Rapoport explains the role of social structures in the built environment and their interaction. In addition to this, Mumford tells us how this interaction is formed. During the 'hunter-gatherer'-era, in pre-historic times, humankind was only capable of adapting its surroundings in an indirect way (Mumford 1961). Humankind had not yet invented tools or mastered crafts that allowed them to actively intervene in their surroundings. However after the transition to the 'agricultural'-society, humankind developed the means to actively adapt its surroundings (Mumford 1961; Diamond 2005) and these means continue to develop up to the present day. Consecutively, this transition accelerated the evolution of the social system in which humans live. Mumford argues that it is here where the human built environment finds its roots (Mumford 1961). Following Mumford the human built environment only came to be after the forming of social structures. We define a social structure as a group of individuals agreed on norms, standards, rules and expectations, sharing ideals, images, schemata and meanings. The built environment can be regarded as the physical expression of social structures. Change within the built environment then can only be achieved when changes in social structures happen as well. Rapoport's definition of the built environment deals mostly with those elements that make up the social structure, applied to the built environment.

In our research we focus specifically on cities. We chose this particular field of the built environment based upon the trend of urbanizing societies. According to the UN the urban population will rise to 60% in the year 2030. (Anon. 2006).

'Urban can be described as a geographical term characterizing the land use of an area. [...] Its broad definition, as used mainly by ecologists, states that an urban area or a city is a fairly large, densely populated area characterized by industrial, business, and residential districts.' (Yli-Pelkonen and Niemelä 2005)

The focus within the former stated lies in its social structures. According to Godschalk 'Communities are the social and institutional components of the city. [...] In sum, the communities act as the brain of the city, directing its activities, responding to its needs, and learning from its experience.' (Godschalk 2002). This leads us to believe that communities are the key to the level of resilience of the city, or the urban environment.

3 Resilience

The seminal work on resilience has been done by C.S. Holling. His paper *Resilience and stability of ecological systems* (Holling 1973) still is one of the most influential works in the field. Holling's definition of resilience is the most referenced one, although in literature many adaptations to this definition have been made. Holling himself has given different definitions in his works as well. It goes too far to cite all different interpretations. However, all relate to the ability of a system to deal with external changes and the ability to exploit and incorporate these changes while maintaining its identity. As opposed to robustness, resilience does not repel change but embraces it.

3.1 Resilience in systems

Walker et al. (2004) show with their theory on stability landscapes that a system will resist change up to a certain point (resistance). This can be regarded as the robustness of the system. Subsequently the system can change again, up to a certain point (latitude). It adjusts to the change and incorporates it (fig. 1). Once the system has no more leeway to change, it will radically change and become a different system. A stability landscape is a metaphor describing the possible systems, so-called 'basins of attraction' adjacent to each other, between which a system's state can pass (fig 1).

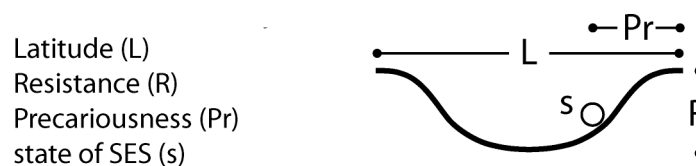


Fig 1. Basin of attraction

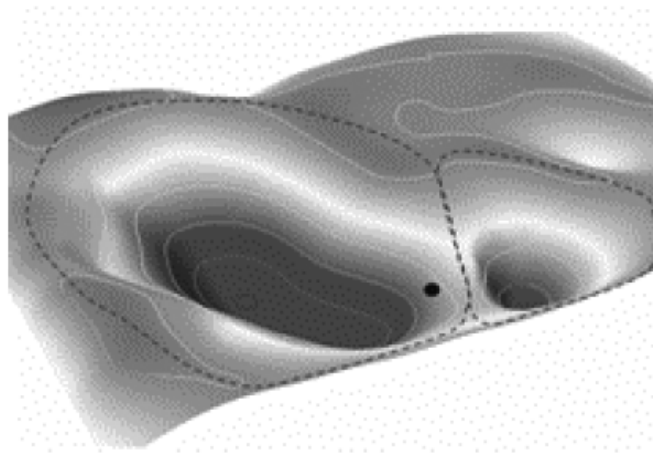


Fig 2. Stability landscape showing two basins of attraction.
 The dot represents the current state of this particular given system.
 Image taken from Walker et al. 2004

Resilience has been used to describe ecological systems, social, social-ecological systems (SES). To describe ecological systems Holling puts resilience next to adaptability and transformability. Adaptability, according to Holling, is characterized by the ability of a system to move thresholds, change the resistance to external inputs, move the current state of the system and to manage the cross-scale interaction. Transformability is defined as “The capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable. Transformability means defining and creating new stability landscapes by introducing new components and ways of making a living, thereby changing the state variables, and often the scale, that define the system.” (Walker, Holling et al. 2004).

3.2 Resilience and vulnerability

Strongly related to resilience is the concept of vulnerability. There are three positions of the concept of vulnerability with respect to resilience to be found in the literature: as opposed to resilience, as an attribute of a system next to resilience, and as an attribute of resilience. Berkes states that “Resilience [...] is important for the discussion of vulnerability for three reasons: (1) it helps evaluate hazards holistically in coupled human-environment systems, (2) it puts the emphasis on the ability of a system to deal with a hazard, absorbing the disturbance or adapting to it, and (3) it is forward-looking and helps explore policy options for dealing with uncertainty and future change.” (Berkes 2007).

With regard to climate change the IPCC states that “vulnerability to climate change is a function both of the sensitivity of a system to changes in climate, and the ability to adapt the system to such changes” (after IPCC reports, Schoon 2005). As Schoon continues, there is no one definition of vulnerability: “To date, there is no consensus definition of vulnerability as it relates to the human dimensions of global environmental change. Common to all of these sources is that vulnerability generally has a human or society-centered perspective.” (Schoon 2005). However, it seems a matter of choice what term is used. The multitude of definitions place the concept as tantamount to resilience, or being the opposite on the same scale. In our study we disregard vulnerability as a separate object of study.

3.3 Attributes of resilience

As mentioned before the attributes of resilience are adaptive capacity, nurturing diversity, constructive feedback loops and self-organization.

1) Adaptive capacity

In order to improve this, we need to build a body of knowledge the lifespan of which surpasses the maximum time lapse between hazards. In doing so, we retain the knowledge needed to cope with the change. At the same time this body of knowledge needs to adapt itself to new situations as a consequence of a hazard and become part of a system renewal. Regarding the hazard, and coping with it as a recurrent event, a renewal cycle can be identified, which opens windows of opportunities for change. Adaptive capacity is seen both as an attribute of resilience itself and as an attribute of a system as a whole. This relates very much to what Walker calls transformability.

2) Nurture diversity

Diversity provides material for renewal and change in each renewal cycle. Diversity in social, ecological and political entities is a universal strategy aimed at reducing risks. Increasing the diversity in constituencies in the policy arena has the potential of bringing new thinking, and expanding the role of information, education and dialogue (Mitchell 2004 from Berkes 2007).

3) Constructive feedback loops

Different types of knowledge for learning need to be combined. Local observations should be combined with global science. According to Folke et al. (Folke, Carpenter et al. 2004) complex adaptive system thinking says that complex system phenomena, such as climate change, occur at multiple scales with feedbacks across.

4) Self-organization: creating opportunities for self-organization and cross-scale linkages. There are four aspects concerned:

1. Strengthening community-based management
2. Building cross-scale management capabilities
3. Strengthening institutional memory
4. Nurturing learning organizations and adaptive co-management

3.4 Adaptive capacity

In the research presented here the focus concerns adaptive capacity. We choose this focus on the basis that the adaptive capacity of a social-ecological system is controlled, or limited, by its actors. As we have seen before the actors are organized in the social structures. Yli-Pelkonen and Niemelä (2005) say about social structures, or as they call them, social system, that “[they] can include urban societal patterns and processes such as economic, cultural, ethical and aesthetic value systems, but also decision-making systems, institutions, and urban systems of knowledge, communication and participation in land use planning” (Yli-Pelkonen and Niemelä 2005). The adaptive capacity of the urban built environment lies in the ‘patterns and processes such as economic, cultural, ethical and aesthetic value systems, but also decision-making systems, institutions, and urban systems of knowledge, communication and participation’; institutes in which individuals are organized.

Nelson et al (Nelson, Adger et al. 2007) view resilience as context for adaptive capacity. According to the authors the resilience framework has developed to incorporate ideas of complex systems and in so doing emphasizes the functioning of the social-ecological system as a whole. The focus is on the relationships between the system components not in the functioning of the individual components in isolation. It rather focuses on context, feedbacks and connectedness of the components. The resilience framework then considers adaptation not in light of specific activities but rather in how activities feed back, either positively or negatively, to the system as a whole through time. It is important to take a closer look to adaptive capacity, or adaptability as it is also known in literature.

Adaptability is predicated on three fundamental characteristics:

- the degree to which the system is susceptible to change while still retaining structure and function, much like the definition of resilience as stated before by Holling and Berkes.
- the degree to which it is capable of self-organization, as Berkes states as fundamental to resilience building.

- the capacity for learning

Adaptability is influenced by a number of factors:

- economic development
- technology
- human capital
- governance structures

The ability to adapt is not only a mechanism for coping with hazards and the consequently change in social-ecological environment, but also offers new frames or opportunities for innovation and development.

Adaptation can be analyzed on three key aspects:

- Relationships between system characteristics;
- Processes of adaptation;
- Outcomes;

Putting adaptation in the context of resilience, using adaptation as a way of dealing with hazards, we speak of adaptive capacity. Adaptive capacity then is a way to describe the preconditions necessary for system to be able to adapt to disturbances.

The adaptive capacity is determined by three components:

- the set of available resources (economic capital, technology and infrastructure, information, knowledge, institutions, the capacity to learn and social capital)
- the ability of a system to respond to perturbations
- the capacity to design and implement adaptation strategies

4. Resilience in the urban built environment

4.1 Urban resilience

What does resilience mean in the context of the urban built environment? In general it is the capacity of a city to cope with unexpected events. As stated, that which is the adaptive capacity of the urban built environment manifests it self in the social structure. The social structure in itself can be resilient up to a certain level, creating a recursive effect. Walker et al. (2004) introduced the notion of Panarchy (fig. 3) in the debate on resilience, stating that the level of resilience of a system in turn is partly determined by the level of resilience of its

subsystems. In other words, the resilience of the social structure determines for a part the resilience of the built environment.

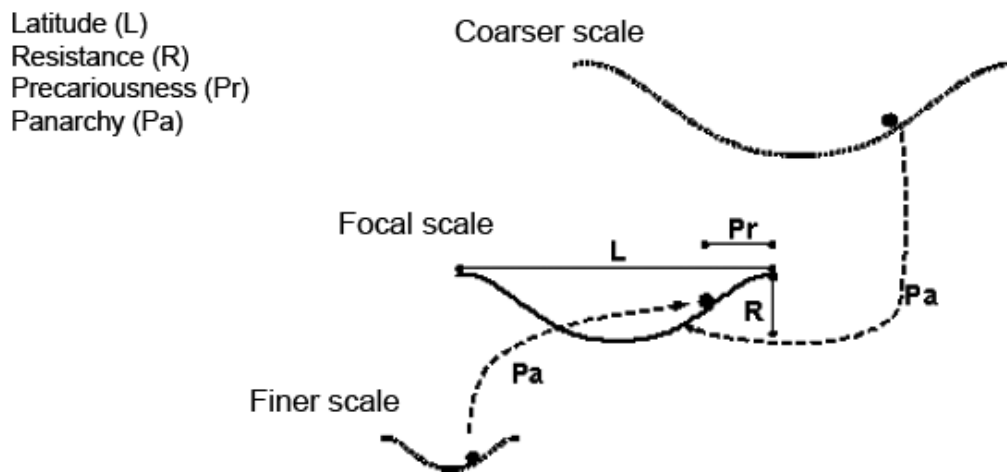


Fig. 3 Representation of panarchy:
the interaction between several layers of resilience from Walker (2004)

In literature several interpretations of a resilient built environment can be found. One of the most concrete interpretations is done by Boshier, who states that “A resilient built environment” should be designed, located, built, operated and maintained in a way that maximizes the ability of built assets, associated support systems (physical and institutional) and the people that reside or work with in the built assets, to withstand, recover from, and mitigate for the impacts of extreme natural and human-induced hazards” (Boshier, Dainty et al. 2008). He refers mostly to what Rapoport calls the fixed elements in the built environment, as does Godschalk (2002). “A resilient city is a sustainable network of physical systems and communities. Physical systems are the constructed and natural environmental components of the city. They include its roads, buildings, infrastructure, communications facilities, soils, topography, geology, water ways, and the like. In sum, the physical systems act as the body of the city, its bones, arteries, and muscles.” (Godschalk 2002)

Another interpretation of resilience of the built environment is by Newman (2009), who states that resilient cities are “those that can substantially reduce their dependency on petroleum fuels in ways that are socially and economically acceptable and feasible”. Newman’s uptake of resilience is very closely related to a sustainable city, heavily drawing from the

consequences of the dependency of oil for the urban environment. His approach and the proposed solutions based on it, can be considered technological solutions.

Furthermore, a part of the literature defines a resilient built environment to be able to withstand and recuperate from terrorist attack. In the light of our point of view, this definition will be not be used.

Finally, as stated before, the built environment can be regarded as the physical representation of social structures and therefore the resilience of the built environment is for a part determined by the resilience of its social structures. Here we need to take a closer look to the panarchy of the system. On a system level, the adaptive capacity of the urban built environment is manifested in social structures. The functioning of the social structure is the determinant in this process. On the next level, the attributes of resilience apply to the social structures themselves. In short adaptive capacity of the urban built environment is believed to be strongly influenced by the adaptive capacity displayed by inhabitants of that urban built environment. However, this can all be incorporated in describing social resilience, specifically where it concerns the adaptive capacity of social structures.

4.2 Social resilience

Social resilience has been defined in the resilience literature. Adger describes it as follows: “Social resilience is the ability of groups or communities to cope with external stresses and disturbances as a result of social, political, and environmental change’ and the ‘ability of communities to withstand external shocks to their social infrastructure” (Adger 2000). Like in urban resilience, the adaptive capacity of a community determines the resilience of the system in which it nests. To describe the resilience of the social structure we apply theories from the social sciences. Of interest is institutional theory, describing self-organization of groups and individuals. It also offers models of decision-making in groups. Secondly learning and probing theory are used, describing the processes of adaptive learning and constructive feedback loops. However, the focus lies on the role of adaptive capacity of communities within the resilience of the urban environment and therefore this paper will not go deeply into the theories.

As the notion of social structures is rather vague and does not allow for specifying groups or individuals, the term ‘communities’ is used. This term is widely used in the resilience literature. Although it yet has to acquire a singular definition within the literature, we define it as ‘the conglomerate of groups of individuals in government, citizenry and professional

bodies within the bounds of the urban built environment'. It is a simplification of Godschalk's description: "Communities are the social and institutional components of the city. They include the formal and informal, stable and ad hoc human associations that operate in an urban area: neighborhoods, agencies, organizations, enterprises, task forces, and the like. In sum, the communities act as the brain of the city, directing its activities, responding to its needs, and learning from its experience." (Godschalk 2002).

The next level in the panarchy of resilience would concern the level of the individual. However, the resilience of the individual within the perspective of the presented research is not relevant to the discussion of urban resilience. The resilience of the individual relates more to the bodily survival of the individual, rather than as a subset of any community's resilience. Or, as Adger states: "...because of its institutional context, social resilience is defined at the community level, rather than being a phenomenon pertaining to individuals" (Adger 2000). Another reason to look at the community level is given by Kelman: "The level of urban resilience developed proactively through community-based processes can therefore hinge on the meaning of 'community' and 'community involvement' -- and on how that 'community' is led." (Kelman 2008). His statement is based on research conducted in Boulder, Colorado, where he studied the results of the relocalization initiative there. Godschalk and Newman both feel that fundamental change is greatly supported by change in the governance and professional body of the urban built environment. According to Godschalk, if we seriously would like to achieve urban resilience "we need to build the goal of the resilient city into the everyday practice of city planners, engineers, architects, emergency managers, developers and other urban professionals" (Godschalk 2003).

4.3 Urban resilience in practice

The Transition Town Movement (TTM) is a good example of resilience based strategies in the urban built environment. The TTM is based upon the assumption that peak oil has occurred or will do so in the near future. Today's modern society is highly dependent on oil and thus will experience serious issues when oil supplies will falter. "Given the likely disruptions ahead resulting from Peak Oil and Climate Change, a resilient community - a community that is self-reliant for the greatest possible number of its needs - will be infinitely better prepared than existing communities with their total dependence on heavily globalised systems for food, energy, transportation, health and housing." (Brangwyn and Hopkins 2008). The TTM searches for ways to become as independent of oil as possible and developed the Transition Model. The model describes a number of steps to facilitate the initiation of a TTM. Underlying the model is a set of principles of which several are very interesting to us, for

they follow the attributes of resilience quite accurately. Hopkins, founder of the first TTM in Totnes, Great Britain, and author of the Kinsale Energy Descent Action Plan (Hopkins 2005), explicitly makes use of the resilience principles and places it over sustainability as for coping with environmental and energy problems (Hopkins 2009). These are the principles of interest:

- Help People Access Good Information and Trust Them to Make Good Decisions;
- Inclusion and Openness;
- Enable Sharing and Networking;
- Build Resilience;
- Subsidiarity: self-organization and decision making at the appropriate level.

Every Transition Town initiative is completely run by a self-organized community, originating from local and individual initiatives. Throughout the documentation of the Transition Town Movement emphasis is being put on the fact that the driver of any change, activity, project or organization should come from the people who take part in it and drive it.

Furthermore, one of the key objectives of the TTM is to create local adaptive capacity to cope with climate change effects and less energy consuming society.

5. Conclusion

Resilience offers an approach capable of both ensuring a durable supply of energy for humankind's needs and adapting to current and future consequences of climate change. It does so by offering a way to deal with uncertainty. Resilience is based on a number of attributes, of which adaptive capacity is a decisive one. Adaptive capacity deals with the ability to adapt in the face of external pressure. The urban built environment is as resilient as its sub-systems allow it to be. This follows the notion of panarchy in resilience theory: the existence and inter-related dependence of multiple levels of resilience, each determined by the level of resilience of a system's sub-systems. Social structures are one of the sub-systems of the urban built environment, potentially containing the largest adaptive capacity within the built environment. Social structures in the context of the built environment are the communities within the urban built environment. The adaptive capacity of an urban built environment is therefore dependent on the resilience of the community. This is what is called social resilience. The resilience of the community is not based on individual acting, but on cooperation. Coming round to creating the basis of resilience at the community level, to ensure a firm grounding of change in society we solve the oldest problem of sustainability: the change of mindset of people which leads them to behave sustainably. When following a resilience approach in dealing with and adapting to climate change effects, sustainable behavior will be the result.

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