Wanglin Yan · Will Galloway *Editors*

Rethinking Resilience, Adaptation and Transformation in a Time of Change

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Foreword

With change become a fact of our modern life the timing of this collection could not be any better. How the world deals with large and serious problems is almost certainly going to shape our collective future. The problems are very challenging indeed, including such things as global emigration that result from a host of causes, from climate change, to war, or economics. As populations increase and urbanize the world over the chance that disaster will impact on our lives grows ever more likely.

In this context, responding to disaster is difficult. Preparing for disaster is even harder. This book offers the lessons of practitioners who are trying to do both, and as such the breadth of topics and expertise is substantial.

The editors, both based in Japan, began their work on the subject of resilience in the context of global climate change, but were forced to rethink their direction when the country was struck by an enormous earthquake and tsunami in March of 2011. By chance they had just begun to develop the Environmental Innovators Program at Keio University and had the chance to shape the content of the program so the problems of managing large scale disaster could be placed at the centre. Building on that decision they invited practitioners from around the world, although mostly from Asia, to discuss both successes and failures with building resilience before and after disaster.

The book provides a number of ideas that can be generalized towards understanding the topic of resilience and how it relates to adaptation and change. Because the articles are written by practitioners there is a strong bias towards the minutiae of quite specific topics. However, the collection as a whole works to bridge theory and practice. Taken together they aim for a holistic understanding of resilience, and search for guidance on how to plan for the long term, and how to become meaningfully proactive without losing flexibility. As such the book is a useful introduction to the meaning of resilience in the age of climate change; where the effects of disaster, whether natural or man-made, are regional if not global, and complicated by local issues that need to be solved at the same time to be truly effective.

Collections such as these will be ever more important as we strive to develop better policies and take better precautions to become more resilient both for today and into the future. I hope this is only the first of a series of books that will allow our leaders and practitioners to make strong evidence based decisions going forward.

Yoshitsugu Hayashi
Professor Emeritus of Nagoya University,
Full member of the Club of Rome

Acknowledgements

The authors of this book all share the experience of speaking at a series of workshops and symposiums held at Keio University in Tokyo, Japan, from 2011 to 2014. The timing of these gatherings is significant because the editors, and many of the contributors, were in Japan during the massive disaster that struck the northern coast of the country in March 2011. The disaster was remarkable not only for its size, but also because it starkly exposed the contradictory fragility and strength of the country and its communities. At the time we had already planned and started a series of events that would focus on climate change adaptation. We would invite leaders who were active in the field, including architects, scientists, and governmental agents and try to build a consensus on how to work across disciplines in the real world. Faced with the raw brutality of the disaster and its long-term consequences, we immediately modified our plans. Keeping the basic structure our focus moved towards understanding resiliency and more specifically we asked contributors to talk about the actions that might be taken to build resiliency both before and after a disaster takes place. In hindsight this shift was not so large, because the real topic is change, and how to deal with it in a positive way.

The goal of this book then is to share the lessons gathered over 4 years and to shed some light on some of the tools and the recent understanding of adaptation and resiliency in a global context. It is also intended to underline the developing meaning of resilience and its use as a tool for advancing positive change.

We would like to thank William Siembieda, Sander Ernst Van der Leeuw, and Krishne Gowda for their efforts to make the book as clear as possible. Also we are indebted to The Environmental Leaders Program and the financial support from MEXT (The Japanese Ministry of Education, Culture, Sports, Science and Technology) that supported it. The Research Center of Keio University at Shonan Fujisawa Campus offered additional support through the project. Finally, we owe a great deal of thanks to the students and staff in the Environmental Leaders Program, including Ryo Uemtasu, Takafumi Miyasaka, Mayumi Aida, and Mie Iijima.

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Part I
Introduction

Chapter 1
Understanding Change Through the Lens of Resilience

Wanglin Yan and Will Galloway

Abstract Though change is often problematic and complicated by circumstance, and in the case of disaster profoundly damaging, it can also be an opportunity to improve otherwise intractable systemic problems. With that in mind, this chapter defines the nature of change as viewed through the lens of resilience and further outlines the relationship between resilience, adaptation, and transformation. Because change is often negative, strategies to build resilience are rationally directed towards coping with its consequences or resisting it outright. Similarly, because change is complicated, with many inter-connected parts, it is difficult to prepare for even when its causes are well understood. Most contemporary theories of resilience recognize the role of complexity, risk and vulnerability, but there is not yet a strong understanding of how to manage change as it impacts groups differently across scales, from local communities to regions, or even nations. The authors propose that resilience planning and theory can be improved by acknowledging the complexities of the adaptive cycle and panarchy in particular. The chapters of the book are offered as case studies and amplification of this idea, either in practice or in theory, from the perspective of multiple fields. The point of view is global, but includes informative chapters written by Japanese contributors who focus on the unprecedented change brought about by the 2011 Tohoku disaster in northern Japan. This perspective is often missing in such collections primarily because of the language barrier.

A Time of Change

Change never takes us where we expect.

This book nonetheless looks at how change, planned or otherwise, can be used in a positive way. One of the more important lessons of our time may be the simple

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recognition that change is not a process that can be easily quantified or managed. Ironically it is more likely that coming to terms with our inability to predict the future is a key step in learning to adapt to uncertainty. It is not clear that we have taken that step in enough places yet, but there are positive signs in that direction, some of which are presented here.

Why is this topic important? Once it may not have mattered so much how people managed change, because it was mostly a local issue, with local impacts. Today, change is global and inescapable. Economics, energy production and trade are interconnected across the globe, as are climate change, pollution and, sadly, war. As a result, isolating problems to a single source is difficult, making them hard to resolve, or even to understand. On the other hand, that same interconnectivity can be helpful. It means for instance that recent efforts to manage climate change adaptation on the plains of Mongolia can be productively grouped with a discussion on the role of community in rebuilding after disaster in the United States. The group of articles collected here is built on that insight. While there is a diversity of themes they are held together by a shared experience with adapting to change and the problem of how to build resiliency in the real world.

Resilience and Change

Responses to change depend on the attitude of the stakeholders. When the scale of the event is large, as in a natural disaster or social crisis, the tendency is to work reactively, taking action only after there is visible damage and an urgent need. This kind of activity can be seen as a form of coping and includes policies and systems that deal with natural hazards, disasters and social crises after the fact. Alternatively, it is possible to take action pro-actively. Proactive responses include behaviours that optimize future choices by keeping options open and by aiming to create opportunity in advance of actual need (Newman and Dale 2005). Currently most change is dealt with after the fact, and is reactive, as we might see in the efforts to rebuild a city after a natural disaster. Given the nagging fears of creeping climate change and the increased frequency of intense and sudden disastrous events around the world, the importance of shifting to a proactive stance, in the form of prevention and mitigation strategies for instance, is widely recognized.

By now resilience has become a word that is losing meaning through overuse, but there is still enough to discuss. Is resilience merely reactive? Can it be used in advance of disaster or massive change? Alternatively, can resilience become a tool for transformation, so the negative impacts of events are reduced even as they unfold? More interestingly, can a more mature view of resilience be used to respond simultaneously to inter-connected problems? Such an ideal would require a virtuosity that is rare, not to mention a perfect awareness of the complexities that might be impossible. It is too early to judge, but the authors collected in this book hint at the possibility of a change in that direction as we take advantage of new opportunities; including an increase in computational power, a willingness to make connections across fields of knowledge, and a slight shift in politics towards adaptation-based solutions to the problems arising from massive change.

Looking in hindsight at the chapters of this book we would like to suggest that it is in fact time to re-imagine the meaning of resilience, and to consider the term as a single point in a constellation. The authors collected here often mention or allude to adaptation and transformation as much as to building resilience in their texts. These terms seem to be similar, but there is a distinction that we think is important to underline as it hints at possible future directions that research and practice might be taken in the face of disaster or other forms of change.

Defining Resilience

Resilience is the capacity of a system to absorb disturbances and reorganize while undergoing change. At the end of an event the system should more or less retain its original structure and function, and therefore its identity (Folke et al. 2010).

The term resilience has a relatively long history, and its meaning has changed substantially since its first use. As an idea it was originally studied in the context of engineering, and was a term commonly reserved for discussions on the strength of materials. Adopted by ecologists in the 1970s the term began to be used to describe the amount of disturbance an ecosystem could withstand without losing its self-organized processes and structures (Holling 1973). More recently the meaning has expanded to fit the need to manage more pointed, even political, types of change. In the context of climate change for instance, resilience is defined as "*the ability of a system and its component parts to anticipate, accommodate, or recover from the effects of an event. It can do so through preservation, restoration, or improvement of its basic structures and functions*" (IPCC 2012). Others give the term an even broader meaning: "*Building resilience into human–environment systems is considered an effective way to cope with change characterized by surprises and unknowable risks*" (Tompkins and Adger 2004).

As the word resilience has grown in breadth it has simultaneously deepened. Significantly, in most current usage the ability to bounce back from a shock does not imply a simple restoration to some previous marker from the past. Instead, resilience assumes that lessons learned from a crisis are embedded in the recovery, so a community or system will be stronger than before. Lessons are not always equally applied, especially in resource-poor communities, however as a general statement we can say that a purely reactive form of resilience is rare. Pro-active elements naturally become part of almost all resilience activities. Which is to say resilience is not a pure concept. For much the same reason, as a tool for planning we should be careful to avoid using it normatively to characterise objectives, because we cannot always determine whether a particular characteristic of resilience is good or bad (Béné et al. 2012). This conception requires that any proactive activity is viewed as tentative and temporary, open to change as new information and experience is gathered. This is a supremely objective view of the term, and as such difficult to carry out.

The notion of resilience has been used in academic literature and political policies, sometimes as a buzzword (Davoudi et al. 2012), or as a utopian ideal (Sudmeier-Rieux 2014). At the risk of muddying the waters further it is worth noting that increasing the resilience of a group is not generally speaking a neutral activity, and could easily become exploitative of the vulnerable. To avoid confusion and negative interpretations of the term, the authors offer that resilience is inseparable from the concepts of adaption and transformation.

Defining Adaptation

While resilience has its origins in engineering, the term adaptation comes from evolutionary biology. In its broadest definition, adaptation refers to an action that allows a form or a structure (i.e., a household, community, group, region, or even a country) to better cope with a stressful condition. For a more nuanced understanding, consider its origin in biology, which stresses the process of modification to better fit into a changed or changing environment (Smit and Wandel 2006). In this field of study, a structure with higher adaptive capacity is thought to be more resilient, and vice versa. In the context of climate change, adaptation has a more precise meaning, and refers directly to the process of adjustment to an actual (or expected) shift in the climate in order to mitigate harm or to exploit an opportunity (IPCC 2012).

In hindsight it is surprising that the IPCC consciously focused for so many decades on mitigation to climate change while downplaying adaption. The IPCC was concerned primarily with introducing regulations or new technology in order to reduce exposure to harmful change (Nelson et al. 2007) and to reduce greenhouse gas emissions. With that goal in mind, adaptation was seen by some as a distraction. However, with major storms and other natural disasters causing ever more damage around the world, awareness of the need for adaptation (if not to climate change then at the very least to risk in general) has increased significantly. Among those who study climate change the topic has found renewed interest, and many scientists and economists now consider adaptation as a complimentary strategy to mitigation and even argue that both strategies must be pursued simultaneously (Biesbroek et al. 2009; Swart and Raes 2007; Klein et al. 2005; Martens et al. 2009). As an example of the broad effect of this change of heart, the recent IPCC report (AR5) presents climate change as one inter-connected problem among many, its characteristics determined by interaction with a mixed set of complicated and often changing problems.

Recognition of complexity in this way is a positive step, but underlines the reason adaptation was kept from the centre of climate change debate for so long. Discussing mitigation is easier because the goal is clear and the methods are relatively transparent, if difficult to achieve. Adaptation on the other hand requires complicated solutions, where several problems are tackled at once, and the objectives and methods can be very hard to use as examples for others—because of the complexity involved they are innately difficult to copy. When seen from this point of view solving climate change becomes less about mitigation and more about managing social challenges. These can include specific issues like the rapid de-population of rural Japan, or massive migration in south-east Asia. Or they can be very broad and might include the need to develop economic equality, women's rights, or the development of a skilled global workforce. As Rob Roggema points out in Chap. 16, these are wicked problems, difficult to solve.

With such large issues on the table it is natural to imagine that adaptation must lead to fundamental change. However, that is not always the case. As an activity, adaptation has no inherent value, and depending on the context it can be either positive, negative, or even neutral in its effect (Smit et al. 2000). With that in mind, instead of being defined by change, adaptation might better be understood in terms of its relationship to time. That is, whether it is undertaken in advance of an event, or after. Hearkening back to the discussion above on the definition of resilience, adaptation activities that are taken before a risk turns into a hazard is called proactive, often taking the form of disaster risk reduction. The other end of the scale is occupied by reactive adaptation, which takes place during or after an event or a disaster. This kind of adaptation often takes the form of reconstruction.

Planning for adaptation is not something that happens in the natural world. Unless humans are involved, adaptation in unmanaged natural systems is invariably reactive. Being self-aware and able to imagine different scenarios for the future does not mean that adaptation is often pro-active. To the contrary, in socio-economic systems adaptation is usually reactive or concurrent, which means they take place as events unfold (Smit et al. 2000). When adaptation is planned there are, as one might expect, more options available, which is on the face of it an important advantage. The distinction between pro-active and reactive adaptation is not always clear however. For example, evacuating people from a flood-hit area is reactive adaptation, even if it is planned for in advance. Modifying coastal zoning laws in anticipation of stronger sea surges however is proactive adaptation (Shalizi and Lecocq 2009). There is much to be said for proactive efforts because it can save both lives and property. However, to be fair it is difficult to convince people to take significant steps in advance of a disaster that has not yet taken place. The gap between a theoretical future and the reality before us is often difficult to bridge.

Reality places constraints in other ways as well. For instance, there is a danger that adaptation policy will be used only to preserve the prevailing economic system, even when that is a less effective choice. Theoretically, adaptation can just as easily be used to foster new kinds of development or to increase access to opportunity, but that kind of change might challenge those who benefit from an existing system, and so it becomes difficult to shift. Pelling argues that when it comes to adaptation governing bodies are seldom allowed to incorporate the interests of future generations, of non-human entities, and especially their own marginalized communities (Pelling 2011). This is perhaps an old trope, but in the face of climate change the issues are more pressing than ever, and the impact will be felt as much by the privileged as by marginalized populations. The problem is, as always, that inertia is difficult to overcome and the future is not perfectly clear, and planning in some way dependent on conjecture. Yet in a complex system, which is what most of us live in today, transformative actions are increasingly needed. Overcoming the inertia of the status quo is one of the largest hurdles that needs to be overcome in order to meaningfully adapt to change.

Transformation

According to Park and his colleagues, Transformational adaptation is "*...a discrete process that fundamentally (but not necessarily irreversibly) results in change in the biophysical, social, or economic components of a system from one form, function or location (state) to another, thereby enhancing the capacity for desired values to be achieved given perceived or real changes in the present or future environment"* (IPCC 2012; Park et al. 2012). The capacity to change a part of a system is called transformability. In other words, it is "*…the capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable*" (Walker et al. 2004). In comparison with adaptation, the term "transformation" is presumed to be proactive and progressive. It also presumes some degree of feedback, as complex patterns of change take place at the personal, cultural and institutional level.

The critical issue in transformation is the so-called tipping point, or threshold. When transformability is high the range of options in the face of change is broadened. To give an example, instead of weathering a crisis, a system can sometimes reach a tipping point where its internal structure lies on the brink of collapse without actually failing (Manson 2001). In just that instance a crisis can become "*a moment of transformation—a moment in which it is recognized that a decisive intervention can, and indeed must, be made*" (Hay 1999).

If there is capacity for change then transformation becomes possible. In that case disaster can be viewed as an event where the system has passed its tipping point. Without losing sight of the pain and personal costs that disaster entails, it can also be a window of opportunity for positive transformation as recovery and reconstruction takes place. To take advantage of that moment is, again, a matter of overcoming inertia. As Christopher Field and his colleagues point out, "*transformational responses are not only possible, but they can be facilitated through learning processes, especially reflexive learning that explores blind spots in current thinking and approaches to disaster risk management and climate change adaptation*" (IPCC 2012). They elaborate on this idea by pointing out that "*because there are risks and barriers, transformation also calls for leadership—not only from authority figures who hold positions and power but also from individuals and groups who are able to connect present-day actions with their values, and with a collective vision for a sustainable and resilient future*" (IPCC 2012). The kind of leadership they imagine is defined by a willingness to accept risks and to take on burdens in order to achieve worthwhile goals. Finding those leaders in the absence of a crisis is the challenge, and the heart of the matter. How do we encourage transformational leadership without the incentive of danger or a powerful crisis? Is there a tipping point that we might search out, or perhaps an approach that is persuasive in other ways, be it economic or cultural, which can set things in motion?

Going Beyond Resilience—The Transition from Resilience to Transformation

The meaning of resilience with regards to change can be difficult to pin down. It is not always clear if the term is intended to mean resistance, adaptation or transformation. In response to this issue, Folke et al. (2010) developed a theoretical framework that they labelled Resilience Thinking, which aims at understanding the drivers of social-ecological systems (Walker and Salt 2006; Folke et al. 2010). In their conception, resilience is best described as the "*dynamics between periods of abrupt and gradual change and the capacity to adapt and transform for persistence*" (Folke et al. 2010).

By contrast, Mark Pelling offers a more critical approach. He says that resilience is a subset of adaptation. In his framework, adaptation takes three forms, namely resilience (maintaining the status quo), transition (incremental change) and transformation (radical change). When adaptation is undertaken through resilience it is working at its "*most contained level*". Interestingly, for Pelling resilience is a negative term, designed only to preserve existing power structures and social systems (the implication is that such preservation is at the cost of others not in power). Adaptation through transition offers a better way forward but is still imperfect. He suggests that when adaptation assumes that form then critical engagement with governance plays a larger role, but is limited to the simple assertion of "*rights and responsibilities*" without changing the actual power regime. His final category, of transformation, is clearly preferred in his view, and is accordingly defined as "*reform in over-arching political-economy regimes and associated cultural discourses on development, security and risk*" (Pelling 2011). This three-part framework is conceptually clear and useful, but in practical terms it is also simplistic because it does not recognize the complexity of issues at different scales. It also fails to acknowledge that each scale might require "*separate or integrated levels of resilience*" (Béné et al. 2012). In this light the term resilience should perhaps not be applied so liberally to discussions of adaptation in the face of disaster or other kinds of massive change.

Christophe Béné et al. (2012) offer a more flexible vision of resilience. Responding to previous work by Guhan (1994), Béné and his colleagues propose that resilience has different characteristics depending on the impact of the disturbance. In other words, the meaning of the word is itself not fixed. To the contrary they suggest that "*managing…resilience requires directing a system in a way that promotes* ***resistance*** *in a period of small disturbance,* ***adaptation*** *in a time of*

Table 1.1 Conceptual framework of resilience, adaptation, and transformation

Articles	Coping	Adjusting	Transforming
Climate Adaptation (Pelling 2011)	Resilience	Transition	Transformation
Adaptedness (Nelson et al. 2007)	Resilience	Incremental	Transformative
Resilience Thinking (Folke et al. 2010; Walker and Salt 2006)	Resilience	Adaptivity	Transformability
Resilience (Martin-breen and Anderies 2011)	Engineering resilience	Systems Engineering	Complex systems
Morphogenetic Cycle through lens of reflexivity (Davidson 2012)	Structural conditioning	Social-cultural interaction	Structural elaboration (Morphogenesis)
3P&T-3D Analytic Framework (Béné et al. 2012) (Objective/outcome)	Absorptive capacity (Persistence)	Adaptive capacity (Incremental adjustment)	Transformative capacity (Transformational response)

greater disturbance, and ***transformability*** *when conditions are becoming unviable or unsustainable*" (Emphasis added, Béné et al. 2012). The salient point is that resilience emerges from each kind of activity, and each leads to different outcomes. Béné also raises the important question of cost. Although he is unable to claim any certainty, his assumption is that transformation has a higher cost and a higher risk than simple resilience. In his words, *"[It] costs more to transform a system than to maintain it as it is or to rebuild it as it was*" (Béné et al. 2012). This is a very important point that underlines the difficulty of overcoming inertia when faced with change, even if there is a crisis forcing action.

Table 1.1 gathers a selection of theoretical frameworks created to understand resilience, adaptation, and transformation, and describes the attributes of each author's conception of these terms when applied to the real world. They all share a theoretical basis in complex systems to some degree, and are all useful in that they offer a point of view that easily accommodates both slow and rapid instances of change. On the other hand, all of the frameworks share the same weakness, namely that the boundaries and factors of a system are not so easily defined in a period of genuine uncertainty and emergent complexity. Overcoming that limitation requires a new approach.

Rethinking Resilience

Awareness of Vulnerability

Resilience reduces the vulnerability of a system, and increases the capacity to absorb and adapt to surprises. But what is vulnerability? According to Miller "...

resilience and vulnerability are potentially complementary, in the sense that actor-based vulnerability analyses look at the processes of negotiation, decision-making, and action, whereas systems-based resilience analyses complement this approach by examining the interaction of social and ecological processes" (Miller et al. 2010). It is important to recognize that resilience and vulnerability are not opposite terms. As ideas they represent two ways to understand the response of systems and/or actors to shocks and surprises.

The term vulnerability is open to sub-division. For example, exposure to hazards can be thought of as a kind of "physical vulnerability", defined by the potential damage to a system that could come from a disaster (Brooks 2003). Vulnerability that is embedded in a system because of its internal characteristics is called "Inherent Vulnerability"; it is sensitive to geographical, geological, and ecological conditions. Finally, according to Adger, "Social Vulnerability" is defined as the potential exposure of groups or individuals to stress as a result of disaster (Adger 1999).

It is useful to look deeper into these terms. For instance, physical vulnerability can be understood as a function of the frequency and severity of a hazard; that is, a hazard causes no damage if it occurs in an unpopulated area or in a region where human systems are adapted to cope with it. Social vulnerability on the other hand is more complex. As an example, the quality of housing is an important determinant of a community's social vulnerability to a flood or a windstorm, but has less impact on vulnerability in the case of a 20-year drought (see for instance Amir in Chap. 9). In the same way, poverty, inequality, health, access to resources and social status can determine the vulnerability of communities and individuals with relation to a very broad range of hazards (Brooks 2003). In most cases, vulnerability combines both physical and social aspects. Separating them can be a challenge.

Although resilience differs from vulnerability in its framing and its scale, the starting point is similar. Both look at how social groups or communities are exposed to shocks and stressors and how they differ in terms of their sensitivity and coping capacity. Both also emphasize the influence of spatial, physical, and social characteristics. What is often neglected in vulnerability research is the interaction between long term and short term ecological and biophysical changes. That is, researchers predominantly focus on the response to hazards or shocks, rather than on longer-term adjustments and changes. Adaptation measures, for instance, often fail to address persistent and intractable vulnerabilities, thus undermining their success and their sustainability (Nelson et al. 2007). The study of resilience on the other hand offers a framework for dealing with the long term, and as such is an essential starting point for the examination of vulnerability as well.

As a theory the issue may seem academic. However, there are real consequences that lend weight to this point. After the tsunami disaster struck Aceh in 2004, the government, along with academia, and social agencies began developing concepts and approaches to improve the resilience of communities facing environmental risk in coastal zones. However, an over-emphasis on tsunamis as the single most important source of disaster on the coast led, in some cases, to a failure to anticipate other risks and disasters from natural change. After some time, it became clear that other kinds of environmental change, even anthropogenic behaviour or man-made hazards should be prepared for as well (see Alamsayah's discussion on this point in Chap. 8).

Increased awareness of vulnerability often is followed by improved attention to climate change, especially as policies and practices are followed through in both developed and developing countries (see Chap. 11, and the role of business development in response to vulnerability, according to Hiramoto). That said, it is significant that, while adaptation activities were once dealt with as single incidents, it is now more common to see each activity in the context of a larger holistic plan. The creation of National Adaptation Plans (NAPs) around the world are a key outcome of that trend in terms of policy, although it is too soon yet to know how much impact they will have.

Embracing Change, or Resilience Thinking

Change in modern society can be described diagrammatically as the result of feedback between stressors. The difficulty is that while such a simplistic observation can be easily made, it is hard to recognize and identify either the feedback, or the stressors. Complicating the issue further, recognition does not translate into understanding, especially when the issues at hand are complex or political. The very complexity of climate change presents a particular example for policy makers and resource managers because the available science is often uncertain (Scarlett 2010; Berkes et al. 2003). We are familiar with rapid onset events such as earthquakes, droughts, floods, and even an economic crisis. Those events are the final eruption after the accumulation of slowly building stress and only become apparent when the gradual change passes a certain threshold. As mentioned previously, a threshold is a tipping point when a system flips from one state to another. However, neither nature nor humanity are linear and predictable. We seldom know when and where the thresholds are to be found or even what they look like. A threshold can be physical, or it could be formed by a group or a particular sector within society (Ionescu et al. 2009). Theoretically if we are aware of the existence of an important threshold we will be able to act (reactively or pro-actively) and postpone or prevent a collapse. The problem is that the time scale of both natural and political processes are difficult to perceive (Streets and Glantz 2000). Coping with the slow pace of this kind of change necessitates that we learn to understand both slow and rapid onset events synthetically so we can not only adapt to change, but also take advantage of change as it happens. Unfortunately, the long-term view of large areas is not easy to maintain when local short-term problems are so immediate and apparently powerful. With this in mind, Resilience Thinking provides a framework for embracing change and disturbance rather than denying or constraining it (Walker and Salt 2006). It is built on the theory of complex systems, where self-organization is described as part of an adaptive cycle.

The adaptive cycle describes the way a social and ecological system behaves over time as it moves through cyclic patterns of growth and conservation (called the fore loop) followed by release and renewal (called the back loop). The so-called fore loop is characterized by the rapid accumulation of capital and potential in a stable and conservative context. In contrast the back loop is characterized by slow change combined with uncertainty. These cycles are in motion at the same time, a perfect representation of the dichotomy of complex systems. What this means is that a complex system may be growing and appear robust however there is at the same time some amount of slow and accumulating change that could suddenly and drastically transform the system, like a continuous conveyer belt that moves at different speeds within its length. A catalysing event can shift a system rapidly from the fore loop to the back loop, which can be destructive. Ironically it is just at this time that creative (or destructive) transformational actions can be most easily introduced.

Collectively speaking, most of our research and nearly all of our management and policy development is focused on fore loop behaviour. We know little about complex systems in their brief and chaotic, but very critical back loop periods (Walker and Salt 2006). It is important that we learn more. When a feedback loop begins breaking rigid connections and behaviours, new opportunities open up and new resources are made available for growth.

Taking advantage of that point in time is not easy. It was once thought that reconstruction after the Tohoku disaster in Japan in March 2011 would induce change in the fundamental social and economic systems of Japan, but it is hard to conclude yet whether transformational change has begun or if it is even possible. Still it is interesting that for many people the final evaluation of the crisis will not be made with regards to how well Japan restored its coastline communities. Instead the focus is on how well Japan managed to develop systems and institutions that will allow the nation to revitalize the country on a continuous basis (see Dimmer's discussion in this point in Chap. 2). Delving deeper into the problem, in the case of Japan the Tohoku disaster was massive, and undeniably destructive. However, there was already another massive but slow process of change underway that could just as easily be as damaging, and which will almost certainly bring about unexpected kinds of change across the country. Specifically, Japan has crossed the tipping point into a period of rapid population decline that is as yet only tentatively being addressed. Curiously the Japanese government and academics have known for years that there was a crisis coming, but did not act to slow it down (to be fair, it is possible that no action could have made a difference). This is perhaps a perfect example of how hard it can be to manage slow change, even when it is well understood. Ideally, Japan would take advantage of the crisis caused by the Tohoku disaster to also respond to their population crisis. Similarly, it is possible still that Japan will reduce its reliance on fossil fuels in the long term as it finds way to manage the loss of energy production from nuclear power. Without the nuclear disaster at Fukushima, described with some detail by Uehara in Chap. 18, it is unlikely that such a change would have become a possibility in Japan. Time will tell which direction the country will eventually take on these essential issues for its future.

Sustainability

Since the concept of sustainable development was proposed in the 1970s our knowledge about the limits of natural resources and the importance of diversity has been magnificently improved. Sustainability is the capacity to create, test, and maintain adaptive capability (Holling 2001). It depends on building and maintaining the adaptive capacity needed to deal with the shocks, surprises and longer term structural transformations that are increasingly common in our world. On the other had development is the process of creating, testing, and maintaining opportunity. It is a "*continuous process of adaptation and accommodation between individuals and their environments*" (Waller 2001).

Resilience Thinking shares many concepts of sustainable development. Walker and Salt tell us that a "*resilient social-ecological system in a 'desirable' state has a greater capacity to continue providing us with the goods and services that support our quality of life while being subjected to a variety of shocks*" (Walker and Salt 2006, p. 32; Pisano 2012). Similarly, resilient social-ecological systems are able to absorb larger shocks without changing in a fundamental way. If massive transformation is inevitable, resilient systems contain the components needed for renewal and reorganization (Folke et al. 2002). In other words, a resilient system can cope, adapt, and reorganize without sacrificing the important contribution of ecosystem services (Folke et al. 2010).

This coincidence of concepts is not presented as a substitution for sustainable development. It is introduced as a conceptual model that might help us to understand how to actually make change sustainable in practice. We are now, it is suggested, feeling the consequences of a shift from simple modernity to something new, which Beck calls a period of reflexive modernity. This is a global phenomenon to varying degrees, sometimes also called the 'post-growth' economy. At the risk of over simplifying, a sustainable society must first be a resilient society. As Jordan points out in his overview of the problems facing the African continent, there is a compelling need for a more equal distribution of economic security and well-being. While that is a topic beyond the scope of this book, the idea is touched upon in many of the chapters. Responding to social and economic issues as well as the more obvious material needs that come with disaster or sudden change is important. It may be that we can learn lessons from those who are engaged in sustainable development as we try to respond or plan for resilience in the face of massive change.

Reframing Resilience

Vulnerability, resilience, adaptability and transformability are important concepts that can be used to describe a complex system. Despite a wide range of discussion concerning each one on its own in the literature, a clear description of how they are integrated is rare (Lei et al. 2013). Based on the material outlined above we propose to organize these key concepts of resilience thinking as in Fig. 1.1. In this diagram vulnerability and resilience are seen as the input and output of a system as it moves towards a more sustainable form. Adaption and Transformation are the processes by which change is responded to. They are not mutually exclusive from each other but can take place simultaneously and at several scales. In this way Resilience Thinking follows the adaptive cycle and the rules of panarchy.

Vulnerability is a core concept in disaster risk management. Although the concept has long been incorporated into practice in development, food security, and disaster risk communities, there are few examples that document how resilience is explicitly incorporated. In most cases resilience and vulnerability are potentially complementary, in the sense that actor-based vulnerability analyses look at the processes of negotiation, decision-making, and action, whereas systems-based resilience analyses take a similar approach by examining the interaction of social and ecological processes (Miller et al. 2010). That said, vulnerability researchers predominantly focus on the response to hazards or shocks, rather than on longer-term adjustments and changes. The interaction between long and short term ecological and biophysical changes is often overlooked.

Adaptive capacity (or adaptability) refers to the capacity of a particular system to cope with shocks (Gunderson 2013). Given that the term is used in the context of a specific system it is implicitly focused on smaller time scales. Longer time scales become apparent when looking at the capacity to transform. Transformability is the ability of a part of a complex adaptive system to assume a new function (Martin-breen and Anderies 2011). It is most relevant over larger time scales, and can be understood as the ability of a system to change its identity.

The four concepts can also be understood to mirror the phases of the adaptive cycle. That is, they are all equally important, and highly interconnected. On the surface one aspect may appear to be dominant, as when there is a regime change, or a period of stability, however the reality is that there is a basic state of constant movement if not outright change (Walker and Salt 2006). The concept of panarchy is particularly useful to understand this statement because it assumes a relationship between activities taking place at different scales. In this world view transformational change at the small scale makes stability or resilience possible at the large scale, and vice versa. The capacity to undertake change at the smaller scale draws on the capacity for resilience at other scales. It is because of this relationship that a crisis can become an opportunity for innovation and for the implementation of novel ideas. Experience and knowledge can be re-combined to navigate periods of social–ecological transition (Folke et al. 2010). With this in mind, the application of resilience thinking depends on our perception of the scale, or the boundaries, of a

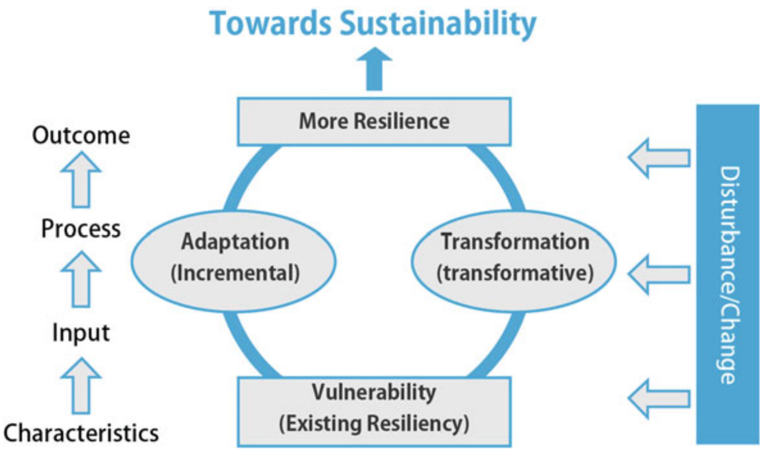

Fig. 1 The relationship between vulnerability, resilience, adaptation, and transformation is best understood according to the rules of panarchy

system. To give an example, in our highly globalized and urban world, people tend to migrate to cities in response to climate extremes. Chulun gives us the example of herders in Mongolia moving to the city as they escape the climate disaster known as Dzud (see Chap. 6). Over time the density of agglomeration overwhelms the existing urban form, and short circuits the adaptive cycle, resulting in structural transformation of the economy at the individual, regional and national level.

Rethinking Change Through the Lens of Resilience

Although substantial discussions in research literature provides more than enough information to develop a theoretical framework of resilience, there are few documented cases for how the various theories are adopted and applied by managers, community leaders, and policy makers (Miller et al. 2010). Nonetheless the practice of resilience is ubiquitous around the world, whether it is undertaken with any knowledge of the theories outlined above or not. Several of the articles in this book make this point clear. That is not to say the framework outlined above is only useful as an academic exercise. Resilience can be improved, and better planned for, by involving the complexities of the adaptive cycle and by acknowledging the complexities of panarchy. Especially with this point in mind we would like to suggest that change and crises are important opportunities that can be taken advantage of to improve social and economic conditions for everyone. The examples in this book were selected specially to highlight this potential.

The theory of resilience places change within a dynamic system in order to understand its ability to absorb, adapt, and transform. Within the adaptation cycle (which follows a cycle of growth, followed by conservation and then re-organization) resilience and vulnerability are essential characteristics that can be found throughout the pattern. In a similar way, while it is a slight simplification, adaptation can be understood as the path taken by a community or a group as they transform a point of vulnerability to a point of resilience.

Epistemologically, resilience is a bridge to sustainability on several scales. It provides a lens for the examination of change in a systematic way around the world. Under this lens, change is normal. Under this lens, the collective tendency of complex systems is mostly seen as a positive thing. However, complexity can also be fragile and difficult to manage. The more complex a system, the more likely we are to be surprised by an unanticipated point of failure. It is clear that we will never be able to prepare for every hazard, and so it seems better to aim for flexibility instead. In theory that is the logical conclusion. Yet, in reality the first role of resilience is to resist change. In this regard the "precautionary principle" (which can be summarize with the aphorisms of "do no harm", or "look before you leap") provides a pragmatic political option for dealing with uncertainty, risk and vulnerability, and it is much easier to realize because the boundaries are clear. It is a useful tool, in fact, because it is so pragmatic. Yet it is nonetheless essential that we do not limit ourselves to organizations that only allow this approach and as a result are designed to inhibit the mobilization of knowledge and resources that might lead to more diverse and flexible strategies for managing change. The precautionary principle is applied when we do not have sufficient knowledge at hand. Our hope is that we will begin to know more about managing change and its consequences and thus become more pro-active and increase the benefit of policies for all. The precautionary principle is not sufficient to the challenge.

Crises and disasters provide opportunities to collectively and reflectively embark upon incremental adaptation and structural transformation. As Pelling has said, climate change and the crisis of capitalism is a chance to reclaim self, society and nature (Pelling 2012). However, disasters and reconstruction do not automatically invoke proactive activities. To the contrary, transformative change often challenges the status quo, threatening those who benefit from the current systems and structures. As a result, it is particularly hard to begin, never mind to see through, real change. In this way transformation to a resilient society is unlikely to be achieved through political power. It may be more likely realized through an iterative process of learning within communities.

Community has the potential to play an important role in the reorganization of natural and social resources. The high potential of social capital and the opportunity for every stakeholder to join in the process are the most important characteristics of a community-based approach to developing flexibility. In this regard so-called reflexive learning supports learning through social practice as it responds to failed development projects and programmes. To be successful it requires the transformation from the simple modernity of industrialization to *"…a reflexive second modernity that not only changes social structures but also revolutionizes the very* *coordinates, categories and conceptions of change itself*" (Beck 1992). This is very appealing and yet it is not clear how this might be used to balance resilience between all of the layers of a stratified society.

We live in a time where change appears infinite but our knowledge is limited. Continual surprise from disasters and crises is becoming a normal state. The question to answer is how to act within that context. Resilience is simultaneously a theory about change, a methodology to manage change, and a mind-set about how to live with change. It can be used as a tool for precaution, adaptation and transformation, and is neutral enough to fit into a collaborative process that brings together divergent groups facing strident differences. The potential is quite clear, and yet its use as a tool in practice is not yet well resolved. This book sets out to give a snapshot of how change is being managed, offers some lessons in the form of case studies, and suggests ways to move forward from the current situation.

The material covers a breadth of topics, but is grounded by the shared point of view of active practitioners. To give a structure to the chapters we have grouped them into five sections. Part one looks at how to recognize vulnerability; part two considers the challenge of preparing for change; part three introduces some of the tools that we can use to build resiliency; part four considers the potential of using change as an opportunity to build better places and institutions; finally, part five focuses on the very important role of community in building resilience. Taken together the text forms a useful outline for understanding where we might go next.

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Part II
Recognizing Vulnerability

Recognizing vulnerability is far from simple, and understanding its cause is even harder. Part of the problem is technical, as we are still learning how to measure the problems around us. Part of the problem is inertia, or the inevitable slow change that defines politics and culture. Finally, it is a straightforward lack of resources. The five articles collected in this part each illustrate a different aspect of vulnerability and its recognition, or lack thereof. Broadly speaking two types of change are used to consider the problem; climate change, and disaster.

Global climate change brings with it a specific kind of vulnerability. At this point it seems to be an unavoidable future and indeed a part of our present as well, with adverse impacts becoming observable and ubiquitous. Many locally degraded systems may have already crossed the threshold into collapse, imposing compound impacts on the environment, some of which are characterized by rapid onset (floods, disease outbreaks, food price increases). The extreme weather event in Mongolia called Dzud is one such example (see Chuluun et al. in Chap. 6 for more on this). Slow onset shocks are also underway, as in the case of increasing drought in the arid environment of Tunisia (see Ouessar in Chap. 3). If we add the challenge of managing communities and human behavior to the mix, understanding change and measuring vulnerability becomes ever more difficult.

With this in mind, Dimmer builds a vision for reconstruction in Japan after the Tohoku disaster that emphasizes the need for soft policies and strengthening of community networks. At the same time, he describes the long-term demographic problems that rural Japan is facing and how those issues may leave the country more vulnerable than the relatively short-term impact of the 2011 tsunami (as large as it was). Although Japan has recognized the trend for some time, few recovery plans include it in the reconstruction process, which could exacerbate the problem in the future. In this case recognition is not the same as action.

Sato shows the interconnection of environmental problems. He describes the kinds of vulnerabilities that are accumulating as a result of poor traffic planning in the case of Sao Paolo, Brazil. The physical nature of the city and its traffic infrastructure make it even more vulnerable to heavy rains and damage caused by climate change. Though he does not offer a particular solution to this problem, he does make a clear case for measuring vulnerability as part of a complex system.

Ouessar describes a specific range of problems directly related to expected climate change, in his case focusing on the suitability of farming land for olive tree production in Southern Tunisia. The study is narrowly focused on particular aspects of the climate model for the region up to 2050; however, it offers a clear example of what the country might be expected to deal with in the near and distant future. His research also shows that there are tools available to measure expected changes, if we choose to use them, an important point that is made by several of the authors in this collection.

Chuluun et al. show the unexpected impact of climate change. Their contribution is a somewhat technical paper but it underlines the difficulty of measuring change and also of managing knowledge and its application in the form of policy and activities. Politics and human behavior create barriers that are not always obvious or expected.

Sekine considers the role of human health and living conditions in the context of the 2011 Tohoku disaster in Japan. He suggests that these issues can be understood as secondary disasters, which follow or go hand in hand with a larger disaster. Much like Dimmer shows in Chap. 1, Sekine offers evidence for one of the key challenges of building resilience and managing change; namely, that problems with potentially large impacts are often ignored or sidelined in favor of the more easily understood and visible ones. This might be understood as the age-old case of the squeaky wheel getting the most attention. Nonetheless, it is an important insight in general for the topic of resilience and one that should be considered when examining the impact of disasters and other kinds of change.

The issue of global climate change, and what to do about it, has put economics to a severe test. Economists are already challenged to model (or at least conceptualize) fundamental notions including risk and uncertainty as a result of relatively well-understood trends such as modernization, never mind climate change. It was once thought for instance that developing and emerging economies were more vulnerable than the developed ones. However, the devastation caused by the nuclear disaster in Japan in 2011 demonstrates very clearly that risk and vulnerability are ubiquitous, and unrelated to the wealth of a country. The loss and damage brought about by the unprecedented triple disaster in Japan revealed multiple vulnerabilities of modern society, from the national energy infrastructure and the strength of local communities (Dimmer, Chap. 2) to the challenge of maintaining living conditions and human health (Sekine, Chap. 5).

Similarly, the kinds of change that come about as a result of climate change are difficult to predict. In the case of Mongolia, extreme weather events combined with a regime shift in the 1990s saw the country change from a socialist to a market economy. In a context defined by political and economic transformation, the climate disaster of Dzud did not lead to the transformation of grazing habits of herders so they would be more sustainable. Instead the herders migrated to the cities, creating new problems for the country. Some kinds of vulnerability only become apparent in hindsight, in which case our models for resilience need to be particularly flexible.

Chapter 2
Japan After March 11th 2011: Between Swift Reconstruction and Sustainable Restructuring

Christian Dimmer

Over five years after the “triple disaster” of an earthquake, a tsunami, and the subsequent nuclear accident at the Fukushima Daiichi power plant that devastated Japan’s Tohoku region on March 11th, 2011, reconstruction is still progressing slowly. The difficulties are unprecedented and vast in scope: over 400 communities in 62 municipalities are affected in six different prefectures, along hundreds of kilometres of coastline. The challenges are complex and differ in their particular manifestations: earthquake damage, displacement from nuclear disaster, and tsunami destruction. They are dynamically interrelated and cumulative; rural regions, long confronted with depopulation and ageing, are additionally affected by disaster, and the effects are exacerbated by slow recovery and uncertainty. It will be difficult to rebuild more resilient communities that are sturdy and adaptable in order to respond to the challenges of inevitable demographic and economic transformation and global climate change, if planners ignore countervailing trends of demographic decline and environmentally harmful lifestyle preferences. The purpose of this chapter is therefore threefold: First, to provide a comprehensive overview of factors that are complicating reconstruction in Tohoku; second, to show that many of the underlying, structural problems of rural Japan are caused by a proliferation of environmentally harmful lifestyles, which existing top-down urban planning prescriptions fail to address. Thirdly, to stress the importance of complementary, ‘soft’ policies that aim at raising environmental awareness and strengthening social resilience by reinforcing community networks and utilizing endogenous development potentials.

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Introduction

It has been more than five years since the so-called "triple disaster" of an earthquake, a tsunami, and the resulting accident at the Fukushima Daiichi nuclear power plant devastated significant parts of North-Eastern Japan on March 11th, 2011. Even so, the overall reconstruction effort is still only progressing at a slow pace.

Although Japan's government has committed vast financial resources to facilitate a speedy reconstruction, and a fair number of promising grass-roots recovery projects[1] have sprung up across the region, these efforts are frustrated by the enormous spatial expanse of the affected areas, with over 400 communities in 62 municipalities affected in six different prefectures, along hundreds of kilometers of coastline; by very divergent socio-economic and topographic conditions at each locality, a shortage of personnel and reconstruction materials, as well as the wide spectrum and great magnitude of the tsunami devastations. Thus, there can be no single, one size fits all recipe for reconstruction.

However, it is not only these physical factors that distinguish the impacts of the Great East Japan Earthquake from those of the similarly destructive Hanshin-Awaji Earthquake in Kobe, in 1995. Since the mid-1990s, decentralization and devolution of government authority have progressed significantly in some policy areas and shifted the power balance in Japan from the central government to the municipalities, as well as from the state to civil society. This has created ambiguity and stress about responsibilities and leadership in the reconstruction endeavor and it stymies the communication and coordination between all stakeholders involved.

The creation of sustainable, resilient, and adaptable post-disaster communities—the often-stated objectives of many reconstruction policy documents—is further complicated by the fact that the affected regions are mostly located at the rural periphery and have long been confronted by a less spectacular, hidden disaster. Long before they were destroyed by the Tsunami on March 11 2011, these communities in the prefectures Iwate, Miyagi, and Fukushima were marked by atrophying local economies as a result of succession problems in agriculture, forestry, and fisheries, decreasing birth rates, a concentration of elderly population, outmigration of the young and disintegration of local communities (c.f. Hayashi and Saito 2011; Matanle et al. 2011; Matsuyama and Biggs 2011).

All these factors complicate the reconstruction process immensely and distinguish it from earlier precedents. It will be difficult to rebuild more resilient communities that are sturdy and adaptable enough to respond to the challenges of demographic and economic transformation, global climate change, or energy and food security, if such countervailing trends of shrinkage and the preference for environmentally harmful lifestyles are ignored. There is a danger that scarce public resources are misspent, which a highly indebted country like Japan could use otherwise.

The purpose of this chapter is therefore first to provide a comprehensive overview of factors that are complicating the reconstruction process in Tohoku. Second, I will show that changing lifestyle choices of the citizens causes many of these underlying problems and that consequently mere top-down directed urban planning prescriptions are likely to fall short. Thirdly, I will stress the importance of complementary, 'soft' policies that aim at strengthening social resilience and sustainability and reinforce social networks as well as endogenous development potentials in the affected communities.

The Disaster in Figures

On March 11th 2011, at 14:46 local time a massive earthquake struck off the pacific coast of Japan's northeastern Tohoku region. The quake measured a record 9.0 on the Richter scale and was the strongest ever recorded in Japan. The mighty tremor shifted the tectonic plates by more than five meters eastwards, into the Pacific and caused parts of the Tohoku coast to subside by over 1 m—exposing towns, factories, ports, and agricultural land to the whims of the tides; erasing property lines and public records.

The tremor triggered a mighty tsunami that reached the land between 20 and 140 min later and wiped out whole communities along a stretch of coast of over 500 km (Cabinet Office 2011a). The waves claimed around 15.883 lives and as many as 2.667 people are still missing (NPA2013). Furthermore, almost 130.000 buildings were fully destroyed and around 742.000 remained severely damaged (Ibid).

561 km^2 of land were inundated by the tsunami, which is equivalent to nine times the area within Tokyo's Yamanote loop line. Of this, 23.600 hectares of agricultural land were covered with toxic sludge—corresponding to 11% of all farming land in Miyagi (Cabinet Office 2011a). In total, 62 municipalities in six prefectures—Aomori, Iwate, Miyagi, Fukushima, Ibaragi and Chiba—suffered from the natural and the following man-made nuclear disaster.

The degree and the specific patterns of destructions differ widely and are strongly predicated by the particular topographical conditions of the affected communities. The power of the tsunami was amplified for example by the narrow, deep bays along the rugged Sanriku coast in Iwate with their steep slopes. Here the tsunami's run-up height reached up to 40 m and cities like Minamisanriku and Rikuzentakata were therefore nearly fully destroyed. On the other hand, in the flat alluvial plains around Sendai the waves travelled as deep as 10 km inland but didn't develop an equally destructive force.

Disastrous as they were, the destructions of the tsunami reached farther than the coastal areas that were directly affected.

Catastrophic Chain Reaction

Richard G. Little points out that today's interconnected urban infrastructure systems are highly vulnerable. "*A cascading failure in an engineered system occurs when a failure in one of the collection of interconnected parts that delivers a service, triggers the failure of successive parts …(thus), an infrastructure disruption spreads beyond itself to cause appreciable impact on other infrastructures, which in turn cause more deleterious effects on still other systems*" (Little 2009, p. 29).

The earthquake and the tsunami of March 11 2011 are a graphic example of such a cascading failure of complex infrastructures—*infra*structure, by definition mostly invisible and part of the hidden processes that keep cities operational. Susan Leigh-Star suggests this normally invisible quality of working infrastructure becomes only visible upon breakdown; only then do we get a more nuanced understanding of it's relational nature (Leigh-Star 1999). The waves that were triggered by the earthquake overwhelmed the emergency power supply of the Fukushima Daiichi nuclear plant. The resulting lack of power led to a nuclear meltdown of at least three of the uncooled reactor blocks, which in turn necessitated the hurried evacuation of over 200,000 residents, living in a radius of 20 km around the damaged plant (Harlan and Mufson 2011). Today it is still not clear if, or when, these people will be able to return to their homes, or whether they are willing to take the risk of potential long-term exposure to low-intensity radiation.

The failure of the Fukushima reactors led to the subsequent shutdown of all nuclear power plants in Japan in order to conduct safety tests. This in turn caused an unprecedented energy crisis in Eastern Japan and necessitated rolling brownouts throughout the summer of 2011 in order to curb energy consumption and prevent a complete collapse of the national power grid. The energy crisis as well as the shutdown of important infrastructure and lifelines such as highways, airports, railway lines, telecommunication lines, oil refineries, etc. led to gasoline and food shortages and impaired relief operations in the disaster-affected regions. Shortages of key components, manufactured in Japan, even caused significant disruptions to the supply chains of a highly interconnected global economy (cf. Cukier 2012b).

For days following the earthquake, food and water were in short supply, even in Tokyo, and on March 11th when the public transportation system of the megacity ground to a halt, millions of commuters were stranded without a place to sleep or food to eat. Left without water and electricity many inhabitants of Tokyo's countless tower condominiums found themselves in dire straits and it was learned that in the early days after the meltdowns in Fukushima then-prime minister Kan's administration was secretly considering to evacuate the whole capital (Fackler 2012b). These and other worrying problems highlighted the vulnerability of the Tokyo agglomeration, with its nearly 37 million inhabitants, and strongly suggested the need for speeding up the implementation of governmental disaster preparedness plans and dispersion of vital urban functions (Daily Yomiuri 2012a). It also highlighted the need for private companies to think about contingency plans and business continuity planning (Ito and Chu 2011).

The Disaster Behind the Disaster: Japan's Shrinking Periphery

Less visible than the triple disaster of earthquake, tsunami and nuclear catastrophe, but equally destructive is a fourth, hidden crisis that has been affecting Japan's rural regions for decades and that poses great challenges for the creation of sustainable, adaptable communities irrespective of the reconstruction process in Tohoku. Long before March 11, 2011 towns and communities along Japan's rural periphery, outside the metropolitan growth areas, were confronted with declining birthrates, over-aging, outmigration of the young, vacant real estate, and succession problems in forestry, agriculture and fisheries (cf. Matanle and Sato 2010; Matanle et al. 2011; Matanle 2011; Nakamura 2008; Seaton 2010).

Worse, Hayashi and Saito (2011) have pointed out that the population within 1 km distance from the coast of the three disaster-hit prefectures Fukushima, Miyagi and Iwate will have declined in average by 46% until the year 2040 (Table 2.1). This is well beyond the projected population decline for these prefectures as a whole.

The reasons for this are natural demographic change with deaths constantly outnumbering the number of births, but also lack of economic opportunities. Over 64% of Japan's 2.27 million farmers were older than 65 in 2014, and so are nearly 35% of all 174.000 employees in the fishing industry for example.[2] These figures then also raise the question about how to increase Japan's dwindling future food self-sufficiency.

The Great East-Japan Earthquake of March 11 2011 is likely to accelerate these negative demographic trends, as few new jobs have been created so far and reconstruction is progressing slowly. Uncertainty about a successful recovery also

Table 2.1 Projected population development within 1 km distance from coast

		Iwate	Miyagi	Fukushima
Overall population	2005	72.770 (1.385.041)	106.907 (2.360.218)	42.994 (2.091.319)
	2040	37.245 (962.093)	56.860 (1.894.070)	26.792 (1.504.029)
Population aged 65 and above	2005	20.244 (340.753)	27.619 (471.413)	10.232 (475.158)
	2040	16.813 (365.339)	24.000 (649.223)	10.274 (540.812)
Population aged 65 and above as a percentage of total population (%)	2005	27.8 (24.6)	25.8 (20.0)	23.8 (22.7)
	2040	45.1 (38.0)	42.2 (34.3)	38.3 (36.0)
Population development as a percentage of total population in 2005 (%)	2005–2040	−48.8 (−30.5)	−46.8 (−19.8)	−37.7 (−28.1)

Source Hayashi and Saito (2011), p. 4, Translated by Christian Dimmer
In brackets Figures for the overall prefecture

prevents shopkeepers and restaurant owners from reopening their businesses, or starting up new ones, as it is not clear if the purchasing power of the future community will be strong enough. In the areas that were affected by the Fukushima nuclear disaster, radiation fears are another strong reason for further out-migration.

Soon after the disaster Jun Iio, working group leader of the national government's Reconstruction Design Council, pointed out "*the problems faced by the people in those disaster-ravaged areas are a microcosm of the problems being faced by all of Japan*" (in Matsuyama and Biggs 2011) with its ageing and declining communities. Tohoku community rebuilding could therefore serve as a model for the revitalization of other similar rural regions in Japan, but as Tohoku University professor Masashige Motoe, points out, "*the tsunami attacked our poorer communities and (has) shown us how much they were already struggling. (However), no one wants to see that. No one wants to face it*" (Quoted in Hawthorne 2012).

For a sustainable reconstruction process in which limited financial and human resources are wisely utilized, these underlying processes of demographic and economic decline have to be taken into account. The fact that a similarly large disaster could happen anytime elsewhere in Japan adds further urgency.

Reconstruction Principles

On June 25 2011, Japan's Reconstruction Design Council, an expert commission directly appointed by then-prime minister Naoto Kan presented its seven principles for reconstruction (Cabinet Office 2011b). The council was chaired by the civil society expert Makoto Iokibe and brought together 15 leading experts from a variety of academic disciplines and from diverse roles in society. Its members included the architect Tadao Ando, who has been central to some of the country's larger national projects, such as the successful bid to host the 2020 Olympics in Tokyo, or Takashi Onishi, a former Tokyo University professor and leading regional planning expert in Japan.

The commission was well aware of the difficulties and the magnitude of the reconstruction task, but also of the opportunity to encourage more livable, sustainable communities that are able to deal with the demographic and economic challenges outlined above. It recommended therefore that local communities should be the foundation for reconstruction, with the national government only supporting reconstruction through general guidelines and additional institutional design. In order to revive the disaster-afflicted regions, the council recommended that recovery and reconstruction should harness the region's endogenous potentials and lead to technological and social innovation not only for Tohoku but also serve as model for all of Japan and in particular for rural areas, facing similar population decline.

A key element would be preserving and fostering strong social bonds among local residents in order to construct disaster-resilient, safe communities. A system of distributed energy generation is identified as a key to creating redundancies and reducing the vulnerability of the existing centralized systems. The Reconstruction Council links reconstruction and the country's ailing economy as it stresses that Japan's economy cannot be restored unless the disaster areas are rebuilt and that the disaster areas cannot be truly rebuilt unless Japan's economy as a whole is restored. Finally, the council urges that *"(a)ll of us living now (in Japan) shall view the disaster as affecting our own lives, and shall pursue reconstruction with a spirit of solidarity and mutual understanding that permeates the entire nation*" (Cabinet Office 2011b, p. 2).

Two years later, the Reconstruction Promotion Committee (Reconstruction Agency 2013), a follow-up body under a newly elected Liberal Democratic Party (LDP) government, called for the creation of a "New Tohoku." It too stressed the need for a robust, resilient social infrastructure, able to mitigate future disasters, and for self-reliant local societies, utilizing regional, endogenous resources (Reconstruction Agency 2013).

Nonetheless, more than five years after March 11 2011, the reconstruction effort is still only progressing at a slow pace and the widely optimistic reconstruction vision so far has not lived up to the plans' promise "Hope beyond the Disaster;" a "New Tohoku" has not yet emerged. This can be partly attributed to the months of political strife within the then ruling Democratic Party of Japan (DPJ) and between the DPJ and the then oppositional Liberal Democratic Party (LDP), who rejected any meaningful collaboration with the government. Many have suggested the national government reacted too slowly and too hesitantly to the crisis (Cukier 2012a; Hawethorne 2012). Only in February 2012, for example, was a national Reconstruction Agency established and, much to the criticism of the people in the disaster-hit areas, it is headquartered in Tokyo with local reconstruction bureaus in Iwate, Miyagi and Fukushima prefectures as well as branches and other smaller offices in disaster-hit areas (Mainichi 2012).

Despite the validity of such criticism it has to be admitted that never before has an advanced, highly technological society been hit by such a complex and massive disaster, and thus no templates were readily available for policy makers and responders.

Despite the government's own bold rebuilding vision and countless "grand designs," proposed by scholars, urban planners, architects and other policy entrepreneurs the reality of the reconstruction process has been sobering, with many unforeseen challenges obstructing a swifter recovery. Some of the crucial factors that stood in the way of rebuilding entirely new cities, more in line with sustainability and resilience principles, will be discussed in the following section.

Obstructions to a Swifter Reconstruction Process

One of the most fundamental problems has been the enormous time pressure. The highest priority was the revitalization of the fishery industry; economic backbone of the coastal region (Matsuyama und Biggs 2011). With every day the ports in

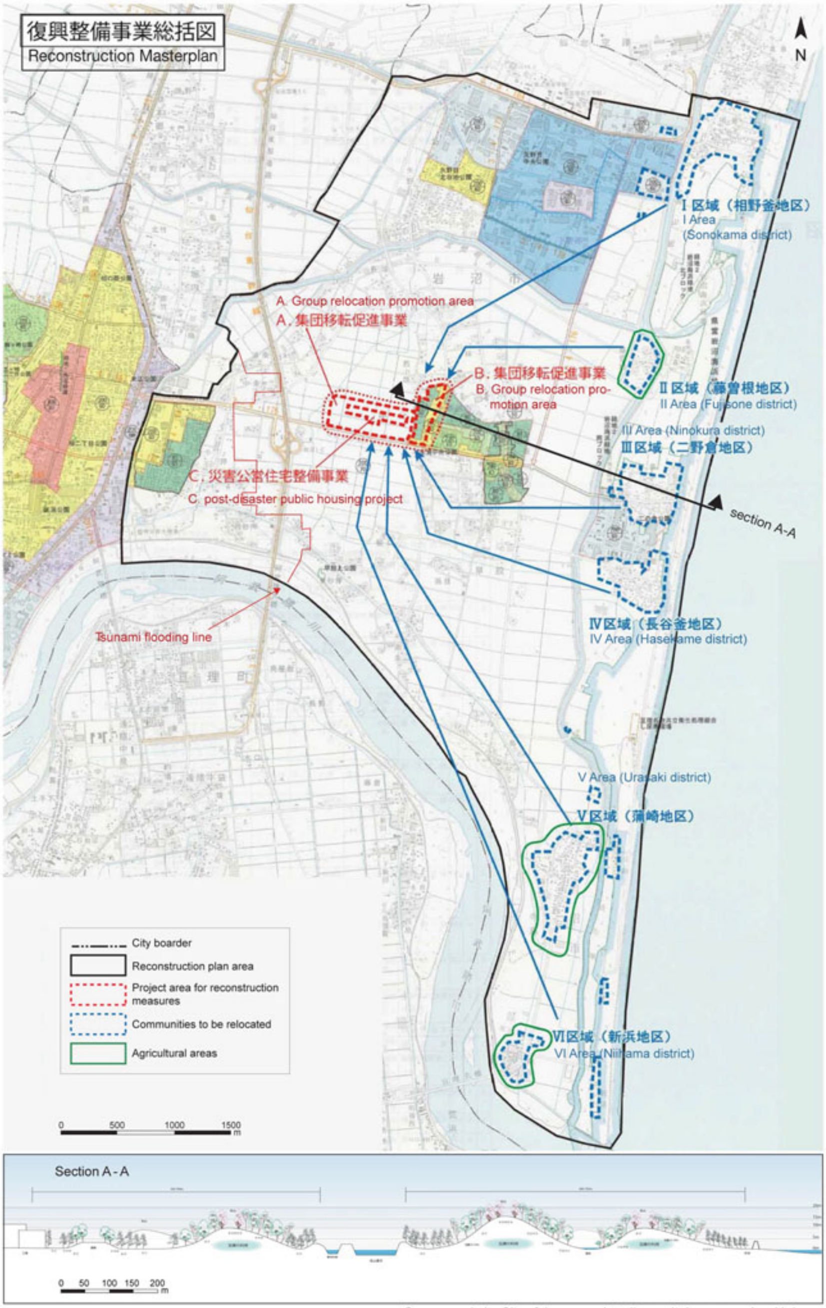
Tohoku were not operational and processing plants not working, the probability increased that fishing fleets would land their catches in the ports of West Japan, spared from the disaster. Fears were strong that once new alternative arrangements evolved, fishery wouldn't return to Tohoku even after the reconstruction was complete. The following figures highlight how severe the damage of this vital primary industry was: In Iwate Prefecture 95% of the 10.522 fishing vessels had been destroyed, in Miyagi 90% of 13.570 and in Fuku.

shima 80% of 1068 boats. In Iwate 98% of 111 ports were destroyed, in Miyagi all 142 and in Fukushima all 10 fishery ports (Wright 2012). If new jobs would not be created soon, it was feared, younger employable people would leave the region to find work in other parts of the country. Because of this time pressure municipalities and planners felt that they couldn't afford the time needed for intensive, lengthy citizen participation during the drafting of reconstruction plans.

To make things worse, many survivors were isolated from their friends and family, as the scarcity of land in the rugged geography made it difficult to build temporary housing facilities and keep former communities together. In March 2014, 97,113 people were still living in some 44,211 prefabricated temporary housing units, 120.657 in 49,863 leased private houses, and 23.551 in 8.740 public apartments (Reconstruction Agency 2014). Like in 1995, after the Hanshin/Awaji Earthquake in Kobe, temporary housing was allocated through a lottery system, giving priority to the elderly, disabled people, or other vulnerable groups. Maly and Shiozaki point out that "*while the idea to provide additional support to vulnerable members of the community is admirable, it does not consider the entire community, excludes many from needed support, and does not take into account the effect of grouping vulnerable populations together in temporary housing … When the impact on overall community networks is considered holistically, the randomized selection of temporary housing residents led to communities being fragmented and displaced from their former neighborhoods*" (Maly and Shiozaki 2012, p. 59).

Uncertainty about future infrastructure allocation is another problem. The reconstruction of individual livelihoods can only begin, once it is decided if and where tsunami-hit communities will be relocated, and how high new protective seawalls should be in order to rule out future disasters (cf. Miyake 2014).

The city of Iwanuma, located in the plains south of Sendai, is a positive example. Within months after the disaster, an agreement on group relocation of whole communities was reached here between municipality and the affected residents. Aided by the fact that the reconstruction coordinator—then a well-known then-Tokyo University professor for landscape planning—was of Iwanuma descent, already in summer 2011 a reconstruction plan was decided. In August 2012 the relocation of six villages began, which were merged into one new "reconstruction community", protected by three staggered, up to 15 m high embankments that are raised by utilizing tsunami debris. Extensive protective forests and water flows between the embankments serve as additional means to slow down a possible tsunami (Fig. 2.1).



Source: website City of Iwanuma, http://www.city.iwanuma.miyagi.jp/

Fig. 2.1 Relocation plan in Iwanuma city

Such a solution is much more difficult in places with a more dynamic topography, and depends on the availability of buildable land. While it is feasible to terrace gentle slopes in order to prepare land for new housing many cities and towns along the jagged Sanriku coast have difficulties to finding sufficient amounts of land above the tsunami line. In many cases the only solution is relocation to areas with a more gentle topography, farther away from the coast. This is, however, often not a viable solution for people whose livelihoods depends on the sea (Ueda and Torigoe 2012).

Uncertainty has also persisted after the disaster about the exact location of new seawalls and their height. Communities are often deeply split whether to hide behind high embankments, or accept a higher risk in order to allow for a closer relationship between town and sea. The prefectural government of Iwate has given out unified height standards as late as November 2011 with the result that the disaster-affected municipalities had only four months to prepare their infrastructure plans for streets, or public buildings that had to be finalized by the end of the fiscal year, in March 2012. According to the Daily Yomiuri only 13%, or 41.7 km, of the tsunami-damaged seawalls was reconstructed by May 2013 (Daily Yomiuri 2013).

Conflict lines in the reconstruction process emerged between citizens, who were trying to fend off unwanted new infrastructure, and governments urging a swifter reconstruction. However the situation is more nuanced, and conflicts between different groups within local communities have also surfaced. Some, still traumatized by the disaster, demand higher seawalls to protect them from any probable future tsunami, which could exceed the height of a five-storied building in some cases. For others preservation of the close relationship between coastal towns and the ocean is more important. Furthermore, the exact siting of the seawalls determines which properties will be protected and can be used as building plots and which are rendered unusable and lose their market value.

Further conflicts surfaced between different generations. While younger people tend to embrace the opportunity of consolidating and future-proofing their towns through the reconstruction process, older people are often more conservative and instead interested in recreating what was lost. It is for example difficult for elderly people to make large investments in renewable energy installations, or to go through lengthy reconstruction processes when it is not clear how much of their lifetime is still ahead of them. The town of Onagawa on the Oshika Peninsula is a case in point. In the aftermath of March 11 2011 the incumbent mayor Nobutaka Azumi proposed to merge 15 tsunami-hit fishery villages into one new settlement in order to consolidate public services of the cash-stripped rural community. The mostly older people in the community resisted the proposal, not least because they feared to lose valuable fishery rights as a result of the merger (Onishi 2012).

Another critical issue for successful reconstruction is the difficult staffing situation of municipal governments. In communities where many city officials, or even mayors died through the tsunami, leadership was lacking critically and reconstruction plans were delayed. In a few cases, however, this also opened up opportunities for grass-roots initiatives that couldn't unfold in other communities. In Akahama, a settlement belonging to Otsuchi Town in Iwate and host community of the Ocean Research Institute of the University of Tokyo, the mayor perished in the tsunami. In the months preceding the election of a new mayor in August 2011, University of Tokyo community planners intensively engaged in the community and developed a first planning vision together with local residents. The subsequent official rebuilding plan was significantly informed by the earlier citizen draft plan.

Whether communities succeed with reconstruction or not is often contingent on the leadership of mayors and local officials and how they manage to tap into funding sources and negotiate with Japan's notoriously segmented and inflexible state bureaucracy. Mayor Futoshi Toba of the massively devastated Iwate town of Rikuzentakata became famous for openly criticising the inability or unwillingness of politicians and ministries in Tokyo to cut red tape, speed up the reconstruction process and allow for local innovations (The Economist 2012). His colleague Kimiaki Toda in nearby Ofunato, on the other hand, a former executive of one of Japan's big general contracting corporations, with 26 years of working experience abroad, was less confrontational than his colleague. As a result, some see reconstruction in Ofunato advancing swifter than in the admittedly harder-hit Rikuzentakada (Cukier 2012a).

Where city halls weren't sufficiently staffed to handle the reconstruction challenge, municipalities from other parts of Japan dispatched employees when a previous partnership was already established, or sometimes on an ad hoc basis (cf. Samuels 2013, pp. 170–175). While key managerial positions were mostly held by local officials, technical experts were on loan from other city governments, particular from Western Japan. Here administrators had already gathered valued experience after the Great Hanshin/Awaji Earthquake of 1995. Although many city planning responsibilities had been formally devolved to the municipal level since the local reform of the Local Autonomy Law (2000) and the so-called Trinity reforms of the Koizumi administration (2001), in practice sufficient local planning expertise hadn't developed yet. Local government planners have therefore been overwhelmed by the scope of the reconstruction work, while central government officials were hesitant to step in. Furthermore, the last wave of municipal amalgamations (*gappei*) between 1999 and 2010 and the resulting reduction of municipal personnel has been blamed for slow rescue and relief efforts. The newly formed cities had become so large that emergency services and reconstruction planning were too far away from the local communities and that the staff was simply overwhelmed (cf. Samuel 2013, pp. 165–170).

Lack of clear leadership, understaffing, and insufficient skills were exacerbated by the fact that official records and land registers were lost in the floods, while some boundaries became unclear as a result of subsidence. Moreover, only 49% of all land in Japan has been properly surveyed and registered in cadastres (Daily Yomiuri 2012b). On the forested slopes landownership patterns are often unclear and the preparation of land for relocated communities can be delayed by this. Similarly the progress in rebuilding coastal seawalls that were destroyed or damaged by the massive tsunami is obstructed by difficulties in securing the necessary land, as some of the property owners went missing in the disaster (Daily Yomiuri 2013).

Equally important for the success or failure of the rebuilding of more sustainable communities are deeply seated lifestyle choices that are discussed in the following sections.

Lifestyle Choice Hindering Sustainable Reconstruction

Since the far-reaching deregulations of the so-called Act for Locating Large-Scale Retail Stores (*Daikibo kouritenpo richi hō*, in short *Daitenhō*), from 1991 on (cf. Hakogi 1993), and its subsequent abolition in 2000, the mediating influence of local shopkeeper associations on the design and siting as well as on the maximum size of retail facilities was eliminated. As a result of this foreign-induced deregulation, large-scale suburban shopping malls have rapidly proliferated in rural Japan. In combination with quickly growing numbers of inner- and extra-urban convenience stores, and with suburban housing developments this has furthered the decline of the roofed shopping arcades (*Shōtengai*), so characteristic of Japanese towns (cf. Arata 2012).

This "mallification" and suburbanization of rural Japan was, however, not merely supply-driven, by a liberalized regulatory framework, but, more importantly, by a profound shift of lifestyle choices. Like their peers elsewhere in the world, people outside of Japan's well-equipped metropolitan centers *want* to use their private cars for shopping and they prefer the conveniences of suburban shopping strips with their large, comfortable parking lots to narrow downtown shopping arcades. After two decades of economic crisis, consumers have also grown more price-sensitive to the disadvantage of small, downtown mom-and-pop stores who cannot compete with the low prices of superstores.

Accordingly, person-trip surveys across Japan show that along with the growing suburbanization of residences, shopping and leisure facilities as well as work places the car ridership has sharply increased at the expense of a declining public transit ridership. In the Sendai region, for example, of all person-trips made in 2002, 53.5% were made by car, 20.2% by walking, and 10.5% by bicycle (Fig. 2.2). Thus, while in 1982 nearly one third of all trips were made by car and one third by walking, in 2002 the balance had shifted. Today car-dependent lifestyles clearly dominate and thus merely supply-side targeting planning policies are bound to fail (Sendai City 2003: p. 6).

This spatial dispersion has not only consumed more and more valuable agricultural land but has also contributed to the thinning out of social life in rural Japan. However, as Aldrich (2012) and Vedantam (2011) convincingly show, the intensity of social networks within a community is not only the key to survival in the event of a disaster but also a crucial factor for successful post-disaster recovery. Although the creation of resource-efficient, walkable, or compact cities is an undisputed guiding principle among planning experts (cf. Hayashi and Saito 2011; Japan Today 2011), and even of the country's officially appointed reconstruction council (Cabinet Office 2011a), it will be nearly impossible to reverse the dominant trends

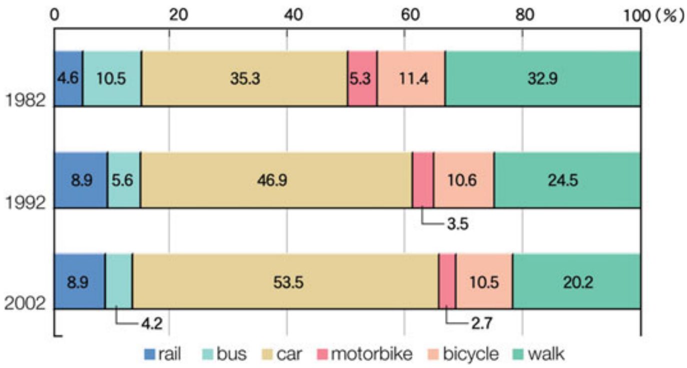


Fig. 2.2 Modes of transportation in Sendai urban region. Source Sendai City (2003), p. 6. Translated by Christian Dimmer.

towards further suburbanization and spatial dispersion if the demand side is not properly addressed.

Ishinomaki in Miyagi prefecture, the largest tsunami-hit city, is a good example. After the devastation of the downtown area, only relatively few shops and residents have returned yet. While well-known city planning experts and architects are propagating the idea of a public transit-oriented compact city[3] as guiding principle for the reconstruction of the old centre, more and more people are voting with their feet and settle down around the Hebita business park. This area at the urban fringe is not only close to the next highway intersection and is host to many large-scale shopping facilities, but it has also proven tsunami-safe. Accordingly, the land prices had nearly doubled there within the first year after the tsunami disaster (Daily Yomiuri 2012c). With every family, however, that decides to resettle to the suburbs instead of returning to the center, the potential critical mass for a successful downtown business center and for cost-efficient public transit decreases. As residents look for jobs in the service sectors instead of primary sector, they move in the opposite direction to the natural potential of the region with fishery manufacturing as major industry in the town centers.

A successful downtown recovery seems even less probable in the aging steel town of Kamaishi in Iwate prefecture that lost nearly half of its peak population of 81.000 between 1955 and 2005, as a result of economic and demographic decline (cf. Nakamura 2008). Reconstruction planners successfully attracted a large-scale Aeon shopping center on the brownfield of a steel factory near the old downtown. It is now serving as a strategic growth core for recovery and planners hope that a flourishing city center will emerge around it.

Conclusion: Decentralizing, Empowering, Building Social Networks

For a sustainable reconstruction in the disaster-affected areas resilience against highly probable future disasters is required. Furthermore, as existing depopulation trends in these rural regions of Tohoku are likely to accelerate due to slow reconstruction and loss of jobs, adaptability to future change has to be built into these communities. As Jeremy Rifkin suggests in his book 'The Third Industrial Revolution' (2011) energy regimes largely determine the way societies are organized, and how the fruits of commerce and trade are distributed, how political power is exercised, and how social relations are conducted. Leaving large-scale power generation in the hands of a few monopolistic utilities in Japan, for example, safeguarded sufficient energy to power the country's economic miracle in the past. However, these "elite energies"—coal, oil, natural gas, nuclear fuel—also helped to create highly centralized, command and control systems, and massive concentrations of capital to exploit them. "*The ability to concentrate capital—the essence of modern capitalism—is critical to the effective performance of the system as a whole. The centralized energy infrastructure, in turn, sets the conditions for the rest of the economy, encouraging similar (monopolistic) business models across every sector*" (Rifkin 2011, p. 108).

Turning this argument on its head, a decentralized energy system is not only less vulnerable in the event of a disaster, it also promotes a true devolution of political power, enables community empowerment and leads to a more even distribution of wealth. The example of Japan shows that the country's highly concentrated, capital-intensive energy regime was mirrored in an equally monopolistic political system, in which large-scale energy providers and politicians formed close symbiotic relationships that had hitherto resisted democratic control and attempts for meaningful decentralization. Honma (2012) and others have also highlighted the collusive role between Japan's major advertising agencies, the printing and broadcasting media, and Tokyo Electric Power Company (TEPCO), which led to media self-censorship that eventually allowed TEPCO and other energy utilities to get away with unsafe practices and malfeasance for years.

A locally managed system of distributed energy generation would therefore reduce disaster vulnerability on the one hand and increase resilience and energy self-sufficiency of peripheral communities. However, the growing number of energy cooperatives in Germany, for example, also indicates another useful side-effect: a distributed energy system with citizen-managed wind- or solar parks, or cooperatively operated local energy agencies creates jobs, fosters a sense of civic pride, and leads to more community activism and political participation. Thus, the formation of social capital, a sense of self-responsibility as well as new democratic practices could be fostered, where local communities take energy matters into their own hands.

In his book ‘Building Resilience’ (2012) Daniel Aldrich shows convincingly that social capital and active community ties increase survival rates in times of disaster. More importantly, by using the example of post-disaster reconstruction after Hurricane Katrina, he suggests that these social ties are also vital prerequisites for a swift physical reconstruction as well as for a positive sense of recovery. As an extension of this argument I would propose that a key to adaptable, resilient and sustainable cities is just as much the presence of a healthy civil society, with close-knit, active community ties and a vital public sphere as it is the presence of smart, adaptable urban hardware. Our idea of planning should thus be turned on its head: Instead of using citizen participation merely as means to get projects built, planners should also understand that the planning process can be, in itself, a part of resilience building. Carefully designed participation processes in which the citizens take the central stage can act as venues were new community ties and social capital are created—these are vital resources for the creation of adaptable communities (Dimmer 2014).

The example of the reconstruction process in Christchurch, New Zealand that was affected by a powerful earthquake on 22nd February 2011 offers some important suggestions of how communities can be placed at the center of a reconstruction process. Although the time pressure to rebuild was similar to Japan, the local government used the reconstruction process as an opportunity to aim at reconfigurating and restructuring the city significantly. The work on the recovery plan was entrusted to the well-known place-making consultancy of Jan Gehl. When David Sim, chief planner of Gehl Architects stood in front of the assembled citizens he stated: “*I am here to listen, find out what kind of city you want to have, and then do everything I can to help you get it*.”[4] In the following weeks over 100,000 suggestions regarding the draft plans were submitted by the citizens themselves; thus, taking an active interest in the restoration of their city and its improvement.

This is not to deny the importance of urban hardware and infrastructure. Well-designed community centers, parks and public facilities do play an important role as venues for public life to materialize. When the creation of physical infrastructure is not tied to community, and is in fact only a self-serving end, a sustainable reconstruction is difficult, as the example of Okushiri, Hokkaido shows. A powerful earthquake and a tsunami devastated the island on 12th July, 1993. Following the intrinsic logic of Japan’s highly infrastructure-centered ‘construction state’, the equivalent of around 1 billion US Dollar was spent for memorials, coastal protections and public facilities. However, as Fackler (2012a) shows, this single-minded focus on the construction sector ignored the inability to develop new economic and social visions for the future. As in Tohoku, rebuilding brought a surge of well-paying but only temporary construction jobs. However, having grown accustomed to higher salaries, many of the remaining young people refused to return to the hard work of the fishery industry and after reconstruction was completed, they left the island in search of salaried work elsewhere.

Notes

1. For an overview of spatially relevant recovery initiatives, see for example the interactive Tohoku Project Map, compiled by the non-profit, volunteer organisation Tohoku Planning Forum: www.tpf2.net/tpm (accessed 31st May 2014).
2. Fact sheet on the website of the Ministry of Agriculture, Forestry and Fisheries. These numbers are based on the year 2012. The number of employees in fishery excludes the disaster-hit prefectures Iwate, Miyagi and Fukushima. Source: http://www.maff.go.jp/j/tokei/sihyo/ (accessed 31st May 2014).
3. For details see the website of the 'Compact City Ishinomaki Inner City Creation Conference': http://www.ishi-machikyou.com/ (accessed 31st May 2014).
4. See website of Gehl Architects: https://gehlcitiesforpeople.dk/page/28/ (accessed 31st May 2014).

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Chapter 3
Climate Change Vulnerability of Olive Oil Groves in Dry Areas of Tunisia: Case Study in the Governorate of Médenine

Mohamed Ouessar

Abstract Climate projections for Tunisia show a rise in temperature by 2020 of 1.1 degrees Celsius (°C) and 2.1 °C in 2050. The south of the country is much more of a concern. Rainfall is projected to decrease between 10% in the north and 30% in the south over the same period. In the province of Médenine, in Southern Tunisia, where the bio-climate is dry (rainfall ranging from 100 to 200 mm), rain-fed olive tree cropping dominates (more than 80%) the land-use system. The aim of this work is to conduct a prospective study on the potential impacts of climate change on the spatial distribution of olive growing orchard areas to be used as guidelines for decision-making in climate change-related adaptation programs. Presently, 73% of olive groves are located in highly suitable conditions, but this figure will drop to only 8.5% by 2020 and 7.9% in 2050, while groves located in moderately suitable conditions will change from its current 19.3% to 78.2% and then 67.4%, in the same time frame. Orchards found in low to marginal conditions, which represents only 7.7% today, will increase to 13.3% and further to 24.7%, in 2020 and 2050 respectively. Although the olive tree is well known for being able to grow in harsh environments, climate change is expected to negatively influence the potential for expanding the plantation of these trees under exclusively rain-fed conditions. Therefore, planners and decision-makers need to discourage farmers from growing olive trees in large areas of the province where the rainfall amount is expected to fall by large amounts in the coming decades.

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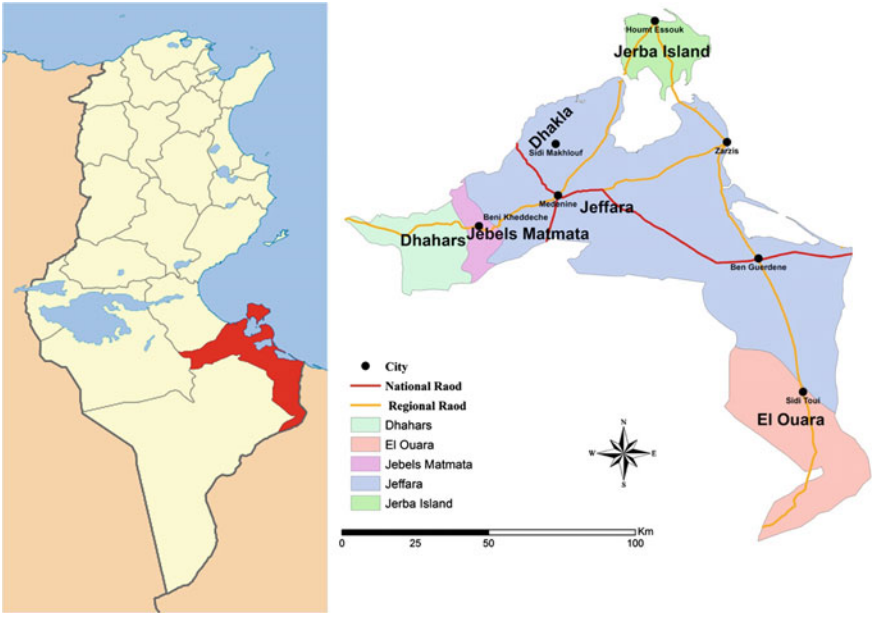

Fig. 3.1 Location of the governorate of Médenine and its main natural regions

Introduction

Tunisia is ranked second in the world for the production of olive oil, after the European Union, with an average annual production of 165,000 tons. More than 30% of its arable lands are devoted to olive trees and comprise about 70 million trees. As such, the olive-growing sector occupies a strategic place in the Tunisian economy.

The governorate of Médenine is found in the southeastern part of the country. It covers an area of 400,000 hectares (ha) and can be subdivided into four major agro-ecological zones: the coastal area (annual rainfall of 200 mm), the Jeffara Plain (annual rainfall of 140–160 mm), the mountains of Jebel Matamata (annual rainfall of 200 mm), and the plateau of Dhahar and Ouara inland plain (annual rainfall less than 100 mm) (Fig. 3.1). Olive orchards have around 4 million trees and cover an area of approximately 200,000 ha, mainly under rain-fed conditions. In addition to the fluctuation of olive production from one year to another in relation to alternating biological phenomena, production is highly variable due to unpredictable climatic conditions (MEAT 1998).

Methodology

The general framework for assessing the vulnerability of olive trees to climate change is detailed in Sghaier and Ouessar (2013). As impact on olive tree productivity is considered among the most important physical effects of any climate change scenarios, the assessment methodology entailed translating the effect of decreased and/or increased water availability. Therefore, a simple water balance based approach was followed (Fig. 3.2).

Features exposed to climate change will concern water resources, as represented by precipitation and runoff, which allows us to make a water supply map. Soil resources, assessed using depth and texture maps, make it possible to produce available water storage estimates. These layers are necessary to establish the potential land suitability for an olive crop map.

King and Nasr (2007) reported the selection of a model and scenarios to predict the evolution of Tunisia's climate, based on a study by the Tyndall Centre concerning Tunisia. It compares the results of four models: Canadian (CGCM2[1]), Australian (CSIROmk2[2]), American (DOEPCM[3]), and British (HadCM3[4]) models. A1 and A1F1 extreme scenarios, as well as average A2 and B2 scenarios of SRES,[5] have been combined with the cited models. These projections show that, at the annual scale, DOE and CSIRO models give, respectively, the lowest and the highest extreme results. The MAMC and HadCM3 models predict an increase in average temperatures of +3 °C by the year 2080. The HadCM3 model gives the most probable results for Tunisia and was therefore used to make projections for temperatures and precipitation in 2020 and 2050.

The modeling was performed by making use of a simple water balance model named "BUDGET". Developed by Raes (2002), it uses a time step of one month. BUDGET is public domain software that calculates the water storage in a cropped soil profile as affected by input and output of water for a given period. When testing this model in similar agro-climatic conditions (Tunisia, Iran, Burkina Faso), Raes et al. (2006) concluded that with the help of the simple, robust BUDGET model, reliable relative yield estimates can be obtained by using daily rainfall data and ten-day ET0 data, good estimates of the initial soil water content and the sowing/planting date and indicative values for crop and soil data. The same model

[1]CGCM2: Canadian Centre for Climate Modelling and Analysis.

[2]CSIROmk2: CSIRO global coupled ocean-atmosphere-sea-ice model.

[3]DOEPCM: USDOE Parallel Climate Model.

[4]HADCM3: Hadley Centre Coupled Model.

[5]SRES: Special Report on Emissions Scenarios.

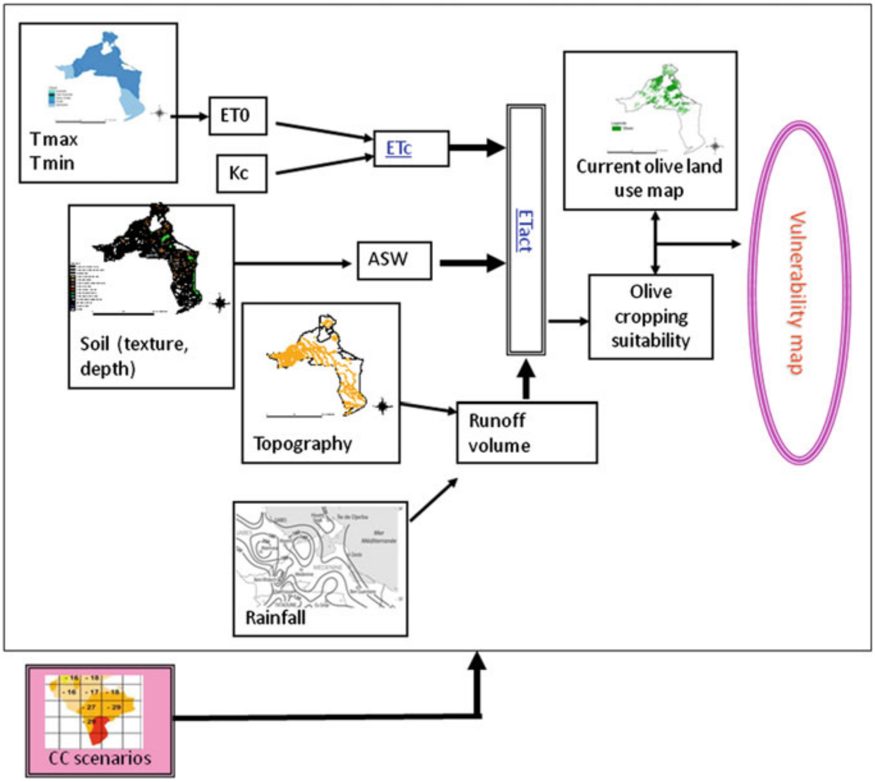

Fig. 3.2 Methodological approach for olive trees vulnerability assessment. *Note* Tmin, Tmax = minimum, maximum temperature; ET0 = reference evapotranspiration; Kc = crop coefficient; ETc = crop evapotranspiration; Etact = actual evapotranspiration; ASW = available soil water; CC = climate change

was also applied by Schiettecatte et al. (2005) and Ouessar (2007) to assess the impact of water harvesting systems (*jessour*[6]) on olive tree growth performance in the arid mountain region of Béni Khédache (Southern Tunisia).

The model was run for all possible combinations of position (mountain, plain), soils (all soils), meteorological stations (Médenine and Houmet Souk), and rainfall gauges (all). For each combination, the ETc actual was determined. Those values were extrapolated for mapping purposes by means of ArcView software. The following runs were conducted:

[6]*Jessour* is a plural of *jessr* which is a traditional technique for water harvesting in the mountain arid regions of Tunisia.

Table 3.1 Definition of suitability classes for olive tree orchards

Class	Eta/Etc (%)
Very high	>75
High	62–75
Moderate	55–62
Low	<55

- Run 1: average year (normal based on the historical data)
- Run 2: average year with climate change projections of 2020 horizon
- Run 3: average year with climate change projections of 2050 horizon

Soil classes and their characteristics (texture, depth, etc.) were obtained from the soil map (at 1:500,000 scale) of the Jeffara Plain. However, use was also made of other available soil maps at finer scales, such as the soil map of Zeuss-Koutine (1/200,000) which was produced by Taamallah (2003).

On the other hand, as in previous studies (Ouessar 2007, Ouessar et al. 2009), the soil map was modified to take into account the "artificial" soils built up behind the water-harvesting units as deposited sediments. Therefore, the boundaries of the soil units were adjusted based on the visual interpretation of Google Earth images in addition to expert knowledge. Further field investigation with GPS positioning has been conducted when needed. Two classes were added: JESR (soils behind *jessour*) and STAB (soils behind *tabias*).

Already measured available water capacity (AWC), bulk density (BD), and saturated hydraulic conductivity (K_{soil}) (Maati 2001) were used. However, and as is frequently done in watershed modelling where the soil properties are not fully available (e.g., Heuvelmans et al. 2004; Bouraoui et al. 2005; Ouessar et al. 2009), the missing water characteristics of the remaining soils were derived by means of the calculator of Saxton (2005).

On sloping lands, runoff is calculated as an input to the model (irrigation) to take into account the presence of water harvesting systems (*jessour*, *tabias*[7]). The runoff volume was estimated simply based on previous works in the region (Fersi 1985; Kallel 2001; Schiettecatte et al. 2005).

The adopted classes for the land suitability map for olive tree cropping were based on the Eta/Etc ratio as follows (Table 3.1).

[7] *Tabia* is very similar to *jessr* which is a traditional technique for water harvesting in the piedmont and plain of the dry regions of Tunisia.

Results

The results are summarized in Table 3.2 and Fig. 3.3. They demonstrate that because of the dominance of an arid climate throughout the territory of the governorate, the very high suitability class for olive orchards is absent. In the base (2010) situation, 92% (more than 180,000 ha) of olive plantations occupy areas in favorable conditions (average to high suitability). However, as a result of climate change this amount will drop to about 87% and 75%, in the 2020 and 2050 horizons, respectively (according to the Hadley Centre Coupled Model, version 3). In contrast, low to marginally suitable areas will expand from the current 7.7% to nearly 25% by 2050.

The reference situation (2010) is characterized by the importance of favorable areas that cover a large proportion of the governorate, from the mountainous area to the coastal zone, passing via the Jeffara Plain. Indeed, areas close to the sea are

Table 3.2 Evolution of suitability classes (%) from 2010 to 2050

Years suitability	Base (2010)	2020	2050
Low	7.7	13.3	24.7
Moderate	19.3	78.2	67.4
High	73.1	8.5	7.9
Very high	0.0	0.0	0.0

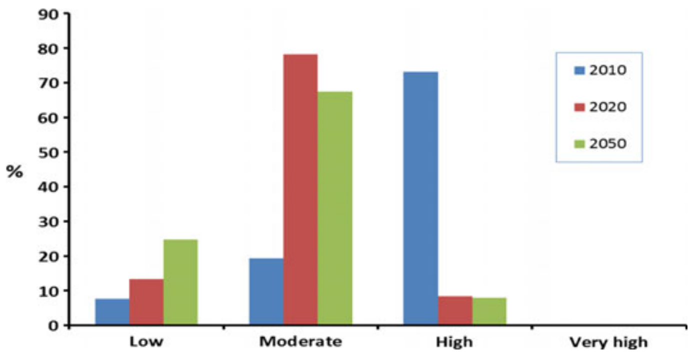

Fig. 3.3 Percentage of suitability classes for different scenarios 2010, 2020, 2050

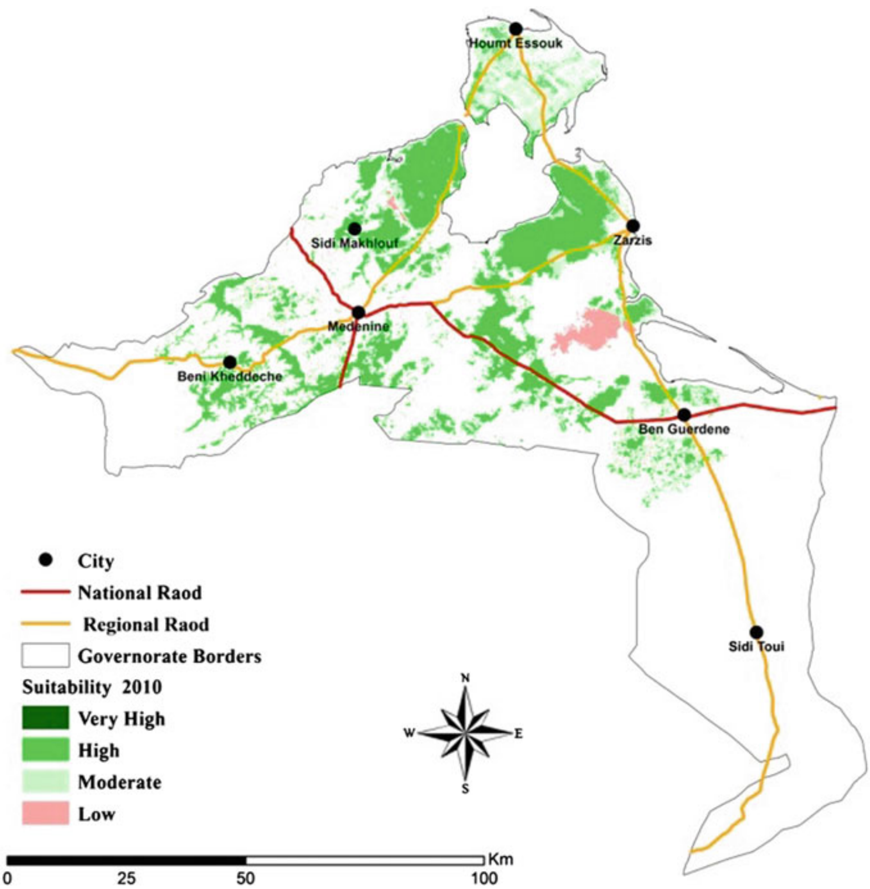

Fig. 3.4 Suitability of soils for olive growing (base situation, 2010)

benefiting from higher rainfall, greater humidity, and milder temperatures. On the other side, water-harvesting techniques, concentrated mostly in mountainous regions with a favorable topography, can ensure the mobilization of important quantities of runoff that can supply the trees with additional water resources. In addition, in both cases, soils are deep and offer real reserve storage capacity for important water and nutrient stocks. Areas with low suitability are limited to shallow soils located between Zarzis and Ben Guerdane (Fig. 3.4).

As shown in Fig. 3.5, in the 2020 horizon, under the effects of climate change (decrease in precipitation and increase in temperature and evapotranspiration), areas

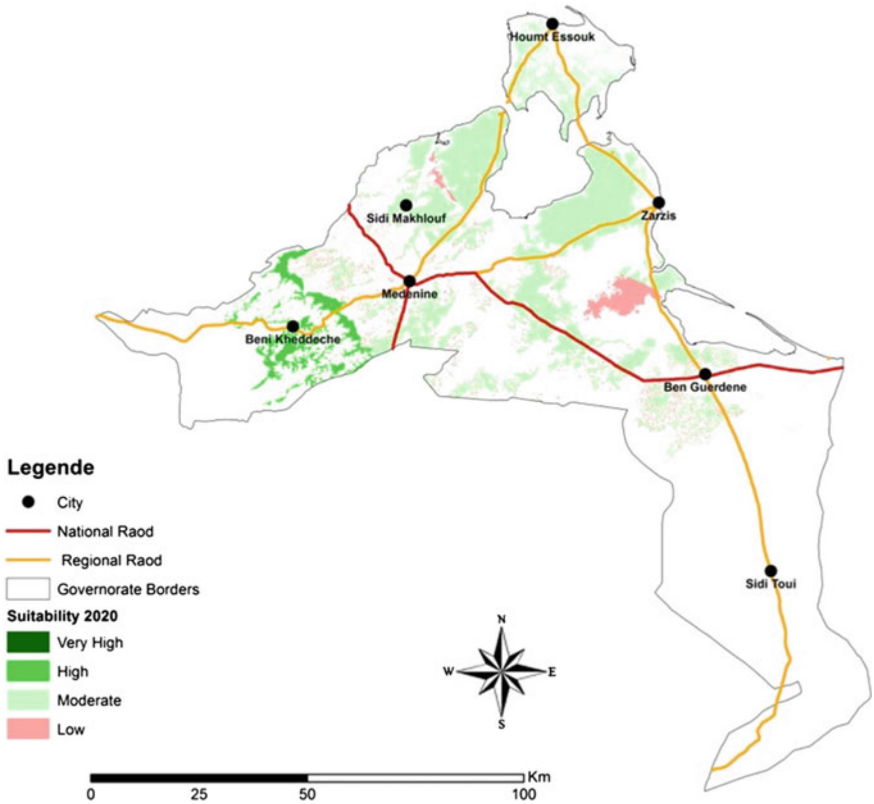

Fig. 3.5 Suitability of soils to olive growing (2020 horizon)

with average suitability will become dominant, covering practically all the Jeffara Plain and coastal zone. In parallel, other areas of low suitability start to appear where soils are very shallow (east of Sidi Maklouf). The soils located behind the *jessour* continue to maintain high suitability (mountainous region around Beni Khedache).

In the 2050 horizon, low-suitability areas expand to cover, alongside other areas of Jeffara Plain, part of the coastal area and the island of Jerba. In contrast, the areas treated with water-harvesting structures (especially *jessour*) continue to maintain their status as high suitability despite the accentuation of the effects of climate change. The traditional olive-growing areas of Zarzis and Dakhla also maintain their average condition (Fig. 3.6).

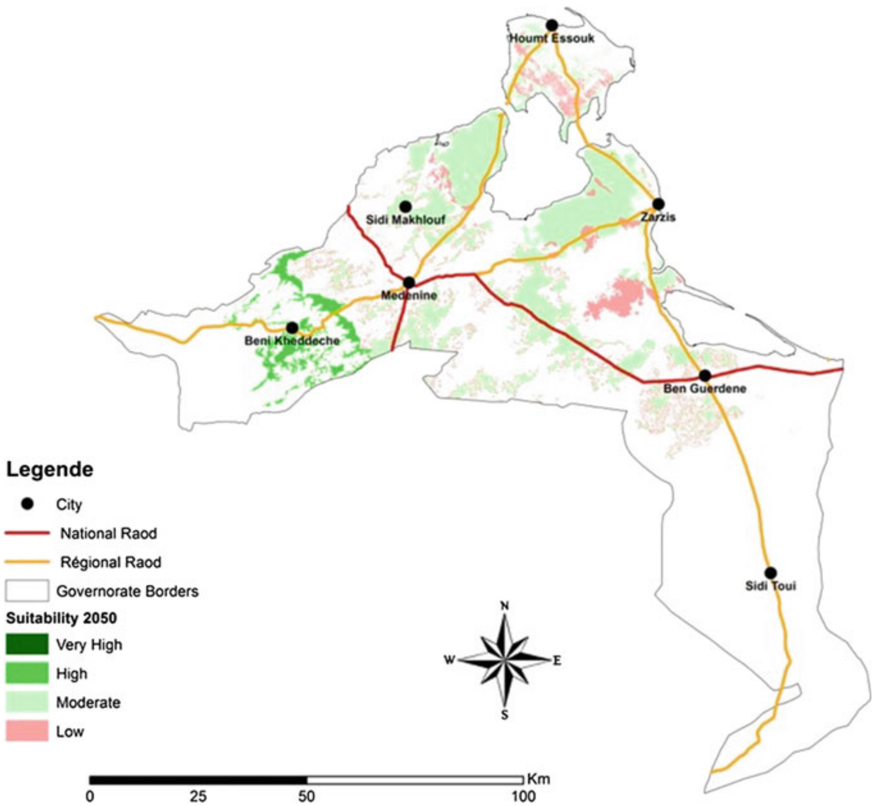

Fig. 3.6 Suitability of soils for olive growing (2050 horizon)

Conclusion and Prospects

Despite the fact that the olive tree is well known to grow under harsh environments, climate change is expected to negatively influence the potential for expanding the plantation of this tree under rain-fed conditions. Therefore, planners and decision-makers need to discourage farmers from growing olive trees, and warn them that doing so will be an increasingly risky in large areas of the governorate, where the annual rainfall amount is expected to fall considerably in the coming decades. This pertains mainly to the areas of the Dhahar Plateau, El Ouara Plain, and some large parts of the Jeffara Plain, especially where the soil is relatively shallow. In addition, the consideration of other factors such as crop pests, socioeconomic constraints (land tenure, market, etc.) will certainly further reduce the suitable growing areas for olive trees.

Many authors have shown that even limited amounts of water from supplemental irrigation during critical growing periods (spring and autumn) could be very effective in maintaining and even improving the yield of olive trees. Ben Ahmed et al. (2007) found that providing 33% of crop evapotranspiration (ETc) can respond to the needs of the *Chemlali* olive cultivar in a semi-arid region of Tunisia (Sfax) without impairing photosynthesis activity and olive production. However, this option is applicable only where water is available. Unfortunately, it is expected that climate change would reduce significantly the water resources in the dry areas of the country (MARH 2007). Water-harvesting systems such as *jessour*, *tabias*, etc., where they are applicable, could play an important role in augmenting the adaptive capacity to cope with climate change by providing additional water through the mobilization of runoff for sustaining plant growth and reduce, therefore, the vulnerability of dryland farmers to climate change (Oweis and Hachum 2006; Ben Mechlia and Ouessar 2004; Schietteccatte et al. 2005; Fleskens et al. 2005; Ouessar 2007; Thomas 2008).

Use of remote sensing data is of great importance in assisting efforts to locate water-stressed olive orchards, in order to direct and prioritize urgent interventions. Er-Raki et al. (2008) obtained significant improvement of the FAO-56 ET method for locating suitable areas for olive orchards in a semi-arid region of Morocco through the combination of thermal data (remotely sensed and ground based), energy balance model and extrapolations of instantaneous ETa to daily values.

As stressed by Masmoudi et al. (2007), further investigations are needed to better select the crop factor of the olive tree as a function of the ground cover percentage (tree density), rainfall and temperature regimes, irrigation method, and rooting depth. In addition, linkages should be established with yield, as done, for example, by Fleskens et al. (2005) with the objective of determining the effects of climate change on olive yield production (effects including quantity and possibly quality).

It is worth recalling that the present study considered only the effects of climate change on the water balance in olive cropping lands. Other important factors, such as crop pests, physiology, and socioeconomic conditions, etc., have not been taken into account. In addition, scenarios were calculated based on average climatic conditions, for both the baseline situation as well as for 2020 and 2050 horizons. Therefore, it is highly recommended to integrate other key features, such as tree, physiology, production, socioeconomic constraints, markets, etc., in order to improve this tool. In addition, once other sectors (cereals, water, rangelands, etc.) are studied, they could be coupled at a later stage with agricultural potential maps in order to be used as a complete and integrated tool for decision-making in the context of climate change.

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Chapter 4
The Vehicle Transportation Problem in the Megacity São Paulo (Brazil)

Renato Cesar Sato and Luciana Ferreira da Silva

Mega-cities are a growing phenomenon. It is expected that the number of cities with a population greater than ten million people will increase from 26 megacities in 2012 to 41 in 2030. These massive urban centers are a unique phenomenon in the history of humanity. In 2010, about 50% of the world populations were living in cities and the growing trend towards urbanization is expected to continue until 2050 when only 30% of the world populations will be living in rural areas. This often uncontrolled agglomeration promotes a number of fragilities in social systems, and often brings environmental repercussions as well. The city of São Paulo in Brazil is the largest metropolis in South America, with about 11 million inhabitants in 2012. An uncontrolled increase in the fleet of vehicles has become a major challenge to public policy and planning. In January 2008 the fleet size was about 6 million, and in July 2012 it increased to 7.3 million, indicating a trend towards growth and congestion. This situation poses a challenge regarding the quality of life in the city and vulnerability in the transportation system. The impact of climate change may further aggravate this situation with an increase in the frequency of environmental disasters and bouts of heavy rainfall over short periods. From the public policy point of view, measures including vehicular restriction and vehicle inspection only promote temporary relief, but fall short as long-term solutions. From the economic point-of-view, heavy traffic is responsible for a loss of about 27 billion dollars per year. In this chapter we address the expansion of the car fleet in São Paulo, together with its impact on the city's environment through a case study of transportation public policies.

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Introduction

We began the twenty first century with a strong and worrisome debate on climate change, its causes, and consequences for the planet, and more specifically for humanity. The effects of climate change include difficult scientific, political, economic, cultural and ethical aspects. The situation requires the development of efficient solutions for public policy and a better understanding of the role of science in measuring the problem and developing solutions (Silva 2003).

The Intergovernmental Panel on Climate Change (IPCC), formed in 1988, analyzes and evaluates possible changes in the climate and its effects, as well as the possibility of anthropogenic causes for those changes. According to IPCC's studies, the environmental, economic and social impact of the planet's average temperature increase would be large and mostly negative, both for the environment and for human society as a whole. This is especially true for vulnerable ecosystems and social groups that already have a reduced capacity to adapt. Megacities such as São Paulo may fit into this category as well, with existing vulnerabilities, unrelated to climate change, but potentially made worse as a result of the added instability. Megacities present a complex system of issues and opportunities. Solutions to any problem in this context are far from simple, and the various climate change scenarios under consideration by groups such as the IPCC only underline vulnerabilities in the city.

The IPCC has concluded that the predicted average global temperature rise is very probably due to the increase of atmospheric concentrations of greenhouse gases emitted by anthropogenic actions. Although Brazil and other nations are aware of the issues, (Dunlap et al. 1993; Leiserowitz et al. 2010; Lopes 2010), public policies seem to be "grid-locked" and are not efficient in dealing with the emerging challenges (Prins et al. 2010; Sarewitz and Pielke Jr 2007). Despite the fact that Brazil has a National Climate Change Plan, as well as initiatives related to mitigation and adaptation, as we will further analyze, the megacity of São Paulo mirrors the difficulties presented on a national level to articulate political action, public finances, and planning. The escalation of existing socio-environmental issues is potentially aggravated by Climate Change scenarios in Brazil.

Looking to the field of urban management from the point of view of climate change, responses are enormously challenging to implement, either as a result of the amount of planning and resources needed, or by the controversy and skepticism about the topic. In spite of these issues an important regulatory point for the city of São Paulo was reached in 2009 when the Municipal Law on Climate Change (Law number 14,933) was enacted after a year-long process. The main goal was to reduce greenhouse gases by 30% by the year 2012—a goal which still was not accomplished in 2014.

Still, the Municipal Law on Climate Change is an important legal instrument for effective planning with regards to vulnerability related to mitigation policies and Climate Change adaptation. It places the question of norms and regulations for urban living in the middle of the search for an elusive sustainability. Amongst the main directives of the Municipal Plan are topics consistent with the argument defended in this article, such as: prioritization of public transportation; incentivizing transportation with lower potential to pollute; monitoring of cargo distribution during night-time; implementation of bus lanes; progressive reduction of fossil fuel use; establishment of mandatory recycling programs and solid urban waste reduction; enforcing regulated energy-efficiency criteria; requiring the environmental sustainability and efficiency of materials used in new construction; adapting construction to counter floods; and following the precepts of the "compact city" concept of urban planning. The complexity of implementing these actions is manifest. Above all, compliance is ineffective, neither best practices nor construction of sustainable models for the community as a whole are well established—we are still in the early stages of understanding the application of the law and its benefits in terms of sociability and public policy achievements.

Cities like São Paulo are considered megacities; the term is related to cities that have agglomerations of five million inhabitants or more, often undergoing an accelerated urbanization process. The effects of climate change will pose a huge challenge for megacities due to the difficulty of implementing changes to the urban system and infrastructure. It is estimated that by 2030, there will be 41 megacities in the world with more than 10 million inhabitants (United Nations 2014). Besides the quantitative issue, megacities place before us challenges that involve a redefinition of collective living arrangements, the definition of urbanity itself, as well as the question of sustainability with regards to new and complex interactions between the environment and society.

On the whole, urbanization can be accompanied by large environmental impacts and accelerated growth. Evidently, if growth is too quick it cannot be supported by measures originally designed to maintain sustainability and infrastructure. Moreover, the complexity of social life in megacities is related to economics, politics, management, the environment and culture. We should not forget the dynamic characteristics of a city as they emerge from the regular process of construction and destruction under pressure from unpredictable economic change and external migration (Harvey 1989). To generalize, cities are a complex spatial system which depend on the functional interactions of both public and private areas. In the case of megacities, high urban concentration leaves them prone to high risks. They have a large exposure to risk; infrastructural issues, inordinate densities of occupation, and heavy vehicular traffic increases the vulnerability to natural disaster.

In urban areas the increase in concrete and asphalt layers intensifies warming in certain places, also known as hot spots. These areas are simultaneously less permeable, which is an added problem. Environmental scenarios predicted by the National Institute for Space Research in Brazil (*Instituto Nacional de Pesquisas Espaciais—INPE*) demonstrate a great probability of an increase in floods and overflows, more intense rainstorms, as well as a higher incidence of lightning strikes. In this scenario the transportation system, which relies heavily upon cars and buses, faces high risks of urban deadlock, which means more traffic, more delays and more vehicle damage. In the next section we present a brief analysis of the evolution of transportation in São Paulo.

The Evolution of Vehicle Transportation in São Paulo City

According to Santos (1990), the city of São Paulo was "*born as a modern productive and consumerist city*" during the industrialization period that began at the end of the 19th century and accelerated in the 1930s (Suzigan 1971). As in many metropoles around the world, one of the most infamous issues in the city of São Paulo is its intense vehicular traffic. In this case it can be argued that high dependency on automobiles is in part due to failures in economic growth. Evidence is found in the creation of an intricate but limited public transport system that ultimately fell short in light of political policies that fomented the use of public transportation mostly for low income populations. The direction of policy was reinforced by development of social meaning and status connected to being the owner of a private car.

Until the 1920s public transportation was the main traffic mode in the city, complete with trains and tram systems. This was possible due to opportunities and investments in urban infrastructure. For instance, an Anglo-Canadian initiative negotiated a contract that guaranteed the management of public and cargo transportation, as well as the generation and distribution of electricity and street lighting. As a result of this agreement the São Paulo Tramway, Light and Power Company (Light & Power Co.) was created—at the time the company was known as Light. The Light & Power Co. also acquired the Company of Water and Energy of the State of São Paulo, and consolidated a monopoly on public services in the city (Pereira 2013).

By 1933 the city had a trolley car network of 258 km, three times the current subway network length. The system was responsible for 84% of public transportation at that time, in a city with a population of 888 thousand inhabitants—less than 10% of the population in 2012 (Rolnik and Klintowitz 2011). Over time low profits from the tram system acted as a disincentive for expansion of the network to peripheral areas by the Light & Power Co. At the same time a contradictory vision of the city government's urban plan offered flexible access to urban areas using avenues built for cars and not trams. Their reasoning was to ensure that urban growth would not be limited to those areas where a tramway could reach. In the process the policy simultaneously ended the monopoly of the Anglo-Canadian Light&Power Co. In 1942 the tram system shrank to a 41 km while buses increased from 16 to 37% (of the preferred modal choice among inhabitants). In 1968 the tram system disappeared from the city (Rolnik and Klintowitz 2011).

The growth of São Paulo during the period from the 1930s through the early 1980s reflects the economic development of Brazil as a whole at that time. In this period we find the establishment of new urban industries, which resulted in a migratory flow from the countryside. One of the main strategies to develop the industrial sector in Brazil was a focus on the automotive industry. This contributed to the development of other related sectors in the economy such as petroleum, credit, and industrial production. It is not coincidental that it is also during this period that highways and roads were constructed, along with bridges and tunnels. Within decades, the car became the main means of transportation, responding to city growth and the desire and need for mobility. Low income populations were relegated to living far from business centers and necessarily relied public transportation in the form of buses (Vasconcellos 2001; Rolnik and Klintowitz 2011). Consequently, a public transportation system was developed to connect peripheral housing areas to the downtown metropolis. The expansion of the transportation network allowed for the development and emergence of new neighborhoods around the city (Camargo 1976).

From the 1960s, the city of São Paulo experienced considerable growth in the production of durable goods and construction which led to an increase in the Brazilian GDP. An expansion of the domestic market and consolidation of the middle class occurred, which in turn strengthened the association of cars with mobility and status. At this time, the city had four million inhabitants and 500,000 vehicles, and the expansion of the city limits reached the metropolitan scale. The road system expanded in concert with a 778% increase in urban land area over a decade, requiring some 536 km of new lanes (Rolnik and Klintowitz 2011).

Not surprisingly, the car fleet increased and the urban transportation map was transformed due to the reduction and abandonment of the existing train system as well as the inauguration of a subway system (initially a North-South corridor) in 1974. The goal of these new investments in transportation was to increase speed, be it by construction of new streets and avenues, or by the creation of the subway system, which was intended to reduce cross traffic between the Northern, Central and Southern regions of the capital. The automobile fleet expansion was in fact associated with higher speeds, and the ability to travel longer distances. Public transportation on the other hand, composed mainly of buses, remained flat, with speeds unchanged since 1930s and 1940s due to technological limitations. Despite the introduction of the city subway, the impact was limited despite a global demand for transport, especially to the suburbs (Rolnik and Klintowitz 2011).

During the 1980s and 1990s, high inflation plagued Brazil; there was a reduction of public investments, an increase in unemployment, and an overall decrease of income and consumer spending power, and a concurrent growth in the informal economy. Despite these facts São Paulo itself experienced an increase in the size of its car fleet even as a new subway line (West-East) was added between 1980 and 1988. The subway's expansion was slower than expected, and created a huge deficit between capacity and demand. At the same time, settlements started to develop in ever more distant areas, away from factories and industry, while consolidation and expansion of commerce and services occurred within the city. The fragility of the urban transportation system was made clear by the insufficient expansion of the subway system and the poor integration of other public transportation. By the beginning of the twenty first century the city had made investments in beltways surrounding the city in order to avoid the heavy traffic of cargo fleets and to reduce traffic in the city. However, this investment again mostly privileged cars and trucks. The evolution of motorized vehicle transportation in the city was a result of past urban planning decisions, with choices often re-affirmed over time, culminating in a dependence on the current transport mode, including a large vehicular fleet.

As mentioned previously cars have a social and symbolic meaning in São Paulo, related to power and authority. Private motor vehicles additionally offer a sense of freedom, to move around. Stone (1971) points out that automobiles allow us to move without limits in public spaces and yet remain in a completely private world (Vasconcellos 2001). Table 4.1 demonstrates the correlation between income rate and mobility—whereas a high correlation can be observed between income and individual and vehicle mobility—and Table 4.2 shows the increase of this mobility.

During 2002, São Paulo city as a whole made 7.4 million journeys using urban public transport, while there were 8 million private motor vehicle journeys. Fifty-three per cent of the total number of trips in the metropolitan area were by car. A small decrease in the number of trips was estimated due to a program called "Single Ticket" (*Bilhete Único*), which enabled the use of an established rate per trip for public transportation regardless of distance or number of connections. This transportation policy was responsible for the resurgence in the use of public transportation, but there are still significant shortages to supply in the system as a whole to increase more the use of public transportation (Biderman 2008). Journeys between home and the workplace in São Paulo are on average 31% longer than the average for metropolitan areas in Brazil (IBEU) during the period 1992–2009, according to National Household Sample Survey (PNAD) (Pereira and Schwanen 2013). These results suggest that new policies and public transport structures have so far had only a temporary effect on the urban transport problem. The economically least fortunate population is the most affected by the insufficiency of the transport system.

Table 4.1 Mobility index in São Paulo city in 1997

1997	Mobility index				
Income rate	Collective	Individual	With vehicle	Without vehicle	Total
Under 760	0.41	0.13	0.54	0.71	1.25
760–1520	0.61	0.21	0.82	0.76	1.58
1520–3040	0.71	0.44	1.15	0.73	1.87
3040–5700	0.72	0.86	1.58	0.57	2.15
Above 5700	0.50	1.67	2.16	0.38	2.54
Total	0.62	0.59	1.22	0.65	1.87

Table 4.2 Mobility index in São Paulo city in 2007

2007	Mobility index				
Income rate	Collective	Individual	With vehicle	Without vehicle	Total
Até 760	0.56	0.17	0.73	0.81	1.54
760–1520	0.71	0.26	0.98	0.80	1.78
1520–3040	0.81	0.55	1.36	0.63	1.99
3040–5700	0.74	1.12	1.86	0.45	2.31
Above 5700	0.49	1.86	2.35	0.35	2.70
Total	0.71	0.58	1.29	0.66	1.96

Source Origin and destiny research 2007—domestic research information summarized (Secretaria dos Transportes Metropolitanos 2008)

Economic Losses

As previously mentioned, high traffic density alone generates substantial economic loss in terms of money. These costs come from time lost in traffic jams, from a lack of sufficient public transport access, as well as difficulties in moving goods to and from the city. The impact of climate change, and the expected increase of environmental vulnerability, will inevitably underline the risk to the national economy and demonstrate the fragile balance between maintaining a healthy environment and boosting the national economy. This case can be exemplified using São Paulo city's specific features—geographic and geopolitical as well as economic, social and cultural.

São Paulo alone represents a little over 12% of Brazil's Gross Domestic Product (GDP), and hosts 63% of Brazil's multinational companies. The city produces 60% of the total revenue of the service sector, as well as 39% of that of the industrial sector, of the entire state of São Paulo—hence the city is referred to as the "engine" of the Brazilian economy. It is estimated that losses due to traffic amounted to approximately R$40 billion in 2012 (Cintra 2013), an increase of 48% over the R$ 26.6 billion in 2008 (Cintra 2008). This number would have been even higher if there weren't for political efforts to mend transportation, such as the Single Ticket program and the restructuring of transportation (in the form of new subways lines, as mentioned above), as well as the restriction of the number of vehicles allowed in circulation during rush hours, which alleviated the problem but did not provide an overall solution. The growth of the vehicle fleet is one of the main causes of excess traffic and, consequentially, of the losses attributed to traffic related problems. Remarkably, between 2002 and 2012, the vehicle fleet increased by 47% while the population grew only 8%. The number of cars per inhabitant rose from 0.3 to 0.42, while the national index of vehicles per inhabitant increased by 0.22 (Cintra 2014).

The reasons for economic losses related to traffic are as follows (O Impacto do Caos 2012):

Logistic costs: The cost of transportation increased because of excessive wear and increases in the amount of time needed to deliver cargo. Vehicles used for this activity perform fewer delivery cycles, which require an increase in the fleet size or an in-crease in subsidiary contract services in order to meet the scheduled orders. The increase of economic costs is clear and there is no foreseeable path for improvement, instead only an increase in the severity of the problem.

Gas costs: Increases in the usage of an already inefficient system also increased the consumption of gasoline, be it petrol or alcohol-based. In the case of ethanol this causes an even higher demand on plantations to meet the demand of fuel consumption. In the case of gasoline, the economic system is compromised due to price fluctuations.

Production costs: The inefficiency of the transportation system demands that companies operate with more stock and with higher risks of interruptions in production due to the lack of raw material, especially in the case of perishable products. This poses yet another risk for loss.

Table 4.3 Evolution of traffic costs in São Paulo city

Year	Traffic cost (Money lost) (A) R$	Lost opportunity cost (B) R$	Total cost of traffic in São Paulo (A + B) R$
2002	6,985,879,139.07	10,342,299,788.00	17,328,178,926.74
2004	7,300,650,847.88	13,128,172,049.00	20,428,822,896.69
2006	8,377,422,602.14	17,193,443,050.00	25,530,862,651.66
2008	10,107,981,983.43	24,282,318,282.00	34,490,300,265.60
2010	8,803,248,575.19	27,112,094,149.00	35,915,342,724.13
2012	9,983,704,463.74	30,175,803,397.00	40,159,507,860.97

Source Sobral (2013)

Loss in consumption and other activities: Time spent in traffic could be better used for production or social activities. Part of the population, especially residents in suburbs farther from the downtown area or from business centers spend a significant time in traffic. This lost time could be better used to increase the quality of life in big cities.

Sao Paulo city is faced with the challenge of finding a compromise between maintaining a transportation system needed to sustain economic growth and overcoming the deleterious effects of uncontrolled growth of the vehicle fleet as a result of the limited public transport system. To elaborate on this latter point, growth in the vehicle fleet produced an increase in traffic costs in the city as shown in Table 4.3.

A 42% increase in costs due to traffic can be observed during the period between 2002 and 2012, however, the cost to business opportunities grew even more, at 191% during the same period. The accounting for these losses suggests an amount of economic loss that impacts not only the megacity of São Paulo, but also the nation as a whole. In the next section environmental vulnerability issues due to climate change are presented for São Paulo.

Environmental Fragility

Forecasts point to a doubling in size of the metropolitan area of São Paulo by the year 2030 if the current growth trajectory continues. Importantly, the size of the outermost regions of the megacity, which are occupied by a low-income population and are vulnerable to disaster, is to increase. So is the number of floods during summer months. The São Paulo metropolitan area suffers from an increasing number of days with heavy rain; one study (Nobre et al. 2010) suggests that between the years of 2070 and 2100, the city will experience an increase in temperature of 2 °C–3 °C, which in turn may double the number of days with heavy rain (more than 10 mm.) in the city. This same study suggests that before 1950, this kind of heavy rain did not occur in the city at all, and that it was the megacity phenomenon that led to the problem. Combined with global warming, the number of days with heavy rain will be ever more frequent.

Travel by cars and trucks is part of a perverse cycle that is connected to the expansion of peripheral areas, economic growth, and consumerism facilitated by improvements in mobility. Combined with climate change it represents a huge challenge for the future. High dependency on fossil fuels contributes decisively to the increase of pollution in the metropolitan area and its surroundings. It is estimated that motor vehicle transportation is responsible for 70% of polluting emissions; 35% produced by motor vehicles running on gasoline and 32% on diesel fuels (Fig. 4.1).

As discussed previously, cities are presented with many demands and barriers related to urban and environmental management and it is important to mention that the pollution in cities is not only produced by vehicles. It also includes the whole structure of the city, which is composed of buildings and other facilities, so that development policy in urban centers should focus on countering the green-house effect and mitigating the effects of climate change in all its aspects. But, in the case of plans to mitigate and adapt to climate change in the city of São Paulo, specifically with respect to its transportation system, the goals (according to the Municipal Committee on Climate Change and Eco-economy and the Working Groups for Transportation 2011) are as follows:

1. Give priority to the use of public transportation
2. Give priority to non-motorized transportation
3. Give priority to change in the energy matrix, stimulating renewable fuels and clean energy
4. Implement measures to improve transportation efficiency and to expand intermodal integration.

These goals may not be sufficient to promote change in the city system, but they can be an important start in dealing with environmental vulnerabilities and simultaneously reduce the transportation costs caused by overwhelming traffic.

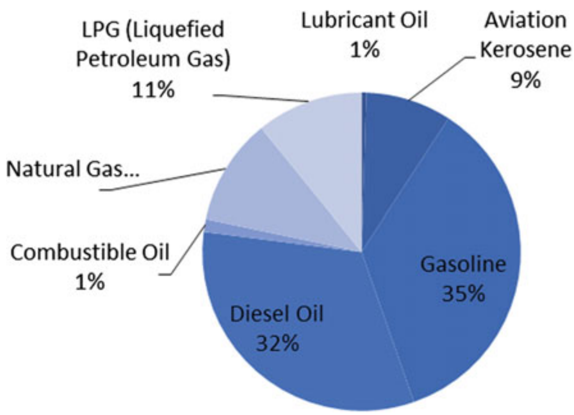

Fig. 4.1 Emissions in São Paulo city (2003) in GgCO2 equivalent

Final Considerations

São Paulo is a megacity with many issues, including uncontrolled urbanization—especially in peripheral areas—and a marked difficulty with regards to organization and management of environmental issues. The situation is complicated by social, economic, and political issues, to mention but a few. Historically, the city developed huge contrasts and contradictions during its development, leaving São Paulo un-prepared to deal with current environmental risks. Taking into consideration the expected increase in environmental instability in the future, the need for adaptation to climate change and also the need to reduce the impact of other related challenges should be taken into consideration now, not later. Transportation is vital for daily operations in any metropolis, but the lack of means to deal with the difficulties that go with it creates huge economic and opportunity costs and poses a risk to public safety.

In this chapter we offered some ideas on how current environmental issues in an urban area can be amplified by climate change. We used the case of the transportation system to argue that a plan based solely on the immediate needs of motor vehicles can exacerbate and accelerate environmental issues and their associated risks. The city as a whole will be affected by related losses, and moreover the uncontrolled occupation of the city's furthest areas places the population in danger. The transportation system has, and will continue to have, a key role in megacity form and development: the transportation of persons and goods is an inherent characteristic of big cities with dynamic production and social life. That said, coordinated actions, as well as measures to promote a more resilient city, are needed. The city needs to build capacity for adaptation and to mitigate environmental changes.

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Chapter 5
Disasters and Their Impacts on Air Quality in the Human Living Environment

Yoshika Sekine and Naohide Shinohara

Abstract Although clean air is one of the most important necessities for human life and health, the risk of natural disasters causing air pollution that reduces or inhibits "resiliency" of the victims and communities has not been well understood. This chapter examines the secondary disaster of the air pollution events induced by the Great East Japan Earthquake and subsequent tsunami in 2011—such as the release and diffusion of radioactive substances from the severely damaged Fukushima Daiichi nuclear power plant, chemical contamination in indoor air of temporary housing built (so-called Sick House Syndrome), and the scattering of asbestos fibers liberated by the quake and tsunami. Air pollution is something that often cannot be seen until severe impacts are noticed later. The paper then describes the importance of air quality monitoring by scientific means and sharing knowledge for risk recognition and immediate pollution controls based on the identification of source of problems for risk reduction, in the context of resilience.

Introduction

In assessments of human well-being, poor air quality is one of the typical kinds or causes of human insecurity, but people often pay little or no attention to the deteriorating quality of air until it begins to harm their health, erode ecological systems, or generates unexpected impacts on the global climate (Wang and Sekine 2009). Natural disasters may cause significant physical destruction, loss of life and property, and drastic changes to the environment. Some disasters, such as forest fires and volcanic eruptions, become a source of air pollution, which increases the

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risk of respiratory and heart disease in the population, by emitting large amounts of gases and particles into the atmosphere (Brimblecombe 1996). Meanwhile, little is known about the *secondary disasters* of air pollution induced by natural events such as earthquakes, floods, tsunamis, landslides, hurricanes, and so on. Since secondary air pollution is not a direct result of a disaster (it is often man-made) and sometimes occurs in indoor environments, it often merely becomes a popular topic of discussion. However, in previous instances disaster victims or their communities have suffered from health problems caused by disaster-induced air pollution in the human living environment. Examples include the chemical intolerance of hurricane and earthquake victims living in temporary housing (Tang et al. 2009) and latent illness caused by past exposure to asbestos (Mainichi Shimbun 2012).

On March 11, 2011, the Great East Japan Earthquake and subsequent tsunami devastated the northeastern coast of Japan. The tsunami swept away most coastal towns and cities in the region, destroying many buildings and much infrastructure, and severely damaging the Fukushima Daiichi nuclear power plant, which led to the release of radioactive substances into the environment. While this natural disaster caused catastrophic environmental degradation in many ways, this study focuses on secondary air pollution problems that threaten human comfort and health, namely the diffusion of radioactive substances, chemical contamination in temporary housing, and the scattering of asbestos. Figure 5.1 illustrates major and possible human health concerns related to air pollution problems induced by the 2011 earthquake.

In this chapter, we attempt to identify the vulnerability of air quality in the human living environment, in the context of the 2011 disaster, and discuss the importance of monitoring air quality in order to recognize risks in terms of resilience.

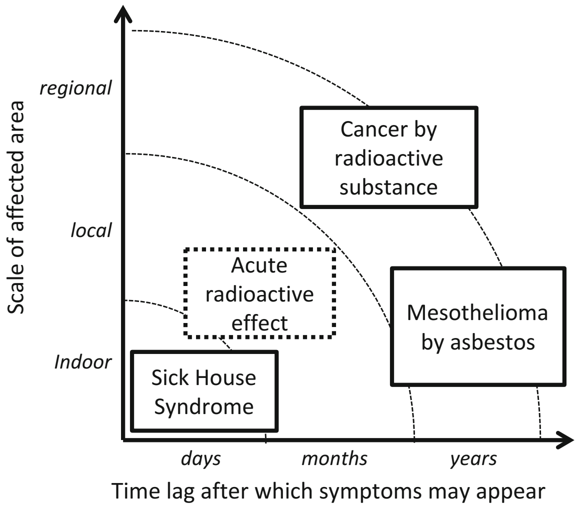

Fig. 5.1 Conceptual image of the potential health problems related to air pollution induced by the Great East Japan Earthquake. The issues are categorized by both the scale of the affected area and the time lag after which symptoms may appear after significant exposure to each air pollutant

Diffusion of Radioactive Substances

The Fukushima Daiichi nuclear accident consisted of a series of power failures beginning on 11 March 2011, nuclear meltdowns, and releases of radioactive substances at the nuclear power plant. It is the largest nuclear accident since the 1986 Chernobyl nuclear accident and has to date been classified as a Level 7 event (major accident) on the International Nuclear Event Scale. On March 14, a total of 77,000 residents were evacuated from ten towns and villages within 20 km (kilometers) of the power plant, and people living within 20–30 km of the site were urged to stay indoors because of leakage of radioactive substances into the atmosphere from the containment unit damaged by hydrogen explosions at the plant. While the release of radioactivity to the environment is of concern, owing to the potential acute and long-term health effects, radiation levels in the atmosphere indicated the long-range transport of radioactive nuclei even in the Kanto region (in the eastern half of Japan, which includes Tokyo and Kanagawa Prefecture). However, the number of radiation monitoring sites was not sufficient to properly ascertain the distribution of radioactivity both in time and space. Insufficient information aroused a feeling of fear among citizens about the accident, and the public's general lack of scientific literacy on radiochemistry spurred further confusion. Some people voluntarily evacuated from the Kanto region to the western part of Japan, while some foreign students and residents decided to leave the country.

During this time, the authors were carrying out regular sampling of airborne particulate matter at Hiratsuka, in the prefecture of Kanagawa, approximately 260 km from the damaged plant, for the observation of yellow sand carried by air flow from the Asian continent. Aware of the possibility of the transport of radioactive substances from the plant, we then began immediate measurements of radioactivity of the collected particulate matter. Our findings included the presence of radioactive cesium (134-Cs, 137-Cs), iodine (131-I, 132-I), and tellurium (132-Te), which are relatively volatile nuclei typically produced by nuclear reactions involving uranium, and were likely released from the plant (Ikeda and Sekine 2012). These findings suggested that the deposition of radioactive nuclei onto the ground may have produced "radiation hot spots," or sites specifically contaminated by radioactive substances, even in the Kanto region. This situation was soon proven by the detection of high levels of radiation in agricultural products and radiation monitoring by the government, conducted by aircraft, in September 2011 (MEXT 2011). Our detailed investigations also showed that the radioactive substances were transported by air in the form of fine particles with a diameter of approximately 1 μm (micrometer) (Ikeda and Sekine 2012). Such fine particles, when inhaled, can be deposited in airways or lungs. Long-term exposure to these radioactive fine particles may increase the incidence of adverse health effects such as thyroid cancer and leukemia. This information was shared with the scientific community to encourage the evaluation of risk to humans.

After the major release of radioactive materials on March 15 and 16, 2011, the leakage of these materials from the damaged plant decreased due to the great efforts of plant workers and luck. Based on monitoring and epidemiological data, a World Health Organization (WHO) report in 2013 concluded that the predicted risks were low and no observable increases in the occurrence of cancer above baseline rates were anticipated for the general population inside or outside of Japan (WHO 2013). However, even at the controlled level, many people in Fukushima and the surrounding area are still being exposed to radiation at present. It is coming from the soil, plants, and pavement contaminated through air pollution. Since there is still existing uncertainty on the health effect of exposure to low levels of radiation for decades, especially on babies and children, the victims are forced to be in invisible, unexpected, and latent fear of the radioactivity. It is essential to remove the radioactive substances from the living environment in order to promote the "resiliency" of the victims and their communities.

Indoor Air Pollution Caused by Chemicals in Temporary Housing

Many people who lost their homes due to the earthquake and tsunami, or who lived within a 20 km radius of the plant, were forced to evacuate to temporary housing areas. More than 54,000 temporary houses have been built since the disaster in the prefectures of Miyagi (22,000), Fukushima (18,000), Iwate (14,000), and others (METI 2012). Related to this housing, it is important to be aware of the indoor air quality of the newly-built temporary houses. Studies have described the problem of secondary air pollution caused by harmful chemicals that produce the so-called "sick house syndrome" (SHS). For instance, when Hurricane Katrina struck the Gulf Coast of the United States in 2005, victims were temporarily housed in trailers provided by the government. The trailer residents soon reported sinus infections, respiratory problems, and a burning sensation in the eyes, due to exposure to dangerous levels of formaldehyde gas in the indoor air (Parthasarathy et al. 2011; Maddalena et al. 2009; Madrid et al. 2008). After the 2008 earthquake in Sichuan, China, many survivors, including expectant mothers, moved to into temporary mobile homes. Though the Sichuan government explicitly prohibited media organizations from reporting, more than 100 miscarriages by women were found in the community, probably because of exposure to high concentrations of formaldehyde emitted from interior materials (New York Times 2009).

Ordinarily, indoor air quality in newly built permanent dwellings is regulated in Japan by guidelines for indoor air concentrations of volatile hazardous chemicals and by building codes that mandate ventilation and emission rates of formaldehyde from building materials. Temporary housing, however, is exempted from Japan's building code. Furthermore, house builders may have felt compelled to use interior building materials without considering emissions of volatile hazardous chemicals, due to shortages of proper materials to construct the large quantities of temporary housing required to meet the immediate and simultaneous demand for housing of disaster victims. Knowing these circumstances, researchers in the field of indoor environments became concerned about the health effects of poor indoor air quality in the newly built temporary dwellings.

Miyagi prefecture required builders to report indoor air concentrations of only five specific chemicals (formaldehyde, toluene, xylene, ethylbenzene, and styrene), and testing was only required for one house per construction order (typically 50–60 houses). The five chemicals were subject to the Housing Quality Assurance Act in 2002 and the Standard of School Environmental Sanitation in 2004. Some experts, however, call for more detailed and extensive testing in order to prevent indoor air pollution problems, because chemicals other than the five compounds are known to have caused health disorders in recent cases (Kobayashi et al. 2010). Subsequently, the authors urgently conducted a field survey on the indoor air concentrations of chemicals at five houses in one temporary housing area in Miyagi in June 2011, with the cooperation of the Miyagi prefectural government (Oikawa et al. 2011). The target substances were three carbonyl compounds, 43 volatile organic compounds, and total volatile organic compounds (TVOC). The results showed that the indoor air concentrations of chemicals whose indoor air guidelines were previously set were below the guideline levels at all sampling sites. However, TVOC concentrations ranged from 1,700 to 3,000 μg per cubic meter (m^3), 4–7.5 times higher than the tentative guideline for TVOCs. Chemicals not regulated by the governmental countermeasures contributed to such extraordinarily high concentrations of TVOCs in the temporary houses surveyed. The results were soon announced on the website of the Society of Indoor Environment, Japan (SIEJ), for the reference of indoor air quality of temporary houses under construction. A broader and more exhaustive survey was conducted separately at 19 newly-built temporary houses in Minamisoma City, Fukushima Prefecture, from August 2011 to January 2012 (Shinohara et al. 2013). The mean air changes per hour in the temporary houses were 0.28, and no 24 h ventilation systems were installed. To an expert, these facts suggest the houses are air-tight compared with ordinary houses (the Japanese standard requires 50% air change of a house every hour) and can potentially lead to severe indoor air pollution when stand-alone combustion heaters are used in winter. Meanwhile, indoor concentrations of volatile organic chemicals other than acetaldehyde and TVOCs did not exceed the indoor guidelines even in the air-tight houses. Although there was a report on suspected sick-house syndrome incidents (Jiji Press 2011), the secondary disaster of indoor chemicals in temporary houses has not been remarkable, probably because of careful use of building materials and monitoring by both the government and voluntary research groups.

Incidentally, the survey in Minamisoma also showed that the shielding effect from radiation was less in temporary houses than in reinforced concrete or steel-framed buildings (Shinohara et al. 2013). The air-tight temporary houses were good at preventing the penetration of airborne particulate matter or dust, even when the air was contaminated by radioactive substances, but radiation from radioactive substances may pass through the walls of the houses. These findings suggest that the shielding effect of the buildings' roof and walls should also be considered as an important item for the further improvement of specifications of temporary houses in order to reduce cancer risk caused by radiation when will be built in the contaminated sites.

Asbestos, A Time Bomb

Meanwhile, the Great Hanshin-Awaji Earthquake in 1995 destroyed many buildings containing asbestos, a long, thin fibrous crystal of silicate minerals used for thermal or sound insulation and fire-proofing. In 2011, 16 years after that quake, a man who had worked disposing of earthquake debris died from mesothelioma, probably due to past inhalation or ingestion of asbestos fibers liberated by the quake (Mainichi Shimbun 2012). It is predicted that the number of victims will increase in the near future, because symptoms often do not appear until decades after exposure to asbestos. A similar situation can be predicted for the 2011 earthquake and tsunami case, from which disaster-related wastes are being collected at temporary waste storage sites in great amounts. The asbestos-containing wastes, as well as other hazardous wastes, are being separated from other waste and disposed according to their properties, in accordance with the "Guidelines for Disaster Waste Management after the Great East Japan Earthquake" by Japan's Ministry of Environment. Past experience has shown that it is essential to control the exposure of workers to airborne asbestos in order to reduce the risk of mesothelioma throughout the treatment process. The failure to do so can turn inhaled asbestos into the equivalent of a time bomb.

Conclusion

Natural disasters may well be unavoidable by human intervention, but secondary disasters that reduce or inhibit the "resiliency" of the victims and their communities could be better managed by identifying the sources of problems. As mentioned above, the Great East Japan Earthquake induced serious air pollution problems in the human living environment. Air pollution is something that often cannot be seen until severe impacts are noticed later. Air quality monitoring by scientific means is therefore essential in order to minimize environmental health risks. In addition, measurement systems or tools should be made more easily accessible for non-professionals so that anyone can ascertain the status of personal air quality in an emergency, with a special priority for children, the elderly, and the poor, and people who are already ill, as these groups are more susceptible than the general population to the risks of air pollution.

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Chapter 6
Vulnerability of Pastoral Social-Ecological Systems in Mongolia

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Pastoral systems, where humans depend on livestock, exist largely in arid and semi-arid ecosystems in Mongolia, where climate is highly variable. In many ways, pastoral livestock systems are intimately adapted to climatic variability. Extensive nomadic systems are found in the most variable regions; less extensive, more intensive modes of livestock management occur in areas where forage dependability is more secure. Direct feedback exists between nomadic land-use systems and ecosystem dynamics. Interactions between ecosystems and nomadic land-use systems co-shaped them in mutually-adaptive ways, making both the rangeland ecosystem and nomadic pastoral system resilient and sustainable. This chapter shows how changes in climate variability, ecosystem dynamics, and socioeconomic factors have been interacting in novel ways to determine nomadic land-use systems during the past several decades in Mongolia. The traditional resilience of pastoral community-cultural landscape systems is being affected by climate and socioeconomic changes related to global warming, mining, and goat-cashmere production, which have led to losses in resilience and further degradation of the rangelands, peri-urban areas, and water bodies. This is an example of a "tragedy-of-the-commons". Opportunities still exist, however,

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for a sustainable transformation pathway to conserve ecological, social, and cultural resilience associated with these rangeland ecosystems. Different policies need to be applied in different ecological-economic zones of Mongolia. Traditional pastoral community-cultural landscape systems should be strengthened in the western part of the country; modern de-centralized technologies should be introduced, such as renewable energy and wireless communication technology; and value-added approaches are needed to manage livestock, raw materials and sustainable tourism in central part of the country.

Introduction

The Mongolian rangelands have a diversity of ecosystems, ranging from forest-steppe in the north, to the Gobi Desert in the south, with the steppe ecosystem dispersed in between. The Altai Mountains in the southwest, along with the Khangai Mountains and the Khentii Mountains in the north-central part of the country, add to a diversity of landscape, habitat, and resource availability. The Mongolian nomadic pastoral cultures occur as an emergent feature of the variable ecosystem dynamics of the arid and semi-arid systems (Chuluun et al. 2011). These pastoral systems have adapted to variable environmental conditions responding to variation in resource availability. The emergence of hierarchical pastoral networks or cooperative groups based on common location of grazing and family relationships, as a complex adaptive system, increases the resiliency of these systems to climate variability.

Recently, evaluation of the pastoral systems has been conducted in the region (Ojima and Chuluun 2008; Fernández-Giménez 2006). Pastoral systems, where humans depend on livestock, exist largely in arid and semi-arid ecosystems where the climate is highly variable. Thus, in many ways pastoral systems are resilient to climatic variability. The Mongolian pastoral systems are very sensitive to climate variability and extreme events, such as drought, fires, pests, and *zud* (the Mongolian term for severe winter conditions for livestock). Various winter conditions affect pastoral vulnerability in Mongolia: too much snow (white *zud*), too little snow (black *zud*), or ice-cover of pastures (iron *zud*). These *zud* types cause a decrease of forage and water availability for livestock in Mongolia. It is plausible to assume a direct connection between climate variability, ecosystem dynamics, and the nomadic land-use system in Mongolia. Interaction between ecosystems and nomadic land-use systems has co-shaped them in mutually adaptive ways for hundreds of years, thus making both the Mongolian rangeland ecosystem and nomadic pastoral system resilient and sustainable; however, socioeconomic and climate conditions of the past several decades are affecting these management systems in dramatic ways.

Throughout the region, large changes in environmental, demographic, political, and economic driving forces in Mongolia during the past two decades have affected the pastoral systems. The general trend involves greater intensification of resource exploitation at the expense of traditional patterns of extensive range utilization. These sets of social factors tend to override the climate drivers during periods of economic change. Thus, climate relationships to land use/land cover have been modified by these socioeconomic changes and are leading to over-exploitation of natural capital. These changes have resulted in a more sedentary livestock management system, to more intensive stocking rates in localized areas, especially around water facilities and villages, and changes in the animal breeds used. During the past decades, political changes and opening of economic constraints have led to modifications in pastoral management due to relaxation of central government controls, privatization of livestock, and access to "free enterprise" and open-market systems. What will result from these recent changes is unclear, and the effect on human and natural resources of these arid and semi-arid regions needs to be determined (MNE 2001).

The majority of lands (about 90%) in Mongolia are drylands (Mandakh et al. 2007). Hyper-arid, arid, and semi-arid zones occupy more than 80%, and the dry sub-humid zone occupies less than 10% of the country's territory. The deserts (southern part of the desert-steppe) fall into the hyper-arid zones. The desert-steppe (northern part of the desert-steppe) and dry steppe fall into the arid zones. All other steppe ecosystems, such as steppe, mountain steppe, forest steppe, and meadow steppes, are included in the semi-arid zones. This aridity greatly contributes to the sensitivity of this region to climate warming and variability in precipitation, and pastoral responses to this range of aridity is reflected in the mobility of nomadic patterns of pastoralists. Some of the hyper-arid zones are not used by herders, and herders in the dry sub-humid zones are the least mobile, moving for short distances and only twice a year between summer-fall and winter-spring pastures. Herders, living in arid and semi-arid landscapes, are more mobile with seasonal movements.

The response of pastoral systems to political and economic changes has led to a tripling of goat numbers and a reduction in cattle numbers across Mongolia since its transition to a market economy, due to the cashmere industry, with both socioeconomic and ecological consequences. This set of drivers is orthogonal to the above described climate drivers. Thus, we expect climate-land/use-land cover relationships to be crucially modified by the socioeconomic forces mentioned above. Nevertheless, the complex relationship between climate variability and pastoral exploitation patterns will still form the environmental framework for overall patterns of land-use change.

In order to understand changes of key environmental and social factors such as drought, *zud*, grazing intensity and poverty, and their integrated impact on pastoral social-ecological systems, it is necessary to make vulnerability assessment of pastoral systems spatially and temporally. The objective of this chapter is to assess current trends in key factors affecting the vulnerability of the Mongolian pastoral social-ecological systems to climate and other stresses during the past decades.

Method for Vulnerability Assessment of Social-Ecological Systems

Vulnerability is the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt (Adger 2006; Coleen et al. 2007). Ecological vulnerability is high with drought and *zud* increase and plant biomass decrease due to overgrazing. Ecological vulnerability includes drought, *zud*, and the pasture-use index. The integrated vulnerability of social-ecological systems is presented by combination of ecological vulnerability and poverty level in Fig. 4.4.

There are many types of zud, including white, black, stormy, cold, iron, and glassy, according to herders' traditional evaluation. Often, the impact of drought is made apparent during winter and spring zud conditions. Therefore, it is better to combine summer-time drought events in data for the following winter when assessing conditions in Mongolia.

Vulnerability Index of Social-Ecological Systems

This index is derived by combining the ecological vulnerability index and poverty index as in Eq. 6.1.

$$SE = V + P \tag{6.1}$$

SE Vulnerability index of social-ecological systems;
V Ecological vulnerability Index;
P Poverty index (NSO and UNDP 2009).

Ecological Vulnerability Index

We calculated drought, *zud*, and grazing intensity indexes and assessed the ecological vulnerability of pastoral social-ecological systems at different inter-connected scales for the country. We calculated drought and *zud* indexes first, then the integrated *zud* index, which incorporates previous summer droughts, and overlays drought and *zud* assessments. We produced an ecological vulnerability assessment of pastoral systems by overlaying an integrated *zud* map and rangeland use map, as shown in Fig. 6.1, assuming that the vulnerability of pastoral systems would be greater if both climatic disasters, such as drought and *zud*, and rangeland-use intensity are high. The methods used in each assessment are described in more detail below.

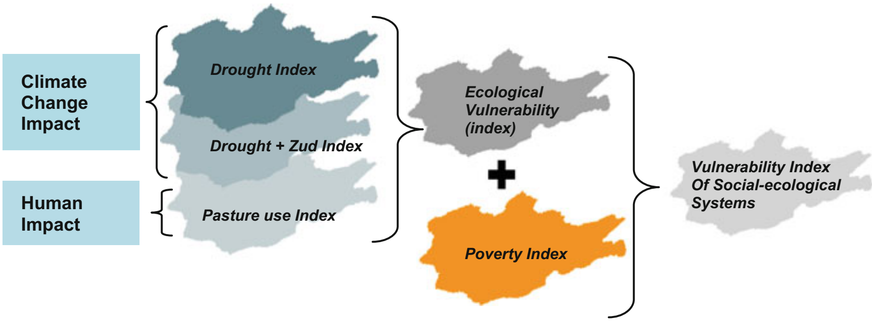

Fig. 6.1 Schematic diagram of the vulnerability index calculation

The vulnerability index of pastoral systems to climate and land-use changes was calculated as the sum of the *zud* index and grazing intensity index. The vulnerability of rangelands is higher when both *zud* and rangeland-use intensity are higher (Eq. 6.2).

$$V = \Delta N + \Delta S \tag{6.2}$$

ΔN is the grazing intensity index; ΔS is the *zud* index (it integrates previous summer drought).

Integrating the Zud Index

Natsagdorj et al. (2003) developed an integrated zud index based on the fact that zud occurred when winters were colder by 2–7 °C (degrees Celsius) than normal and had snow deeper than 15–20 cm (centimeter). Also, the biggest livestock loss happened during zuds when there was a previous summer drought. For example, 8 million animals (1/3 of total livestock) were lost during the 1944–1945 zud. A severe drought happened in 1944, and the temperature between November 1944 and April 1945 was minus 5.9–14.4 °C colder than the long-term average, the snow depth was 15–28 cm, and cold storms were happening frequently. Thus, the integrated zud index (Natsagdorj and Sarantuya 2004) is higher when winter is colder and snowy, and summer is drier and hot. This integrated zud index (Eqs. 6.3 and 6.4), which accounted for the previous summer drought, had a very good correlation with the livestock numbers lost during the zud. The summer drought index and winter indexes were calculated using Ped index-difference normalized temperature and normalized precipitation indexes as:

$$S_{summer} = \sum_{t=1}^{n} \left(\frac{T - \overline{T}}{\sigma_T} \right) - \sum_{t=1}^{n} \left(\frac{R - \overline{R}}{\sigma_R} \right) \tag{6.3}$$

$$S_{winter} = \sum_{i=1}^{n} \left(\frac{T - \bar{T}}{\sigma_T} \right)_i - \sum_{i=1}^{n} \left(\frac{R - \bar{R}}{\sigma_R} \right)_i \tag{6.4}$$

where T_i and R_i—temperature and precipitation for particular months at the "i" station.

T_i and R_i—an average temperature and precipitation for particular months at the "i" station.

σ_T and σ_R—fluctuation of temperature and precipitation for particular months at the "i" station, defined with the following formula:

$$\sigma = \sqrt{\frac{1}{n-1} \cdot \sum_{i=1}^{n} (x - \langle x \rangle)^2} \tag{6.5}$$

where x_i is the "i"-th value of x and <x> is arithmetic average.

A drought is severe when S_{summer} has high value (with high temperature and low precipitation), and *zud* is severe when S_{winter} has low value (with low temperature and high precipitation). The integrated *zud* index, which considers previous summer drought conditions, is defined as the difference between drought and *zud* indexes (Natsagdorj and Sarantuya 2004):

$$\Delta S = S_{summer} - S_{winter} \tag{6.6}$$

The integrated *zud* index (Natsagdorj and Sarantuya 2004) has high value (*zud* is severe), when S_{summer} has higher value (summer is drier and hotter) and S_{winter} has lower value (winter is colder and snowy).

We calculated the *zud* index, making slight modification in terms of winter and summer months to capture the seasonal difference in different ecological zones. The integrated *zud* index accounted only for white *zud*, in other words winter condition with a lot of snow. Black *zud* (no snow condition) was not considered in that index, and even black *zud* conditions is considered as not a severe condition. However, winter precipitation and duration of snow cover are decreasing in the Gobi and dry steppe regions due to global warming. No snow conditions haves double-negative impacts: no drinking water for both animals and herders in winter and no snow moisture in spring for plant growth. Therefore, we decided to include black *zud* in our assessment. We considered black *zud* conditions to be when winter precipitation was less than 20% of long-term average, and this is indicated by reversing the sign before S_{winter} in Eq. 6.6.

Grazing Intensity Index

Grazing intensity relative to carrying capacity index was calculated using Eq. 6.7:

$$\Delta N = \alpha\left(\frac{N - N_o}{N_o}\right) \tag{6.7}$$

where N—livestock density, sheep unit/ha; N_0—carrying capacity, sheep unit/ha (MAS 1990, 2009; Tserendash 2006); α—pasture management coefficient. This grazing intensity index is high and positive when livestock density exceeds carrying capacity.

Research Outcomes and Discussion

Drought Assessment

Drought was assessed in temporal and spatial scales at the aimag level (an aimag is equivalent to a province) for Mongolia. Drought incidence had an increasing trend during the 68 years between 1940 and 2008 (Fig. 6.2). The highest drought average index was in Omnogovi, Hovd, and Uvs aimags during the period 1970–1990, but the area with the same high index was expanded into central and western parts of Mongolia since 1990. Uvs, Hovd, Govi-Altai, Bayanhongor, Omnogovi, Dundgovi, and Tov aimags are on this list. Increased drought frequency and intensity during the last 68 years can be explained by global warming. Knowledge of current drought trends and dynamics is very important, not only to minimize and prevent future risks but also for the development of climate change adaptation policy and implementation.

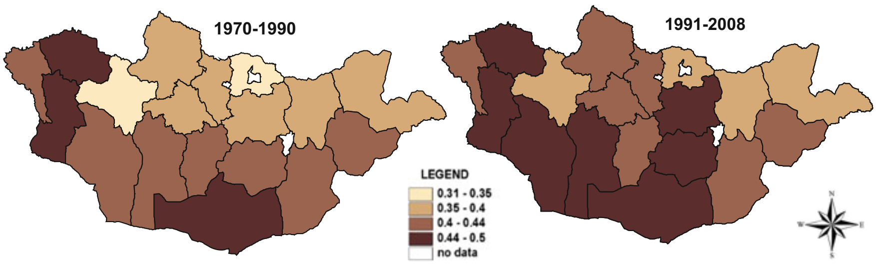

Fig. 6.2 Drought assessment of Mongolia

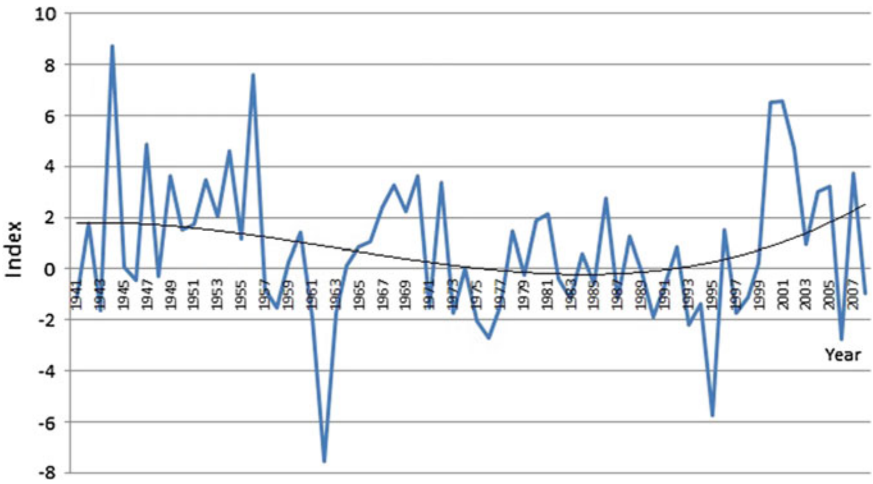

Fig. 6.3 Long-term zud dynamics of Mongolia

Zud *Assessment*

Natsagdorj and Sarantuya (2004) calculated a *zud* index, which incorporated drought from previous summers, for the period 1940–2002. This index accounts only for white *zud*. We calculated a *zud* index that includes both white and black zud, also incorporating drought instances from the previous summer. Temporal dynamics and spatial distribution of integrated assessment of drought and *zud*s for the period 1940–2008 are shown in (Fig. 6.3).

We can generalize three different periods: high (until 1956), low (1957–1998), and high (since 1999) of an integrated overall *zud* index for Mongolia, which does not show any spatial characteristics. Comparison of drought and *zud* conditions between 1970–1990 and 1991–2008 periods shows *zud* with previous summer drought conditions was prevailing in Hovd, Dundgovi, and Dornogovi aimags for the period 1970–1990, but it has been prevailing in the western and southern parts of Mongolia since 1994. The Gobi aimags Hovd, Govi-Altai, Dundgovi, Dornogovi, Omnogovi, Uvs, and Bayanhongor are the most vulnerable to climate disasters; other aimags located between the Govi, Khangai, and steppe region are also vulnerable to climate disasters.

Grazing Intensity Index

In addition to climate change, human factors are critical for land degradation and desertification. Overgrazing tends to be increased in central regions, where human density is increasing due to migration from rural to urban areas. The grazing

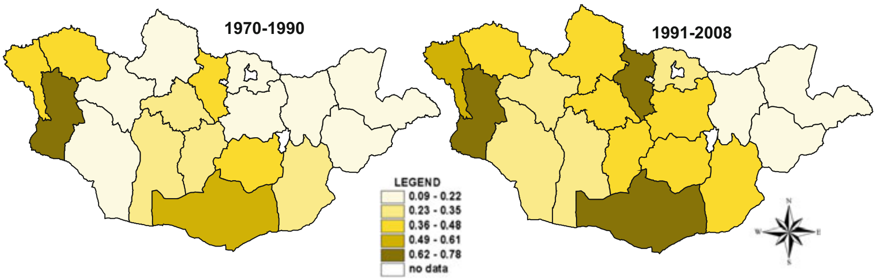

Fig. 6.4 Grazing intensity assessment of Mongolia

intensity index defined by livestock density relative to carrying capacity is shown spatially and temporally. Hovd aimag, followed by Omnogovi, Dornogovi, Bayan-Olgii, and Uvs aimags over-used their pastoral resources for the period 1970–1990, and the whole western and central regions started to overgraze since 1990. The Hovd, Bulgan, and Omnogov aimags are leading in terms of overgrazing. Pasture-use dynamics follow the same pattern as livestock dynamics, being relatively constant for the period 1970–1990, increasing until 1999, and then dropping due to droughts and *zud*s, and increasing again since 2002 (Fig. 6.4).

The Mongolian pastoral system was resilient in terms of livestock recovery since 2002, but it is not sustainable from the coupled social-ecological point of view. The rangelands are being degraded by overgrazing, exceeding carrying capacity. In addition, it is possible that we may face a major economic drop if similar climate disaster events as in the period 1999–2002 recur. We could have had less loss even during the 1999–2002 events if we had a successful policy in meat export. Increased meat export is a win-win situation both socio-economically and ecologically.

Ecological Vulnerability Assessment

We tried to assess ecological vulnerability in temporal and spatial dimensions for the first time in Mongolia (Fig. 6.5). Climate disasters and grazing intensity were two factors we accounted for in this assessment. Ecological vulnerability is high when both *zud* risk (with previous summer drought) and overgrazing are high (Altanbagana and Chuluun 2010).

Ecological vulnerability was high in the three western aimags (Hovd aimag was the most vulnerable) and in the three southern Govi aimags (Omnogovi was the most vulnerable). However, ecological vulnerability has increased enormously since 1994. Ecological vulnerability increased almost everywhere, with the only exceptions being northern (except Bulgan) and eastern aimags. Dundgovi, Uvs, and Bulgan are added to the list of most vulnerable aimags. It is likely that ecological

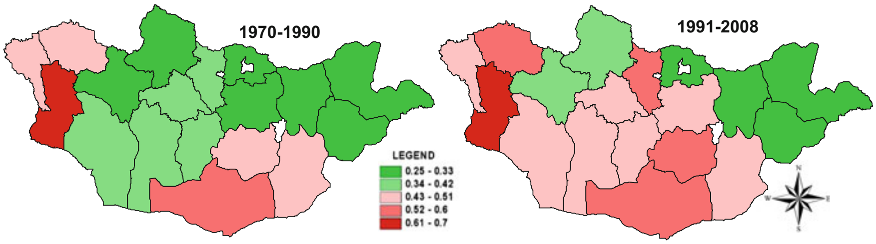

Fig. 6.5 Ecological vulnerability assessment of Mongolia, including Biophysical (drought, zud) and Human (pasture degradation) impact

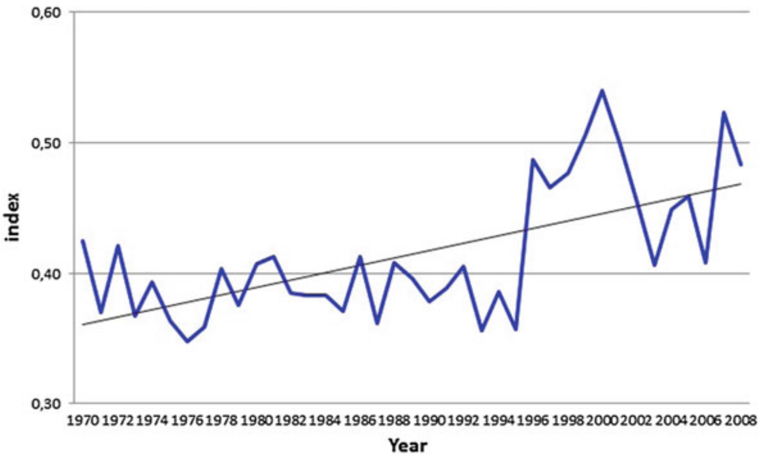

Fig. 6.6 Long-term ecological vulnerability dynamics in Mongolia

vulnerability at the country scale jumped to a higher level since the mid-1990s, according to the long-term dynamics, increasing by about 8% (Fig. 6.6).

Vulnerability Assessment of Social-Ecological Systems

Figure 6.7 shows the social-ecological vulnerability of Mongolia based on the population census of 2000 (NSO and UNDP 2009) and ecological vulnerability index (Chuluun et al. 2011). Social-ecological vulnerability was assessed by combining ecological vulnerability and poverty indexes. According to Fig. 6.7, the most vulnerable aimags are Hovd, Uvs, and Dundgovi aimags. The social vulnerability index determines the poverty level because vulnerability increases due to poverty. In remote areas, the social-economic vulnerability increases because of high transportation cost, low infrastructure development, and high poverty level.

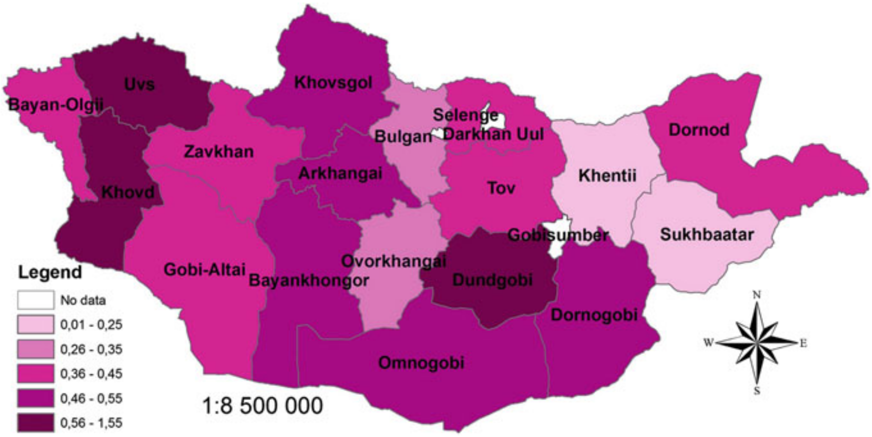

Fig. 6.7 Vulnerability assessment of pastoral social-ecological systems

Vulnerability of Ecological Zones

Ecological vulnerability (Fig. 6.8) was assessed in ecological zones. Seven aimags were integrated in the Govi region: three aimags in the transition zone between the Govi and Khangai mountains, two aimags in the steppe region, and six aimags—in the forest steppe region. Ecological vulnerability of pastoral human-environmental

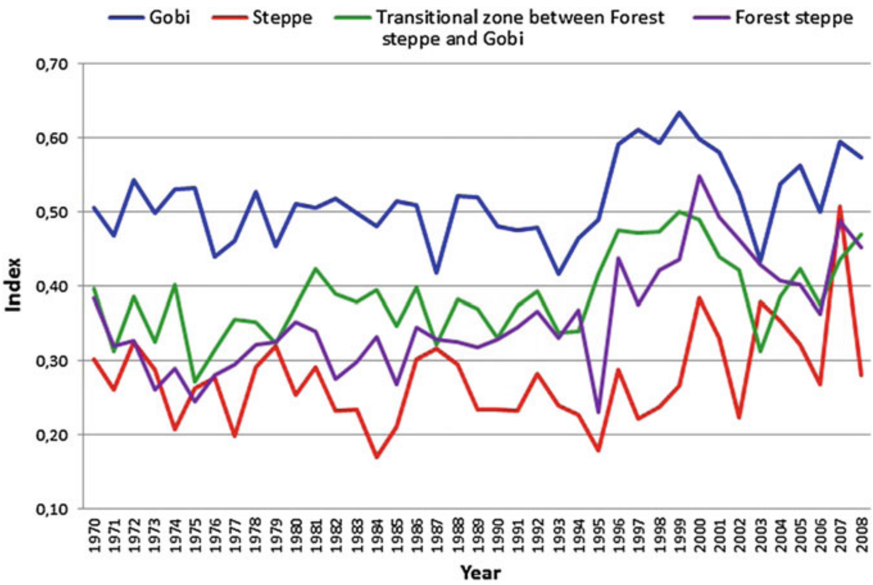

Fig. 6.8 Long-term ecological vulnerability dynamics in ecological zones of Mongolia

systems, calculated as sum of drought-*zud* and pasture use indexes, had increasing trends in all ecological zones during the last decade. The ecological vulnerability index in the Govi zone was the highest relative to other ecological zones, however it rapidly increased in the forest-steppe and steppe zones during the last decade.

Vulnerability Implications

During the transition to capitalism, livestock, shelters, and wells were privatized and customary rights to certain pasture lands became weak or unclear, especially in central Mongolia. Now local governments are responsible for resolving land-use disputes rather than using the former policies of the negdel (socialist cooperative) period. Although some vestige of customary herding rights remain in current policy the transition is problematic because of the lack of clarity about authority and access rights.

Similarly, livestock numbers were relatively stable until 1990, oscillating between 20 and 25 million animals. However, since the privatization of livestock ownership and entry into an open-market system, livestock numbers have been increasing, despite occasional but dramatic losses during *zud* events. A dramatic example can be seen in the goat population, which nearly tripled in number due to increased access to the global cashmere market. In this way opening Mongolia to the global market has had a drastic effect on herders, especially with the cashmere export opportunity to China (NSO 2003, 2006, 2008).

The existing behavior of herders—which is to maximize livestock numbers and which is the rational choice of herders in the existing incentive structure—is the primary challenge to developing a sustainable rangeland management system. The solution is to find and implement mechanisms and tools to encourage herders in adopting more sustainable strategies of income generation, namely, building their own capacity to mitigate risks, improve productivity, and develop alternative businesses. Productivity improvement and alternative income generation activities are particularly crucial for changing the existing behavior of herders and to maximize animal numbers while compensating for potential income loss as a result of restricting animal numbers.

Two interesting self-organizing processes are currently ongoing in Mongolia. The first is the migration from rural to urban areas. The central region, where three major cities are located, with about half of the population, and which has the best infrastructure and social services in the country, became an attractor for rural populations. The new Mongolian Constitution of 1992 guarantees people the right of free choice in their place of residence. This is the legal basis for the ongoing internal migration process in the country. Rural to urban migration can be seen to peak after a *zud* event (i.e., after drastic loss of herders' animal population due to the severe weather). The second trensd is the emergence of traditional pastoral networks such as hot ail (several households living together) or neg golynhon (traditional community from one river).

The key to sustainability lies in enhancing the resilience of communities (Walker and Salt 2006). Resilience is the ability to absorb change and still retain basic function and structure. Interestingly, cooperatives based on traditional pastoral networks first emerged in response to drought and extreme winter conditions in 1999–2002 in Mongolia. A comparative study of pastoral communities showed that a pastoral community, where a cooperative was based on a traditional network, had lost less livestock compared to other communities during the recent climate disaster (Fernández-Giménez 2006).

Today the Mongolian rangelands are at the bifurcation stage between two pathways: predominantly private land ownership versus traditional land-use culture operated by traditional, resilient pastoral networks. It appears that enhancement of cooperatives based on these letter networks will lead to a reduction in the future vulnerability of Mongolian pastoral systems. Adaptation options in the past included the development of cultural landscape restoration, which incorporated community based conservation and sustainable use of natural resources, the addition and protection of water points for additional pastureland, the agreement between neighboring sums for the communal use of otor (pasture used by some herders to fatten livestock) and reserve pastures, and the enlargement of administrative-territorial units in order to restore cultural landscapes (Chuluun et al. 2008). For pastoral communities living in riparian zones, current options for adaptation include diversification of the economy and intensification of the livestock industry through ecotourism and farming, the prevention of riparian ecosystem degradation and desertification, and taking animals to otor pastureland during the summer period. Protection of springs from degradation by livestock was critical for communities living in the mountain and forest steppe.

The key resources and ecosystems for pastoral social-ecological systems are water and supporting riparian and forest ecosystems. Pastoral systems are sensitive to any change in water resources due to global warming (i.e., disappearance of water sources, reduction of water resources, delayed or early melted snow, permafrost melting, and snowless conditions). Because of their importance the protection of what might be called "natural green walls"—riparian ecosystems and forests—is perhaps the most valuable adaptation measure possible at the present time.

The development of modern cultural landscapes in Mongolian rangelands includes the strengthening of pastoral traditional networks with introduction of modern technologies such as wireless communication, renewable energy resources, access to appropriate livestock breeding, use of healthy veterinary practices, and access to markets of more finished products. Further development of early-warning systems with use of integrated technologies, such as remote sensing and modeling and distribution through wireless technologies, can reduce risk in these very vulnerable but productive systems.

Comprehensive measures are needed in order to prevent and reduce vulnerability, and to increase adaptation and resilience of pastoral socioeconomic systems. Current conditions that need to be managed include the increase in frequency and intensity of both drought and *zud*, reduced water resources, and desertification due to climate change. These problems are especially troubling in the aimags located in the Gobi and central part of Mongolia. Quick action is needed to reduce the current ecological vulnerability. We may need to spend more in the future if we do not take action now. Long-term sustainability can be addressed only when the climate change issue is adequately considered.

Conclusion

Vulnerability to climate change-related drought and *zud* (severe winter conditions for livestock) is high in the western and transboundary areas of Mongolia between the steppe and Gobi, particularly in Hovd, Uvs, Bayanhongor, and Dundgovi aimags (provinces). The stocking rate increased, due to increased livestock numbers and decreased ecosystem productivity in most aimags, particularly in Hovd, Bulgan, and Omnogovi. Similarly, ecological vulnerability has increased in Hovd, Uvs, and Omnogovi aimags since 1990. Thus, the need is clear to increase adaptive and resilient capacity in these aimags through sustainable pastoral ecosystem protection management.

Pastoral social-ecological system dynamics are driven by global warming, reduction of water and forage resources, an increase in goat numbers, human population change, renewable energy and increasing access to information communication technology. The cumulative effect of climate change and overgrazing is an example of the whole being more than the sum of its parts, specifically because of the complex interactions of these effects with key ecosystem services. Vulnerability to climate change is amplified by the overgrazing of rangelands, which has become a large-scale problem of ecosystem degradation near settlements and water sources. As a result ecosystem services have become degraded, leading to desertification, water scarcity, increased dust events, and lack of forage. Taken together these problems reduce the carrying capacity of the area and are leading to reduced well-being of herders.

The fragmentation of cultural landscapes in arid and semi-arid lands has increased vulnerability and reduced the adaptive capacity of pastoral systems to climate change. The “tragedy of the commons” is being acted out and observed, with the most environmental degradation found in the areas with the most fragmented resources (Ostrom 2008). There is some evidence of a reduction in economic performance as a result of the fragmentation of cultural landscapes, while social resilience based on traditional pastoral communities tends to be lost. Herders’ groups that are not based on traditional pastoral communities may not endure for many more years according to our observations in the study area. Meanwhile, traditional pastoral communities, which have existed sustainably for centuries, are already eroding in the central part of Mongolia.

There is still opportunity to follow paths that lead to a sustainable transformation of Mongolia. One such path would conserve ecological, social, and cultural resilience associated with rangeland ecosystems in the country. We need to make use of collective memory and experience in order to manage the adaptation and transformation of current pastoral social-ecological systems. Different policies need to be applied in the different ecological and economic zones of Mongolia. For example, in the western part of the country we should strengthen the traditional pastoral community-cultural landscape systems, introduce modern technologies (i.e., renewable energy, wireless communication technology), and introduce value-added investment in livestock, raw materials, and sustainable tourism. In the central part of Mongolia, where the bulk of the current urbanization and mining activities are taking place, we need to rethink development.

Acknowledgments The NASA funded "Northern Eurasian C-land use-climate interactions in the semi-arid regions" project (Project # NNG05GA33G), United Nations Development Programme (UNDP), the Ministry of Social Welfare and Labor project on "Poverty study and job support," and Asia Pacific Network on global environmental change project on "Dryland Development Paradigm (DDP) Application for Pastoral Systems in the South-facing Slopes of the Khangai Mountains, the Most Vulnerable to Climate and Land Use Changes in Mongolia" (DDPPS) (APN: 2008CB-FP12-Togtohyn).

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Part III
Awareness and Preparedness for Change

With four of the six chapters in this part written about Japan, there is a certain bias towards the Japanese point of view. In part the balance reflects an opportunity taken; to expose English-speaking readers to Japanese research and practice in the field of resilience, an area that is under-represented because of the tendency of Japanese researchers and especially government leaders to write only in Japanese. More importantly, we also chose to highlight the Japanese perspective in this part because Japan is often thought to be well prepared for disaster and particularly capable of managing change. The reality is that while Japan is very good at managing the clean-up after a disaster, it is as a nation more radical with its policies regarding resilience in other countries than it is in its own boarders. From a broader perspective, the six chapters collected here offer a snapshot of how change and disaster are being prepared for from the local scale to the global. It is perhaps most telling of our times that awareness of change, even climate change, is still just beginning to grow, and that preparation for disaster and other kinds of massive change are similarly tentative. The chapters underline the challenges that most communities and even nations are facing as they try to manage and prepare for large-scale change.

In spite of the constant announcements in the news about climate change, at the smaller scale of a community awareness is not always high. Complexity and uncertainty represent a strong barrier, difficult to overcome. A gulf in communication between scientists, policy makers, and the public exacerbates the situation, as Jones shows in Chap. 6. At the larger scale, though scientists are working assiduously, to design international protocols for adaptation for instance (see Kato, Chap. 10), regular use of the knowledge being gathered is nonetheless very slow.

Jones' chapter compares how climate change data is being used to preserve heritage sites in the UK and in Japan. In the Japanese example, a significant gap between knowing and acting appears to put even a World Heritage site in danger. Looking deeper, the gap he has found is between those who gather information and those who make policy, not only in the governmental level but also locally. The situation that he has uncovered is remarkable because it is not the result of denial or disinterest but rather a lack of awareness of the problem. It is not hard to imagine that similar scenarios are playing out around the world and in areas where the consequences of inaction will be severe.

Alamsyah describes changes in development planning as awareness of environmental issues expands. The archipelagic region is already managing changes in sea level rise. Individuals are forced to decide if they will move away, or change their way of life, becoming fishermen instead of farmers, or do something entirely different. Planning for change is very hard and in this case Alamsyah makes the argument that the kinds of change will not only be physical but cultural. The latter is often overlooked but extremely important.

Amir describes the severe damage from flood, drought and other climate change related disaster in Pakistan, offering the nation as a case study for dealing with massive change. Because the scale of disaster has been so large, it is perhaps easier to see the effects and to imagine what is needed to manage future disaster and the cost of not acting in time.

Kato discusses the need to integrate adaptation policies into climate change planning. This is an important shift, as climate change was until recently seen as a problem that would be solved though mitigation alone. Hiramoto's chapter goes further, suggesting that adaptation is not only necessary but also an impetus for the development of new business. He outlines the potential of the Bottom of Pyramid approach as viewed from the perspective of Japanese government policy for foreign investment and support. Interestingly he connects some of the lessons learned after the Tohoku disaster in Japan with the possibility for new business models in developing countries.

Finally, Tanaka gives a very honest appraisal of the situation immediately after the Tohoku disaster struck Japan. It is revealing, and underlines the need to be reflective and to learn while acting in the case of a large disaster. His chapter also shows that even in a nation like Japan, which is relatively prepared for massive disasters, the problems that actually arise are often unexpected and so there is no process in place for dealing with them as they come up. It may be the only way to manage uncertainty is to ensure that leaders are trained to be flexible, or more cynically, to hope that such people will emerge at the same time as the challenges that require them.

Chapter 7
The Importance of Information Availability for Climate Change Preparedness in the Cultural Heritage Sector: A Comparison Between the UK and Japan

Matthew Jones

Abstract Greenhouse gases produced by human activities are widely accepted to be warming the earth and causing an immediate and observable global impact. This has led to the need for different industry sectors to investigate how climate change will impact their interests. In this context this research looks into what is being done in Japan in the cultural heritage sector through a case study of Itsukushima Shrine. Itsukushima Shrine is a UNESCO World Heritage Site, located on Miyajima Island in Hiroshima Prefecture. Since 1963, tide gauge data from the Japan Meteorological Agency shows that sea levels in the region have been rising and causing an increase in flooding events at the site. This rise mirrors a global increase in sea levels, with many researchers arguing it is a direct result of global warming. Research into global warming and its impacts upon climate systems over the next century strongly suggest that global sea levels will continue to rise. This paper makes use of examples from the United Kingdom to identify ways in which the situation in Japan can be improved. In the UK the cultural heritage industry and researchers have actively sought to investigate, mitigate and adapt to potential threats posed by climate change. Those efforts are helped in part through Government-funded climate change information dissemination and education. This paper details how different sectors are embracing this freely available information to mitigate the impact of climate change on their own interests. Finally, recommendations are made based on the findings from the Itsukushima Shrine case study and also through a detailed appraisal of the UK's approach. These recommendations are applicable to organizations and cultural heritage sites across Japan and would also benefit other sectors.

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Background

Global warming is a widely accepted phenomenon, whereby anthropogenic greenhouse gas emissions cause temperatures to rise, which has a direct impact on weather patterns, sea levels and other aspects of the natural and built environment. In recent years, climatic changes associated with this warming are becoming increasingly evident. This has been confirmed through the work of countless researchers, and is especially clear in their contributions to the Intergovernmental Panel on Climate Change's (IPCC) regular reporting on the issue. In Assessment Report 5 (AR5) they noted that global warming over the period 1800–2012 had led to a 0.85 °C increase in the globally averaged combined land and ocean surface temperature. These and other temperature-related changes have occurred alongside other observed long-term trends, including changes in precipitation and sea level.

Extreme weather events in recent years also have many individuals, including scientists, pointing the finger at climate change as a contributing factor and even a cause. A recent report on the relationship between climate and extreme events, jointly produced by climate scientists from the US's National Oceanic and Atmospheric Administration (NOAA), UK's Met Office, and other institutions, noted that it is not possible to blame climate change for every extreme event (Peterson et al. 2012). However, the same group did attribute climate change to a number of extreme events that occurred in recent years. Similarly, a report published in the Bulletin of the American Meteorological Society (BAMS), suggested the conditions that led to a drought in Texas, USA in 2011 are twenty times more likely to occur now than they were in the 1960s due to increased atmospheric concentrations of greenhouse gases and associated climatic changes. The BAMS report also points to the exceptionally cold winter of 2010/11 in the UK as an example. With the coldest December in more than 100 years, it was characterized by lows reaching 5.0 °C below average, and with the highest number of air frosts for at least 50 years. BAMS concludes this event was the result of anthropogenic climate change and further that it was half as likely to have occurred just 50 years ago.

Recent observational findings are further confirming climate change as an important field of study throughout the world; with future projections suggesting climatic changes and associated extreme events will become more and more commonplace. Indeed, the emissions path the world follows will have a significant impact on how much global temperatures will increase in the future, which in turn will determine the nature, severity and number of associated extreme weather events. Recent emissions data suggests that mitigation efforts to date have not done enough to curb global GHG emissions. A report, published in December 2012, notes that current CO_2 emissions are tracking high-end emission scenarios, "making it even less likely global warming will stay below 2.0 °C" (Peters et al. 2012). It was the European Union (EU) that set a target of limiting global temperature increase to below 2.0 °C in order to prevent irreversible climate change. This number has since been accepted by scores of Governments across the world as a point at which climate change becomes "dangerous".

However, with current carbon emissions exceeding even the highest widely agreed scenario for a safe level of emissions, this 2.0 °C target is becoming increasingly difficult to achieve. This is even more concerning given the fact that on January 1st 2013, the only legally binding international climate regulation, the Kyoto Protocol, expired. In a special report in the journal 'Nature' on the Kyoto Protocol, it is noted that even though those industrialized countries that struck with the treaty were able to cut their collective emissions by 16%, worldwide emissions have surged by 50% from 1990 levels in the same time period (Schiermeier 2012). The uncertain future regarding mitigation targets and actions means that preparing for projected climatic changes is more important than ever.

Part One—Climate Change and Cultural Heritage in Japan: A Case Study of Itsukushima Shrine

Introduction

Many sites of historical significance in Japan are located along low-lying coastlines. One such place is Itsukushima Shrine, located on Miyajima Island, Japan (Fig. 7.1). The site itself is located on the shore of the Seto Inland Sea, which is connected to

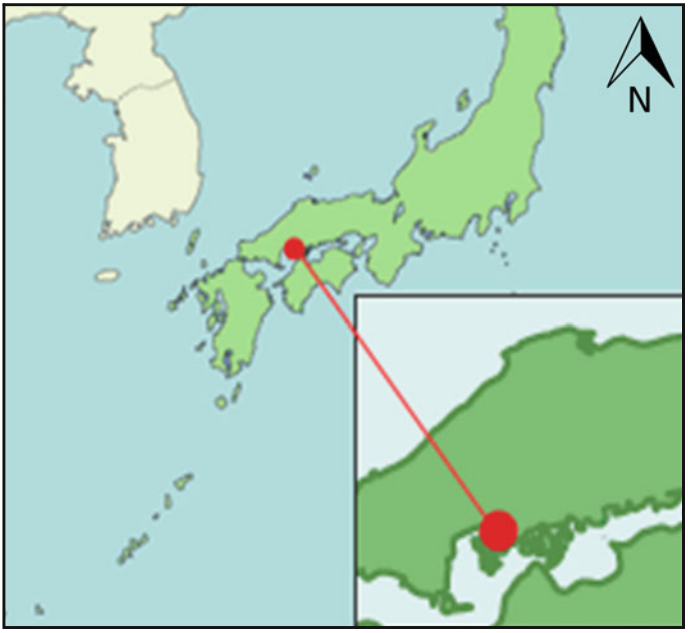

Fig. 7.1 Map showing location of Itsukushima Shrine

Fig. 7.2 Itsukushima Shrine at low (*above*) and high tide (*below*)

both the Pacific Ocean off Japan's east coast and the Sea of Japan to the west. Itsukushima Shrine is a UNESCO World Heritage Site and a designated Japanese National Treasure. The shrine is built on posts sunk into the seabed that allow it to appear as if it's floating on the sea during high tide (Fig. 7.2). The effect of this design is visually stunning but leaves it very vulnerable to flooding events. Indeed, rising sea levels are a real threat to the site's continuity. This is particularly concerning as current local government and site-level management plans do not include any information on climate change.

Objective

The objective of this case study was to investigate the observed and projected impact of climate change on Itsukushima Shrine. The site was chosen due to the fact that it is an important cultural heritage site in Japan and as such would serve as a high profile example of the potential impact of global warming. A further reason for the site's selection is its coastal location and its proximity to the sea, particularly during high tides. The major threat to the shrine posed by climate change is sea level rise and as such this is the focus of the case study. However, other impacts are also considered as part of this chapter.

The case study aims to ascertain whether any sea level change has been witnessed in the vicinity of Itsukushima Shrine and, if so, whether this is attributable to climate change. Furthermore, climate models allow future climatic changes to be identified, and their projected impacts visualized, based on differing greenhouse gas emission scenarios. Such data can be used to clearly show the potential threat climate change, and its associated sea level change, will have for the site. It is also an opportunity to demonstrate the importance of making data of this kind readily available to those who require it.

Hypothesis

Following an initial visit to Itsukushima Shrine in December 2011 as well as background research into climate change and cultural heritage in Japan, the following hypotheses were proposed for this case study:

- Projected climate change in the future will cause sea levels at Itsukushima Shrine to continue to rise
- Itsukushima Shrine will experience increased flooding events in the future as result of this sea level rise
- A lack of available information regarding sea level rise means stakeholders are unprepared for its potential impact.

Methodology

In the absence of readily available climate change data for Japan, the methodology for this study involved obtaining, processing and interrogating climate model data. The climate model that was chosen for this project was the 'MIROC-ESM model'. This model was a collaborative development from a number of Japanese Universities and research institutions. It was chosen as it made use of the latest RCP emission scenarios and also because one of the individuals involved with the model was available for consultation if questions arose during the project, as they did on a number of occasions. Data was downloaded from the Coupled Model Intercomparison Project Phase 5 (CMIP5) online repository. Climate model data was downloaded for the four different RCP scenarios; RCP2.6, RCP4.5, RCP6 and RCP8.5. In addition, the output from a version of the climate model that had been run historically was downloaded in order to test the model's historical output against observed data.

The climate model is divided into different outputs; of interest to this case study were the sea level data. The relevant data were downloaded and processed using ArcGIS and Microsoft Excel. The output of the model took the form of point data. Based on these data the nearest point to Itsukushima Shrine was identified and the sea level values for that point formed the basis for the study. A more geographically accurate result could have been achieved if the points were interpolated into a raster. However, to do this for such a large of quantity of data was not feasible given the time constraints of the project. A 2004 paper noted that a sea level rise of just 10 cm at Itsukushima Shrine would lead to sustained frequent flooding of the Shrine, as the Shrine's corridor is constructed just 30 cm above normal high tide (Tokeshi and Yanagi 2004). In this light an important goal of the case study research was to understand when this would occur and to produce graph outputs displaying the information.

Current sea level data was acquired in order to understand how sea levels will change from their current heights in the coming years. For this purpose, tide gauge data was retrieved from an online repository of global tide level data, Permanent Service for Mean Sea Level (PSMSL, http://www.psmsl.org). The data itself for tide gauge stations in Japan is provided by JMA. PSMSL then takes these data and converts them into a common format, where data between different tide gauge stations can be directly compared. For the purposes of this study, tide gauge data were acquired for all recording stations in the Seto Inland Sea, where the majority of recording stations have data available from around 1960. Finally, global mapping data were acquired to allow visual outputs of both the climate model data and tide gauge data to be produced.

Observed Sea Level Change

Since 1963 the sea level in the vicinity of Itsukushima Shrine has been steadily rising. Tide gauge data is not available for Itsukushima Shrine or Miyajima Island; however, data is available for Hiroshima, which is located approximately 16 km away. It was assumed to be sufficiently close to inform the study.

Figure 7.3 demonstrates sea level rise at Hiroshima since 1963. The causes of sea level change at this location are complex and include land subsidence and complex natural processes, namely variations in seawater density and oceanic circulation. As a result, and as noted earlier, JMA has conceded that attributing sea level rise on Japan's coast to climate change is very difficult (JMA 2009). In order to better understand how sea levels changes over time in the vicinity of Itsukushima Shrine, tide gauge data were collected for all stations where they were available in the Seto Inland Sea.

The averaged data for all the stations show a rising trend at a faster rate than the global average (Table 7.1). The work of the IPCC has shown that global sea levels have been rising over the past century and there is conclusive evidence to suggest that this sea level rise is linked to increasing atmospheric temperatures due to

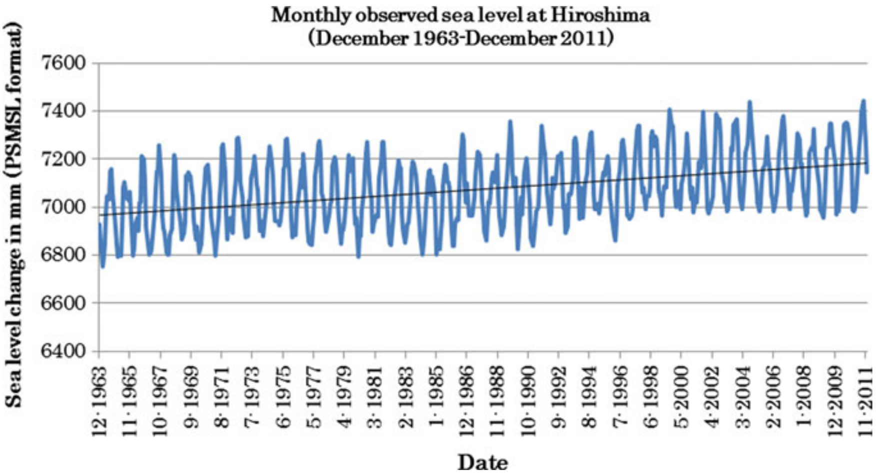

Fig. 7.3 Monthly observed sea level at Hiroshima December 1963–December 2011 (*Source* http://www.psmsl.org/)

Table 7.1 Rate of sea level rise for Seto Inland Sea and global average (*Source* http://www.psmsl.org/ and IPCC AR4, 2007)

Year	Annual seto inland sea level rise (mm)	IPCC Annual global sea level rise (mm)
1960–2010	2.1	–
1961–2003	2.8	1.8 [±0.6]
1993–2003	8.8	3.1 [±0.7]

anthropogenic warming of the earth as the result of the burning of fossil fuels (IPCC 2007).

It is not unreasonable to suppose that at least part of this rise in sea levels in the Seto Inland Sea is due to climate change. Because the Itsukushima shrine is so vulnerable to even small increases in the sea level it is prudent to acknowledge this change as a real threat. There is some question about what constitutes a flood event however, and while government data seem to indicate a rise in the number of floods in recent years, data produced by the shrine itself are slightly more flat (Fig. 7.4).

Projected Sea Level Change

In order to understand how sea levels around Japan's coasts are projected to change in the coming decades, data from the MIROC-ESM climate model were used. By assembling multiple time slices of future sea levels under the different emissions

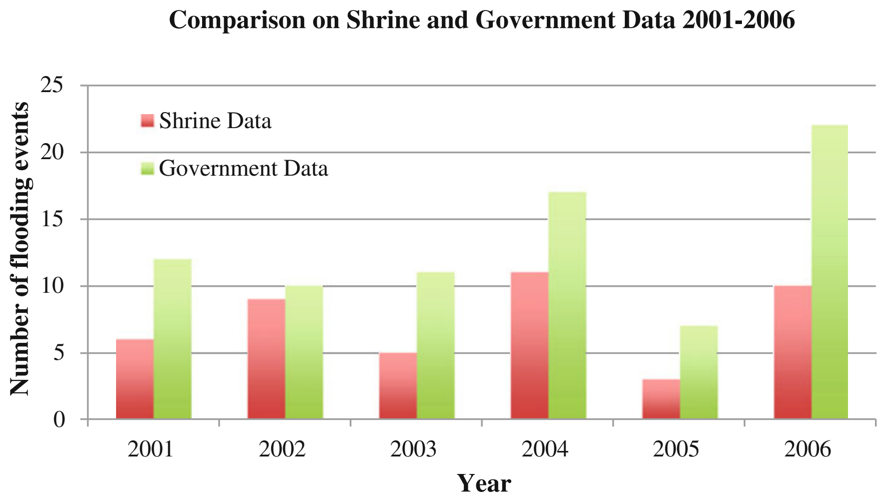

Fig. 7.4 Flooding event data from Itsukushima Shrine organization and the National Government

scenarios, it is possible to calculate the projected change in sea level between two different time slices. The climate model projects that Japan will see sea level rise along all of its coasts. The amount depends on the emissions scenario, with RCP2.6 showing significantly less sea level rise than RCP8.5 (Fig. 7.5). It is important to note that the climate model does not take into account factors such as land subsidence, which is important given the fact that land subsidence has been identified at a rate of 5 mm/year at Hiroshima.

As has been shown, the MIROC-ESM climate model shows sea levels in the study area increasing for all four emissions scenarios. Sea levels are projected to be between approximately 0.4 and 0.7 m higher by 2100 (Fig. 7.6) in the vicinity of the shrine. Until approximately 2075, all four emissions scenarios show a similar rate of increase. From this point onwards RCP2.6, RCP4.5 and RCP6 continue to see a similar rate of increase, whilst RCP8.5 shows sea levels rising by a significantly greater amount. This output is consistent with the idea of 'committed climate change' as detailed by the IPCC (2007), whereby even if anthropogenic CO_2 emissions were drastically reduced, global warming and associated climatic changes would continue to occur for the next several decades. It has been noted by Tokeshi and Yanagi (2004) that a 10 cm average sea level increase at Itsukushima Shrine would lead to sustained frequent flooding as a result of high tides. According to the climate model output data, this will occur before 2035, regardless of the emissions scenario. Again it is important to note that land subsidence has not been taken into account for the data presented in Fig. 7.6. This is corrected with Fig. 7.7, which show how sea levels could rise in the future if land subsidence continues at its current rate.

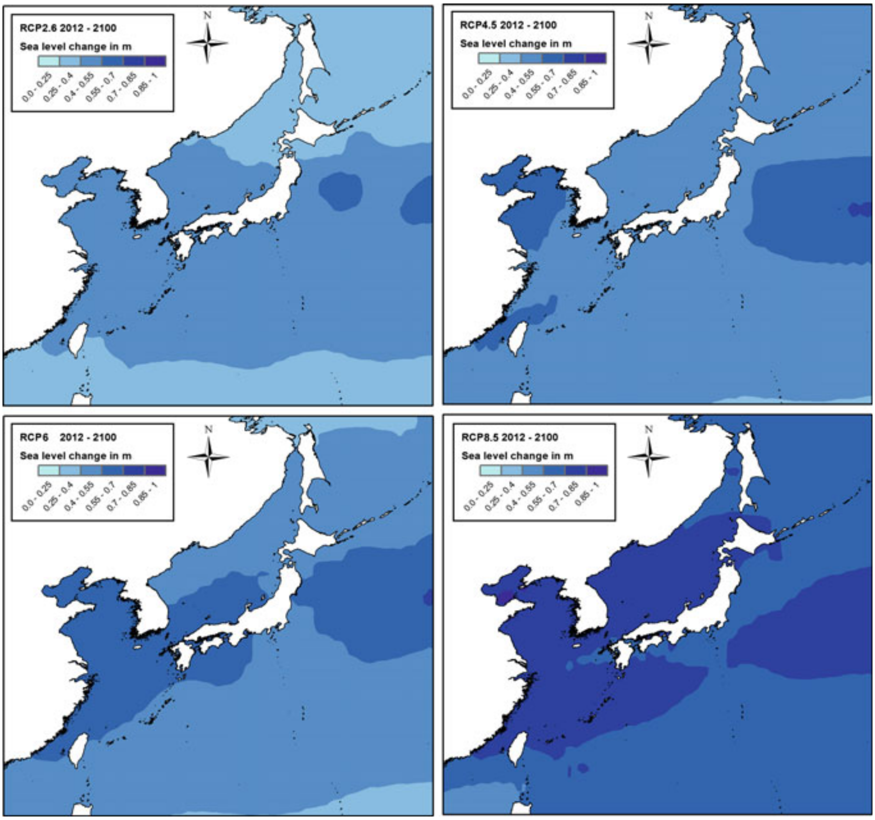

Fig. 7.5 GIS output showing projected sea level change in vicinity of Japan 2012–2100 under different emissions scenarios

When land subsidence is taken into account, an increase of 0.1 m will occur in the early 2020s regardless of emissions scenarios, with sea levels projected to increase in the region of Itsukushima Shrine between 0.89–1.14 m by 2100 depending on the emissions scenario. This compares to a projected rise of between 0.45–0.7 m when land subsidence is not included.

Other Potential Impacts of Climate Change

Sea level rise is the clearest example of how climate change is projected to impact Itsukushima Shrine in the future. However, analysis of climate model data as well as research into other potential impacts of climate change on Japan, shows that this may not be the only area in which the shrine could be impacted. Reports into how the future climate of Japan may impact typhoon activity have shown that whilst the

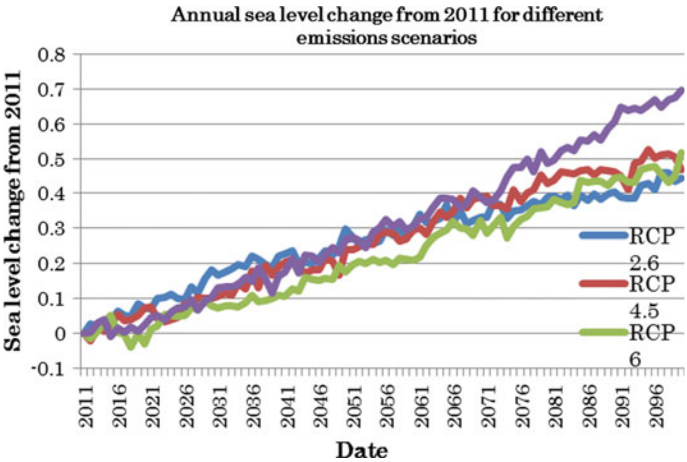

Fig. 7.6 Annual average sea level change in vicinity of Itsukushima under different emissions scenarios

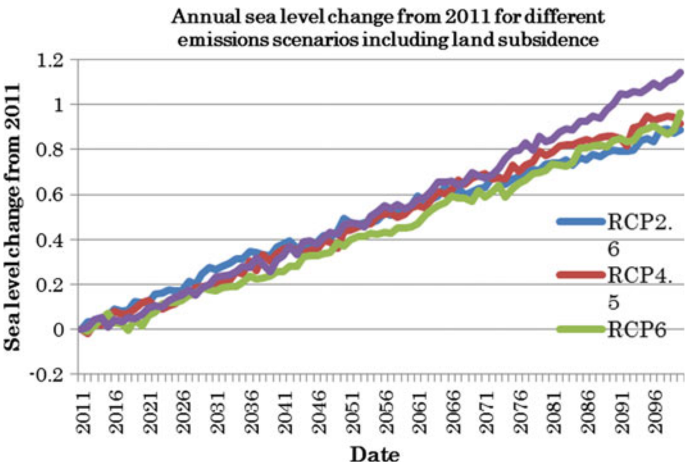

Fig. 7.7 Annual average sea level change in vicinity of Itsukushima under different emissions scenarios including 5 mm land subsidence

number of typhoons is projected to decrease, their intensity is predicted to increase (JMA 2011). This is a significant problem for the shrine as typhoons in the past have done major damage to shrine buildings.

Furthermore, based on published reports that make use of climate model data, other potential climatic changes in the region include:

- Surface temperature increases of between 2–3 °C, depending on emissions scenario (JME 2008).

- 10–20% increase in winter precipitation (JME 2008).
- 140% change in maximum daily precipitation in the next 100 years (JME 2008).

It is not known exactly how these climatic changes could impact cultural heritage sites like Itsukushima Shrine in Japan, as no studies have been undertaken that look into the possibility. However climatic changes of this sort were identified as having significant impacts on cultural heritage sites in Europe (Sabbioni et al. 2010), and it is not overreaching to imagine similar impacts in Japan.

Conclusions

The analysis completed and detailed in this paper shows that, regardless of the emissions scenario, the sea level in the Seto Inland Sea, and in the vicinity of Itsukushima Shrine, will continue to rise in the coming decades. The fact that humans have committed themselves to decades of global warming and associated climatic changes means that sea level rise in the study up to 2075 does not seem to be heavily impacted by future atmospheric CO_2 concentrations. It should also be noted that the results of this work suggest that sea levels in the vicinity of Itsukushima Shrine will, by 2100, increase by more than the IPCC predicted in their 2007 report.

The results are concerning as previous work has suggested that a 10 cm increase in sea level at Itsukushima Shrine would lead to frequent, sustained flooding (Tokeshi and Yanagi 2004). The results suggest this will occur before 2035 and it could occur even earlier if land subsidence continues at its current rate. Monitoring of the sea level at Itsukushima Shrine and the development of a management plan that takes future sea level rise as a result of climate change and subsidence into account is essential for the shrine’s continuity. The lack of investigation into the impacts of climate change at the shrine and the fact that there is no provision in the local government’s shrine management plan means a World Heritage site is currently at risk and unprepared for the future. This case study highlights the importance of climate change projection data and how they can be effectively used to understand potential impacts of climate change.

Part Two—Climate Change and Cultural Heritage in the UK

Climate Data Availability

In the UK, climate projection data is publicly accessible via the Government-funded UK Climate Projection (UKCP) program (last updated in 2009). This online data repository allows users to select their region of interest, the climate parameters of relevance to them, the emissions scenario, as well as the time-scale for the search and the degree of certainty based on current scientific understanding of climate change impact.[1] This information can be used directly to shape an organization's management strategy as well as allow organizations to prepare for any projected climatic changes that may threaten. The site provides a number of case studies showing how the data have been used to date. These range from local councils creating climate change information portals for their residents, to water companies planning to effectively manage future water supplies based on projected changes in precipitation patterns. Academics and researchers who may not have the technical knowledge to access and process raw climate model data can also use this online repository.

In the context of cultural heritage, this information has already been used by a number of researchers to understand how future climate change in the UK might threaten cultural heritage sites in the country. One such study analysed the output from UKCP to identify a list of 18 important changes (Cassar and Pender 2005), including temperature and precipitation, as well as humidity, soil and sea level changes. Visual outputs were then generated to show overlay projection data over cultural heritage sites. This kind of information is very useful for heritage bodies to understand which sites are under threat and to target resources accordingly. Following this data collection and analysis, questions were devised around the identified climatic and meteorological changes. The authors explained their methodology in the context of the questionnaires they developed as follows:

"The questionnaire was circulated widely to national, regional and local scientific and heritage experts, and local site managers requesting evidence of links between climate change and its impact on cultural heritage, the likely future effect on heritage of current climate change predictions and the planning and preparation that would be needed to ensure a timely management response" (Cassar and Pender 2005, p. 612).

The authors also organized regional workshops and a policy makers' workshop. Recommended policy outputs were centred on three themes: cooperation, funding, research and education.

Guidance and Publications in the UK

Publications and guidance in the UK have predominantly come from major heritage organizations; namely English Heritage and the National Trust. The National Trust's 'Shifting Shores: Living with a Changing Coastline' (National Trust 2008) publication made the following points with regard to effective adaptation to sea level rise and climate change:

[1]The UK climate projections online repository is available to all and can be found at http://ukclimateprojections.defra.gov.uk.

- There are serious shortcomings in baseline information
- The need for more coastal risk assessment studies
- The need for long-term planning at least at the time scale of 50–100 years
- To work with nature not against it
- Solutions need partnerships
- The need to raise awareness among the public of the impacts on coastal sites.

English Heritage is the UK Government's statutory advisor on cultural heritage and first published information on climate change and cultural heritage in 2006 entitled 'Climate Change and the Historic Environment' (English Heritage 2008a, b). This publication was updated in 2008. It provides information on climate change in the UK, as well as how this may impact cultural heritage in general in the UK through the use of specific case studies. English Heritage sees the purpose of its publication as a tool for the development of strategies and plans relating to climate change impacts. They also see it being useful for projects relating to risk assessment, adaptation and mitigation. Both English Heritage and the National Trust have sections of their websites that provide tools and further information on climate change that are available to all.

More recently other bodies and key stakeholders have begun to publish information relating directly to climate change and cultural heritage. In 2012, the Northern Ireland Environment Agency published a document entitled 'The Impacts of Climate Change on the Built Heritage of Northern Ireland' (Northern Ireland Environment Agency 2012). The report drew upon UKCP projection data to summarize projected climatic changes in Northern Ireland. It also explained how other countries in the union were addressing climate change and cultural heritage. Its main focus, however, was to see how climate change would impact cultural heritage in Northern Ireland, including coastal, wetland and general heritage sites. The report concludes with the following statement:

> In summary all predicted climate changes are likely to have negative consequences for the historic environment of Northern Ireland. While all built structures are likely to have to deal with this there are strong additional negative consequences for historic features near coasts or freshwater and wetlands plus those on/in clay soils which will need particular attention. NIEA Built Heritage is currently developing recommendations for managing the built heritage of Northern Ireland during this period of rapid environmental change. (NIEA: 2012).

This publication clearly outlines the position of the Northern Ireland Environment Agency. It raises awareness on the issue and also provides generalized information as a precursor to further work.

Historic Scotland have gone one step further and published 'A Climate Change Action Plan for Historic Scotland 2012–2017' (Historic Scotland 2012). This publication follows a 2009 joint statement produced by various Scottish institutions, including Historic Scotland, that acknowledged that,

> Climate change is the most serious threat to Scotland's environment, now and over coming decades. It will have far-reaching effects on Scotland's people and places, impacting on its economy, society and both natural and built environments. (Scottish Environment Protection Agency et al. 2009)

The 2012–2017 action plan document provides background information on climate change in Scotland as well as Historic Scotland's responsibilities on the issue, and sets out 7 'Strategic themes and actions'. These are:

- Reducing energy use in buildings
- Improving operations
- Improving energy efficiency in traditional buildings
- Building resilience: preparing the historic environment for climate change
- Improving sustainability of the historic environment
- Developing and promoting sustainable tourism
- Informing and influencing others.

These themes cover both mitigation and adaptation and clearly define Historic Scotland's commitment to preparing and combatting projected climatic changes. Of particular interest is the 'Building resilience' theme. Historic Scotland outlines their actions in regards to this theme as follows:

- "We will develop a methodology for assessing the impact of climate change on heritage assets including historic buildings and monuments, buried and submerged archaeology, historic landscapes, plantings and battlefields".
- Undertake a climate change risk assessment across the Historic Scotland estate to evaluate which sites are most at threat from issues such as coastal erosion, flooding, rainwater penetration etc.
- Work with a range of external partners to research and evaluate specific threats to buildings and monuments, such as increased biological growth and enhanced stone decay, and develop strategies to manage impacts.
- Review Historic Scotland's on-going maintenance and condition survey programs in the light of climate change predictions to modify conservation strategies and target priority sites where necessary.
- Input climate change factors into estate management strategies and business continuity planning, for example where threats to sites are likely to affect future visitor numbers and income.
- "Respond to current and emerging climate change threats by prioritizing our grant funding". (Historic Scotland 2012)

These actions are incredibly important if cultural heritage sites are to be protected from potential climatic and meteorological changes.

All of these publications are unequivocal in their view that climate change will have an impact on cultural heritage in the UK, and that the impact would be overwhelmingly negative. They aim to publicize the issue by clearly stating the organization's position on the issue, identifying areas that need attention, and providing details on actions they are taking. No such publications currently exist in Japan. Interestingly, all of the publications reference UKCP data and findings.

Compared to Japan

The information presented in this paper underlines the EU, and more specifically the UK, approach to the issue of climate change in the context of cultural heritage. It is multi-tiered, involving national and local governments, heritage bodies, academic researchers and individual cultural heritage sites. Their work is mutually beneficial and the information is disseminated between stakeholders. The situation in Japan is entirely different, and no sector is investigating the impact of climate change on cultural heritage. Government and heritage bodies have not produced any guidance or published statements relating to climate change and its impact, nor have academics investigated the potential impact of climate change on cultural heritage sites. It is perhaps not surprising that individual sites like the Itsukushima Shrine have not incorporated climate change into their management plans. The lack of information and easy access to climate model data, is a significant barrier to taking the needed steps in this regard.

The existence of the UKCP online repository and associated tools means that anybody in the UK is able to understand the impact of climate change in any area of the country. With this information in hand the cultural heritage sector has responded with guidance, mission statements and management plans targeting climate change and its impacts. Figure 7.8 shows a simple diagram of how UKCP data drives knowledge and guidance in this sector forward. This clearly shows that providing such an accessible resource for climate change information is highly beneficial for cultural heritage bodies.

Furthermore, academics studying cultural heritage, often without a natural scientific background, have been able to investigate the projected impacts of climate change on cultural heritage sites. If a similar repository were available in Japan, those with an interest in the conservation of cultural heritage sites would be able to understand the impacts of climate change and would be able to adapt accordingly.

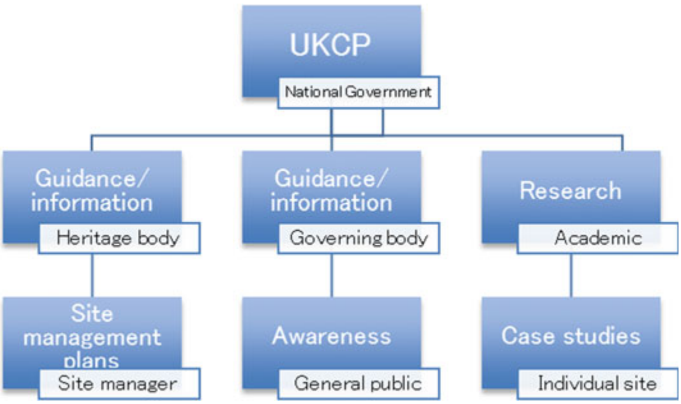

Fig. 7.8 Diagram showing UKCP and its relationship to the cultural heritage sector in the UK

UKCP Use Outside of the Cultural Heritage Sector

It is not just in the cultural heritage sector where organisations can benefit from easily accessible climate change data and up to date information. The widespread application of UKCP data and findings in the UK is a testament to this. In this section examples will be provided of how organisations from numerous different sectors have made use of climate change data to mitigate the impacts of projected climate change to their organisation and interests. It has allowed local governments to investigate the impacts of climate change within their geographic boundaries. Examples include Hampshire County Council, who have used the data to develop emergency planning scenarios; Kent County Council, who have used the data to visualise the impact of climate change on their county; Milton Keynes Council, who have undertaken a vulnerability assessment; and Oxford City Council, who present climate change information to local residents on their website. The final example of Oxford City Council is particularly important as it shows how organisations can easily repackage the information based on their requirements, in this instance presenting detailed information for a particular geographic area. Without the freely available UKCP portal, it is unlikely local governments would have the resources or expertise to undertake this kind of climate change related work. Indeed, in a paper introducing the 2009 UK climate projections, Street et al. noted that, "A recent survey of users of the UK Climate Impacts Programme's (UKCIP's) decision making tools showed that projections of climate change for the UK are the one UKCIP tool that stakeholders use most widely to plan adaptation strategies" (Street et al. 2009).

Projects within the building industry that have made direct use of UKCP information include PROMETHEUS, which aims to future proof design decisions in the building sector; and PROCLIMATION, which involves developing a simulation of a building's environmental performance in a changing climate. The water industry has also embraced UKCP data to understand how climate change will impact the water supply chain in the UK and to develop plans to mitigate these impacts. Severn Trent Water and Scottish Water have used the projections to undertake risk assessments to their business, whilst Thames Water has pioneered the use of UKCP data in water management planning. In regards to sewage, work has been undertaken by Atkins to understand how climate change may impact on the sewage network in the UK. Government bodies are particularly interested in how climate change will impact the environment and have made use of the data to investigate negative changes climate change may bring. The Environment Agency has undertaken analysis to estimate changes in flood damages as well as how climate change may affect pollution in the UK. The Department for Environment, Food and Rural Affairs (Defra) has completed a coastal flooding and erosion risk assessment, as well as investigating how climate change will impact crop yields and domestic food availability.

These examples show how organisations without the means to develop their own climate models to project future climatic changes have used UKCP to understand

and mitigate for potential climate change impacts. The academic sector has also used the information and a large number published papers rely on the availability of the data. These works are diverse and range from a study looking into how climate change will impact the railway industry (Baker et al. 2010) to a paper on winter road maintenance and traffic accidents in the West Midlands (Andersson and Chapman 2011). Other works have been published that are also directly relevant to business sectors in the UK. For instance a study on how solar radiation will change in the coming decades (Tham et al. 2010) is particularly relevant to the building industry and allows planning to be undertaken to make optimal use of solar energy power generation in building design. Environmental studies have also been taken and include a national estimate of changes in seasonal river flows (Prudhomme et al. 2012) as well as a paper assessing the impacts of climate change on flood frequency in Britain (Kay and Jones 2012).

Conclusions

With regards to cultural heritage and climate change in the academic sector in Japan, this study has shown that there is a complete absence of studies that investigate the topic. The methodology employed in the case study of Itsukushima Shrine shows that the site is under threat according to the latest climate model data and scientific understanding of climate change. The methodology can be used for other sites that are vulnerable to climatic changes and their associated impacts. Furthermore, the methodology presented here can be used as the basis for vulnerability assessments of other heritage sites in Japan. These assessments need not be limited to sites at risk from sea level change. The basic methodology of using sea level projection data is repeatable with other kinds of climate model output data—for example, temperature and precipitation. Indeed, work funded by the European Union has shown how climate model data can be used to assess the risk to cultural heritage properties (Sabbioni et al. 2010). Examples have also been provided for how organisations from other sectors can make use of the information to mitigate the impacts of climate change.

Recommendations

This report has shown that when organizations have easy access to up-to-date, unbiased, and easily understandable climate data they take action. This has been demonstrated through a study of the approach by the cultural heritage sector in the UK. With access to the Government funded UKCP data, heritage bodies have published statements, guidance, and plans relating to climate change and its impact on cultural heritage. Other organisations have also produced guidance and publications relevant to their interests. Without access to this information, it is unlikely these documents could have been produced, as the data and its implications are directly referenced by all. The lack of knowledge at all levels of the heritage sector in Japan is partly due to the lack of a comparable information resource in Japan. In an interview, management at Itsukushima Shrine admitted that they had no access to unbiased information and would not know where to turn if they wished to access climate model data themselves. They also expressed a willingness to use such information if it was available to them. Furthermore in a separate interview with the Hiroshima Prefectural Government, they said that they believed any such information should be provided by the national Government.

During the course of this research, the majority of information in regards to climate change in Japan has been in the form of reports from JMA. Some sectors, for example the agricultural sector, have dedicated information regarding climate change. However, no such information resource exists for cultural heritage sites. Furthermore, academic work is available regarding climate change in Japan but there is no chance to access that data directly without the technical skills and knowledge to download and process the raw data. Those working outside of the academic sphere are not expected to seek out this kind of information and there is a clear disconnect between what is known and being done in the academic sector and those working in the public and private sectors. This is clearly the case in regards to cultural heritage in Japan as knowledge and information that is abundant and accepted in the academic world is absent at the site level. By providing data to Japan in an easy to access format like that provided in the UK, other sectors and the general public would also benefit as any individual could investigate how climate change would impact their home, business or organization.

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Chapter 8
Anticipating Environmental Change in Development Planning for the Archipelago of Indonesia

Abimanyu Takdir Alamsyah

Abstract Indonesia is an archipelagic country comprised of seventeen thousand islands in an expansive marine area in the tropics. Thousands of mountains and hills, both on land and under the sea, are a geological consequence of being located on the Pacific "Ring of Fire." Being situated here has meant that different parts of the country are periodically subjected to disasters, including earthquakes and tsunamis. As a result, the more than 200 million people now inhabiting both the large and very small islands in the region have developed strategies to survive by anticipating and adapting to changing local conditions. Throughout its history Indonesia has lived with environmental hazards and disasters—great losses were suffered not only by the poor and those living in remote areas but also by the relatively wealthy who live in major cities. Since the 1980s, development policies of the country began to incorporate environmental issues, and the environmental impact of infrastructural development programs began to be examined carefully before implementation. Development considerations should include anticipation of the impacts of both tsunamis as well as climate change. In the past, planning for environmental impacts was separate from development planning. Recently, however, Indonesia's National Development Planning Institution started integrating all sectors into a single National Action Plan on Climate Change Adaptation. This paper elaborates the changing awareness of environmental issues, outlines development problems, and recommends further improvements to reflect the complex changes already occurring in ocean-island settlements in this archipelagic region.

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Climate Change Issues in Indonesia: Challenges for a Large Archipelagic Region

Indonesia is an archipelago consisting of thousands of islands spread over a large area of ocean in the tropical zone. With only about one-third of the country's territory made up of islands, ranging in size from very small to large, and the rest being ocean, the conditions in many parts of the country are similar to those of other island countries in other parts of the world. The western parts of the country experience heavy rains, while the eastern parts are mostly dry. From June to August, tropical storms tend to hit the northern and southern parts of the region, while seasonal winds blow, followed by high tides, usually in the southeastern parts of the country. Strong northwestern winds, heavy rains and high tides were once the norm from December to February, however the timing of dry and rainy seasons appears to be shifting. Now, even in the August many parts of the region face heavy rains followed by flooding all over the country.

In the dry season, with its warm to hot local climate, it is now more common that some parts of the country face so called "mine fire" hazards, especially in the eastern regions. These occur because the hot weather occasionally sparks the heated coal under the land surface and triggers fires in the dry rainforest. Sometimes fires burn in the "new savannah," the fields of wild grass that grow after rainforest is cut down, or in dry, old, unproductive palm oil tree plantations on the islands of Kalimantan or Sumatra. Such fires are not always natural, but can be linked to anthropogenic causes such as irresponsible behavior by forest resource exploiters or palm oil agricultural companies.

Indonesia encompasses thousands of mountains and hills, both on land and submerged beneath the ocean, a result of being situated in the Pacific "Ring of Fire." Being in this geographic location comes with the periodic occurrence of disasters such as earthquakes and tsunamis, which strike different parts of the country in different ways. Disasters are more common on the west coast of Sumatra, southern parts of Java, and the eastern islands, where the most active volcanoes are located. However, in general most communities inhabiting the coastal areas of both the large islands and micro islands in Indonesia have inadequate ability to deal with environmental risks in the region. The way of life of the inhabitants plays a role in this regard. Indonesia has a population of more than 200 million spread throughout the archipelago, with a wide range of local cultures inhabiting thousands of islands. The country covers a large area and is a close neighbor to The Philippines in the north, Australia in the south, and Malaysia and Singapore in the West. Within the islands there are a variety of communities and lifestyles, many entirely land-based, while others are more connected to the water. Some communities live in stilt dwellings around islands but have a terrestrial way of life. There are also many water-based communities which have built traditional settlements on the water along rivers and lakes, or off the sea coast of small islands.

In the case of water-based communities the pilings that secure their dwellings are driven into the shallow seabed, or alternatively they live on boats or make use of floating structures made of wood. Each region has a different type of environmental risk, with potential hazards that require different responses. Meanwhile, different cultures have their own local wisdom to help mitigate or adapt to the changing environmental conditions where they live. Over time the various regions have become the home of several ethnic communities with different cultures. With this in mind, local governments and development experts need to be aware of the differences in the survival strategy of each community, especially between the terrestrial and water based communities who live in the same, ever changing, sea-land region (not only the changing characteristics of the inundated land in the coastal areas but also the changing functions of land or ocean regions in a group of small islands).

In this archipelagic region, four major islands are shared between two countries: Papua Island (Indonesia and Papua New Guinea), Kalimantan Island (Indonesia and Malaysia), Timor Island (Indonesia and East Timor), and Sebatik Island (Indonesia and Malaysia). The five "big" islands in Indonesia measure more than 100,000 square kilometers (km^2) each, with Java having an area of 138,793 km^2 and the largest, Papua Island, having an area of some 785,753 km^2. There are more than 13,000 smaller islands, ranging from medium-sized islands with areas less than 30,000 km^2, to small islands less than 2,000 km^2 and micro islands with areas less than 1 km^2. The problems faced by those living on the big islands are very different from those of living and surviving on the small or micro islands, or even in the water (type 2, 3, 5 and 6 in Fig. 8.1).

Although Indonesia officially states that there are 17,480 islands in the country, more than 18,000 islands could be identified from the air, while only about 13,000 have been ground surveyed. Even fewer have been named by local communities or ethnic groups. Although Indonesia has hundreds of ethnic communities, each with its own mother tongue and culture, similar names are used for many islands all over

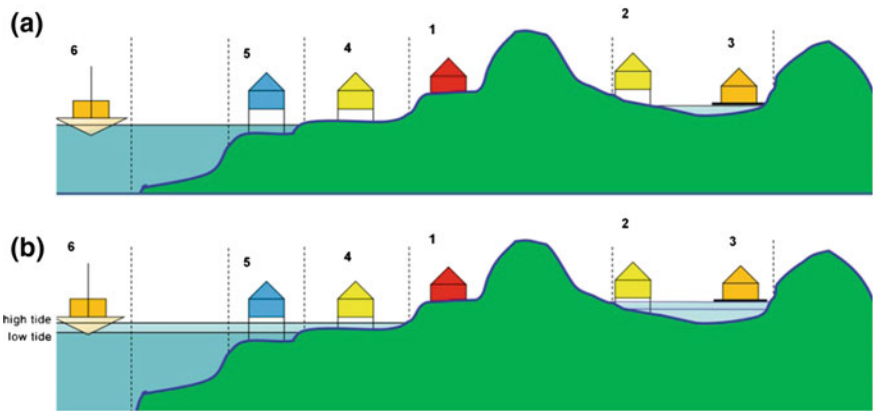

Fig. 8.1 Types of traditional human settlements in Indonesia during low tide (*top*) and high tide (*bottom*). Modified from Alamsyah, 2006

the country. More work is needed to properly identify all the islands and agree on a specific name for each one.

Long before Indonesia's Declaration of Independence (August 17, 1945), the country's founding father had already declared Indonesia as "Our Tanah-Air," meaning that he identified the areas where land and water altogether as the identity of the country. Twelve years later, in 1957, Indonesia claimed the islands and seas contained in the present national territory. (The Philippines claimed its territorial waters in 1955.) Through the United Nations Conference on the Law of the Sea (UNCLOS 1982), the international boundaries of the country were formalized; consisting of territorial zones plus exclusive economic zones in the marine regions surrounding the territorial zone.

Several methods can be used to define an "island," and each could be used as the basis for counting the number of islands in the country. But there is still disagreement on how to define an island's boundary. According to UNCLOS (1982), an island is the area circumscribed within the high tide line. Under that definition, even if trees grow or dwellings are built in an area, if submerged at high tide the land cannot be identified as part of an island. If only a terrestrial-based concept is thus used, it will be difficult to identify the population density of communities living on the water surfaces. Furthermore, if this definition is used as the baseline for delineating the surrounding water, UNCLOS's water boundaries around micro islands in places such as Indonesia's Takabonerate, Wakatobi Islands, and Kepulauan Seribu (Thousand Islands), or even Australia's Ashmore Reef, would not be the correct standard for defining conservation areas in coral reef zones or other sea-based regions (Figs. 8.2 and 8.3).

The conditions of a closely connected group of islands or coral reef zone are very different when compared to the conditions of a single piece of land in an isolated island environment. When sea-level rises the coastal land areas become extensions of the aquatic zone, and not only will terrestrial ecosystem conditions change, but ways of life and cultural values of the people who live there will change

Fig. 8.2 Micro Islands in Kepulauan Seribu—apparent size versus real structure of the Islands

Fig. 8.3 Water based settlement: housing density in water based settlements are different from those on land (*Source* Google Earth)

as well. The concept of a region should then be revised in relation to the changing conditions of the coastal environment and the new cultural space-time of the community. In short, the land-based point of view cannot adequately define the conditions of non-terrestrial regions.

Climate Change: One Aspect of Environmental Change

Though not a continent, Indonesia is the largest archipelagic country in the world, and has the longest coastline in the tropical zone. Survival of the people who live in these areas depends on good management of natural risks. It is important to note the greater diversity in tropical areas compared to non-tropical areas. Each island has its own topographical features, coastal vegetation, and local species, both on land and in the water. Similarly each coastal region of Indonesia faces a different combination of environmental threats, ranging from erosion, tropical storms, high tides, floods, earthquakes, and tsunamis, in addition to climate change and its associated sea-level rise.

In the 1980s, work was undertaken to identify each kind of environmental risk. Standard approaches and governmental regulations were established to control and minimize negative impacts, mostly in the context of significant infrastructure or development projects. Lessons were learned from previous failures, especially when the impacts of development projects were not properly anticipated. New regulations therefore are expected to include not only environmental issues, but should anticipate the effect of development, cover social concerns related to the increase and the improvement of local community involvement, and should likewise ensure community benefits after development is carried out.

After the tsunami disaster in Aceh in December 2004, the government, academia, and social agencies started developing concepts and approaches to improve the resilience of local communities facing environmental risks in coastal zones. Focusing solely on tsunamis as the source of potential disaster in coastal regions in some cases led to a failure to anticipate other kinds of risks and disasters from natural change. An example of this occurred 2 years after the tsunami in Aceh, when an earthquake occurred in Kota Gede, south of Yogyakarta. Thinking that a tsunami would come from the southern sea, people ran northward. Unfortunately, the real earthquake had occurred on land north of them, so they should have escaped to the south. A similar situation also happened in West Sumatra.

Not only tsunamis pose environmental risks, so preparations should face all possibilities—such as earthquakes, floods, high tides, and tropical storms. Every kind of natural risk should be identified and anticipated. Some regions also consider man-made disasters when examining risks, recognizing that anthropogenic behavior or the man-made environment could be the real source of hazards.

When climate change issues appeared on stage, people became aware that not only short-term risks should be anticipated in developments, but also the long-term impacts of climate change. At first, the general public was not concerned about decreasing carbon emissions. People felt that reducing air pollution was outside their concern, and that existing regulations to reduce pollution were not effective. Mitigation actions were not related to everyday life for people on the streets. The Reducing Emissions from Deforestation and Forest Degradation (REDD+) program was only noticed by certain disciplines or experts focused solely on land-based policy.

People living in coastal areas face special challenges. People who live close to the sea will be affected, but the impacts of sea-level rise will also affect people in land-based communities, such as farmers and urban workers. The effects of climate change and sea-level rise are not just in the distant future. They are already being felt. Besides anticipating further impacts, it is important to take action to help people who are already experiencing negative impacts. Potential natural risks and human-made disasters should be anticipated through integrated development plans.

Taking Stock: Core Issues in Anticipating Change

Managing the huge archipelagic region of Indonesia is a challenge. It extends across a vast watery region more than twice the area of the land base. Managing development on scattered and isolated islands of diverse sizes is complex. Thus, Indonesia requires an understanding of the environment, the processes that bring about environmental change, the people who live on land and water, and the cultural context of each community.

Failure to understand environmental change will mean that development plans for the future will not properly recognize natural risks. Safer buildings and infrastructure will reduce the costs of recovery and rehabilitation of buildings and of cities after natural disasters and will also reduce the loss of human life. All types of experts and specialists have a role to play. Environmental experts will establish new development concepts for each condition and transformation, but also architects, planners, engineers, scientists, sociologists, economists, lawyers, political strategists, and other experts will be needed. All have a role in creating new ways of thinking to face change in this archipelagic region.

Generally, work or research aimed at anticipating the potential of each natural hazard was carried out separately, usually along the lines of specialized disciplines and the concerns of experts. However, the separation of those approaches were recognized as inappropriate to the varied problems of natural disasters. In August 2014, disaster experts and institutions in Indonesia came to the conclusion that all of the problems should be solved collaboratively and the solutions should be integrated into regional development plans for each region.

Funds for this work came from ministries and central government institutions, or from donor countries who offered grants to address certain kinds of disaster. It is worth noting that the funds for improving coastal community resilience did not come from the same sources as funds to help people who suffered from disasters such as farming failure, tropical storms, river flooding, and earthquakes.

Indonesian Initiatives: Integrated Adaptation Plans Anticipating the Impacts of Environmental Change

It is important to view climate change as an integral part of all of the environmental transformations that impact on the sustainability of human life. Building awareness and increasing involvement in planning for change in anticipation of the need for mitigation and adaptation is challenging. Much can be learned by sharing the experience from disasters in other communities, even if they took place far away.

Planning of that type first started in Indonesia the early 2000s. Even though Indonesia certainly recognized itself as an archipelagic country before then, until then there had been only limited attention given to the hazards and problems faced by small islands, and marine, and coastal areas, and the particular problems faced by the people who live in those places.

After the establishment of the Ministry of Marine Affairs and Fisheries (Kementerian Kelautan dan Perikanan, or KKP), a strategy emerged to identify marine and coastal problems and the hazards faced by the people who live in vulnerable locations. Within this strategy, topics included tsunami disasters, border-island conflicts related to national territorial issues, sea-level rise, etc. It was felt these topics would make people more aware of the potential problems related to the marine areas in the country. Meanwhile, a second set of issues was considered with regard to increasing awareness of the resource contribution of coastal waters for the country. These included the diversity of coral reefs and small island environments, which are valuable resources for tourism. With this in mind the Coral Triangle Initiative (a multilateral partnership of six countries) aims to conserve the sea and its fisheries, and is working toward food sustainability for the future as well as other uses of coastal resources.

Until recently, the work of anticipating environmental impacts was separate from development plans for some regions. Recently, Indonesia's Ministry of National Development Planning/National Development Planning Agency (Badan Perencanaan Pembangunan Nasional, or BAPPENAS) has started to integrate all sectors into one National Action Plan on Climate Change Adaptation (Rencana Aksi Nasional Adaptasi Perubahan Iklim, or RAN API). Under this Plan, the years 2013 and 2014 mark the start of activities to gather data, develop a system, and make preparations for a development action program for the next decades. The years 2015–2019 and 2020–2024 are slated for implementation and improvement programs, respectively. In 2013 and 2014, several proposed programs will be developed and implemented by individual ministries or institutions. In the subsequent periods, other development plans will be carried out by multiple institutions. There are five main sectors in RAN API: economic resilience, life system resilience, resilience of environmental services, special region resilience, and support systems. Each sector contains sub-sectors and each sub-sector includes clusters to be coordinated.

Through this integrated climate change adaptation plan, BAPPENAS is attempting to integrate the efforts of various sectors and ministries to work together to adapt to climate change, using a collaborative approach. About 40 institutions were involved in the preparation of the program, including the ministries, central and local government institutions, research institutions, national and local planning boards, and universities. All the identified programs will be significant inputs for Indonesia's Long Term Development Program. From this information it is clear that in the future, mitigation and adaptation to the impacts of climate change will be important issues to consider before implementing any development actions.

Case Study: Training to Improve Coastal Community Capacity Through Development of Regional Centers (KMB)

In 2002, Indonesia's Ministry of Marine Affairs and Fisheries introduced the Sea Partnership Program (Program Mitra Bahari/PMB), an idea adopted from the National Oceanic and Atmospheric Administration (NOAA) of the United States, but it was not popular at first. In 2003, only five universities in Indonesia were ready to establish a Regional Center (Konsorsium Mitra Bahari, or KMB) in their provinces. Their role was to become coordinators on research, training, outreach, and policy development related to improvements of marine and fisheries activities in local communities. Surprisingly, the number of KMB institutions has since then grown very quickly. In 2012 there were 33 in total, or one regional coordination office in every province. It is expected that the activities undertaken by the KMB's will grow in number, and later will see an emphasis on quality. Additionally the country is hosting numerous national and international seminars and conferences related to marine, fisheries, and coral reef issues.

KMB members consist of universities, local governments, non-government organizations, and private sector companies. They also include local institutions that are interested in developing research, training, outreach, and policy development programs on coastal, marine, and fisheries issues. Each KMB is located in, and coordinated by, one a local participating university. In the central government, the National Secretariat has coordinated national-level activities since 2003. Starting from that year, KMB have introduced several training programs related to marine and fisheries issues, especially anticipating significant issues faced by coastal communities. Similarly, the central government has been active. The Ministry of Marine Affairs and Fisheries (KKP) created a number of development programs aimed at improving the conditions of communities in coastal regions. One important endeavor aims to improve resilience and is called the Resilience Coastal Village Development program (Pembangunan Desa Pesisir Tangguh, or PDPT), which acts in all 33 provinces of Indonesia.

Our case study concerns a program called "*Training for Trainers on Disaster Mitigation and Climate Change Adaptation in Coastal and Small Islands Region*" (*in short the TOT Program after its Bahasa title*). It was undertaken as a KKP activity (from May 28 to 31, 2013) and related to the PDPT, and was attended by members of universities from nearly all of the provinces of Indonesia.

As a case study the program looked to three villages in the northern part of Central Java that had decades earlier been surrounded by rice fields or other agriculture land and fish ponds. The physical situation has changed dramatically in recent years (see Fig. 8.4a, b). Currently parts or most of the village areas are inundated by water as a result of sea-level rise. Thus, villagers who were once terrestrial-based have been forced to change both their behavior and their culture to become water-based communities, living in an inundated village surrounded by the sea. The response to this physical change in circumstances is varied.

Some villagers moved away from their village, some have changed profession from farmer to industrial laborer, while others tried to become fishermen or restructure the boundaries of their fish ponds by adding higher nets and setting piles higher up from the water's surface. Participants of the TOT project learned from the

(a)

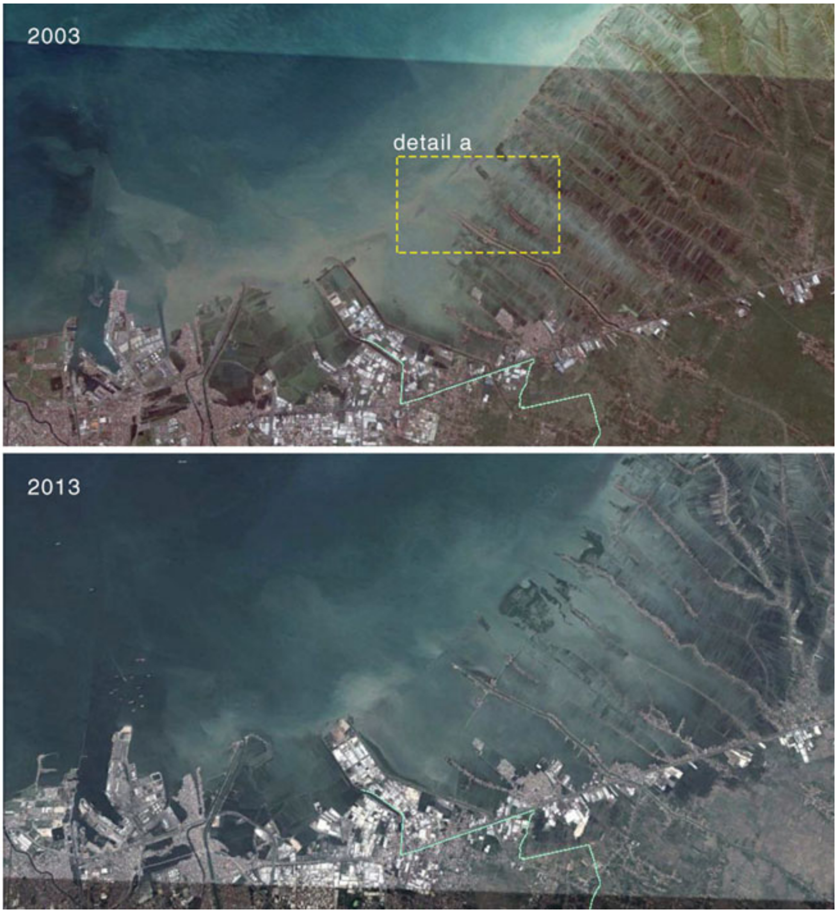

Fig. 8.4 **a** Bedono village: a terrestrial village transformed from a water based village due to sea level rise. **b.** Detail a, Bedono village: a terrestrial village transformed from a water based village due to sea level rise

community and analyzed the problems and possible solutions to improve the coastal community's resilience and quality of life. After completing this program, participants are expected to develop similar or better TOT programs in their own provinces to support their coastal communities as they work to survive similar challenges, improve quality of live, and increase resilience to the specific coastal environmental changes and problems found in their own regions (Figs. 8.5 and 8.6).

(b)

Fig. 8.4 (continued)

In general, coastal environmental problems are caused either by changes in natural conditions or by human behavior. Both need to be studied and anticipated to find integrated solutions. Ideally the solutions should effectively reduce existing vulnerability and improve the resilience of local coastal communities for the long term. Some problems will be site-specific, depending on local conditions, but many development strategies can be derived from more general and broader aspects of environmental change. This TOT training program is still young, but should be reviewed and improved to reflect findings from different environmental conditions all over the country.

Fig. 8.5 Three stages of unsustainable adaptation of type 1 housing in an inundated Bedono Village. From left to right, 2nd stage development, 1st stage inundation, 3rd stage development (*Source* private collection 2013)

Fig. 8.6 Primary school inundated by sea level rise

Conclusion: Lessons Learned from Specific Initiatives

Both RAN API and TOT were organized as strategies to change the awareness of government officials, academics, experts, and local communities facing environmental change. Both programs also are founded in a philosophy of intervention or action in anticipation of the impacts of climate change in specific issue areas. They could additionally have some impacts beyond their level of intervention. For example, RAN API works at a higher policy level for integrating actions among related sectors, while TOT was constructed to help communities facing concrete and current problems. Some challenges could arise in the implementation of their activities and their outcomes need to be further evaluated and improved. That is, studies should look at the situation before and after interventions were put in place, taking into consideration the complexity and dynamic changes of ocean-island development processes.

In conclusion, the authors offer the following observations based on the activities and outcomes of the TOT coastal development and sea partnership program to date:

- Though climate change issues were discussed on several occasions, there was still inadequate understanding of the impacts of climate change and sea-level rise by all of the Indonesian universities. Proper understanding requires an adequate awareness of what can be mitigated and what adaptation strategies can be developed.
- In the past training with regards to natural hazards dealt with potential future events. This program instead looked at responses to natural disaster after they had already occurred. As a consequence, trainees faced more complex problems. This meant that they needed to go beyond the task of anticipating natural hazards, and also implement possible action plans for day-to-day recovery activities.
- The main issue of living in a dynamic coastal region is how to change from a terrestrial way of life to a new water-based way of life. Changing behavior is a long-term process, but the day-to-day problems caused by changing environmental conditions and space-time need to be solved in a shorter period.
- The program itself has been in place over a very long period. The government, private sectors, and other agencies have already been involved and tried to give several solutions, with varying results in the field. These previous activities can be seen as constraints, as a result of which the trainees faced difficulties in collecting data and recognizing the right source of information to identify the main issues for today.
- Most participants came from the marine and fisheries disciplines. Few of them have a background in coastal engineering, construction, and other aspects of physical development.

Similarly, the authors have found some issues of note with regards to the location of study areas that should be considered as factors in the TOT coastal development and sea partnership program:

- Even in the same sub-district, each place has very different physical conditions and access to the city, industry, and other higher economic centers or job opportunities.
- Despite being an archipelagic country, the government, academia and experts in Indonesia still pay more attention to terrestrial REDD (Reducing Emissions from Deforestation and Forest Degradation) + and insufficient attention to problems associated with sea-level rise.
- Few scientific and technological solutions have been developed to anticipate the impacts of sea-level rise. Some solutions only help with short-term problems but not longer-term issues.
- It is important to recognize that some short-term solutions could give rise to new problems in the future (e.g., new roads built at higher levels could act as dams that keeps water from flowing back to the sea at low tide).
- Terrestrial-based communities may not easily transform into a water-based cultures.
- In the concept of a "blue carbon" economy, the change from anthropogenic farming to natural mangrove forest could also be valued as a natural mechanism to increase carbon sinks.

Terrestrial experts and government personnel with backgrounds in terrestrial planning should learn more about how to change their mindsets to support (future) water-based communities:

- The challenge is how to adapt to new living conditions in water regions rather than continuing to develop earlier terrestrial cultures, which cannot continue in the new wet or water-based environments.
- The construction of terrestrial buildings and roads will lead to greater risks than if they were designed and engineered as water-based structures.
- There is a need to change the content of educational programs on design, construction, and planning in engineering schools and universities so that more experts in coastal issues will be matriculated.
- There is a need to change to a new concept of development funding for coastal development, based on the special and specific conditions of each coastal region, small islands, and water-based communities in Indonesia.
- For an archipelagic country like Indonesia, there is also a need to develop new laws that are not only based on terrestrial paradigms but additionally include water-based possibilities for the future.

Indonesia is an ocean-island country, consisting of thousands of islands. The dynamic geo-physical behavior of the environment all but requires that the country should develop its resilience to natural hazards. Ironically the very high bio-diversity of species that live in the ocean-island environment means there is also a limited number of each species alive, which means they are vulnerable. To sustain the limited number of each species, the country has needed to (and still must) conserve its island and ocean resources very carefully. The different conditions and problems found in the ocean typologies of other regions makes it difficult to use them as models that could be easily adopted in Indonesia. Even the differences between the eco-anthroposystems and cultures within Indonesia itself, in the eastern, middle, and western parts of country for instance, makes it difficult to generalize about development methods, either as policy or in implementation. Approaches to development in the dynamic coastal areas or in the changing ocean-island regions require different perspectives and methods and cannot rely on traditional (terrestrial) way of thinking.

Sea level rise will reduce the terrestrial area of the islands. In the long term the country should maintain marine resources as a new, alternative, support system. The limited terrestrial land area, as it is now especially as it will be in the future, ensures that every change that is made, and every development that is undertaken, will have an impact. Such activities therefore should be undertaken to ensure they are 'in tune' with changes in the other parts of the ocean-island area in question. As a part of a multi-cultural eco-anthroposystem, and in recognition of the wide variety of lifestyles of the inhabitants, the country needs a more democratic planning approach. Anticipating environmental change should not stop with understanding a changing ecosystem but also should look to the need for cultural change. This is as true for people living in the areas undergoing change as it is for the planners, the experts and the government authorities that will be involved in the process.

As an archipelagic country, Indonesia cannot not limit itself to following the development strategies of other terrestrial countries. As the biggest archipelagic country, Indonesia should set the example, developing its own planning approach, which could then be followed by smaller island nations in the tropical region.

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Chapter 9
Institutional and Technical Innovation in Pakistan for Resilience to Extreme Climate Events

Pervaiz Amir

Abstract Pakistan is on the forefront of climate extremes, as evidenced by the 2010 and 2011 super floods, which cost accumulated damages of over $U.S.15 billion, roughly 5% of its GDP. It has also shown remarkable resilience in coping with humanitarian crises, such as the 2005 earthquake that killed over 70,000 people, while the death toll from the *War on Terror* and as a front-line state exceeds 40,000. It is ranked as the top country in terms of the costliest climate-related disasters during the last 10 years, as seen in the 2012–13 cold waves that broke records of the past 50 years. This has reminded policymakers that without chalking out comprehensive adaptation plans with effective community-based strategies, it may be difficult to address climate change at the grassroots, with multiple threats and consequences for over 180 million Pakistanis. It is putting into place new institutions, adaptation plans, and a climate change policy (2012) designed to develop greater resilience and transformation. Pakistan's case has much to offer the international community in terms of learning how to cope and adjust to the ramifications of climate change. This chapter sheds light on its experience and what is being done to overcome difficulties that persist, even long after the extreme events are over, by presenting it as a case study, and discusses policy options in light of the UNFCCC's COP 18 recommendations to urgently focus on loss and damage strategies, methodologies, and policies as a way forward for climate change adaptation.

Keywords Climate resilience · Floods · Droughts · Loss and damage · Policy options · Investment strategy · Community-based · Adaptation

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Introduction

Pakistan is a nation of over 220 million, which is poised to reach a population of 344 million by 2050. Its current economic challenges are marred by a full-blown energy crisis that hampers its development and growth rates, putting brakes on all economic activity (Planning Commission of Pakistan 2013). The newly elected government, which took power on 6 June 2013, faces enormous challenges in economics, social harmony, a war on extremism, and daunting challenges from climate change in the form of flooding and droughts that put extra burden on visioning for a future and an otherwise well-endowed resource-based country on a track of economic progress. Water is an important determinant of how this agriculture-based economy will perform in the coming decades. The World Bank (2006, 2013) projects severe water stress for Pakistan, with deleterious consequences for agriculture, human populations, and the pace of development and harmony in South Asia.[1]

The Intergovernmental Panel on Climate Change (IPCC 2013) AR-5 report leaked to the media points to a world with almost 99% certainty that the Earth's climate is quickly warming. Marked changes in the level of precipitation, with short but intense bouts of rainfall/precipitation, are predicted for South Asia, followed by a prolonged period of drought. For Pakistan, the Global Change Impact Studies Center (GCISC 2009) predicts an average ten year increase of 0.74 degrees Celsius (°C) in temperature, reaching between 4 and 5 °C by the turn of century. The new climate change policy approved by the Pakistani government in 2012 takes cognizance of these predictions and sets to lay out a comprehensive strategy to address climate change, with a balanced focus on adaptation and mitigation, the former being the thrust of the overall approach. Adaptation is the dominant concern of Pakistan's environmental planners, with five sector impacts: water, agriculture, health, forestry, and biodiversity. While mitigation is important, Pakistan ranks 135th in the world as a carbon emitter, and despite facing a serious energy crisis has opted for clean energy, even though it has some of the largest coal resources in the world. There is strong desire to invest heavily in water-related infrastructure to make the country more water-secure in the wake of warnings issued by the World Bank that Pakistan is rapidly moving to being a water-stressed nation. However, investment and funding has been slow, with only a recent revival from China to undertake storage and power projects in the northern areas.[2]

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[1]Also see http://www.worldbank.org/en/news/feature/2012/11/18/Climate-change-report-warns-dramatically-warmer-world-this-century.

[2]Commitments reaffirmed in May 2013 on the occasion of the visit of China's President to Pakistan.

Floods in Pakistan

Pakistan experienced its worst flooding in 2010 and 2011. Other floods that caused destruction in the country's history include the flood of 1950, which killed 2,910 people. On 1 July 1977, heavy rains and flooding in Karachi killed 248 people, when, according to Pakistan's meteorological department, 207 mm (mm), or 8.1 in., of rain fell in 24 h. In 1992, flooding during the monsoon season killed 1,834 people across the country; in 1993, flooding during monsoon rains killed 3,084 people; in 2003, Sindh Province was badly affected due to monsoon rains that caused damages in the billions of dollars and killed 178 people; while in 2007, Cyclone Yemyin submerged the lower part of Baluchistan Province in seawater, killing 380 people. Before that, it killed 213 people in Karachi on its way to Baluchistan. The floods of 2010, however, were widely considered as the most devastating in South Asia in recorded history, especially from the perspective of spatial distribution and economic devastation. It is estimated that over 20 million people and one-fifth of the country were affected. The causes are still debated, ranging from an abnormal monsoon due to a low-pressure system in the Indian Ocean, rising temperatures in the Indian Ocean changing the monsoon pattern intensity, a collision of two different weather systems over the northern areas, shifting of traditional cloud mass, etc. (Kamal et al. 2012). The sudden onset of a

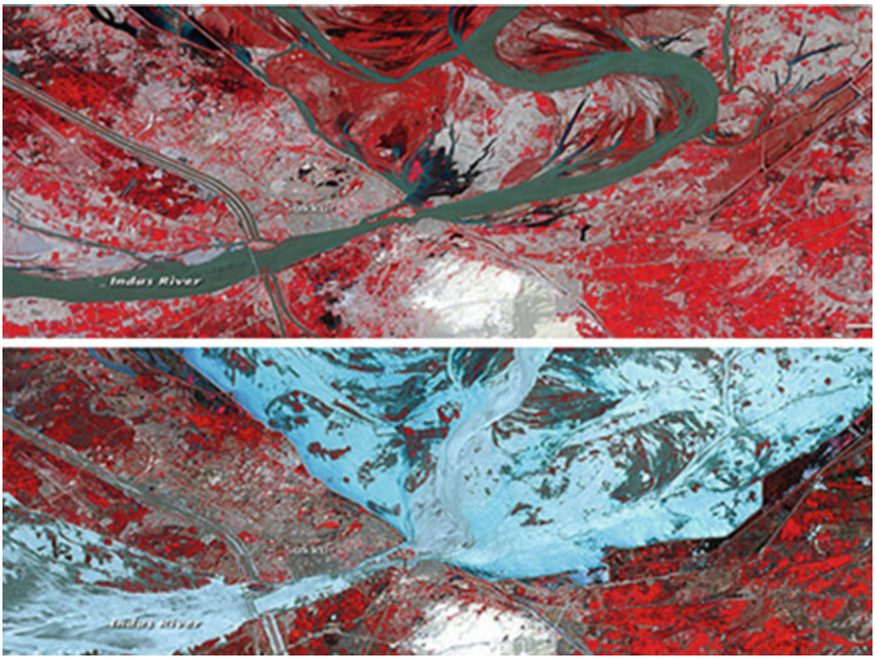

Fig. 9.1 Before and after satellite images of 2010 floods in Pakistan. *Source* http://essentialurbanism.wordpress.com/tag/water, 2010

monsoon system that resulted in over 500 mm of rainfall triggered in a short span resulted in the floods, with both the Indus River and Kabul River overflowing, leading to widespread destruction costing over $10 billion (Aslam et al. 2011) (Fig. 9.1).

The floods of 2010 and the repeat floods of 2011 (localized to the southern part of Pakistan) caused a combined economic loss of over $14.5 billion, or around 5% of gross domestic product (GDP). The United Nations Framework Convention on Climate Change's (Aslam et al. 2011) NEED study, based on different adaptation-costing approaches, suggests an annual adaptation cost of between $6.5 billion to $14 billion. Based on different frequencies of floods, this cost could be even higher. While the adaptation costs calculated are based on different estimation techniques, they point to high adaptation costs upfront and declining over time, as necessary no-regret options are put into place. Pakistan has also been able to contribute to the working methods for loss and damage, gaining much experience during the 2005 earthquake and floods of 2010. Loss and damage was considered an important track under the UNFCCC's Conference of the Parties (COP) 17 and 18 and COP 19 in Warsaw, Poland in 2013. The adaptation committee is giving it much attention and so are the Subsidiary Body for Implementation (SBI) and the Subsidiary Body of Scientific and Technological Advice (SBSTA) (Bonn meetings, 4–15 June 2013) (Fig. 9.2).

Pakistan has underscored the need to look beyond the traditional insurance model, which has lower applicability in South Asia, as evidenced by the fact that even life and property insurance are rather small compared to the overall population insured. Pakistan's floods provide extensive scientific data that largely remain un-analyzed to address future eventualities, and can shed light on loss and damage estimation by sector of impact (e.g., infrastructure, agriculture, forestry, and health).

Fig. 9.2 Floods in 2010, near Peshewar: damage and spread of flooding

Pakistan has learned valuable lessons from the 2010 flood. While some investment in disaster risk management was put in place following the 2005 earthquake that claimed over 70,000 lives, this investment, while inadequate, also showed the overall weaknesses in the institutional response to such large-scale natural disasters. Despite challenging issues of governance and mismanagement that led to a judicial inquiry into the causes and handling of the 2010 floods (Flood Inquiry Commission 2010), much of the blame was placed on how the irrigation department and authorities mishandled the situation, diverting water to areas where marginalized populations were largely impacted at the cost of saving the politically influential groups whose crops were saved and their areas spared. It also became clear that the poor, marginalized, elderly, and children are the most vulnerable to floods.

The political economy of flood management has become a central piece of the debate on flood mitigation. Since, despite adequate warning provided to southern Punjab and Sindh provinces, the widespread displacement of populations and the prolonged delays in resettlement are cause for much concern. As per the statement of United Nations Secretary-General Mr. Ban Ki Moon in his pledge for international support for Pakistan: "This has been a heart-wrenching day for me," he said after flying over the hard-hit areas. "I will never forget the destruction and suffering I have witnessed today. In the past I have witnessed many natural disasters around the world, but nothing like this." He had seen many such catastrophes but none like the Pakistani floods on the scale of damage and widespread impact.[3] The key lessons learned from the 2010 floods in Pakistan can be summarized, as follows.

1. Large-scale destruction costing over $10 billion can have enormous impact on economic growth rates of developing countries like Pakistan. While later floods in Thailand in 2011 and Hurricane Sandy in the United States in 2012 caused much economic loss, the major focus of these floods was localized with impacts on urban populations, while the Pakistani flood created major impacts over one-fifth of the country's land area and impacted over 20 million people. The 2013 floods in Europe, particularly in Germany and Austria, were costly and forced the evacuation of more than 27,000 persons, but death tolls from these floods were low due to excellent relief efforts, even though infrastructure damages ran into the billions of euros.
2. Governments and civil society will always be poorly prepared to handle such widespread floods that cover almost 25% of the country. Pin-pointing the future scale of flooding can greatly benefit disaster relief operations.
3. Early warning systems are extremely effective in predicting floods and provide sufficient warning for taking action, but Pakistan lacks an organized system to predict the impact of flash floods that further contribute to the overall volume of water in the Indus River. Rising global temperatures create anomalies in weather patterns that lead to extreme events, with widespread implications for

[3]See http://www.huffingtonpost.com/2010/08/15/pakistan-floods-ban-ki-moon_n_682649.html.

international debate at the UNFCCC and the need for united action through UN sister organizations.

4. Government decision-making revolves around saving the world's largest irrigation system and shows poor judgment in following updated standard operating procedures (SOPs) that give sufficient attention to human suffering and strike a balance between saving populations versus infrastructure.
5. A cascade of dams on the Indus River, as per the suggestion of a 1960s World Bank study and highlighted during the Indus Basin Treaty (1960), could have had a major impact on mitigating and controlling the water flows downstream and provided sufficient storage to save water for over 900 days, which is an opportunity lost worth several billion dollars of economic gains and welfare distribution.
6. Lack of expertise in hydrological modeling and pool data management on historical handling of floods suggests wide gaps that, if filled, would have high pay-offs.
7. There is considerable indigenous knowledge on flood management which could be coupled with scientific knowledge and satellite-based imagery and meteorology to address flood management, especially in the riverine areas, that remain untapped.

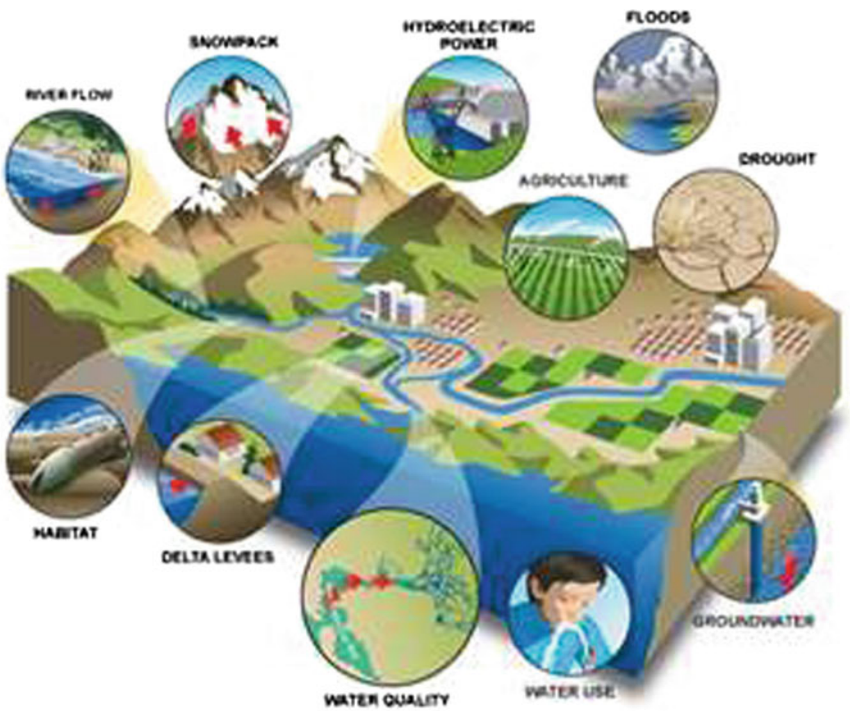

Fig. 9.3 Conceptual model (*Source* www.e-education.psu.edu)

8. Government lacks a comprehensive decision-making model to address flood management, and its existing institutions, like the Flood Commission of Pakistan, are no longer effective in designing strategies to address flood management along scientific lines. The end result is that ad hoc systems are put in place with a low level of expertise involved in decision-making, with resultant decisions that are faulty and costly. A more rigorous review of the institutional mechanism, with close linkages to water-related institutions like the irrigation department, modeling units, academia, and international centers of excellence, can have high pay-offs in addressing future eventualities.
9. Pakistan will benefit by looking at the integrated nature of water and its various linkages with different sectors. Addressing floods and droughts will require a clear conceptual understanding of water and building capacity amongst water managers to quantify and learn to manage these linkages, paying attention to both the constraints and opportunities that water abundance and shortages pose. The strong linkages with climate change are key determinants on water resource management in the future, with different water uses and sectoral dependence (see Fig. 9.3).

Drought in Pakistan

Droughts are a common phenomenon in South Asia and Africa, with long-term consequences for agriculture, economic growth, and continued peace and harmony. The latter is only recently being linked as one of the reasons forcing affected populations who lose employment and livelihoods to become potential recruits for extremist groups, as has been witnessed in the Baluchistan and Waziristan areas in Pakistan.[4] Although such attribution to political turmoil is not new, as can be noted from the recent drought in Syria that is further fueling conflict, and earlier in Jordan and Morocco, where prolonged drought created problems of peace and harmony for the government,[5] as people start to migrate to cities for work and find fewer opportunities on arrival—sufficient cause to blame regimes for their miseries. Many attribute the prolonged droughts in Africa to further the result in polarization amongst extremist groups, as evidenced by conflicts in Sudan and Somalia.[6]

Pakistan has witnessed several droughts in its 65 years of independence. It has a long history of drought events (1958, 1965, 1966, 1967, 1968, 1975, and 1979), but the recent drought (1997–2001) was the longest dry spell in the past 50 years. The

[4]For impact of climatic variables on terrorism in Pakistan, see http://www1.american.edu/ted/ice/pakistan-flood.html.

[5]Links of drought in contributing to conflict in Syria noted in http://thinkprogress.org/climate/2012/03/03/437051/syria-climate-change-drought-and-social-unrest/?mobile=nc.

[6]The Africa case alluded to in http://www.thedailybeast.com/articles/2011/07/03/african-drought-in-sudan-and-somalia-breeds-famine-and-bloodshed.html.

Table 9.1 Country-wide deaths, affected population, and financial losses due to droughts, 1900–2010

Country	Deaths	Affected (in thousands)	Financial loss (U.S.$) (in thousands)
Afghanistan	37	4,808	250
Bangladesh	1,900,018	25,002	n.a.
India	4,250,320	1,061,841	2,441,122
Nepal	–	4,600	10,000
Pakistan	143	2,200	247,000
Sri Lanka	–	6,256	n.a.

Source EM-DAT, created on 24 August 2010

most recent 1998–2002 drought in Sindh and Punjab has had negative impacts on economic growth and extremely high rates of livestock mortality in Baluchistan (see below). By some claims, over 50% of the livestock population vanished and large segments of the population moved from their traditional abodes (FAO 2001). Pre-partition India saw the worst of the droughts, with the infamous Bengal famine causing over 10 million deaths in 1770. It was not the availability of food in some areas but access to food, as disease, malnutrition, and despair were followed with long-term consequences for economic recovery. Africa has seen a similar fate. (A historical listing of accumulative losses is shown in Table 9.1.)

Drought impacts in Baluchistan:
Human population affected: 1,911,534 (32%) with 51 causalities
Livestock population affected: 7,916,966 (30% of total livestock in province)
Crops affected: 1,973,169 acres (45%) of all crops grown
Orchards damaged: 20%
Tubewells dried: 320; karazes dried: 905; springs dried: 63
Source: Shahid Ahmad et al. (2004).
Drought impacts in Sindh:
Area affected: 22,000 km^2.
Population affected: 1.3 million; out-migration: 0.30 million
Livestock affected: 5 million
Water resources: shear drop in groundwater levels, deterioration of groundwater quality, seawater intrusion in delta area due to reduced surface discharges
Source: Pomee et al. (2005).

Droughts caused by disturbed rainfall patterns are serious during both the monsoon season and winter. In particular, lack of winter rains has serious consequences on grain production, as spring wheat grown in Pakistan requires a good spread of rains. Prolonged droughts spread over a few years take a heavy toll on the economy, with widespread implications of further marginalizing groups and contributing to abject poverty.

Pakistan has developed a functional early warning system, with significant investment in the Pakistan Meteorological Department following the 1998 drought, and additional capacity added since the 2010 floods. While predicting drought is

Fig. 9.4 Drought in Sindh, Pakistan, 2001 bring about shifting water-saving techniques like furrow planting

difficult, there are good indications of its impacts and various definitions on its type and severity that help classify what drought will entail for the public at large (Fig. 9.4).[7]

Since droughts seldom cause structural damage compared to floods and are often of a slow onset nature, the Pakistani government has paid insufficient attention to coping with droughts and seldom treats them as a national emergency, due to the possibility of low death tolls, as people migrate temporarily. Much of the response has been in the form of improving infrastructure in the drought-prone areas. The DERA (I and II) projects were aimed at improving the resiliency of communities through the provision of basic infrastructure like roads, water ponds, etc. However, such efforts, while being of a no-regret nature, fail to relieve the economic miseries of those exposed to droughts. Given the widespread and space-time dimensions of drought, response is slow and communities often have to cope on their own. Those who stay behind and fight the drought often lose much of their savings, whether kept in the form of livestock or agricultural assets, and face lost employment, malnutrition, and related hardships. In some areas, communities decide to follow an exit strategy and relocate to a less harsh climate.

a. *Technical Innovations*

   1. Breeding of heat-tolerant varieties more resistant to heat and disease under conditions of moisture stress
   2. Undertaking projects on rain-water harvesting
   3. Changes in cropping systems in response to anticipated droughts by following mixed cropping, strip cropping, and introduction of new crops like oil seeds and millets
   4. Replacement of high delta fruits like apples with low-water requirement fruits like grapes in Baluchistan, which is most prone to droughts

[7]For regular updates from the National Drought Monitoring Center, see http://www.pmd.gov.pk/ndmc/quater1.pdf.

5. Improving the utilization of groundwater through traditional technologies like karez[8] by rehabilitating old structures, many constructed over several hundred years. The International Union for Conservation of Nature has successfully demonstrated that, by improving flows of old karezes by utilization of modern PVC pipes karez, flows can be enhanced by more than five times and village incomes increased multifold (IUCN 2010)
6. Cross-breeding of animals with more drought-resistant livestock strains and technical innovation in housing and livestock husbandry to withstand drought
7. Feed banks and regulations/bans on burning of crop residues in brick kilns to serve as feed for livestock during periods of stress
8. Tree plantation campaigns to reduce stress on homesteads and planting of multi-purpose tree species to provide year round fodder supplies, especially during drought periods
9. Revision of crop water requirements during periods of stress and establishment of new protocols for watering under extreme energy shortages
10. Establishment of weather information dissemination through an extensive network of mobile telephones and linking mobile companies with weather centers to relay key messages on droughts
11. Introduction of climate change curricula in school and college level curricula with greater attention to nature, causes, and remedies for extreme event phenomena like droughts in light of recommendations in the Climate Change Policy (GOP 2012).

b. *Institutional Innovations*

1. Strengthened capacity to predict droughts and linkages with international initiatives of the World Metrological Organization (WMO) and Food and Agriculture Organization (FAO)
2. Investment in dryland agriculture research centers
3. Establishment of National Disaster Management Authority and Provincial Disaster Management Authorities
4. Capacity building and training at grassroots level to expand the understanding of droughts and undertake community-based adaptation through government departments and non-governmental organizations (NGOs)
5. Mass awareness through environmental programs in print, TV, and radio, with greater exposure to the consequences of drought
6. Establishment of new agriculture universities with enhanced focus on dryland agriculture and/or new sub-campuses of existing universities e.g., University of Agriculture Faisalabad, Barani (Arid) Agriculture University, etc.

[8]The karez is common in Iran and Afghanistan. It is a gently sloping tunnel with a series of dug wells constructed through traditional technology. Modern rehabilitation methods employ heavy equipment to rehabilitate karezes. It is estimated that there are over 3,000 karezes in Pakistan.

7. Improved linkages with international dryland centers like ICRISAT (India) and ICARDA (Syria) for technology transfer in crops and dryland innovations
8. Greater attention to crop loss monitoring through satellite imagery and linking this with ground truthing (checking with ground surveys) in drought-prone areas.
9. Investment in on-farm water management to introduce water-saving technologies like furrow cropping, raised-bed crop-planting techniques, water conservation through sprinkler, bubbler, drip irrigation
10. Regulation of canal water and revision of protocols of the irrigation department to handle special situations arising out of drought in canal fed areas.

New Initiatives in South Asia to Address Climate Resilience and Drought

There are new initiatives being proposed to address climate change challenges related to water and agriculture under the WACDEP program of the Global Water Partnership (GWP, Sweden).[9] Pakistan is a part of this six-country initiative that includes India, Bhutan, Bangladesh, Nepal, and Sri Lanka. The project aims to enhance climate resilience by addressing issues related to climate events like droughts and floods through regional cooperation, knowledge sharing, technology demonstration, and capacity building by engaging with governments and civil society to address climate challenges.

The project has strong linkages with the other Asian networks and works in collaboration with organizations like Asia Pacific Adaptation Network (APAN), Climate Development Knowledge Network, Asia Pacific Network for Global Change Research (APN), and several others (see GWP website). While initially for three years, it is expected that the Integrated Drought Management Program (IDMP) being implemented with WMO-Geneva will be implemented over a 10-year period to adequately address issues of drought. Distinct work packages proposed under this program relevant to drought include:

1. regional coordination and cooperation of drought monitoring, prediction, and early warning activities, serving as an interface between climate service providers and various stakeholders in drought management by communicating information to all stakeholders concerned with drought and its impacts;
2. inception of pilot projects and coordination of regional projects to showcase best practices in scientific inputs, policy, and planning for drought management and drought risk reduction through demonstration projects;

[9]See http://www.gwp.org/WACDEP.

3. collection and dissemination of information and knowledge on good practices;
4. guidelines, methodologies, tools, and supporting documentation on policy development and management practices and procedures; and
5. capacity building and advice on integrated drought management based on global synthesis and initiation of pragmatic approaches to address climate change through regional cooperation.

Sharing Knowledge

It is now increasingly evident that South Asian countries, including Pakistan, are taking measures to fast-track climate changes into policies, plans, and approaches to development. In the case of Pakistan, floods and droughts, along with addressing glacier melt and sea-level rise in the delta regions, is high priority. Likewise, agriculture, water, and disease are recognized as priority areas for adaptation.

Likewise, government- and state-level projects are being designed to address drought due to climate changes, as listed in the National Climate Change Policy 2012, that complement regional initiatives including those of SAARC, the regional platform of South Asian countries.

Conclusions

This chapter looked at the case of Pakistan, which has faced severe floods and droughts in the past decade. Recent floods have drastically impacted economic development and continue to be a viable threat, as predicted by various national and international models of the IPCC. Pakistan has undertaken several institutional innovations, such as establishing a National Disaster Management Authority with provincial centers; upgraded its meteorological department on modern lines to enable drought and flood forecasting; and initiated new projects. The country is also keenly pursuing capacity building at all levels to address extreme climate events. In the area of technical innovation, technology centers are now focusing on new agriculture crop varieties that are heat- and excess-water-tolerant and better suited to the changing climate. However, the projected temperature increases are already impacting crop and livestock yields, with serious implications for food security. The challenges in addressing floods and drought in Pakistan require strong capacity to warn early on-set and time-tested protocols that work under a variety of conditions. Regional co-operation can greatly enhance responses to some of these calamities, and several new initiatives including regional efforts by different networks are underway. While much of the focus is on influencing the policy environment, knowledge-sharing and introducing Pakistan to best practices elsewhere is important. It is adapting to these changes, often at high cost. In Pakistan's case more than $10 billion is estimated to be required annually for both planned and autonomous investments, which are becoming more and more difficult, given the severe energy crisis it faces. Loss and damage assessment is an emerging area that needs to receive attention as the country plans for future extreme flood and drought events. Likewise, developing strong capacity for climate change modeling and interpretation at different levels of decision-making are core activities that need to be included in future plans. Academic attention is required to develop new methodologies to evaluate the social, economic, and environmental impacts of climate change on projects, as the methods and approaches are still poorly defined. Pakistan has considerable to offer to the international community as a case study of extreme floods and droughts. The data are amenable to further analysis and documentation that provides opportunities for international academic cooperation. A science-based decision model would further enable a decision-making framework that incorporates multiple dimensions, leading to better judgment and response to extreme events in one of the most vulnerable countries in South Asia.

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Chapter 10
Development of an International Institutional Framework for Climate Adaptation and Practice in Adaptation Planning in Developing Countries

Makoto Kato

Adaptation to climate change is an iterative process the IPCC defines as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". Together with mitigation, adaptation is regarded as one of two fundamental pillars of efforts to address climate change. It is relatively new and underdeveloped, far smaller in terms of investments made so far, and since the level of uncertainty remains high, it poses enormous challenges for policymakers and investors to take concrete actions. One significant aspect is that it should be based on, and more integrated into, sustainable development planning. By introducing the historical development of international negotiations on climate change adaptation, and its recent dramatic changes, this chapter aims to provide a macro-perspective on an institutional framework regarding adaptation to climate change under the UNFCCC. It also argues that the focus of efforts at international, national, and local levels will shift to a more holistic approach instead of responding to adaptation needs on an ad hoc basis. This shift will happen by elaborating and implementing national and local adaptation plans that support a society resilient to climate change. Since experience with adaptation planning is still limited, it is important to share technical information based on national experience. By so doing, the international climate change regime can better serve the promotion of resilient societies at the national and local levels in a practical manner.

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Introduction

Adaptation to climate change is an iterative process, which the Intergovernmental Panel on Climate Change (IPCC) defines as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". It also distinguishes various types of adaptation, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (IPCC 2001). Generally speaking, adaptation to climate change is regarded as one of the two fundamental pillars of efforts to address climate change, together with mitigation efforts.

Compared to mitigation efforts, adaptation to climate change is relatively new, underdeveloped, being far smaller in terms of investments made to date, and since the level of uncertainty remains high, while the scale of necessary investment appears to be large, it poses enormous challenges for policymakers and investors to take concrete actions. Until now, in other words, scientists and policymakers have found no perfect solution to the issues, which include highly scientific and technical challenges, together with extremely complicated economic and social implications.

In recent discussions in international climate change negotiations, however, several significant steps have been taken, driven by both increased sentiment for advancing adaptation efforts and accumulation of lessons learned from practices on the ground in developing and developed countries. One significant aspect of the development is that in discussions on a future climate change regime, increased focus has been given and institutional arrangements within the United Nations Framework Convention on Climate Change (UNFCCC) have expanded. Another significant aspect is the recognition that adaptation should be based on, and more integrated into, sustainable development planning, rather than formulated as stand-alone projects. Namely, Parties to the Convention have now started emphasizing the formulation of national adaptation plans, with a view to realizing a climate change resilient societies.

This chapter aims, by introducing the historical development of international negotiation on climate change adaptation, and its recent dramatic changes, to provide a macro-perspective view on an institutional framework regarding adaptation to climate change under the UNFCCC. Also, it tries to argue that, as a general direction, the focus of adaptation efforts, at international, national, and local levels, will shift from responding to adaptation needs on an ad hoc basis to a more holistic approach by elaborating and implementing national and local adaptation plans, which would support promotion of a climate change resilient society.

Historical Background and Development of Adaptation Under the UNFCCC

In order to take stock of the placement of adaptation to climate changes, and foresee possible institutional development, it is important to revisit the relevant documents adopted and agreed in the UNFCCC (Table 10.1).

Placement of Adaptation to Climate Change in the UNFCCC and the Kyoto Protocol Text and Their Related Decisions around Marrakesh

As one of the three Rio Conventions, the UNFCCC was adopted by the United Nations Conference on Sustainable Development (UNCED, or Rio Summit) and signed by 155 countries in 1992, and entered into force in 1994. With 195 Parties (as of May 2013) having ratified it, the Framework Convention is the largest legal and political umbrella for international society, under which Parties are encouraged and coordinated to take actions. Given the function to provide a framework for

Table 10.1 Chronological events on negotiation on climate change adaptation

1992		**UNFCCC** adopted at Rio Summit
1994	COP 1	**Berlin Mandate,** Decision 1/CP.1
1997	COP 3	**Kyoto Protocol (KP)**
1999	COP 6	Hague Conference was not able to agree on KP implementation rules
2000	COP 6.5	**Bonn Agreement** (basis for the Marrakesh Accord)
2001	COP 7	**Marrakesh Accord**, Decisions 5/CP.7, 7/CP.7, 28/CP.7, 29/CP.7 Included adaptation activities to be supported, National Adaptation Programme of Actions (NAPA), Least Developed Countries Expert Group (LEG), Least Developed Countries Fund (LDCF), and Special Climate Change Fund (SCCF)
2004	COP 10	Buenos Aires programme of work on adaptation and response measures, Decision 1/CP.10
2006	COP 12	**Nairobi Work Programme on impacts, vulnerability, and adaptation to climate change (NWP)**
2007	COP 13	Enhanced action on adaptation under the Ad Hoc Working Group on Long-Term Cooperative Action (AWGLCA)
2010	COP 16	**Cancun Agreements**, The Cancun Adaptation Framework (CAF) which includes the NAP process, work programme of Loss and Damage (L&D), and the Adaptation Committee
2011	COP 17	**Durban outcomes** Decisions operationalizing elements of the CAF (NAP process, L&D, Adaptation Committee) Provisions for the review of the work areas of the NWP
2012	COP 18	**Doha Climate Gateway** Decisions on Loss and Damage

international decisions, commonly seen in other multilateral environmental agreements (MEAs), the UNFCCC has its Conference of Parties (COP), for countries to meet once a year, to negotiate, and instantiate generalities into specific decisions.

Noting that the description of all substantive items in the Convention text remains at the general level, it provides basic elements and fundamental goals for the Parties. Among others, Article 4.1 stipulates as the commitments by Parties: (a) submission of GHG inventories; (b) formulation of national programmes on mitigation and adaptation; (c) promotion of transfer of development and technologies; (d) sustainable management of carbon sinks; (e) cooperation for adaptation to climate change; (f) consideration on social and economic impacts; (g) promotion of and cooperation in scientific and technological research; (h) exchange of information on climate systems, etc.; (i) promotion of education, training, and public awareness; and (j) national communications to the UNFCCC. Article 4.2 and beyond stipulates differentiated legal obligations of Parties by their categories under the Convention; there is no prejudgment on whether Parties should prioritize mitigation to adaptation, or vice versa. The parties contained in the Annex I (Annex I Parties) consist of the Organisation for Economic Co-operation and Development (OECD) member countries at the time of the adoption of the Framework Convention and the Economies in Transition (EIT) countries, such as the Russian Federation and Ukraine. The Annex I Parties are obliged to submit their National Communications including GHG inventory annually under the Convention. Parties contained in Annex II are obliged to provide financial support to non-Annex I Parties for the preparation of their National Communications, as well as for other supports such as technology development and capacity-building.

From the earlier part of negotiations for the Convention Text at an International Negotiating Committee for a Framework Convention on Climate Change (INC), and at the first session of COP (COP 1), however, it was regarded by Parties as political priority to formulate specific legally binding instrument on Qualified Emission Limitation and Reduction Objectives (QELROs) of greenhouse gases (GHGs) to be undertaken by the Annex I Parties. In this regard, the Berlin Mandate, adopted by COP 1 (UNFCCC 1995), mostly focused on mitigation by the Annex I Parties and was targeted at adoption of such an instrument at its third session (COP 3).

As a result of the negotiation mandated by the COP 1 decision, at COP 3 the UNFCCC Parties agreed upon the adoption of the Kyoto Protocol. As earlier mentioned, high attention was given to the QELROS of the Annex I Parties, and a major part of the Protocol Text is related to mitigation and its flexibility mechanisms, including Joint Implementation (JI, Article 6), the Clean Development Mechanism (CDM, Article 12), and Emissions Trading (Article 17). Almost the only part that mentions adaptation is Article 12.8, about the share of proceeds, which would provide a financial resource to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation. This Article became a legal basis for establishing the Adaptation Fund (AF).

Driven by the adoption of the Kyoto Protocol, COP 4 provided a new mandate in the form of the Buenos Aires Plan of Action (BAPA), which provides a road map for agreement on implementation rules of the Protocol at COP 6. The overall political attention was still focused on mitigation, and adaptation, as such, and hardly showed its face in the center of the negotiations at that time, while at COP 6 and its resumed session, the establishment of the Least Developing Countries Fund (LDCF) and the Special Climate Change Fund (SCCF) under the Framework Convention, and the Adaptation Fund under the Kyoto Protocol, were agreed as negotiation deals for developing countries, in return for the introduction of the flexibility mechanisms. These were finally agreed upon as a package of the Marrakesh Accord, which opened the door to operationalize the Kyoto Protocol.

From the Stagnant Period to Accelerated Work in the Future Regime

After COP 7 at Marrakesh, there was an attempt to increase efforts toward COP decisions regarding adaptation, although it was limited to those related to LDCs, such as elaboration of and support for the National Adaptation Programmes of Actions (NAPAs). From COP 8 through COP 11 and the first session of the Conference of Parties serving as the Meeting of Parties (COP/MOP or CMP) of the Kyoto Protocol, generally speaking, there was not much development regarding adaptation to climate change. COP 11 and CMP 1, however, mandated respectively the start of negotiation on a future climate change regime, including mitigation efforts both by developed and developing countries, and on adaptation, as one of the bargaining chips, starting to draw more attention in the negotiations.

For example, at COP 12, the Parties agreed to elaborate the Nairobi work programme on impacts, vulnerability, and adaptation to climate change (NWP), which would aim to improve their understanding and assessment of impacts, vulnerability, and adaptation to climate change; and to make informed decisions on practical adaptation actions and measures to respond to climate change on a sound scientific, technical, and socioeconomic basis, taking into account current and future climate change and variability (UNFCCC 2007).

At COP 13, Parties established the Ad Hoc Working Group on Long-term Cooperative Actions (AWG-LCA). Under the CMP 11, the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP) was established. While the negotiation topic under the AWG-KP was related only with mitigation actions by the Annex I Parties (Protocol ratifiers), but essentially the negotiation on a future regime was structured in a parallelism approach, so that whether or not and the extent of which developing countries urge developed countries Parties under the Protocol to accept commitments may be captured in a balance with the level of support they are receiving including those for adaptation areas. At the same time adaptation was regarded as a building block of the Bali Action Plan (UNFCCC 2008) and in its history, it came to be a central issue of the climate change negotiations. At COP 13, the Cancun Agreements provided a fairly large part of the contents regarding adaptation to climate change, which were consolidated as the Cancun Adaptation Framework (CAF) (UNFCCC 2010). Under the CAF, LDCs are enabled to formulate and implement national adaptation plans (NAPs), building on NAPAs, as a means for (a) identifying medium- and long-term adaptation needs, and their integration into development planning; and (b) developing and implementing strategies and programmes to address those needs. The COP requested the Subsidiary Body for Implementation (SBI) to consider the elements, modalities, and guidelines for the LDCs, as well as other developing country Parties to employ the modalities formulated to support the NAPs in the elaboration of their planning efforts. Further to this, COP 17 provided initial guidelines and modalities for a National Adaptation Plan (UNFCCC 2011).

Also in the Cancun Adaptation Framework, the Adaptation Committee was established in order to (1) provide technical support and guidance to the Parties; (2) share relevant information, knowledge, experience, and good practices; (3) promote synergy and strengthen engagement with national, regional, and international organizations, centers, and networks; (4) provide information and recommendations, drawing on adaptation good practices, for consideration by the COP when providing guidance on means to incentivize the implementation of adaptation actions, including finance, technology, and capacity-building; and (5) consider information communicated by Parties on their monitoring and review of adaptation actions, support provided, and received.

Looking back at the history of climate change negotiations, discussion on the adaptation issue attracted a relatively low level of attention at the earlier stage, and was sometimes dealt with as a bargaining chip for mitigation commitments by the Annex I Parties, as well as possible mitigation actions to be undertaken by Non Annex I Parties, in the form of requesting support. In recent years, however, despite partially being dealt with as a bargaining chip, COP decisions started taking up more technical contents of the issue. This may show that some issues cannot be confined within only political and vaguely conceptual discussion anymore, as the level of maturity in technical aspects became higher, thanks to accumulation of knowledge and experience about adaptation work. Especially, in relation to financing adaptation work through the GEF Trust Fund, the LDCF, the SCCF, and the Adaptation Fund, as well as other multilateral and bilateral finances, experience was gradually accumulated, and elements that enabled adaptation have been better studied, including the availability of data and information and planning as a backbone for specific adaptation actions (GEF 2007).

International Finance for Adaptation to Climate Change: Relevance with Planning Aspects

While the scale of, and access to, funding available for developing countries have always been a matter of political tension and continue to be negotiated under the UNFCCC, climate finance for adaptation has widened its range gradually. As mentioned above, COP 7 was a milestone for adaptation finance, and those established funds started to operate several years later, with their own modalities and scopes of actions. Figure 10.1 shows the currently available finance sources related to adaptation.

These funds were established by respective COP or CMP decisions, as well as initiatives led by donor countries and institutions. While they are all established for the purpose of providing financial support to adaptation-related work, the focal areas of work vary depending on the design of their fund.

For example, while the LDCF, which is one of the earliest funds for adaptation, supports LDCs to elaborate NAPAs, the Adaptation Fund specifically supports concrete adaptation projects or programmes. Also, the Climate Investment Fund (CIF) provides large amount of investments for hardware, while the GEF Trust Fund under the Strategic Priority Adaptation (SPC) funds projects related with increasing adaptive capacity (GEF 2011). In addition to these funds, the Green Climate Fund (GCF)—established by the Cancun Agreements and currently in the process of designing its institutional and operational structure—is expected to cover finance for adaptation, in complementarity with other funds.

At first glance, these financing schemes look very different from each other and are operating in a relatively disorganized way. Indeed, how to increase the effectiveness of respective financial support in the same country or same sector remains a question, and such a role should primarily be played by a recipient country. However, such recipient countries (and in many cases, ministries in charge of adaptation) are not necessarily prepared for coordinating donors, as well as other ministries and key stakeholders. In this regard, it is increasingly recognized that elaborating of national and local adaptation plans is extremely important, in the sense that such plans provide a common platform and show directions for all relevant stakeholders.

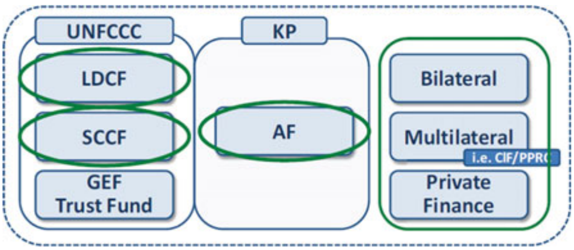

Fig. 10.1 Finance on adaptation related to the UNFCCC (Fukuda 2012)

Table 10.2 Major funds related to adaptation and their focal areas of support

Funds	Focal area
GEF Trust Fund (GEF5)	• Strategic Priority Adaptation (SPC) Support pilot and demonstration adaptation projects that provide real benefits and can be integrated into national policies and sustainable development planning in developing country Parties
Least Developing Countries Fund (LDCF)	• To finance work programme of the LDCs • To finance preparation and implementation of NAPAs
Special Climate Change Fund (SCCF)	• To finance adaptation activities, programme, and measures (as one of the four financing windows)
Adaptation Fund (AF)	• To support concrete adaptation projects and programmes
Climate Investment Fund (CIF)	• To support formulating Pilot Program for Climate Resilience (PPCR)

Note GEF5 means the work period between May 2010 through June 2014 after the 5th replenishment

From the financers' perspective as well, in order to design a good project or programme, and to avoid maladapted work due to miscalculated data or lack of prioritizing the correct needs, it is more useful to have a backbone plan, such as plans related to land-use or agricultural development.

For example, the SPC of the GEF emphasizes its function as support to pilot and demonstration adaptation projects that provide real benefits and can be integrated into national policies and sustainable development planning in developing country Parties. Also, the Pilot Program for Climate Resilience (PPCR), supported by the CIF, actually provides foundational information resources, including relevant sectoral policies. In the case of the Adaptation Fund, which explicitly states that the Fund would support concrete adaptation projects and programmes, having a national, sectoral, or local plan integrating such specific actions is considered valuable, from the technical perspective. In a recent case of accreditation of a national implementation entity (NIE) in South Africa, it was clearly stated: "*The key element in its accreditation had been the creation of a national development plan.*" (AFB 2012) Table 10.2.

National Adaptation Plans

Against the above-mentioned background, both from the negotiation as well as the practical point of view, the importance of making national adaptation plans has gradually been recognized. Since it has been a challenge for many developing country Parties, in particular for those least developed, however, COP 17 adopted 5/CP.17, containing "Initial guidelines for the formulation of national adaptation plans by least developed country Parties."

According to the same decision, the objectives of the national adaptation plan process are (a) to reduce vulnerability to the impacts of climate change, by building adaptive capacity and resilience; and (b) to facilitate the integration of climate change adaptation, in a coherent manner, into relevant new and existing policies, programmes and activities, in particular development planning processes and strategies, within all relevant sectors and at different levels, as appropriate. While NAPAs supported by the LDCF mainly are targeted at short-term and immediate actions, the characteristic of NAPs is to cover not only short, but also medium- and long-term adaptation actions. By so doing, slow-onset events such as coastal erosion and ecosystem changes may be also captured, integrating such concerns into planning related to sectoral policies.

There has been a strong sentiment among Parties that the decisions by COP in this context should not be too prescriptive, and instead that the developments should be more country-driven, so that the 5/CP.17 itself is limited only to sort out a very basic concept of national adaptation planning, and a process to enable LDCs to formulate NAPs. Indeed, some country Parties already expressed the view that the guideline itself was too general, and would require them to additionally specify steps and methodologies on how to formulate a NAP (UNFCCC 2012a).

However, in addition to the above-mentioned decision, the Least Developed Countries Expert Group (LEG) also provided technical guidelines, which provide more specificity and example steps to be taken to prepare for a NAP, as shown in Fig. 10.2 (UNFCCC 2012b). It generally consists of four major steps, namely, (a) laying the groundwork and addressing gaps; (b) preparatory elements; (c) implementation strategies; and (d) reporting, monitoring, and review. Since these descriptions are quite generic, and in order to assess the effectiveness of these guidelines, it is useful to see examples of countries which have already made indicative steps for formulating a NAP.

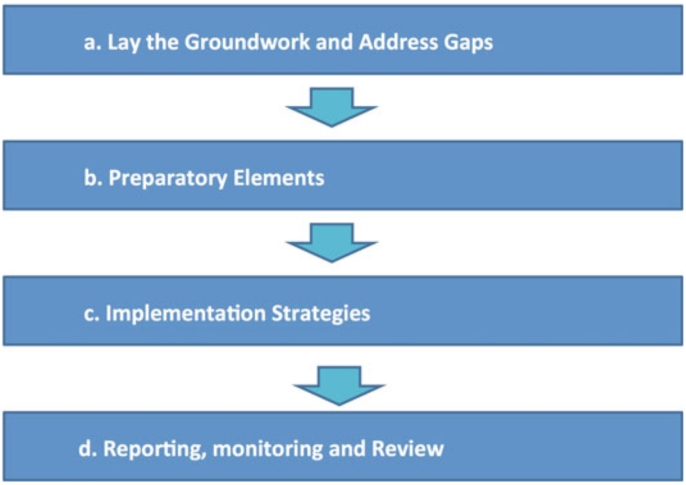

Fig. 10.2 Main elements and steps of national adaptation plans

Table 10.3 shows Tanzania's submission regarding its experiences, namely, elements and steps of its NAP process, which applied LEG's guidelines in their formulation process.

By assessing Tanzania's case, one may be able to say that there is strong leadership by a domestic leading agency, to coordinate line ministries and other key stakeholders. According to its submission, For instance, Tanzania mentioned that the Office of Vice-President would take the lead in the NAP process (UNFCCC 2012c). Also, in formulating the NAPs, it has identified major tasks to be undertaken, such as, assessment of institutional arrangements, programmes, and capacities, the status of integration of climate change adaptation into national and local government authorities' plans, etc. Rather than being a planning document describing actions to be taken, it is more significant to say that the NAP will provide the process of formulation, implementation, and evaluation, where the country may integrate adaptation concern into its sustainable development policies at various levels, participated by key stakeholders.

In the past, when a NAP was not available, the implementation of an adaptation project was done more in a stand-alone manner. Thus, there was a risk of ineffectiveness or lack of coordination in relation to relevant sectoral policies and stakeholders. If NAPs are established widely in developing countries (not necessarily LDCs only), the operation of the above-mentioned funds, and possibly adaptation finance in future may be more smooth and effective. As of today, since it is an early stage of the NAP process in many countries, experience with implementation and evaluation is not yet available. In this regard, it is also important to accumulate knowledge and information regarding the latter steps of the NAP process, with a view to further improving the process, in a reiterative manner.

Strengthening Institutional Development for Adaptation to Support Efforts Toward Resilient Society

As shown above, with a small start of adaptation work in the negotiations more as a bargaining chip, the level of attention to the issue has been gradually elevated, along with increased experiences with practices by developing and developed countries in partnership with donors. It is significant that, while adaptation actions tended to be dealt with in a stand-alone manner, it has been now recognized that each respective action should be placed under a holistic plan. To advance such efforts, COP decided to promote NAPS, and many developing countries responded.

To date, the negotiation on a future climate change regime is still in process, and it is expected to reach an agreement on a legal instrument by the end of 2015, with a view to entry into force in 2020. In this negotiation, the issue of adaptation is part of the package, and expectations of developing countries are high. It is important to enhance adaptation action in the future climate change regime, including scaling up the level of finance. To do this, Parties are making several proposals. Given the

Table 10.3 Submission by the Republic of Tanzania: "Elements and steps for the NAP process showing indicative activities"

Steps	Indicative activities
Element A. Lay the groundwork and address gaps	
Initiating and launching of the NAP process	a. Operationalize the NAP process through provision of support b. Conduct briefings to policymakers about climate change adaptation challenges and opportunities, and the NAP process in particular c. Enhance a national vision and mandate, for the NAP process. Define a framework and strategy as well as a roadmap, including sequencing of various NAPs and monitoring and evaluation plan for the NAP process
2. Stock-taking and gap analysis: identifying available information on impacts, vulnerability and adaptation, and assessing gaps and needs of the enabling environment for the NAP process	a. Conduct stocktaking of ongoing and past adaptation activities b. Synthesize available analyses of current and future climate at the broad national level, including vulnerability analyses and studies on the economic impacts of climate change c. Coordinate compilation and developing a (distributed/shared) database for the NAP process d. Conduct a gap analysis to assess capacities and weaknesses, adequacy in the NAP process e. Assess potential barriers to the planning, design, and implementation of adaptation activities
3. Addressing capacity gaps and weaknesses in undertaking the NAP process	a. Enhance enabling institutional and technical capacity for the formulation of the NAP b. Identify and enhance awareness of potential opportunities for the integration of climate change adaptation in development planning at different levels c. Step up the implementation of climate change communication programmes, public awareness raising, and education
4. Comprehensively and iteratively assessing development needs and climate vulnerabilities	a. Compile information on main development objectives, policies, plans, and programmes.. Identify synergies between development and adaptation objectives, policies, plans, and programmes with a view to identifying risks to investment and opportunities for collaboration and realizing co-benefits (starting with climate-proofing), including economic benefits
Element B. Preparatory elements	
Steps	Indicative activities
1. Analyze climate risks	a. Analyze current climate to identify trends in variables and indices that could be used to support planning and decision-making b. Characterize broad future climate risks and levels of uncertainty using scenario analysis at the national level c. Communicate projected climate change information to all stakeholders and the public

(continued)

Table 10.3 (continued)

Steps	Indicative activities
Element A. Lay the groundwork and address gaps	
2. Assessing climate vulnerabilities at the sector level and others, and identifying adaptation options	a. Develop/downscale future climate change and socioeconomic scenarios for target areas and sectors b. Assess vulnerability to climate change at the sectoral levels (by applying applicable frameworks) c. Rank climate change risks and vulnerabilities d. Identify and categorize adaptation options at multiple scales to address priority vulnerabilities
3. Reviewing adaptation options	a. Appraise individual adaptation and apply decision analysis to identify adaptation priorities at the sectoral levels b. Compile and communicate sectoral plans or strategies
4. Compiling and communicating a National Adaptation Plan	a. Aggregate sectoral adaptation priorities into a draft National Adaptation Plan through a stakeholder ranking process and avail the draft for review b. Integrate review comments into the prepared National Adaptation Plan and process its endorsement at the national level, as defined in the mandate for the NAP process c. Communicate and disseminate the NAP and other NAP outputs widely to all stakeholders in the country
5. Integrating climate change adaptation into national development and sectoral planning	a. Identify opportunities and constraints for integration of climate change in planning b. Build and enhance capacity for integrating climate change in planning c. Facilitate the integration of climate change adaptation into existing nation planning processes

nature of adaptation, which is country-driven and requires both domestic initiative and international cooperation, it is important to maintain loose coordination between relevant bodies within the UNFCCC. Also, since experiences of adaptation planning are not yet extensive, it is important to share technical information based on national experiences. By so doing, the international climate change regime can better serve the promotion of resilient society at the national and local levels in a practical manner.

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Chapter 11
Mainstreaming Climate Change Adaptation Products and Services by Japanese Companies with Base-of-the-Economic-Pyramid (BoP) Businesses

Tokutaro Hiramoto

There is a natural overlap between adaption based business ventures and so-called Bottom of the Pyramid (BoP) ventures. BoP is a decades old term that refers to the potential for making businesses that are both profitable and socially meaningful in the world's largest but poorest population—the economic assumption is that the size of the population will offset the financial wherewithal of the group as a whole. Since the Great East Japan Earthquake, which struck the northeast coast of Japan on March 11, 2011, Japanese companies have realized the important potential of what might be called the 'Adaptation businesses with regards to climate change issues. This coincides with a growing investment in BoP businesses. Some Japanese companies that already are working to implement BoP businesses in developing countries have shifted their focus to harmonize with adaptation ventures in order to expand the market while creating positive social impact. There are four major commonalties between the BoP sector and "adaptation businesses" that solve problems caused by climate change through their business activities: (1) they are for people living in areas lacking basic social services such as clean water, electricity, and medical services; (2) they require continuous support; (3) they provide products and services tailored to the status and needs of the target location; and (4) the will and voluntary activities of local people must be respected so they can be self-sufficient. The Japanese government recognized this movement and instituted a new feasibility study system in order to accelerate the efforts of Japanese companies in developing adaptation measures through their business activities. With regards to business in emerging and developing countries, it is indispensable to approach both governments and local companies as well as consumer markets for business expansion and stable profits. From that perspective, adaptation measures are a vital concern of these governments and they offer the potential of significant business opportunities for private companies.

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Common Ground among Climate Change Adaptation Activities Re-invented through Restoration Activities by Japanese Companies after the Great East Japan Earthquake

The Tohoku–Pacific Ocean earthquake and tsunami (Great East Japan Earthquake) that struck on March 11, 2011 wrought tremendous havoc upon the northeast region of Japan. The damage caused by the earthquake was significant, while the damage from the subsequent tsunami was enormous. At the same time, however, Japan is seeing positive new developments in various fields emerging out of the reconstruction efforts. An example is the contribution to climate change adaptation by Japanese companies through their business activities. This is now being called "adaptation business."

BoP is an abbreviation for "base of the economic pyramid," which refers to the lowest income group, and not incidentally the largest population group, found at the bottom of an economic pyramid. In Japan, the number of companies focused on BoP businesses has increased since 2009. As these companies have accelerated their entry into emerging markets since the economic collapse caused by the bankruptcy of Lehman Brothers in 2008, the BoP sector has come under the spotlight as a potential middle layer of the economic pyramid of the future. BoP businesses aiming to solve global issues such as poverty have also attracted other business attention at the same time. Among the various definitions of BoP, Japan's Ministry of Economy, Trade and Industry (METI) defines it as the income group with an annual per capita income below U.S. $3,000 (based on local purchasing power parity in 2002). The BoP group comprises 4 billion people worldwide, accounting for an astounding 70% of the world's total population (Fig. 11.1).

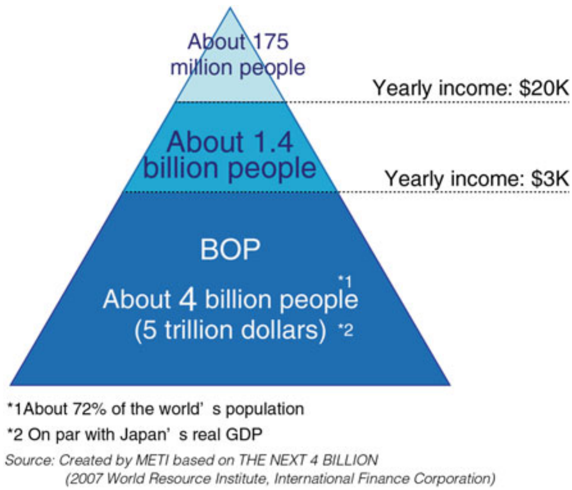

Fig. 11.1 The base of the economic pyramid (BoP) accounts for an astounding 70% of the world's total population

The BoP sector is defined by METI as sustainable business targeting the BoP group in developing countries (consumers, producers, sellers, or any combination thereof), and a new business model is expected to contribute to solutions to social problems in the local areas (water, provision of daily necessities and services, poverty reduction and the like).

One of the better-known BoP businesses is Project Shakti in India, which Hindustan Unilever Limited (HUL), a subsidiary of Unilever N.V./Unilever PLC, has been operating since 2000. Under Project Shakti, HUL gained the means of distribution its products in farming communities by training women to be door-to-door salespersons in farming villages. Having these female entrepreneurs sell its small soaps and other products packaged in smaller sizes, HUL had trained 48,000 salespersons by the end of 2012. As a result, it successfully turned more than three million households into new customers in villages with over 100,000 people in 15 Indian states.

As a result, HUL has significantly improved the hygienic environment of the BoP group through this business. Thanks to making washing hands with soap before meals a daily habit, the incidence of infectious diarrhea has markedly decreased, enabling many people to engage in farming or day-hire jobs without taking sick days off. Consequently, their income increased. In this way, HUL sold its products, and on top of it, successfully approached potential repeat customers.

As mentioned, an increasing number of Japanese companies are also engaging in the BoP sector, providing, for example, solar-powered lanterns to generate light in villages still without electricity; electronic IC cards used in buses in Bangladesh; water-purifying agents to turn muddy water into drinkable water; octopus pods (traps), a technique taught by Japan used in octopus fishing in Mauritania, Africa, a place very far away from Asia (which helps them trade with other countries); and mung beans, the raw ingredient for bean sprouts, being cultivated on land damaged by seawater due to the effects of climate change. These examples are all products and services of Japanese companies in the BoP sector that contribute to creating a more sustainable world. As described above, the technology flow has usually been from developed to developing countries, yet innovative products and technologies used in the BoP sector are provided to solve global issues such as those outlined in the United Nations' Millennium Development Goals (MDGs).

On the other hand, as suggested by the concept of "reverse innovation," popularized by the company General Electric and Stuart L. Hart, a Cornell University professor, there is a need to provide innovative products and technologies that were initially created for (and in) developing countries, to developed countries in order to create a more sustainable world (Hart 2010, Immelt et al. 2009). This "reverse flow" has clearly emerged in Japan in the wake of the Great East Japan Earthquake.

After the disaster, Japanese companies actively distributed the products and technologies from their BoP businesses in developing countries in Japan, in order to help Japanese communities affected by the earthquake and tsunami. For instance, Panasonic Corporation donated a number of its Life Innovation Containers, a system designed for areas with no electricity, which includes a solar power generation system consisting of solar lanterns, solar panels, and storage batteries manufactured by SANYO Electric Co., Ltd. The technology was originally designed for the BoP sector and related activities in non-electrified areas in countries such as Kenya, Tanzania, Uganda, India, and Indonesia. Another example is Nissin Food Products Co., Ltd., which dispatched seven “kitchen cars” with an in-car hot water supply unit, and provided one million servings of “cup noodles,” an instant noodle product, to communities in the affected area. The kitchen cars had originally been used to provide fortified noodles to people living in parts of Kenya where clean water is scarce. Furthermore, Nippon Poly-Glu Co., Ltd. supplied water-purifying agents to communities in the disaster areas, which had originally been sold through local female entrepreneurs to people in areas with no access to clean water such as in Bangladesh.

In turn, the products and technologies developed as part of the reconstruction efforts after the Great East Japan Earthquake, later began to be used in the BoP sector in developing countries. For example, NEC Corporation (NEC) is running a BoP business in India, leveraging the hydroponic cultivation techniques from GRA Inc. that were used to deal with salt-damaged land due to the tsunami in the Japanese town of Yamamoto (Watari district, Miyagi Prefecture). NEC is using the hydroponic cultivation techniques and its energy management systems to help stabilize power supplies needed for hydroponic cultivation by better controlling the electrical power from the grid and residential power generators. Moreover, a partnership with the College of Agriculture in Pune, India, has enabled NEC to train students to be production managers through on-the-job training with hydroponic technologies. Social problems such as seawater damage are increasing in developing countries as a result of climate change impacts. We thus observe that some of the new products and technologies that emerged during the reconstruction phase after the disaster in Japan are proving capable of solving these problems.

In this way, a two-way street of innovative products and technologies between developed countries and developing countries has generated a new innovation cycle in post-disaster Japan (Fig. 11.2).

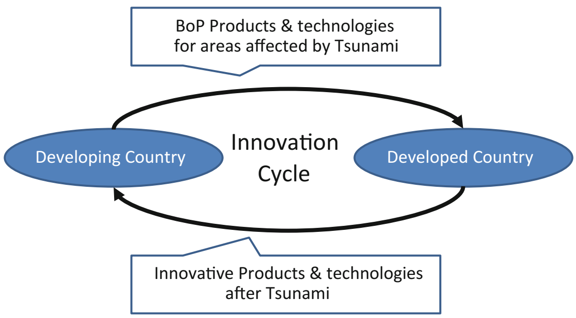

Fig. 11.2 New innovation cycle in Japan after the Great East Japan Earthquake

Japanese Companies that Integrate Climate Change Adaptation and BoP Businesses

The new innovation cycle that has emerged in Japan is an important countermeasure against global climate change. In climate change adaptation, in particular, it could serve as a driving force to spur corporate activities.

In this sense, climate change adaptation is a concept that people may use to confront social problems that have already grown large due to the effects of climate change, notably by making the best use of Japanese technologies. The societal problems concerned are quite diverse, including above-mentioned disasters such as tsunamis and flooding, water shortages, and decline in agricultural productivity due to climate and temperature changes, epidemics, increasing numbers of refugees, and energy shortages. These problems are beginning to be brought to the fore in countries that consist of many islands and in African regions vulnerable to climate change. These problems are often matters of life and death, particularly for low-income earners such as those in the BoP group.

There are four major commonalties between the BoP sector and "adaptation businesses" that solve problems caused by climate change through their activities: (1) they are for people living in areas lacking basic social services such as clean water, electricity, and medical services; (2) they require continuous support; (3) they provide products and services tailored to the status and needs of the target location; and (4) the will and voluntary activities of local people must be respected and encouraged so they can be self-sufficient. These commonalities are surely the cause of the above-mentioned innovation cycle born out of the disaster in Japan.

The Japanese government has actively promoted businesses in the BoP sector. It has also improved existing measures and policies and developed new ones after the disaster, so that new technologies developed in the wake of the disaster will be fully leveraged in the BoP sector. This chapter shows the trends of public-private partnerships (PPPs) by the Japanese government, referring to private companies as an illustration of the policy framework in the adaptation sector.

BoP Business Promotion Schemes and New Trends After the Disaster in Japan

In the discussion so far, we have seen cases of companies that had already been considering or were actually engaging in the BoP sector offering their products in the earthquake/tsunami-affected area. This would not have happened if the companies had operated businesses targeting only developed countries. In other words, the disaster occurred against the backdrop of expansion in the BoP sector among Japanese companies, which led to expansion of the adaptation business in our country. In Japan, 2009 is considered the first year of the BoP business sector. Since METI established the BoP Business Policy Study Group in 2009, BoP business promotion initiatives have been launched and expanded by Japanese government-related organizations such as the Japan International Cooperation Agency (JICA), Japan External Trade Organization (JETRO), and international organizations like the United Nations Development Programme (UNDP). In particular, systems to provide funding for feasibility studies and to help companies find potential local business partners are believed to be the drivers of a significant increase in the number of Japanese companies trying to enter the BoP business sector. Already, over 200 companies have been seriously considering starting a BoP business or are operating a BoP business because of the support systems available. Against the background of an expanding BoP sector, various companies have tried to utilize their experience and technologies—accumulated and developed in their own BoP business—for the recovery efforts from the disaster, while still searching for ways to support the earthquake/tsunami affected area.

It must also be mentioned that many companies not already running a BoP business contributed to recovery efforts by applying their experience and technologies, since the damage caused by the disaster was enormous. Various new technologies were born out of these activities.

The Japanese government recognized this movement and worked to send Japan's new technologies out into the world. Specifically, JICA improved its existing "Preparatory Survey for BoP Business Promotion". It also encouraged proposals promoting the utilization of technologies used during the recovery phase from the Great East Japan Earthquake, proposals from companies based in the earthquake/tsunami affected area, and proposals for countermeasures related to flooding in Thailand and other parts of Asia.

In addition, METI instituted a new feasibility study system to accelerate the efforts of Japanese companies in developing adaptation measures through their businesses (feasibility study on visualizing the contribution by the Japanese private sector to the adaptation needs of developing countries). As a result, seven Japanese companies were selected for the Adaptation Business Feasibility Study (see Table 11.1). Among them, Yamaha Motor Co., Ltd., SANYO, and Yukiguni Maitake Co., Ltd. have used the feasibility study system in JICA's BoP business support system. We can tell from this example that the BoP sector and adaptation sector have a close affinity.

Moreover, the UNDP and METI held a joint symposium and workshop in Tokyo called "Possibilities of Inclusive Business and Adaptation to Climate Change in Africa" on March 6 and 7, 2013. Companies currently operating an adaptation-related business—Sharp Corporation, Panasonic, Toray Industries, Inc., and Wellthy Corporation—appeared on the stage. METI has already publicly solicited proposals for a feasibility study from FY2013 to FY2016, as it did in FY2012. The combination of enlightenment activities and measures to promote and support business launches, it is believed, will further increase the number of Japanese companies entering the adaptation sector.

Table 11.1 List of companies selected for FY2012 METI feasibility study on visualizing contribution by the Japanese private sector towards adaptation needs in developing countries

Company	Products/services	Project objective	Country
Sharp	Electrolysis water purification system	To increase access to safe water, which is reduced by climate change	Kenya
Toray	Desert greening promotion	To prevent desertification by PLA (Polylacticacid) sand- tube and convert desert to farmland	South Africa
Yamaha motor	Water purification system by filtration	To increase access to safe water, which is reduced by climate change	Cote d'Ivoir Ghana
Ajinomoto	Aminoacid contained fertilizer	To make crops durable to higher temperature and increase yield amount	Tanzania
Kawasaki geological engineering	Slope disaster prevention	To prevent slope disaster triggered by increasing torrential rainfalls and storms	Vietnam
Sanyo electric	Solar lantern	To increase the safety of refugees due to drought by providing them with solar lanterns	East Africa
Yukiguni Maitake	Bean production in salinized area	To produce mug beans in salinized area which is increased by climate change	Bangladesh

Source Japan Ministry of Economy, Trade and Industry (2012) Study on Sustainable Contribution by the Japanese Private Sector to Developing Countries' Adaptation Needs (Tokyo: Ministry of Economy, Trade and Industry)

The Benefit of Strong Companies

As discussed, participation in the adaptation sector has been expanding gradually among Japanese companies. Regarding climate change, in general, Japanese companies are expected to make contributions through business in additional fields. For example, agriculture, forestry and fishery industries, water, health, energy, disaster prevention, and education could be new fields where their accumulated advantages could be utilized (Table 11.2).

Table 11.2 Fields and measures in need of climate change adaptation measures to which contributions by Japanese companies are expected

Fields in need of climate change adaptation	Adaptation measures
Agriculture, forestry and fisheries industry	Secure and increase crop harvests, promote eco-friendly agriculture and develop crops resistant to climate change
Water	Supply safe water and resolve water shortage
Forestry	Measures against desertification and prevention for forests
Health	Medical treatment and prevention of communicable diseases from spreading due to climate change
Energy	Improve access to renewable energy
Disaster prevention	Building a strong society against natural disasters such as flooding and drought
Education	Enlightenment and education to adapt to climate change

For instance, it is projected that up to 250 million people in Africa could suffer from water shortages by 2020, in countries highly vulnerable to climate change. Agricultural production relying on rainwater is expected to decline by as much as 50% (IPCC 2007). Each nation has its own strengths and abilities, however if we were to give an example, water-purification technology is one in which Japanese companies have a competitive advantage. The nation also has cultivated some expertise in making efficient use of limited rainwater for agricultural production, which could be useful in reducing the impact of water scarcity. In a sense every time a nation faces a disaster or adapts to a challenge they are accumulating knowledge that could be useful not only to the immediate members of society but also might be used in the future to develop business opportunities. Again, in the case of Japan, the development of infrastructure resistant to disasters caused by climate change may also be a field in which Japanese companies have accumulated expertise through the recovery efforts following the 2011 tsunami and earthquake.

Funding by governmental and international organizations for adaptation measures will increase as the effects of climate change become larger. In addition, if climate change emerges as a corporate operational risk, companies must pay the expense for measures to address the risk. In reality, climate change threatens raw material procurement of food companies. They used to reduce procurement costs by reducing the number of sourcing countries; however, they are beginning to diversify their procurement sources all over the world in order to reduce the risk of having inadequate supplies of raw materials, as a result of disasters due to climate change. They choose to do so, even though diversification means an increase in procurement costs.

With regards to business in emerging and developing countries, it is indispensable to approach governments and local companies as well as consumer markets for business expansion and stable profits. From that perspective, adaptation measures are a vital concern of these governments, and they offer the potential of significant business opportunities for private companies.

It is possible to take some general lessons from our experience, On March 2011 the Great East Japan Earthquake caused catastrophic damage to Japan that arrived at the shore in waves, culminating in a nearly unprecedented tsunami and nuclear disaster. While the disasters were profound in their impact, if Japanese companies take advantage of the challenge to develop groundbreaking solutions, they might be able to get ahead of others and promote new businesses in the fields where adaptation pays off.

This can be true of any nation struggling with similarly massive events. Based on the Japanese experience however it seems that governments should strengthen public-private partnerships (PPPs) in adaptation measures. As the adaptation sector expands all over the world, it brings the possibility of enabling people worldwide to overcome challenges brought about by climate change, which is likely to become more serious in the future.

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Chapter 12
Systems Established for Reconstruction After the Great East Japan Earthquake, and the Current Situation on the Ground

Sosuke Tanaka

This chapter offers the insight of disaster reconstruction in Japan from the point of view of a government agency working between policy, planning, and implementation. The chief frame of reference is the earthquake and following tsunami that struck the northern coast of Japan on March 11, 2011. At a magnitude of 9.0 the scale of the Great East Japan Earthquake was unprecedented for modern Japan, firstly as an earthquake and secondly for the sheer breadth of devastation that resulted from the ensuing tsunami. Some 500 km of coastline was affected. The government response to the ensuing challenges was necessarily of a large scale and also innovative in many ways. Planning for reconstruction was purposefully shifted from the more typical centralized and top-down approach of Japan to a local and community based approach. The intent was to build flexibility and awareness of the local situation into the decision making process in order to take better decisions more quickly. Similarly the Reconstruction Agency was created to bridge across multiple government bodies in order to provide a one-stop contact point, where communities and other groups could go to resolve problems and undertake reconstruction efforts without the need for multiple visits to multiple agencies. The new agency is emblematic of a kind of government that works to understand local needs better and that enables communities to act in their best interests as a result of being better informed.

From the editors

This article is particularly of its time. Written as it is in the fall of 2013 it is intended to highlight the state of Japan some two and a half years after one of the largest natural disasters to strike a nation in recent history. It is not intended to be read as an analysis made after some years have passed. Rather it shows the ambitions,

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hopes, and concerns that the government had for its reconstruction efforts as they were being planned and carried out. As such is a very important and useful record.

The Great East Japan Earthquake which struck in March 2011 was an extensive disaster. The main area hit by the event covered an area stretching 500 km from north to south and included three Tohoku prefectures. Many other parts of the country also felt the effect of the earthquake if not the tsunami, but the impact was without any question, felt by the entire nation.

The Japanese government implemented novel and diverse measures to respond to this unprecedented scale of disaster, including the establishment of the Reconstruction Agency as a one-stop contact center. The Agency integrates measures across different governmental agencies to respond to requests from local governments and provide them with assistance in an integrated manner. The measures include a system of Special Zones for Reconstruction, aiming to introduce special measures to the affected area such as tax breaks and relaxed requirements in regulations and procedures, and special grants for reconstruction to integrate town rebuilding efforts by local governments, allowing them to undertake their own reconstruction efforts virtually without bearing expenses. In addition, learning from disaster response experience in the past, the government promptly leased private rental accommodations for the evacuees without awaiting the completion of temporary housing so that they could swiftly put their lives back in order.

As a result, more than 99% of the evacuees, who had numbered about 470,000 immediately after the earthquake, were able to move from shelters to housing within the span of 6 months. In spring of 2014 the number of households living in private rental accommodations was larger than the number living in temporary buildings constructed after the disaster. With regards to businesses, in contrast to reconstruction measures for disaster-stricken companies in the past, which only provided special loan programs and credit guarantee systems, in this case a variety of additional systems were provided These included free maintenance and free lending of temporary shops and factories; group subsidies that provide up to 75% of facility and equipment costs needed for business reconstruction; and a double loan relief system under which a government agency takes over debts owed by companies before the disaster. Moreover, an easy-to-use system for small and midsize companies was introduced by local governments. To finance these measures, the national government provided drawdown reconstruction funds that could be requested for unspecified purposes.

While these systems were put into place, it is expected that the real measures for reconstruction will take the form of long-term efforts. One major reason is that the biggest damage was caused by coastline subsidence due to the earthquake and the tsunami that followed. Based on the fact that the affected area along the Sanriku Coast and other regions were historically and frequently affected by tsunamis, the ground is being raised along the coastlines and residential zones were being transferred to higher ground inland in town rebuilding efforts.

The cost to raise commercial land and develop residential zones on higher ground inland from the coast was and is borne by the national government in the form of grants to local governments. However, collecting local residents' opinions and purchasing building sites is essential and a prerequisite before proceeding with actual projects. Even if change is not apparent in the affected area since the disaster constant efforts are being made under the surface to build a consensus. It is only natural that it should take a long time to make serious decisions that may determine the future course of life of each one of the affected people—all of whom differ in age, occupation, income and background.

On the other hand, the long suspension of normal business may lead to terminations of contracts and other problems, making it harder to rebuild businesses. In view of this, the government started to build and provide temporary shops and factories for affected enterprises. This was done using public funds in advance of full-scale community building programs. In addition, a new reconstruction subsidy system was established for businesses that could quickly restore business with full-scale facilities. This subsidy system allowed enterprises to collaborate with partners, including their clients, to form a group, and develop a business plan aimed at becoming more robust than before the disaster. Applicants could receive funds from the national and prefectural governments that subsidize up to 75% of the capital expenditure. In this regard at least 3400 zones of temporary buildings have been developed and a reconstruction subsidy was granted to more than 9200 people within 2 years of the disaster.

It is important to underline that these administrative measures for restoration and reconstruction were provided purely for the purpose of giving assistance to local businesses, not for the authorities to run businesses themselves. Unless market economy principles are fully in effect, local businesses will neither be able to gain market shares in other regions in Japan nor overseas, nor will they become winners among competitors in their respective sectors. Now is the time for local businesses, trade associations (including fishermen's cooperatives, tourism associations, commerce and industry associations and the local chambers of commerce and industry), and local governments to make concerted efforts focusing on market expansion, improving product development capacity and promoting the attractions of the region. The period when the general public gives attention to the region simply because it is a disaster-stricken region devastated by the earthquake is approaching the end. In fact, the affected area currently receives funds about three times the annual budget of the Small and Medium Enterprise Agency, an agency that develops national policies concerning 4.2 million businesses nationwide. It is not clear until when this kind of special treatment can be continued. Meanwhile, some companies that made aggressive capital investments and resumed business immediately after the disaster have increased sales compared to pre-disaster periods. Other companies that actively sought assistance from other regions in Japan and developed their business based on the new connections have succeeded in getting their businesses on track. Local businesses should not depend entirely on the assistance provided by the government and from other regions. Based on the principle of independent management and self-determination, they must obtain the know-how needed to get through this crisis and to move forward.

The Reconstruction Headquarters in Response to the Great East Japan Earthquake, the predecessor of the Reconstruction Agency, was created in June

2011. This took place after evacuee assistance efforts required in the immediate aftermath of the disaster met their general goal, and the Basic Act on Reconstruction was implemented. To give some background to the process, firstly staff of ministries and agencies assigned to this task came together to create the secretariat of the Reconstruction Design Council (RDC 2011a). They drew an overall picture of reconstruction, developed the Basic Guidelines for Reconstruction (RDC 2011b), made budgets for reconstruction, and wrote relevant laws and regulations based on their policies. As a prompt response was required to deal with situations and problems that were changing on a daily basis in the affected area, no departments or sections were created in the headquarters. Senior officials, including the director-general (administrative vice minister level), directors (bureau chief level) and counselors (section chief level) did not have fixed positions, which made it possible for them to organize a new team in a flexible manner and deal with new tasks as soon as they surfaced. Their subordinates, who were non-managerial staff, also reported to different managers following oral appointments, changing their desks almost each month, which brought a high level of flexibility to the organization.

Close cooperation amongst ministries was essential to their task, including cooperation with the Ministry of Finance, the Ministry of Internal Affairs and Communications (on reconstruction funds), the Ministry of Land, Infrastructure, Transport and Tourism (on town building), the Ministry of Economy, Trade and Industry and the Ministry of Agriculture, Forestry and Fisheries (on occupation restoration). The staff from the various ministries and agencies assigned to the headquarters responded promptly whenever cooperation was required through their personal connections with their original places of work. In addition, since the Reconstruction Headquarters in Response to the Great East Japan Earthquake consisted only of a few dozen staff, it was easy to share information on each ministry's situation and ask the top of the organization, the Head of Reconstruction Headquarters, to make a decision. As a result, they could implement new measures at speed, which was unprecedented in any other administrative organization in Japan at the time.

The Reconstruction Agency, created in February 2012, was composed of diverse human resources from the beginning, including staff from private companies, local governments and NPOs assigned to the same workplaces where the existing staff from ministries had been assigned. Although it was a hastily formed and motley group, the fact that they had a clear purpose, (reconstruction), and a clear field (the affected area) led to a cohesive organization and made information on the affected area easier to collect.

To give an example, assistance to the seafood processing industry on the Sanriku Coast involved not only the local governments providing information on the fishery operators and the Fisheries Agency subsidizing the project. It also involved other diverse measures and groups including subsidy projects provided by the Small and Medium Enterprise Agency, grants for town rebuilding projects, market development efforts aided by private company employees, staffing in cooperation with the local governments, and disaster victim care services provided by NPOs. These organically linked participants brought about good results more effectively as a team than they would working without some understanding of the total picture. The more complicated a problem in the field is, the more it can benefit from the know-how accumulated in the group.

The Reconstruction Agency, unlike other ministries and agencies, was organized with 11 local bureaus in the affected area in addition to its main office in Tokyo, each of which was given the authority to develop its own measures. To give an example of this arrangement in practice, the Miyagi Regional Bureau of Reconstruction, located in Sendai, developed its own response measures based on "*ties between the affected area and other regions*". This is different from the more conventional tools of "*budgets, taxes and regulations*" used by central government ministries and agencies. As a more detailed example, staff assigned from private companies succeeded in matching local fishery operators with companies in other regions as part of the reconstruction effort (RCA 2012).

A phenomenon unique to post-disaster recovery is that, as more and more attractive administrative measures are provided, people tend to alternate between strong optimism and strong pessimism, after each temporary assistance measure is disclosed. However, what we really should evaluate is not how to undertake a simple temporary recovery. Instead we need to look at how systems and institutions are developed that could allow us to address regional revitalization on a continuous basis. The word "reconstruction" can only take root in the real world after the regional economy finds independence. The affected area of this earthquake does not have a natural large-scale market, which makes it difficult to attract major financial investors. On the other hand, this is the kind of area to which new value can be added through cooperation with diverse players such as local banks, credit banks, credit unions and NPOs. In the case of the latter group, the number of NPOs in the three prefectures in the Tohoku region multiplied three times since before the disaster. The number of new corporations created in the coastal region has exceeded 1000. I believe a fundamental picture needs to be created for the future of Japanese society and especially for the thinly populated communities, where each individual or company plays multiple roles. The idea is that they would employ these new approaches as a driving force to revitalize the region and create a small market with a large impact.

New connections and businesses can be created, and a variety of resources (including public and private assistance measures) can be used, when diverse players such as enterprises, NPOs and local governments aim to accomplish one common goal. For example, a shopping mall in Otsuchi Town in Iwate Prefecture, which was hit by the tsunami and buried under rubble was rebuilt using government subsidies and debt factoring. These assistance measures made it possible to reduce store rents in the mall, which in turn made it possible for local stores swept away by the tsunami to move in. As a result, there are more stores than before the disaster, creating a place where local people can gather. Following on this early effort a town hall office and a bus stop were, creating a center for the town reconstruction effort.

Similarly, the city of Ishinomaki in Miyagi Prefecture gives assistance for business reconstruction to skilled hairdressers who lost their salons in the tsunami by giving assistance to entrepreneurs as well as using funds from a private foundation. A franchise system was formed to establish salons for hairdressers. Building on this, hairdressers and nursery school teachers were assigned to each salon, which was accordingly equipped with a children's playroom to help women return to work.

The Reconstruction Agency compiled constructive reconstruction examples like these into a collection of case studies (RCA 2013a). Our intention is that people can consult this collection as a reference and prescription to show how to utilize a variety of regional resources. The hope is that this kind of reading will lead to further successful cases in reconstruction. In addition, we send an e-mail newsletter (RCA 2013b) to companies and local public entities working on reconstruction of the affected area. The content include disaster-related information shared by the Reconstruction Agency and other ministries and agencies, as well as information on progressive approaches adopted by companies and local public associations in the affected area. We believe the national government should function as a hub that links many different players as well as provide conventional resources such as budgets, taxes and regulations. While currently the government plays a central role in providing information and assistance, we hope local public associations and local associations of commerce and industry will eventually take over that role. The reason for this is that we believe that basically only the region itself can work out what is best for it. Each region has different needs, and the requirements to meet their distinct needs are determined on a case-by-case basis. Each region should think about its own affairs since there is no prescription that can deal with the affected area as a whole.

The Reconstruction Agency, the Ministry of Internal Affairs and Communications, the National Governors' Association, the National Association of Towns and Villages and other relevant organizations each have secured a budget and staff to provide manpower to affected municipalities to improve reconstruction efforts in each area. The Japan Association of Corporate Executives, NPO corporations and other organizations also provide human resources to affected companies and organizations. It may be possible to expand these currently discrete activities into wide-area activities if these projects for public and private disaster-relief mobilization of human resources can be developed into a public-private alliance. This type of network-based reconstruction was also discussed and identified as an agenda that needs to be addressed at a meeting of the Reconstruction Promotion Committee, an expert committee established under the Act for Establishment of the Reconstruction Agency (RCA 2013c).

We need to create a society in which the public administration and communities are no longer working in the business-as-usual situation. This is important if people are to be less easily influenced by stereotypical assumptions and news reports. It is also important if everyone is to receive and correctly act upon direct information about the actual situation on the ground, including primary information from the government. We should not consider this ambition only in terms of temporary events such as disaster reconstruction. We must closely analyze social problems, consider them as our own, and take action to address the issues in a constructive way in cooperation with many groups. I believe that taking action in this way is our mission as major players in the next generation.

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Part IV
Tools and Methods for Building Resiliency

The details of weather and climate are likely to remain unpredictable to some degree over the long term. Likewise, uncertainty about human culture and activities, and especially technology, is inevitable. If we accept that these statements might be true then the most important factor relevant to building resilience in any community, large or small, is learning to live with change and uncertainty. Practically speaking, if we are honest about how little we know still, and how little we ever can know, a certain amount of precaution might be useful. As the saying goes it is better to be safe than sorry. In that case, what tools do we need in order to fulfil that ambition? What do we need to know so we can protect ourselves, and how can we put our knowledge to use in practice? This part gathers four authors who shed some light on that question, each looking at a particular issue. The topics do not form a comprehensive list, but they do introduce some of the more difficult problems that need to be solved.

Ye describes a toolbox that does not yet exist, but should. He begins with the observation that even if scientists and other researchers gather the information needed to make good decisions, there is at best only a poor communication corridor between them and policy makers, government leaders, and community groups. The people entrusted with making plans and decisions have no easy way to learn what is needed to build resiliency.

Imbulana's chapter considers the fact that the effects of climate change are not constrained by national borders. There is a need to monitor changes and to make plans that extend across regions. At the same time, every country has its own cultural norms and systems of governance in place, in which case a regional response must necessarily be modified to suit very local ways of life and be respectful of local knowledge, even as the effects being responded to are nominally equal. As he points out, in that context the empowerment of communities is essential to improving resilience.

Perera and Bin Khailani extend this point, focusing on the importance of local planning and how resilience and vulnerability reduction are built into the design of cities. They use a case study in Malaysia to underline their discussion and most importantly find that higher and lower level governments can be working at odds with each other in terms of their policies and activities. This finding can easily be imagined as a problem in other countries and cities around the world, and likewise their call to build a bridge between governmental bodies and to empower local leaders to take action rings true as a general requirement for resiliency. Developing the social tools to make that call a reality is important.

Roggema and Popov take a different tack, and examine the potential of computing power in the planning process. In their chapter they describe an early version of an urban planning tool they are developing in order to manage uncertainty and to make room for flexibility in the planning process.

Taken together, the authors advocate each in their own way for tools and codes of conduct they can fall back on when an unexpected event takes place. Learning to "expect the unexpected" is an oxymoron that resilience almost certainly requires. We might suggest that it is also important to avoid focusing only on risks and precautionary measures in order to leave room for diversity and flexibility. Reducing vulnerability by absorbing external shocks and adapting to change incrementally or even through a revolutionary transformation is a large step. It is more than enough to ask for. Still, we hope that as the tools outlined here are developed and become more mainstream, that communities will also remain open to multiple strategies for building resilience.

Chapter 13
Developing an ICT-Based Toolbox for Resilient Capacity Building: Challenges, Obstacles and Approaches

Qian Ye, Xiaobing Hu and Zhangang Han

Resilience is now more than a buzzword, as we learned from the impact of several recent very large-scale disasters around the world. Both the international academic and policy communities recognize that the accumulation and reduction of disaster risk is closely intertwined with the fields of sustainable development, environmental protection and climate change, as well as humanitarianism. It is important that policies in these areas are designed to be mutually reinforcing, whether at the local, national or international level. With the increasing pace of interconnectivity in current social-ecological systems, there are many challenges and obstacles to overcome, including a lack of breakthroughs in theoretical studies of complex dynamic systems, a lack of knowledge brokers needed to improve communication between science and policy, and the ever present difficulty of developing and evaluating multidisciplinary education, training and research projects under the current academic system. In this paper, by discussing challenges and obstacles in the development of the science-policy interface, the framework for an ICT-based toolbox is proposed that consists of four major components, including: data collection, analysis and dissemination, simulations based on both natural science models and agent-based models driven by social regulations and economic rules, and an interactive visualization platform. These are developed with a fourfold purpose: (1) facilitating knowledge gathering that will cumulate in the classroom, (2) sharing knowledge and equalizing access to knowledge amongst multidisciplinary research groups, (3) transferring knowledge for use in training, and ultimately, (4) applying knowledge in decision-making processes (in government or elsewhere).

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Background

The world is currently faced with a number of complex challenges of global importance. To name a few, societies in both developed and developing countries, such as China, are marked by an aging population, with severe implications for public debt, political inertia, and total productivity. The global economy has entered a phase of slow growth after a spectacular surge, and is now faced with the aftermath of the global financial crisis. The rapid development and monetization of Information and Communication Technology (ICT) is generating an overwhelming and ever-increasing volume, velocity, and variety of data, especially in visual formats. On the one hand, new business opportunities, such as big data and cloud computing, are becoming rising stars. On the other hand, the increasing controversy over using big data technology to uncover and monitor terrorist activities sets collective security against the desire to protect privacy as well as human rights. This kind of problem is not only changing the role of governments in the IT business, but also has an impact on international relations, as exemplified by the questions related to the massive amount of classified information (from the United States National Security Agency) that Edward Snowden controversially made public in 2013.

Dramatic changes in the global socio-economic system are not only reshaping national politics and international relations but also putting great pressure on the global environment—from biodiversity loss, deforestation, soil erosion and land degradation to air and water pollution (Rockström et al. 2009a). In particular, global climate change is now being recognized as a principal challenge. By leading to shifts in long-run trends in, for example, temperatures and rainfall patterns, climate change is not only already having significant impacts on global food production and water resources (IPCC 2007), but also, most ominously, is making the natural environment more fragile. Extreme weather events, such as winter storms and hurricanes, and extreme climate events, such as heat waves and floods, are expected to increase in frequency and severity and this trend will intensify—even in the best-case scenario (IPCC SREX 2012). As reported recently by the World Meteorological Organization, the 2001–2010 decade was the warmest since the start of modern measurements in 1850, and the world experienced unprecedented high-impact climate extremes during the decade (WMO 2013).

To prevent dangerous anthropogenic interference with the climate system, the United Nations Framework Convention on Climate Change specifically sets up its ultimate objective under Article 2: to stabilize greenhouse gas concentrations in the atmosphere at a level and within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, with the secondary ambition to ensure food production is not threatened and to enable economic development to proceed in a sustainable manner (UNFCCC 1994). Unfortunately, recent observations show that concentrations of greenhouse gases are still increasing in the atmosphere, and that CO_2 emissions (with the exception of a temporary decrease due to the global financial crisis) are following the upper end of the IPCC scenarios (Le et al. 2009). In addition, analyses by Rockström and co-authors show that climate change is only one of several interconnected threats to the stability of the planetary system (Rockström et al. 2009a, b).

The 2013 Global Assessment Report on Disaster Risk Reduction found that as one of the results of interaction between the global social-economic system and the Earth's ecological system, the global economy's transformation over the last 40 years has led to a growing accumulation of disaster risk. Annually, economic losses already amount to hundreds of billions of dollars. Even though the specific consequences differ among sectors and countries, countless everyday local events and chronic stresses involving multiple disasters and disaster chains are an ongoing burden for an increasing number of countries. Clearly, in the coming decades, countries across the world will face enormous challenges caused by the combination of long-term adverse impact of unmitigated climate change and environmental degradation and short-term disruptions from disasters that lead to conflicts over access to natural resources, mass movements of human population, and the potential for increased social and political instability.

Recognizing the need to simultaneously increase the capability to resist shocks and to strengthen the ability to recover from disasters (and maximize potential opportunities), the concept of building a resilient society has been raised more and more frequently by the international community in the past decade. It puts emphasis on building a bridge between the emergency response and long-term development goals.

The Hyogo Framework for Action—the first internationally accepted framework on Disaster Risk Reduction (DRR), adopted in 2005, was the first comprehensive attempt to detail the ingredients of resilience. In the chair's summary of the Fourth Session of the Global Platform for Disaster Risk Reduction, it re-states that "*Both the accumulation and reduction of disaster risk are closely intertwined with the fields of sustainable development, environmental protection and climate change as well as human mobility. It is important that policies in these areas are designed to be mutually reinforcing, whether at the local, national or international levels. An emphasis was placed on integrated, multi-sectoral approaches to disaster risk reduction, and to strengthening disaster risk reduction in key sectors, such as education, agriculture and health. Development and resilience are unlikely to be sustained unless disaster risk is explicitly addressed in all development initiatives*" (UNISDR 2013).

However, as discussed in the following section, because of the complex nature of the issue, in order to put the concept into action, two categories of questions emerge. Cultural or political questions, such as who is qualified to take action, and what kind of training and education do they need, are particularly difficult. However, technical questions, such as what tools are needed, and how those tools might take advantage of the fast development of information and communication technology, should also be better addressed.

In the following sections, we first discuss the challenges of creating a new science and policy interface, mainly looking to the complex nature of the problems, the fast development of Information and Communication Technology (ICT) and the lack of a specially trained professional group. By analysing obstacles in the current education, research and science/policy communication systems, we propose to develop a new science and policy interface which is supported by the development of ICT data collection, storage and analysis, computer model simulations, and agent-based modelling and visualization. This new interface will be developed with four goals in mind. It should act as an educational tool, to be used by students to learn about and explore complex systems. It should be a research package, to be used by scientists to undertake projects with a multidisciplinary nature. It should work as a training tool for different users, including policy makers, to develop capacity supported by science-based scenarios. Lastly it should work as an operational system which can support decision making processes in real life conditions such as disaster response and recovery.

Challenges

With the increasing pace of global environmental change and degradation, the global community agrees the business-as-usual approach to the multiple goals of managing natural resources, meeting the challenge of global climate change, preventing and reducing the loss caused by disasters, and meeting development targets, will not work anymore. The creation of resilient societies worldwide has become a new development goal promoted by United Nations agencies (UNDP 2013; UNISDR 2013). Recently, in an attempt to clarify confusion on various definitions of the term "resilience", the United Nations Development Programme (UNDP) offered the following: "[Resilience is a] *transformative process of strengthening the capacity of people, communities and countries to anticipate, manage, recover and transform from shocks*" (UNDP 2013). In this section, learning from some recent very large scale disasters, we discuss three challenges and their associated obstacles, which should be addressed in the process of building a resilient society.

The first challenge is the increasing degree of complexity in social-ecological systems. Recent studies showed that since the social-ecological system by its nature is driven not by single, linear forces but by complex interactions between multiple environmental, social, political and governance factors (Shi et al. 2012), there is increasing risk of systematic failure both in subsystems and in systems as a whole. In many recent global events, the causes of collapse and/or standstill of major systems were did not involve a single problem but the interaction of a combination of problems or stresses.

For example, the riots in northern African countries in 2011 could be traced back to the global food crisis, which was partly contributed to by the development of the biofuels industry, which was itself intended to reduce global carbon dioxide emissions. In the past decade, pressured by the increasing price of foreign oil and environmental protection regulation, the USA developed and expanded its biofuels industry at an impressive rate, overtaking Brazil in 2005 and producing about 1 billion gallons of ethanol in 2012. Because the United States produces 60–70% of world corn exports, and corn is one of the largest three grain crops, U.S. corn plays a heavyweight role in the world food picture as sustenance for both humans and livestock. Until 2010, about 40% of US corn went into biofuels, which drove the global food prices upwards significantly. This was a contributing factor to the uprisings in Tunisia and Egypt and sparked riots in several other countries where poorer people often spend up to 80% of their income on food (Rice 2011).

The Triple Disaster in Japan on March 11, 2011 shows another example of how one country's disaster could impact another country or even cause a global chain reaction. Although most casualties of Japan's "311" Triple Disaster (also known as the Great East Japan Earthquake and Tsunami, occurring on March 11, 2011) came from an exceptionally high tsunami triggered by the magnitude 9.0 offshore earthquake, the most significant impact in its aftermath is how the general public and local municipal authorities lost their trust in the central government because of its inappropriate response to the subsequent nuclear accidents and recovery efforts. This distrust of the government's ability to deal with nuclear power in Japan then quickly led to the momentous decision to phase out nuclear energy development in Germany while its climate policy goals preclude a simple expansion of fossil fuel use.

Both cases demonstrate that to avoid unintended economic and social consequences, and in order to generate co-benefits and win-win outcomes, there is an urgent need for global communities to improve their understanding of the interconnectedness of global systems (food and energy in the biofuels case) and to recognize that the processes of making local and national policies are not just affected by local and national interests but more and more linked and triggered by global events.

The second challenge is the so-called "problem of the science/policy interface". As more and more government officials are better educated and trained in both natural and social science and come from technological disciplines, policy and decision makers are increasingly relying on the scientific community for recommendations, suggestions and sometimes even policy options during the policy and decision making process.

To respond to these requests, developing a science and policy interface has been paid great attention by UN agencies, international scientific research organizations, and national government agencies. For example, the International Council of Scientific Unions (ICSU), the most prestigious international scientific organization, states in its Strategic Plan 2006–2011: "*The long-term ICSU vision is for a world where science is used for the benefit of all, excellence in science is valued and scientific knowledge is effectively linked to policy-making*" (ICSU 2005).

Most efforts have been made so far by organizations with a focus on developing a ***direct dialogue platform*** between scientists and government decision makers. This approach is built upon the rational assumption that if additional information is provided and effectively used, the decision-making process will inherently improve (Homes and Clark 2008). One of the most common approaches is to have training workshops with scientists and government officials sitting in the same room and sharing their common concerns. This kind of training workshops is usually led by scientists as trainers with a goal to teach or train government officials to understand and learn how to "use" or "apply" certain scientifically developed models (for example, a flood management model or an earthquake recovery model) in their decision processes. Unfortunately, this linear model of science and policy relationship has been observed to commonly end with the so-called "problem of little effect", i.e., the observation that large quantities of knowledge produced for the benefit of policies are never used in actual policy-making (In't Veld and de Wit 2000).

In his excellent, brief paper, Marc Saner, the executive vice-president of the Council of Canadian Academies, summarized four key points that should be remembered when developing the science and policy interface: (1) There are conceptual reasons why science and policy are fundamentally different; (2) There are cultural reasons why scientists and policy-makers find it difficult to communicate; (3) There are benefits to some players if the linkages between science and policy remain weak; and (4) The manifestations of the science/policy interface in government are manifold (Saner 2007).

The third challenge is associated with the people who are responsible for making decisions and taking actions to build a resilient society. Since resilience-based sustainable development must be comprehensive in nature, it requires integrated responses from individuals, communities, organizations and governments around the world, all working together with a commitment to building an alternative future. Unfortunately, the various stakeholder groups not only have their own agendas and goals, which sometimes conflict with each other, but also change their interests when their social and economic status changes. As identified by McNall and Basile (2013), trust and culture are "*critical variables affecting people's ability to work together toward solutions for common ecological, political and economic problems*". This has been well demonstrated in the Haiti earthquake case.

In 2010, a magnitude 7.0 earthquake in Haiti killed more than 220,000 people. After the earthquake, the international community, particularly the NGOs, rushed into first dispatch rescue and medical teams, and later pledged a total amount of 36 billion US dollars from 134 countries. Unfortunately, after 1 year, "*the only positive aspect of the past twelve months has been the exposure of the failures of the NGO aid system, and the international community's long-standing use of the country as a laboratory for cashing in on disaster*" reported by *Isabeau Doucet (The Nation, 2011.1.13).*[1] International watchdog groups also reported that part of the problem is that charities spent a considerable amount of money on "*soaring rents, board members' needs, overpriced supplies and imported personnel*". After more than 4 years, the government of Haiti is recognizing that integrated risk reduction should be the centrepiece of its recovery efforts and of collaborative efforts between donors, NGOs, and federal and local governments. Also they identified eight key areas of potential support, including capacity building, infrastructure creation, knowledge and innovation development, research, risk assessment, disaster risk reduction programming in priority areas, seismic and cyclonic risk reduction,

[1]http://www.npr.org/2011/01/13/132884795/the-nation-how-ngos-have-failed-haiti.

communication and public awareness.[2] However, in combination with a weak unpopular government and in the face of differing goals and priorities amongst the international and local NGOs, there will be a lot of challenges ahead.

Obstacles

As discussed in the previous section, to design and implement policies that lead to the creation of resilient societies, there are many common challenges (we specifically discussed three of them) on both the science and policy side. In order to overcome these challenges, obstacles must be managed, including the current state of education, research systems and science/policy communication processes, as pointed out by many authors, for example, Saner (2007), Strang (2009), and Cent et al. (2011). It is quite unfortunate that most of these obstacles are not new, and well known to the scientific community for at least the past four decades. In this section, we will only revisit a few of the issues that are relevant to this paper's topic.

The first obstacle is an extremely difficult and fundamental theoretical issue, the lack of scientific understanding of networks and complexity. In his well-known book, "The Turning Point" in 1982, a famous physicist, Fritjof Capra stated that the challenges our global community is facing are "*systemic problems, which means that they are closely interconnected and interdependent. They cannot be understood within the fragmented methodology characteristic of our academic disciplines and government agencies*" (Capra 1982).

According to Capra, "*the main characteristic of a complex system is nonlinear and complexity theory is a set of mathematical concepts and techniques that deal with nonlinear systems*", and "*a network, by definition, is nonlinear*". So, it is easy to understand why networks and complexity theory have been identified as two hot research areas to deal with systematic problems. But, as Capra pointed out, there are very few people today who have used complexity theory to study networks. We have not seen any breakthroughs in this theoretical research field to date.

The second obstacle is the lack of a specially trained group that can improve the dialogue between the fields of science and policy. Clearly, to understand and know how to deal with complexity in the real world requires a better understanding between these groups. As Capra points out, a paradigm shift, a new vision of reality, a fundamental change in our thoughts, perceptions, and values is needed (Capra 1982). To this point, Saner noticed that "*Most scientists and policy-makers are university-trained and it is likely that the origin of the process of cultural divergence is located in the relatively brief period between high school and the professional workplace. Universities may be aware that they are the overseers (or even promoters) of this*

[2]http://www.prnewswire.com/news-releases/haitis-disaster-risk-management-and-recovery-experience-showcased-at-prestigious-global-meeting-in-washington-dc-147782915.html.

short and fateful process but it is not clear that they currently have an incentive to effect change" (Saner 2007).

In the foreseeable future, it is very hard to expect that the current science and technology evaluation system, which discourages exchange between scientific and technological researchers on the one hand and policy makers on the other will be easily changed. Meanwhile, for most scientists, their research interests will be still limited and bounded by the directions of their narrow fields, and there is a lack of incentive to work on issues requiring interaction with other disciplines and other stakeholders in society.

Fortunately, some efforts have been made to overcome this obstacle worldwide. For example, a new profession of so-called knowledge-brokers has been fast growing in Europe and North America for the purpose of improving communication between the scientists and policy-makers (Cent et al. 2011).

Broadcasting knowledge is not new. Traditional and new media both are comprised of well-established professionals who transfer knowledge every moment, from scientists, businessmen, policy makers and other professionals to the general public, the poor and rich, educated and illiterate alike. In recent years, driven by development of the knowledge economy, the business sector has promoted the idea that knowledge should be both used and useful, should boost the economy, and be transformed into marketable products or patents, and have a cultural, social, or political value (Meyer 2010). Now, working with various job titles, such as liaison officers, technology transfer officers, knowledge translators, knowledge intermediaries, and innovation brokers, a growing number of knowledge brokers work in many sectors with the same role of creating a two-way interaction between knowledge producers and knowledge consumers.

Drawing lessons and experience from Canada, the UK and Australia, Bielak et al. (2008) conclude that for policy audiences in particular, when science is relevant to the issues of the day, there is an urgent need for interactive knowledge brokering approaches that can deliver synergistic combinations of "science push" and "policy pull" in order to go beyond the traditional idea of knowledge as something being simply 'transferred' from scientists to policymakers.

Although a successful knowledge broker does not necessarily have a Ph.D. or even a science degree, he or she does need special training to identify good sources of information and critically analyse evidence, to communicate science to various audiences. This is important especially to reveal the implications of what scientists are doing, and to understand the different ways of thinking and the different contexts in which scientific information can be used. In our current education system, knowledge brokerage is an under-researched field and there is little systematic, practice-oriented research on knowledge brokerage between research and policy-making (Cent et al. 2011). Moreover, in the current working environment, the most difficult challenge for knowledge brokers is to get people in their own institution or organization to understand that what they are doing is valuable in order to win the support of colleagues and management, as identified by the K*Initiative[3] which is a knowledge brokers' community support system.

In a fast changing world, to have well trained knowledge brokers without appropriate support tools is the same as a car salesmen without a sales manual. Though it may not guarantee failure it is certain there will be difficulties when trying to communicate with policy makers. Developing the right toolkits for knowledge brokers, however, is not an easy task. It is the third obstacle we would like to address.

Since the invention of modern computers, the idea of building computer models to assist in making decisions has attracted scientists in all disciplines, from engineers to businessmen, government policy makers and even computer game players. After more than a half century, especially in the last two decades, with the capacity of computer hardware improving at exponential rates, the use of computer modelling techniques is becoming a must for policy makers when faced with the need to make complicated decisions in a timely manner and the volume of information is overwhelming.

Currently, almost all disciplines develop their own specially designed computer models. In general, these computer models are a model of a real-world system governed by a specific set of variables and their interrelationships designed to represent a situation. These models run on a computer and use step-by-step methods to explore the approximate behaviour of a mathematical model. Examples include global climate models and economic models. Today, computer modelling is not only helping scientists to explore new theories and make predictions, it is also used to assist policy makers to develop appropriate decisions, and widely used in classroom settings to help students visualize hidden structures in phenomena and processes that are impractical, impossible, or costly to illustrate in a "wet" laboratory setting.

But, when facing the systematic problems such as global climate change issues, these discipline-driven computer models are not individually sufficient. Using climate disaster reduction and recovery decisions as an example, one of the fundamental issues in government decision making is how to predict what will happen in the event of future disasters and encourage climatically-beneficial behaviour and reduce existing conditions of vulnerability in the community. Clearly, to help policy makers and the general public understand the consequences of various actions, testing strategies within different scenarios with computer models is a good choice. However, the actual reality is governed by at least two distinct systems; storms are mainly controlled by natural climatic systems while behaviour is decided by social-economic systems. Two results emerge from this situation. Firstly, the types of data in each kind of system are rarely comparable, and do not mesh readily. Second, the strategic approach to data management and modelling for each system is also very different, leading to significant difficulties in integrating the data and the

[3] http://inweh.unu.edu/world-water-week-workshop-summary/.

models. In this regard the models become difficult to use when aiming to make comprehensive climate-disaster related decisions.

In the case of climate modelling, physical climate researchers put emphasis on improving global climate system models with ever higher spatial-temporal resolution, improved parameterization, and inclusion of ever more chemical species. For scientists who are interested in the human dimension of climate change, although a great number of integrated assessment and socioeconomic models have been developed, each model has its own strengths and weaknesses in terms of what components are included and the degree of detail in which they are described (Ortiz and Markandya 2009).

A New Toolbox for Science and Policy Interface

As discussed in the previous sections, the scientific community, policy makers and members of the business community have all recognized that finding solutions to complex systemic problems is difficult. Building a resilient society at the interface between the environment and human society requires systematic thinking from both the natural and social sciences, relies on interaction among scientists and other stakeholders, and requires specially trained knowledge brokers to assist in the decision making process, from conception to action. Each of these three user groups has different needs. To educate the next generation, it is necessary to transfer knowledge that can then be built upon. For scientists working across disciplines, developing better communication and an environment for collaborative research is needed. For policy makers, in order to achieve a more sustainable path to a resilient society and simultaneously to manage the fast pace of change that is becoming normal in their daily duties, novel approaches are needed to generate innovative solutions.

With the rapid development of Information and Communication Technology, the way of collecting, transferring, storing, analysing and presenting information has changed dramatically. There is more of it, presented more quickly and with more variety. ICT is now not only helping to assess information faster and more efficiently, but also helps to simplify the decision-making process. The use of ICT is fast becoming one of the preferred methods for making decisions. In this section, we propose a framework for an ICT-based toolbox that should be developed by a multi-disciplinary team with multiple perspectives, knowledge and approaches. This toolbox will be developed with a fourfold purpose; (1) Facilitating knowledge gathering that will cumulate in the classroom, (2) Sharing knowledge and equalizing access to knowledge amongst multidisciplinary research groups, (3) Transferring knowledge for use in training and, ultimately (4) Applying knowledge in decision-making processes (in government or elsewhere). Some examples are offered below to illustrate what we would like to achieve in this ambitious endeavour.

The first, essential step of moving towards systematic thinking is to educate undergraduate and graduate students in a multidisciplinary learning environment. This is important as a background in order to ensure that they have the opportunity to develop the knowledge, skills, and abilities that will allow them to successfully engage in multidisciplinary efforts to solve social-environmental problems.

Currently, some private universities in the world, for example, Keio University in Japan, have developed curricula to train students to resolve complex social problems by integrating courses and practice in technology, science, design and policy (Yan 2011). Some unique techniques are applied to help students better understand the kind of collaboration needed between their disciplines, and to help them to understand the social/economic mechanisms involved, and the implication of new technology in developing a different kind of society. A good example is the 24 h workshop used in Keio University's Environmental Innovator Program. This training workshop is used as a collaborative approach that bring together a student body with several different specialties to create an innovative social and economic and environmental design system in a short-term trial (Kobayashi 2011). In this training course, students with multidisciplinary background first spend most of their time to raise and discuss problems using their own specific knowledge on the project assigned by instructors. At this stage, the identification of key essences of the project is expected. Second, under the instructors' guidance, students discuss the ideal system to deal with the problems and set a goal for the workshop. Third, students work in a collaborative way by playing their own role in order to reach the goal. Finally, students use computer models and other ICT tools to show a new network of mechanisms across multiple disciplines. By adjusting the parameters in the computer model developed, students learn to categorize the key factors, identify the links between these factors and get the experience of learning to integrate knowledge from disparate domains of the complex social-environmental issues. Because ICT used in this training workshop is not just fast and automated, but also interactive and multimodal, it works as a tool for transforming the way students think and learn tasks associated with information access and management, problem-solving, decision-making, communicating, creative expression, and empirical reasoning.

In the scientific community, using ICT is not new especially for almost all of the natural science disciplines. Scientists develop computer simulation models based on the governing equations and physical laws in their disciplines. Most recently, in order to conduct multidisciplinary projects, say in order to provide policy analysis for global climate change issues, more and more efforts have been made in the development of integrated modelling frameworks that couple climate, ecological, hydrological, and socioeconomic models. For example, a group of German scientists have built a developer interface for the implementation of natural science and socioeconomic simulation models in the so-called GLOWA-Danube project. In that project, by integrating up to 15 simulation models from various disciplines, including meteorology, hydrology, plant physiology, glaciology, economy, agriculture, tourism, and environmental psychology, a framework was successfully created for the construction of a distributed simulation system. This was used as a tool for decision makers to support the sustainable planning of the future of water resources in the Upper Danube basin (Hennicker et al. 2010).

It should be pointed out that although great efforts have been made in the global scientific community to couple climate, ecological, and socioeconomic models in an integrated framework, there are still three main obstacles that need to be overcome. Specifically, these are: (1) Process resolution, (2) Temporal and spatial resolution of operation of the different models that are to be coupled, and (3) Data set availability (Bowyer et al. 2011). The research community admits that all three issues will remain as a challenge for some time. That situation notwithstanding, development of a fully dynamic two-way interactivity between the different natural (physical, biological, chemical) and human (economic, political, social, and cultural) systems is currently underway.

In better preparing to make policies involving various agencies, there is a great need for government officials from different agencies to acquire interpersonal training for skills such as negotiation, leadership, interviewing and cultural training. ICT-based environments can be incredible training tools when used properly. One successful example is the so-called "Decision Theatre",[4] developed at Arizona State University.

Designed to help decision makers manage complex issues and to develop a shared understanding of issues based on each member's area of expertise quickly and confidently, the Decision Theatre provides a platform for participants to create a shared mental model of their problem domain. Decision-support tools and practices developed at the Decision Theatre help stakeholders communicate within and across disciplines. It enables decision makers to see things differently, develop consensus and make knowledge-based decisions. In the Decision Theatre, a purpose-built room called the "Drum", has a 270° faceted screen used to display panoramic computer graphics or 3D visualizations, accommodating up to 25 people in a theatre-like or discussion-oriented layout. Participants create and modify their own models through group discussions until simulated outcomes are judged sufficiently useful to take action.

Using ICT to deal with complex issues in the real world is also in an uptrend. Global ICT companies, such as IBM, have developed software to help city managers around the world to better handle their daily operations. A system is now operating in the City of Rio, Brazil, which integrates a citywide system of some 30 agencies, all under a single roof. This virtual operations platform acts as a Web-based clearinghouse, integrating information that comes in via phone, radio, e-mail and text message. City mangers sit in front of a giant wall of screens—a sort of virtual Rio, rendered in real time. Information, such as video streams from subway stations and major intersections, rainfall across the city predicted by a sophisticated weather program, the locations of car accidents, power failures and other problems, is all displayed on the screens. The system can also analyse historical information to determine, for instance, where car accidents tend to occur. This experiment is expected to shape the future of cities around the world.

Inspired by the ideas, concepts and technologies used in the successful examples illustrated above, we propose to develop a general toolbox which is supported by new ICT developments in data collection, storage and analysis, computer model

[4] http://dt.asu.edu.

simulation, agent-based modelling and visualization. This toolbox will be developed with a fourfold purpose, i.e. as an educational tool to be used by students to learn and explore the complex systems, a research package to be used by scientists to conduct projects with multidisciplinary nature, as a training and exercising tool for different users, including policy makers, to develop their capacity based on scenarios, and last as an operational system which can support decision making processes in real situations such as disaster response and recovery. Due to the rapid evolution of ICT, we are only able to outline the overall approach for developing such a toolbox and each component is also to be described in a conceptual way.

In general, this toolbox will consist of four basic components, a database (historical data sets and web-based real-time survey data), equation- and algorithm-based simulation models, agent-based simulation models, and an interactive visualisation platform.

The starting point is data collecting and analysis. This component should consist of a historical dataset module and a web-based real-time access to survey information. It will store and/or link to all natural and sociological information sources collected by all disciplines. For example, the database should include meteorological and hydrological data as well as disaster loss information due to past flood or drought events. The Web-based real-time information collection module should be a user-friendly application that is accessible through various mobile web-enabled devices and would allow volunteer workers, the general public, emergency response teams and field experts to transfer their measured, written and camera-captured field observations of the system for further processing.

The web-based information collection module would not only include collection functions but also tools for the processing and dissemination of real-time information. It would also be used to document, manipulate and propagate relevant observations from emergency preparedness exercises and past real-world events. The information points would help decision makers working in real time. This module, therefore, also serves as a tool to facilitate the elaboration of lessons learned, and to help develop best practices and innovative strategies for dealing with future events.

The second component consists of so called equation-based simulation models. They are mainly models from natural science disciplines such as atmospheric dynamic models, hydrological models, land models, and so on. These models share the same character in that they are all based on global differential equations that govern the motions of individuals. Since many excellent models having been developed in the past three decades, this toolbox will select a number of them to create an ensemble of simulations and outcomes that could then be applied to the agent-based model component.

The third component is a group of agent-based simulation models. Agent-based models are mainly used in the social and behavioural sciences, though they can also be found in such disciplines as artificial life, epidemiology, ecology, and any discipline in which the networked interaction of many individuals is being studied. In agent-based simulations the behaviour of the individuals is dictated by their own local rules. For example, in retail business, agent-based models use business-driven rules for individuals (e.g., individual consumer rules for buying items, individual retailer rules for stocking items, or individual firm rules for advertising items) to determine holistic, system-level outcomes (e.g. to determine if brand X's market share is increasing).

The last component is the visualization platform that is used as the interface between scientists and other user groups. Visualization environments are heavily used in military simulations and computer games. By incorporating various models, this environment can provide training for physical skills, team training, and group decision-making. For example, in the Decision Theatre mentioned above, it has been used by various groups in leadership training, negotiation, cultural awareness and building interviewing skills. By incorporating scientific models with the participants' own knowledge and experience, the visualization tools can effectively perform all these tasks. It can also be made applicable to a wide range of training and educational tasks that currently require labour-intensive live exercises and role-playing.

It should be pointed out that what we propose to do in this paper is not an easy and a short term task. Developing the general toolbox outlined in this paper requires a cooperative endeavour that not only involves multidisciplinary teams but also requires government officials, business decision makers, educators, NGOs and the general public to participate. Fortunately, the fast development of ICT and the quick drop in hardware costs make this approach achievable, and we already observe a trend towards developing similar systems in universities, governments and business sectors worldwide.

Conclusion

As the number, type, and severity of disasters increase around the world, the whole social-ecological system is facing great risks of system failure, including in the financial market, transportation, power generation, communication, and water, food and energy distribution (Helbing 2013). The economic cost and social consequences of failure in these socio-technical systems are expected to escalate exponentially. It is not only government policy makers who need to have a better communicating interface with multidisciplinary experts to better understand these interdependent operating systems efficiently and simultaneously, but also the business decision makers need improved, scientific knowledge based supporting tools to monitor and then make adjusting and adapting the balance between demand and resources available to manage sudden surges in demand from both natural induced and man-made extreme events.

In this paper, an outline of an ICT-based integrated toolbox is described. Consisting of four major components, i.e., data collecting, analysing and disseminating, simulating models from natural science disciplines, agent-based models driven by social and economic rules, and an interactive visualization platform, this toolbox will be developed with a fourfold purpose, i.e. facilitating knowledge elicitation and cumulating in classroom, knowledge sharing and reaching common ground for multidisciplinary research programs, knowledge transferring to train user groups, and ultimately, knowledge application in decision-making processes.

If successfully developed, this toolbox will provide an entirely new kind of decision support tool for use in the area of sustainable development and resilient society. It will serve to increase the interaction between stakeholders and the scientific community, make scientific knowledge more accessible and understandable to stakeholder communities, and ultimately increase their ability to make knowledge based strategic decisions for their own, future development.

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Chapter 14
Development of Tools to Assess Vulnerability to Climate Change in South Asia

Upali Imbulana

South Asia is recognized as one of the world's regions most vulnerable to climate change. Its vulnerability is influenced by a large number of social, economic, political, and technical factors, some of which are peculiar to the region. The diversity of such factors makes vulnerability assessment a challenging task, but proper assessment of vulnerability to climate change will provide a good base for framing resilience strategies. The region is heavily dependent on water for human livelihood, and therefore, several water-related parameters are indicative of the challenges it faces. Traditional indicators which measure water scarcity do not account for the constraints imposed outside the political boundaries of a country. Considering the complexity of the challenges faced by the region, there is a need to re-think the indicators and mechanisms to assess water, food, and energy security. Assessment tools have to be capable of incorporating regional, national, and individual capabilities and constraints to climate change adaptation. Regional cooperation and water management treaties, cooperation among major water-using sectors, community empowerment in water-related decision making, the level of technology to address resilience issues, and the community's access to technology need to be incorporated into vulnerability assessment tools.

Background

South Asia, comprising Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka, is recognized as one of the most vulnerable regions to climate change in the world. The vulnerability of this region is influenced by a large number

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of social, economic, political, and technical factors, some of which are peculiar to the region. A proper assessment of its vulnerability to climate change provides a sound base for framing methodologies to improve resilience.

The majority of the South Asian population lives in rural areas, and a high proportion of them are dependent on agriculture. Water plays a key role in the life and livelihoods of the region, and therefore, several water-related parameters are indicative of the challenges faced by the community.

Vulnerability Assessment

The vulnerability of a region, a country, or an individual to climate change impacts depends on many factors. An important guidance in this regard is that it will depend on exposure, sensitivity, and adaptive capacity.

Out of the factors influencing vulnerability, adaptive capacity—defined as the ability or the capacity of a system to respond successfully to climate variability and change (IPCC 2007)—is a factor which has given rise to considerable discussion and debate. This is due to many reasons, including different national aspirations and the diversity and complexity of the parameters or indicators contributing to adaptive capacity.

The IPCC (2007) recognizes the diversity of the criteria for identifying and assessing "key vulnerabilities" and associated scientific uncertainties and value judgments. Such diversity results in difficulties in ranking one country relative to another in terms of vulnerability. South Asia is a region with a high degree of diversity with respect to the parameters influencing vulnerability.

Nevertheless, national level vulnerability is important for countries to know in order to design their strategies, and for donors to focus support. In addition, population density, poverty, gross domestic product (GDP) per capita, adult literacy, and area covered by forests are some of the social, economic, and environmental parameters that influence adaptation capacity to climate change.

Figure 14.1 provides a view of the diversity among South Asian countries with respect to some parameters that affect adaptation capacity at the national level. The coefficient of variation (standard deviation/mean) was used as the metric to compare across the countries, and to bring several parameters to a common scale. Though not a comprehensive assessment of all the relevant parameters, the data indicates that while South Asia could have common goals, with regards to climate change adaptation the strategies would have to be framed in reference to the social, economic, and environmental characteristics of each country.

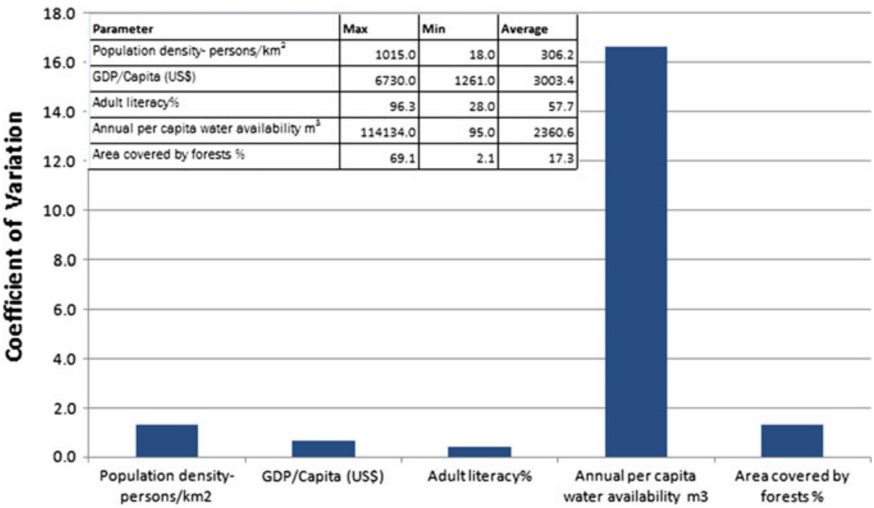

Fig. 14.1 Coefficient of variation of selected parameters from South Asia affecting vulnerability to climate change

Table 14.1 A summary of climate resilience related indicators of South Asia

Country	Area (km^2)	Population (millions)	Population density Per km^2	GDP/ Capita US$ (2009)	Adult literacy % (2004)	Annual per capita water availability (m^3)	Area covered by forests (%)
Afghanistan	652,230	26.1	40	1352	28.0	2,709	2.1
Bangladesh	144,000	146.2	1015	1593	43.0	8,370	11.1
Bhutan	38,390	0.7	18	5167	–	114,134	69.1
India	3,287,260	1182.1	360	3266	61.0	1,603	23
Maldives	300	0.3	1000	6730	96.3	95	3.3
Nepal	147,180	28.3	192	1261	48.6	7,642	25.4
Pakistan	796,100	166.5	209	2700	49.9	1,064	2.2
Sri Lanka	65,610	20.7	316	4747	90.7	2,200	28.8

Water Resources and Their Relation to Climate Change Vulnerability in South Asia

South Asia, while supporting about 23% of the global population, possesses less than 5% of global annual renewable water resources (IGES and GWP SAS 2012). However, Fig. 14.1 shows that annual per capita water availability has a large variation across the region, with extremely high values reported from Bhutan to very low values from the Maldives. On the other hand, agriculture plays a major role in the rural livelihoods of South Asia, and the percentage of rural population is about 70%. Considering the heavy dependence of agriculture on water, the latter's availability has a notable influence on vulnerability as well as the adaptation capacity of all South Asian countries. A summary of the statistics is shown in Table 14.1.

Some of the biophysical indicators, such as per-capita water availability, groundwater availability, and water withdrawals as a percent of annual water resources (UNESCO-WWAP 2003), have been used for a very long period to compare water stress among nations.

Annual per capita availability of renewable water resources is often used as a metric to assess water scarcity. In South Asia, Bhutan (more than 100,000 m^3 [cubic meters]), Bangladesh (8,370 m^3), and Nepal (7,640 m^3) (IGES and GWP SAS 2012) have high per capita water resources. However, a closer look at the constitution of this indicator demonstrates its relevance to vulnerability and adaptation capacity.

For example, annual precipitation in Bangladesh is 2,666 mm, which results in 105 km^3 (cubic kilometers) of internal renewable water resources. But out of more than 230 rivers in Bangladesh, 57 are transboundary rivers or international water courses (Khan 2012). As a result, when the net water volume entering the country is considered, the total annually renewable water resources (TARWR) are estimated at 1,227 km^3 (FAO 2012), resulting in annual per capita water availability of about 8,000 m^3.

However, more than 90% of the total annually renewable water resources of Bangladesh are produced outside its boundaries, and the country has little control over those water resources. As a result, Bangladesh is subjected to floods in the wet seasons and drought in the dry seasons. As such, the high per capita TARWR in Bangladesh does not ensure the country's resilience to climate change. If only the internally renewable water resources are accounted for, the annual per capita water availability would drop to below 700 m^3.

Both in Bhutan and Nepal, snow contributes substantially to annual water resources. Climate change has increased the volume of glacial lakes and the incidence of glacial lake outburst floods, of which the predictability is low. In addition, several transboundary rivers contribute to the total water resources. In the case of countries such as Sri Lanka and the Maldives, the situation is different: the total amount of water resources are generated within the country and the ability to predict water availability depends mainly on the predictability of rainfall.

The above discussion shows that the vulnerability resulting from water resources depends on not only the per capita water availability, but also on the proportion of water resources they can control and the uncertainty of the hydrological parameters that contribute to water resources.

Several other parameters are highly relevant to South Asia, in reference to climate change. As climate change is considered a result of unsustainable energy consumption, renewable and "green" energy generation has an effect on climate change mitigation. Some countries in South Asia, with their steep terrain and abundance of water resources, have the potential to help address the energy deficits in the region. It is reported that less than 2% of the hydropower generation potential has been exploited in Bhutan (IGES and GWP SAS 2012), and there is considerable potential to be exploited in Nepal, as well. The situation is different in Sri Lanka, however, where most of the major hydropower generation potential has already been exploited. Other renewable energy generation options in Sri Lanka include solar and wind power, which at the present level of generation are insufficient to meet demand. Sri Lanka's dependence on imported sources of energy such as coal and petroleum will contribute to its vulnerability in the long term.

Vulnerability at the Local Level

While the assessment of vulnerability at regional and national levels are important when developing regional and national strategies, eventually adaptation activities are implemented at the community level. There is a considerable effort to increase the awareness of communities about the impacts of climate change, but experiences show that their empowerment is also essential to improving resilience.

For example, in Sri Lanka, it has been observed that high-intensity and erratic rainfall has resulted in an increase of the breaching of small village-based reservoirs and diversion weirs. Many such structures are built on small, un-gauged catchments, so there are data constraints to make use of advancements in engineering hydrology, and the increased hydrological uncertainty due to climate change further complicates the situation. Closer interaction with farmers, however, shows that they have their own design principles to deal with such uncertainties. In one instance, the farmers explained that their irrigation diversion system was traditionally designed so that the paddy fields upstream of the diversion weir were allowed to be inundated during high flows, and water was gradually released to downstream paddy fields for irrigation purposes. However, a subsequent design by the authorities using flood protection bunds (a bund is a low wall or a dike) to prevent inundation resulted in the collapse of the diversion structure during the rains. A new design carried out with stakeholder consultation accommodates farmers' irrigation methods, and a modified Duckbill weir with a gate arrangement accommodates the uncertainty of hydrology. The important lesson from this experience is that farmers' ability to influence the decisions affecting their livelihoods reduces their vulnerability to climate change impacts.

Technology

Technology will continue to help reduce the unpredictability of hydrological parameters. Among the constraints to accurate prediction of floods and droughts are the un-gauged catchments and inadequate precipitation measuring stations. Advanced modeling methods, use of radar technology, and remote sensing have compensated for some of these drawbacks. Improvements in communication technology have facilitated the community's access to weather-related information and their contribution to data collection at remote locations. Examples are the use of mobile phones and radio for weather-related information dissemination, which is fairly widespread in South Asia.

The high cost of power generation and transmission can be a constraint for rural and poor households in remote locations to access electricity. The costs of solar and wind energy generation have been reduced due to technological advancements, and research could bring down the costs further.

Therefore, both advancements in, and better access to, technology would improve the resilience of communities to climate change.

Conclusion

The foregoing discussion shows that some of the traditional indicators of water stress require detailed analysis when water-related vulnerability to climate change is assessed. Both good governance and improved technology can reduce vulnerability. Where trans-boundary water resources influence vulnerability, regional cooperation and bilateral and multilateral water treaties could have a positive effect. Experience has also shown that better cooperation among energy and irrigation sectors can optimize water-use efficiency. Where data and information are constraints, there are many instances where local knowledge and community participation have served to narrow the knowledge gaps. Therefore, community empowerment is an important factor as well. National and local level interventions can incorporate factors such as adult literacy and forest cover. Tools that assess vulnerability should reflect the standard of water governance, which influences regional, bilateral, and inter-sectoral cooperation in water resources management and community empowerment. Such tools should also assess the level of technology to address resilience issues and the community's access to such technology.

The analysis shows that development of tools for climate change vulnerability is not an easy task. Annual per capita water availability, which is sometimes defined as "water stress index" (White et al. 2012) is a suitable tool to assess water related vulnerability at the national level. However, we should be able to assess the amount of water that can be regulated, out of the annual water resources. Accordingly, the water storage capacity as a proportion of annual water resources can be cited as a suitable indicator to estimate the amount of regulation of water resources. Another factor to be considered is that demand for water differs from country to country, depending on the type of predominant water uses. Total annual water withdrawals as a proportion of total annual water resources (White et al. 2012) is a measure of the vulnerability related to water demand. Therefore, using these indicators in a matrix form will help to develop a tool to measure water-related vulnerability to climate change, and would enable the use of such a tool to compare the status of different countries. The amount of cooperation for water sharing among countries is an important indicator for a regional level analysis, while the degree of community empowerment is a parameter to be used in local level analysis. As such, development of tools for climate change vulnerability calls for further collaborative effort from researchers and practitioners in the field of climate change adaptation.

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Chapter 15
Development Plan as a Tool to Improve the Disaster Resilience of Urban Areas

Ranjith Perera and Dzul Khaimi bin Khailani

Abstract This chapter argues for the mainstreaming of disaster resilience attributes in local development plans as an overarching adaptive measure with regards to urban areas facing climate related disasters. The chapter is based on empirical research involving a group of professional urban planners and managers who are responsible for formulating development plans for local urban areas in a developing country. Using the key-informant technique, the research investigated the ideas of a set of professional planners and managers regarding the suitable urban planning strategies to improve the resilience of local areas against a common hazard (e.g., flooding) that has a tendency to intensify due to climate change. In the next step, the common attributes of more frequently suggested strategies were identified using the principal component analysis technique. In the last step, the extent to which the local development planning system has responded so far to the vulnerability reduction and resilience improvement needs of the civil society. The findings indicate that local planners are sensitive to the flood risks faced by people. They have incorporated policies and strategies in the local development plan to minimize exposure of the people and property to flood hazard and improve the adaptive capacity of the urban settlements. However, the sector-based organization of the plan prepared by the federal level planners was found to be a hindrance to improving mainstream disaster resilience attributes in development planning. Therefore, the paper calls for strengthening the participatory planning and development capacity of the local authorities to enable more resolute mainstreaming of disaster resilience in local development plans.

Keywords Climate change · Disaster resilience · Local development plan · Mainstreaming

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Introduction

In much of the world the development plan is the main tool used to guide and control physical development in local urban areas. They are also referred to as structure plans, local plans and master plans, depending on the context, but the basic function is the same.

Development plans primarily focus on land-use control and infrastructure development as strategies to stimulate socio-economic development and environmental management. They are conventionally implemented by enforcing regulatory and incentive measures. With the increase in large-scale problems caused by climate change, it has been found that development plans in general, and land-use planning and building regulations in particular, are not effective enough to ensure the sustainability of the achievements of development so far. For example, it has come to the point that hazard risk reduction in urban areas cannot be addressed through land-use zoning and building regulations alone. This is particularly true in developing countries, where it is common knowledge that land-use zoning and building regulations are abused and disregarded. Therefore, urban planners and managers have to devise more comprehensive and effective measures to adapt local areas in order to face more frequent and intense hazards induced by climate change. Local development plans need to change from their current use as general guidance and development controls, and take on the role of strategic plans that will ensure the sustainable and resilient development of urban areas.

According to Klein et al. (2003), local and city governments should be aware of current and future climate risks and take appropriate initiatives to enhance the resilience of urban systems and communities. The 13th Conference of the Parties to the United Nations Framework Convention on Climate Change, held in Bali in December 2007 affirmed the increased willingness of city governments to take actions to address climate impacts. Furthermore, Smith (1996) alleges that local government authorities may take several precautionary steps to modify urban land use and development by-laws to respond to increasing climate risks. For example, land use, buildings, and infrastructure change or depreciate over time, requiring their managers to incorporate risk reduction measures to make them less vulnerable. One adaptive action that governments can implement is non-structural mitigation, achieved through the use of development planning control; land use controls can affect anthropogenic activities vulnerable to climate hazards (UNISDR 2002) and it is useful to reconsider which controls are put in place as a result. Smith (2001) also points out that one of the key benefits of development planning control is the reduction of risk and increased resilience.

Development plans are the main tools used by local authorities in guiding sustainable development within their jurisdictions. Among them, the 'local plan', is the primary instrument used to guide physical development at the local-authority level (Bruton 2007a, b). However, inadequate actions have been taken to analyze the extent to which local plans are effective in disaster mitigation (Deyle et al. 2008). Carter (1991) observes that disasters cannot be prevented but the effects can be mitigated. According to this view, hazard impacts may not happen or can be reduced if land use planning is integrated with disaster risk reduction activities.

Saavedra and Budd (2009) emphasize the importance of understanding the inherent resilience of local areas and enhancing this resilience through strategic interventions involving stakeholders. Inherent resilience is the natural capacity of people, communities and habitats to cope with and adapt to major perturbations. Local people and community leaders usually possess an understanding of inherent resilience. Thus, Godschalk (2003), Wamsler (2005), Campanella (2006) and Ernstson et al. (2010) have pointed out the importance of a participatory approach in urban planning and the utilization of indigenous knowledge in order to identify strategies to reduce the vulnerability of urban areas. Contemporary urban planning practices are becoming more participatory, involving stakeholders in decision-making. However, little empirical evidence exists on the extent to which urban planning practices and products (i.e. plans) have incorporated inherent resilience or have improved resilience through strategic interventions derived from a participatory urban-planning process. Few studies have attempted to understand the extent to which the stakeholders' needs to reduce vulnerability are embedded in urban development plans and strategic proposals. Therefore, the central research question addressed by this chapter is: to what extent have local development plans incorporated the attributes of resilience, in consultation with local stakeholders, to adapt to the changing disaster scenario? In other words, the chapter questions whether development plans have become effective tools to improve the disaster resilience of urban areas. This chapter attempts to answer these questions with respect to an urban area selected for the empirical part of the research.

The Process of Planning for Resilient Cities

Planning for resilient cities requires urban planners to go through a participatory process in plan making, plan adoption, plan implementation and governance. Using Malaysia as the context, this section examines the realm of urban planning in general and the local planning process in particular.

Plan Making

It can be argued that in general, urban plans are built on the policies and strategies pertaining to socio-economic development sectors such as housing, infrastructure, transportation, and health (Phong and Shaw 2007). However, other than referring to general safety and hygienic conditions, there is no explicit set of strategies to ensure public safety and security against natural hazards, even though the improvement of quality of life is the overall goal of most urban plans. The lack of reference to safety and security against natural hazards is a crucial gap in the context of climate change, raising a major sustainability issue. In the context of Malaysia, this omission is due to the sector-based format used to propose policies and strategies in the development plans. The state "structure plan" is organized according to the needs of the development sectors of the state, and as a result the same approach is used to organize district local plans, which are designed to implement the policies and strategies of the structure plan. As a result, cross-cutting issues, such as security and safety in local areas and the reduction of vulnerability to multiple hazards, have not been explicitly included among the strategies in the local district plans of Malaysia.

A local plan serves as a tool to communicate land-use and resource-use promotion, prevention, and conservation in a local area. In this regard, the local plan can be used to identify areas vulnerable to climate related hazards and can prevent or control development in those palces. Conversely, characteristics that provide resilience can be conserved (e.g., mangrove forests) and areas with inherent resilience, such as firm ground above the high flood level, can be allocated and promoted for human settlements. Sustaining and improving resilience should be a major strategy requiring special consideration in local plans.

Several scholars argue that barriers need to be overcome when formulating disaster resilience strategies in urban development policies and plans. As a starting point, Pelling (2006), Berke et al. (2006), and Singh (2008), argue that the formulation of disaster resilience strategies is an integral part of the process when preparing district local plans in which people participate, decide and plan the area based on their own needs and resources, and considering the general safety, security and quality of life issues. Ainul (2008) asserts that residents have their own safety objectives regarding how they want the plan to direct development of their living environment. For example, in the rebuilt city of Kobe in Japan, some settlements were able to adapt after the earthquake disaster in 1995 because of the communities' desire to live in structures that complied with building codes and that were served by the necessary infrastructure and service systems. In Smit and Wandel's (2006) words, people are sensitive to their vulnerability, take measures to minimize their exposure to hazard and strengthen their adaptive capacity to live with inevitable hazards. In view of that, public participation is required at all stages of the planning process to achieve improved understanding and identification of critical issues, and their resolution through socially acceptable, environmentally sustainable, technically viable and economically feasible strategies.

Plan Adoption

Once a plan is prepared, it needs to be adopted by the relevant authorities before it can be implemented. If the policy direction and legal backing are in place, the plans can themselves drive the adoption of disaster resilience in the planning process. The current need is not simply to be prepared for a particular disaster but to prepare for multiple disasters induced by climate change. The most appropriate levels of intervention to improve preparedness for climate change-induced disasters are found at the large scale of national planning and the small scale of local planning (i.e., “think globally and act locally”). The impacts of disasters are felt most strongly at the local level and therefore national policies are most suitably implemented at the local level (UNISDR 2005b). In order to do that it is first necessary to understand how a district local plan can influence the resilience of a local area. A district local plan also provides the basis for local governance under a decentralized administrative system and is therefore the most appropriate level of intervention to introduce adaptation strategies for climate change-induced disasters.

Plan Implementation and Governance

Many local development plans are not action oriented or time specific (Berke et al. 2006). Their implementation relies mainly on private developers who carry out development projects at their own pace, location and schedule, resulting in leapfrogging developments and causing environmental problems. In this regard the implementation of local plans requires better coordination between local authorities, development players and local communities. If private developers implement projects at their own pace they might affect the coordinated implementation of the plan (prepared on the basis of meeting the needs of all stakeholders). Saavedra and Budd (2009) argue that some natural hazards are very location-specific and their deepest impact may not be within administrative boundaries. This condition weakens the effectiveness of plans prepared for administrative areas and based on the needs of the stakeholders in that area. In countries like Malaysia, urban areas often exceed the jurisdictional boundaries of local authorities. Urban fringe areas are especially under great pressure for development (FDTCP 2006). These areas may come under rural local authorities that are not organized well enough to initiate a participatory planning process. In this context, district level analysis and intervention could be more effective even though preparation of the district plan in that case might be based on the findings and recommendations of the State Structure Plan. In a similar way plan making and implementation with regards to disaster planning might be undertaken more effectively at the district level when considering the spatial impacts of multiple disasters that do not conform to the boundaries of a local area.

A local plan fulfills certain important functions. An important activity is to ensure that local issues are included at the local planning level, thus providing a broader basis for development control and coordination. There are also arguments in favor of improving disaster resilience in the process of local plan. In those cases, residents are able to decide and plan their own environment, based on their knowledge of the local capacities and resources. Noor (2004) points out that every local plan has its own objectives, which reflect the way the population wishes to develop.

Recent studies note the importance of urban governance in promoting the planning of resilient cities. UN-HABITAT (2002), Ignesias and Arambepola (2007) and Tanner et al. (2009) write that good urban governance plays an important role in the success of planning and management of cities that are working towards resilience. From these same sources we also take the argument that good urban governance implies equity, efficiency, transparency, accountability, civic engagement and citizenship, as well as security and sustainability (UN-HABITAT 2002).

Still, consideration of the socio-physical resilience of people and settlements is not adequately incorporated in many development plans, and thus lack the qualities needed to ensure some degree of resilience. In the absence of a systematic approach, new settlements continue to expand towards disaster prone areas, or even increase the vulnerability of areas due to rapid land use changes that do not recognize existing capacity for resilience.

Within the paradigm of participatory development planning, it is important for urban planners to consider the need for vulnerability reduction and improved resilience strategies among the stakeholders of a civil society. When disaster preparedness is absent in the urban planning process and likewise absent in its practice, the need for adaptation to climate-change related hazards tends to be overlooked. Therefore, this chapter focuses its attention on the prospects of vulnerability reduction in general, and resilience improvement in particular, through the use of development planning.

A local plan is the result of a prescribed procedural process (see Fig. 15.1). It begins with the preparation of the terms of reference by the Local Planning Authority (LPA), followed by review of sectoral reports (Noor 1999). As stated in Sect. 12A of Act 172, the LPA should publicize the preparation of a local plan in the area for which it is being planned. This public information should contain the objectives and the purposes of the plan, as well as the main developmental issues that the LPA proposes to include. This is to ensure that the public will be aware of the forthcoming plan and gives it an opportunity to participate in the planning process. Similarly, after the draft plan is finalized, it must be made available for public scrutiny. Any objections and comments by the public will be considered by the LPA at a public hearing conducted by a special committee appointed by the SPC, and the plan will then be revised accordingly. The SALP 2020 went through the procedure shown in Fig. 15.1. It is used as the main document to guide physical, social, economic and environmental development in the Shah Alam City's jurisdiction until 2020.

Shah Alam City's planning policy evolved from a garden city concept in the early 1980s to a sustainable urban development concept for the plan that is to be carried out between 2003 and 2020. Climate change mitigation and adaptation are claimed to be central to the new plan with the inclusion of the 'resilient city' as a planning goal. However, climate change as a factor that influences sustainable urban development was not widely discussed among planning professionals and

The Shah Alam Case Study in Malaysia

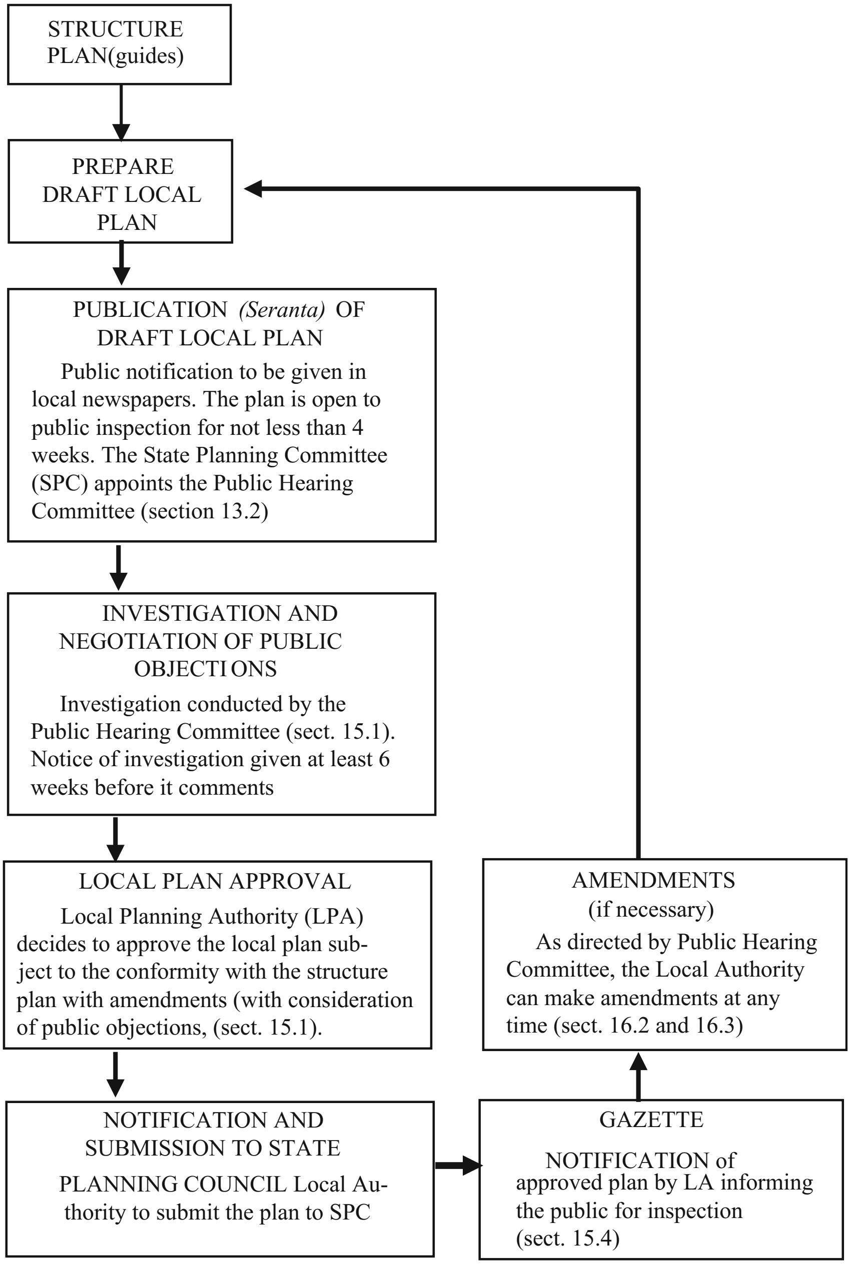

Fig. 15.1 Local plan preparation procedure according to town and country planning Act 1976 (Act 172)

scholars in Malaysia until the early 2000s. Whether the local development plan has met vulnerability reduction and resilience improvement needs is assessed in the next section.

The Perception of Key Informants' on Strategizing for Resilience Improvement

The key informants interviewed for this study include senior/executive level policy makers, urban planners and managers who were involved in the development planning of Shah Alam City. They are attached to the federal and state level planning authorities as well as the local authority of Shah Alam City. Without referring to the SALP 2020 or any planning or management measures that have already been taken to improve the resilience of Shah Alam City, these key informants were asked about their general perceptions on making Shah Alam into a resilient city. They were particularly asked about strategies to improve resilience against climate change related hazards, in order to make Shah Alam City more resilient. Any reference to climate change mitigation strategies was excluded as the focus of this study is on adaptation to climate change. Table 15.1 lists the 42 strategies (out of a total of 47) that were shared by more than a third of the key informants. It is noted here that each respondent pointed out a number of strategies to improve the resilience of Shah Alam City in response to an open-ended question. These strategies are listed in Table 15.1 in descending order of recurrence. It should also be noted that similar ideas were identified as a single strategy and re-phrased to encapsulate the concept being described by the various actors.

The list remains too large to incorporate into a local development plan. Therefore, the list was further analyzed using the Principal Component Analysis (PCA) technique to identify clusters of common ideas. The clusters indicate the most important and most frequently shared set of strategies needed to make Shah Alam a resilient city. Strategies with a 'Measure of Sampling Adequacy (MSA)' less than 0.50 were removed from further analysis.

Eight groups of strategies having *Eigen values of* >1 were identified using varimax rotation with Kaiser normalization to maximize intra-component variance as suggested by Tabachnick and Fidel (1996). The percentage of variance garnered by each group of strategies was the basis for ranking the groups. In other words, group 1 is considered as the most important group of strategies among the eight groups obtained by the PCA. These groups of strategies were given separate names (statistically called new variables) based on the common attributes of the strategies in each group. These new variables are indicated in Table 15.2.

Table 15.1 Strategies identified to improve disaster resilience of Shah Alam city by the professional urban planners and managers (N = 115)

Serial No.	Strategies to improve resilience (*strategies identified for analysis under PCA are shown in italics*)	Frequency of citation	% of cited respondents
ST1	*Ensure rule of law for development control*	98	85.2
ST2	*Involve stakeholders in risk mapping*	97	84.4
ST3	*Improve the capacity and readiness of local government officers*	95	82.6
ST4	*Regulate development of land in the urbanized areas*	93	80.9
ST5	*Encourage stakeholder participation in adaptation planning*	93	80.9
ST6	*Localize land-use zoning and building regulation by-laws*	88	76.5
ST7	*Sustain value of property and assets*	87	75.6
ST8	Reduce the percentage of impervious surfaces	85	73.9
ST9	*Protect ecologically sensitive areas*	85	73.9
ST10	*Establish environmental stewardship within communities*	83	72.2
ST11	*Improve solid waste collection and disposal*	82	71.3
ST12	*Allocate land for public spaces and uses*	80	69.6
ST13	*Enhance inter agency collaboration for disaster preparedness*	80	69.6
ST14	*Improve the quality of public transport services*	79	68.7
ST15	*Reduce soil erosion rate*	78	67.8
ST16	*Protect lifelines and critical infrastructure*	78	67.8
ST17	*Integrate city-wide emergency and rescue services*	77	66.9
ST18	*Disseminate zoning* and *building regulations among the public*	77	66.9
ST19	*Improve community awareness on hazard intensity and frequency*	76	66.1
ST20	*Protect water retention areas such as wetlands and ponds*	75	65.2
ST21	*Ensure residential and commercial activities to be in safer zones*	74	64.3
ST22	Improve public warning and evacuation systems in communities	74	64.3
ST23	Increase the percentage of public transport users	74	64.3
ST24	*Improve sanitation system*	72	62.6
ST25	Protect greenery and soil cover	72	62.6
ST26	*Improve public understanding on climate change and risks*	71	61.7
ST27	*Improve the access to safety zones*	70	60.9
ST28	Allocate budget and subsidy for community actions	70	60.9
ST29	*Enhance and sustain social capital*	69	60.0
ST30	*Improve transportation network*	68	59.1
ST31	*Inculcate saving and insurance habits among people*	67	58.3
ST32	Ensure satisfaction on the quality of life in every citizen	65	56.5
ST33	Disseminate the emergency response plan on a regular basis	65	56.5
ST34	*Support community-based environmental management actions*	65	56.5
ST35	*Restrict single occupancy vehicles in times of emergency*	63	54.8
ST36	*Propagate the city's development vision regularly*	62	53.9
ST37	Ensure no obstructions on natural drainage channels	58	50.4
ST38	Disseminate guidelines on risk reduction and mitigation	50	43.5
ST39	Control the percentage of residential floor area in the city centre	48	41.8
ST40	Control population growth rate of the city	45	39.1
ST41	Improve health and wellness of people	44	38.3
ST42	Diversify the types of employment in the city	40	34.8

Table 15.2 Eight strategy groups identified from the result of PCA

Group of strategies (Principal components)	Common attribute	Percentage of variance explained
Group 1	Community resilience	8.459
Group 2	Infrastructure resilience	7.616
Group 3	Ecological resilience	7.060
Group 4	Environmental quality resilience	6.953
Group 5	Land-use resilience	6.893
Group 6	Emergency readiness and responsiveness	5.752
Group 7	Stakeholder participation	5.534
Group 8	Socio-economic resilience	5.459

Implementation Efficacy of the Resilience Improvement Strategies in the Shah Alam Local Development Plan

Before assessing SALP 2020 for its implementation efficacy, it should be reiterated that the plan is not specifically a climate change adaptation plan. Nonetheless it is argued that local development plans should ideally be comprehensive in nature and not limited to guiding the socio-economic and physical development of the plan area. In this sense it is also argued that disaster preparedness in general, and resilience improvement in particular, should be part and parcel of a local development plan. Therefore, the purpose of this assessment is to verify the extent to which the specific attributes of resilience as identified by the PCA are integrated in the local plan. Any shortcomings are indicators of room for improvement and formal mainstreaming of resilience as an attribute in future plans.

The assessment used a 5-point Likert Scale (1.0 = extensively implemented, to 0.0 = not implement at all). The Weighted Mean Score (WMS) was used as a tool to arrive at an overall assessment of the extent of implementation of each short-listed strategy. WMS for each strategy was computed using the formula $\sum W_i/n$. After determination of the individual weighted mean score (index) for each strategy, an "index mean" for the set of strategies (and thereby for the attribute) was prepared using the formula $\sum W_i f_i / \sum f_i$ (where W_i = the individual's weighted score for each strategy, f_i = frequency of that particular score). Tables 15.3, 15.4, 15.5, 15.6, 15.7, 15.8 and 15.9 provide a summary of the implementation efficacy of the short listed strategies in the local development plan of Shah Alam City (SALP 2020). The summary provides an Index Mean Score for each specific attribute of resilience to indicate the integration of that attribute in the local development plan. Any Index Mean Score of more than 0.75 was considered as an indication that an attribute was adequately integrated into the local development plan.

The first principal component is 'Community Resilience'. Table 15.3 indicates that strategies to achieve community resilience have been more or less adequately

Table 15.3 Implementation efficacy of resilience improvement strategies for community resilience as suggested by the key informants in SALP 2020

Principal component	Resilience improvement strategies	Responses of the professional planners and managers (N = 97)					Weighted Mean Score (WMS)
		Extensively implemented (1)	Adequately implemented (0.75)	Moderately implemented (0.5)	Inadequately implemented (0.25)	Not implemented at all (0)	
Community resilience	ST21. Ensure residential and commercial activities to be in safer zones	63 (65.08%)	23 (23.7%)	4 (4.1%)	5 (5.2%)	2 (2.1%)	0.86
	ST12. Allocate land for public spaces and uses	50 (51.6%)	33 (34.0%)	7 (7.2%)	8 (8.3%)	9 (9.3%)	0.83
	ST19. Improve community awareness on hazard intensity and frequency	57 (58.8%)	22 (22.7%)	7 (7.2%)	6 (8.2%)	5 (5.1%)	0.81
	ST10. Establish environmental stewardship within communities	32 (33.0%)	51 (52.6%)	2 (2.1%)	7 (7.2%)	5 (5.2%)	0.75
	ST26. Improve public understanding on climate change and risks	35 (46.4%)	22 (36.1%)	18 (8.3%)	15 (5.2%)	7 (4.1%)	0.66
	ST29. Enhance and sustain social capital	12 (12.4%)	23 (23.7%)	15 (15.5%)	37 (38.1%)	10 (10.3%)	0.47
Index Mean Score for the attribute							0.73

Table 15.4 Implementation efficacy of resilience improvement strategies for infrastructure resilience as suggested by the key informants in SALP 2020

Principal component	Resilience improvement strategies	Responses of the professional planners and managers (N = 97)					Weighted Mean Score (WMS)
		Extensively Implemented (1)	Adequately implemented (0.75)	Moderately implemented (0.5)	Inadequately implemented (0.25)	Not implemented at all (0)	
Infrastructure resilience	ST36. Propagate the city's development vision regularly	46 (47.4%)	23 (19.6%)	6 (6.2%)	19 (19.6%)	7 (7.2%)	0.73
	ST30. Improve transportation network	34 (35.1%)	23 (23.8%)	10 (10.3%)	22 (22.7%)	8 (8.3%)	0.64
	ST16. Protect lifelines and critical infrastructure	34 (35.1%)	19 (19.6%)	9 (9.3%)	26 (26.8%)	9 (9.3%)	0.62
	ST15. Improve the quality of public transport services	22 (22.7%)	31 (32%)	18 (18.6%)	17 (17.5%)	9 (9.3%)	0.60
	ST35. Restrict the single occupancy vehicles during times of emergency	15 (15.5%)	34 (35.1%)	8 (8.3%)	29 (29.9%)	11 (11.3%)	0.54
	ST13. Enhance inter agency collaboration for disaster preparedness	9 (9.3%)	20 (20.6%)	18 (18.6%)	28 (28.9%)	22 (22.7%)	0.41
Index Mean Score for the attribute							0.59

Table 15.5 Implementation efficacy of resilience improvement strategies for ecological resilience as suggested by the key informants in SALP 2020

Principal component	Resilience improvement strategies	Responses of the professional planners and managers (N = 97)					Weighted Mean Score (WMS)
		Extensively Implemented (1)	Adequately implemented (0.75)	Moderately implemented (0.5)	Inadequately implemented (0.25)	Not implemented at all (0)	
Ecological resilience	ST20. Protect water retention areas such as wetlands and ponds	28 (28.9%)	35 (36.1%)	15 (15.5%)	10 (10.3%)	9 (9.3%)	0.66
	ST9. Protect ecologically sensitive areas	25 (25.8%)	36 (37.1%)	12 (12.4%)	1 (15.5%)	9 (9.3%)	0.64
	ST15. Reduce soil erosion rate	22 (22.7%)	31 (31.9%)	16 (16.5%)	18 (18.6%)	10 (10.3%)	0.60
	ST18. Disseminate zoning and building regulations among the public	16 (16.5%)	24 (24.7%)	27 (27.8%)	17 (17.5%)	13 (13.4%)	0.53
Index Mean Score for the attribute							0.61

Table 15.6 Implementation efficacy of resilience improvement strategies for environmental quality resilience as suggested by the key informants in SALP 2020

Principal component	Resilience improvement strategies	Responses of the professional planners and managers (N = 97)					Weighted Mean Score (WMS)
		Extensively implemented (1)	Adequately implemented (0.75)	Moderately implemented (0.5)	Inadequately implemented (0.25)	Not implemented at all (0)	
Environmental quality resilience	ST4. Regulate development of land in urbanizing areas	48 (49.5%)	31 (32.0%)	11 (11.34%)	5 (5.16%)	2 (2.10%)	0.80
	ST11. Improve solid waste collection and disposal	43 (44.3%)	28 (28.9%)	13 (13.4%)	6 (6.2%)	7 (7.2%)	0.74
	ST24. Improve sanitation system	35 (36.1%)	23 (23.7%)	26 (26.8%)	10 (10.3%)	3 (3.1%)	0.70
	ST34. Support community-based environmental management actions	11 (10.7%)	26 (26.8%)	33 (34.0%)	14 (15.4%)	13 (13.4%)	0.52
Index Mean Score for the attribute							0.70

Table 15.7 Implementation efficacy of resilience improvement strategies for land use resilience as suggested by the key informants in SALP 2020

Principal component	Resilience improvement strategies	Responses of the professional planners and managers (N = 97)					Weighted Mean Score (WMS)
		Extensively implemented (1)	Adequately implemented (0.75)	Moderately implemented (0.5)	Inadequately implemented (0.25)	Not implemented at all (0)	
Land use resilience	ST27. Improve the access to safety zones	42 (43.3%)	26 (26.8%)	22 (22.7%)	5 (5.2%)	2 (2.1%)	0.76
	ST1. Ensure rule of law in development control	33 (34.0%)	16 (16.5%)	29 (29.9%)	13 (13.4%)	6 (6.2%)	0.65
	ST2. Involve stakeholders in risk mapping	9 (9.3%)	20 (20.6%)	18 (18.6%)	28 (28.9%)	22 (22.7%)	0.41
	ST6. Localize land-use zoning and building regulation by-laws	–	3 (3.1%)	20 (20.6%)	39 (40.2%)	35 (36.1%)	0.23
Index Mean Score for the attribute							0.51

Table 15.8 Implementation efficacy of resilience improvement strategies for emergency readiness and responsiveness as suggested by the key informants in SALP 2020

Principal component	Resilience improvement strategies	Responses of the professional planners and managers (N = 97)					Weighted Mean Score (WMS)
		Extensively implemented (1)	Adequately implemented (0.75)	Moderately implemented (0.5)	Inadequately implemented (0.25)	Not Implemented at all (0)	
Emergency readiness and responsiveness	ST3. Improve the capacity and readiness of local government officers	38 (39.2%)	24 (24.7%)	19 (19.6%)	11 (11.3%)	5 (5.2%)	0.70
	ST17. Integrate city-wide emergency and rescue services	3 (3.1%)	5 (5.2%)	37 (38.1)	29 (29.9)	23 (23.7%)	0.34
Index Mean Score for the attribute							0.45

Table 15.9 Implementation efficacy of resilience improvement strategies for emergency readiness and responsiveness as suggested by the key informants in SALP 2020

Principal component	Resilience improvement strategies	Responses of the professional planners and managers (N = 97)					Weighted Mean Score (WMS)
		Extensively implemented (1)	Adequately implemented (0.75)	Moderately implemented (0.5)	Inadequately implemented (0.25)	Not at all implemented (0)	
Stakeholder participation	ST5. Stakeholder participation in climate change adaptation planning	7 (7.2%)	22 (22.7%)	28 (28.9%)	25 (25.8%)	15 (15.5%)	0.45
	Index Mean Score for the attribute						0.45
Socio-economic resilience	ST7. Sustain value of property and assets	19 (19.6%)	37 (38.1%)	24 (24.7%)	10 (10.3%)	7 (7.2%)	0.63
	ST31. Inculcate saving and insurance habits among people	–	16 (16.5%)	30 (30.9%)	28 (28.9%)	23 (23.7%)	0.35
	Index Mean Score for the attribute						0.50

implemented under the SALP 2020. This condition is indicated by the Index Mean Score of 0.73 (≈0.75). It is also an indication of the Shah Alam City Council's highest priority, making the communities resilient against climate change induced flooding. It is noted that only two strategies to improve community resilience have not been adequately implemented under the SALP 2020. They are; ST26—"Improve public understanding on climate change and risks" (WMS = 0.66); and ST29—"Enhance and sustain social capital" (WMS = 0.47). These two findings indicate that the Shah Alam City Council should take action to improve the understanding of climate change and its risks among for members of the city population. Social capital is a relatively new term for urban planners and managers although the existence of it is evident in traditional *gotong royong* (mutual help) activities. With urbanization and modernization, these traditional practices gradually disappeared from civil society, and so the city council faces the challenge of rebuilding social capital in its communities. Successful actions will help to increase community resilience against climate change related hazards as well as other unforeseen.

'Infrastructure Resilience' is the second principal component. Although improvement of resilience with regards to infrastructure, especially in the case of the city's major lifelines, is the second highest priority for urban planners and managers, achievement of that target in implementing SALP 2020 is only moderately successful, as shown by an Index Mean Score of 0.59 (see the last part of Table 15.4). Apparently this deficiency is largely due to inadequate collaboration between agencies that manage infrastructure networks.

The relevant strategy, ST13- Enhance inter agency collaboration for disaster preparedness, has garnered only a WMS of 0.41, indicating less than moderate success in implementation of that strategy under SALP 2020. Therefore, the city council has to play a stronger role coordinating different agencies functioning in the city in order to improve the resilience of transport and other critical infrastructure.

The third highest priority for urban planners and managers is the improvement of the ecological resilience of the city. Implementation of strategies targeting ecological resilience garnered an Index Mean Score of 0.60 indicating slightly more than moderate level of implementation. The analytical results presented in Table 15.5 indicate that further dissemination of zoning and building regulations among the public (i.e., ST18) may lead to higher level of ecological resilience in the city.

According to the fourth principal component, the SALP 2020 has more or less adequately implemented strategies to improve the resilience of environmental quality in the city, as indicated by an Index Mean Score of 0.70. The analytical data presented in Table 15.6 indicates that the city council has given only moderate support for community-based environmental management actions (WMS for ST34 = 0.52). It is a fact that local government authorities in many cities collaborate with community organizations to improve the environmental quality in residential areas and thereby the whole city. Apparently the Shah Alam City Council has not done enough to support the community-based environmental management actions. On the other hand, Table 15.6 does not indicate that support from the city council to improve the environmental quality of the communities is a particular need of the people. Even so, more support and collaborative activities with community organizations can further improve the environmental quality in the city.

According to the fifth principal component, the land-use resilience of Shah Alam City is only moderate, as indicated by an Index Mean Score of 0.51 (see Table 15.7). Apparently the urban planners and managers have been inadequately successful in involving stakeholders in the mapping of climate change risk areas in the city. This is indicated by a WMS of 0.41 for the relevant strategy (ST2). On the other hand, as this strategy is ranked number 2 and cited by nearly 85% of the key informants—it is clearly significant from their point of view (see Table 15.1). Therefore, Shah Alam City Council needs to make a concerted effort to collaborate with local stakeholders in order to uncover the areas of climate change risk in the city, and use that information for climate change adaptation planning. Moreover, it is worth noting that it is difficult for urban planners and managers to increase land-use resilience without localizing land-use zoning and building regulations.

There is a common set of land-use and building regulations applicable throughout Malaysia under the Town and Country Planning Act of 1976 (Act 172) and the Street, Drainage and Building Act of 1974 (Act 133). The land-use and building regulations in SALP 2020 are based on these Acts, while local authorities such as Shah Alam City Council are allowed only to enforce by-laws under the Local Government Act of 1976 (Act 171). This provision is inadequate with regards to counteracting climate change related risks (Khir 2008). Therefore, the majority of the urban policy makers, planners and managers (76.5% of the key informants) share the view that 'localized land-use zoning and building regulation by-laws' are a critical need (see ST6 in Table 15.1). However, such by-laws are difficult to enforce without amending the Local Government Act (Act 171) in a way that will empower local authorities to enact 'localized land-use zoning and building regulations'. Until this change takes place, improving land-use resilience will remain a challenge for the Shah Alam City Council.

The sixth principal component is 'Emergency Readiness and Responsiveness'. Table 15.8 indicates that 'emergency readiness and responsiveness' as a specific attribute of resilience has fared only moderately well (Index Mean Score = 0.52) in the implementation of SALP 2020. The main reason for this level of implementation is due to inadequate integration of the city-wide emergency and rescue services (WMS = 0.34 for ST17, see in Table 15.8). As discussed earlier, integration of city-wide emergency and rescue services which often compete with, and duplicate each other, is a difficult task. Therefore, Shah Alam City Council will find it difficult to improve the overall status of 'emergency readiness and responsiveness' without taking strenuous actions to integrate city-wide emergency and rescue services.

'Stakeholder Participation' is the seventh principal component. Stakeholder participation in climate change adaptation planning was found to be inadequately implemented under SALP 2020. This deficiency is indicated by a WMS of 0.45 for ST5 (see Table 15.9). The urban policy makers, planners and managers rank stakeholder participation very highly as indicated by more than 80% of the key respondents pointing it out as a key strategy to improve the resilience of Shah Alam City from climate change related hazards (see Table 15.1). However, collaboration between urban planners and managers and local stakeholders appears to be difficult. It may be that there is a need for training in order to build skills and techniques necessary to improve stakeholder participation.

'Socio-economic Resilience' is the eighth and last principal component. Surprisingly, socio-economic resilience features last in the list of specific attributes of resilience. It also fares moderately in terms of implementation under SALP 2020, as indicated by an Index Mean Score of just 0.50 (see Table 15.9). The main reason for this moderate level is due to the difficulty of inculcating saving and insurance habits among people. The relevant strategy (ST31) has a WMS of only 0.35 indicating inadequate implementation under SALP 2020.

Discussion

Although Shah Alam City has a modern society, when it comes to saving money, habits remain very traditional. It is not uncommon to find that many people place their savings in precious metals like gold, for instance. Similarly, taking an insurance policy against disasters is an uncommon practice although many suffer from floods annually. Instead, many try to cope with emergencies by themselves or with the support of their relatives and friends, and it is difficult to inculcate new habits of saving and insurance. As a result, the socio-economic resilience of people in Shah Alam will remain low from the perspective of urban planners and managers. However, the findings of the social survey suggested the exact opposite is true, as the majority of respondents have regular incomes from salaried jobs. In this regard the evidence of needs related to improving resilience do not likewise indicate that socio-economic resilience is poor. On the other hand, community resilience featured at the top of the specific attributes of resilience (see Table 15.2). Therefore, it can be inferred that socio-economic resilience is more critical at the collective level than at the individual level.

Moreover, the results of PCA and the subsequent discussion on the strategies pointed out by key informants revealed that SALP 2020 has also inadvertently integrated all 8 specific attributes of resilience.

Regarding the specific attributes of resilience, it was revealed that 'community resilience' and 'environmental quality resilience' are integrated in SALP 2020, and more or less achieved through the implementation of their relevant strategies. Similarly, 'Infrastructure resilience', 'Ecological resilience', 'Land-use resilience', 'Emergency readiness and responsive-ness', and 'Socio-Economic resilience', are also integrated in SALP 2020, but only moderately achieved through the implementation of their strategies. Only the strategy on 'Stakeholder participation' was inadequately implemented. Which is to say, the status of 'Stakeholder participation' as a specific attribute of resilience in SALP 2020 is questionable.

It can be preliminarily concluded that both general and specific attributes of resilience are already integrated into the local development plan of Shah Alam City although there is room for improvement. It is reiterated here that the integration of general and specific attributes of resilience in the local development plan is a finding of this research based on the interpretation of the contents of SALP 2020 and the strategies proposed to make Shah Alam a resilient city. Based on these findings, the research argues the case for formal mainstreaming of disaster resilience attributes in the local development plan.

Closing Remarks

This chapter examined how adaptation of disaster resilience attributes in the local development plan can satisfy the goal of creating a resilient city. In order to investigate this possibility, the urban policy makers, planners and managers who shape the destiny of Shah Alam city were asked a reverse question; what are the planning interventions needed to make Shah Alam a resilient city? The answers to this question by key informants were analyzed in order to identify common themes among them and then reconsidered those themes as the specific attributes of resilience. The analyses lead to the distillation of 8 specific attributes of resilience. Adaptation of those specific attributes in the local development plan will be necessary to achieve the planning goal of a resilient city, according to the views and opinions expressed by the planners and managers who might wish to see such an ambition carried out. Since the opinions of the key informants were more or less general and not so specific to Shah Alam City and its development plan, the specific attributes of resilience identified above can be considered as applicable for any city in Malaysia that face the threat of climate change induced disasters.

It is reiterated here that adaptation is a higher status of integration which requires the subject to adapt in order to be specifically included in the plan making, plan adoption and plan implementation process. As the Hyogo Framework for Action 2005–2015 recommends, adaptation to climate change related hazards require resolute actions by planning agencies and local authorities (UNISDR 2005a). If the disaster resilience attributes were resolutely adapted in SALP 2020, and relevant strategies were specifically targeted to improve sensitivity to hazards, exposure minimization, and adaptive capacity improvement, the plan would have been more effective in fulfilling peoples' needs. In other words, the findings support the initial proposition of the study that adaptation of disaster resilient attributes in the local development plan can make it more effective in achieving the planning goal of a resilient city. Answer to the research question give directions on how to adapt disaster resilience attributes in the local development plan from the perspective of urban policy makers, planners and managers. This kind of adaptation has the potential to make the development plan an effective tool to improve the disaster resilience of urban areas.

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Chapter 16
Swarm Planning—Developing a Tool for Innovative Resilience Planning

Rob Roggema and Nikolay Popov

In dealing with the unexpected impacts of climate change our current spatial planning tools are un-responsive and inflexible. Using these tools often results in plans that cannot be adjusted, that do not anticipate change, and are not agile, resulting in cities that are unchangeable. These inflexible cities are very vulnerable to climate hazards. In response to this problem, an innovative tool has been developed to support spatial planning so that plans might anticipate future change and lead to cities that are easily adjustable. The required dynamic in these cities is enhanced through creating space for surprises, which forms the basis of the concept of Swarm Planning. When we allow the urban fabric to adjust dynamically to external shocks, like a swarm of bees does, the city becomes more adaptive. Further, when we know how a city may evolve under external shocks we can start to plan it and anticipate these changes. Swarm Planning finds its basis in complex adaptive systems theory. An on-screen user-friendly tool to design flexible cities is currently under construction. The tool consists of a supporting agent based model, which, when fed with the relevant data for a site will model the urban fabric. This model can be subsequently modified with 'external shocks', meaning climate-driven spatial challenges, after which the model rearranges the urban fabric and determines its adaptive capacity in terms of decreased impact as a result of floods, bushfires, the urban heat island, and so on. The first results of this project and the features of the model will be described in the chapter.

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Introduction

Climate change is not entirely predictable. Research shows that changes occur in a non-linear fashion, as step-changes (Jones 2010). To be clear, a "Step change" is here defined as a sudden and significant change in the way a process works or in behaviour leading to positive increase and benefit. The results are, partly, uncertain and surprising. There is a need for research aimed at understanding such changes better, but society also needs to become more adaptable to uncertain futures. Urban design is one vehicle for this latter goal as it is focused on arranging the various uses of urban precincts. But it comes with a major problem. The majority of urban designs in the European-Australian world at least pursue a fixed, nearly unchangeable, end situation. Once a certain use is determined and adopted in a land-use plan it is extremely difficult to modify. When an area is under threat of an unpredictable future this approach is contra-productive. If an area is hard to change, it will face difficulties to adapt. In order to tackle this problem a new planning approach, Swarm Planning, has been developed (Roggema 2012a), in which dynamics and change lead the process, and external influences direct the design. Like a swarm of bees, the plan adjusts itself constantly to meet changing demands. The approach is tested in several pilot-designs and deemed a plausible direction to deal with uncertainty. However, further research needs to shed light on whether it can deliver results that allow adaptation to climate change. This research, supported by NWO's Rubicon-grant,[1] consists of several research components. Firstly, urban objects in two urban precincts (one in Australia and one in the Netherlands) are identified and 'loaded' with properties or attributes. This makes it possible to understand them and their behaviour as part of complex adaptive systems. The second component is to model the 'swarm' behaviour of these objects under influence of external climate impacts. Each object relates to its environment according to simple rules, describing flocking or swarming behaviour. The last component is to design a spatial intervention that aims to improve the adaptive capacity of the area and test this through modelling. The interrelationships of objects lead to a certain spatial configuration, or to a future that is constantly 'reconfiguring' (e.g. objects keep on moving in search for better locations).

Problem

In order to plan for wicked problems, and more specifically for climate adaptation, we need to take into account that it is likely that climate change will force (step-) changes (Jones 2010), that climate change has locally specific characteristics and that it will need responses that can bridge long-term impacts. Therefore, it is useful to explore the potential of complexity theory in three ways. Firstly, we need to understand complex (adaptive) systems, their non-linearity, and the idea that small

[1] http://www.nwo.nl/en/funding/our-funding-instruments/nwo/rubicon/index.html

changes might have big impacts. Secondly, we need to understand cities as self-organising systems. And thirdly, we need to build upon the former to make this knowledge available for urban design.

Complexity Theory

There are many scholars of complexity and the self-organisation of non-linear dynamic systems (Prigogine and Stengers 1984; Gleick 1987; Lewin 1992; Mitchell Waldrop 1992; Cohen and Stewart 1994; Kauffman 1995). The subject has been defined, elaborated and further explained (Johnson 2001; Miller and Page 2007; Johnson 2007; Northrop 2011). The key concepts from complexity theory that are useful in a planning context are the *self-organisation* of complex systems, the *surge of actors to attractors*; the concept of the *fitness landscape*, the change and transformation of a complex system in times of crisis; the existence of *bifurcation*, or '*the point in time where for identical external conditions various possible structures can exist*' (Allen 1996); and *tipping points*, '*the point at which the system 'flips' from one state to another*' (Gladwell 2000).

Adaptation is an internal process of *self-organisation*, which is the tendency in complex systems to evolve toward order instead of disorder (Kauffman 1993). The state of equilibrium is called an attractor. In order to stay within their current attractor, complex adaptive systems need to self-organise and adapt. The system only shifts to other attractors (alternative states) after a shock that drives the system out of its current state (e.g. due to significant changes in climate). After the shock the system self-organises in order to meet the adjustments that are needed.

The process can be represented in the form of a *fitness landscape* (Fig. 16.1) (Mitchell Waldrop 1992; Langton et al. 1992). This is a concept from evolutionary

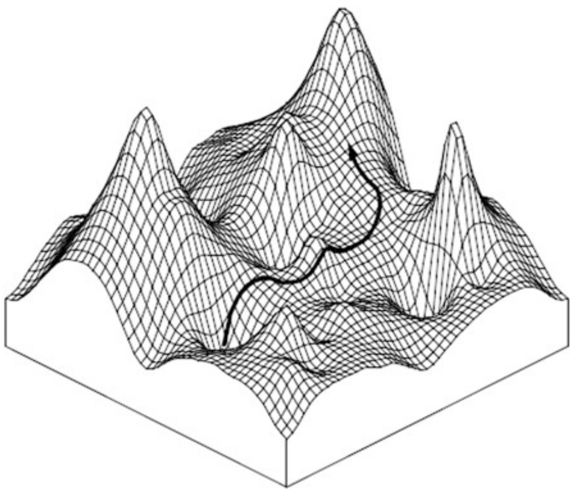

Fig. 16.1 The fitness landscape (Cohen and Stewart 1994) showing a complex system moving from a less favourable to a more favourable position or attractor

theory that describes the fitness of a form to its surroundings in a graphic form. It includes favourable positions (the mountain tops) and less favourable positions (the valleys). A complex system tends to move, while crossing less favourable valleys, to the highest possible position in the landscape, which is an attractor. At the 'mountaintop', the highest possible position and not necessarily the highest top, the adaptive capacity is highest. There the system can adapt more easily to changes in its environment. It is often the case lower peaks than optimal are climbed, implying from there the ability to get off and on to the peak that is actually a better fit is nearly impossible. What to do when lower peaks are climbed easily, but do not represent the best possible position from a sustainability perspective? Once the apparently sustainable ambition to save energy is reached, it is hard for the system to climb a higher peak, for instance a peak where energy saving, energy efficiency, the use of renewables, and the re-use of waste are all achieved at once.One could say in this example the wrong peak has been climbed. However, this peak was already an improvement compared with the valley positions. The challenge of the fitness landscape is to identify those attractors that are so powerful they will attract the system, even when a (semi-) favourable position is attained. In the Swarm Planning concept this problem is tackled through the visualisation of a very attractive long-term future, which is for the involved agents so seductive they would jump beyond the first-gained wins in the fitness landscape. For instance, this vision can be a future landscape safe for climate impacts, prosperous and beautiful. Individual agents then will start moving towards realising that vision and slowly the system turns and moves towards the higher peak.

Cities as Complex Systems

Complexity theory has been applied to cities by others. However, the majority of scholars (Allen 1996; Batty 2005; Portugali 2000, 2006, 2008) use it mainly to understand self-organising processes in cities through the modelling of reality.

Modelling remains a central activity at the intersection of complexity and spatial science (O'Sullivan 2004) but there is growing concern about the limitations of this 'orientation on modelling' (O'Sullivan et al. 2006). Still, the main attention focuses on the different computational representations of spatial analyses (O'Sullivan et al. 2006) and the representation in models through agent-based modelling or cellular automata (Crawford et al. 2005). The question is whether this '*mathematicalisation*' of the city offers more than just an understanding of self-organisation in cities. In many modelling exercises spaces (and places) are seen as objects to study, analyse, explain, understand, and describe (Portugali 2006), but this understanding is hardly used to inform design processes.

Use of Complexity in Planning

As a bridge between the understanding of complexity in cities and planning for complexity, a key set of interrelated concepts are helpful (Manson 2001). The literature suggests we can apply the lessons of these findings in artificial systems like cities, but only to a limited extent (Portugali 2006). Social systems, such as cities and landscapes exhibit complexity on more than one level (Portugali 2006, 2008): the city as a whole is a complex adaptive system in itself, and so are each of its parts (e.g. human or organisational entities or agents). The entirety cannot be sufficiently explained by the behaviour of individual components.

At the core the *relationships* between its components and its environment determine the whole of the system. Because of the wide array of complex internal relationships, the system is in most cases able to respond to novel, external, relationships, but in case there is no internal component capable of responding to novel circumstances, for instance to climate impacts, this may end in a catastrophe for the system.

The system exhibits *emergence*. This concept can be described most simply as system-wide characteristics that stem from interactions amongst components (Lansing and Kremer 1993). In this way it is more than a simple addition of qualities. From this perspective it is difficult to anticipate change beyond the short term, because several components of the system adjust to changes in the environment at the same time but in different ways and those changes interact each other, amplifying or damping the collective outcome (Youssefmir and Huberman 1997). Any single change can therefore have far-reaching large-scale effects (Lansing and Kremer 1993).

A complex system performs *change and evolution* through three different functions: (1) self-organisation, or the ability to adjust its internal structures to better interact with a changing environment; (2) development of dissipative structures, allowing the system to suddenly enter a more organised state after spending a certain period in a highly unorganised state (Schieve and Allen 1982), and (3) self-organised criticality. This allows the system to maintain a balance between collapse and stability through an internal restructuring, almost too rapid to accommodate, but necessary for survival (Scheinkman and Woodford 1994).

Finally, *path dependency* defines the development of a system as ‘a trajectory as a function of past states’ (O’Sullivan 2004). With regards to planning, though the past sets the starting point, the trajectory is towards the future, as the plan has yet to be realized, and in this sense is a reverse form of path dependency (Portugali 2008).

Swarms (Fisher 2009; Miller 2010) are self-organising systems that have a facility for responding to changing circumstances. This is achieved through (1) multiple interactions between a large number of similar and free moving ‘agents’, which (2) react autonomously and quickly, towards one another and to their surroundings, resulting in (3) the development of a collective new entity and coherent unity of a higher order (Van Ginneken 2009). Most systems performing *swarm behaviour* represent high resiliency, reducing the impact of uncertainty, complexity and change through emergent patterns and structures (Van Ginneken 2009).

Modelling Complexity in Urban Precincts

The complexity of the urban system can be modelled in order to understand how the adaptive capacity of precincts might cope with the impact of climate change. The scale of the urban precinct has been chosen firstly as a complexity that, given the number of elements and agents, actually can be modelled. The entire city, municipality or region would become too large from a data perspective. Secondly, the precinct was chosen because the impacts of climate change can be made visible on this scale as the different components of the precinct, building locks, streets, parks, rivers etcetera, play a crucial role in adaptation practice. These components need to adapt, reposition or reshape impacted by climate change and at the level of the precinct they can. The neighbourhood level, depending on the definition of neighbourhood scale, and the building block are too small to allow enough levels of freedom for the components to adjust and change.

Generative Design

Before proceeding further, it is useful to understand the term Generative design (McCormac and Dorin 2001; Galanter 2003; Boden and Edmonds 2009; Fischer and Herr 2001). Commonly it is understood to be a '*methodology and philosophy that views the world in terms of dynamic processes and their outcomes*' and has a certain '*degree of autonomy and independence from the designer*' (McCormack, et al. 2004). It can be used to support a designer or even to remove human authorship from the design entirely. In generative design, the focus lies on the design process and its *expression* rather than on the design objects themselves. Objects are generated at one remove, by the design of interacting components, systems and processes (McCormack et al. 2004). The adaptability of life over time suggests such mechanisms have the ability to overcome problems and to generate novelty and diversity from relatively simple units.

The concept of *morphogenesis*—or the ability to generate form using internal resources and without the need for input from outside—is fundamental to generative design. In architecture, urban design and urban planning, morphogenesis ("digital morphogenesis" or "computational morphogenesis") is defined as a group of methods that employ digital media as generative tools for the derivation of form and its transformation (Kolarevic 2000), and often aspiring to express contextual processes in built form. Recent discourse on digital morphogenesis in architecture links it to a number of concepts including emergence, self-organization and form-finding (Hensel et al. 2004).

The elements of a design have agency on their own. Additionally, their properties and proximity to other elements determine local interactions (Testa, et al. 2001). In architecture and design, problems are multifaceted and designers try to address them syncretistically. Moreover, the types of problems designers deal with are often seen as “wicked” (Rittel and Webber 1973; Buchanan 1992; Coyne 2005). In this regard they resist singular solutions. In the case of generative design, software is specifically developed to generate myriad self-organising spatial configurations, using decentralised and parallel logic to understand the individual behaviour of design elements as well as their influence on other parts. This viewpoint encompasses the recognition of hierarchies (Wilensky and Resnick 1998) and the understanding that complex, collective, macroscopic phenomena can emerge from the local and simple interactions of individual units. Such understanding provides system level insights that are influential in developing an adaptive design (Testa et al. 2001). Following on these ideas, generative design views objects and their various degrees of autonomy, as secondary to the principles and processes through which they evolve and change. In this context a finished design is the result of the emergent properties of an interacting system (McCormack and Dorin 2001).

Generative systems have the following key properties (McCormack et al. 2004):

- Ability to generate complexity (e.g. database amplification): interacting components generate aggregations of far greater behavioural or structural complexity than its components;
- Complex interconnections between “organism” and the environment.
- Ability to self-maintain and self-repair—generative systems may adapt themselves to maintain stable configurations within a changing environment.
- The ability to generate novel structures, behaviours, outcomes or relationships.

Methodologies for Generative Design

Apart from the application of Evolutionary Systems (Bentley 1999; Dorin 2001), Shape Grammars (Stiny 1975) and Self-Assemblage (Davies 2005; Banzhaf 2004), Self-organisation and Agent Based Modelling (ABM) seem the most useful methodologies for the design of highly adaptive complex urban precincts. The reasons for this conclusion are elaborated below.

Self-organisation

Self-organising biological systems receive and react to multiple layers of negative and positive feedback, and while they may appear chaotic, they are not random. The study of feedback loops has enabled researchers to separate the organisation of a system from its physical structure. These systems have three main features:

1. They are open to their environment, and yet can attain and maintain a structure in non-equilibrium conditions;
2. The flow of energy allows them to self-organise spontaneously by developing novel structures and new modes of behaviour. Self-organising systems are therefore said to be 'creative';
3. They are complex. Networks of feedback loops, operating at different levels, scales and rhythms connect their component parts.

'*Systems that show adaptive self-organisation can arrange their structures in ways not simply dictated by the properties of the structures' subunits, but also according to the (unpredictable) environment in which they find themselves*' (Davies 2005, p. 14). Given these capacities, biological morphogenesis offers more flexible solutions for designing adaptive complex urban precincts.

Agent Based Modelling (ABM)

The methodology and philosophy of generative design provides us with a new epistemology, a new way of understanding patterns as the result of emergent properties of iterative parallel *actions* of simple, autonomous and local processes. As such it provides a promising paradigm for urban design. According to the theory, urban design then is the '*outcome of interconnected feedback loops, which replaces a top-down reductionist tradition, with dynamic relations and emergence*' (Coates 2010, p. 1). In order to make use of the philosophy in a practical way generative designers adopted and advanced an array of computational frameworks, including the key technology of Agent Based Modelling (Whitelow 2004).

Agent Based Modelling describes time and space using agents. Every agent has a strategy and is aware of some part of its surroundings. All agents try to implement their strategies synchronously and can alter their positions in space in discrete time steps. These take place in Euclidian space and therefore distances, angles, and other metrics are significant. When studying natural morphologies the models that come from this approach are useful in comparison to classical deterministic models because they better fit with experimental observations (Bonabeau 1997). At the same time, if a design system is conceptualised as a living thing then self-organizing models are very useful (Weinstock 2010).

Swarm Planning

Currently, few measures are taken in spatial plans to anticipate future climate change and urban designs are insufficiently prepared for future impacts. It is here postulated that the theories and tools of self-organization, including ABM, might be used to design urban precincts with higher adaptive capacity and better preparation. Swarm Planning builds from this starting point.

Climate adaptation is seen as a wicked problem (VROM-raad 2007; Commonwealth of Australia 2007) or even a super-wicked one (Lazarus 2009), meaning that the problems fit within *"...a class of social system problems, which are ill-formulated, where the information is confusing, where there are many clients and decision-makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing. Most of the design problems contain a fundamental indeterminacy, which implies that these problems need to be dealt with in a permanent condition of uncertainty and of a situation in which a preferred path only gradually emerge"* (Rittel and Webber 1973). It is difficult to integrate a wicked problem in a system that doesn't aim for (fundamental) change. This implies the difficulty of capturing long-term, wicked, and uncertain problems. In order to improve the adaptive capacity of urban precincts, self-organising processes may need to play a bigger role.

A swarm is a biological example of a self-organizing system that is structurally less vulnerable to sudden changes in the environment (Fisher 2009; Miller 2010). A chief aspect of the system is swarm behaviour, which is characterised as being highly resilient and capable of minimising the impacts of uncertainty, complexity and change through the use of emergent patterns and structures (Van Ginneken 2009). Swarm Planning (Roggema 2012b) emphasises the inclusion of complexity, multiple rhythms in layers and non-linear processes in spatial planning (Fig. 16.2).

Two Levels of Complexity

As Portugali (2000) describes it, the city manifests self-organisation at two levels: the level of the whole city and the level of individual components. If we extend his reasoning beyond the city and consider its application in the realm of landscape, it seems useful to support self-organization at two levels as well. Using this approach, the goal is to perform better with regards to adaptation in the landscape. At the level of the system this is best achieved through strategic interventions in locations that can be discovered on the basis of a network analysis. The nodes in networks (physical, social, urban etc.) that are most inter-connected are the most likely places to intervene. At the level of individual components (e.g. a road, a building, a canal) each part is understood to have varying degrees of self-organising capacity. Taken together both levels of complexity determine the adaptive capacity of the system under investigation.

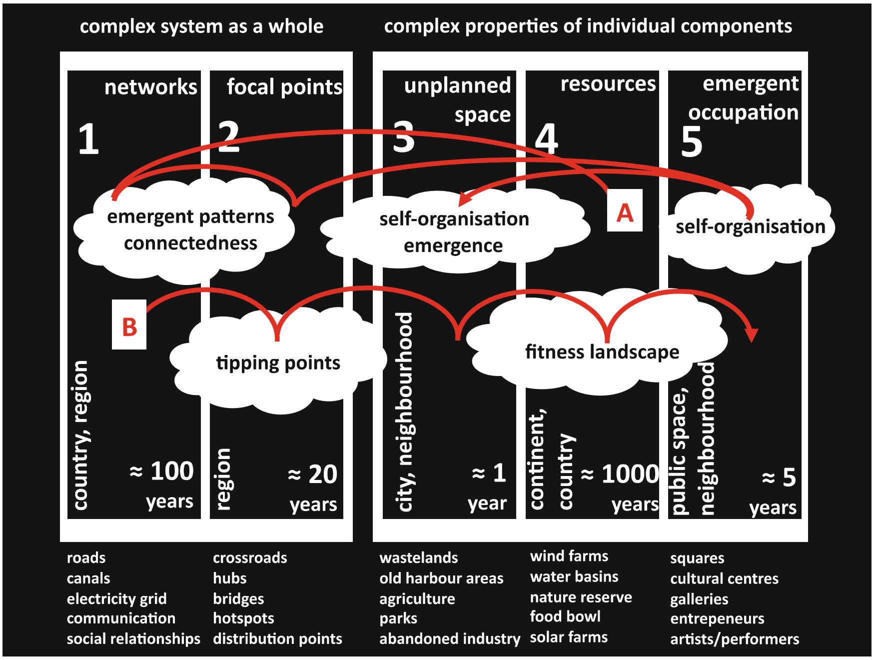

Fig. 16.2 The swarm planning framework

Five Layers

Not every part of a landscape (or a city) changes at the same pace. A tree for instance, changes in the long term, while a street café changes rapidly. When spatial elements of similar changeability or 'time-rhythm' are connected with a spatial layer, the spatial dynamic can be captured and it becomes possible to enhance, predict or facilitate transformations. To make use of this rather simple observation we propose to imagine the landscape through five spatial layers that become larger and slower changing from bottom to top. Building on the work of Frieling (Frieling et al. 1998) our model is described by layers that move from networks, to focal points, unplanned spaces, natural resources and emerging occupation patterns (Fig. 16.3).

Non-Linear Processes

When a designer has the goal of transforming a system so that it might have a higher adaptive capacity in the face of climate change it is necessary to unite two contrasting objectives. On the one hand the system needs to be able to change

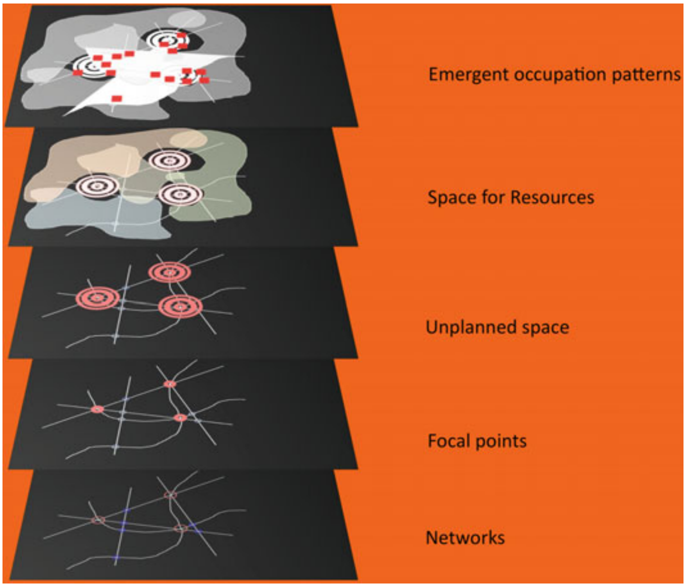

Fig. 16.3 Layer theory adjusted for climate adaptation planning

enough to deal with climate impacts. On the other hand it requires stability in order to carry out the basic operations it originally served. In our case the system is the city. We would posit that it is possible to increase resilience in this setting by balancing physical urban elements with the systems that surround and interact with them. Generally speaking, it is understood that any city is in itself an example of dynamic equilibrium, constantly in flux but more or less maintaining its shape.

The way that equilibrium is maintained however is worth considering. If it is forced and static there is no room for adaptation. When there is too much freedom the city becomes randomly chaotic. With regards to swarm planning, a model is therefore aimed at finding a balance between these extremes. In order to test this idea, we have engaged in a research project aimed at bridging the gap between theory and practice. A case study area is used as the focus for a simple agent-based model, which explores the potential of swarm planning as an applied theory and the problem and opportunities that need to be resolved in order to develop a working model. The results from our preliminary efforts are presented below as a first step in the process of building a holistic model.

Fishermans' Bend—a Case Study

Case Study Area

The 240 hectares of Fishermans' Bend Urban Renewal Area is a mixed-use area approximately 3 km to the west of Melbourne's central business district and is currently defined mostly by low impact industrial uses. The area is for the largest part located at the southern shore of the Yarra-river and is cut through by the main freeway leading up to the West Gate Bridge and also to the Bolte Bridge (City Link connection). Small parts of the area are at, or even a little below, current sea level, but the majority is currently not vulnerable to flooding. Due to the relatively high percentage of impermeable surfaces (roads, roofs) the area is vulnerable to heat. An increase in temperature may cause substantial suffering from Urban Heat Island Effects. State government, together with the City of Melbourne and Port Phillip City Council are currently in the early stages of designing a future for this area. The main objective is to create a lively, relatively high-density residential area with multifunctional uses. It is expected to accommodate around 25,000 jobs and 50,000 residents. In the next 10 years 5,000 dwellings will be built with an expected economic impact of approximately $1.5 billion.[2] In the structure plan for the Montague precinct (where the highest densities will be realised) the following ambitions are being aimed for (City of Port Phillip 2012a):

1. A diverse, inclusive and well serviced community;
2. A high quality, vibrant and diverse mixed-use precinct;
3. An exemplary environmentally sustainable precinct;
4. A highly connected place;
5. A place with a well-defined and unique identity.

Additionally, the City of Port Phillip strives to create a vibrant neighbourhood, with a high spatial quality that is sustainable and resilient (City of Port Phillip 2012b). For Montague precinct a total of over 13,000 new dwellings are planned, requiring a density of 268 dwellings/hectare or 510 residents/ha. A substantially lower density is foreseen for the other districts, including Lorimer, Sandridge and Wirraway (Fig. 16.4).

The Modelling Process

Modelling for Fishermans' Bend was approached in several steps. Firstly, planned and existing urban objects were defined according to their physical size and location, how the objects reacted with other elements in the area (what their individual

[2] http://www.dpcd.vic.gov.au/planning/projects-and-programs/fishermans-bend-urban-renewal-project

Fig. 16.4 The precincts in Fishermans' bend

behaviour was within the system), as well as the expected climate impacts that could affect it in the near future. (Table 16.1). Secondly, the specific rules were described for each object. These rules were derived from existing flocking and swarm models. The third step was to define which of the existing objects would remain unchanged, and the final step before executing the model was to decide on which climate change issues to include.

Urban Objects

The relevant urban objects for Fishermans' Bend, including dwellings, infrastructure, ecological objects and waterways, were defined specifically along with their response to potential climate impacts, as in Table 16.1.

General Rules

To simulate the swarm behaviour of an urban precinct, the properties of urban objects are required in addition to general 'flocking' algorithm rules (Reynolds 1987;

Table 16.1 Urban objects, their definitions and rules

Urban object	Definition (size)	Rule/response
Single detached dwelling	10 × 15 × (2 × 3.20) m	Distance to other buildings min. 5 or 50 m from high-rise buildings Top-up to maximum 2 dwellings At least 250 m from a freeway, 25 m from a collector road and 50 m from major electricity line
		If flood-level is 30 cm, 1 or 5 m, dwelling withdraws above 30 cm, 1 or 5 m contour If intense rainfall, enduring drizzle or intermittent rainfall occurs, dwelling moves outside the flood extension If a heat-wave or extremely hot days occur, dwelling moves in between green or blue space
Attached dwelling	(2 × 10) × 15 × (2 × 3.20) m	Maximum of 6 units can attach in a row or 50 m from high-rise buildings Top-up to maximum 2 units (4 floors) At least 250 m from a freeway, 25 m away from collector road and 50 m from major electricity line
		If flood-level is 30 cm, 1 or 5 m, dwelling withdraws above 30 cm, 1 or 5 m contour If intense rainfall, enduring drizzle or intermittent rainfall occurs, dwelling moves outside the flood extension If a heat-wave or extremely hot days occur, dwelling moves in between green or blue space
Multi-unit building	10 × 15 × (6 × 3.20) m	Distance to other multi-unit building min. 25 or 50 m from high-rise buildings At least 250 m from a freeway, 25 m from a collector road and 50 m from major electricity line
		If flood-level is 30 cm, 1 or 5 m, dwelling withdraws above 30 cm, 1 or 5 m contour If intense rainfall, enduring drizzle or intermittent rainfall occurs, dwelling moves outside the flood extension If a heat-wave or extremely hot days occur, dwelling moves in between green or blue space
High rise	9.70 × 10.16 × (8 × 3.20) m	Max. 6 units can attach to other high-rise (max 8 floors) Top-up to max. 16 floors, Distance to other high-rise buildings at least 100 m At least 250 m from a freeway, 25 m from a collector road and 50 m from major electricity line

(continued)

Table 16.1 (continued)

Urban object	Definition (size)	Rule/response
		If flood-level is 30 cm, 1 or 5 m, dwelling withdraws above 30 cm, 1 or 5 m contour If intense rainfall, enduring drizzle or intermittent rainfall occurs, dwelling moves outside the flood extension If a heat-wave or extremely hot days occur, dwelling moves in between green or blue space
Freeway (2 × 2)	(1.5 + 3 + 0.75 + (2 × 3.75) + 0.75 + 4 + 0.75 + (2 × 3.75) + 0.75 + 3 + 1.5) 31 m	Not connected to access and residential roads, to cycle-paths or to energy distribution grid If a flood of 30 cm, 1 or 5 m occurs it draws back to at least two meter above the flood-line (2.3 m, 3 and 7 m) If intense rainfall, enduring drizzle or intermittent rainfall occurs, freeway moves outside the flood extension If a heat-wave or extremely hot days occur, freeway moves to large green space or wide canal
Collector road	(3.6 + 2.4 + 0.45 + 2.75 + 0.45 + 4.05 + 0.45 + 2.75 + 0.45 + 2.4 + 3.6) 22.45 m (3.6 + 2.4 + 0.45 + 2.75 + 1.1 + 2.75 + 0.45 + 2.4 + 3.6) 18.50 m	If a flood of 30 cm, 1 or 5 m occurs it draws back to at least one meter above the flood-line (1.3 m, 2 and 6 m) If intense rainfall, enduring drizzle or intermittent rainfall occurs, collector road moves at 2/3 between current water-level and max flood extension If a heat-wave or extremely hot days occurs, collector road moves next to green space, canal or stream
Access road	(0.5 + 1.7 + 0.1 + 1.7 + 1.5 + 0.4 + 0.1 + 4.5 + 0.1 + 0.4 + 1.5) 10.50 m (0.5 + 2.5 + 1.5 + 0.4 + 0.1 + 4.5 + 0.1 + 0.4 + 1.5 + 2.5 + 0.5) 14.50 m (1.5 + 1.25 + 0.1 + 5.7 + 0.1 + 1.25 + 1.5) 14.50 m	If a flood of 30 cm, 1 or 5 m occurs it draws back to at least half a meter above the flood-line (80 cm, 1.5 and 5.5 m) If intense rainfall, enduring drizzle or intermittent rainfall occurs, access road moves halfway current water-level and max flood extension If a heat-wave or extremely hot days occurs, access road moves next to green space, a stream or water-body
Residential road	(var + 3.5 + var + 0.3 + 0.1 + 2.75 + 0.7 + 2.75 + 0.1 + 0.3 + var) > 10.50 m	If a flood of 30 cm, 1 or 5 m occurs it draws back to at least half a meter above the flood-line (80 cm, 1.5 and 5.5 m) If intense rainfall, enduring drizzle or intermittent rainfall occurs, access road moves halfway current water-level and max flood extension If a heat-wave or extremely hot days occurs, access road moves next to green space, a stream or water-body

(continued)

Table 16.1 (continued)

Urban object	Definition (size)	Rule/response
Cycle path	(0.5 + 1.7 + 0.1 + 1.7 + 0.5) 4.5 m	If a flood of 30 cm, 1 or 5 m occurs it draws back to at least 1 m above the flood-line (1.3, 2 and 6 m) If a heat-wave or extremely hot days occur, cycle-path moves to the middle of green space or alongside stream or water-body
Waterway	Commercial: between 24.4 m. (depth 3.1–3.5 m) and 55 m (depth 5.6 m) Recreational: 25 m (depth 2.5 m) Leisure: between 4 m (depth 1 m) and 10 m (depth 1.5 m)	Not connected to energy network high voltage lines or energy distribution grid
		If a flood of 30 cm, 1 or 5 m occurs it draws back above the flood-line If intense rainfall, enduring drizzle or intermittent rainfall occurs the waterway stores 1/3 of the total amount of rainwater If a heat-wave or extremely hot days occur, the canal moves as close as possible to residential buildings
Ecological object	Forest: (10-20-10) > 40 m and > 50 m^2 meadow-scrub: (2-8-2) > 12 m and > 50 m^2	Not connected to energy network high voltage lines or energy distribution grid
		If a flood of 30 cm, 1 or 5 m occurs it draws back above the flood-line If intense rainfall, enduring drizzle or intermittent rainfall occurs the waterway stores 1/3 of the total amount of rainwater If a heat-wave or extremely hot days occur, the canal moves as close as possible to residential buildings
Ecological stream-pond	Bank/shore: > 4 m depth 0.4-1.0-1.5 m. spawning ground: > 15 m^2, depth 0.7 m. amphibian pond: > 100 m^2, depth 1.5 m. bypass: > 10 m. eco-passage: 5-10-15 m., length: > 100 m height > 6 m, depth: 1 m	Not connected to energy network high voltage lines or energy distribution grid
		In case of flooding, stream/pond can be in flood zone If intense rainfall, enduring drizzle or intermittent rainfall occurs the ecological connection stores max 1/3 of the total amount of rainwater If a heat-wave or extremely hot days occur, ecological connections get as close as possible to residential buildings

Wilensky and Resnick 1998). They add richness and variability to the performance of the flocks and yield visually interesting representations, hence better reflecting reality and dramatic results (Fig. 16.5).

Reynolds' Flocking Algorithm

The flocking model was originally developed as an algorithm for computer simulations of the flocking behaviour of birds, both for animation purposes and as a way of studying emergent behaviour (Reynolds 1987). They are used to represent virtually every 'flowing' system, including examples in architecture (Miranda and Coates 2000; Westre 2008, Linardou 2008). As a term the "flocking" is an example of emergent collective intelligence that is built on local and simple stimulus-reaction rules without the need for a leader to guide behaviour. Each agent has direct access to the geometric description of the whole world, but reacts only to flock mates within a nearby 'field of view'. Classically the basic flocking model consists of three simple steering behaviours:

1. Maintain Separation—This prevents agents from crowding too closely together, allowing them to scan a wider area;
2. Maintain Cohesion—This rule supplies an agent with the ability to cohere (approach and form a group) with other nearby agents, and is controlled by computing the average position of all nearby agents. A steering force is applied in the direction of an average position;
3. Maintain Alignment—This gives an agent the ability to align with other nearby characters. The average 'heading' vectors of all nearby agents defines the alignment of each individual.

These rules only affect the agents' headings, and speed is assumed to remain constant. The steering behaviours are also entirely deterministic in the sense that there are no random numbers in the algorithm. In this general flocking model, seven parameters can be adjusted: *population, vision-distance, vision-angle, minimum-separation, max-separate-turn, max-align-turn, and max-cohere-turn*. Working from these rules and parameters, numerous behaviours can be modelled—tighter flocks, looser flocks, fewer flocks, more flocks, more or less splitting and joining of flocks, more or less rearranging within flocks, etc.

To achieve more diversity in the collective behaviour other rules are then added:

1. Acceleration. Agents that are not part of a flock can fly faster to catch up, while agents that have flock mates adjust their velocity to the average velocity and, as a result, the whole flock slows down;
2. Chase, Avoid and Eat rules. There are two types of agents: predator and prey. The predators can diverge from their flock and chase the closest prey. Prey agents try to avoid any predators in their field of view;
3. Obstacle avoidance rule. Agents detect the closest obstacle in their 'cone of vision' and determine the distance between themselves and the obstacle. They then turn left or right in such a way that, as they get nearer to the obstacle, they veer away from it, retaining their smooth movements.

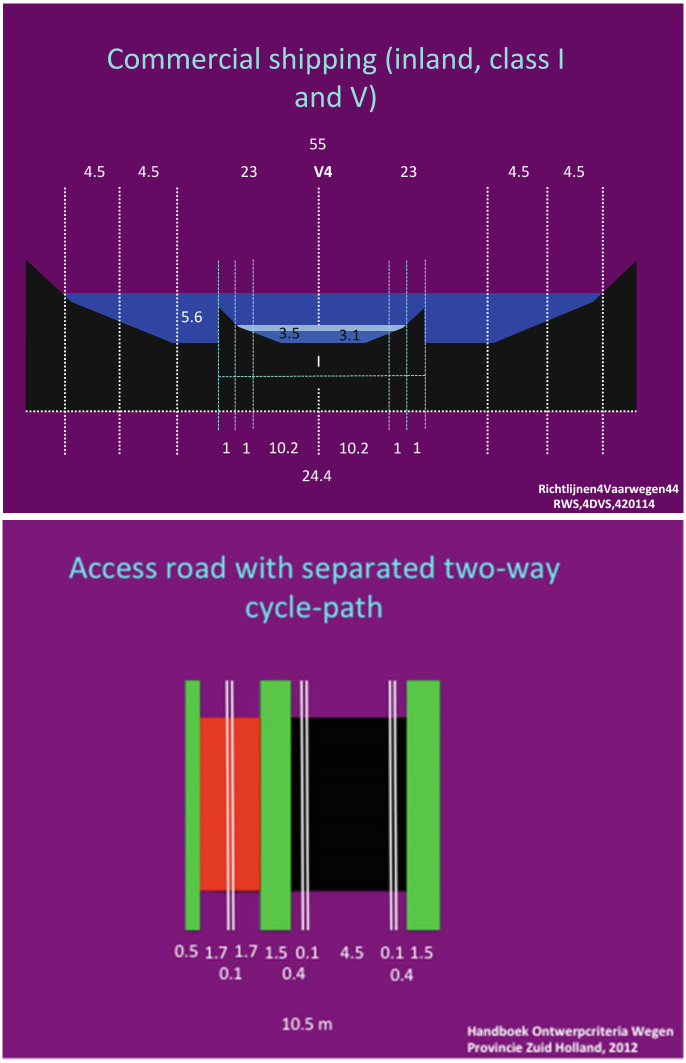

Fig. 16.5 Two examples of urban objects, waterway and roads with *cycle-path*, and their definitions

Exploratory Flock

In performing exploratory geographical and landscape analyses emergent flocking behaviour is seen as an effective search strategy (Macgill and Openshaw 1998; Miranda and Coates 2000). If a member of a flock discovers an *interesting area*, it will attract other members to explore that area in detail. This technique utilises variable velocities and colours for the flocking agents. Both velocity and colour have ‘meaning’ in regards to the success of an agent in finding an area of interest. The flocking agents move and swoop around together while being attracted to interesting areas. The swarm agents are not restricted to the boundaries of the site and have the ability to perceive contextual information. Agents can alter their speeds and the colours and their ability to attract/repel other agents.

The following rule set governs exploratory flocks:

Every agent assesses its current location and the number of other agents in its cone of vision. After that it changes its colour as described below:

- If there are other agents, but nothing interesting in the environment, then the agent turns yellow.
- If there are other agents and some interest in the environment then the agent turns green.
- If there are other agents and a significant interest in the environment then the agent turns blue.

Then each agent adjusts its heading according to the following list of instructions:

- If the closest neighbour is too close then separate from it regardless of its colour.
- If the closest neighbour is green, disregard it.
- If the neighbour is blue, feel attracted.
- If neighbour is yellow, then avoid it.

Every agent takes the weighted average of all target points generated above and moves towards that point with the following velocity rules:

- If I’m yellow move faster (This area is not interesting).
- If I’m green move at constant speed (There is some interest and I don’t want to miss anything).
- If I’m blue, move slower.

When agents find an interesting area they will slow down and cluster in order to explore the area. Agents that have not detected anything of interest will speed up and be attracted to heavier and slower agents. The idea is that the information is stored in the velocities of the agents. Speeding up corresponds with ‘forgetting’. If the area does not have enough weight, it will not be able to attract agents. After iterating the algorithm numerous times, the flock will ‘forget’ the areas of low interest, while forcing the agents to move continuously ensures that some of them may be attracted to another area of interest.

Consolidated Objects

Even though the generative rules used in the model are identified, and each urban object is defined and its rules are specified, two decisions remain before the model can be started.

The first decision that is required is to mark the stationary urban objects. These fixed objects consist of major infrastructure, such as freeways, rivers or main energy grid lines. Other fixed objects include heritage sites (such as historic buildings), natural waterways (such as rivers and streams), and ecologically valuable areas (such as nature reserves). All other objects have the ability to move according to various rules and inputs, including general generative rules, their response to climatic impacts, and relations with other objects. The mobile objects will each reorganise and locate according their interactions over time and will try to occupy the best possible place for their needs. However, the competition for space is fierce and certain patterns are expected to emerge in response to the demands of each object. Some of the objects will find their place quickly while others will continue to search for better options that are perhaps not available, and remain mobile. These persistent mobile objects could include a temporary space used for water storage, which has the potential to transform into urban agriculture or nature. They could also be mobile houses, or routes that are flexibly opened or closed for traffic when environmental changes occur.

Typology of Climate Impacts

The second decision that needs to be taken is which climate change impacts will be included. The typical impacts in the Fishermans' Bend case study are floods as result of sea level rise, flash-floods, and heat. For each of these categories the predictions vary and are uncertain and so a margin has been defined for each one as it is introduced into the model. For sea level rise, levels of +30 cm, +1 and +5 m form the input, being the lower regional estimate in 2100, the general average expectation for 2100 and a challenging level that might occur if land-ice melts at an accelerating pace. The inputs for flash flooding are determined by the frequency and intensity of rain, which can range from intense and brief showers, to long enduring drizzles. Heat can be experienced as a singularly extremely hot day, or a prolonged heat wave. These impacts can be used individually or in combination.

Preliminary Results of Modelling

Flocking was used along with a set of exploratory rules to develop a preliminary test model, which included fixed elements, buildings, and a single specific climate impact–flood resulting from sea level rise. The test was used to examine whether the urban morphology could be modelled as a self-organising system using agent based modelling. If it was successful, the system would generate complex spatial configurations leading to emergent behaviour. Variations of the rules used in the first trial were then built upon, leading to a model consisting of the following components:

- The environment was represented as a two-dimensional array of squares or *patches*. Every patch is characterised by two variables: *elevation* and *fitness.*
  - The elevation was represented as a Digital Elevation Model of the study area, built up in ArcMap (ArcGIS). Subsequently, elevation data was written into the model patches as a variable called elevation. This variable simulated sea level rise.
  - Fitness was a random function, which varied in value between 0 and 1. The higher the fitness value the more attractive the location is for buildings to move to.
- Three types of residential buildings were used as agents: 'unattached', 'attached' and 'high-rise'.
- The model was shaped by the following rules:
  - The setup rules write elevation and fitness into patches, and locate existing buildings and other fixed objects on the site;
  - The 'sea level rise' factor could be adjusted to higher and lower levels to meet user demands using a slider. In response to that shift, buildings below the new sea-level would be randomly relocated to higher ground in vacant patches within the site boundaries.
  - Relocated buildings, each with different properties (see Table 16.1; high-rise, attached or unattached), would start following exploratory flocking rules. These are defined to support the search for the best 'fitness' in the environment. Each building typology follows different parameters with regards to flocking rules. For instance, minimum-separation (i.e., the minimum distance a building needs to sit at from another building) was much higher for high-rise buildings than for unattached or attached houses. When a building finds a location in an area where the fitness is over a pre-defined minimum value, and there is still a free patch to occupy, it was allowed to stop moving and settle definitely at the location.

These rules were used to undertake the initial modelling, as shown in Fig. 16.6. The left images show progressing flood levels of 0, 1, 2 and 4 m height, and the right images show the objects that are progressively flocking towards optimal locations according to the fitness of the underlying landscape and planning regulations. The environment, defined by patches, is organized according to a 'fitness' variable, which indicates how suitable the area is for the objects. When objects start to move under influence of rising flood levels, the fitness changes and the colours of the objects change from yellow or green to blue. A flooded area has a fitness value of zero (0) and the objects within that area become mobile and start flocking until

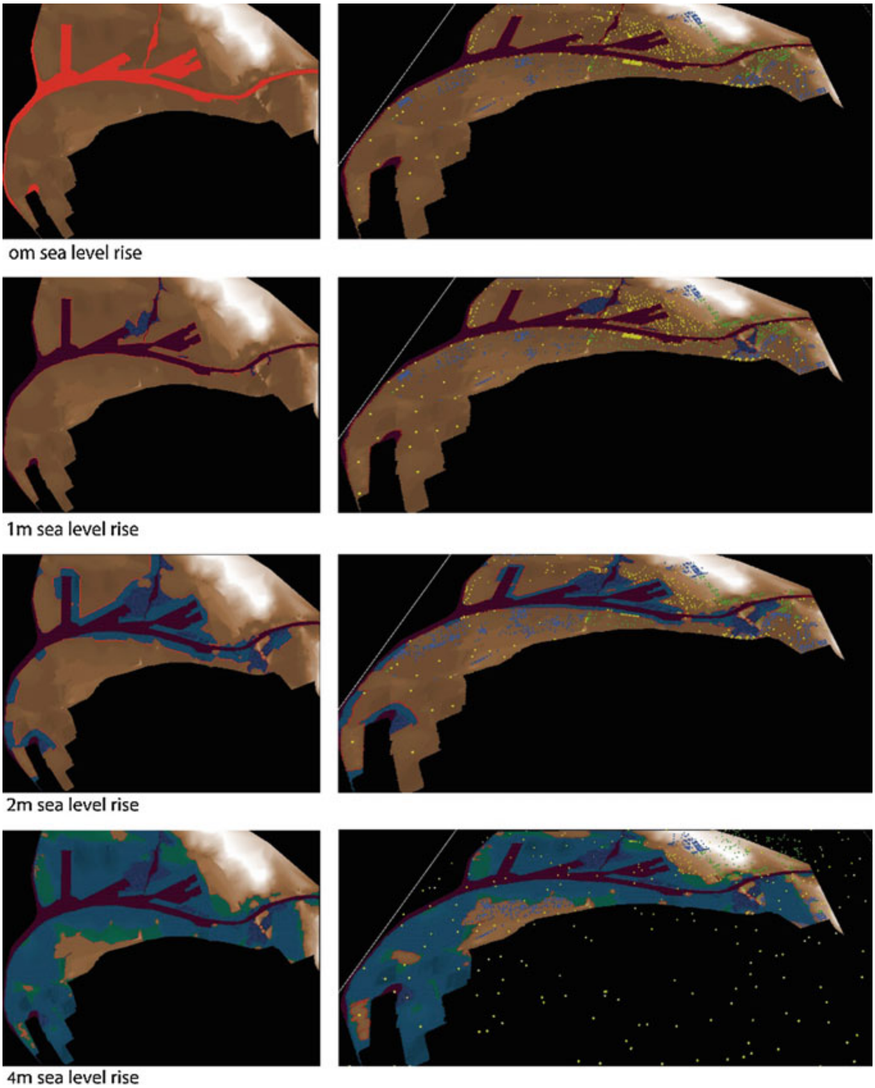

Fig. 16.6 Series of stills from dynamic modelling animation: flood height at 0, 1, 2 and 4 m sea level rise (*left*) and flocking buildings (*right*)

they find a new "fit area" where they decelerate and finally stop moving. The images show what happens when open space becomes limited (especially in the +4 m scenario). The objects compete for space until they are satisfied and find, clustered, their final destination, where they occupy the largest part of the site.

Discussion and Further Study

Several issues were identified as important to examine before more elaborate modelling is conducted:

1. The choice of agent types. The agents used in the modelling, and the way they are applied, leads to obvious outcomes. When urban objects are taken as the agents, they will form an aggregate land use for the precinct. This leaves out the less predictable outcome of human agents, which is based on social interactions and movements;
2. It is uncertain if the modelling shows design options or if it is in fact a tool that points out the actual construction of the urban fabric. If the modelling is used to investigate design options, it may result in a strategic spatial plan for the precinct that is more resilient than a regular planning process. If it is taken to be a reflection of reality, then it can be used to uncover individual buildings that may need to be treated differently over time;
3. The modelling shows a coherent outcome when there is only a single climate change impact included. If the climate change impacts are increased the results may look more like compromise, or the majority of objects might respond by continuously moving. In reality, flash flooding, sea level flood and heat-waves generally do not happen at the same time, but the urban constellation on the other hand cannot be continuously reconfigured. Elaboration of the modelling will need to include both additional climate impacts as well as other urban objects, such as infrastructure;
4. The fitness assumed in the current modelling is seen as a constant factor, which does not change. This does not reflect reality, and is not a good goal to aim for in the case of buildings and infrastructure;
5. It is unknown if the generative rules used in this model can be applied to other sites. Similarly, a test is needed to determine the suitability of the rules used in the model. Other generative rules might result in completely different spatial outcomes. A more sophisticated model is indicated.

Conclusions

The model we have presented is work in progress, and represents a preliminary attempt to build an interesting modelled urban system. The future steps are expected to guide us in two directions. Firstly, the model itself needs to be further developed and refined in order to include a complexity of layers relevant for urban planning, such as land ownership, land prices, cultural-historical values etcetera. The second direction is the role this modelling can play in the urban design of precincts in cities. In this respect it is not a model that allows planners and designers to respond after a disaster but anticipating a disaster and then model the most optimal urban layout. Whilst modern planning covers extreme cases by standard planning practice, they are only doing so after the disaster, never before one. For example, the Tohoku disaster in Japan made it illegal to build in dangerous areas immediately after the disaster (because of the possibility of 15–30 m high waves). After, and not before Hurricane Sandy in New York a new set of regulations were created to raise homes in an adaptive measure that is set by flood projections.

The model aims to combine human decision-making with flocking algorithms, resulting in representing and predicting urban patterns. We have still a way to go before we can include more data that are relevant for urban design and additionally, the coding of some aspects, such as human behaviour requires further research. For instance, the way people respond to impacts of disasters, or the question whether and when they would move because the model indicates this is the better option is difficult to include in the model itself. This keeps being a searching issue, which we will investigate throughout our research program.

In the results we currently presented we predict the locations of building elements under pressure of climatic impacts. As for now we only took flooding as an input impact in the model, but we think that it needs to be combined with other impacts, climatic (heat, fire?) or other (economic, demographic, politic), which, coded into the model will provide us with more insight about optimal land use and urban design patterns. From there we can simulate the movement of building blocks to places where they can easiest deal with change, or where the adaptive capacity is highest. This then subsequently functions as the starting point for design of adaptive urban precincts.

The combination of impacts integrated in the modelling and the anticipative character of the modelling, taking into account worst-case scenarios, maybe even worse, as the starting point of the design process, is expected to lead to a different design outcome with new and different urban patterns and location criteria. In this sense the modelling will overhaul current planning practice in which guidelines are put in place for thematic topics such as flooding, which result in flood-lines that are put in the planning directives, but only after a disaster has occurred.

Obviously, moving away from the flood is not the only response possible. There are other solutions, such as building floating houses, as we have seen recently in IJburg, the Netherlands or Bangladesh and Indonesia. The movement in these cases is upwards instead of away from the flooding. In general, these villages are being rebuild after an event took place, and it is rare these villages are anticipating future events. Nevertheless, these options need to be part of the proposed model and together with the other layers, as mentioned before, need to form a dynamic and anticipative model for urban design informing the designers how and where optimal places could be created within an adaptive urban precinct.

The modelling should emphasise the possibility of the urban fabric to respond, and anticipate (climatic) impacts when its objects are made mobile, both moving away from the threat as also moving above the threat. Conversely, when we keep urban objects fixed to their location designing adaptive urban precincts delivers only suboptimal results. The question here is to what extent urban objects need to become physically mobile in order to continue to move when in the future climatic impacts might change again. Further research is necessary to investigate which parts, and which specific objects might be made physically mobile and, therefore, de-coupled from their environment (underground, neighbouring buildings), operating de facto as temporary buildings occupying spaces, allowing people free and rule-less choices how to build in these riskier areas, understanding and accepting their vulnerability and legal responsibility. This also reinforces the role humans and their behaviour need to play in the set up and functionality of the model as they may suddenly invent entirely unexpected forms of creative adaptations without the estimated necessary decoupling from the site.

The elaborated modelling can be used as a tool in the design phase of projects in order to increase the flexibility in proposals. During the design phase modelling is an excellent and iterative tool to determine the best possible locations for urban objects under influence of a diversity (climatic) impacts. Changing and/or combining different impacts may produce different design options, which can be compared and refined during the design process.

This modelling also opens the opportunity to use complexity and self-organising principles for improving the quality of the city. Different from many other modelling studies, which are mostly oriented on understanding the complex behaviour of the city as it is (or was), this modelling anticipates design options, which can be further elaborated in concrete and more refined urban designs.

The research results to date do not measure the adaptive capacity of urban configurations that emerge from the process. Further research should include a measurement that would indicate whether the urban pattern would perform better in terms of decreasing economic and human vulnerability in the case of floods and higher temperatures.

At this stage the results give only virtual insights into possible urban futures, but the real physical consequences are not yet debated. The question whether we really would want to adjust our urban areas in the way these models suggest is still open and requires discussion with urban planners and designers as well as the public sector. Similarly, the research did not take into account the feasibility of the proposals, in terms of economic or social values, or how to deal with current land ownership. More importantly, the question remains, what does a desirable urban future consist of, beyond becoming resilient to climate impacts only?

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Part V
Transformation from Disaster and Crisis

Disasters can be understood as a tipping point in a system, where long-term problems are suddenly brought to the fore. The damage and suffering that result from a disaster, whether natural or man-made, are often talked about in the news as though they are momentary effects. In actuality, the problems that communities face after a disaster are often problems that existed before but were never properly addressed. In some cases, they may even have been suppressed.

Without taking away from the gravity of what a disaster means for individuals and communities, the need to act can itself become a powerful if temporary window of opportunity. A chance to make transformative changes and to resolve problems that otherwise might not be recognized. On the other hand, disaster can also reinforce pre-existing social and political relationships, even when they are demonstrably negative. The four chapters in this part do not offer comprehensive solutions to that challenge, but do work well as case studies for opportunities missed and opportunities yet to be taken up. An important question that they all raise is whether we should take action before disaster strikes or after. They also share a belief in the potential to take positive social or political action in response to disaster.

Ichinose's chapter considers the constant transformation of land use in response to low production in a case study area on Awaji island in Japan. While undertaking research on the island he became aware of the relationship between forest cover and the availability of water to support successful crop growth. There is evidence that the government also understood this relationship and supported it as a way to maintain the areas green infrastructure. From there he offers a critical response to a top down, one size fits all, approach to protection from future disasters and suggests that local knowledge should be taken into account. One interesting point, measured in passing, is that locals sometimes follow the pattern set by the tragedy of the commons, and cause damage that government rules were created to prevent.

A good reminder is that local actions are not always the wisest and the government sometimes sees better.

Uehara outlines the political, economic, and bureaucratic reasons that site planning for the Fukushima nuclear power plant, made famous by the 2011 nuclear meltdown, was flawed. He offers an alternative vision of how the planning might have been carried out if tools available at the time had been adopted by the planners and the government. As a cautionary tale, he also describes the challenge of introducing new tools for measurement and management in the highly bureaucratic environment of Japan. This is an important point to consider today, as the consequences of some decisions can exacerbate a disaster in profound ways, as the example of the nuclear meltdown attests. Made in hindsight the assessment is not intended to lay blame at anyone's feet, still it is a useful reminder if we are thinking about how to apply the lessons learned and to change the way things work today. The window of opportunity since the disaster seems already to be closing, which raises the question, how large does a disaster need to be before transformational change can be accepted?

Nameki offers some answer to this question with her chapter on the program to clean radioactive waste around the Fukushima nuclear reactor site. Written a few years after the disaster the article is still remarkable because the problem is still in its early stages. That this kind of program needs to be undertaken at all is a remarkable example of how difficult it is to prepare for disaster and massive change. Communities suddenly need to decide how to respond to the request to locate contaminated radioactive waste near their homes. The amount of information they need to take that decision and the fact that the government might give them advice in the process are both remarkable each in their own way. Could these communities be transformed positively by this experience or are they merely being asked to cope with an unwelcome new need?

Jordaan's chapter zooms out to the larger scale, describing the vulnerabilities and opportunities as Africa transforms under the pressure of globalization. Africa is enormously varied, and some governments and leaders are already taking action to create a better future, however it seems that while the continent has abundant resources there is still a great need for innovation.

Chapter 17
Green Infrastructure in Reconstruction After the 2011 Earthquake and Tsunami: A Case Study of Historical Change on Awaji Island in Japan

Tomohiro Ichinose

The magnitude 9.0 earthquake that struck the northwestern Pacific Ocean off Japan on 11 March 2011 and the subsequent tsunami wrought massive destruction and reawakened Japan to the importance of *green infrastructure*. As a case study, this paper introduces the history of green infrastructure on Awaji Island, in central Japan. After forest resources began to decline three centuries ago the government began instituting forest management practices. In the eighteenth century it prohibited the cutting of trees in some areas, and in the nineteenth century it started protecting some valuable tree species and introduced afforestation and a policy of harvest distribution. Historical and more recent maps are compared to reveal both constancies and changes in land-use patterns, including the distribution of rice paddy fields and forests. Historical documents indicate that coniferous forest, especially *Pinus densiflora*, was important for disaster prevention and water recharge, and that forests were carefully managed. Similarly, GIS (geographic information system) analysis shows that drier sites were selected for orchard development and that less productive paddy fields were simultaneously abandoned. The paper also presents an example in which green infrastructure has had a role in Japan's discussions about reconstruction from the most recent disaster. The paper concludes that although we cannot protect ourselves against natural disasters by constructing high breakwaters along the coast, for example, we can learn from the history of green infrastructure and the wisdom of our forebears.

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Introduction

A magnitude 9.0 earthquake struck northeastern Japan on 11 March 2011. The subsequent tsunami wrought destruction on a massive scale. Reconstruction has now started amid an animated discussion on how best to rebuild. The Japanese government has proposed to build breakwaters to reduce damage from future tsunamis.

In Miyagi Prefecture, one of the most heavily damaged regions, the city of Kesennuma has been presented with plans for breakwaters ranging from 5.0 to 11.8 m (meters) in height, even though the most recent tsunami topped 12 m. Many local people object to the plans. In particular, one fishing village has submitted a formal request to the mayor of Kesennuma to withdraw the plan for its 10 m breakwater, even though most of the houses there were lost to the tsunami. 24 households have instead accepted a government offer to relocate uphill.

The tsunami caused heavy damage to coastal areas of the Sendai Plain, in the central to southern parts of Miyagi Prefecture, and killed over 3000 people in th area. The region had experienced only a few tsunamis, historically speaking; the last large earthquake and tsunami occurred over 1100 years ago. The 2011 tsunami reached as far as 6 km (kilometres) inland, catching most people unaware in spite of the tsunami warning. Whereas sprawling residential areas were heavily damaged, most houses in rural settlements survived, in part thanks to their traditional small woodlots, which mitigated the power of the tsunami. Historical maps show that the coastal areas were previously used for agriculture but became urbanized after the Second World War. By contrast to the area above, during the last century most coastal areas along the northeastern Sanriku region of Honshu experienced several large tsunamis, and created an important experience base that changed the impact of the disaster. In the 2011 tsunami, only four persons died in the fishing village that submitted the request to refrain from building a sea wall (see above). The residents survived because they recognized the unusual ebb tide following each earthquake as the sign of an impending tsunami and took refuge uphill.

Many buildings in the Tokyo metropolitan area were damaged by the earthquake, and liquefaction was observed over huge areas. Over 26,000 buildings were damaged in the Kanto District, over one-third of them in the city of Urayasu, Chiba Prefecture (only 10 km from central Tokyo), where three-quarters of the city area is built on land reclaimed from tidal areas since the 1960s. The city, an important commuter town, is famous as the location of Tokyo Disneyland. Former bogs, rivers, lakes, and paddy fields also liquefied. Since the earthquake, historical maps have become popular among people who want to know the previous land use of the properties their homes rest on.

Green infrastructure is the ecological framework for environmental, social, and economic health—in short, our natural life-support system (Benedict and McMahon 2006). It is appearing more and more frequently as a topic in the United States and

Europe, however it was not a remarkable subject in Japan before the earthquake, even though the country experiences many natural disasters every year. Instead, people pay most attention to land prices and the distance of homes from the city centre. The 2011 earthquake has since triggered a greater awareness of the importance of green infrastructure. In fact, Japan has a long history of its use, some of which will be introduced in this chapter.

Forest Cover on Awaji Island from the Edo Era to the End of the Showa Era

Japan is one of the most forested countries in the world. Japanese people have used wood as fuel, building material, and other products since ancient times (Tatman 1989). However, this resource declined dramatically from the beginning of the Edo era (beginning of the seventeenth century, common era [CE]). In response, the government began instituting forest management policies: in the eighteenth century it prohibited the cutting of trees in some areas; in the nineteenth century it started preserving some valuable tree species, and introduced afforestation and the policy of harvest distribution.

Awaji Island, in central Japan, is currently part of Hyogo Prefecture, but formerly it belonged to the Awa domain (an old administrative unit) (Fig. 17.1). Covering 592.26 km^2 (square kilometres), Awaji is as large as Singapore, but with a 2010 population of 143,025. Its closeness to Kyoto has long made it a popular

Fig. 17.1 Location of Awaji Island

place to live, and the island was once important to transport. Although Awaji means "road to Awa," it was not connected by bridge with Tokushima Prefecture until 1985 or with Honshu until 1998; at 3.9 km, the bridge to Honshu is the longest suspension bridge in the world. The island is famous as the epicentre of the Hanshin–Awaji earthquake of 1995, in which over 6,000 people died, and both cities and rural areas were heavily damaged.

A complete map of Japan begun by Tadataka Inō and finished in 1821 is famous as the first modern map of Japan drawn using a European method of survey. In the same general period, Sanzo Okazaki and his family surveyed the whole of the Awa domain using a Dutch method, from 1802 to 1847, and drew detailed maps, most of which remain. One such map of Awaji was drawn between 1832 and 1847 (Fig. 17.2). Whereas Inō drew the entire coastline and some mountains and landmarks, Okazaki surveyed open water, roads, fields, and forests (Fig. 17.3), making his map the first modern land-use map in Japan. Ichinose and Itoh (2007) combined the two historical maps of the island and transformed the image using many ground control points (Fig. 17.4), then compared the map with vegetation maps drawn in 1982, near the end of the Showa Era, by the Japanese Environment Agency (Ichinose and Itoh 2007). Okazaki's historical map identifies just five land-use types: *yama*, open water, fields, village boundaries, and roads. The usual meaning of *yama* is mountain, but it is sometimes used to mean forest. As many forests were over-cut in the Edo era, some converted into shrubland or grassland. Because we cannot know what proportion of forest had been converted into other uses, we treated *yama* as forest and grassland combined. The total area of forest plus

Fig. 17.2 Historical map of the northern part of Awaji Island, drawn between 1832 and 1847 by Sanzo Okazaki and his family. The scale is approximately 1:18,000

Fig. 17.3 Part of the historical map. We can identify roads, houses, irrigation ponds, rivers and forests

grassland in 1847 was 349.15 km^2, nearly 60% of Awaji. There was no notable shrubland or grassland in 1982, except for a golf course. The total area covered by tree species in 1982 was 347.29 km^2, a decrease of only 0.53% compared to the 1847 area. Although the *yama* area would not have been entirely covered by forest in 1847, the result nevertheless suggests that the total area of uncultivated land use on the island has barely changed over that time period.

Analysing the relationship between *yama* and topography in the Edo era, we found a significant correlation between slope angle and the proportion of *yama* in 1 km grid cells (Fig. 17.5). This correlation suggests that the land on steep slopes could not be developed as fields, and thus forest and grassland would have remained.

Land-Use Patterns on Awaji Island in the Edo Era

Although the historical maps present limited information about land use, they show us various aspects of the management of natural resources in the pre-industrial period. The oldest modern topographical maps of Japan were drawn by the army from 1880 to 1886 at a scale of 1:20,000 and cover the Tokyo metropolitan area.

Fig. 17.4 Combined historical map of Awaji Island

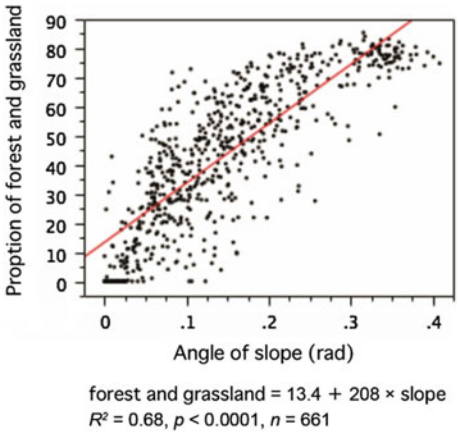

Fig. 17.5 Relationship between (arcsine-transformed) proportion of forest + grassland and the angle of slope in each 1 km^2 grid cell

(These have been digitized and can be viewed at http://habs.dc.affrc.go.jp/index_e.html.) Topographical maps of central Japan were drawn some years later than the maps of Tokyo. According to many analyses of these maps (e.g., Sprague et al. 2007), these reveal the land-use patterns and landscapes in the Edo era, although surveys for these maps were done over 10 years after the end of that era.

Based on maps of Awaji Island from 1896, we analysed the land-use patterns by GIS (Itoh et al. 2005). We defined 12 land-use types: still water, river, paddy field, dry field, orchard, coniferous forest, broadleaf forest, mixed forest, bamboo forest, wasteland, beach, and urban area. We selected a central part of the island as a study site, which is comprised of one town and 12 villages (Fig. 17.6), and analysed the 1896 land-use map (Fig. 17.7). We found that some areas of wasteland, for example, in the north and south of the district, took the form of shrubland and grassland, created from overuse. Approximately 40% of the land in each town or village was comprised of paddy fields, and another 30–40% was coniferous forest (Fig. 17.8). Interestingly, paddy fields and coniferous forest showed a strong, significant correlation ($r = 0.92$, $P < 0.001$). Correlations between other land-use types were also significant (see Fig. 17.9).

What explains these correlations between land-use types? The natural resources on Awaji were managed as in other domains in the Edo era: statutes of the time indicate that people were prohibited from cutting several species, including *Pinus densiflora*, *Quercus acutissima*, *C. obtusa*, *Myrica rubra*, and *Cryptomeria japonica*. In particular, it was a pecuniary offence to graze livestock in pine forests. In the middle of the seventeenth century, a convicted criminal would be forced to plant pine seedlings as punishment. These statutes tell us the importance of pine forests at that time.

Annual precipitation on Awaji is about 1000–1300 mm, and the soil is poor, being derived from granite. These conditions favour *P. densiflora* for afforestation. Some documents indicate that local residents used most of the pine forest as a commons, where they gathered branches and herbs. Even so, the mountains were

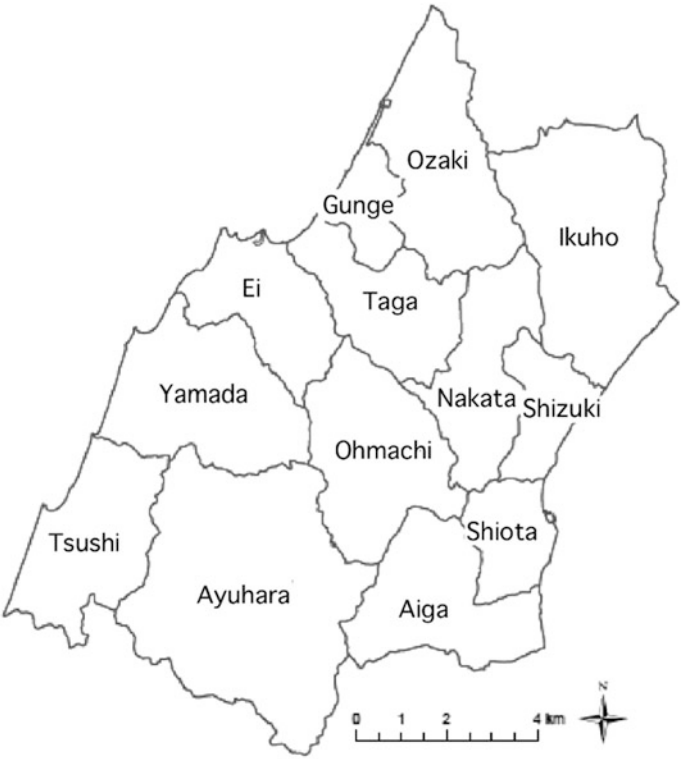

Fig. 17.6 Administrative map showing Shizuki Town and 12 surrounding villages

denuded in the Edo era as a result of over-cutting of the forest, although many shrubs and herbs remained in the hilly areas of Kinki District, in which Awaji was located (Mizumoto 2003). Nevertheless, our results show that wasteland covered just a small area on Awaji, generally found adjacent to coniferous and other forests (Fig. 17.7). Several villages shared a commons, as delineated in the rectangular area in Fig. 17.7. As might be expected, without supervision overuse could change these commons into shrubland or grassland. For example, the digging up of stumps caused serious soil erosion, although the feudal load often forbade it.

The shortage of precipitation, especially in summer, and the lack of a river long enough to function as a reliable source of water meant that the water supply was the largest problem for agriculture and residents of the area, a problem that continues even today. Drinking water is now piped in from Honshu, but farmers still have to control their water use carefully during the summer. This limitation explains the huge number of irrigation ponds on the island: about 22,000, half of the total in Hyogo Prefecture, which has 20% of all ponds in Japan; meaning that Awaji has 10% of all ponds in Japan. Many wells drilled for irrigation after the Second World War also supply some water. Historically speaking, the 1847 map shows many

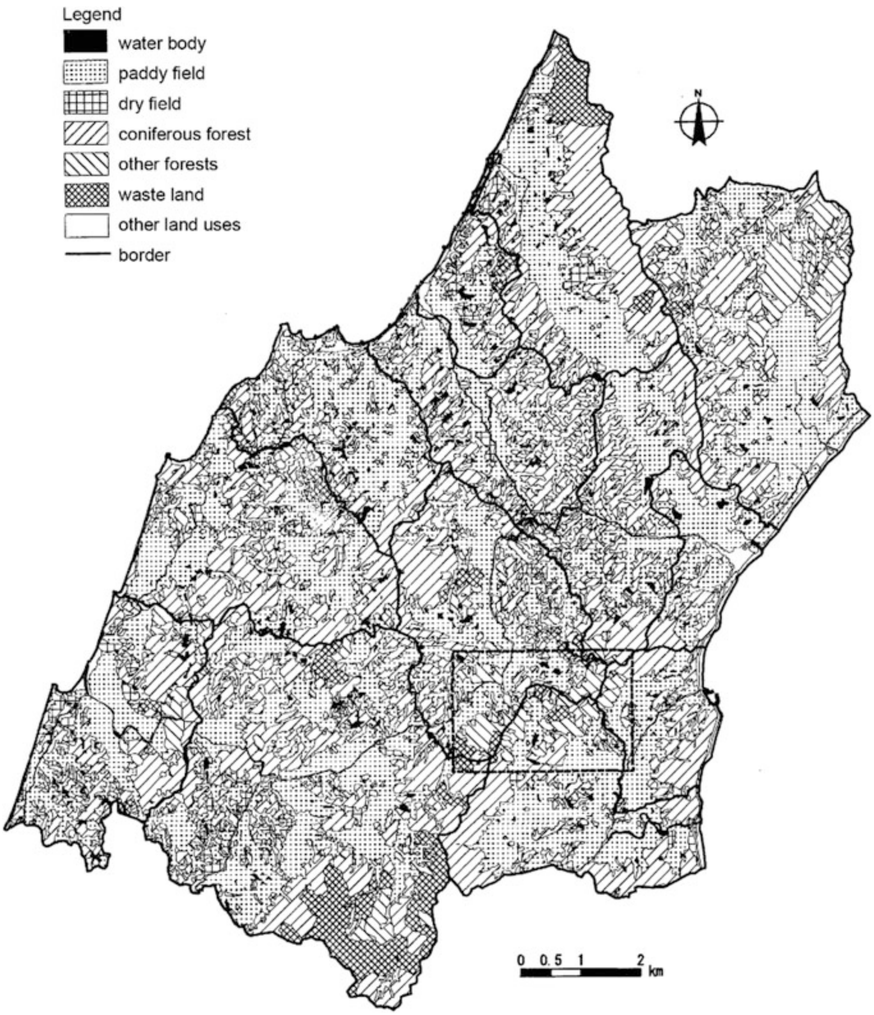

Fig. 17.7 1896 land use map (Itoh et al. 2005). Land use types were classified by topographical maps. The *rectangle* delineates the commons used by several villages

ponds, most of which are still in use. Farmers developed a complex irrigation system to maintain and use water efficiently (Cheng et al. 2001). Knowing the amount of water needed per unit area, they could accurately calculate the amount of water needed for each field. In addition, they have long recognized that the pine forest is a source of water; for instance, a document written in 1881 shows that people had to conserve and increase pine forests in response to the increasing area of fields used for cultivation.

A local religion on Awaji recognizes the relationship between the forest and agriculture. Farmers who lived next to forests in the uplands used to celebrate a

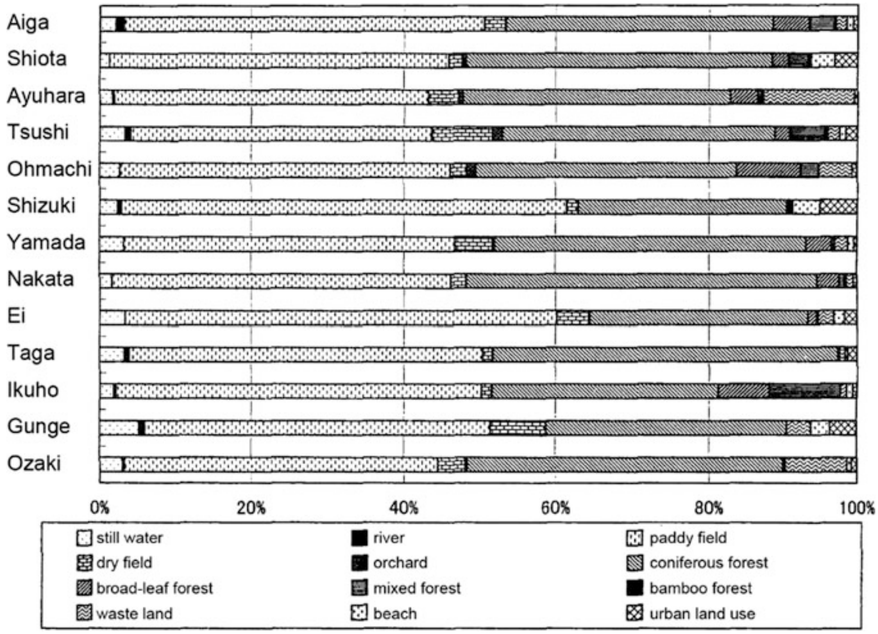

Fig. 17.8 Area of each land use type in the villages (Itoh et al. 2005)

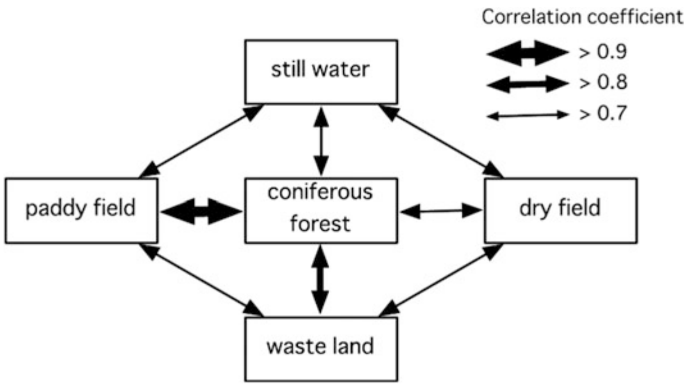

Fig. 17.9 Correlations between land use types (modified from Itoh et al. (2005)). The *thickness* of the line indicates the strength of correlation between the types

wedded couple called *Yamadossan*, who made their way from a mountain in central Awaji to villages on 9 January. Residents marked the way to their houses and set out delicacies. Realizing that water comes from mountain forests, they would pray to fertility gods to supply enough water in the spring.

Land-Use Change from the Edo Era to the End of the Showa Era

We analysed the pattern of land-use change from the Edo era to the end of the Showa era to understand the individual land uses (Itoh and Ichinose 2007). We combined land-use types into water body, paddy field, dry field, orchard, forest, urban, and other, and compared the most recent land-use map, drawn in 1976, with those from 1896 on a 100 m grid. In that time the area of orchards increased by nearly 30 times while the area of paddy fields and forest decreased by 11 and 13%, respectively (Table 17.1). Nearly 7 km^2 of paddy fields were converted into forest through abandonment, while 7.4 km^2 of forest were converted into paddy fields through deforestation (Table 17.2). In addition, 3.0 km^2 of paddy fields and 5.2 km^2 of forest were converted into orchard.

A number of orange orchards were developed in the 1960s under the guidance of the Ministry of Agriculture, Forestry and Fisheries, but many have since been abandoned because their locations were unsuitable, or because competition from imported oranges increased dramatically since the 1970s, while restrictions on orange trade were removed in 1991. Thus, the 1976 land-use map probably showed the peak of orange cultivation. To analyse which locations were converted into orchards, we calculated a topographic wetness index (Wilson and Gallant 2000) for

Table 17.1 Composition of land use types in 1896 and 1976 (area in ha)

Area (ha)	Water body	Paddy field	Dry field	Orchard	Forest	Urban land use	Other
1896	138	5899	363	30	6005	79	247
1976	98	5222	273	860	5243	661	404
variation	−40	−677	−90	830	−762	582	157

Modified from Itoh and Ichinose (2007)

Table 17.2 Change of each land use type from 1896 to 1976 (area in ha)

	1976								
1896	Area (ha)	water body	paddy field	dry field	orchard	forest	urban land use	other	Total
	Water body	65	46	2	7	14	3	1	138
	Paddy field	24	4,306	137	297	690	356	89	5,899
	Dry field	1	124	42	32	90	51	23	363
	Orchard	0	2	0	2	25	0	1	30
	Forest	8	736	91	521	4,423	107	119	6,005
	Urban land use	0	0	1	1	1	70	6	79
	Other	0	8	0	0	0	74	165	247
	Sum	98	5,222	273	860	5,243	661	404	12,761

each grid cell, which is a humidity index based on a digital elevation model. Paddy fields converted to orchard and forest were significantly drier than expected ($P < 0.01$), as were forests converted to orchards ($P < 0.05$). These results mean that drier locations were preferred for orchard development and that unproductive paddy fields were abandoned.

Economics and technological modernization drive land-use change. Awaji should be no exception, although dramatic changes did not take place until the end of the Showa era. Field abandonment has increased recently owing to the ageing of the population (a problem found now all through Japan, not only in Awaji) and loss of the farming population in particular. Irrigation, which once played a big role in maintaining the water supply available for agriculture, is also declining, as some irrigation ponds have now been abandoned. The decreasing number of farmers is making it increasingly difficult to maintain the irrigation system. At the same time, low-lying land has become urbanized, and land has been reclaimed from the sea. Many experts expect a massive earthquake in the Pacific Ocean near central Japan within the next few decades; such an earthquake would generate a tsunami with a height of a few meters that would hit Awaji. These are major trends and rewinding them is very difficult if not impossible. However, we can learn from history and make wise use of natural resources in response to the knowledge we gain from its study.

How Can Green Infrastructure Play a Role in Reconstruction After a Disaster?

In Japan we face a big task in rebuilding after the 2011 disaster. We also have to prepare for the next natural disaster. The Japanese population has decreased since 2004 and the proportion of aged people continues to increase. Both trends were already critical issues before the earthquake. The government's proposed reconstruction plan, released in June 2011 (it is possible to view the plans online at http://www.cas.go.jp/jp/fukkou/english/pdf/report20110625.pdf), explains that we need to change our attitudes about disaster prevention. For example, although 10 m breakwaters erected in a residential district of Sanriku worked well against a tsunami caused by the great Chilean earthquake of 1960, they were destroyed by the 2011 tsunami, which killed 200 people and flattened 1000 houses in the area. We have to recognize that we cannot completely protect ourselves against natural disasters. Nevertheless, even higher breakwaters are planned for some areas. As mentioned above, a small fishing village in Kesennuma has objected to the plan for a breakwater. This village is already famous for its afforestation movement, called *Mori wa Umi no Koibito* ("The Forest is a Lover of the Sea"). In 1989, an oyster farmer named Shigeatsu Hatakeyama started planting trees on the hills around the village to preserve the seawater quality for his oysters. In 1990, he and his colleagues started environmental education programs, which 10,000 children have so far attended. In 2009, he established a non-profit organization. Since the earthquake, the movement has attracted a great deal of attention, and Hatakeyama received a “forest hero” award from the UN Forest Forum in 2011. His activities have influenced previously uninterested residents to object to the breakwater plan. They propose to restore marshes and tidal flats on land that subsided with the earthquake and is now flooded. The older members of the local community recall a larger tidal area in their childhood, where they enjoyed hunting for shells and crabs, and want to restore the former environment. The decision of a small fishing village has now influenced other areas. For example, citizens in the centre of Kesennuma City began discussions in August 2012. The governor of Miyagi Prefecture strongly argued at that time that large breakwaters should be necessary for all small fishing villages. But he has accepted some requests from villages to withdraw or change the plan.

In this chapter I explained the traditional land-use patterns and land management in Awaji Island. It should be identified as an example of green infrastructure in preindustrial Japan. We have long-term land management history in the pre-modern period, when people had to use natural resources and prevent natural disasters carefully, using limited technology to do so. We have to learn from these traditional examples of green infrastructure in order to engage in sustainable land-use in the future.

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Chapter 18
The Long Term Economic Value of Holistic Ecological Planning for Disaster Risk

Misato Uehara

In 1980 a planning report was published by the National Land Agency of Japan for the Tohoku region, including a detailed ecological base-map for Ian McHarg's Ecological planning method, which included layers of inter-related data sets that should be used to criteria of land use suitability holistic evaluation. The method was made famous by McHarg in his seminal book, Design With Nature, published in 1969. Unfortunately, while the National Land Agency's report was prepared for application of McHarg's method to Japan, it was not used for decades. Its importance became clearer after the triple disaster that struck Tohoku and especially Fukushima on March 11, 2011. This paper's aim was reconsider the site selection process by McHarg's method and 1980's data base for the now infamous Fukushima daiichi nuclear power plant, which was damaged in the 2011 tsunami and experienced a nuclear meltdown that continues to affect Japan both financially and socially. Built in the 1970s, the nuclear power plant could not have been located according to 1980's information in the data set, nonetheless this paper highlights the value and importance of holistic planning generally, and especially in cases where potential risks are large. Investigation into the process that led to the site selection for the power plant indicates that short-term economic and political goals led the decision making process at the time. The site was selected at a location where development expenses were cheapest; saving the developers some 7.11 billion yen. However, costs from the earthquake, tsunami and release of radiation exceed 11 trillion yen as of 2014. Although back-casting analysis is easier than forecasting, a holistic layer-based analysis with McHarg's method and the data of the 1980 Japanese report can show the coastal site of the nuclear power plant was in an area demonstrably vulnerable to disaster. In addition to these findings, the difficulties involved in making use of the environmental data in the 1980 report

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suggests the need for better communication of existing knowledge as well as a need to provide a simple way to access information without losing the necessary detail that scientific analysis can provide.

Introduction

Holistic Planning According to Ian McHarg

Scottish landscape architect and regional planner Ian McHarg (1969) proposed the concept of "human-ecological planning" (also called layer analysis) in his seminal work, *Design With Nature*. In his work he showed how environmental assessment could be used not only to preserve and conserve the natural world but also for the constructions of human artifacts, and in particular new town developments. McHarg's overlay methods are especially useful as they can be used to integrate conflicts with land-use suitability.

McHarg's environmental evaluation approach is not only objective, but also creative. Although the balance between creative interpretation and objective analysis is important for sustainable environmental planning, resistance to the approach is not uncommon. Somewhat ironically, in Japan, designers consider McHarg's method is too scientific (objective), and scientists consider this method is too artistic (subjective). Adding to above misperception, similarities of names of both McHarg's ecological planning and Forman's landscape ecology brings many Japanese researchers and city planners further misperception of these two major landscape principles difference. To clarify McHarg's approach, this human-ecological planning method provides better land-use choices by a multi-layered analysis of different environmental features. By contrast, the study of "landscape ecology" offers indicators for the biodiversity of different spatial patterns, without referring directly to the technical systems created by mankind. In other words, human-ecological planning offers insight with regards to a series of human-centered development choices, while landscape ecology provides a spatial template for natural systems that should be maintained in order to conserve biodiversity.

Building on McHarg's seminal work, researches in the United States have expanded on the concept of human-ecological planning. For instance, Anne Spirn introduced human-ecological planning methods to urban design when she criticized the failure of regional planning to make use of available knowledge about nature in city planning. She wrote: "…*although knowledge of city geology is extensive, it is customarily employed mainly to short-term advantage […] It is too seldom applied to the prevention of disaster, to the safe disposal of urban wastes*" 1984 (Spirn 1984). Spirn similarly criticized the lack of understanding of the influence of individual developments at the regional scale of planning. On this point she wrote: "*Design and planning professionals normally concern themselves with a short-sighted scale, that of an individual building project or that of planning for metropolitan-wide services*" (Spirn 1984). Building on this declaration she further insisted that design should make use of characteristics inherent to the natural world, and that interactions between the natural and manmade are in themselves important; successful examples include Olmsted's planning of the Fens in Boston and the natural drainage system in Woodlands, Texas, designed by McHarg, Wallace, Roberts, and Todd. Spirn further points out the difficulty of evaluating the overall situation of landscape planning in the case of the United States, because vested interests stop efforts to manage cities and their regions as holistic systems.

Extending these observations, Collins et al. (2001) contributed to the analysis of complex environmental conditions by pointing out the particular value in the perception of both whole and simple processes in land-use planning. In their work they (2001) reviewed research on ecological planning (specifically, they looked at "land-use suitability analysis") with a special emphasis on the increasing popularity of numerical modeling and geographic information systems (GIS) (Steinitz 1993; Banai 1993; Dyer et al. 1992; Yoon and Hwang 1995; Openshaw 1994). Although feasibility and research costs were limiting factors, according to their study the problem at the time was largely that "*…the use of artificial intelligence (AI: automated heuristic search process) in the fields of planning and geography is only in its infancy, and thus few examples of its application to land-use suitability are present. The technology at this point is much too experimental, high-tech, and expensive to be considered for main-line planning*" (Collins et al. 2001).

With the passage of time and the improvement of technology, the volume of information that can be analyzed has increased, and the processing methodologies have similarly developed. However, these are only an improvement of one part of McHarg's ecological planning process. Indeed, after the 1980s, a hi-tech simulation could not offer any useful policy choices for the 2011 earthquake, tsunami, and the eventual diffusion of radioactive material that followed. This failure brings new question "what method is better when taking on risk reduction for a community or a region?" Which is better to work well enough, holistic ecological planning process or individual short-term planning processes? Few researchers have addressed this question from the point of view of a land use scenario comparison. Bo offers an assessment of five land-use scenarios in The Woodlands, Texas, a town created following Ian McHarg's ecological planning approach (Bo and Ming-Han 2011). Kongjian Yu tried to embodies a methodological integration including the so-called "layer" method of Ian McHarg, Kevin Lynch, Richard Forman, and the geographical information methods of Stephen Evin (Kongjian 1995). However, there are no studies which inspected an avoidance possibility of actual natural disaster using McHarg's method and Japanese original environmental data base which is first challenge Ecological planning process application to different country level.

Holistic Planning in Japan

The concept of human-ecological planning was introduced to Japan in 1971 by the landscape architect Tadayoshi Inoue and the artist/ecological planner Yukihisa

Isobe (Inoue et al. 1971; Isobe and Yoshihara 1971). With regards to the March, 2011 disaster in Tohoku, and the nuclear power plant disaster at Fukushima that ensued, the location of the power plant in hindsight was problematic, and naturally the question arises as to how the siting was planned.

In 1980 the National Land Agency of Japan developed a base data map as well as a report on ecological planning for the Tohoku region at a scale of 1:50,000 (National Land Agency Japan 1980). The agency was established in 1972 by Prime Minister Kakuei Tanaka (PM from 1972 to 1976), the first high level politician to advocate for the necessity of overall regional planning as a political initiative. He was himself born in Nigata prefecture, which adjoins the Tohoku region, and was the promulgator of the so-called "*Japanese Islands Revitalization Policy*", which promoted decentralization in order to transfer wealth from the large western cities of Japan to more rural population centers such as Tohoku (Tanaka 1973).

The 1980 report was put together in conjunction with a consulting firm called the Regional Planning Team (the office of Yukihisa Isobe) and Harvey A. Shapiro. Both were students of McHarg at Pennsylvania University. Considering the history of the authors this effort should have introduced holistic planning into the normal workings of the Japanese government in Tohoku, however in practice the data was not used. The main reason is because the investigation was undertaken only to evaluate the condition of a proposed administrative unit, and not to inform development. Additionally, Kakuei Tanaka (the National Land Agency's virtual director) did not have sufficient time to practice a holistic planning model in place. His tenure as PM was cut short due to the political fallout from soaring inflation of property costs, the *Nixon Shock* (1971) and the *World Oil Crisis* (1973).

Japan has organization's administrative issues, so practice of this data is difficult. To be precise, an administrative organization which could use the data to create a composite regional landscape only existed within the National Land Agency of Japan. And it forfeited an opportunity for carrying them out properly by Prime Minister Kakuei's demission. This is because Japanese administrative units are based on the subdivision of responsibilities and are generally single purpose, normally concerned with a relatively small scale and with short-term goals. As a result, the government cannot normally consider conflicts in land-use suitability, which is potentially a considerable gap. The adverse impact of this particular gap and the importance of more holistic planning in general were demonstrated after the Great East Japan Earthquake and tsunami that struck northern Japan on March 11, 2011. The damage at the Fukushima nuclear plant and its environment remain especially serious after the disaster of a nuclear meltdown. This is therefore valuable as both an historical ecological planning case study, and as a simple simulation of alternative administrative procedures for the Tohoku disaster area.

It is important to qualify the following analysis in order to not give the wrong impression. The daiichi power plant at Fukushima was built before the 1980 environmental study was undertaken. The Fukushima daiichi (one) nuclear power plant was built between 1971 and 1978, while the daini (two) nuclear power plant was built between 1979 and 1982. As such the ecological planning material was not available to the government when the sites for each were decided. That notwithstanding, the

1980 database is still useful for reviewing disaster prevention planning at the site and also to consider how planning might have progressed if an alternative approach were taken both before and after construction. Once the material became available it was theoretically possible to make plans to prepare for potential disasters based on the knowledge gathered after the fact. This did not happen for a number of reasons, some of which are discussed in this paper, with significant consequences.

Method

With regards to the siting of the Fukushima nuclear power plants in Tohoku, Japan, the author will describe what is known about the actual site selection decision-making process in the 1960s, which can be characterized as primarily political and economic. This process is then considered in contrast to what is known about the site according to a McHarg's landscape analysis, using data gathered in 1980 for the region. The holistic environmental assessment is used in particular to show how useful a regional-scaled analysis can be when considering vulnerability, risk reduction, and preventative adaptation to disaster. To this end, a series of maps were generated in the author's laboratory according to the available data and combined in order to develop a broad understanding of vulnerability for the region. Based on this test it is possible to offer some conclusions about better practices with regards to holistic design in vulnerable regions in Japan.

To give some background, Fukushima prefecture went through three separate nuclear power plant development phases (Fig. 18.1).

1. Fukushima daiichi (Fukushima Power Plant One): completed in 1971 by Tokyo Electric power Co., Inc. (TEPCO) without any protests from local residents. This plant suffered from disastrous radiation leakage and a nuclear meltdown after the earthquake and tsunami struck in 2011.
2. Fukushima daini (Fukushima Power Plant Two): completed in 1982 by TEPCO. Local resident's opposition campaign had happened, but nuclear plant development was achieved.
3. Namie-Odaka: The Tohoku Electric power Co., Inc. tried to develop Fukushima daisan (third) nuclear power plant, but they could not achieve by landowners and local residents protests.

A Review of Site Planning Processes Based on Economic Reasoning (The Short-Term Approach)

A central function of regional planning should be to minimize the cost to society from natural disasters, especially if they are avoidable. The Japan Broadcasting Corporation (NHK) (2014) summarized the amount of damage caused by the accident at the Fukushima daiichi nuclear power plant as being in excess of

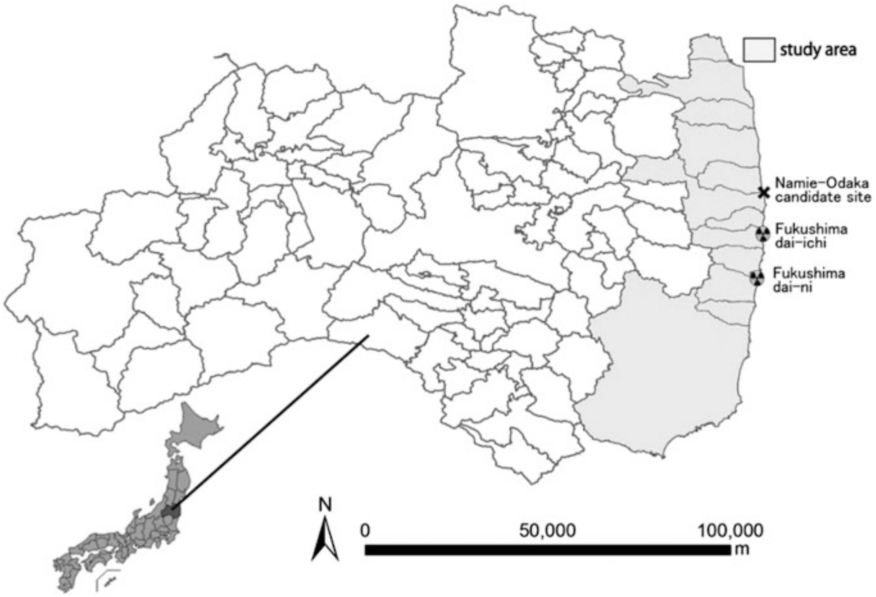

Fig. 18.1 Schematic map of the study area in Fukushima Prefecture, including the Fukushima nuclear power plants and the Namie-Odaka candidate site

11 trillion yen (approx. US $110 billion at the rate of 100 yen to 1 U.S dollar); 2.5 trillion yen (cost of decontamination), 1.1 trillion yen (development cost of interim facility to manage waste decontamination), 2 trillion yen (decommissioning the power plant, and polluted water depuration), 5 trillion yen or more (compensation to victims), 200 billion yen (subsidy to Fukushima Prefecture), 160 billion yen (recovery grant), 96 billion yen (health investigation cost), 73 billion yen (construction for public housing after the disaster), 40 billion yen (nuclear disaster recovery fund).

It is unlikely that the original cost calculations included these items when planning was undertaken for the location of the power plants. Incidentally, Fukushima daiichi (i.e., Fukushima Power Plant One) was the first nuclear plant to begin operation in Japan. The owner of the power plant, TEPCO, insisted that the site was safe up until the 2011 earthquake when it became apparent that there were significant risks. That said, details of the site selection process were generally unknown by the public, making it difficult to independently verify which criteria were used to select Fukushima as the site of the nuclear plant when planning began between 1957 and 1961.

In order to uncover the site selection criteria for the nuclear power plant the author made use of research undertaken by Kobayashi (1971) and Kainuma (2011). Based on their work it is possible to get a clearer picture. The location of the Fukushima daiichi nuclear power plant was decided for an area abutting the towns of Futaba and Ookuma in 1961, and plant operation began from 1971. The Fukushima daini (second) nuclear plant abutted the towns of Tmioka and Naraha, with development starting in 1968, and operation beginning in 1982. These facilities were the realization and culmination of a long-cherished desire for Japan to have nuclear power, as the United States forcefully prohibited Japan from producing any nuclear energy for decades. Using Kobayashi and Kainuma's findings the author was able to confirm the immediate rationale for selecting the site for the Fukushima daiichi nuclear power plant, as well as the organization of its key facilities. In addition, a 1962 map of the area was found that indicated the average income for the Fukushima coastal region. These documents support the conclusion that by building the nuclear daiichi facility in an area with unused, low-value land of Fukushima prefecture was able to obtain a particularly high cost-benefit performance, and that this was in fact the most important factor used in choosing the site.

A Review of the Unrealized Holistic Site Planning Process Making Use of Ecological Planning—From the Perspective of Disaster Vulnerability

This section focuses on the criteria for land evaluation based on the 1980 report made by the National Land Agency of Japan, entitled *Ekorojikaru puranningu niyoru tochiriyou tekisei hyouka syuhou tyousa* (*Land use Suitability Investigation through Ecological Planning*). The basic investigation data offers a rare case study of McHarg's ecological planning system as applied to Japan.

Although the data was gathered by researchers with experience in the McHarg methodology, the National Land Agency did not make use of the accumulated database to create a site overlay analysis. Instead they tried to use the information solely to generate a new ecological spatial unit for the Tohoku region. In the end, the National Land Agency only just proposed a watershed-base of planning units for Tohoku region. These units were offered as alternatives to the existing administrative regions. A key goal of this work was to achieve social equity as part of the national development plan—the Tohoku region was poor in comparison to affluent western Japan at the time. Within this context the National Land Agency had control competence for the environmental management of regions that included cities, farmland, and forests. Its perspective was therefore holistic and environmentally centered. By contrast other agencies took a less overarching view. As an example, the Ministry of Construction of Japan placed emphasis on measuring and understanding only urban areas and ignored potentially related open green space (forest, farm land, park space). Unfortunately, Prime Minister Kakuei Tanaka stepped down in 1976, and the agency he established was eventually absorbed by the Ministry of Construction in 2001.

The report included five maps drawn at a scale of 1:50,000, each one offering detailed environmental evaluations. The report also included seven maps containing wind direction information; Taking advantage of the hindsight that comes from our knowledge about the nuclear disaster in 2011 the author used three of the maps to examine the known potential for wind blowing inland from the sea, as the diffusion of radiation released from broken nuclear plant into residential areas would be more serious than diffusion toward the sea. The author analyzed these 1980 maps for the six prefectures in the Tohoku district, including the locations affected by the disaster on March 11, 2011. In total the author generated six new vector maps using the 1980 report data, with each map focusing on a specific environmental feature; namely geological, landform classification, slope distribution, vegetation, physiography, and wind direction. These maps made it possible to examine the potential significance of the 1980 regional ecological planning data. It is worth noting that the author could have used raster data containing similar information, but chose not to, as the spatial resolution of the raster data was either too large or too small for the purpose.[1]

The margin of error of the results, given the resolution of the raster data, is a significant technical problem for GIS and remote-sensing research because of Japan's complex natural environment. Diverse geographic and geological features are commonly scattered within the narrow scope of the mosaic. As a result, the author took the position that the influence of a reduced scale would be smaller for vector (polygon) data than for raster data and proceeded to digitize the disaster risk evaluations for landslides, earthquake resistance, flood and soil maintenance, as well as the possibility of air pollution dispersion on each of the feature maps. The disaster risk categories were referenced as attributes from tables in the 1980 Land Agency report. The author also made a figure map containing prevailing wind predictions from the sea to the land.[2]

Additionally, the author made use of a vulnerability index connected to each environmental feature from the 1980 database. It is worth pointing out that this kind of study was not used to inform the planning of the Fukushima power plants, and indeed was not undertaken until much later. Interestingly, even after the study was complete it was not used to inform policy regarding the reactors, possibly because of its complexity as an environmental index. For example, the vegetation map includes three additional environmental indices beyond disaster vulnerability (land-stability), including (1) the degree of human disturbance to the vegetation; (2) rarity of vegetation; and (3) water-retention of the land. Adding to the complexity, the first division (the degree of human disturbance to the vegetation) had ten further sub-classifications. And the next two indices (rarity of vegetation, and land water-retention) were classified according to four relative degree ranks. The complexity of the information, while technically correct and nominally useful, made it difficult to use in terms of planning policy. The inherent complexity of Japan's environment required a density of division as well as a complicated evaluation index that is in general more complex than McHarg and his followers faced in the United States. In order to re-evaluate the results of land selection according to the methods of holistic planning, the author created a vector map showing disaster vulnerability

[1]Vector data (polygonal) includes attributes and topology (spatial relationships such as adjacency) and can therefore be used to directly relate information, such as a vulnerability index, to a physical location regardless of scale. Raster data is made of a single composite image and resolution is fixed by the original scale of the image data.

[2]All of these works were undertaken using ArcGIS 9.3.1.

according to each environmental feature, and including their disaster risk degree (rank) according to the 1980 report. The author also created a map showing the possible dispersal of air pollution, based on information for prevailing winds blowing from the sea to land included in the same report. The author then superimposed data describing the six disaster vulnerabilities discussed above in order to visualize the cumulative disaster hazards. Finally, the author analyzed the natural disaster vulnerabilities at the Fukushima nuclear plant location based on these results.

Results and Discussion

Revaluating Land Selection Results from Short-Term Planning

Many Japanese did not know much about the location and details of the Fukushima nuclear plant until the accident in March 2011. We also were not aware that the Fukushima nuclear power plant, though located in the Tohoku region, delivered electricity to Tokyo. Kainuma published a book entitled *Fukushima ron* (A Treatise on Fukushima) that focuses on the relation between the construction of the nuclear power plant and regional society. According to Kainuma (2011), the site selection process for the Fukushima daiichi (one) nuclear power plant in 1961 progressed smoothly and without trouble, due to the decision to purchase unused, inexpensive land. In this case the land was previously used as an airport by the Japanese army in 1938, but it fell into disuse following a U.S. Army air raid in 1945. It was then used briefly as a salt farm from 1950, but its operations ceased in 1955. After its abandonment the land was no longer viable for farming because of damage from the salt production and therefore was of particularly low value. As it happened, by the 1960s this land sat within the most economically deprived area in Fukushima Prefecture.

Construction of the second nuclear (daini) power plant was not as smoothly accepted as the first (daiichi). A protest campaign was launched but failed to stop the purchase of the land for the daini Fukushima nuclear plant, as instructions from the mayors of nearby towns, Tomioka and Naraha, as well as the prefectural governor Morie Kimura, over-ruled all objections. Kainuma (2011) quotes a statement made by the prefectural governor Morie in 1968 insisting that "*There is no worry of pollution and safety in the construction of a nuclear power plant. As evidence of the degree of safety of these nuclear plants, in the United States and the United Kingdom, nuclear power plants are constructed close to inhabited urban areas.*" However, the governor's explanation suggested no attention was paid to tsunami and earthquake disaster prevention in any real terms.

Given the depressed values of land and the findings of Kainuma, it is likely that the locations of the Fukushima nuclear power plants, daiichi (one) and daini (two) were decided according to a simple and short-term criteria set. These were that a large tract of coastal land could be purchased at low cost, close to the ocean, but also some distance from large population centers in order to ensure some margin of safety for most of the region's population. This assumes a simplistic reading of the concept of vulnerability as it presumes physical distance would be sufficient protection. However, beyond the idea of safety it is clear that one of the actual main deciding factors for selecting the final site was the existence of unused land that could be easily purchased at low cost. Data on the wealth gap of the prefecture as of 1962 underlines this point (Fig. 18.2). It is perhaps of some interest that the income of the area was improved significantly from the 1970s onward, directly as a result of the construction of the nuclear power plants. However, before this change took place, income disparity created a few specific coastal zones in which land costs would be low in comparison to the rest of the prefecture.

Indeed, Kobayashi (1971) also reports that the Fukushima daiichi nuclear plant site was selected in a location where the development expense and the cost of placing electric power lines was the cheapest. He was a member of TEPCO's Fukushima daiichi nuclear plant site selection committee. Interestingly, he also attested that from the point of view of the investors, politics and the social conditions in the area were disregarded in the final process of choosing a site. Development expenses included the cost of the land (420 million yen) and the construction of the power plant itself (in total about 7.9 billion yen) which included related expenses such as the cost to compensate farmland owners and fisheries, the construction of water cooling machinery, and modifying or building harbors, landings, roads, paying investigation fees, and installing temporary equipment. TEPCO's selected Fukushima daiichi site was cost-effective land.

At the Fukushima daiichi site energy cost was estimated 2887 yen/kW, while at other sites the average cost was some 4530 yen/kW, in 1967 currency (Kobayashi 1971). The cost saving was about 6.6 billion yen. In contrast, the purchase of Fukushima daini nuclear site was more onerous. The daini plant site included privately owned prime agricultural land, and the owners resisted sale of their property for nuclear development. Kainuma (2011) disclosed that Fukushima prefecture organization bought dissident land owner's land by main force. This situation indicates the fukushima daini nuclear plant site's value was higher than daiichi site's value. Thus the time taken to accumulate the land of Fukushima daini was substantially longer than Fukushima daiichi site. Purchasing land to develop the daiichi plant site took 1 year, while 5 years was needed to assemble the land for the daini plant site. That daiichi site was entirely unused (and indeed was un-usable for farming) in one case and under cultivation in the daini site, made a large difference.

These facts support the conclusion that simplicity of land acquisition (low cost and few land owners) were primary decision making criteria for the selection of Fukushima daini nuclear plant site. Since these aligned with the political goals of every level of government the final siting of the power plant was simplified in a profound way. Both approaches (i.e., political and economic) are based on relatively short-term goals and are in stark contrast to the decision that might have been made if ecological landscape planning had been used.

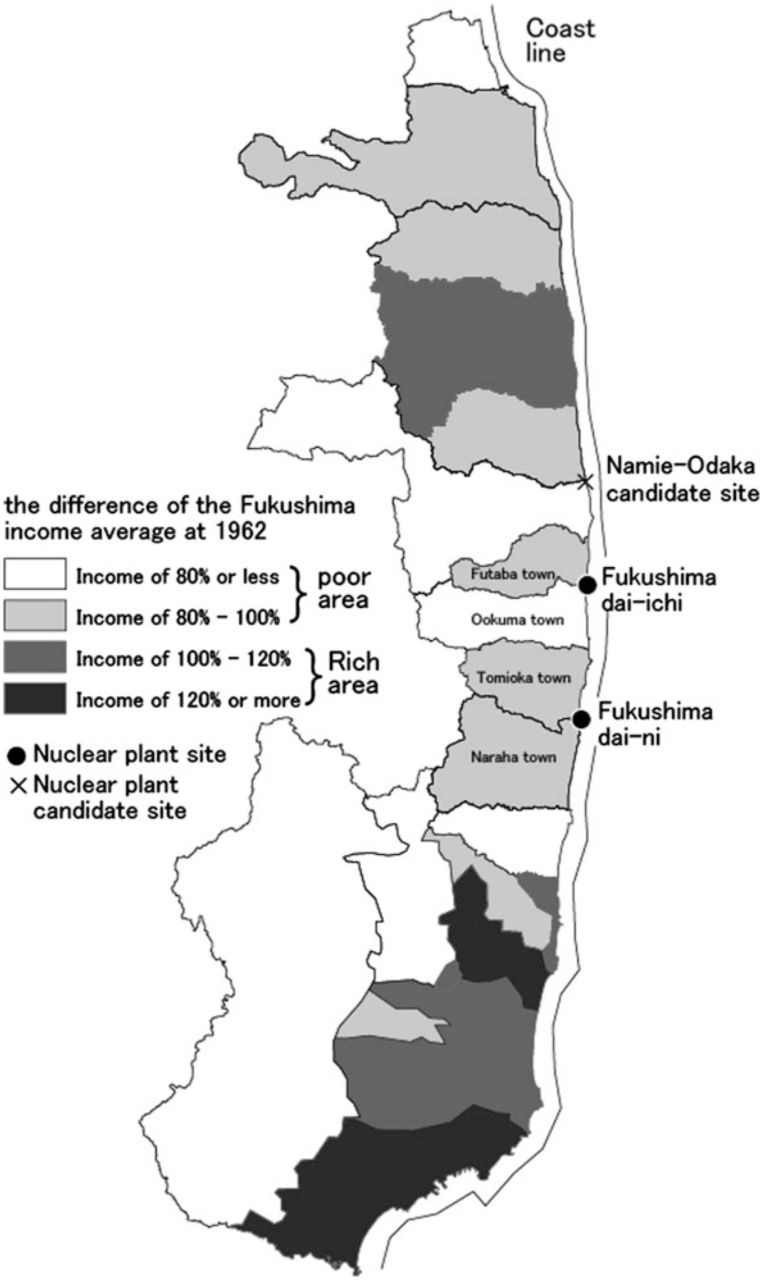

Fig. 18.2 Difference of average income in Fukushima Prefecture in 1962: a chief rational behind the location of the nuclear power plant sites may have been the relatively low cost of unused land on the coast line

Re-Evaluating the Results of Land Selection by Holistic Planning

This paper makes use of the 1980 report by the National Land Agency, "*Land use Suitability Investigation through Ecological Planning*". It is a valuable primary case study showing how ecological planning methods were applied to environmental evaluation in Japan. It is unfortunate that the 1980 report was not made public. In fact, had the author not obtained this material from a pile of books being readied for disposal in Shinshu University's landscape laboratory in 2008, it would have been lost by 2011.

The reasons the 1980 report disappeared from view appear to be twofold: (1) Japan has a fragmented, department-by-department, governmental structure, so no single organization was able to use the comprehensive information; and (2) Japan is composed of complex geographical vegetation features, and as a result the report required a complex matrix for each environmental map category as well as a complicated environmental evaluation. The complexity made it difficult to extract meaningful conclusions that could be used by the government in making policy decisions at that time. Kobayashi and Yan (2008) points out that it was difficult to use the (analog) data in the 1980s paper within environmental agencies because the information was not digitized, and thus not available for what is now considered routine analysis with GIS or other software. While the complexity and richness of information can be managed and analyzed with software, and then put to productive use, it is much more difficult in terms of time and labor to obtain such results when working only by hand with physical maps.

From the data available the author produced several digital maps, described in detail below. Figures 18.3, 18.4, 18.5, 18.6 and 18.7 show the disaster risk for each of the five environmental feature maps (landslide, earthquake resistance, and flood and soil maintenance), ranked according to the 1980 report. Figure 18.8 shows the potential inland diffusion of radioactive substances by wind from the sea.

To be more precise, Fig. 18.3 is a map of earthquake resistance rankings for each geological feature: Rank 1 (low) composed of sand-pebble-clay; Rank 2 (middle) composed of sandstone · mudstone · conglomerate, terrace deposits · diluvial gravel, crystalline schist, sandstone · shale · conglomerate; Rank 3 (high) composed of andesite, granite, slate · sandstone · chert · schalstein, gabbro · diabase, serpentine · Peridotite.

Figure 18.4 displays the risk (predisposition) for landslides for each geological feature: Rank 1 (rather high) with sandstone · mudstone · conglomerate; Rank 2 (high) with andesite; Rank 3 (middle) with granite, terrace deposits · diluvial gravel; Rank 4 (low) with sand · grave · clay, crystalline schist, sandstone · shale · conglomerate, slate · sandstone · chert · schalstein, gabbro · diabase.

Figure 18.5 shows the probability of landslides based on the degree of slope: Rank 1 (rather high) at 8°–20° slope; Rank 2 (high) at 20°–30° slope; Rank 3 (middle) at 3°–8°, 30°–40°, or 40° slope or more; Rank 4 (low) at 0°–3° slope.

Figure 18.6 ranks the stability of land for each vegetation and land-use feature: Rank 1 (low) indicates paddy fields, dry fields, logged forests, or urban areas;

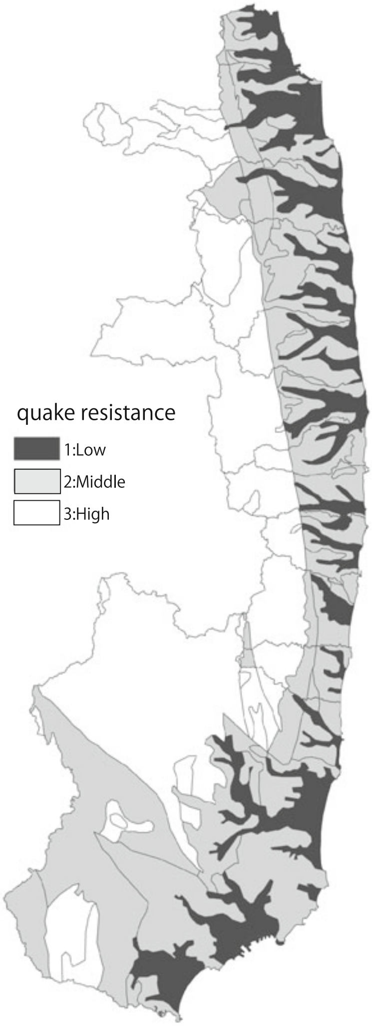

Fig. 18.3 Quake resistance for each geological division

Rank 2 (middle) with *Pinus*; Rank 3 (high) with *Quercus serrata*, *Thuja standishii-Pinus parviflora*, *Castanea crenata-Quercus crispula*, and *Pinus thunbergii*, *Cryptomeria japonica* and *Larix kaempferi* plantations.

Figure 18.7 is a ranking of potential flooding for each physiographic feature: Rank 1 (rather high) with deltas · tidal land · marshy valely bottom lowland, lower peat land; Rank 2 (high) with fan and valley bottom lowlands; Rank 3 (middle) with sand dunes, beach ridges, mud flow landforms, or Volcanic ash plateau; Rank 4 (low) with steep and gentle mountain slopes.

Figure 18.8 shows the potential inland diffusion area of radioactive substances by prevailing winds coming from the Pacific Ocean. The higher the density of gray the

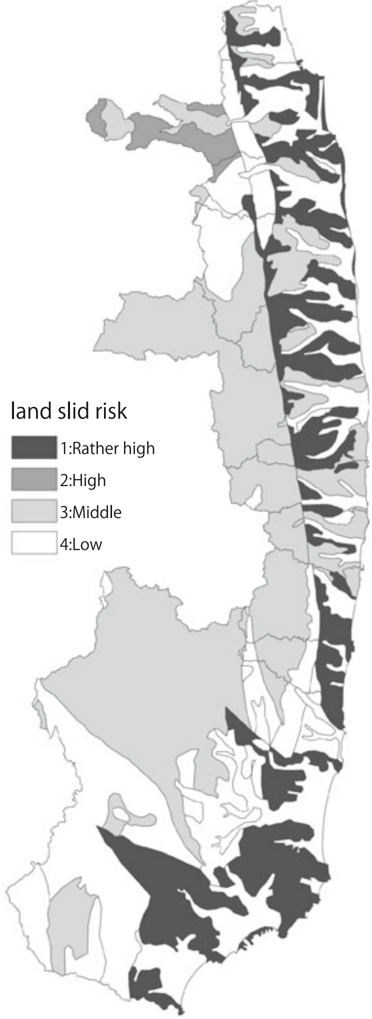

Fig. 18.4 Landslide risk for each geological division

higher the risk of diffusion of potentially radioactive substances in the case of disaster (Fig. 18.8). It is worth noting that although the 1980s ecological planning data-base exposed the possibility of dangerous inland wind patterns they were not considered with regards to the siting of the already built daiichi nuclear power plant. This had real consequences over time. For instance, a historical committee report conducted in 1985 for the area did not recognize the issue in their nuclear site location survey report (possibly because they lacked access to the wind data) (Okuma-town 1985).

At the time of the nuclear reactor's meltdown in March 2011, government experts understood the wind patterns and had developed modern computer simulations to demonstrate wind movement in detail. However, this information was not

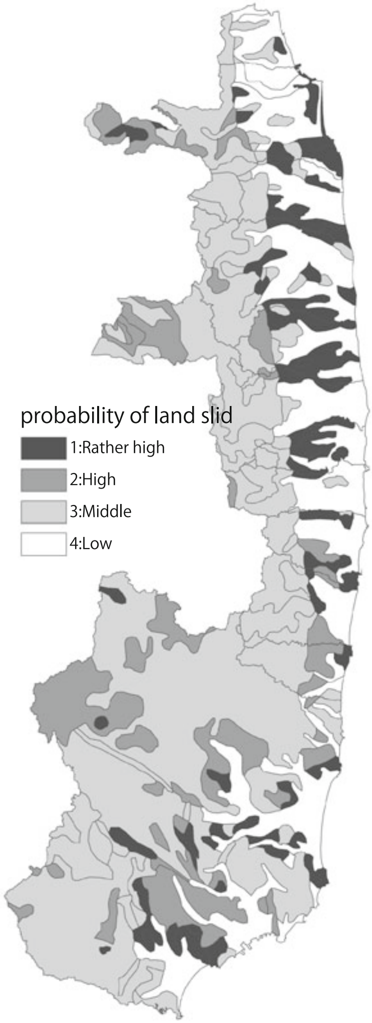

Fig. 18.5 Landslide probability based on the degree of slope

shared publicly. Had citizens been able to access more information about the landscape, and better understood the characteristics of their environment, perhaps radiation exposure due to by wind transport could have been avoided or reduced.

Finally, in order to build a clearer picture of what these data sources mean in aggregate the author overlaid the respective results of each of the six disaster hazard evaluations to create a holistic disaster hazard map. Figure 18.9 presents a synthesized disaster hazard map by cumulative estimation value, and overlays the location of the Fukushima daiichi (first) and daini (second) nuclear plants. The density of the gray color increases proportionally to the risk of disaster.

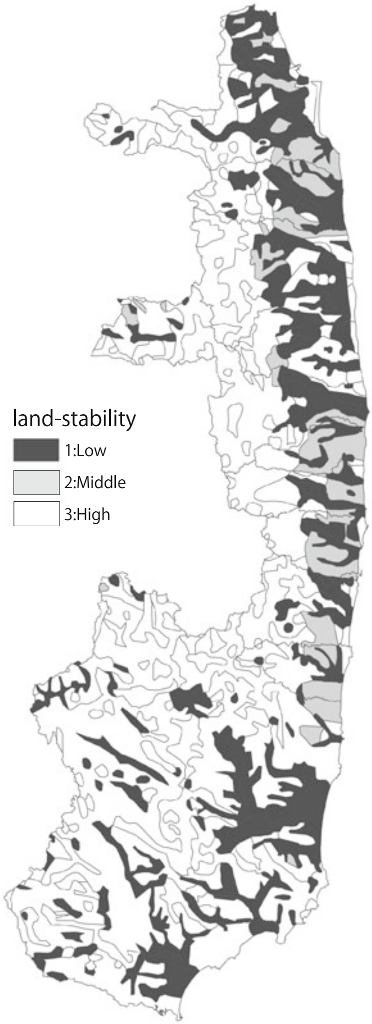

Fig. 18.6 Capacity for land-stability for each vegetation type

The Potential of Land Selection According to Holistic Planning

According to Kainuma (2011), the location selected for the Fukushima daiichi nuclear power plant was chosen primarily for an extremely simple reason: the area consisted of unused, inexpensive land (Fig. 18.2). With this in mind the Japanese federal government and the prefectural governor cooperated to promote the selected land as a candidate site for the Fukushima daiichi nuclear plant. In particular, the prefecture's governor (a member of a pro-nuclear power faction at the time) decided

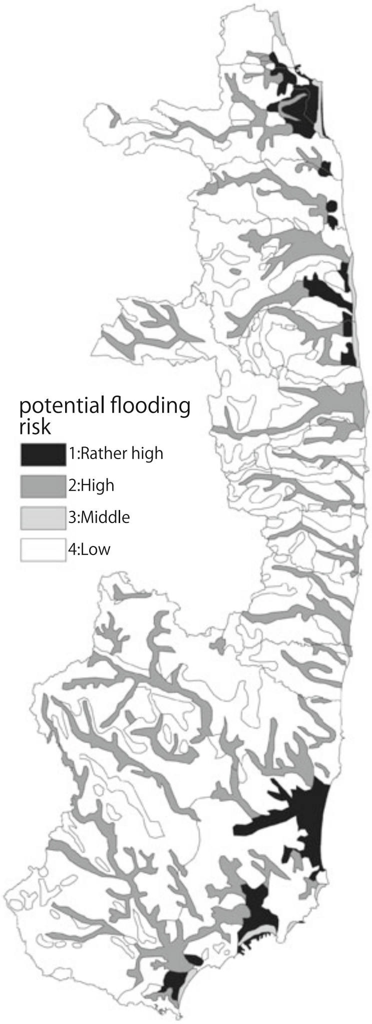

Fig. 18.7 Potential flooding for each physiographic division

for political reasons that the daiichi nuclear power plant should be built in the poorest region, which was host to unused and low-value land (Kainuma 2011). The developer, Tokyo Electric Power Company, found the daiichi site suitable, not least because of the increased profit that could be ensured as a result of the low investment costs involved in procuring the land (Kobayashi 1971). Inasmuch as the site selection could be considered the outcome of mostly political and economic decisions the final location was the outcome of short-term planning. Similarly, because they did not make use of a detailed environmental report (indeed one was not even prepared until after the site was already decided and construction

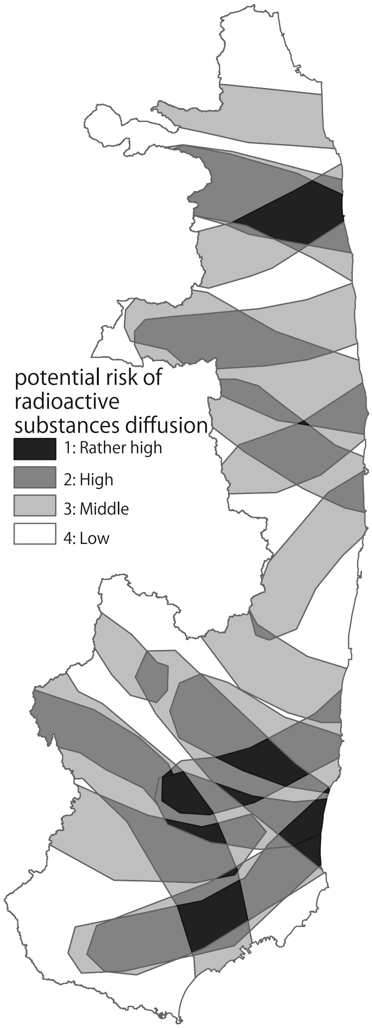

Fig. 18.8 Potential risk of radioactive substance diffusion due to the prevailing wind coming from the sea

completed), the power plant cannot be said to have been located according to a scientific, never mind a holistic, understanding of the local environment.

The integrated disaster hazard map shown in this paper, however, clearly indicates the coastal site of the nuclear power plant was in a relatively dangerous location when considering the overall disaster vulnerability for the region (Fig. 18.9). The reasons for selecting the site do not seem reasonable in light of the coast's vulnerability to earthquake, tsunamis, and diffusion risk.

A focus on short-term planning promoted construction of nuclear power plants next to the ocean so that less expensive water-cooled systems could be built. While

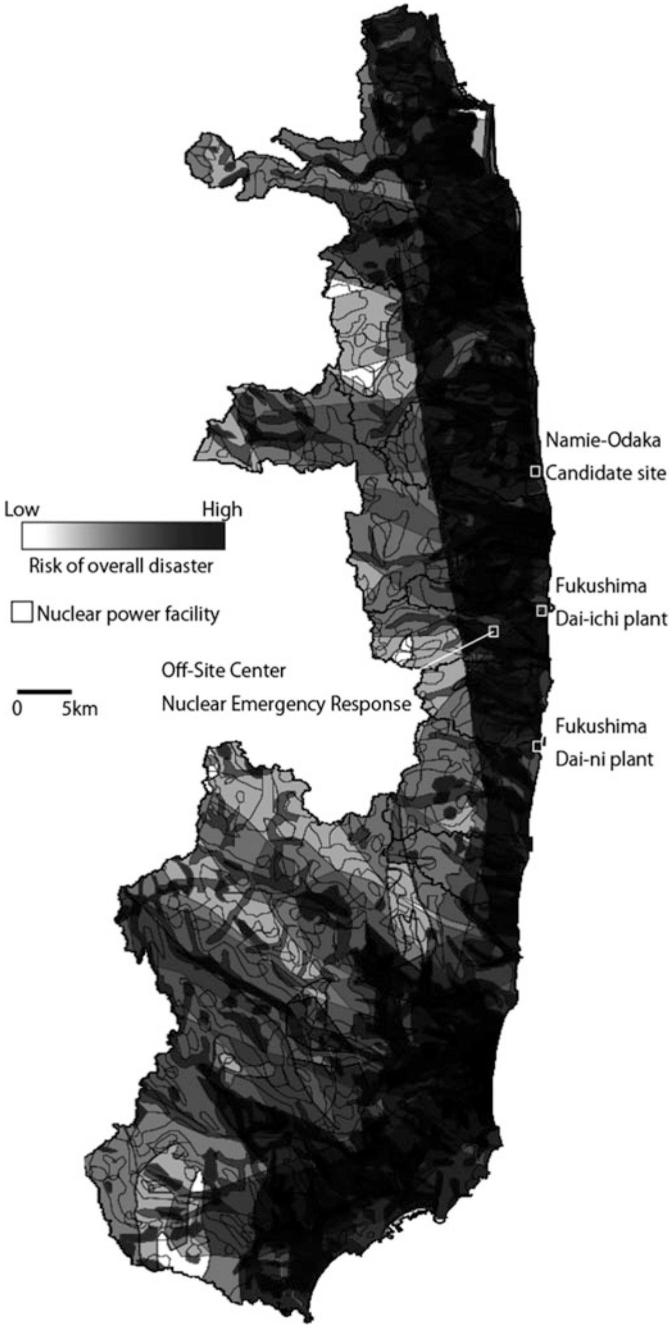

Fig. 18.9 Overlay results of each of the six disaster hazard evaluations. Regular power supply to the Daiichi, Daini and the Off-site Center was lost due to the earthquake on March, 2011. In addition, the preliminary emergency power supply of daiichi plant was lost by tsunami, while the Off-site Center was closed by the radioactivity from daiichi plant

the cooling system itself made use of fresh water, heat could be extracted from the fresh water using the abundantly available seawater. In contrast, nuclear power plants in Europe and America are located inland, so excess heat is managed with a cooling tower system (i.e., they are cooled by air). Even with access to a working power supply the Japanese system has no means for cooling the reactor if the seawater cooling apparatus is damaged. Taki (2011) indicates that dependence of Japanese nuclear reactor buildings on seawater for cooling is an important weak point. In the same article he points out that some nuclear experts believed that the nuclear disaster could have been avoided if Fukushima daiichi's nuclear reactor had been designed with the more expensive air-cooled system. Although power loss at the daiichi nuclear plant was first caused by the collapse of transmission lines due to the earthquake, the breakdown of the Fukushima daiichi nuclear plant's primary emergency power supply was directly caused by the tsunami. If this were not enough the author recently learned from Dr. Kotaro Ohga that the sea's inflow and outflow in the area as a result of tidal action affects the movement of coastal water underground. Water flowing into the underground portion of the damaged reactor building is being contaminated at a rate of 400 tons a day.

Kobayashi (1971) reported that in addition to the savings made from the site selection itself, the cost of development for the daiichi site was reduced further by the internal organization of the plant facilities. In particular, he makes reference to the nuclear reactor building and the intake gate of the cooling system. Three arrangements were considered for these items on the site, and considered in terms of cost:

Plan A1—estimated cost, 8.43 billion yen
nuclear reactor building and intake gate located on existing coastal land
Plan A2—estimated cost, 7.89 billion yen
nuclear reactor building on the coast, intake gate on reclaimed land
Plan A3—estimated cost, 8.4 billion yen
nuclear reactor building and intake gate located on reclaimed land.

After some consideration the 540 million yen saving that could be achieved by building according to plan A2 was implemented. Unfortunately, this cost-saving measure made the facility more vulnerable to tsunamis and groundwater inflow.

The site was located at a height of 30 m above sea level, and was excavated to a depth of just 10 m above sea level in order to build a cooling system that did not require expensive water pump facilities. This is a condition that might not have been foreseen in 1980, but it is a powerful reminder that the environments in which we live and work are highly interconnected and difficult to predict without integrating a broad range of knowledge and research.

Conclusions

The site chosen for the construction of the Fukushima daiichi nuclear power plant was close to the coast because of the desire for ease of access to water that could be used as a coolant. The land was also distant from large population centres, which was thought to be important. However, according to Kobayashi (1971) and Kainuma (2011), the low cost of the land of daiichi plant was given priority in the final decision for both economic and political reasons.

The development cost reduction that resulted form the site location confirmed in this study came to some 7.11 billion yen. This is the result of a 6.6 billion yen saving in direct site development expenses added to 540 million yen saved by the arrangement of the nuclear reactors and intake gate on the land itself. In current monetary value this would amount to a savings of about 14.2 billion yen, or $14.22 million dollars. By contrast a tentative calculation of the damages as a result of the accident suggest a cost of about 11 trillion yen, or US $110 billion dollars, although this must remain tentative for some time, as costs continue to accrue. The cost of damages from the meltdown of the Fukushima daiichi nuclear power plant (including healthcare costs and the cost of relocating residents from the area) are far larger than the initial savings made by selecting inexpensive land to build on. In this instance the short-term savings caused excessive and punitively high long-term expenses.

Looking at the issue with the benefit of hindsight, our results indicate the site selected for the nuclear plant was in a relatively vulnerable location. The overall disaster vulnerability for the area, as demonstrated by our holistic site analysis (making use of the 1980 environmental data set for Tohoku) offers a much clearer perspective than was available to the decision makers at the time of the original site planning. Nonetheless, the author believes that a safer site might have been chosen if a holistic site selection approach was used. More importantly, it is useful to acknowledge that this particular, holistic, approach is valuable even after construction is complete. In other words, it is never too late to consider the prevention of disasters triggered by multiple natural accidents (e.g., earthquakes, landslides, flooding, and air pollution). In the case of the Fukushima reactors, while the sites were already selected by the time the 1980 environmental review was undertaken, there was still more than enough time to implement preventative measures to minimize the impact of known vulnerabilities, such as a powerful tsunami, or wind blowing inland from the sea over a potentially radioactive area.

The approach demonstrated in this paper for holistic environmental assessment is valuable, because it provides tools to consider the possibility of a natural disaster, even after a site has already been built on. If this kind of study had been used in the earliest planning phase, or even after construction was completed, the 11 trillion-yen disaster cost might have been evaded, and certainly would have been worth more than the increased development cost. Short-term and narrowly focused planning goals led to long-term and broadly impacting problems that will endure for some time to come. Going forward, the data presented here could be useful in dialogue between pro-nuclear and anti-nuclear groups. Beyond the nuclear debate the approach is equally valuable for any kind of planning, if not as spectacular.

The author further observed that the 1980 data for ecological planning and land evaluation may have been too complex and extensive for easy comprehension and utilization, even though the amount of detail was appropriate for ecological planning purposes. Therefore, as with other instances of planning, holistic environmental planning approaches must establish simple and easy-to-understand ways to communicate findings and risks. This is an essential step in making holistic planning more acceptable to policy makers as well as politicians and local residents.

In the case of Namie-town in Fukushima Prefecture, the Namie-Odaka nuclear power plant was not built as a result of NIMBY (Not in My Back Yard) protests. In some respects, this was a miraculous victory. However, because of its proximity to the disaster, Namie was polluted by wind from the Fukushima daiichi (one) nuclear plant which had reactor meltdown. This reality highlights an important point, namely that local avoidance of a particular risk may not be sufficient to save an area from risk that is embedded in the region as a whole. Similarly, the broad impact of the disaster shows the importance of holistic landscape planning and the need to consider the ways that a site is inter-connected with its surroundings.

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Chapter 19
Disaster Response and Public Consultation in Cleaning Up Radioactive Contamination of the Environment

Mimi Nameki

Abstract The March 2011 accident at the Fukushima Daiichi nuclear power plant in Japan triggered one of the largest environmental pollution disasters of all time. Despite the need to decontaminate the affected areas, local residents are reluctant to accept any decontaminated soil and waste in their own living environment, a situation that is delaying decontamination work. With the disaster as a case study, this chapter investigates the role of public involvement and decision-making in disaster response, based on international experience with cleaning up radioactive contamination of the environment.

Introduction

The March 2011 accident at the Fukushima Daiichi nuclear power plant, owned by Tokyo Electricity Power Company (TEPCO) in Japan, was categorized as Level 7 on the International Nuclear Event Scale (INES), making it one of the world's most serious nuclear accidents of all time. The area where citizens could be exposed to an additional annual radiation dose above 1 mSv (millisieverts) covers more than one hundred municipalities in eight prefectures. Within that area, about 1,300 km^2 of land are polluted to the degree that citizens could be exposed to an additional annual dose above 5 mSv, and on 500 km^2 within that area the annual dose could be above 20 mSv (IAEA 2011).

To deal with the extensive radioactive contamination of the environment caused by the accident, the government enacted the Act on Special Measures concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District—Off the Pacific Ocean Earthquake that Occurred on March 11, 2011 (hereinafter the "Special Measures Act") on August 26, 2011. This Act sets forth the requirements to deal with environmental pollution from radioactive substances. It designates two

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types of area for off-site decontamination based on pollution level: Special Decontamination Areas, where the annual cumulative dose for citizens could be above 20 mSv, and Intensive Contamination Survey Areas, where the annual dose could be from 1 to 20 mSv. Decontamination work is conducted by the national government in Special Decontamination Areas, while in Intensive Contamination Survey Areas, local municipalities conduct detailed surveys of contamination and then develop decontamination plans based on the findings. Decontamination work in Intensive Contamination Survey Areas is implemented by each municipality, with financial and technical support from the national government.

Progress to Date with Off-Site Decontamination

The degree of progress so far with off-site decontamination varies by municipality. Decontamination[1] requires a series of steps, starting from surveying the state of contamination, developing a work plan for decontamination, securing temporary storage sites for soil and waste generated from this work, obtaining the consent of landowners, conducting decontamination, and treating the waste and soil generated from decontamination.

According to Japan's Ministry of the Environment, just after two and a half years since the accident (September 2013), ten of eleven municipalities in Special Decontamination Areas had developed work plans, three had decided on the location of temporary storage sites to meet all needs, and seven had done so for at least a portion of the needs. Actual decontamination work was implemented in seven municipalities in 2013, and completed in one of them. Progress varied considerably among the 11 municipalities, with some still planning and some at or near the completion stage. Special Decontamination Areas include areas with high contamination levels, where cumulative annual doses for citizens could be above 50 mSv. For such areas, trial decontamination work is to be conducted by the national government, followed by decisions on the best approaches for environmental remediation.

In other polluted areas, of the 100 municipalities in eight prefectures designated as Intensive Contamination Survey Areas (104 municipalities were designated, but four had been removed from the list as of Sep 2013), by September 2013, 94 had developed work plans, while six had not decided whether or not to develop a plan. Actual progress also varied considerably depending on the area. By the end of September 2013, decontamination work had been completed for public and child-related facilities (e.g., schools, nurseries and parks), but decontamination had

[1]The definition of "decontamination" used here follows that of IAEA's Safety Glossary 2007 Edition: "the complete or partial removal of contamination by a deliberate physical, chemical or biological process." In practice, at these sites in Japan, this often means physically relocating the toxic material to storage in another location (IAEA 2007).

been completed at only about 20–30% of private homes where work was planned. A few more years may be needed to finish all planned decontamination work.

Delays with Decontamination Work and Their Causes

The media have stridently criticized delays in decontamination work. In the spring of 2014, 3 years after the disaster, the press suggested these delays were hindering post-disaster reconstruction.[2] The limited progress being reported may be one reason residents feel that the conditions in their "living environment"[3] have not improved (e.g., about 70–80% of private dwellings in the Intensive Contamination Survey Areas remain contaminated).

What are the reasons of these delays? In parliamentary discussions by the Environment Committee of the House of Councilors on March 21, 2013, Hiroaki Kobayashi, head of Environment Management Bureau of Ministry of the Environment, gave the following response to a question from parliamentarian Masaharu Nakagawa on the state of decontamination efforts: "The progress of decontamination is slow in areas where temporary storage sites have not been decided on. It is also turning out to be quite difficult and time consuming to acquire the necessary approvals (from landowners). To tackle these problems, it will be important to secure temporary storage sites, and for the long term, intermediate storage sites. We will make efforts to accelerate decontamination by securing those sites and learning lessons obtained so far."

The temporary storage sites are intended to be places to temporarily store waste and soil generated from decontamination work. The most significant reason for problems in securing such sites is the difficulty of obtaining agreement from local residents. Below are what appear to be the four main reasons for difficulty in obtaining agreement, based on issues articulated by individuals who participated in briefings about temporary storage sites.

The first is anger about the very idea that residents should be expected to accept any temporary storage sites nearby. The general thinking is that the immediate removal and treatment of polluted substances should be the responsibility of the national government and TEPCO, both of which were the ones to promote nuclear power. They ask, "Why do we need to store these pollutants in our own living environment?" It may be quite understandable that residents would feel this way, considering the fact that it is not their fault the land was contaminated.

The second reason is a sense of mistrust about the effectiveness of decontamination. People doubt that decontamination work will be able to reduce radiation dosages below a certain level in residential areas. Many are also concerned that

[2]E.g., *Asahi Shimbun,* article issued March 4, 2014.

[3]"Living environment" is a term used in Japanese legislation to indicate the ambient environment where people live, and is interpreted from the perspective of the affected person.

even if that level is reached, radiation from contaminated forests and the general environment will still affect them, in the absence of more comprehensive decontamination work.[4] People with these concerns cannot accept the idea of temporary storage sites, since they regard the very effectiveness of the proposed measures as questionable in the first place.

Third, they question the “temporary” nature of the proposed “temporary” storage sites. The national government has stated that all soil and waste generated from decontamination will first be stored at temporary storage sites, then transferred to intermediate storage sites in about 3 years, and then ultimately to final disposal sites within 30 years. Some doubt whether such promises will ever come to pass. The fact that no decisions have yet been made about the locations of intermediate facilities exacerbates such concerns. The above statements by an official from the Ministry of the Environment to the Diet committee were also based on these concerns.

Fourth, people are anxious about the risks posed by temporary storage sites, where the quantity of radioactive pollutants will accumulate. They fear that temporary storage sites in their own neighborhoods might become new sources of radiation, even though decontamination will have helped reduce ambient dosages in the surrounding environment.

Clearly, it will not be easy to achieve agreement on where to locate temporary storage sites without dispelling those concerns.

Another cause of delay relating to decontamination work after the Fukushima accident relates to the need to obtain the approval of landowners. A vast area was contaminated by the accident, and much of the land is privately owned. Even under normal conditions, it would take considerable administrative effort to identify all landowners and gain their approval for work for anything affecting their land. These tasks are even more difficult in the case of the Fukushima accident, since some municipal offices were forced to relocate and many landowners have evacuated the most highly polluted areas.

Finally, the situation is further complicated by the fact that temporary storage sites will have to be large, because the quantity of waste and soil generated from decontamination work will likely be enormous. The reality is that the larger the area required, the more difficult the consultation with stakeholders will be.[5]

[4]The Japanese government’s policy on decontamination of forests so far has been to decontaminate only the forests in proximity of houses.

[5]As of November 2016, 96 municipalities are designated as Intensive Contamination Survey Area. 93 had developed decontamination work plans. Dedontamination work is near the completion stage. In Special Decontamination Areas, decontamination work has completed in seven municipalities. The work is still on-going in remaining four municipalities as of September 2016. For the most recent development on environmentl remediation, please check: http://josen.env.go.jp/en/.

Other Approaches for Quicker Remediation

What can be done to speed the recovery from the environmental pollution caused by the nuclear accident? The author is of the opinion that the key to prompt remediation is stronger stakeholder involvement in decision-making. As such an approach involves more processes and consultation, some may say that it will require more time. Examples from international experience, however, suggest that good stakeholder involvement in disaster response is the key to smoother recovery efforts.

The International Commission on Radiological Protection (ICRP) points out that in existing exposure situations, where individuals need to live with certain levels of radiation dosage, the behavior of those individuals is the key to radiological protection. The implication is that stakeholder engagement in policy decisions is important. This view is articulated in ICRP Publication 111, entitled "Application of the Commission's Recommendations to the Protection of People Living in Long-term Contaminated Areas after a Nuclear Accident or a Radiation Emergency." Japan's Ministry of the Environment—the body in charge of decontamination—states that decontamination is conducted "in order to decrease radiation doses in the living environment" (MOE 2013). To decide how to effectively conduct decontamination—in other words, to effectively reduce radiation doses in the living environment—the involvement of the affected people (i.e., the local residents) is essential.

Meanwhile, the safety standards of the International Atomic Energy Agency (IAEA) clearly stipulate that remediation programs shall provide for the involvement of interested parties (note that in practice, the IAEA treats decontamination as a subset of remediation). In early October 2011, the International Mission on Remediation of Large Contaminated Areas Off-site the Fukushima Daiichi Nuclear Power Plant, organized by the IAEA, visited Japan and reviewed accident responses in terms of off-site remediation. The mission's final report notes that many important lessons from past radiological pollution incidents—particularly, lessons about involving and informing stakeholders—are applicable in the case of the Fukushima accident, stating that "Timely stakeholder involvement increases the credibility of the whole remediation process and the probability of success." The final report also acknowledges that the Special Measures Act explicitly mentions stakeholder involvement and the efforts of a large number of volunteers as important and effective components of self-help efforts. The IAEA's advice on stakeholder involvement is that "The central and local governments are encouraged to continue strengthening the involvement of and cooperation between various stakeholders."

Several other experts visited Japan after the nuclear accident and provided advice in line with the IAEA recommendations. For example, Jacques Lochard, Chair of Committee 4 of the ICRP and Director of the Nuclear Evaluation

Protection Centre (CEPN),[6] explained lessons learned from the Chernobyl nuclear accident. He stated that where severe conflicts had erupted between villagers and the local government, stakeholder dialogues that included experts as third parties were useful in re-establishing communication between the villagers and the authorities and in helping to develop effective radiation protection practices for local citizens. Lochard told Japanese audiences that this kind of stakeholder dialogue with outside experts, and cooperation of citizens, authorities and experts, would be useful in the case of Fukushima.[7]

Yasuo Onishi, of the Pacific Northwest National Laboratory, commenting on experience in the United States with radiological protection, has stated that stakeholder involvement right from the planning stage is a key to success. He describes the case of a remediation plan for a contaminated area, developed without any stakeholder involvement. Locals rejected the plan, requiring it to be re-written from scratch through local community engagement. Onishi concludes that although processes involving consultation with all stakeholders might seem to be time consuming, such processes are ultimately the quicker path to the desired results.[8]

Strengthening Stakeholder Involvement

The Special Measures Act clearly stipulates that related parties' opinions are to be taken into account in decontamination efforts. Section 3 of Article 36 empowers the prefectural governor or other relevant authority to form a committee to ensure that the decontamination plan is implemented effectively and smoothly. Section 4 stipulates that the opinions of the committee or other concerned parties must be heard prior to the formulation of a decontamination plan. Many local governments have developed such committees to discuss decontamination-related issues. None of the relevant regulatory documents under the Act, however, provide specific information about who is to be counted as a concerned party other than the entities performing the decontamination work, though residents are obviously important and not specifically excluded. Given the level of public discontent over the lack of progress with decontamination after the Fukushima accident, however, one could say that the will of residents deserves more respect if the government wishes to achieve sound implementation of decontamination in an "effective and smooth manner."

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[6]Committee 4 of the ICRP is in charge of application of the commission's recommendations and plays a role as a major ICRP contact point with other organizations (2009).

[7]Jacques Lochard, "Rehabilitation of Living Conditions After a Nuclear Accident: Lessons From Chernobyl," presentation to the Japanese Cabinet Office, Oct. 28, 2011, and personal communication with the author (2011).

[8]Yasuo Onishi, "Environmental Remediation Examples and Remediation Strategic Planning," Presentation at the International Symposium on Decontamination—Toward the Recovery of the Environment—Oct. 16, 2011, and personal communication with the author (2011).

In Japan, stakeholder involvement—particularly that of local residents—in environmental policymaking has not been as robust as in other developed countries. Nevertheless, this country's environmental impact assessment (EIA) processes could serve as tools to share information among stakeholders and to reach decisions with stakeholder participation. Professor Sachihiko Harashina proposed a simplified form of EIA, in the case of Fukushima, as one way to secure stakeholder engagement in order to determine where to locate temporary storage sites (IGES 2012, IGES 2013). The number of EIAs actually conducted in this country is relatively limited, since Japanese legislation requires EIAs only for large projects. Also, Japanese EIA processes currently take a few years to complete and require an enormous amount of documentation, making them unpopular with project proponents. In contrast, simplified EIA processes could be conducted in just a few months (Harashina 2011).

EIAs are just one example of how stakeholder involvement could be improved. The point to be noted here is that better processes could improve information sharing and exchanges of opinion, both of which could go a long way to alleviate the concerns of residents.

Nevertheless, even with improved stakeholder dialogue, it is probably impossible to completely eliminate the fundamental public resentment that exists. The damaged environment and customary ways of life will never be completely restored, but without better dialogue among stakeholders, the resentment of the people will likely continue to increase. The level of public mistrust of the government and experts is already at an all-time high as a result of the response to the Fukushima accident to date.[9]

The current situation has shown that top-down methods—the government's traditional approach in Japan—may not satisfy the local people, since these approaches make it difficult to earn the public's confidence. Unless greater attempts are made to strengthen stakeholder involvement, especially that of local residents, and unless a sincere attempt is made to take the public distrust seriously, environmental restoration will remain a distant dream for the local people, and for the country itself.

Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the official policy or position of any agency of the government of Japan.

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[9]Presentation by Kyo Kageura, private meeting between Goshi Hosono (Environment Minister) and experts on Health Communication with Nuclear Disaster Victims, August 2011.

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Chapter 20
Building Resilience in Africa Through Transformation and a Green Economy: Challenges and Opportunities

Andries Jordaan

Abstract This paper reviews the transformation opportunities and threats for a resilient society in Africa. The debate about the place and timing of a green economy in Africa is intense and receives attention at all levels of society. Africa is blessed with an abundance of resources, yet its people remain poor and vulnerable to exogenous shocks. New technology imbedded in a green economy and green agriculture could provide opportunities for development but it could also have the opposite unintended effect. Africans rightfully ask if it is morally justifiable for the developed world to expect African countries to implement green technologies in order to reduce CO_2 emissions while first world countries developed their economies with cheaper and well-known technologies. The challenges in Africa are complex and not only centered on technology or the lack thereof. Governance and policy should be used to create an enabling environment for the implementation of new and green technology for economic growth and development. Examples of major infrastructural development projects in parts of Africa are evidence that African leaders in some countries already recognize its importance. Most of these project focus on transportation, energy generation/distribution, and water related services. The food-water-energy nexus is critical for the future development in Africa and innovative technology should be utilized to increase access to education, unlock the potential of natural resources, increase the efficiency of transport systems, unlock markets, and to increase the efficiency of food production, food storage and food distribution.

Introduction

Humanity and humans today influence every inch and every aspect of Earth and in the future we might well have the same influence on the planets and space surrounding earth. The question raised by many is for how long can we continue doing

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what we are currently doing in the way that we are doing it? Obviously at the core of the survival of the human race is innovation, and the ability to maintain our capacity to adapt, to change, and to invent. In order to do so, we have had to take risks. In his book "Against the Gods: The Remarkable Story of Risk" Bernstein (1998) wrote: "*The revolutionary idea that defines the boundary between modern times and the past is the mastery of risk: the notion that the future is more than an act of the gods and that men and women are not passive before nature.*"

Innovative thinking, planning and implementation is at the core of our survival as human beings and one could expect it as a core element in our education systems. Unfortunately, the poor state of education in Africa does not reflect these sentiments. We need to admit; the concept of environmental innovation is not a priority in most education structures in Africa. Maybe we are too busy with survival today to think about tomorrow?

Africa indeed has many opportunities and resources but we also have challenges that limit the potential for Africa to develop and to take its rightful place amongst other developed continents in the world. Africa is poised for the development and implementation of new technologies, and pockets of expertise are already developed in some fields, such as with climate change research (Calestous 2013). The 2013 World Economic Forum held in Cape Town reached a consensus that Africa's science and innovation agenda will be driven by agriculture, health and the environment.

This article firstly deals with the potential and opportunities in Africa, secondly with the challenges and the factors that limit growth and potential, thirdly with what innovative thinking, planning and implementation can achieve, what are the global trends and lastly how environmental innovative actions could make a difference in Africa.

Paradoxes of Africa

Africa is a continent of paradoxes. It is widely acknowledged that Africa has great natural potential with large percentages of the world's most sought after minerals, an agricultural potential to be the fruit basket of the world, fantastic climate, good soils and sufficient supplies of water. Yet Africa remains the poorest continent on earth. The complex interplay between the political and economic factors appears to make it impossible to use a substantial part of revenues from the exploitation of natural resources for the well-being of people at grassroots level.

Africa's opportunities and wealth are captured in (i) its people, especially the youth, (ii) agriculture, with good soils, climate and water, sufficient to be the food basket of the world, (iii) minerals, (iv) energy, through non-renewable resources (oil) as well as renewable resources (water, wind, solar) (v) geographic location with easy access to the world's markets, (vi) water for energy, food production and human consumption, (vii) climate for food production, tourism and year round productivity, (viii) scenery for tourism.

Most of the challenges in Africa provide an opportunity for innovative planning and implementation. With an enabling environment provided by good governance, most of the current problems in Africa can be resolved. Africa has the opportunity to learn from mistakes made by the developed world and implement new innovative and green technologies in order to resolve its problems. The next section summarizes some of the current problems and opportunities in Africa.

Population Growth

Population growth and urbanization is a world-wide challenge and an opportunity —with the current population at approximately 7.2 billion people and an expected growth of another 1 billion in the next 12 years (UN 2013). The UN (2013) projects the portion of the global population in the so-called developing world will grow from the current 5.9 to 8.2 billion people by 2050 with the most rapid growth in the 49 least developed countries. Africa is regarded as a high-fertility continent and will see the most rapid population growth alongside countries with large populations such as India, Indonesia, Pakistan and the Philippines (UN 2013). Most of the future mega cities will be located in the so-called 10/40 window—the area in Africa and Asia between north latitude 10 and 40°. This region demarcates the regions of the world with most socio-economic challenges. Four-fifths of the world's poor and two-thirds of the world's total population live in these regions. Adding to this is the complexity of opposing religious identities and ethnic groups living in the area (Mills 2010). It is also in these same areas where we can expect friction between traditional values and systems on the one hand and the need for modernization and innovation on the other hand.

The sub-saharan population is expected to grow from the current 800 million to 1.4 billion by 2030, and it is projected that by 2025, 23% of the world's youth will be living in the region (UN 2013). The greatest natural asset in Africa could as well be its youth and not its minerals, as widely reported, but the danger is that this greatest asset is also undermining the continent's prosperity due to the lack of proper education and employment opportunities (Mills 2010). Africa's youth should be harnessed as a source of talent and energy through new innovative thinking; instead, in some countries they became a destabilizing force—mainly uneducated and unemployed—and even a threat to Africa's security. It is estimated that one in four young people will be from Africa by 2025. We need to develop Africa's youth through education and employment to reach its full potential and to become a stimulus for innovation and development.

Urbanization is coupled to population growth. Predictions are that by 2025, 50 cities in Africa will have more than 1 million citizens. Four of the world's mega cities, with more than 10 million inhabitants, will be in Africa by 2015. Africa is traditionally regarded as a rural continent, and this is borne out by the numbers. But the balance is changing. Only 5% of its population lived in cities in 1900, growing to 15% by 1950, and 37% by 2000. By 2025 fully 50% of its populace is expected to live in cities, and by that time Africa in essence will become an urban continent.

Education

Africa has more than 46 million children that receive no school education whatsoever. Two thirds of those children are girls. Only 52% of children in Africa are enrolled in primary school (Mills 2010). This has many negative impacts. Illiteracy in the most populous country in Africa, Nigeria, for example is 66% due to a neglect of the education system and infrastructure (UNICEF 2013).

Reasons for the problems in education are (i) lack of facilities, (ii) lack of well-trained educators, (iii) long travel distances in rural areas, (iv) proportionally large spending on military instead of education, (v) conflict, (vi) inefficient institutions (Mills 2010; UNICEF 2013).

Strife and Conflict

Africa is plagued with strife and conflict. More than 9 million people are currently refugees or internally displaced because of conflicts and civil wars on the continent. Millions have been slaughtered in the past decade alone. Similar killings in the developed world would certainly be treated as a global threat, or another world war. Seemingly, it is different in Africa (UNHCR 2011).

During the period between 1960 and 1990, there have been about 80 violent changes of governments in the 48 sub-Saharan African countries (Adedeji 1999). Different types of civil strife, conflicts and wars were part of the government changes of most of these countries. At the beginning of 2000, eighteen countries faced armed rebellion, 11 experienced severe political crises and only 19 enjoyed various versions of a stable political condition (Bujra 2002).

The causes for conflict are manifold and vary from (i) conflict over the inequitable distribution of resources and the control over them (DRC, Nigeria), (ii) human right violations (Sierra Leone, Somalia), (iii) power struggles (Cote D'Ivoire), (iv) lack of democracy and the role of a political class in the manipulation of ethnic and regional sentiments (Libya, Egypt), (v) food crises (Ethiopia, Somalia, Kenya), (vi) conflict between countries (Ethiopia and Eritrea), (vii) ethnic and religious conflict (Sudan, Nigeria, Rwanda), (viii) labor unrest (South Africa), (ix) social inequality, (x) a defective education system (Adedeji 1999; Bujra 2002; Mills 2010).

Strife and conflict not only limit the capacity to govern. They limit the capacity of people to plan for the future, to create an environment for innovation. They limit the potential for foreign investment, for the free transport and flow of goods, and for the production of goods. Development is simply not possible in a conflict-ridden environment. We need innovative ideas and plans to address the issue of conflict in Africa.

Health

Life expectancy in Africa is only 50 years compared with the global average of 65 world-wide and 79 for the developed world (Mills 2010; WHO 2013). Africa accounts for 90% of the world's 1 million deaths due to malaria. Most of these deaths are amongst children below the age of 5: 2500 deaths per day (Mills 2010; WHO 2013). Sixty nine percent of all people in the world living with HIV are in Africa, and up to 72% of all AIDS deaths in the world are in Africa as well (UNAIDS 2010). Water borne diseases are also responsible for the deaths of thousands of Africans daily. Many do not have access to clean drinking water; unplanned, or poorly planned, urbanization will exacerbate the problem (WHO 2013).

Throughout their lives, Africans are more prone to illness or physiological infirmity than other people from the developing world. This has a huge impact on their social and family life and productivity. Most Africans are likely to go hungry more than once during their lifetime (WHO 2013).

Poor Governance and Corruption

In spite of commitments from African leaders, corruption and poor governance still affects most Africans on a daily basis. The Corruption Perception Index (CPI) scored 90% for African countries falling below the symbolic 50% mark (Transparency International 2013). Most countries in Africa will remain poor as long as its leaders and the political class enrich themselves by monopolizing the wealth and resources of their nations. It can be said that corruption has a direct influence on development, and is therefore a development issue. In this way corruption can be labeled as a crime against development, democracy, education, prosperity, public health and justice and a direct attack against the pillars of social wellbeing (Lucas 2010).

According to the 2013 African Progress Report at the World Economic Forum on Africa, the continent is losing more money through illicit outflows than it receives in aid and direct foreign investment. Kofi Annan, during the same conference made the following statement about Africa: "*We are not poor, we need to manage our resources better*".

African leaders in general made bad choices in the past because Africans and the international community allowed them to do so. African leaders have successfully managed to externalize their problems and make them the responsibility of donors. The international community has lacked the political will to manage their relationships with African countries according to democratic reform and delivery records of African countries (Mills 2010). Mills (2010) goes so far as to say that Africa is poor because its leaders choose their people to be poor.

Some African leaders have been able to get away with self-interested decisions, enriching themselves and their families by exploiting the wealth and the resources of their countries. They do so while the majority of the population continues to suffer with poverty, lack of services, and poor infrastructure. It is not strange to find African politicians and their families amongst the richest people in Africa. They are allowed to get away with ruinous, self-interested decisions because of the relative lack of democracy and single party dominance. At the same time there is little pressure from the populace to challenge their decisions. Mills (2010) calls this the culture of neo-patrimonial (big man) chieftain style rule. It is a system many African leaders prefer as they thrive on corruption and nepotism. In his writings Mills (2010) compares the African dilemma and lack of development with the Asian success story, where Asian countries managed to lift themselves out of poverty. He suggests the Confucian mindset of assuming responsibility and working together for the development of all is important. This paradox is best described by Briguglio and Kisanga (2004) in his writing on the Singapore paradox.

Natural Resources

Africa is a continent with abundant natural resources, yet the continent failed to capitalize on its richness. Instead, resources have become the source of conflict, corruption, oppression, nepotism. Ultimately this is the source of all the negative labels placed on it. The case of Nigeria is a good example. With estimated oil revenues totaling more than US$400 billion in the past 40 years, it witnessed a per capita increase from US$33 in 1965 to US$325 by 2000, and yet the number of Nigerians living on less than one dollar per day rose from 19 million (27% of population) to 90 million (75% of population) in the same timeframe. Eighty percent of Nigerians' oil wealth today accrues to only 1% of the population (UNICEF 2013).

It is not only oil and minerals. Soil, climate and water are sufficiently abundant to make Africa the breadbasket of the world, yet 35 of 48 sub-Saharan countries are net importers of food. By comparison, Asian countries tripled their food production outputs during the past 40 years and Latin America doubled its food production during the same period. In the mean time Africa's food production level has remained flat at best. There are pockets of production that follow a different pattern however. An example is South Africa where food production nearly tripled during the past 40 years. On the other hand Zimbabwe, once a net exporter of food, flowers, and tobacco, became a net importer during the last century, largely because of the land grab policy of Robert Mugabe. Maize production declined from 11 to 15 tons per hectare on commercial farms to only 300 kg per ha under the management of new smallholder farmers (Mills 2010).

Free Flow of Goods

Success in terms of economic growth during the past 20 years has much to do with the free flow of goods and efficient service provision. Well-connected countries can have access to many more markets and consumers, while the costs of exclusion are considerable and growing. The risks of missed opportunities loom large, especially for the poorest landlocked countries, many of them in Africa (Arvis et al. 2013). Singapore, Japan, Dubai and other successful countries realized the importance of global and free trade and opened their borders to the transfer of goods; they increased efficiency in terms of processing of imports and exports and reduced trade restriction policies, at least in some markets.

Most African countries, on the other hand remain paranoid about the presence of foreigners. Factors that inhibit free flow of goods in Africa are many, but include (i) numerous roadblocks manned by corrupt police and military personnel, (ii) inefficient and corrupt border control personnel, (iii) poorly maintained road and rail infrastructure, (iv) few ports that can handle large volumes of goods, (v) trade restrictions, and (vi) traditional transport systems (Heinz 1988; Anderson 2001; Soesastro 2008). The paranoia of African leaders and African Security Forces regarding free movement of people, goods and foreigners, whether they be investors or tourists, remains a governance issue that needs to be addressed if Africa wishes to compete and trade globally.

Africa Could Learn from Others

Some governments are successful in providing a better life for its citizens, others not. What are the differences between successful countries and those that remain poor in spite of an abundance of resources?

Briguglio and Kisanga (2004) identified four extreme scenarios into which countries can be classified according to their vulnerability and resilience. Figure 20.1 depicts these scenarios, with countries classified on the x-axis according to their nurtured resilience and on the y-axis according to their inherent vulnerability. The vulnerability index (y-axis) refers to permanent features in a country over which the populace or government have little or no control. Examples include earthquake prone countries, landlocked countries with no access to international markets, and countries with little or no natural resources. The resilience index (x-axis) refers to what a country can do to mitigate or exacerbate its inherent vulnerability. Scores on this axis reflect the appropriateness of policy and good governance.

The four categories are worst case (upper left), self-made (upper right), prodigal-son (bottom left) and best-case (bottom right).

Worst-case scenarios are those countries that compound the adverse effects of their inherent vulnerability by adopting policies that counter economic resilience

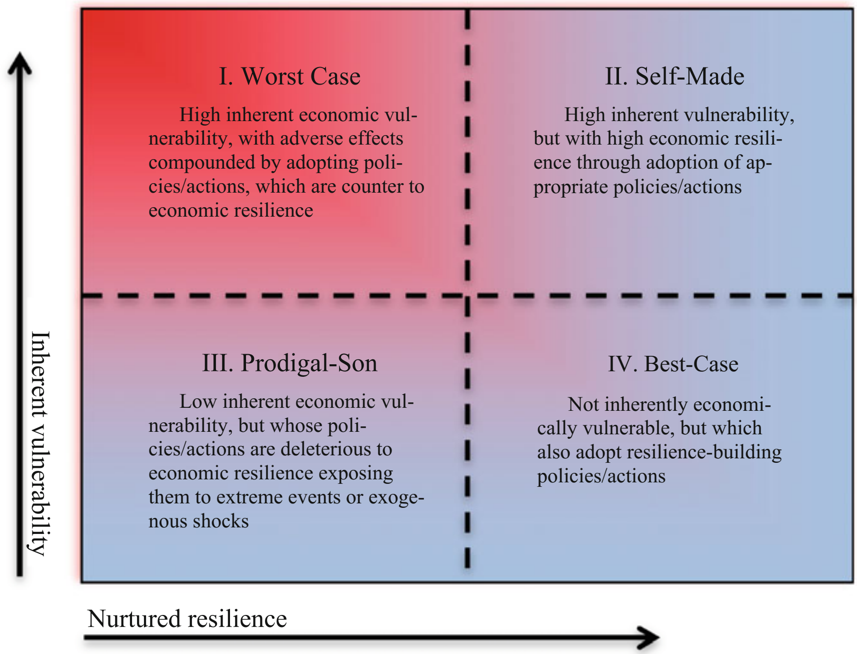

Fig. 20.1 The Singapore paradox (Briguglio and Kisanga 2004)

and growth. In other words, these are countries with few resources that are poorly governed. Examples in Africa are Swaziland and Lesotho.

- The prodigal-son countries are those with a relatively low degree of inherent vulnerability but whose policies run against economic resilience and growth. These are countries with sufficient natural resources, which are inherently resilient, but poorly governed. Many African countries fall into this category. With many resources and a large potential for development, bad governance, corruption and nepotism instead result in high vulnerability. Zimbabwe, Malawi, DRC, Congo Brazzaville and other nations are typical prodigal-son examples because of their poor economic performance in spite of vast and rich natural resources.
- Self-made countries are those with inherently high vulnerability but with the adoption of good policies and good governance are able to cope with or withstand the potential negative effects. These are countries with few natural resources that are well managed. Examples here are Japan, Dubai and Singapore. No good examples exist in Africa.
- Best-case scenarios are those countries with inherently low vulnerability that also have resilience building policies and good governance. These include countries with ample natural resources and opportunities, with good policies and a Government that governs well. Botswana and to some extent South Africa

might be the closest in this category in Africa but if one looks at international ratings for good governance, corruption, Gini-coefficient, and so on, then no country in Africa really qualify for this category.

The challenge in Africa is to move from a worst-case and prodigal-son scenario to the self-made and best-case scenarios. In this regard, much can be learned from the success of Asian countries. Japan is possibly the best examples in the world of a self-made economy.

Two other recent examples are these of Singapore and Vietnam. Both governments applied a particular philosophy to attract private investment and to liberate entrepreneurship through private ownership within a state-led economic development framework. Singapore started with the process in 1965 and Vietnam followed a similar path in 1986. This philosophy resulted in spectacular economic growth, which can be viewed as a precondition for social development and individual prosperity. The private sector was the engine of economic growth, fueled by an environment with fewer restrictions and working within a free market environment.

Vietnam emerged from decades of devastating wars, followed by communist rule that oversaw a period of hyperinflation, high unemployment and poverty. In time the deliberate change in land ownership policies enabled Vietnam to change from a rice importer to a rice exporter. This, along with foreign direct investment allowed the country to build a high paced economic growth of approximately 8% per annum for 20 years (World Bank 2013).

The lessons learned from the success of Asian countries such as Malaysia, Singapore, Indonesia and Thailand are clear.

- The need for an educated and healthy workforce. Good and affordable education for all is a prerequisite for economic developments. African countries should spend less on military and security budgets and more on education. The paranoia of African leaders to protect themselves and their political cronies are one of the Achilles heels for development in Africa.
- Timely investment in infrastructure ensured not only jobs during the construction phase but also provided capacity to attract and host international firms. A good road, port and transport infrastructure ensured the flow of goods through the respective countries.
- Extension of governance by involving the population at all levels. Accountability in governance encouraged conditions where efficient policies were made and implemented.
- A concerted effort to access the global economy. Free markets and the fact that the free flow of goods was actively promoted attracted additional investments and interest from the private sector. It also made life easier for the entrepreneur —big or small.
- Productivity. Confucian morality and ethics played a big role in the success of the Asian countries. Africa has low wages but the output per capita is amongst the worst in the world. Productivity is at the root of wealth creation and in this regard we in Africa can learn an important lesson from Asian countries.

- A very flexible labour market assisted firms to withstand external shocks, changes and challenges. This was driven by a philosophy that accepted low wages over unemployment.

The question now remains: If we manage to get these things right in Africa, is it sufficient to take us beyond 2025 and to the next generation? In order to assure success we will need to implement sustainable development policies aimed at reducing poverty and promoting economic growth. We will need to educate the youth of Africa, promote productivity, privatize where it is useful, and promote entrepreneurship as well as the free flow of goods. Governments and politicians must be accountable and transparent, we must uproot corruption and nepotism and governments must provide basic services to its people.

Environmental Innovation in Africa; Opportunity to Lead in a Sustainable Development Path

Emerging technological and social innovations involve huge potential to improve the lives of Africans in a sustainable way, but only if we incorporate knowledge of social-ecological systems as well the concept of "planetary boundaries" in framing their future development.

Social-ecological innovation is defined as technological and social innovation—including new strategies, concepts, ideas, institutions, and organizations—that enhances the capacity of social-ecological systems to generate bundles of essential ecosystem services. These have the potential to improve the capacity to learn from, respond to, and manage environmental feedback from dynamic ecosystems. Both concepts are important. Africans need to think and implement innovatively to transform the environment we live and share with other humans and species, but first we also need to apply common sense and basic knowledge. There are many lessons learned on how to stimulate development and building resilience.

The environmental impact of agriculture, industries and mining has led market actors to propose innovations that are consistent with sustainable development principles. Since the early 1990s economists have been particularly interested in the principles of green economy, which call for new ideas to achieve a sustainable socio-technical regime (Warner 2000). The transition process to a green economy promoted the theory of transition management to propose multi-level analysis while using prospective tools to design environmental innovations. The concepts of green economy and environmental innovation are inextricably linked to each other (Chen 2008). When talking about a green economy one refers to all spheres of the economy including food production, energy, mining, industry, transport etc. In the case of Africa's development at a strategic level the food-energy-water nexus and how that will be governed in Africa is important.

The difference between non-environmental innovation and environmental innovation is sustainability, and one needs to distinguish between the two concepts (Chen 2008; Romain 2012). With this in mind, it is important firstly to understand and agree on the concept of environmental innovation. Schumpeter (1939) and Swedberg (1989) define innovation as "*doing things differently in the realm of economic life*" According to them, innovation can be unlimited and linked to the introduction of new goods, new production methods, new work, new organizations or institutions, new outlets and new raw materials. Contrary to normal innovations, environmental innovations have a particular identity, which includes sustainability (Romain 2012).

The European Union and the OECD report (2011) define environmental innovation as "*the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives*" (Kemp and Pearson 2007). Kemp and Arundel (1998) point out that environmental innovations are "*... new or changed procedures, techniques, systems or products to reduce or avoid environmental damage*". Rennings (2000) defines environmental innovations as "*innovation processes towards sustainable development*"; these are "*measures taken by firms and households, which (i) develop new ideas, patterns of behavior, products and processes, introduce or apply them, and (ii) contribute toward the reduction of environmental damage or to ecologically specified sustainable targets*".

The Technological Path for Environmental Innovations in Africa

Put in economic terms evolution or transformation depend on push and pull factors. More concretely, these factors are called demand-pull, technology push, science push and regulation push. Figure 20.2 illustrates the pull and push factors for eco-innovation. According to Dosi (1982), this matrix opens endless opportunities for transformation that can be slowed down by path dependency, representations, social acceptability and network externalities. In the case of environmental innovation, the main driver is the quest for optimization of raw materials, or the optimal use of natural resources (land, water, and climate) and of energy consumption. Science and technology are closely related, since science is responsible for the development of new technology in most cases. Secondly, environmental innovations are shaped by taxes, standards and regulations. The market plays an important role in that it reflects what, and how much, consumers need (Kemp and Pearson 2011).

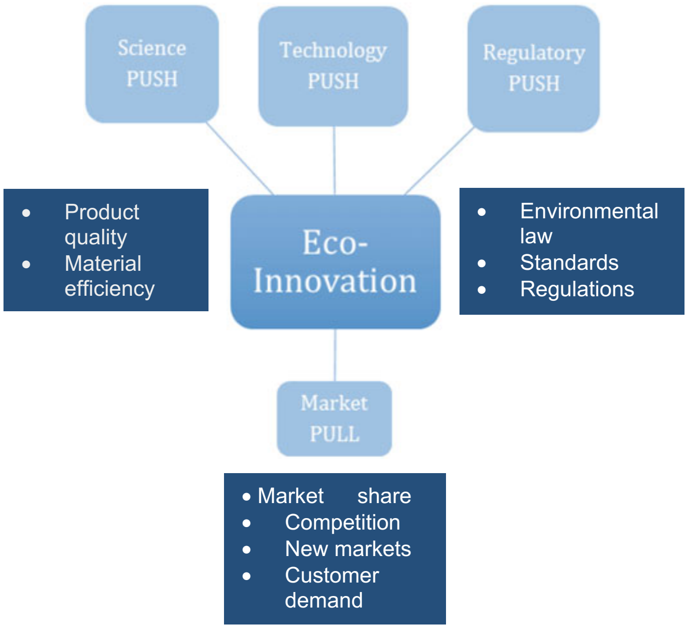

Fig. 20.2 Matrix of drivers for environmental innovations (Romain 2012)

The Food-Water-Energy Nexus

Food

Considering the potential of food production in Africa and the fact that agriculture is regarded as the engine of economic growth in most African countries, one can expect the agricultural sector to be exposed to dramatic transformation with a large scope of environmentally innovative technologies (Juma 2011; Wilke 2010).

Agriculture in Africa in most cases still uses traditional technologies and one might classify some of the technologies as "*green*" with examples of cattle and donkeys used as draught power and as a means of transport respectively. Food in rural Africa is also produced according to certain guidelines for "*green*" production; fields are cultivated by hand with low fertilizer and chemical applications with resultant low yields (Wilke 2010). That is one of the reasons, apart from the land ownership issue, why food production in Africa remains at the same levels of 20 and 40 years ago. Because of the low productivity these technologies may not be sustainable in the context of a growing African population (Fig. 20.3).

Dramatic changes in the agricultural sector are possible with mechanization and with investment in large-scale food production. It is already taking place with some mega-farms established in Sudan, Zambia, Nigeria and other countries. These investments in farming are mainly from the Arab States (in Sudan, Tanzania and

Fig. 20.3 Traditional agriculture in some parts of Africa, "*green*" but low yield

Kenya), China (in DRC, Mozambique, Tanzania, Zambia and Zimbabwe), South Africa (in Congo Brazzaville, Botswana, Mozambique and Zambia), India (in Ethiopia), Jordan (in Sudan), South Korea (in Sudan), Sweden (in Mozambique), United Kingdom (in Tanzania) and the United States (in Sudan) (FAO 2009). If the trend continues in the near future we will see more agricultural land occupied by large commercial farms, with small-scale farmers working as labourers and many migrating to larger cities (Cotula et al. 2009).

Figure 20.4 illustrates the push and pull factors currently influencing the movement of commercial farmers in southern Africa. As entrepreneurs, individual commercial farmers and large-scale food production companies need to make profits. Profits in agriculture depend on sustainable production and reliable markets and good management principles just as in any profitable business. Farmers or farming businesses have to be competitive and they will move to products, markets or geographical regions where they have a competitive advantage.

Water, energy and governance are core motivations for companies that invest in agriculture in certain areas. Food production naturally moves away from water scarce areas with high energy costs and an insecure political environment with

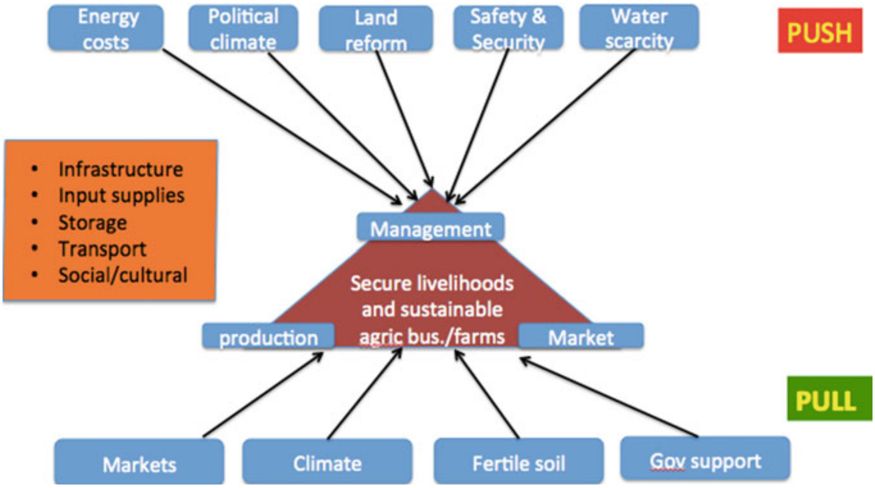

Fig. 20.4 Push and pull factors for food production patterns in southern Africa (Author)

regards to agricultural production—push factors. The pull factors are the market, fertile soils, favorable climatic conditions and a political climate favoring food production. Barriers to this movement include poor infrastructure such as roads and storage facilities, shortage of input supplies and social and cultural changes. For the entrepreneur these factors in fact provide additional opportunities.

Agriculture as a sector is taking strides towards the introduction of green economic principles with for example no-tillage and precision agriculture becoming the norm rather than the exception amongst progressive commercial farming enterprises in southern Africa. Similarly, the Ethiopian government has set ambitious targets in its "*Climate Resilient Green Economy*" *strategy*. Amongst other ambitious goals, it strives to reach "carbon neutral middle income" status, and to reduce its dependency on fossil fuels with 30% by 2025. In terms of agriculture the government adopted a policy that supports improvement of sustainable crop and livestock production in order to increase yields, and importantly, to ensure food security and improve the income of farmers. As part of this process they elevated the importance of industry, transport and construction as priority areas for investment in new energy efficient technologies (World Bank 2012).

Energy

The World Bank (2012) reported that less than a quarter of the population of sub Saharan Africa has access to electricity and that African economies lose at least 2.1% of GDP due to energy shortages. In spite of the fact that some African countries have access to oil reserves, little of it actually contributes to net economic growth for the continent as a whole. The greed of some African leaders who exploit the reserves of their countries for personal wealth contributes toward the unequal allocation of the wealth from oil extraction. The rise in global crude oil prices therefore left most African countries with reduced budgets for investment in other areas. Senegal for example pays more than 8.5% of its GDP to import oil; funds that could be used for education or development.

Africa is endowed with natural resources that make it a prime candidate for a switch to renewable energy. The potential for wind and solar power generation is nowhere in the world as promising as in Africa. The solar power potential in Africa compared to Europe, where many strides have been made toward solar power, is illustrated in Fig. 20.5.

Tunisia offers a good example of innovative planning and policy where a national fund for energy management has been established in response to calls for investment in renewable sources of energy production. The solar market development is a key government priority with the creation of the Tunisian Solar Programme (PROSOL). As a result of PROSOL the net reduction in the national energy bill reached US$1.1 billion, with 50,000 families receiving heated water as a result of solar energy. The program reduced CO_2 emissions by 214,000 tonnes annually.

Global investment in renewable energy is on the rise, reaching US$211 billion in 2010. During this time, investment in African hydro-power also increased dramatically, with Chinese firms involved in most hydro power developments in the region. Figure 20.6 illustrates hydro-power projects under construction and planned for the next few years. The largest hydro power project on the board is the Grand Inga dam in the Congo river, with an estimated cost of 50–80 US$Bn, and a potential of 30,000–50,000 MW capacity. Once connected to a continental grid, these hydro-power sources have the potential to provide most of Africa's energy.

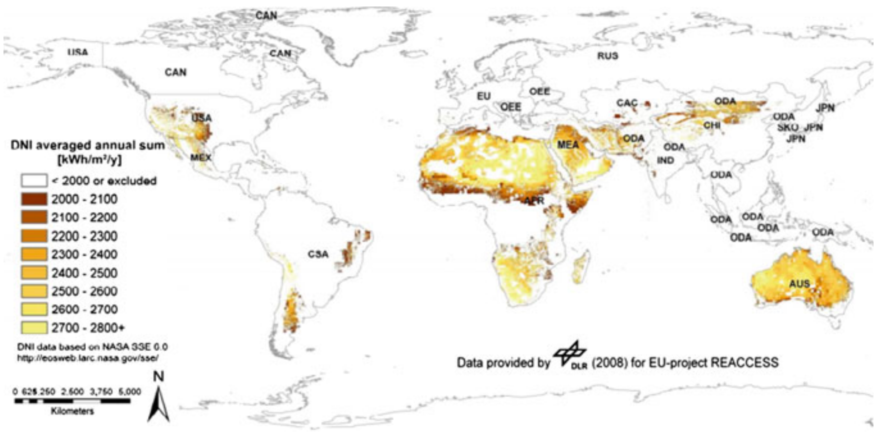

Fig. 20.5 Solar power potential in the world (Trieb et al. 2009)

Fig. 20.6 Hydro-power schemes planned and under construction by Chinese firms

Adding the potential of solar and wind power it is not hyperbole to imagine an Africa that is fully supplied by renewable energy in 20 years' time.

These developments should put Africa at the forefront of the green energy revolution in the world, but much will depend on whether countries value the long-term over the short-term, and assumes investments can be made. Can Africa shake off the shackles of its dependence on oil imports and really move toward green energy? Political leaders should usher political rhetoric into tangible gains for the energy sector and for all sectors that form the core of economic growth.

Water

The magnitude of the global freshwater risk and crisis is largely under-estimated. The UNDP (2012) reported as follows:

- Approximately 700 million people from 43 countries suffer from water scarcity
- One billion people are without reliable water resources
- More than 2 billion people are without sanitation
- By 2025 1.8 billion people will be living in countries with absolute water scarcity
- 250 million people in Africa will be living under high water stress conditions
- between 24 and 700 million people will be displaced in the next decade due to water scarcity
- sub-Sahara Africa has the largest number of water stress countries of any continent (see Fig. 20.7)

The Green Economy and water are linked together. Much new technology will be reliant on water, whether it be in the food sector, energy sector, health sector or industry. UNEP (2011) provides six key messages related to the resource in its 2011 Green Economy Report: These are:

- Water, as basic necessity for sustaining life, is still not accessible to many of the world's poor.
- Existing inadequacies in water provision and sanitation services generate inefficiencies through additional social costs and economic inefficiencies.
- Current water management practices will lead to an unsustainable gap between global supply and demand for water withdrawal. This is exacerbated by failure to limit water losses and to collect and treat used water for subsequent uses.

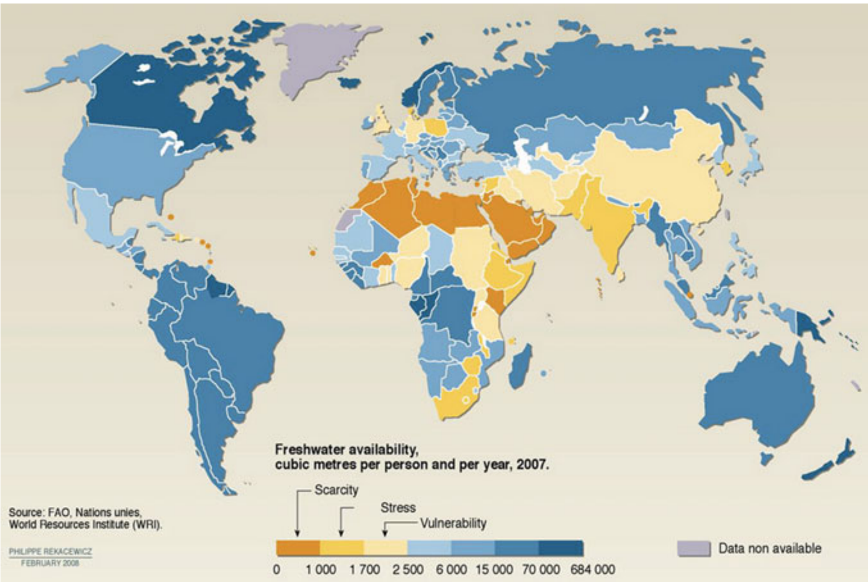

Fig. 20.7 Water stress countries of the World

- The availability of an adequate quantity of safe water is a service provided by ecosystems.
- Increased investment in water-dependent ecosystems and infrastructure as well as in water management can be expected to expedite the transition to a green economy.
- The efficiency of investments in water infrastructure and management will be enhanced when coupled with improved institutional arrangements and policies that address entitlement and allocation systems.

The question is: How will Africa respond to the above messages?

Green Economy, Technology and the Future for Africa

Africa has all the ingredients for a bright and prosperous future. The way her people will govern and manage these resources will determine how well it is met. The green economy, and environmental innovations could ensure the sustainable use of these resources. Africa need not "*re-design the wheel*" and repeat the mistakes of developed countries. Africa should instead take the lead in the development and implementation of green or "*smart technologies*".

At the core of the challenge is institutional capacity. Ardakanian and Jaeger (2012) sees institutional capacity as a pre-requisite for the implementation and enforcement of measures to shift from "*business-as-usual*" to green water economies. They further stated that the actual implementation of innovative and green technology ultimately depends on the efficiency of institutions. That implies sound institutional frameworks plus the capacity within institutions to implement, monitor, evaluate and improve policy and technology. The UNWATER report "*Water and the Green Economy*" further underlines the importance of inter- and intra-disciplinary research and planning as well as innovative thinking as a required approach for the reduction of future water related risks and to ensure sustainable use of water resources (Ardakanian and Jaeger 2012).

Several research projects focus on "*smart households*" and "*smart communities*". Japan and some European countries have already implemented and tested the concepts through research. These communities are either off grid or they are linked to a "*smart power grid*" system. Whether they actually are effective or not, by contrast large areas in Africa are still not linked to a power grid at all. While this might seem a negative situation, in fact it is an opportunity to develop an off-grid system, whether it is informed by the "*smart communities*" or not.

An improved concept might be called "*smart catchments*" where the principles of integrated water management are integrated with food and energy provision. Innovative technologies in a "*smart catchment*" could address (i) sustainable food production, (ii) sustainable use of water for energy, food and household use, (iii) renewable energy generation through solar, wind, hydro and bio-techniques, and (iv) communication connections and networks. Government should provide the policy framework for the establishment of smart catchments, but the initiative must be commercially viable with a bottom up approach.

The Rio+20 Conference called for the establishment of a green economy and recognized the importance of the development of coherent national strategies and policy frameworks. Much research has been done on green economy although many initiatives are still nascent. A transition to a green economy presents many challenges, especially in under-developed societies that characterize much of Africa. The initial stages of harnessing new technologies necessary to develop a green economy, including renewable energy and other innovations, are costly and require considerable expertise. Research institutions and developers in Africa could contribute by implementing new technologies in selected catchments (*smart catchments*) at small scale and through a process of action research, expand and improve on the practical application of a green economy at the larger scale.

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Part VI
Building Resiliency with Community

The previous parts describe a view of resilience aimed at balance and inclusion. Flexibility is balanced with concrete plans, the large scale is balanced with the small, policy is balanced by practice, and government is balanced with community. This part is dedicated to the latter. Communities, small groups, or even towns and villages, are small enough to act quickly when the unexpected takes place. Some communities are better prepared than others however, and it is worth considering the lessons of how resilient communities are organized.

Roggema and Vos introduce the value of role playing and community resilience planning carried out by the communities themselves, using intensive design charrettes to capture local knowledge.

Banerjee et al. introduce a program to build community-based solar energy networks in India and explain the specific challenges of working with community and their successes and failures in the context of third world development. This chapter offers a fascinating sense of the direction that community-based resilience could take if scaled up sufficiently. Scaling is an issue in itself, and one that is not addressed directly so often in this collection. Banerjee's case study suggests some ways that planning for resilience could be undertaken at the scale of a nation without losing site of the individuals and the local community groups.

Aldrich's work is fundamental and very important. Though government has a central role in preparing for and responding to disaster he shows the even more important role that a strong community and civil society plays in speeding recovery after disaster. Considering his work, policy might be directed simply at developing links within a community so that it will be empowered and capable of dealing with unexpected events. In that case planning for specific disasters might be better treated as a corollary ambition.

Kobayashi describes the role of community in actual construction projects that he carried out as an architect after disasters in Japan, the Philippines, and in Myanmar. Community engagement is central to his work. Poignantly he describes the first failure of his approach, which came about because the local community was not sufficiently engaged with the project. This is an important lesson and his willingness to be honest about the project is very welcome. Bringing the members of a community into the design and construction of a building changes the way that they view it, and also alters the impact the building has on their lives.

Chapter 21
Community Based Environmental Design: Empowering Local Expertise in Design Charrettes

Rob Roggema, Lisa Vos and John Martin

Planning for climate change adaptation aims to increase adaptive capacity and resilience in communities, but current spatial planning and design projects often neglect the creative power and expertise available in the communities they ostensibly serve. This results in communities that are poorly prepared for the future, and especially the uncertainty of future climate change impacts. This is partly caused by historically determined design processes that leave little room for an enhanced role for community in designing, and deciding, their own future. The design charrette approach is an intensive design-based way to empower local knowledge. In the design charrette process community members and local experts are mixed with academics, designers and regional policy makers. As a group they design and model a desired future for their community, which can as a result reach a higher adaptive capacity that is inherently more resilient and better capable of dealing with unforeseeable climate impacts. The impact of the charrette is twofold. Firstly, the normal social constellations change as community members, with different interests, are connected through new tools for collaboration and exchange. Secondly, the design propositions imply spatial transformations in the city or town.

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Introduction

For a long time, climate change was imagined as a kind of gradual development of increasing temperatures and accompanying characteristics. That image is recently replaced by one of extreme weather events, often occurring without warning (Steffen et al. 2013). Change is not only surprising, it is non-linear, and its representation in graphs looks nowadays more like a staircase than a hockey-stick (Jones 2010, 2011). In response to this new risk landscape (Kahn and Wiener 1967), resilience must be increased in two ways: through planning, and through the introduction of new processes. In dealing with the impacts of climate change current planning practice is rarely flexible enough to include unexpected and sudden change, which will take place at an unknown moment in the future. Therefore, a novel methodology has been developed to increase the adaptive capacity and resilience through spatial planning. This methodology is called Swarm Planning (Roggema 2012a, b) and emphasises a shift from the current technical paradigm, in which every problem is solved in a mechanical fashion, to the organic paradigm, which allows for more dynamic open-ended solutions (Broess 2012; Brouwer 2011). Swarm Planning does not resist change with technical measures but it anticipates it. As an example, the approach is practiced in The Netherlands, in the appropriately named "Building with Nature" projects, which consciously makes use

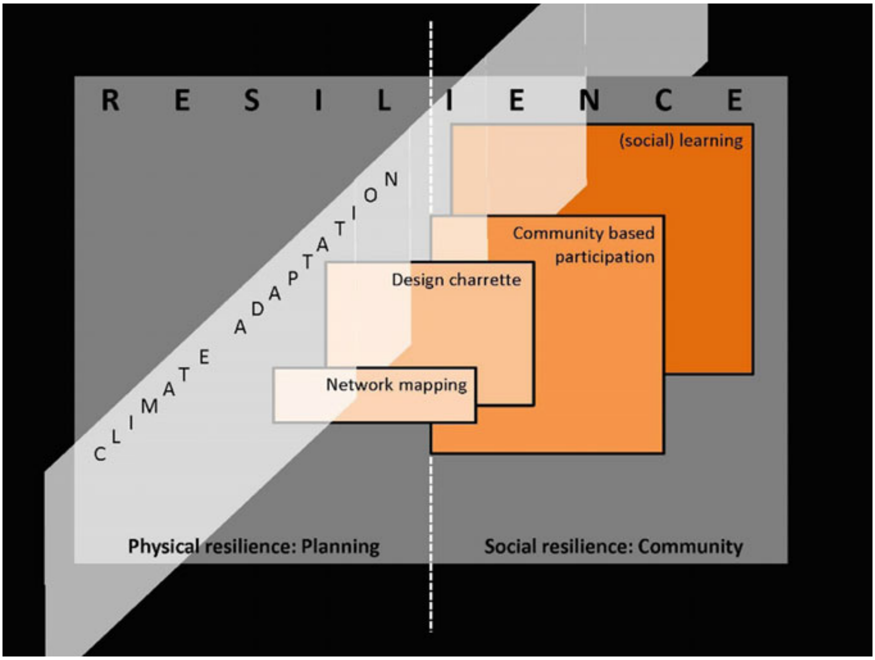

Fig. 21.1 Aspects of social resilience enhancing climate adaptation

of natural processes to improve (coastal) safety (De Vriend and Van Koningsveld 2012) in low-lying delta areas. The approach is based on nourishing rather than fortifying coasts (Inman 2010).

In addition to a new planning methodology there is a need for other processes that increase community resilience through involvement rather than change imposed from above. In this chapter several aspects of community based planning are reviewed and used as a foundation for the successful engagement of communities in design processes. In the design charrette process, community members and local experts are mixed with academics, designers and regional policy makers, and they work together intensively to develop an urban plan or design for a community. The way social learning takes place in community-based participation, and the mapping of social networks, all underpin the successful conduct of design charrettes (Fig. 21.1).

Framing Climate Adaptation

The need for adaptation to climate change is by now a mainstream concept (IPCC 2001). Climate adaptation is here defined as the adjustment of natural or human systems in response to real or expected climatic stimuli or their effects. It is used to moderate harm or to exploit beneficial opportunities (IPCC 2007). For the purpose of this paper, climate change policy is understood to exist between a bottom-up and a top-down approach. Bottom-up when it manages social issues (with a focus on the past and the present), and top-down when responding to physical vulnerability (with a predominant focus on the future) (Dessai and Hulme 2004). Despite the fact that communities are crucial to these definitions, in practice the role for the community when it comes to climate change policy is actually weak. Their involvement in developing policies, contributing to research, or defining their own climate-proof futures (Roggema 2013a) is not extensive, and according to Dessai and Hulme when community is involved it is with a focus on the past and the immediate present rather than on the future.

When it comes to climate change it was long thought that scientists would solve the problem in a laboratory setting. But for the survival of the human race finding solutions depends as much on co-evolution and the power to collaborate (Flannery 2011). The record-breaking weather affecting Australia in recent years (Steffen et al. 2013) suggests the need for innovative adaptation strategies. There is some uncertainty about how to prepare however. Net mean rainfall is estimated to decrease by 6% in Victoria, one of the southern States of Australia and the location of our case studies, where the predicted range of change extends from a 17% decrease to 5% rise (Watterson 2008). In this light, it is expected that very intense bursts of rain will combine with ever more common heatwaves, resulting in longer droughts. Rain will be more intense and concentrated, implying that more extreme droughts, bushfires, heatwaves and flood events will occur more often. Therefore, we need to adapt to these climatic changes through our local and regional planning

(CfES 2012), especially when planning for land use functions that are vulnerable to extreme events, such as water conservation, natural areas, agriculture, and many of the uses that make up the built environment. Apart from adjusting our built structures, we need to adapt ourselves as well (Pijnappels and Dietl 2013). Community action is key to promoting resilience and adapting to the impacts of climate change (CfES 2012). We need to start looking at citizens as scientists. Country towns are, in addition to economic and population decline, under pressure from these increasing climatic extremes (Martin and Budge 2011).

The community itself is the greatest asset and source of potential success in climate adaptation (Beer et al. 2012). In many cases adaptation is not tangible, or it may be hidden in measures taken in other sectors (Pijnappels and Dietl 2013). It is therefore necessary to search for approaches and methods that provide tangible results and involve the community. The authors suggest that one example that fulfils this goal is the practise of design charrettes.

The way communities respond to climate change adaptation depends on the way the issue is framed. It can be argued that climate adaptation is best framed by the theme of social progress, which aims at improving quality of life, and seeking harmony with nature instead of mastering it (Nisbet 2009).

Decision making with regards to climate change adaptation is characterized by uncertainty about outcomes and about cause and effect. Similarly, there are no common objective criteria for judging good and bad adaptation. When social progress is connected to decision-making in this context (Thompson 2003), a strategy of inspiration, characterised by the use of ‘rich picture’ drawing and learning-scenarios (De Boer et al. 2010), is viewed by the authors as the most likely to be beneficial. The analysis and information used in such decision-making is context-specific and as such needs to be embedded in a societal context (Horstmann 2008).

Adaptation can be difficult to address at times. In the context of societies, it is viewed as an outcome, often shaped by technological solutions to environmental challenges. The more measures taken, the ‘better’ the adaptation. However, without a sound understanding of future climate change, it is difficult to judge the soundness of the solutions undertaken today, and difficult to confidently claim good adaptation (Fünfgeld 2012).

Adaptation should be seen as a process. It takes place as a continuous process of learning and institutional change, undertaken in response to new knowledge and changing circumstances. In this gradual process adaptation is dependent on people (Fünfgeld 2012). As a social process it occurs at three nested levels, namely the meta-level of values and beliefs, the conceptual level and the operational level where implementation and decision-making takes place (Horstmann 2008; Fünfgeld and McEvoy 2011). However, these descriptions are biased in that they see the problem as an institutional one rather than a problem to be taken on by citizens. There is little attention to social processes, or co-design, co-development, co-decision-making or co-learning. Adaptation as a social process is not included within the design process. In cases where adaptation does include social process the ‘valve’ of climate change remains closed (Roggema 2012b). This valve can only be opened if adaptation anticipates change instead of reacting after change occurs. The authors contend this is only possible when adaptation is framed as a problem of social progress and the community is involved as citizen-scientists.

Resilience

Resilience thinking (Walker and Salt 2006), and the idea of a resilient city (Newman et al. 2009) are both strongly focused on the mechanics of the system. Core questions are aimed at understanding how natural ecosystems, urban ecosystems and socio-ecological systems function, and look at ways to define and increase resilience. To date, the theoretical framework has not overtly resulted in more resilient cities. The authors contend that concrete, practical directions about how to build a resilient city, even in cases where the metabolism of the city is known in detail, are often lacking (Newman 1999). One reason this might be the case is the emphasis on analysis, and the fact that too much effort is being placed on understanding systems and on functional improvements, rather than understanding the design of the city itself. Urban design, landscape architecture and urban planning are all mostly out of sight when we look to the topic of resilience (Newman 1999). Despite the fact there are many examples around the world, especially in larger cities, where design and resilience planning are done hand in hand, they are few in number and often approached from a sociological resilience perspective.

Defining Resilience

Resilience is also known as adaptive capacity. It is one of three properties of the so-called adaptive cycle and is defined as '*a measure of its vulnerability to unexpected or unpredictable shocks. [Alternatively, it] can be thought of as the opposite of the vulnerability of the system*' (Holling 2001). The adaptive cycle alternates between long periods of aggregation and transformation of resources, followed by shorter periods of uncertainty that create opportunities for innovation. It is proposed by some as a fundamental tool for understanding complex systems, from cells to ecosystems, and to societies.

Ecosystem and social-ecological system dynamics can be represented by an adaptive cycle with two major phases. The first, often referred to as the fore-loop, is defined by a shift from growth or exploitation (r) to conservation (K). It is the slow, incremental phase of growth and accumulation. The second phase, referred to as the back-loop, is defined by a shift from collapse (Ω) to reorganisation (α). This is the rapid phase of reorganisation leading to renewal.[1] The α-phase is important for

[1] www.resalliance.org/index.php/adaptive_cycle.

the resilience of the system (Holling 2001) and is especially important when a system needs to reconfigure during times of crisis or stress, such as might be expected by the impacts of climate change or disaster.

A more straightforward definition of resilience is '*the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks*' (Walker et al. 2004; Walker and Salt 2006). Importantly, this definition includes the ability to learn from disturbance.[2] Generally, resilience is seen as a property of socio-ecological systems, allowing the system to bounce back and recover from an external shock. Adaptability is the capacity of actors to influence resilience (Walker et al. 2004). The collective capacity to manage resilience determines whether the actors can successfully avoid crossing into an undesirable system regime or, if necessary, return to a desirable one. The question is, however, whether these principles can be applied to the design of a city? To a certain extent, the answer is yes. It is beneficial to include biodiversity, clean water and more inclusive social environments in city design. But do these features still function during a disaster, when risk becomes uncertain, or in the case of extreme climatic events[3] (Defra 2012)?

Building resilience is essential in times of crisis. Ecosystems tend to enter a path of turbulent change when they are over-managed for stability (Peterson et al. 2003), and the process seems to accelerate under stress. More to the point, if we keep focusing on the resilient city as an urban area with mechanical sustainability 'features', the question may be raised whether the city can adapt to future climate impacts and whether the city is really resilient at all. In light of the dangers of focusing on stability as a solution, a city might be better off if it were able to constantly change its shape under the influence of external shocks, able to relocate urban components when necessary. Such flexibility can be referred to as functioning like a swarm (Roggema 2012a). We probably don't know yet how to build these cities, however, some of our current knowledge offers hints. Such a city would need to increase its diversity and modularity, contain (tight) feedback sensitive structures (Walker and Salt 2006, cited in Pisano 2012) and include a certain amount of redundancy in terms of functions (Ostrom 1999). These properties would contribute to the resilience of the city, and highlight the potential flexibility and adaptability of (urban) built environments and communities. *Redundancy* provides the city with free space for new functions to emerge, *diversity* multiplies the differences in objects, allowing the city to transform in a modular way. *Modularity*, affords urban objects the ability to move and easily connect and disconnect from each other. Finally, tight *feedback* allows urban objects to mutually react quickly to one another, developing self-organisation and optimizing its form according to change needs. These properties could be seen as a preliminary set of guiding principles that ultimately lead to the creation of Dismantelable Cities, in which

[2] www.resalliance.org.

[3] www.kpmg.com/au/en/issuesandinsights/articlespublications/australia-report/pages/risk-landscape-2012.aspx.

urban objects can be moved around to their most optimal location as climate impacts bring about new conditions. The authors contend that in this way resilience could be increased (Roggema 2013b).

Learning

When (eco-) systems are managed for stability, they tend to end up on a pathway of turbulent change (Peterson et al. 2003). The same is true for governance systems. It places the scientist as one of several actors in the learning and knowledge generating process, alongside local groups and others (Kates et al. 2001). In this context, a crisis seems to trigger learning and knowledge generation, and opens up space for new management trajectories (Westley 1995).

Framed as a goal to be pursued through adaptive co-management, resilience building has the potential to change mind-sets and challenge the status quo. It can do so by taking a systemic, whole-systems perspective and by embracing experimentation. It is important to point out that in spite of being embedded in an understanding of systems, resilience is also local in focus (Wilkinson 2011) as well as regional in its analysis (Polèse 2010). Local groups have long recognised the need to coexist with gradual or rapid change (Folke et al. 2005). Typically this is done by developing robust adaptation strategies that take advantage of change, and if possible, turn them into opportunities for development (Carpenter and Gunderson 2001). Local groups may evoke, survive or follow change (Berkes and Folke 2002). Learning is a key part of that process.

According to Folke, Colding and Berkes, dealing with socio-ecological dynamics during periods of rapid change and reorganisation requires four capabilities, namely: (1) learning to live with change and uncertainty, (2) combining different types of knowledge and learning, (3) creating opportunity for self-organisation towards resilience and (4) nurturing resources for renewal and reorganisation (Folke et al. 2003). Batterbury suggests a fifth requirement, in the form of adaptive learning (Batterbury 2010). In a similar way, there is also a need for adaptive governance, which connects individuals and institutions at multiple levels (Swanson and Bhadwal 2009). These have the potential to self-organise and emerge as flexible community-based systems that are tailored to specific places and situations, simultaneously inclusive of different organisations and levels of governance.

If change is to be managed, one important goal for meeting that task might be thought of as the development of a kind of ‘new order’. However, to invent, and reinvent, a meaningful new order it is important that multiple ideas be treated seriously regardless of their source (Westley et al. 2002). In a way, this is an act of learning, and can be viewed as a social process (Lee 1993; Clark et al. 2001; Wildemeersch et al. 1998) for which trust building is a prerequisite (Hahn et al. 2006). In such a process the expertise and skills of ‘ordinary’ people are extremely useful (CfES 2011), but perhaps difficult to capture. It has been shown however that

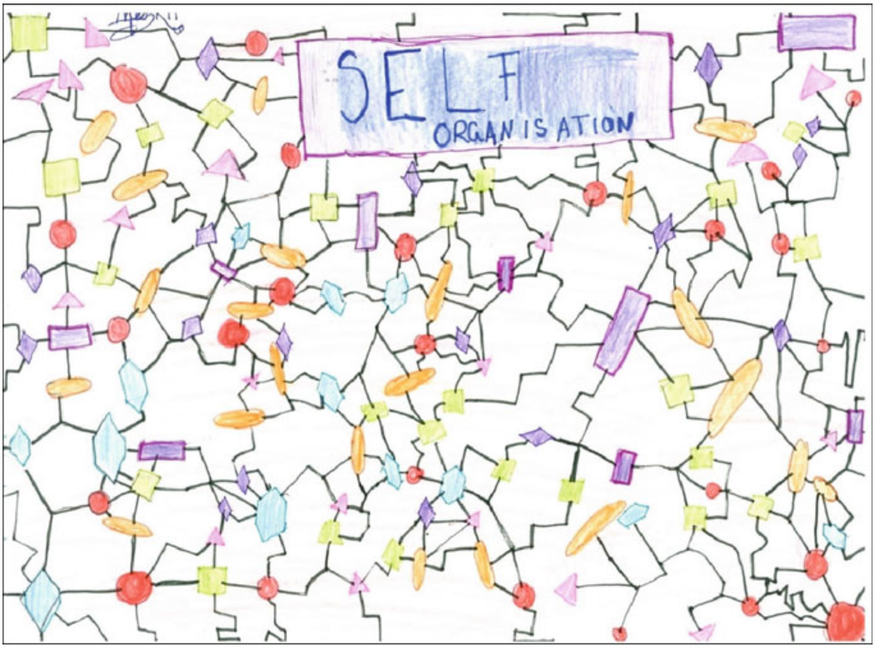

Fig. 21.2 A visualisation of self-organisation (drawing © Inez Roggema)

the use of scenarios in a workshop attended by community members can be useful to overcome that hurdle. Additionally, such a setting offers a platform for social learning to take place. It creates the opportunity to build and strengthen relationships within the community and outside it, enhance participants' understanding of outside perspectives, and trigger systemic thinking (Johnson et al. 2012). Ultimately it is also an opportunity for institutions and their leaders to enhance adaptive capacity and community resilience at the same time (Keys et al. 2013).

It is by now understood that in order to build collective resilience, communities must reduce risk and resource inequities, engage their own local populations, create organisational linkages, boost and protect social support, and '*plan for not having a plan*'. These ambitions require flexibility, decision-making skills, and trusted sources of information that can function in the face of the unknown (Norris et al. 2008).

Vos offers the following core conditions for effective self-organisation (see Fig. 21.2) (Vos 2013):

1. Self-organisation requires a strong sense of common identity, meaning or purpose. These provide a direction to the behaviour of individual agents and to the behaviour of the system overall. Identity is the key 'boundary' that provides containment for the complex of individual drives and actions and enables

commonality and purposefulness to exist amidst conflicting forces and ambiguity.

2. Effective self-organising systems have a rule that governs the way individual agents relate and interact. This 'rule' is not designed but emerges from the system's behaviour itself. In nature and in large social systems this is an emergent process in which rules are 'codified' or reinforced when they improve the system's chances to achieve their purpose or maintain their identity.
3. Self-organisation requires information to flow freely from where it is available to where it is needed. Each individual is able and 'allowed' to act on local information immediately and autonomously, adjusting behaviour in line with a common purpose and identity. Individual people and organisations need to have explicit and full permission to act locally based on local information combined with their best intent to help achieve overall purpose and individual meaning.

With this in mind, if we return to the topic of learning, it is important to consider the 'depth' of the learning that occurs (Homan 2001). Referring to Conant and Ashby's '*Law of Requisite Variety'* (Conant and Ashby 1970), Homan identifies three levels of learning. The first level learning or '*Framing*' refers to applying current views to a task or problem. The second level of learning or '*Reframing*' involves exchanging views and generating a shared set of new and richer views. A continuous and cyclical process of challenging existing views on an ever-fundamental level is called '*breaking the frames*' (third level learning).

(Homan 2001). According to this theory, for wicked problems, and in periods of crisis or rapid change, the third level learning is needed. In this approach, collective and individual learning needs to occur at the same time in an iterative manner, such as can be found in the Kolb cycle (Kolb 1984). These ideas are summarized in Fig. 21.3, which shows how learning objectives and delivery can be applied as complexity increases.

The highest degree of complexity is collaborative learning. In that case, relevant knowledge is present in all members of the learning setting, in both 'facilitators' and 'learners'. There is no single right answer, and no differentiation between 'experts' and 'non-experts'. Knowledge is created in a collaborative process, which is characterised by self-organisation that encompasses multiple connections and interactions between all group members. Learning in this case is of the '*breaking the frame*' type. Novel but effective behaviour comes from the development of a new, shared set of meanings that is only possible with a diversity of perspectives.

This approach is particularly difficult because it challenges current mental models and belief systems, and makes use of the input and commitment of many stakeholders, some of whom may not normally be empowered in the decision making process. To complicate things further, the process is neither conclusive nor linear. This means that the actions taken as a result of the Collaborative Learning process will continually need to be re-assessed and new ideas will need to be developed and applied as the situation changes.

These highly complex learning processes imply an adjusted relation between citizens and policy-makers or scientists. That is, value creation takes place for both

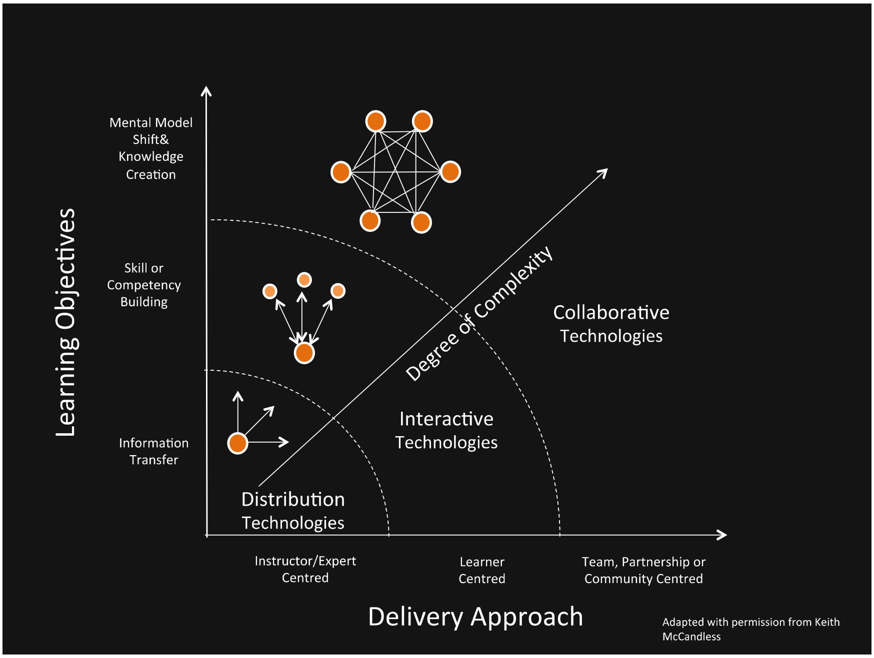

Fig. 21.3 Learning at three levels (Vos 2013)

the society as a whole and the citizen at the same time (Paraphrasing Staub 2012). This is a process of co-creation through every phase of development and realisation (Sanders 2006): when a project is initiated (creating), designed (making), realised (adapting) and used (doing). Each phase has its own type of co-creation ranging from contributing creativity to making and producing things, developing ownership or getting something done.

If we accept that breakthroughs in technologies and implementations are required in order to manage climate change then it may also be necessary to accept that such breakthroughs will only occur if high-level learning becomes the norm. This approach can also be defined as an *open distributed innovation strategy* (Milford et al. 2008). In this strategy new, rapidly scalable, and powerful technologies are assumed to be the core requirement in order to change the game. Open source approaches (and funding) are seen as the way forward, emphasising the contribution of unexpected outsiders and ordinary citizens, freed of established institutions.

In this way climate adaptation has many similarities with the processes of organisational (or social) learning. Two of the more challenging examples include the weakness and ambiguity of signals that urge for change, and the uncertainty about what benefits come from implementation of any of the ideas put forth (Berkhout et al. 2006).

Networks

Complex problems cannot be solved by scientific means alone. Salter, Robinson and Wiek argue that a model where knowledge is co-developed, and where stakeholders work together, is a productive avenue to follow in order to manage the challenge (Salter et al. 2010). Their model is particularly valid because it embraces key characteristics such as reflexivity, flaunting of institutional boundaries, an extended peer review group, and a focus on the process. Learning of the highest complexity is a requirement of this model. If inter-organisational networks followed this model they might become characterised by trust and mutual adjustment. They might become autonomous and as a result replace govern*ment* with govern*ance*. In such a case measurements of effectiveness would change. For instance, Rhodes suggests that efficiency in governance relies on self-organising networks that deliver services once provided by a centrally lead government (Rhodes 1997).

The '*Community based participation*' model (UNDP 2008) has the potential to manage risks and vulnerabilities, and can contribute to climate change adaptation at the local scale (Van Aalst et al. 2008). Public inclusion in policy is not a simple bottom-up approach that leads to decision-making, but a constructive combination of approaches within which there is room for expert-led-discussions and creative brainstorm sessions. These come from a well-deliberated starting point where the parameters for decision-making are clarified. The inclusion of a good mix of people and the legitimacy of the inclusion process are essential factors for public involvement if the process is not to become an illusion (Few et al. 2007). '*Communities of participation'* can be created in which the political, technical and local/experiential domains are represented, appreciating one another's perspective, and working together to address problems. The challenge is not to build a venue where the public can participate (this implies a privilege of the political or expert domain), but to create experience-based methods for engaging with the political and the expert domains (Feldman and Khademian 2007). If this can be achieved people can make sense of global change (Bush et al. 2002) and if impacts are demonstrated at local, and familiar locations (Lindseth 2005), the public will become more mobilised. This is an opportune role for network management, which mediates inter-organisational policymaking (Klijn and Koppenjan 2000), and which assumes actors to be mutually dependent.

The aim of increasing the adaptive capacity of a community or an area must contend with the uncertainty of future climate impacts. This means that we need to understand where and how this capacity can be increased. Network analyses offer the opportunity to identify optimal locations to improve the adaptive capacity. For physical networks, such as the energy grid, the water system, transport networks or ecological systems, specific places in the landscape can be identified (Roggema and Stremke 2012). In combination with the mapping of climate impacts, such as floods, bushfires and others, climate adaptation measures can have the largest effect. The social side of increasing adaptive capacity is often served through capacity building exercises and programs. However, these programs are often directed at random people or groups that are already convinced of the purpose of the exercise. Identifying people with access to social capital is not a specific objective. Still, it is important. One example is the Resource Generator (Van der Gaag and Snijders 2005), which aims to chart people, according to four domains (prestige and education, political and financial skills, personal skills and personal support) that point at stronger relationships and access to social capital. This is an important part of the puzzle, as access to essential resources is easier to take advantage of if connections are stronger, and the resources are more prevalent, visible and appropriate. Finally, people with access to key resources open ways to accessing other resources. If this work is taken one step further and linked with climate adaptation challenges, the Resource Generator could become a geographical mapping tool that highlights where the strongest relationships and easiest access exists. A map built from that information could then be linked with physical objects that are important when dealing with climatic hazards, such as fire stations, the office of the risk management authority, or the rescue station, and an image could be derived that shows where the adaptive capacity of the community is highest in a holistic way. This then could be used when a community aims to identify locations for new housing, social amenities, industries or infrastructure in order to deal with uncertain climate impacts.

Design Charrettes

Learning from these different ontologies when dealing with climate impacts in order to increase the resilience of the socio-ecological system, adaptation is seen as a social learning process, one that is locally based and operates across multiple scales, with multiple actors and institutions. It does not include design as a tool to deal with wicked problems (De Jonge 2009).

This is a significant gap. Design is a process of creating options, rejecting parts, reconstructing and shaping. It is well suited to deal with wicked problems that do not know a single, definite answer (Rittel and Webber 1973). Using design in a collaborative process is extremely helpful to allow participants to contribute and examine the problem from various perspectives. The design charrette is a specific process that in particular uses these features in a practical way (Lennertz and Lutzenhiser 2006; Lindsey et al. 2009). It is a good example of the much-needed inter-organisational innovations discussed above. In dealing with wicked problems and rapid change, the organization of a design charrette needs to comply with a set of conditions (Mandell and Steelman 2003):

- The perception of the problem. Are participants committed to the goals of the organisation they come from or the goals that are/might be adopted by the whole group;

- The intensity of linkages, whether they are existing or develop during the 'operation'. Do people feel linked strongly to their home base or organisation, or are they open to freely building new linkages?
- The breadth of effort. Is participation limited or comprehensive? This includes a perceived judgement about who is required to participate and trust about which participants can be relied upon;
- Complexity of the purpose. Is the process about a simple exchange of information or about complex and interdependent problem solving?
- Scope of effort. Is there commitment to maintain the status quo, or to foster a system change?

The following list shows the known impediments for implementing new strategies of policymaking in response to crises. It also indicates which challenges exist in opposition to the goal of implementing horizontal modes of governance through network management (Termeer 2009):

- Conflicting convictions about what good policy making comprehends: once a particular pattern becomes stabilised, alternatives are even harder to be validated as good or relevant (Hosking 2004);
- Stereotyping partners: all new actors from outside the inner circle are stereotyped as incompetent;
- Framing the situation. For instance, when the process is framed as a crisis, or if there is a strong deadline, it is common to fall-back on old assumptions and habits;
- Fear of undermining existing policy. In horizontal policy making it might happen that negotiations with other stakeholders come under pressure. This may turn into fear and inaction because other targets might be not met;
- Cover up strategies. These strengthen barriers by not showing doubt, by hiding internal struggles, and avoiding the potential of disappointments (Argyris 1990). This implies the cutting off of learning and reflection, and negatively impacts trust.

In response to these impediments, the charrette offers an intensive design-based way to empower local expertise. In the design charrette process community members and local experts are mixed with academics, designers and supra-regional policy makers. As a group these people design and model the desired future for their community. As a result of the open collaborative effort the community has a good chance of becoming more resilient and better capable of dealing with unforeseeable climate impacts. The charrette's impact is twofold. Firstly, the development of new avenues for collaboration and exchange between community members with different interests leads to changed social constellations. Secondly, the design propositions imply resilient spatial transformations in the city or town. There might be less positive outcomes of design charrettes, for instance when they are experienced as a multi-day event of talking without achievement, but our experience is that when the right in-depth and even confrontational questions are initial parts of the design process, the quality of the design is not only built on community support, but also delivering quality spatial designs responding to urgent urban design questions. Therefore, the conditions for conducting design charrettes need to be of a high standard. In conducting design charrettes, Condon (2008) defines nine general rules for a good process. The most significant are:

1. Design with everyone. Despite the fact that becoming a designer requires training and very specific skills, the design process as it is practiced during charrettes is integrative and allows a variety of possible solutions. This is partly an intuitive and judging activity, which makes it accessible for many individuals. Everyone is a designer;
2. Start with a blank sheet: If the group of participants is standing around the table, on which a large map of the site is laid down, the simple action to overlay this map with a blank piece of transparent paper will do. The invitation and the challenge lie before all. Everyone is invited to fill in the future and a shared vision will, in the hours to follow, fill the previously blank paper;
3. Provide just enough information: Too much information causes decision paralysis and too little produces bad proposals. Just enough is mainly arranged through the expertise of the participants and will be provided during the charrette in a concise and accessible manner (maps, schemes);
4. Drawing is a contract: All drawings produced during the charrette embody the consensus as experienced and achieved by the charrette team. They form a well-understood agreement, or contract, in images amongst the group. The drawings cannot be broken without consent of the group and function as such as a very strong commitment.

Building on this starting point, it is useful to add that a design charrette for climate adaptation must be organised as a process of social learning, in which a variety of people feel free to participate and bring expertise, experience and knowledge. It is also important to be aware that in addition to the core ideas above, specific characteristics can make or break a charrette.

First of all, the venue is extremely important. It adds extra meaning to the charrette when the location is linked to the problems discussed and the venue is inviting participants to start discussions and triggered to design.

Secondly, the role of charrette leader is an important issue. As a charrette leader it is very easy to start working along, to come up with ideas and, if you're a designer, to start designing. This all prevents participants from feeling free to contribute. Therefore, the charrette leader must limit himself or herself to creating space for participants to contribute their own designs and ideas, and to keep track of the time;

Thirdly, the input, the working methods and the outputs all need to be visual. Before the start of the charrette climate impacts and landscape analyses are spatially represented through maps, schemes and diagrams. Visual representations climate change (Barker 2003) help to conceptualise the problem, identify potential feedback, and communication between disciplines.

Currently an important gap is the lack of mapping that reveals the adaptive capacity of people in their communities. As discussed earlier, the design charrette process could benefit enormously if access to social capital could be mapped, making use of and extending the Resource Generator (Van der Gaag and Snijders 2005). During the charrette the majority of the work takes place on maps in the form of sketching, drawing, and building models. These results are then, after the charrette, taken as the basis for creating integrative maps that have meaning for the participants.

Fourth, the following steps are key in a design charrette and have proven beneficial in practical application by the authors: an official welcoming speech, the 30–30 exercise,[4] sketching at the regional/landscape scale and the local scale, building a plasticine model at the intermediate scale, and preparing a final presentation.

Finally, experiences with design charrettes have shown that involving primary school children is extremely fertile (Roggema et al. 2012a). Not only do these children have extraordinary ideas, they are also the people that actually will live with their own designs, or the lack of the same. This is generally not the case when professionals or adults are designing. Moreover, the exchange of ideas between adults and children proves to be very productive and opens up the sometimes constrained minds of adults.

The core elements that determine the success of a design charrette can be derived from several charrettes conducted recently in Victoria, Australia (Roggema et al. 2011, 2013). The design charrettes in Bendigo and Sea Lake (Clune et al. 2012; Roggema et al. 2011; Roggema 2012b) have been very successful in harnessing local expertise for climate adaptation planning. Some important points gleaned from these experiences include:

1. People. Potential participants, especially the ones that you really want to appear at the charrette, have busy schedules and tight agendas. Therefore, it is essential to communicate the importance of the charrette, do so well in advance, make the charrette as short and convenient as possible and approach each individual personally beforehand.
2. The Right Mix. With people, it is not about quantity. The strategic key-players in a community, the charismatic group-thinkers, and the specific experts in the field are critical in creating a successful team. Intense discussions, with people who know the local context well, help to pre-select the right mix of people.
3. Support. Local authorities are often busy within their own procedural frameworks and the organisation of a design charrette is something that lies outside the core business of a local council. Therefore, it is essential to safeguard beforehand the support of the local authorities. Often, it is necessary to reconfirm this support along the way. To have personal contacts within the organisation does help to enlarge the supportive base.
4. Time. Potential participants are on a tight schedule. Therefore, it is recommended to organise a short and intense event rather than one spread over a

[4]The 30–30 exercise is asking participants to look back 30 years in history and describe how technology, social aspects, technology and climate appeared, describe the present situation and imagine how these themes would turn out 30 years in the future.

longer period. If the event is short, it increases in intensity and this will lead to keen interest in the results.

5. Reason. A charrette does need to make sense. A purposeless event misses all the goals. In order to let the charrette, play a role in the day-to-day projects and planning processes, the content and especially the outcomes of the charrette must be linked to requirements that are asked in the regular processes. Only if this link is safeguarded the charrette is able to solve a problem.
6. Atmosphere. The place in which the charrette occurs is important, because in a relaxed, but serious environment people tend to perform best. Therefore, a special venue as well as space to "lean back contributes to a pleasant atmosphere. Enough time for (locally produced) lunch and dinner will also support the working environment.

Conclusion

In striving to increase the resilience of a community, and likewise in aiming to enhance the adaptive capacity of a community under the impact of uncertain and unprecedented climate change, deep learning is necessary. Within such learning, transformative processes are also required. Such transformations are necessary to manage the new type of problems we expect to face. In this chapter we conclude that wicked problems, which do not know a single solution, can best be approached with a community-based adaptive learning process. The design charrette is capable of overcoming every-day barriers and practical problems such as the natural '*closing of the ranks'* behavior that happens in many governmental and other organisations. Such behavior can easily stand in the way of innovative, ground-breaking solutions and needs to be purposefully overcome.

The design charrette delivers tangible results in the form of spatial plans and visualized futures that emerge from a collaboration between the expertise and ideas of citizens in combination with academic understanding of the problem. This is a locally-oriented and specific approach, given the fact that climate problems require local adaptation. It acknowledges explicitly that the ideas and contributions of local citizens are not the same from community to community. Finally, the special input from the ones that will ultimately live in their own designs, namely the children, is of high value and a potentially underestimated contribution.

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Chapter 22
Solar-Based Decentralized Energy Solution—A Case of Entrepreneur Based Model from Rural India

Manjushree Banerjee, I.H. Rehman and Jitendra Tiwari

Abstract In India one of every three rural households depends on kerosene based lighting systems that are characterized by low illumination and hazardous smoke. Given the existing and foreseeable gap between demand and supply, universal modern energy access can only be achieved in the short to medium term through a combination of grid and off-grid approaches. The paper presents a case study of solar photovoltaic based micro-grids (generating 75 W–1 kW) used to meet basic lighting requirements of 30 rural communities during peak demand hours (6–10 pm). The communities have adopted micro-level solar-based off-grid systems, which are owned and managed by local entrepreneurs with a 45% equity stake. Case study analysis of this project, in the state of Uttar Pradesh in India shows that:

1. Grid-connected (and even unconnected) rural communities without assured lighting offer a latent market for decentralized alternatives.
2. Access to finance networks at the local level facilitates private investments in off-grid solutions.
3. Technology innovation and customization is necessary for customer satisfaction and management efficiency.
4. Affordable off-grid solutions based on solar energy can be an economically viable and socially acceptable alternative to fossil fuel systems.

Analysis of the project output concludes that decentralized solutions and private investments can play a major role not only in providing universal modern energy access but also in enhancing livelihood options at the village level.

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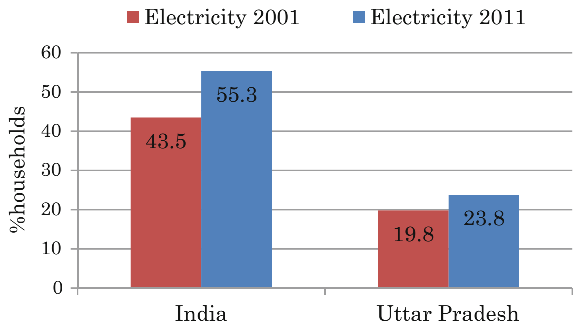
Introduction

Electricity is one of the enabling factors of macro and micro development: a non-negotiable factor of industrial production as well as a salient element of comfortable daily life (Anne Welle-Strand 2011), a factor enabling functioning in society, contributing to poverty alleviation (Kemmler 2007), and crucial to human well-being as well as a country's economic development (International Energy Agency 2011). In spite of all these needs and benefits, 1.5 billion people worldwide have no access to electricity and another billion more have access only to unreliable electricity networks (The Secretary-General's Advisory Group on Energy and Climate Change (AGECC), 28 April 2010). AGECC called on the United Nations member states to commit themselves to two complementary goals; universal access to modern energy supply by 2030 and a 40% reduction in global energy intensity.[1] The goal includes the provision of a reliable and affordable basic minimum threshold[2] of modern energy services for both consumption and production (The Secretary-General's Advisory Group on Energy and Climate Change (AGECC), 28 April 2010). The goal also mentions that the access gaps are to be bridged in a way that is economically viable, sustainable, efficient, and releases the least amount of greenhouse gases (GHG).

Similar targets for improving access to electricity exist at the national level in India under the "Power for All" program and *Rajiv Gandhi Gramin Vidutikarn Yojna*, where free connections are to be provided to 17.5 million rural households living below the poverty line. Bangladesh has a Master Plan for Electrification aimed at universal access to electricity by 2020. It is to be achieved by passing loans and grants to the Rural Electrification Board. Targets for achieving 100% electrification or access for more than 90% of the population are reflected in programmes and plans at the national level around the world. Examples include "Light for All" in Brazil, the National Electrification Scheme in Ghana, the National Energy Management Programme in Indonesia, and the Rural Electrification Programme in Nepal, the Philippines Energy Plan, the Integrated National Electrification Programme of South Africa and the Rural Electrification Master Plan in Zambia (International Energy Agency 2011). The approach towards reducing energy inequality needs to consider the right mix of centralised and decentralised approaches, particularly for rural and remote locations where grid extension may not be viable or beneficial due to substantial demand and supply gaps (Rehman et al. 2012). Global and national targets both call for a combination of grid and off-grid solutions to address the existing supply and demand gaps.

[1]Energy intensity is measured by the quantity of energy per unit of economic activity or output (GDP). The term used in the report is energy intensity and we should use the same term.

[2]The lowest threshold is proposed by International Energy Agency (IEA) is 100 kWh per person of electricity and 100 kg oil equivalent (kgoe) of modern fuels (equivalent to roughly 1200 kWh) per person per year.



Source: Census of India, 2011

Fig. 22.1 Percentage of households reporting electricity as source of lighting in rural India and rural Uttar Pradesh; 2001 and 2011

In this chapter, the case of a renewable energy based, off-grid system is discussed and analysed in terms of the pathways identified (such as; affordability, reliability, technology, efficiency, adoption, and sustainability) to achieve energy access goals. The exploratory and illustrative functions of the case study method are used in order to improve understanding of the dynamics of the approach and its outputs in order to formulate more general considerations. The off-grid system discussed in this case study provides clean and reliable lighting to the households and commercial establishments in rural areas of Uttar Pradesh, which currently has a dense population but poor access to electricity. The initiative to provide basic lighting through solar based decentralized systems owned and operated by local level entrepreneurs is conceptualized and implemented by The Energy and Resources Institute (TERI) and supported by the Norwegian Ministry of Foreign Affair (MFA).

Electricity supply in the majority of rural areas in India is either of poor quality or/and unreliable. 289 million people, accounting for about 25% of the population, are without access to electricity (International Energy Agency 2011). 73 million (43.2%) rural households and 35 million (5%) urban dwellings depend on kerosene based lighting systems that are characterized by low illumination and unhealthy smoke (Census of India 2011). 16.5% of India's population resides in its most populous state: Uttar Pradesh. According to the Census of India (2011), among the 25.5 million rural households in Uttar Pradesh, 75% depend on kerosene for lighting and only 24% households reported electricity as the primary source for lighting. Figure 22.1 indicates that in the past decade (2001–2011) the increase in the proportion of households in rural Uttar Pradesh reporting electricity as source of lighting is much lower than in rural India as a whole.

Framework and Approach

It is usually argued that renewable energy contributes to the sustainability of a specific territory by providing a range of social, economic and environmental benefits (Del Rıo 2009). Sustainability indicators for renewable energy systems have been identified and assessed in literature wherein the indicators broadly include cost factors, technology limitations, resource usage and social impacts (Evans 2009). At the scale of a community or an individual, the complex intersection of renewable, decentralized power generation and sustainability demand the creation of a business model coupled with cost affective and customized technology options. In addition to financial and technological effectiveness, one of the major drivers for success of any renewable energy based system depends on the ability of the technology to adapt to changes in the pattern of energy use (Alvial-Palavicino 2011).

Developing a Participatory Approach

Kaygusuz (2011) also suggests that policies, programmes and projects should start from an assessment of people's needs rather than a plan to promote a particular technology as the needs of different rural communities vary widely, and finding appropriate technologies and effective implementation strategies can be very site-specific. Community meetings were organized in about 50 villages across six districts in Uttar Pradesh to understand the energy needs for domestic and economic purposes. 48 among these 50 villages were already electrified.[3] The supply scenario in all these electrified villages was analogous: villages suffered regular power cuts from 5.00 to 9.00 PM as the supply was diverted to industries and urban areas. The households and other establishments concerned thus received electricity for barely 7–8 h a day.

A broad assessment of livelihood patterns was also carried out during these community meetings. Rural livelihoods in these villages are categorised as; (i) agriculture and allied activities, (ii) non-agriculture based rural industries (such as handloom weaving, pottery making and other handicrafts), and (iii) service sector shops and establishments that support the rural economy. Many of the production and processing entities have alternate arrangements for lighting such as inverters (high capital cost), diesel generators (creates environmental hazard due to inefficient diesel combustion as well as becoming a target for kerosene theft), petro-max lamps (high operating cost of USD 0.2/day) or battery operated lights (inconvenient as batteries need recharging every other day). These are needed in order to continue operating as a business during evening hours. Electricity was demanded primarily for lighting rather than for production or for agricultural purposes. Many of the commercial entities are forced to close during evening hours due to lack of electricity for lighting. In this context, community meetings and assessments identified lighting during evening hours as the most prioritized energy requirement.

[3] A village is declared electrified if 10% of the households are electrified.

Selecting a Technology Option

A compilation of case studies on renewable-based distributed generation implemented in India concludes that small scale power systems are likely to be more efficient and cost effective (Hiremath 2009). TERI developed and installed solar powered Direct Current (DC) micro-grids at 30 sites in rural Uttar Pradesh. The solar micro-grid technology meets the specific energy demands of smaller segments of a community (10–100 households or shops). The capital cost for transmission is reduced significantly as the power generation and distribution points are within the radius of one kilometre. Further, the entrepreneur has the flexibility to make appropriate changes in the system based on the demand of the community.

In this model, photovoltaic power panels are installed in modular units, thus allowing the generation capacity to scale up easily to meet community demand. Power generated during the day charges battery banks, and the power is distributed over a short distance to a cluster of households or shops (each cluster comprising between 10 and 100 households/shops/production units) within the village. Each household or shops is provided with one or two LED lights, which consume very little energy per connection and therefore reduce the need for large quantities of power. Low voltage DC electricity is distributed for 4–5 h each night to power the LED lights, these systems are installed in both electrified and un-electrified communities.

In the electrified villages, the system provides clean, quality lighting during evening hours. In the un-electrified households, the system is the only means for providing such lighting. The lights provide far superior illumination than kerosene, and at a comparable cost. The duration of electricity distribution can be tailored to match local demand. Use of solar energy eliminates all fuel supply needs. Previous experience with solar-powered micro grid installations indicate 325 sunny days (5.5 average sunny hours in a day) in a year can be expected in Uttar Pradesh. The approximate minimum daily solar radiation for Uttar Pradesh is estimated as 4.980 kWh/m^2 (Parekh 2011).

The batteries are to be replaced after every 4–5 years. One of the major advantages linked to DC grids is reduced power theft without the need for close monitoring. The majority of households use Alternate Current (AC) compatible appliances, and so the energy can only be used to power the LED lights or other DC based appliances; ultimately this leads to reduced monitoring by the operator. Over-usage of power by the end users is one of the major problems faced by AC-based micro-grid operators (Fig. 22.2).

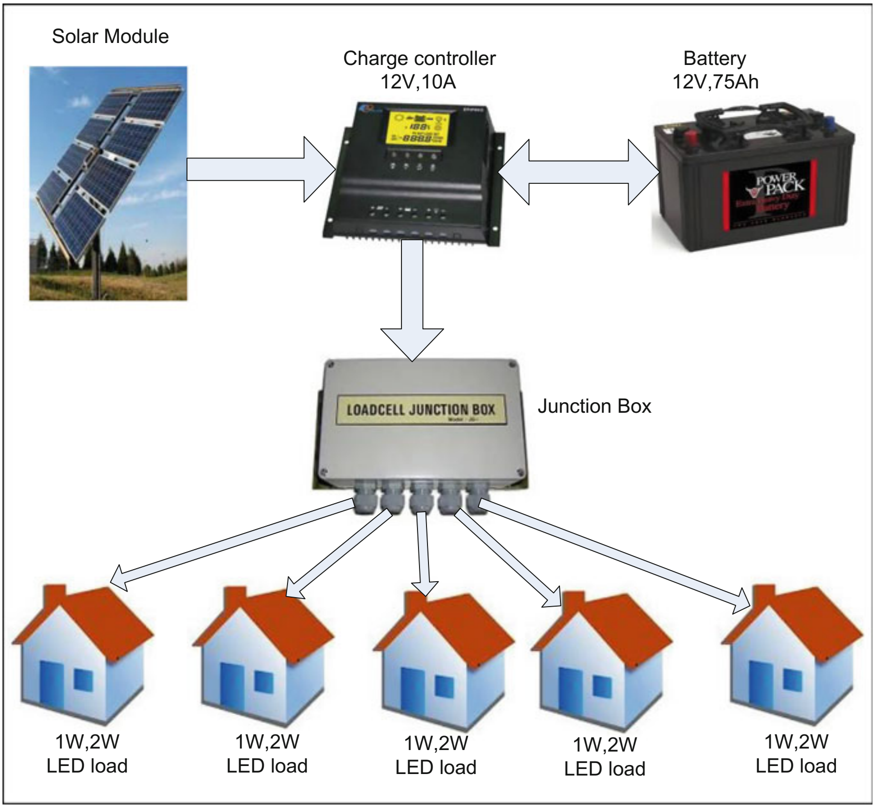


Fig. 22.2 Schematic for a DC based solar micro-grid

An Entrepreneur-Based Approach

Sustainability and affordability was the core mandate of the initiative. At the next level, local entrepreneurs and village *panchayat*[4] were approached and interviewed to understand their interest level, investment capacity, and ability to operate and maintain solar micro grids. Only one village *panchayat* and 29 entrepreneurs had both an interest and capacity to invest and operate a micro-grid. The system capacities and number of connections were defined based on the investment capacity of the entrepreneurs as individuals. In the project the entrepreneurs are called "*Energy Providers*".

The baseline survey captured quantitative and qualitative information such as willingness to pay for the LED based lighting facility, the existing power scenario, and lighting needs of the community, which were used to estimate income

[4]A body serving in an administrative capacity at village level.

Table 22.1 Solar micro-grids: investment and revenue

System capacity (Wattpeak, Wp)	System and installation cost (USD)	Cost per Wp (USD)	Energy providers share (45% of the total system and installation cost) (USD)	Annual revenue (USD)	Break even point (Year)
75	505.30	6.40	227.52	303.36	Year 1
150	1043.48	7.31	469.65	605.80	Year 1
300	2098.85	7.31	944.80	1186.03	Year 1
400	2438.77	6.40	1097.41	1211.62	Year 1
600	3883.39	6.40	1747.06	2423.24	Year 1
800	5230.24	6.40	2353.78	2978.79	Year 1
1000	6084.57	6.40	2737.56	3029.04	Year 1
Average	3040.66	6.66	1368.26	1676.84	

Note Based on the conversion rates as on April 2, 2014, INR = 0.0167566 USD, 1 USD = 59.6778 INR

generation. The baseline also captured details of employment and employability patterns, energy use patterns, income security, education and asset ownership. The objective of the baseline was twofold; first to decide on system capacity and a business model, and second to develop a detailed impact assessment model.

Based on the primary occupation of the end users, sites were categorized as (1) shops and establishments, (2) handloom weaving units, (3) handicraft units, and (4) household and poultry units. Shop owners expressed a willingness to pay in the range of USD 0.08[5] to USD 0.13 per day for the lighting while other units, including households, were willing to pay a maximum of USD 0.08 per day. With this in mind, cash flows were calculated based on a usage charge of USD 0.08 per day. In two rural market-places the micro-grid replaced diesel generators, where usage charge was USD 0.15 per day in order to have lighting for 4 h each evening.

Cost Sharing

The average system and installation cost per Watt peak (Wp) was calculated as USD 6.66. (Please refer Table 22.1 for total system and installation cost). Jawaharlal Nehru National Solar Mission[6] (JNNSM) provides a subsidy of USD 2.51 per Wp for the installation of solar-powered decentralized generation systems,

[5]Based on the conversion rates as on April 2, 2014, INR = 0.0167566, USD 1 USD = 59.6778 INR.

[6]Jawaharlal Nehru National Solar Mission is one of the eight National Missions which comprise India's National Action Plan on Climate Change. It has the twin objectives of contributing to India's long-term energy security and its ecologically sustainable growth. The Prime Minister launched the Jawaharlal Nehru National Solar Mission on 11th January, 2010. The Mission is implemented in 3 stages leading to an installed capacity of 20,000 MW of grid power, 2000 MW of off-grid solar applications and 20 million sq. m. solar thermal collector area and solar lighting for 20 million households by the end of the 13th Five Year Plan in 2022.

which covers approximately 38% of the system and installation cost for a DC based solar micro-grid. However, the subsidy is provided well after the time of system installation and so the 38% of the system and installation cost per site was advanced by the TERI project. Finally, considering the investment capacity of the *energy providers,* and in order to reduce perceived financial risks in the new technology, 55% of the system and installation cost per site was borne by the project fund.

Linkages with Local Financial Institutions

14 Energy Providers expressed interest in availing themselves of credit opportunities. Two regional rural banks[7] (RRB) developed programs for providing a loan of 30% of the total system and installation cost at an interest rate of 12.50% with a repayment period of 5 years. The energy providers who took out credit contributed 15% of the investment themselves, and in one instance 30% of the installation cost was shared by the village *panchayat*.

Institutional Framework

Ownership of the systems was held by the energy providers. As the core actors they were the investors, operators and owners of the solar micro-grid system. Other key players in the framework were the funding institutions, regional rural banks and the *panchayat*. Usage charges were decided by the end users and *energy providers* jointly in order to address the issue of affordability. Local electricians are being trained and introduced to the equipment suppliers and energy providers to expedite repair processes.

Discussions

This section discusses the suitability of the entrepreneur-based implementation model for solar off-grid generation to overcome the barriers generally linked to the success of any renewable technology in India. Painuly (2001) categorizes barriers that have prevented penetration of renewable based technologies as cost-effectiveness, technical barriers, and market barriers. These can also be understood as inconsistent pricing structures, institutional, political and regulatory

[7]Regional Rural Banks were established in India in the year 1975 with the objective to provide credit to the rural people who are not economically strong enough, especially the small and marginal farmers, artisans, agricultural laborers, and even small entrepreneurs.

barriers, and social and environmental barriers. Painuly further argues that some barriers may be specific to a technology, while some may be specific to a country or a region.

Existence of a Market for Solar-Micro Grids

The rural markets (largely retail and processing units, such as grain milling units, pottery-making units) make up the highest share of end users (11:00 connections) (Fig. 22.3). 80% of the retail units in the village markets operate till 19:00 h (Baseline survey conducted by TERI, February 2012), while all the retail units indicated that the period between 17:00 and 21:00 h was the time of the day when quality lighting is most required for their business.

Currently, village markets rely on kerosene and paraffin lamps for lighting although they provide poor quality illumination. By comparison diesel generators

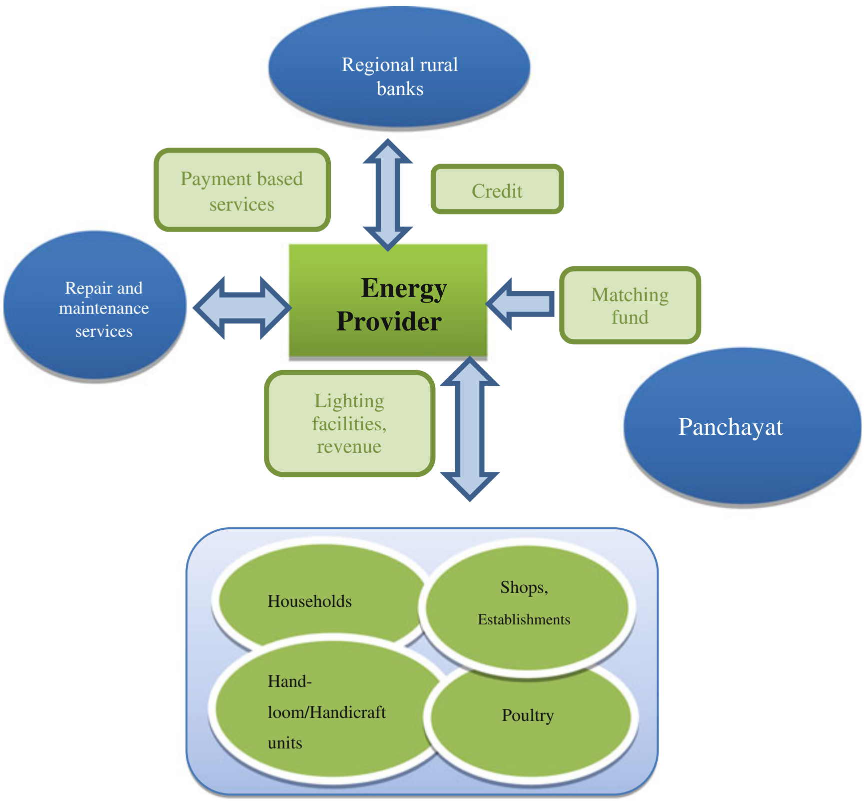
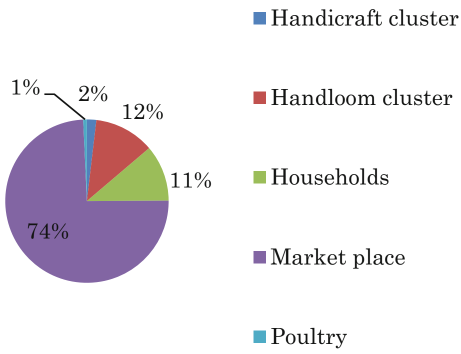


Fig. 22.3 Institutional framework

Fig. 22.4 Distribution of end users



are common in large rural markets (i.e. markets comprising of 100 or more shops/establishments). The tariff for 4 h of lighting provided by these diesel generators ranges between USD 0.08 and USD 0.13, and 90% of the shop owners expressed a willingness to pay this amount per day (this amounts to a minimum of USD 2.51 per month).

The initiative also provides lighting to approximately 185 handloom and handicraft production units across four sites, all of which are located inside private households. More than 80% of these handloom and handicraft units are operational between the hours of 8:00–13:00 and 17:00–19:00, and their users indicated that the time between 17:00 and 21:00 was their peak demand time for artificial lighting. Some 80% of these units expressed a willingness to pay for lighting services.

The option of artificial lighting generated through renewable energy systems is a large latent market in the rural areas of India. Again, commercial establishments, retail, and production units emerged as the potential target market in rural areas as these are able to link the service directly to income generation or savings. The distribution of sites by end users (Fig. 22.4) clearly indicates demand for paid lighting is highest among the retail units.

Innovations in Demand Creation

In two sites, the energy provider delivered lighting services to the end users free of cost for a month. Realizing the better quality illumination of LED lights, customers decided to continue with the connection on a payment basis after their trial periods. A month after installation, four existing energy providers expressed an interest to install additional solar micro-grids in other locations as well. At present, about 40 new entrepreneurs have conveyed their willingness to install solar micro-grids in their localities following a similar business model. It is likely that if the application of the new technology can be matched to existing energy use patterns, the demand for the technology and related services will be boosted by a successful demonstration of the technology.

Cost Effective Substitute to Diesel Generators

The DC based solar micro-grids replaced diesel generators of 800 Wp capacity (with 100 connections) in two market places. The system cost for an 800 Wp micro-grid stands at USD $5230, of which the energy provider is expected to pay 45%, or USD $2354. The system cost of a diesel generator of similar capacity ranges between USD $1290 and USD $1660, far below the total system cost of solar micro-grid. In absence of the 55% investment sharing, the system and installation cost of a micro-grid is 3.5 times higher than a diesel generator with similar capacity. However, a diesel generator consumes about 1080 Litres of diesel in a year, leading to an expenditure of USD $995. In addition, one person is required to attend to the diesel generator when it is operational, and electricity thefts are also common, leading to financial losses. DC based solar-powered micro-grids offer a solution to those challenges. As a result, diesel generator operators in other rural markets have expressed an interest in installing DC based solar-powered micro-grids, as they believe that the comparably small operational cost balances the high investment cost.

The monthly tariff for 4 h of artificial lighting per day for a single connection is about USD $4.02 in case of a diesel generator, which is higher than the tariff for lighting offered from solar–powered micro-grids, which comes to USD $2.51. The end users thus prefer the solar-powered micro-grid over a diesel generator as the source of their electricity.

Cost Effective Substitute to Fossil Based Lighting Options

The handloom/handicraft units and other retail units (other than those who made use of lighting provided by diesel generators) also preferred LED lights over kerosene lamps. In monetary terms the expenditure on kerosene ranges between USD $2.51 and USD $4.19 per month which is comparable to the monthly tariff for a solar-power based lighting service. In addition, LED lights provide quality illumination when compared to kerosene lamps. The monthly charges of solar-based lights are also comparable to the expenditure on battery charging for battery operated lights and Liquid Petroleum Gas (LPG) for petromax lights. Further, solar-based lights eliminate the hassle of procurement of LPG cylinders and battery charging.

Thus, solar energy based lighting options directly compete with conventional options, and are even preferred, if offered at a competitive price. Solar energy based off-grid solutions can be said to be a socially acceptable alternative to fossil fuel based sources of lighting, if the costs are comparable.

Shift to Cleaner Option of Lighting

As a baseline, about 59% of households (including handicraft/handloom units) use 2–4 L of kerosene in a month. Others reported use of petro-max and battery operated lights. On average, the intervention, at present scale is expected to save consumption of kerosene in the range of 350–650 L and about 300 L of LPG per month in the communities for which an alternative has been introduced in the study. Quality of illumination in the case of kerosene lamps and candles are poor while battery operated lights need recharging every second day, costing about USD $0.18 each time. In addition, the battery needs to be transported to a charging station in order to charge it. Micro-grids have replaced diesel generators in two market places (with about 300 connections).

Technology Customization

Sustainability of the renewable technology depends on how cost-effective the technology is with regards to addressing the challenges identified with comparable and popular fossil based technologies. Drennen et al. (1996), while examining the economic competiveness of photovoltaic (PV) systems in developing countries, mentions that the economics of PV applications are unlikely to allow for an unsubsidized widespread adoption of the technology in the near future without a significant technological breakthrough. The solar micro-grid is based on direct current (DC) meaning that only the voltage needs to be considered in the system, whereas with alternate current (AC) systems it is necessary that each element have identical wave shapes to operate. Therefore, given a suitably robust generator and ample storage, solar-powered micro-grids could have an efficient local grid network, using solar PV and integrating electrical storage at higher efficiencies than are possible in a conventional AC system. By locally managing sources and loads, a DC micro-grid can optimize its net surplus of power (output to the grid) or deficit (input from the grid). This local management of both supply and demand creates a buffer to the grid and relieves some of its burden. Also, direct current eliminates opportunities for power theft as most appliances operate on AC, thus reducing the need for monitoring and surveillance efforts to a considerable extent. In addition, light-emitting diode (LED) technology used in the system brings down the cost per watt and also gives more lumen output per watt, thereby bringing down the cost of useful energy from LED based lighting devises (Babu 2008). This eventually reduces the size of the storage battery as well as that of the PV module in PV lighting systems and ultimately leads to overall cost reduction (Chaurey 2010).

The DC based solar-powered micro-grid technology translated the complex process of generation to an “easy to manage and operate” system. Energy providers, many of them with only basic literacy, are able to operate and manage these grids. However, the case highlights the necessity for technological innovation and customization for customer satisfaction and management efficiency.

Demonstration of Private Investment in RETs at Local Level

Government investments and public budgets have proved insufficient to meet the needs of improving energy services in rural areas in a sustainable manner (Chaurey 2012). This calls for innovative yet customized partnerships involving private investors and public partners. Private sector participation in achieving the goal of universal access to modern energy is also emphasised and encouraged in the AGECC report (2010). Martinot (2002) provides examples where the technology worked but there was no effort to create and demonstrate a viable model for further diffusion (Martinot 2002). The adopted model in our case demonstrates an example of private investment in the rural ecosystem within a public-private partnership (PPP) framework, where the risks are shared between the funding institution and a private investor.

Financial Mechanism at Local Level—A Lift to Private Investments

An expansion of local lending capabilities to scale up investments in energy efficiency and access through local banks is proposed in the AGECC 2010 report. AGECC (2010) also suggests creation of new and innovative investment mechanisms to enable accelerated technology deployment with active private sector participation to hasten the spread of locally appropriate technologies. Chaurey (2010) highlights the importance of financial institutions at the rural level and identifies the availability of rural credit, long-term loans and business advisory services as stimulants for the growth of a successful PV market. The high up-front costs for investors and lack of financial institutions to support the effort are identified as major financial and economic barriers in RETs penetration worldwide (Painuly 2001).

A study of World Bank loans in India identifies an aversion to rural credit and a lack of support for entrepreneurs as one of the challenges faced in the context of off-grid solar power (Miller 2000). That say, a network of Regional Rural Banks exists in India and these banks, if convinced about the financial feasibility of the business and credibility of the loan applicants, could be an enabling instrument towards the promotion of renewable energy technologies. In the case of this project the involved banks followed their due diligence process of approving loan applications which also include an assessment of the financial feasibility of the project. Five Energy Providers applied to a national bank and were able to obtain a loan in lieu of a guarantee.

The importance of financing instruments was underlined by the case study. This calls for a consideration at policy level to introduce subsidies (partial/full) on the rate of interest for loans approved by regional rural banks used to finance feasible renewable energy based businesses. Further, the model can be replicated with the involvement of other private financing instruments and agencies such as national level banks and micro credit institutions. Srinivasan (2007) also points out that the decentralized PV market is likely to grow with the support of commercial financing from rural and other developmental banks rather than with subsidizing programmes.

Employment Generation

The initiative has allowed energy providers to earn additional income by retailing energy services up the energy ladder. Kaygusuz (2011) also identifies retailing of energy services as one of the energy related livelihood strategies. Depending on the number of connections in the system an energy provider is able to earn an annual revenue between USD $303 (with10 connections) and USD $3029 (with100 connections). It is worth mentioning that unemployed youths have also expressed an interest in investing in and owning solar-powered micro-grids, and at the same time local electricians are being trained to repair and maintain the systems. The entrepreneurship based model is able to provide both quality and skill-based employment, unlike the national level employment programmes such as Mahatma Gandhi National Rural Employment Guarantee Program (MGNREGA) or *Bharat Nirman.* The national level employment programs in general are creating poor quality and temporary employment aimed at the construction of roads, ponds, buildings and so on. The employment created by entrepreneurship-based solar-powered micro-grids is modest but are permanent in nature. Hiremath (2009), while analysing select renewable energy based decentralized projects across India concluded that employment availability will be greater once renewable energy is mainstreamed into the economy.

Del Rio (2009) concludes that the contribution of solar powered off grid generation has a limited impact on employment creation in rural areas when compared to biodiesel and wind-based off grid generation. By contrast the entrepreneurial business model possesses a provision for creating a number of quality employment positions if it were to be implemented at a greater scale. The introduction of solar-powered off-grid system has added one more employment option to the rural economy, and thereby contributed to employment diversification.

Drivers for Technology Adoption

The introduction of new energy technologies in a rural setting is a challenge, since it generates changes in patterns of energy use (Alvial-Palavicino 2011). Chaurey (2010) raises concerns on the undermined role of users in the adoption of decentralized PV systems. Alvial-Palavicino (2011) has emphasized community participation in decision making to enhance the possibility of adoption of renewable based technologies. Such adoption is linked to various factors such as the ease of use, affordability, compatibility with existing life styles and, most importantly, need. The solar micro-grids are able to provide better quality illumination at comparable costs. Direct linkages to existing income generation options have also acted as an encouraging factor. Unlike the majority of off-grid generation systems, the model adopted in this case transfers ownership of the system to a local entrepreneur from the first stages, enabling the entrepreneurs to participate actively in the process of system design, procurement, installation, and operations.

Conclusion

37% of the households and 15% of the retail units in the case study area were un-electrified prior to introduction of lighting services offered by the micro-grid. The baseline indicates the ubiquity of interrupted or even non-existent power service in electrified areas, particularly during evening. In total, 160 handloom units, 25 handicraft units, 150 households, 1100 retail units and one poultry unit were able to gain access to quality artificial light powered by renewable solar energy sources. The micro-grids have been shown to replace diesel generators and other fossil based options, such as kerosene lamps and petromax, at comparable cost to the end users.

Successful demonstration of the business model where the local level entrepreneurs invest, own and operate direct current (DC) based solar-powered micro-grids and eventually reaps financial benefits has motivated many other rural entrepreneurs. Regional rural banks acted as a catalyst to private investment in this case. The process has created a local rural network that links technology manufacturers and suppliers, energy providers, rural banks and *panchayat.* The model is also able to generate modest but quality employment at the local level as well as indirectly enhancing the income of end users.

Bloomberg predicts cost reductions will spur deployment of solar power, which will undergo the second-fastest percentage growth of all technologies (after offshore wind) from 51 GW in 2010 to 1,137 GW by 2030 (Bloomberg new energy finance 2011). However, in spite of favourable cash flow the behaviour of potential investors is yet to be witnessed in absence of the grant of 55% towards the upfront hardware cost of the system and installation.

The micro-grid option shows that it is possible to provide reliable and clean lighting services to rural markets, establishments, production units and households through collaborative approach of state, energy institutions, community investment, financial institutions, and the resource agencies. Micro grids also contribute to the ‘Energy for All Goal by 2030’ of the United Nations. Analysis of the case study concludes that decentralized solutions and private investments can and must play a major role not only in providing universal modern energy access but also in enhancing the livelihood options in rural areas of India.

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Chapter 23
The Importance of Social Capital in Building Community Resilience

Daniel P. Aldrich

Abstract This chapter uses examples from a number of recent disasters to illuminate the ways that social capital serves as a critical part of resilience. Specifically the article looks at the response from the perspective of social networks to disaster in Bangkok, Thailand, the Tohoku region of Japan, and Christchurch in New Zealand. I introduce three types of social capital—bonding, bridging, and linking—and discuss the mechanism by which they are created and employed using concrete examples. In these cases social cohesion keeps people from leaving disaster-struck regions, allows for the easy mobilization of groups, and provides informal insurance when normal resource providers are not open. Social networks improve disaster recovery for local residents, communities, and the nation as well. Disasters are, and will continue to be, a challenge for both developed and developing countries everywhere. With this understanding in mind, it is important that communities build social capital in advance of disasters by communities as well as by planners and other decision makers. Preparing for disaster with an emphasis on physical infrastructural solutions, such as higher seawalls, raised floors, higher building standards, and so forth, is not sufficient to avoid the negative impact of disasters.

In October 2011 Thailand's capital city of Bangkok faced the worst flooding in its recorded history. The city government provided a five day holiday to residents to allow them time to evacuate (Boston Herald 31 October 2011). The 9 million residents of the city who were unable to flee tried to stockpile food, water and other necessities beforehand (BBC 27 October 2011). By the time the water stopped rising, it had drowned 815 people, reached a height of more than 1.5 m, and submerged much of the first floor of almost every building in the vicinity. With 90% of some areas submerged, the floodwaters caused $45 billion in damage. Responses to and recoveries from the event were not the same across the city. The district known as Sai Noi in the northwest suburbs of the city, while facing the same

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levels of flooding as other parts of Bangkok, managed to work together to fight the raging waters and then mobilized to rebuild quickly after the waters receded. "People with no training and few resources built barriers and monitored flood levels, delivered food and drinking water, evacuated residents trapped in their homes, provided medical services to the sick and injured, and policed their neighborhoods for looters" (Roasa 2013: 1).

People in the community of Sai Noi were able to work together because of shared norms: most of the local residents in the area were migrants from regions of northern Thailand. Their trust in each other allowed them to work communally to form a residents' committee to make quick decisions on mitigation responses and then a five-person security committee to secure the evacuated area from would-be looters. Several locals also had connections to powerful authority figures in organizations such as the military which allowed them to access much needed resources such as hard to find boat engines. Local residents also expected very little from the formal government, recognizing its limited financial and logistical capacities. "During the flood, we found it was better to help ourselves than to rely on the government," explained one resident (Roasa 2013: 9).

This short description of actual events in Thailand illustrates the power of social networks before, during, and post-disaster. Bangkok residents utilized existing social capital to overcome barriers to collective action before the floods and to mitigate the coming disaster. Then, when the waters rose, they used their networks of trust and reciprocity to ensure safety and survival, keeping out looters and sharing resources. Finally, after the disaster, linking social capital to people in positions of authority allowed them to access hard to find resources when most service providers were closed. This chapter will use examples from a number of recent disasters to illuminate the ways that social capital—the ties that bind us together—is a critical part of resilience.

Definitions and Mechanisms of Social Capital

While social scientists have a variety of ways of defining the term (Bourdieu 1986; Coleman 1988; Putnam 1993, 1995; Lin 2008), social capital in this chapter refers to the networks that connect individuals to each other either through weak or strong ties (cf. Chamlee-Wright 2010?; for an overview, see Aldrich 2012 Chap. 2). These connections provide information, reliable data on the trustworthiness of the other network members, and access to resources. Research has identified three distinct types of social capital—bonding, bridging, and linking.

The first type of connection, labeled *bonding social capital*, connects family, kin, and close friends. In rural North America, for example, locals may enter their neighbors' homes without knocking, serving themselves if no one is around, and having deep knowledge of the personal lives of community members. Bonding social capital rests on the sociological principal of homophily, where most of us tend to affiliate with, befriend, and marry people from similar backgrounds, national and ethnic origins, and class. Hence if we are Pattinavar fishermen on the coast of Tamil Nadu south of the city of Nagapattinam, most of our connections will have similar ethnic and industrial characteristics. Similarly, most of our connections through social media such as Face book tend to reflect our political ideology.

The second type of network, known as *bridging social capital*, often works through institutions such as schools, clubs, or corporations. Bridging social capital provides connections to individuals with different ethnic background, religious interests, and norms. In India, for example, Varshney (2001) has identified how peace committees bridged the Muslim and Hindu business communities. During times of ethnic violence, such as the riots that rocked India in the 1990s, these types of bridging social networks dampened intergroup and reduced the number of riots locally. Further, as Mario Small has shown, kindergartens and schools often link parents—even disadvantaged single parents in urban communities—to resources they may otherwise not know about (2009).

The final type of relationship is *linking social capital*. Where linking social capital connects similar individuals, and bridging social capital connects across caste and identity, linking social capital in contrast allows normal citizens' access to power brokers, authority figures, and decision makers. In rural India, for example, many coastal dwellers have never met their elected officials or civil servants representing the government. Those who have the cell phone number and name of the state collector, therefore, are at an advantage when they need work carried out or a favor. Similarly members of the primarily Vietnamese and Vietnamese-American community in the Mary Queen of Viet Nam (MQVN) neighborhood of New Orleans created new political ties to the mayor's office and the governor following Hurricane Katrina. These connections helped the community ensure it would be "on the map" of the recovery process. These types of ties work through three mechanisms (Aldrich 2012).

The first decision made by survivors in developed and developing countries alike following a disaster is whether to stay and rebuild a damaged home, condominium, or business, or relocate. The costs of recovery can involve financial costs, opportunity costs, and psychic costs. For the few individuals who have private insurance, for example, those insurance funds rarely provide full coverage for damage and lost business. Then, the weeks and years it may take to complete the rebuilding process mean that local survivors cannot pursue other opportunities. Finally, the mental costs to remaining in a damaged community and trying to rebuild can be very high. Individuals with more bonding and bridging social capital are more likely to engage in voice, where they stay in damaged areas and work with neighbors to rebuild. Those with fewer connections, who feel less of a sense of place in a disaster-affected community, are more likely to engage in exit. Therefore, strong bonds dampen exit and increase voice (cf. Hirschman 1970).

Next, many of the challenges facing local residents following disaster involve collective action challenges. Authorities may require that a community garner a certain number of signatures before rebuilding infrastructure and restarting utilities such as gas and electricity, and this requires being able to mobilize the entire community. Alternatively, communities where locals rarely work together may find it difficult to articulate their needs to resources providers and be unable to agree on a shared vision of their future neighborhood. In the worst case scenario, a lack of shared norms and trust creates a scenario in which locals may engage in disruptive behaviors such as looting. Communities where the residents share a collective identity, are willing to work together to coordinate their recover, and can overcome free riding problems are ones which will display better resilience.

The final mechanism through which social capital works in disaster and recovery periods is through informal insurance and mutual aid. Following crises, the normal providers of resources such as childcare, temporary living accommodation, gasoline, and food are often shut for days, if not weeks. Some neighborhoods in New Orleans lacked convenience stores and grocery markets for more than a year, for example. Local survivors who need someone to watch their child, or to borrow a power tool to cut out molding dry wall, or a place to stay while fixing their home can only draw on the resources of their nearby friends and neighbors. For individuals who have built strong connections before the crisis, they are well situated to draw on informal insurance after the disaster. For those who were isolated and unconnected, it is very difficult to form new friendships and trust in the “compressed time” period after crisis. I now turn to two recent disasters to illustrate the power of these connections.

Cases

On 11 March 2011, a 9.0 magnitude earthquake struck off Japan’s northeast coast. While the earthquake was quite powerful, high engineering standards and distance to land meant that the quake itself generated few casualties and little damage in Japan. Instead, the strike-slip earthquake set off a tsunami which roared towards Japan’s coast at several hundred miles per hour. The Japan Meteorological Agency (JMA) issued a series of tsunami warnings, providing locals with roughly 40 min in which to evacuate their coastal dwellings and businesses. These warnings went through various channels, including cell phone alerts, radio warnings, television news interrupts, and standing sirens in the area. When the tsunami arrived, it devastated some 120 communities along the coast, killing more than 17,000. The earthquake and tsunami had broader ripple effects: they shut down the back up cooling systems at the Fukushima Dai-ichi nuclear power plant reactors one through three. As a result, the reactors heated up within two days and had full fuel meltdowns which spewed radioactivity into the air and water. Cooling efforts were eventually successful, but containment of the contaminated cooling water has remained an issue, and tens of thousands of people have had full body radiation scanning to understand their exposure levels.

Several aspects of the disaster and recovery process underscore the power of social networks in communities in the Tohoku region. First, interviews with survivors indicated individuals had 40 min between tsunami sirens and arrival of the wave. For able-bodied residents, this was usually sufficient time to save themselves.

For those bedridden, sick, or elderly residents of these coastal times, it was an impossibly short period in which to evacuate safely. Instead, several conditions had to be met for such a resident to escape the wave. First, a neighbor, friend, or caregiver had to know of their condition. Next, that individual had to know that they were home, or at least their location. Finally, the network connection had to be willing to risk death to come to their home and assist them in the evacuation process.

Next, an initial quantitative analysis of tsunami mortality levels in 280 towns, villages, and cities in Tohoku indicated a strong correlation between one widely used measure of social capital and survival. Holding constant the height of the wave, the height of sea walls, the demographics of the community, and other potential confounding factors, the level of crime in the community before the tsunami was strongly connected to mortality levels during the event. Sociological research has long connected lower levels of trust, fewer shared norms, and a lack of social connections with higher levels of crime. In these communities, those areas which before the disaster had more theft, coercion, and murder (although these were rare to begin with in these communities) had higher levels of people killed in the tsunami. I believe that more fragmented communities were ones in which people shared less information, distrusted signals from authorities, and engaged in less collective action (Aldrich and Sawada 2015). Other research has also shown how "areas rich in social capital accomplished speedier recovery" following the Tohoku disasters (Inagaki 2013: 6).

Christchurch Disaster

New Zealand faced two major earthquakes within 6 months of each other: the 4 September 2011 earthquake in Canterbury and the 22 February 2011 in Christchurch. 185 people died, primarily from two buildings collapsing, and the event caused more than $40 billion in damage to buildings and structures in the city. Some observers have criticized the newly created Canterbury Earthquake Recovery Agency (CERA)—created to manage the rebuilding process—as slow moving and top-down. In response, a number of bottom up, community oriented organizations have moved to accelerate the process of recovery.

A number of local city planners, volunteers, and community activists noticed large amounts of land in the city of Christchurch remained ugly and vacant for extended periods after the quake. These areas attracted crime and illegal activities (drug use, etc.) and did little to bolster the spirits of local residents hoping to make a comeback. They formed the Gap Filler Charitable Trust to "see vacant sites—awaiting redevelopment as a result of the many earthquakes or otherwise—utilized for temporary, creative, people-centered purposes" (http://www.gapfiller.org.nz/). Gap Filler tries out small scale, experimental projects with small grants; successful projects are replicated elsewhere. Among their other popular projects are the Summer Pallet Pavilion which functions as a community space and venue for events. The site is made up of recycled wooden pallets, outdoor furniture, potted plants, and a performance space. It has drawn together neighbors who might otherwise have little ability to gather together in a society slowly reknitting after rupture.

The community of Lyttleton was severely by the 2011 earthquake; a number of buildings, including many with historical and social meaning to the community, collapsed. Members of the community worked together through a local community currency program known as the Lyttleton Time Bank to donate time and volunteer hours to each other. Time banking involves earning "hours" of work by carrying out a skill (such as sewing, typing, cleaning, and so forth) and earning an hour credit worth of work from others in return. For people who needed additional assistance after the earthquake, many people donated additional hours to help them out. Seen as a way of developing communities through sustainable local trading, this program has been a bottom up initiative which has caught the attention of policy makers domestically and internationally (http://www.tindall.org.nz/time-bank/).

One final bottom-up, social capital-based approach to the Christchurch disaster has been the mobilization of the organization known as the Student Volunteer Army (http://www.sva.org.nz/). Immediately following the earthquake, Sam Johnson worked with other local students to form emergent groups of volunteers to assist survivors in the aftermath. After a number of gatherings and assistance provision in the area, the founders managed to bring more than 13,000 students out as volunteers per week. This kind of locally based volunteerism provides long term assistance to the hardest hit communities. Many of the younger volunteers who enter disaster-affected communities such as those in New Zealand and in Tohoku, Japan chose to remain and assist with broader rebuilding efforts. Further, rather than simply bringing in outsiders for "short term" volunteer jobs which create few connections with local residents, volunteers from the community itself have a better chance of enhancing social cohesion and building deeper reservoirs of social capital.

Conclusions

This chapter has briefly introduced the idea of the critical role of social capital in disaster recovery (Nakagawa and Shaw 2004), bringing examples from three recent disasters to show the ways that local individuals work together to improve their environment. Bonding, bridging, and social capital keep people from leaving disaster-struck regions, allow for the easy mobilization of groups, and provide informal insurance when normal resource providers are not open. In Thailand, Japan and New Zealand different forms of networks played critical roles after major catastrophe. Neighbors connected through bonding social capital were able to assist each other with disaster mitigation—such as setting up sandbags in Thailand—and evacuation from hazards, such as in Tohoku. In Lyttleton the time bank institutionalized otherwise informal ways for neighbors to assist each other following the Canterbury earthquakes. Bridging social capital and linking social capital allowed for wide scale mobilization and collective action, as seen in the Student Volunteer Army.

Given the importance of social capital in community resilience, disaster managers, town planners, decision makers, and local residents alike should think about mitigation and recovery strategies involving social infrastructure. Well before disasters strike vulnerable areas, for example, local residents can ensure that they have contact information for their neighbors and are aware of pressing medical conditions or emergency needs. This will help the community when the next catastrophe strikes. Further, field experiments have shown that—even in developing nations with chronic challenges such as civil war—it is possible to artificially increase the stock of social capital. Successful strategies for doing so include "focus group" like meetings where local residents meet on issues of common concern with regularity over several months (Pronyk et al. 2008; Brune and Bossert 2009). A final strategy shown successful at building trust and connections has been that of community currency or time banks, where individuals who donate and volunteer their time are rewarded. These rewards then recirculate within the community, creating a virtuous cycle (Doteuchi 2002; Lietaer 2004).

As we move into the 21st century, disasters will remain a serious challenge for developing and developed nations alike. It will not be possible to solely invest in physical infrastructure such as higher seawalls, raised homes, higher building standards, and so forth and expect that we will avoid the negative consequences of disasters. Instead, by investing in social infrastructure, we can better prepare residents and communities alike for future shocks. Resilience will come not from physical engineering—instead, it will come from bottom up responses built on local social networks.

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Chapter 24
The Veneer House Experience: The Role of Architects in Recovering Community After Disaster

Hiroto Kobayashi

This chapter examines the development of a new construction method using plywood to build homes quickly and inexpensively in the wake of disaster; the method does not rely on skilled labor or sophisticated construction equipment. The construction method's primary innovations lie in the plywood fabrication and structural performance; however, in the two cases where it has been used so far, community organization is also seen as essential for successful implementation. The experience in Tohoku, Japan, the area damaged by a series of earthquakes and massive tsunami in March, 2011, underlined the importance of bringing both technical and social skills to disaster reconstruction. Architects must respond not only to technical but also to social and environmental issues in reconstruction projects such as these.

Part 1 Background

3.11 Tsunami

On March 11th 2011, a magnitude-9.0 earthquake (officially known as the Great East Japan Earthquake) hit the Tohoku region of Japan, causing an enormous tsunami that devastated Tohoku's rural coastal villages. The tsunami killed more than 17,000 victims and created 340,000 refugees within a matter of minutes.

This disaster made it extremely difficult for rural villages to maintain their communities (see Fig. 24.1). The extreme damage caused by the tsunami added to the severe challenges that rural villages in Japan already were struggling with: depopulation, declining local industry, caring for an increasingly elderly population, and encroachment of wild animals. The earthquake-tsunami disaster acceler-

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Fig. 24.1 The damage left after the earthquake and tsunami in Tohoku Japan, March 2011

ated an already established demographic problem of young and working-age population moving to cities and away from the countryside. This movement exacerbated the other issues and made their solutions much more difficult to find. The response after a disaster needs to take into account different scales of time. Beyond the immediate need to save lives, provide urgent medical care, and supply food and temporary housing, long-term planning strategies must be developed to avoid or reduce the risk of future crises. In attempting to recover from the tsunami, planners, together with people in devastated villages, have asked themselves how to establish a more sustainable local community and industry, resilient living environment, and quality of life—knowing that natural disasters of this magnitude will occur again sometime in the future.

Architects have asked themselves what they can do for these people and places, what should be done in rebuilding the local environment, and how the profession can operate most effectively. Quite a few are currently involved in the reconstruction of Tohoku, struggling with difficult questions that cannot be resolved instantly and proposing ideas that come from good will, but lack in the nuance of the situation on the ground. In this paper, the author (one such architect) describes his experiences in applying design expertise and an experimental approach to the problem of recovering community vitality from a desperate situation.

Searching for a way to respond to the tsunami's nearly incomprehensible devastation, we must have the patience to comprehend the problems holistically and to find solutions in the same holistic manner. Rather than focusing on isolated facts, we must be determined to study what we knew as a piece of the puzzle and in the context of many related issues. In the case of the Great East Japan Earthquake, we found many problems of the region embedded in various aspects related to planning and reconstruction, including technical, temporal, social, cultural, and spiritual dimensions. Our challenge was to think holistically and to use the process of disaster recovery to address both immediate needs and underlying, pervasive problems. In considering the ideal role we should play in this situation, we tried to comprehend problems from the victims' point of view and to respond to the problems from that perspective. Frequently the victims wanted to know about recovery efforts that could be implemented immediately and by themselves. This attitude provided a "reality check" on our thinking and for our proposals.

From the beginning, we felt that involving people directly in post-disaster planning was an important aspect in the recovery of their communities. Social relationships and a sense of ownership needed to be rebuilt, and recovery efforts could not achieve this simply by giving people homes and facilities without their involvement in key design and implementation issues.

Respect for Locality

Miyagi Prefecture is well known as one of the major wood-producing regions in Japan. A large number of engineered wood manufacturers are located in this prefecture, and many of their factories are located close to the Ishinomaki Bay, a local hub for domestic and international shipping. These factories were severely damaged by the tsunami on 3.11. Although the timber industry is both key for the prefectural economy and essential for the related problem of revitalizing mountainous ecosystems, most of its activity was shut down by the tsunami. Plywood was the construction material in highest demand for the reconstruction of the area after the tsunami, but local companies could not produce any material for more than two years following the disaster.

In light of this situation, one thing we could do to help the timber industry's recovery was to find a new way to use locally produced wood for the local community. Using their own products for themselves would be the fastest and most immediate way for tsunami survivors to recover not only their regional economy but also their regional pride. To test this insight we felt that a good first step would be to provide a common space—a place for local people to gather, on a site familiar to the community—and to construct it using local wood products.

As a team made up of university students and independent volunteers, we had a chance to work together at an important moment for Japan. Although our efforts in the devastated area could not equal the scale of destruction, our team's involvement in the design and construction of community facilities provided an incomparable experience in the lives of victims, students, and volunteers alike. Such a learning experience—at the exact site where people are in obvious and dire need—cannot be obtained in a classroom; it is precious and formative for all involved.

Ultimately we came to understand that what we could offer for the local people was viewpoints and ideas that reflected our different backgrounds and design training. As outsiders, it was important to recognize our ignorance of the local situation, but also to be aware that we had an objective perspective as well, and that this point of view allowed us to recognize aspects of the daily environment that needed to be addressed, but which was not being taken on, or even seen, by the community. Recognizing these needs it was then our challenge as outsiders entering the traditional and sometimes conservative cultural arena of Tohoku, to offer our ideas in a neutral way, so that they might be seen as a resource and not as a critique. The goal was to provide more choices and paths of action for locals as they worked to recover their lives.

An important aspect of our project was to encourage local participation in the process of (re-)construction. This enhanced the participants' attachment to the building and promoted a sense of ownership and responsibility that was essential for the building in the future, as it would need maintenance and care going forward. So-called Do-it-yourself (DIY) construction methods are generally popular because they are less expensive than hiring professional builders and contractors; however, in cases like this one, the sense of ownership and communal responsibility that develops from this approach may be a more significant outcome than achieving the highest possible construction quality.

Pre-fabrication for Housing

The widespread use of pre-fabrication in building construction was a key development in the history of industrialization. Beginning with the modularization of standard building components such as *tatami* in pre-modern Japan, and with the industrialization of the construction industry at the end of the 19th century in many countries around the world, pre-fabrication has been recognized for some time as a strategy for reducing the length of time spent building on site while also improving construction quality. This approach was largely adopted by Japanese housing companies since the 1950s and the production of new houses has accordingly become faster and more affordable. However, the main drawback of the pre-fabricated house, traditionally speaking, is the reduced potential for individual customization. Both the economic virtues and the uniform (sometimes monotonous) appearance of standardized pre-fab construction can be seen in the many emergency buildings supplied to the Tohoku region after the 2011 tsunami.

Applying the idea of pre-fabrication to devise new construction methods for emergency shelters is suitable for the following reasons. First, construction could be largely expedited by having pre-fabricated elements that are supplied according to the needs of the place. Second, the simplicity of assembly allows for non-professional participation. This is important because of the potential scarcity of skilled labor after a disaster, not to mention the difficulty of finding the mix of contractors and builders typically needed on a construction site where structures could easily require specialists familiar with concrete, wood and steel building methods (typically these are not skills found in a single person). Third, repeating the same construction method makes it easier and faster to build, while also improving the quality of construction.

In the wake of World War II, Daiwa House introduced the first steel pre-fabricated house in Japan in response to a housing shortage caused by wartime air raids. The "Midget House", introduced in 1959, officially launched the "pre-fab" industry in Japan. Other companies soon followed, producing similar pre-fabricated houses using different materials and manufacturing systems. The houses were manufactured in a factory, sold at department stores, and assembled by professional staff. Small but relatively reasonable and ready-to-assemble houses soon became popular, and rapidly changed the idea of a modern house in Japan. The pre-fabricated house developed into a variety of configurations to cater to the demands of larger families seeking bigger bathrooms and living spaces. Today's modern housing industry in Japan emerged out of the practical need for quick to build and cost-effective shelters after the war. A similar story can be told in the United States and other countries as well, with a similar connection to the post-war construction boom. However Japan is perhaps unique in the number of homes that are built in factories rather than on site by carpenters.

New Engineered Wood Building Methodology

In exploring the possibility of supplying pre-fabricated building systems in the Tohoku region, we identified the needs of construction and introduced the following notch-cut assemblage. The characteristics of this method are as follows:

Fast — Time is one of the most essential factors to consider. The sooner the living conditions improve, the less the difficultly in recovering as a community. The rapid preparation of houses is imperative to the situation.

Low-cost — After all the emergency shelters are built and the subsidies for new buildings subside, low-cost construction methods become a requirement.

Simple — Due to the lack of professional skills in the region, the simple construction method enables locals to build in response to their needs.

Advanced — Using the most advanced computer-aided technology enhances the productivity of prefabrication. The accuracy and speed of CNC (Computerized Numerically Controlled) routers and laser cutters facilitate fabrication, but do not complicate construction. The technology is embedded in the material shape rather than in the construction technique.

Flexible: In order to reduce the materials and elements for construction, we introduced the notch based joint method. This is a popular mechanism to connect panels without needing any additional elements. A perpendicular composition of two panels makes the structure firm (see Fig. 24.2). This assembly is less complicated than other regular joint systems in wood construction.

Fig. 24.2 Veneer house, notched construction system

In the next parts of the paper, I introduce these applications in the "Veneer Houses," built in the Tohoku region in Japan and in a remote village in Myanmar.

Part 2 The Minami-Sanriku Community House (Veneer House 1)

The first 'Veneer House' was built in the Tohoku region, in Minami-sanriku of Miyagi Prefecture in the fall of 2011 (see Figs. 24.2 and 24.3). Emergency housing were constructed rapidly but without sufficient community space. This gap was pointed out by a volunteer who moved to the area to help those who were struck by the tsunami. At his request, we decided to build a room for local gatherings.

The site prepared for construction was located on a piece of land where buildings had been washed away by the tsunami. In light of that history we had to consider whether it was suitable to build a community building on a potentially vulnerable site, not least because the government had already restricted new construction on areas affected by the tsunami. We ultimately decided that it was undeniable that it was ideally located for civic interaction since it was one of the places in the area where people had already set up active commercial activities. Eschewing such sites could have the unintended outcome of discouraging people from recovering their sense of community, something that is thought to be vital for long-term recovery. As there was high ground nearby and because the building was not going to be used for constant inhabitation we felt the trade-off was reasonable.

Fig. 24.3 Minami-sanriku Community House (Veneer House 1)

We sought to make a temporary community space for refugees and residents to nurture a sense of continuity and a kind of attachment to the place, and to remind them of their former lives. The sense of belonging superseded the threat because there is a psychological need for stability. Our proposed house may well be washed away in the event of another disaster. But accepting that reality is also a demonstration of the people's resilience. Our solution aims to build a much-needed facility for and with the people, in hope of helping to rebuild the community.

The Veneer House 1 (VH1) in Minami-sanriku is a single story building composed of one 50 m^2 open room, one 5 m^2 office, and 2 toilets. The main function is to host meetings and occasional lodgings. The presence of 200 units of emergency housing nearby guarantees that VH1 will be used regularly by the residents who lack other communal buildings.

First Trial

This VH1 was first designed in our architectural design studio by master students of Keio University Graduate School of Media and Governance. We visited Minami-sanriku and conducted research to uncover the kinds of problems the local people faced and what they wanted for their lives in the future. We tried to understand their needs and expectations in terms of their community. What we learned through that process was that many of the communities were destroyed by the local

Fig. 24.4 Veneer house construction system made of smaller components

government's standards of fairness, which inadvertently dispersed the people in assigning emergency shelters. People were forced to live with strangers in a new place. But to build a new community, new relationships are required. One practical necessity is then a space where people can gather and get to know each other.

Unlike the studio work done in schools, students were exposed to ‘real’ problems that demanded viable solutions. To understand such problems, active participation becomes necessary. The students studied the needs of the community and designed a building to meet those needs while also promoting local industry and using a simple construction method designed to attract local participation.

The distinct characteristic of the Veneer House is the use of pre-cut plywood panels that could be assembled by hand. The most used and popular size of plywood in Japan is 910 mm × 1820 mm, small enough to be handled by one person. Notches are pre-cut in the panels before they are brought to the site. These notches are used to assemble panels into columns, beams, and other sub-structural elements of the building. The central concept of the Veneer House is to use this notch to make simple joints and to fasten the structure. As the length of the plywood is limited to 1820 mm, several pieces are combined to make longer supportive elements such as columns and beams. In such a case, screws are used to connect the pieces (see Fig. 24.4).

As most buildings, VH1 required a foundation. In this case it was built from wood piles which secured the main plywood structure to the ground. The finishing materials include zinc corrugated metal for the roofing, polycarbonate panels for the walls, glass-wool for insulation, and tatami mats and Laminated Veneer Lumber (LVL) sheets for the floor. These were all put in place after the plywood structure was built. The process of construction itself took more time than expected because of the number and variety of details needed in this first iteration of the plywood system. In some cases, we needed to use an alternative system. For example, the roof rafters and floor joists were made using 2 × 12 timbers because plywood sheets were not long enough to make the span. This, however, was overcome in later projects.

The use of LVL opens up new ways of capitalizing on veneer products. Cut to a thickness of 50 mm LVL was used in this project for part of the flooring because it provided visual warmth and functioned simultaneously as insulation. The simple but fine texture of the flooring carries an impression of thick wood and provides comfort appropriate to a living space (see Fig. 24.5).

Limitations

Although we designed a simple structural system to encourage local participation, the number of participants from the local community was limited due to the amount of work required to maintain their own businesses, houses and properties. This was a key lesson for us. While their insight and involvement was still essential to the project, we had to look elsewhere for labor. In total, we sent more than 100 students from Tokyo and Sendai City to construct the VH1. Aside from limited local participation, we encountered several other difficulties during construction. One example was in the practical logistics of making the foundation of the building—we

Fig. 24.5 Living space with LVL flooring

could not find professional carpenters for more than a month because of a shortage of skilled labor in the area (carpenters were busy on larger projects). Another issue was that we made use of different materials to construct the different parts of the building, and needed to alter our methods of construction depending on the material. The installation of insulation, for instance, was strenuous and time-consuming because we did not have the right stapler for that purpose. Carpenters normally have such skills or there are specialists for some components of a building, but with our goal being to demonstrate the ability to construct the building without skilled labor this was a challenge to overcome. We had no choice but to become accustomed to using alternative tools. These problems extended the construction period and eventually required professional skills.

Response of the Local People

The most unexpected criticism we received in the process of construction was in using plywood that was damaged by the tsunami. We were told by a local resident that using damaged plywood with dark spots reminded them of the devastation. Since its use was implicitly avoided by the community, he insisted that we paint or hide such marks completely. We were therefore obliged to rethink the idea of using local materials; the mental damage of the people took forms that we had simply not imagined.

Another point to be mentioned is that the building lost its original function when the person in charge left his position. As a volunteer, our client ran a community facility for the local people, but found it difficult to have sustainable voluntarily support with insufficient funds and unpredictable changes in government policies. As a result, the building was passed to the landlord without any conditions, and with no guarantee that the original function be maintained. The lack of a consolidated policy toward recovery meant that the social conditions were changing day by day. Once the hardware, such as the Veneer House, was constructed, there was no telling how changes in policy would affect the building. The lesson we learned is that the hardware must be adaptable to the changes in social and political conditions. In the long run, society will define how buildings are to be shaped and operated. It is our view that VH-1's flexibility of assembly and disassembly will help adjust to such changes.

Construction costs of about 3.5 million yen were covered by access to supporting funds and by raising money through donations. All travel expenses for students and other volunteers were paid by a different fund. The money raising process was itself a productive learning experience for the students.

Part 3 The Maeami-Hama Community House (Veneer House 2)

Maeami-hama of Ishinomaki City, Miyagi Prefecture, is located in the Ojika Peninsula. Originally composed of 40 households that worked in the fishing industry, only 5 homes remained after the tsunami. All of the ships and fishing equipment were destroyed in a day. As part of the recovery they needed a place to gather and to work together (see Fig. 24.6).

Veneer House 2 has a number of functions. Half of it is for meetings and the other half is for working and storage. In Maeami-hama, we could expect labor from the local fishermen even though they could only work in the afternoons after returning from the sea. In the case of VH2, we did not have sufficient students for construction or time to share all the design details in person with the fishermen. Therefore, we prepared an 'assembly manual' that demonstrated the procedures of construction (see Fig. 24.7). This manual explains the number of people, duration of time, quantity of building elements, and the order of assembly required for building certain structural elements such as beams and columns.

The shortage of labor delayed the project. As it turned out, we could not get the fishermen to help every day because their lives were tied to the weather and the fishing schedule. The inconsistent supply of labor made it difficult to estimate

Fig. 24.6 Maeami-hama Community House (Veneer House 2)

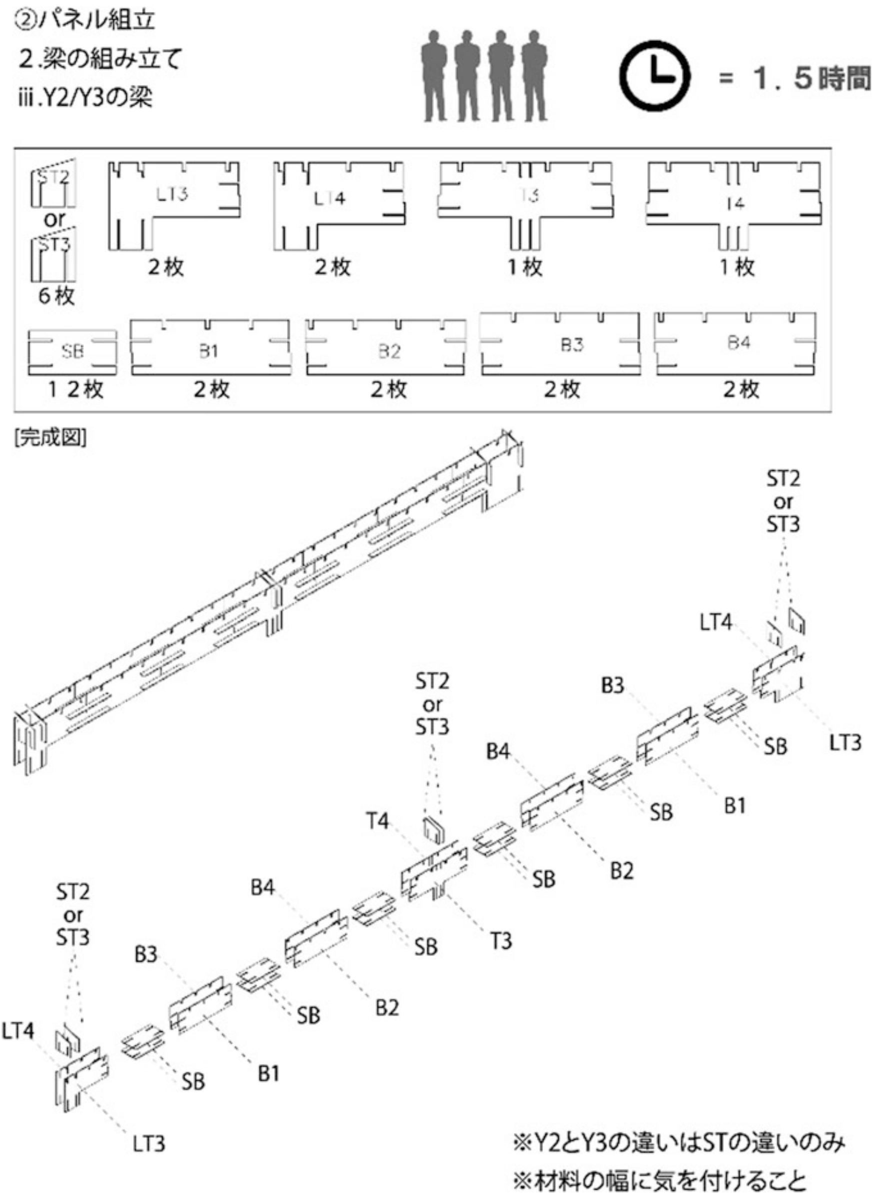

Fig. 24.7 Construction manual for Veneer House 2

the required working hours and the overall duration of the project. This unpredictability obliged us to reduce the effort needed to complete each building task. In this regard, the manual was helpful in composing a series of short construction tasks. In this project, we hired an engineer who could use CNC routers to precut the panels. The precise cutting of notches helped the builders to assemble elements faster and more smoothly. CNC routers and laser cutters unmistakably reduce the labor and time required for building, making it worthwhile to promote the pre-cut panel supply system.

Participation

Construction itself was undertaken by fishermen from the community, who would in fact become the future users of the facility. Participating in the construction process engages the people and creates a sense of ownership, which in turn develops a sense of responsibility in maintaining the building. Buildings that are built by the users are therefore effective in eliminating unnecessary labor costs and in raising the level of motivation (see Fig. 24.8). The VH2 was sponsored by Architecture For Humanity, based in San Francisco in the United States. The construction cost 3 million yen, excluding labor, travel, and living expenses of the construction supervisor. Compared to ordinary wooden buildings that are constructed in a conventional way, the Veneer House is arguably more cost-effective per square meter and therefore worth further applications.

Fig. 24.8 Local community members building their own building

Part 4 The Myanmar Ma Naw Heri Village Learning Center (Veneer House 3)

Veneer House 3 (VH3, Fig. 24.9) is located in Myanmar, in a small country village called Ma Naw Heri near the city of Pathein. Living conditions in the village are very poor in terms of sanitation, privacy, and durability of buildings. The residents of this village were forced to move there after the region they had been living in was hit by a severe hurricane and then suffered from drought in following years; in response, the government designated Ma Naw Heri as a residential district for refugees. Some families were relocated from Myanmar's biggest city, Yangon, while others came from smaller villages. Because of its history it is not a well-established settlement; most houses are poorly constructed and relatively small for the average family size of four to six members. Infrastructure for sewage, fresh water, electricity, and gas are completely absent and the village's only wells were dug some years ago by an international NPO. The weather is dry and sunny for nine months of the year, but between July and September the region experiences an extremely wet rainy season. During this period the village is inundated for weeks at a time, with water rising above the floors of houses and making living and sanitary conditions far worse for this destitute population (see Fig. 24.10).

Fig. 24.9 Ma Naw Heri learning center (Veneer House 3)

Fig. 24.10 Flooding in Myanmar overwhelms local housing

Our design team (the Kobayashi Laboratory of Keio University) was introduced to this village by the local YMCA, which takes responsibility for maintaining a facility for the people of Ma Naw Heri. The YMCA took an interest in our work in Tohoku and asked us to study whether a similar kind of communal facility might be adapted to the climate and social conditions of this village. In the process of researching the village's condition, we held a series of workshops with local children and adults and learned that surviving the rainy season was a serious concern. During the rains and floods, fathers and other potential wage-earners could not work (farming is the main industry of the region), and children could not go out to play either; the extended family must stay together within a limited space for a long time (see Fig. 24.11).

Living space in these homes is quite limited and without any privacy; and likely as a result, domestic violence increased markedly during the rainy season. During our initial visit, we also noticed that the village lacked the kind of communal space that would allow children and adults to escape the restrictions of their small houses and to devote time to education and other productive or fun activities. In response to these conditions, we proposed a village learning center as the program for VH3; the building is mainly intended as a school for local children, but it also invites adults to visit at any time for study and for communal activity. This building would be an important place for people to escape their enclosed domestic spaces, especially in

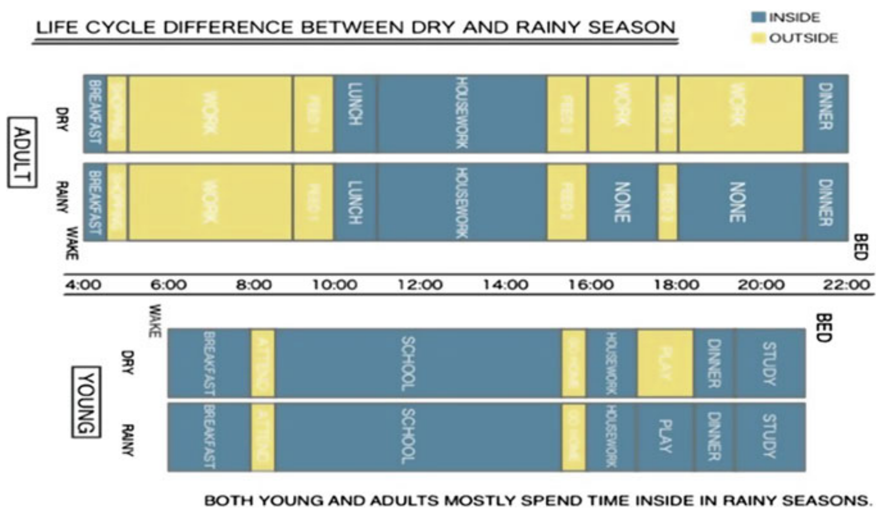

Fig. 24.11 The life cycle of young and old residents during the dry and rainy seasons

the rainy season. The YMCA of Pathein would also use the building for an annual medical clinic it runs for villagers.

Process

After returning from the workshops in Myanmar, our team developed the learning center program in greater detail and designed the building using the same Veneer House system we had piloted in Tohoku. The precut panel assembly method offered clear advantages in reducing the on-site construction time and in making the construction more economical than when using local methods.

We investigated supply routes for local plywood (imported from Thailand rather than produced in Myanmar at the time of VH3) and tested the quality of these panels; though different from Japanese plywood, we found that the Thai plywood available in Myanmar was suitable for the construction method we had devised in Japan. As plywood production is expected to increase in Myanmar in the near future, we anticipate that local residents can build additional structures for less cost soon.

In this project, the construction period was limited by the availability and cost of on-site accommodation for students involved in the construction. We settled on a three-week construction period and determined the construction process accordingly. Because of the condition of the site and small improvements to our methods, we could make the construction period shorter than the previous two projects in Tohoku. After a base of brick and cement had been built to the specifications of

Fig. 24.12 The simpler structure of veneer house 3

local engineers, we erected the main plywood structure within a week (see Fig. 24.12) and then used remaining time to complete the construction of the roof, walls, and a balcony. After the construction of foundations, only three weeks were needed to construct this 60 m^2 learning center—extremely fast compared with ordinary house construction in Myanmar.

Hybrid Use of Advanced and Local Materials

Plywood panels imported from neighboring Thailand formed the primary structure of the building, and local materials for roof (corrugated zinc panels), walls (woven bamboo sheets), and balconies (hardwood posts and beams) completed the structure. While the plywood structure is expected to last a long time, the other locally produced finishes may be replaced more frequently. As local materials, these finish layers are familiar and easily maintained; they also give Veneer House 3 the outward appearance of other local structures, visually integrating the learning center into the village. Maintaining harmony with the existing environment—while strategically making use of affordable new materials and technologies—plays an important role in preserving local culture (see Fig. 24.13).

Fig. 24.13 Local bamboo finish

Participation

The involvement of children from the village was essential in the construction of this learning center; they were to be the primary users, and their participation in all phases of design and construction was critical to their understanding of the building and its future use. Experience shows that every person who participates in constructing a building gains some sense of ownership; this is especially true for children, for whom the shared experience of creating a building where there was none before can be sensational, even life-altering. The sense of empowerment that this construction process gave the children of Ma Naw Heri may well be one of the more profound lessons they will learn during their time at the learning center in coming years (see Fig. 24.14).

Limited Construction Tools

In this construction site, we could not rely on a regular supply of electricity. Without electricity, we came to appreciate the importance of having pre-prepared (pre-fabricated) materials requiring only minimal additional treatment on site. The lack of electricity was frustrating at times as we attempted to cut plywood or screw

Fig. 24.14 University students and young children from the community building their own learning center

pieces together, but in the process we found that we can assemble plywood and many other materials with simple tools such as a saw and hammer; additionally, we realized that diverse construction methods can be imagined and improvised in situations where the local level of technical advancement and available resources are more restricted than in other parts of the world.

Application of the New Housing System in Myanmar

Since building VH3, we have started to design a simple house using the same plywood construction system; the house prototype is intended to raise the living standard of a low-income group of people. If we can provide a small but relatively cheaper house where families can enjoy at least a minimum level of privacy that will surely make some people's lives better. For that purpose, we are currently proposing a formula of 2 × 20 × 200 × 2000; that is, a house that can be built by 2 people, 20 m^2 in size, requiring 200 min and 2000 US dollars to construct. This is the ambition for the next phase of our Veneer House project (see Fig. 24.15).

Fig. 24.15 Veneer House 4—Test model

Conclusion

In helping local communities recover from the devastation caused by the Tohoku tsunami (and from other natural disasters such as earthquakes, hurricanes, floods, and so on), we have learned the importance of maintaining and enhancing community ties during the rebuilding process. Despite being torn apart by disasters—or perhaps because of it—these communities display a strong will, finding ways to gather and share their experiences and hopes for the future. Sharing time together and coming to agreement about the work that must be done is an essential part of rebuilding devastated communities. In each of our Veneer House projects, we have tried as much as possible to involve local people in the process of building communal facilities that they themselves will use, enjoy, and maintain. This process instills in participants a sense of individual ownership and responsibility, as much as it rebuilds a shared sense of community. Our new construction method is based not only on technical invention but also on our commitment to a social dimension: helping people recover a sense of stability and normalcy in everyday life and—if all goes well—weaving an element of renewed joy into those lives.

Part VII
Conclusion

Chapter 25
Understanding Resilience Through the Lens of Change

Will Galloway and Wanglin Yan

Abstract Building resilience requires a good strategy for managing change across disciplines as well as scales of community. The chief difficulty is that it can be difficult to recognize the nature of change even when processes are ongoing and easy to observe. Inertia and the bias of previous knowledge can cloud perspective, while a lack of communication and even awareness of issues between local communities and government or other groups, hinders the process. Change is a powerful motivator for planning resilience. The complexity that usually comes with it suggests we need to build in enough flexibility to manage the unknown as it comes up rather than try to plan for all events in advance. That is not to say that preparation is not useful. To the contrary, it is important to become as best informed as possible of risks and vulnerabilities, as well as to share knowledge about best practices and lessons learned from experience at every level of practice. In that regard, learning is an important part of the process. Building on the body of texts collected in this book the authors propose two key insights:

1. In the case of resilience, learning is best undertaken as a reflexive practice, meaning that knowledge should be constantly tested by practice and critical questioning.
2. Building an approach to resilience that incorporates all scales is essential in order to manage complex problems.

Future research will aim to test these insights by finding case studies that show how communities modified their response as they responded in a crisis. Using that information an evidence based process can be developed for policy makers and leaders in order to prepare communities to act more effectively and be more resilient in the face of change.

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A Time of Resilience?

Although the term resilience is popular, it is difficult to conclude that actions and policies intending to build resilience are becoming commonplace. Adaptation after the fact is happening by necessity, but examples offered in this book suggest there is a line that still needs to be crossed. As Uehara concludes in Chap. 18 even though there is enough knowledge and skill to take action, there may not be a political or community group in place to take advantage of what is known. In the worst case the result can be destructive, as opportunities are missed, or ignored. Improving access to knowledge, including techniques and basic science connected to resilience building, could help to overcome that problem. Developing an interest in resilience thinking among policy makers and leaders is almost certainly necessary.

Wealthier cities and nations are, to some extent, preparing for disaster in many places around the world, as evidenced by the well-designed storm-surge barrier planned for Manhattan by the Bjarke Ingels Group in 2015 (Wainwright 2015). In the case of the United States as a whole, awareness of a need for a national plan is evidenced by the NRC's recommendations to the federal government on adapting to climate change (NRC 2010). Japan has similarly set up *Resilience Japan Initiatives* and enacted the *Basic Act for National Resilience* in 2012 as the umbrella framework for all national and regional plans in the country (NRPO-CS 2012). Other nations around the world are taking similar steps and the number of official National Adaptation Plans (NAPs) for climate change is increasing. These are significant steps, and yet they do not indicate that a tipping point has been reached. Few plans are based on transformational goals, and it is possible to critique the approach in general, as Pelling does (Pelling 2012), for the amount of effort being placed on maintaining a non-equitable status quo for as long as possible. The desire to maintain what is already built is not a bad thing in itself, and as an instinct it is not surprising. However, the kinds of change that need to be responded to (climate change, natural and man-made disaster, demographic change, etc.) may not be easily managed by what amounts to a series of maintenance activities. Returning to one of the key points outlined in the introduction, the role of resilience planning (or resilience thinking) needs to be clarified not only in theory but in practice. Coping with change is an admittedly difficult goal already, however it is worth questioning the possibility of going further and developing a model of resilience where change becomes the engine for improvement. Considering the effort involved, merely coping is not sufficient.

The need for flexibility, if not foresight, is underlined in many of the articles collected in this book. Building up the capacity to act quickly when the unforeseen takes place, or when an opportunity arises, is a common theme, although a need that is not always met. Aldrich (Chap. 23), Dimmer (Chap. 2) and Kobayashi (Chap. 24) offer evidence that community could play a key role in building just that capacity. Combining their insight, we suggest there is a need for a kind of resilience thinking that accepts complexity and that is adaptable, so that a broader range of goals can be integrated as large change events take place. There is a potential benefit in giving local communities the authority and resources to act as change takes place, and the training necessary to see potential problems before they become too large to act in advance. Sharing authority at different scales of community and government is problematic, but could strengthen the system as a whole.

There are political and cultural obstacles to taking such a step. Even when there is full agreement that action needs to be taken, the complexity and interconnectedness of issues can make planning difficult. Local residents may not want to move in the face of rising sea levels for instance, or may not have the resources to adjust without government or other aid. Large corporations and governments may not agree with evidence of culpability, slowing the process further. As plans are put in place it is likely that some communities will be excluded from both the process and the benefits of building adaptation infrastructure. A real effort is needed to ensure that adaptation and resilience efforts are accessible to everyone and that the planning responds to real needs. In the case of Japan for instance, recovery from the Tohoku disaster necessarily should consider the fate of its reconstructed communities as those populations continue to follow the rapid demographic collapse that was already underway before the disaster. Instead we find investment in the construction of seawalls, and little serious planning effort is given over to trying to solve the problems that are now being created by rebuilding cities that will have significantly smaller, aged, and fragmented populations in the very near future. Surely this will be seen as a missed opportunity as the problems become larger over time and the funding and attention long since moved to other places.

Sato offers a similar example in Chap. 4 that bears further discussion. He gives reason to worry that climate change will exacerbate the already unruly problem of managing the number of cars and trucks on the roads in Sao Paolo. In particular, he points out possible damage that could be caused by bouts of torrential rain, a fear that was recently validated by events in 2016, when nearly two dozen people were killed in mudslides and flooding in the city (Attanasio 2016). Complicating his analysis, Sao Paolo, and much of southern Brazil, also suffered from a lengthy and intense drought beginning in 2014 that resulted in economic and political challenges for the entire region (Stauffer 2016). The cause of the drought is contested by some, but researchers mostly agree it is the result of long-term deforestation of the Amazon rain forest (Verchot 2016). Mirroring the concerns raised by Sato, the effects of flooding and drought are worsened by poor urban planning and infrastructural management, meaning the problem is likely to be repeated. Until better planning and management policies are put in place residents of the city face a future where water rationing and semi-permanent shortages are normal.

The challenge in this instance is that the main planning response to both problems (drought and flood), two sides of the same coin, is inaction. Thomas Friedman, writing in a 2014 op-ed in the New York Times, shares a message from Paul Gilding saying that "*…the lack of a serious Brazilian response [to the drought] "reinforces to me that we're not going to respond to the big global issues until they hit the economy. It's hard to imagine a stronger example than a city of 20 million people running out of water. Yet despite the clear threat, the main response is 'we hope it rains.' Why such denial? Because the implications of acceptance are so significant, and we know in our hearts there's no going back once you end denial. It would demand that the country face up to* *the urgency of reversing rather than slowing deforestation"* (Friedman 2014). We can add to his observation. If we look beyond the commentary from the perspective of Gilding's own field (Gilding is a well-known environmental activist), we can see the problem is entwined with other challenges, including urban design, traffic planning, economic policy, and politics. All are precarious and could be unraveled by taking action without thorough preparation and care. It may be the only way to actually manage any of the problems, whether flooding, drought or traffic management is to take on all of them at the same time.

Sao Paolo offers an extreme example; however, the pattern of complex interconnectivity is not uncommon in the articles collected here. Building resilience requires a good strategy for managing change across disciplines as well as across the many scales of community.

Recognizing Change

Acknowledging change can be difficult, even if there is awareness that a shift has taken place. Sometimes the cause is not clear, or its nature is not obvious. As in the case of Japan's demographic crisis being overlooked by the more pressing need to rebuild after the disaster in 2011; immediate problems can easily obscure long-term issues. Inertia also plays a role in how well we recognize new categories of change as they appear. That is, previous knowledge creates a bias that can be difficult to see through. In response to this difficulty Ye (Chap. 13) and Roggema (Chap. 21) advocate for development of more flexible tools that work with community and that are to some extent open-ended. The question is, can policy and planning tools be made adaptable enough that new information is easily integrated into the plans even when it is contrary to what was previously known?

The size of the problem may be a limit on how well we react. Change in the modern world is often extraordinarily large and painted with broad strokes. Millions of people are migrating into cities every week (Nature 2010), while the world economy has grown so large that the volume of economic growth in one year now exceeds the size of the entire world economy just decades ago. In spite of their scale these kinds of change are somehow familiar, because they can be counted, or at least estimated in a meaningful way. Other kinds of change are more difficult to see clearly. To give an example, the very concept of modernization is shifting in a profound way. Once the term was used to describe something like the Green Revolution, which increased food production in much of the world (with both positive and negative effects). Today we speak instead of how nearly every corner of the globe is connected by telecommunication networks. Just like the numbers associated with economic growth and migration these numbers are large and unprecedented. In 2013 the International Telecommunication Union estimated that there were 6.8 billion mobile subscriptions worldwide (International Telecommunication Union 2013). This is a clear number, but quantifying the scope of change is less straightforward because the nature of this shift is decentralized and easily controlled from the bottom-up, something that did not happen with the green revolution. In this regard technology is helping to build a world that Thomas Friedman describes as ‘Flat’, where access to opportunity (and knowledge) is expanding for people and communities that are otherwise unblessed by geography, economics, or their circumstances (Friedman 2005). Admittedly, the economics are less convincing, especially according to writers like Thomas Picketty, who suggest inequality is not so easily overcome by technological aids (Picketty 2014). Still, change can be seen as progressive in the long term. Whether the economic benefits are shared or not, there is a tremendous accumulation of knowledge and an ability to transmit information without oversight that is already changing how global economics and politics play out. The Arab Spring of 2011 is one clear example of how technology changed what was possible for local communities, even small ones that previously had no voice.

Since social media is a new category of activity it is not surprising that the kinds of change it brings about are unexpected. But more traditional patterns are also being disrupted. For example, there are hints that industrialization and modernization will not have the same benefits for developing countries as they did previously for the so-called advanced nations. Mechanization and efficiency have transformed manufacturing in developed countries, reducing employment in an already shrinking sector. However, the history of manufacturing left countries like the United States and even Japan in a relatively strong position economically even as they moved into a post-industrial world. It was once possible to argue that developing nations could expect to follow a similar path from low tech manufacturing to high tech production and then to a service economy, with the understanding that the economic welfare of its citizens would improve as a result. Recent research instead shows many lower and middle-income nations are experiencing a kind of “premature de-industrialization” at a lower economic level than predicted. The cause is linked to globalization and technological improvements in the manufacturing process (Rodrik 2016). As less wealthy countries shift towards service economies (before they should) it means the opportunity for economic improvement of their populations is in serious question. Basic assumptions about the value of modernization and mechanization are not on solid ground at all. This is a high impact change that can affect economies and politics all over the world, and though it has been happening for decades it is only recently being noticed.

It would not be out of place to assume there are more processes like this going on than we are aware of. Recognizing change as it happens, even when the impacts are large, can be difficult because of our biases and the pace of change. In the abstract it is easy to suggest that we take advantage of change in order to improve the lives of as many people as possible, but how do we do that when it is not obvious that anything has changed at all? Do we try to become better informed? That is part of the answer surely. Another solution might be to create a framework for adaptation that allows us to act quickly once we understand a new trend or are confronted by a new disaster. At the scale of community, it may be possible to act quickly enough, but will there be a support system in place?

If climate change is thought of as a slow-onset crisis, disaster is its exact opposite. The 2011 triple crisis in Japan was caused by an enormous earthquake, followed by a devastating tsunami and the catastrophic nuclear power plant accident in Fukushima (all taking place on March 11, and often referred to as the 3.11 disaster by Japanese). Soon after the disasters, Japanese society was collectively calling for wholesale change across a very broad institutional landscape, including energy policy, political decision making, and centralized urban planning. Even modernity and globalization were called into question. However, as Christian Dimmer shows in Chap. 2, as the recovery proceeds there is also growing uncertainty about where and how change can be implemented, particularly in a depopulating countryside. For some Japanese, the post disaster reconstruction is viewed as an opportunity to rethink Japan's past, and proceed in a new direction. For others, 3.11 was a once-in-a-millennium "black swan" event, and could therefore be safely ignored. Still others say Japan must rebuild what was lost to modernity and globalization (Samuels 2013), although as we have seen it is hard to say what that even means today. Dimmer and Aldrich would both add that a strong civil society is essential to any possible future.

Learning Across Scales

A key part of the process towards reducing vulnerability, and the justification for the conferences that became the basis for this book, is learning.

One of the important achievements of science in recent decades is that we have become acutely aware of the limitations of what we know, and what we do not. We understand the nature of uncertainty better than ever and recognize that continuous learning is necessary to keep up with change in a complex adaptive system (Djalante et al. 2012). Reflexive learning, or the idea that we can learn as we are acting on our decisions, is a useful approach to managing resilience. As new information becomes available we necessarily must be able to react accordingly. A reflexive society/community is able to respond to unintended consequences in spite of the limitations of available information, the diversity of viewpoints, and the multiplicity of policy options (Krayer 2005). The nuclear accident at Fukushima Daiichi is a good example. The planning failure suggests the need to change energy production, but also a shift in behaviour. That kind of shift however would require a 'co-revolution' in many spheres, in the need to convince others of the necessity for change, and subsequent regulatory institutionalization of such changes.

In a crisis, local communities have an important role to play (Samuels 2013), as shown in the case of the communities that Aldrich examined in Bangkok, Christchurch and in Tohoku (Chap. 23). Communities have access to ground-based knowledge, to trust, to connections and to social support systems—all advantages, particularly in developing countries where ecological and social systems are deeply intertwined. Building resilience in communities requires a coordinated effort that unites governments, businesses, research organizations, academia and the residents themselves—breaking down silos and creating partnerships that can reflect on shared challenges. In many cases this potential is hard to sustain, in part because of the degradation of place-based communities in both urban and rural areas, and in part because of the limitations of support (financial, technological, political, industrial and intelligence). Professional help from universities and NPOs may be useful as a tool to kickstart resilience (Kobayashi, Chap. 24) in a post-disaster situation. They can help to build coordinated networks, train leaders and entrepreneurs, and delivering scientific information in a slow onset changing environment (Banerjee, Chap. 22). As outsiders however their role will always be a challenge in terms of scaling activities and with building a real basis for future activities.

Revisiting the topic of reflexive learning, the decision-making process requires the policy community to change their attitude towards uncertainty, conflict and decision-making itself. As Tanaka shows from his experience in his chapter on managing the needs of a community after disaster (Chap. 12) a proactive attitude which recognises and accounts for uncertainty is required, and mismatches between needs and actions are better perceived as a learning opportunities than as a battle to be fought over and won (Krayer 2005). Tanaka's chapter is particularly useful as an example because it underlines the gap between local needs and policy set by a distant government authority. In this regard communication becomes a central tool for learning, and a way to ensure that knowledge is passed both upwards and down as a crisis is managed, and as plans are made to build resiliency. More importantly, governments and leaders need to recognize that learning is something that should happen at every scale. In that case building in policy tools that ensure learning at every level, from community to higher government, is something we might consider.

Conclusion

Empowerment is a theme that can be found in many of the articles in this book. From the point of view of policy, it is clear that communities need to have the power to take decisions and to gather information to reduce vulnerability in the long term. More interesting, as in the case of herders measuring change as a collective in Mongolia, and energy entrepreneurs in India making their own electricity as a community, there is an opportunity just now for people to take advantage of technology and empower themselves. Because problems are felt most acutely by local communities, and especially by people living in marginal conditions, any opportunity to empower people to act before consensus is reached by governments or businesses is a thrilling possibility. The examples in this book are initiated from outside, underlining the usefulness of academia and NPOS's, but the fact that communities are able to react positively is promising.

Resilience is an odd subject because it must by definition accept no single solution, nor a single response to disaster or other kinds of change. Technically speaking we are coming to understand the uncertainty of complex systems, and can build a framework that incorporates a certain amount of scepticism about how to act in the case of a crisis. Still, learning from our experiences and changing direction if needed remains difficult, especially in governments and large groups.

Future research might focus on case studies and tools that take advantage of reflexive learning to solve problems better as they unfold. Policy makers and leaders will need information and accessible knowledge as they are forced to incorporate adaptation and resilience thinking into their normal workload. Unfortunately, as the number of disasters and crises around the world is not likely to decrease, and indeed seems to be on the rise, we will have ample opportunity to learn about how to react and to learn from our mistakes. The challenge will be to take that step and improve our response, and to not continuously reinvent the wheel each time a crisis strikes. Ideally we will eventually develop a kind of resilience thinking that can manage change by building it into daily life from the start. That is a goal worth working towards. Based on the work of the contributors to this book we are hopeful that it is a goal that will eventually be reached.

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