

When not every response to climate change is a good one: Identifying principles for sustainable adaptation

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Climate adaptation has become a pressing issue. Yet little attention has been paid to the consequences of adaptation policies and practices for sustainability. Recognition that not every adaptation to climate change is a good one has drawn attention to the need for sustainable adaptation strategies and measures that contribute to social justice and environmental integrity. This article presents four normative principles to guide responses to climate change and illustrates the significance of the 'sustainable adaptation' concept through case studies from diverse contexts. The principles are: first, recognize the context for vulnerability, including multiple stressors; second, acknowledge that differing values and interests affect adaptation outcomes; third, integrate local knowledge into adaptation responses; and fourth, consider potential feedbacks between local and global processes.

We argue that fundamental societal transformations are required in order to achieve sustainable development pathways and avoid adaptation funding going into efforts that exacerbate vulnerability and contribute to rising emissions. Despite numerous challenges involved in achieving such change, we suggest that sustainable adaptation practices have the potential to address some of the shortcomings of conventional social and economic development pathways.

Keywords: adaptation; climate change; environmental change; sustainable development; transformation; vulnerability

1. Introduction

Climate adaptation has become a more visible and pressing issue in recent years. In part this can be attributed to the recognition that the climate system will undergo changes in the

coming century regardless of reductions in greenhouse gas emissions, mainly due to thermal inertia of oceans and the long atmospheric lifetime of carbon dioxide and other greenhouse gases (Matthews and Caldeira, 2008). However, it has also been reluctantly acknowledged

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that emission reductions are unlikely to decrease at the rate and magnitude necessary to prevent climate change that is dangerous to many (Parry et al., 2009; Schellnhuber, 2009). Adaptation is thus increasingly considered as essential to reducing vulnerability to dangerous climate change.

Yet, although adaptation can potentially reduce the negative impacts of climate change, little attention has been paid to the consequences of adaptation policies and practices for sustainability. In some cases, what seems to be a successful adaptation strategy to climate change may in fact undermine the social, economic and environmental objectives associated with sustainable development. Strategies or policies that make sense from one perspective, or for one group, may at the same time reduce the livelihood viability or resource access of other groups. Likewise, an eagerness to reduce climate risk through specific technologies or infrastructural changes may sometimes lead to the neglect of other environmental concerns, such as biodiversity (Næss et al., 2005; Eriksen and O'Brien, 2007; Eriksen and Lind, 2009). Hence, adaptation can have unintended negative effects both on people and on the environment.

A recognition that not every adaptation to climate change is a good one has drawn attention to the need for sustainable adaptation strategies and measures, and for qualifying what types of adaptation are desirable or not (Eriksen and O'Brien, 2007). There is also an increasing recognition of the potential of climate adaptation to address some of the mistakes and shortcomings of conventional social and economic development pathways that have contributed to social inequity, poverty and environmental problems (Ulsrud et al., 2008). It is particularly important to identify the synergies between adaptation and sustainable development because urgent and overwhelming poverty problems in the world are far from satisfactorily addressed, and environmental problems other than climate change also threaten people's livelihoods and quality of life. Indeed, most individuals and communities are adapting to multiple stressors, in

addition to climate variability, extremes and the risk of disaster (Eakin, 2006; Reid and Vogel, 2006; Schipper and Pelling, 2006; Ziervogel et al., 2006; O'Brien et al., 2008).

Developed countries are committed to the goal of jointly mobilizing USD30 billion for the period 2010–2012 (and an additional USD100 billion a year by 2020) to address the climate-related challenges of developing countries, and much of this will go to adaptation (ENB, 2009). The increase in attention to and resources for adaptation suggests that it is critical to 'get adaptation right' in order to solve, rather than exacerbate, problems. Consequently, it is important to understand what it means to sustainably adapt to climate change, or what is referred to in this article as 'sustainable adaptation'. Sustainable adaptation is defined here as adaptation that contributes to socially and environmentally sustainable development pathways, including both social justice and environmental integrity.

This article presents and discusses the concept of sustainable adaptation to climate change and identifies four normative principles to guide responses to climate change. We illustrate the principles of sustainable adaptation and their significance through case studies from diverse contexts. In the conclusions, we discuss the possibilities and limitations for achieving sustainable adaptation in practice. We suggest that despite numerous challenges, attention to principles for sustainable adaptation can contribute to socially and environmentally sustainable responses to climate change.

2. Climate change adaptation and sustainable development

Adaptation to climate change has been described from a wide range of perspectives, and many adjectives have been used to modify the term (autonomous, involuntary, planned, passive, reactive or anticipatory, etc.). In terms of climate change, adaptation has been defined as the process or adjustments through which people reduce the adverse effects of climate on

their health and well-being, and take advantage of the opportunities that their climatic environment provides. Other definitions have argued more forcefully that adaptation includes the reduction of vulnerability (Smit et al., 2000; Debels et al., 2009). Leary (1999) and Burton et al. (2002) referred to climate adaptation as a wide range of behavioural adjustments that households and institutions make (including practices, processes, legislation, regulations and incentives) to mandate or facilitate changes in socio-economic systems, aimed at reducing vulnerability to climatic variability and change. Nelson et al. (2007) defined adaptation as the decision-making process and the set of actions undertaken to maintain the capacity to deal with current or future predicted change. These definitions are summarized in the Intergovernmental Panel on Climate Change (IPCC) definition of adaptation: the adjustment to practices, processes and systems in order to ameliorate negative effects and take advantage of opportunities associated with climate change (IPCC, 2007).

Debates on climate change adaptation have taken place largely outside of the broader discourse on sustainable development (Bizikova et al., 2010). Although sustainable development has been included as a theme in many of the assessments by the IPCC (Munasinghe and Swart, 2000; Yohe et al., 2007), little attention has been paid to the identifying principles that create synergies between adaptation and sustainable development. Cohen et al. (1998) pointed out that although climate change is one of the most important symptoms of an unsustainable economic system, the climate change and sustainable development fields have been separated by differences in discourse. For example, climate change has been largely constructed as an environmental problem that can be solved by reducing greenhouse gas emissions, with little attention to its social, cultural, political and ethical dimensions (O'Brien et al., 2010). This effectively bypasses the complex, context-specific and multidimensional challenges of sustainable development. The concept of sustainable

development initially focused on the close connection between environmental problems, poverty, inequity and basic human needs. However, the concept of sustainability has been criticized as a vague policy term rather than an academic concept subject to rigorous analysis. It has been accused of being malleable to suit any interest, or a 'rhetorical cover for business-as-usual politics' (Cohen et al., 1998, p. 353), distracting attention from any fundamental changes in systems. There have, however, been many calls for 'strong sustainability', which involves changing current modes of development, questioning calls for continued economic growth and appealing for a less managerial approach to human–environment relations (Adams, 2009).

Cohen et al. (1998) argued that it is precisely in forging the links between climate change and sustainable development, in terms of focusing rigorous analysis and policy efforts on the political, social and ethical dimensions, that action in both areas can be achieved. According to Robinson and Herbert (2001), climate change can be made more relevant to policy by contextualizing it within a sustainable development framework. They argue that mitigation and adaptation can contribute to a range of sustainability goals, at the same time that sustainable development policies can contribute to emission reductions. As with debates about sustainable development, the climate change problem raises questions about the underlying development pathways causing both environmental problems and poverty (Adams, 2009). The issues of climate change and sustainable development thus converge in the call for fundamental changes to development pathways. A critical point is the recognition of alternative development paths, and 'how much choice we have about what kind of world we will end up in' (Robinson and Herbert 2001, p. 146).

3. Key principles for sustainable adaptation

An underlying premise for the concept of sustainable adaptation is that many responses to climate

change will create social and environmental externalities, including trade-offs and negative consequences. Sustainable adaptation thus considers the wider effects of adaptive responses on other groups, places and socio-ecological systems, both in the present and in the future. Sustainable adaptation can be distinguished from adaptation in general in that it qualifies actions in terms of their effects on social justice and environmental integrity; that is, adaptation is sustainable only if it contributes (and at the very least does not seriously erode) these two features. This qualifying of adaptation is a response to concerns that adaptation has often been operationalized in practice through changes in technology, institutions and managerial systems (Klein et al., 2007), rather than challenging current development paths, including the social, economic and political structures that underlie many contemporary problems.

Sustainable adaptation can be considered necessary in response to three problems highlighted in the vulnerability literature. First, climate change is a global problem that affects both current and future generations, and responses must be sensitive to both spatial and temporal consequences. Adaptations taken to benefit one sector or group may undermine the security and well-being of others, such as by influencing resource access and the integrity of ecosystems that many people depend upon for their livelihoods (Eriksen et al., 2005). Second, widespread poverty makes many individuals, households, communities and states vulnerable to even small shocks and stressors. The tendency of poor people to be highly vulnerable to climate change is often used as a justification for implementing adaptation; however, whether or not the proposed adaptation measures will actually assist poor groups is seldom assessed. Since not any and every adaptation intervention reduces poverty and inequality (and some poverty reduction measures may aggravate vulnerability), sustainable adaptation measures need to specifically target links between vulnerability and poverty (Eriksen and O'Brien, 2007; Eriksen et al., 2007). Third, the need to drastically

reduce global greenhouse gas emissions and facilitate a rapid transition to low-emission economies suggests that adaptation measures should emphasize low-emission solutions. Responses to climate change can thus be seen as a means for promoting alternative development pathways, such as transitions to low-carbon economies, organic agriculture and horticulture, agroforestry, ecological sanitation, water harvesting, water purification by the use of solar energy, alternative modes of transport, decentralized renewable energy supply, recycling or participatory plant breeding (Ulsrud et al., 2008; Winkler and Marquand, 2009).

Sustainable adaptation differs from a reformist view of sustainable development, and from an interpretation of adaptation as a mere adjustment of current practices and development paths. For example, development paths that contribute to inequity and poverty, or are based on fossil fuel-intensive consumption patterns, are inevitably called into question by the concept of sustainable adaptation. The types of responses that contribute to social equity and environmental integrity will depend on the context, and therefore vary between people and places, and over time. Hence, 'sustainable adaptation' does not suggest that a specific technology or practice can be identified that will be viable in all places or at all times. Instead, practices need to change as the context changes, forming part of the new and dynamic development paths required to reduce both vulnerability and greenhouse gas emissions.

The question then arises as to what characteristics or conditions should be looked for when assessing adaptation responses? How can the concept of sustainable adaptation be realized? Four main principles are presented here, and elaborated on through case studies that illustrate how adaptation can be formulated in different contexts. The challenges in using such an approach are also discussed. As with all responses to climate change, it is important to consider the vested interests, the mismatches between the scales of action and issues of power relations, the prioritization of certain types of knowledge

and the lack of systems perspective in the process of decision-making. These factors are, however, likely to become more visible if the principles are included in adaptation planning.

3.1. Key principle 1: recognize the context for vulnerability, including multiple stressors

Individuals, groups and regions are experiencing many types of stressors, besides environmental change, that together create a context for vulnerability (Eakin, 2006; Ziervogel et al., 2006; Leichenko and O'Brien, 2008; Eriksen and Lind, 2009; Tschakert and Dietrich, 2010). Recognizing the role of multiple stressors in influencing this context for vulnerability involves acknowledging that despite good intentions, some adaptations may not improve social equity and environmental integrity. The underlying social, economic, institutional and cultural conditions that contribute to a wider context for vulnerability thus need to be understood, in order to identify direct and indirect consequences of adaptation efforts, and to be sensitive to the spatial and temporal effects of such efforts. In terms of social and environmental consequences, sustainable adaptation thus places a greater emphasis on how the structural and contextual factors that create vulnerability, such as chronic poverty and unequal terms of trade, influence the outcomes of adaptation measures. This first principle of sustainable adaptation thus holds that responses should be sensitive to the wider context in which climate change is experienced.

3.1.1. Case study: addressing the vulnerability context of poor communities affected by floods and rainstorms in the city of Ilorin, Nigeria

The importance of this principle is illustrated by the case of poor, urban and semi-urban areas of Ilorin, the capital city of Kwara State in Nigeria. There are multiple stressors that generate vulnerability in these areas, and unless socio-economic dimensions are tackled in

combination with infrastructure, climate-related extreme events, such as heavy rainstorms and flooding, will continue to have effects on livelihoods and long-term vulnerability. A large proportion of inhabitants in the case study area are older people (40% are above 50 years of age), levels of education are low and very few are engaged in the formal sector (9%), most working as artisans, farmers and traders. Household sizes are large: close to 80% of the households have more than four people. At the same time, houses are old (more than half are older than 30 years) and many are constructed in materials that do not withstand rainstorms and flooding. Poor waste collection leads to blocked drainage systems. In some parts the situation is made even more precarious due to sparse vegetation, meaning that any heavy rainfall results in flooding (Ijaiya and Umar, 2004). Hence, key conditions generating vulnerability include poverty, overcrowding and social inequity.

A number of socio-environmental changes create the conditions described above. These include the marginalization of urban dwellers in terms of infrastructure, services and income opportunities; rapid urbanization; physical development on environmentally sensitive lands such as wetlands, slopes and floodplains that exacerbates environmental degradation; and flooding risks (Olorunfemi and Raheem, 2007; Olorunfemi, 2008; Mehrotra et al., 2009; Gbadegesin et al., 2010). Extensive damage to properties and livelihoods contribute to the endemic poverty in most parts of Kwara State. For instance, increasingly frequent and severe floods have damaged electricity facilities in some areas for months, disrupted trading, and washed away crops in suburban areas. Traders, artisans and women farmers are among the most vulnerable groups.

In order to develop measures that contribute to sustainable adaptation, it is necessary to address the structural and contextual factors that create vulnerability, such as those described above. Measures also need to include an understanding of how livelihood dynamics form part of the

vulnerability context. For example, support from friends and relatives and personal savings explain how a large proportion of disaster victims cope with its immediate impacts. Sustainable adaptation measures must be sensitive to the need to sustain such support networks. At the same time, however, measures would also need to address the vulnerability context in the long term by complementing household mechanisms and addressing some of the structural processes. This could be achieved, for example, by facilitating livelihood diversification and formal support systems that could relieve the stress on social networks in times of disasters. This first principle of sustainable adaptation involves broadening responses to recognize, and where possible address directly, the context in which climate change is experienced. This context includes stressors such as the marginalization of urban dwellers in terms of infrastructure, services and income opportunities, as well as physical developments that threaten environmental integrity and exacerbate flood risk.

3.2. Key principle 2: acknowledge that different values and interests affect adaptation outcomes

Values and interests play an important yet seldom discussed role in climate change responses, and they influence the adaptation strategies that are prioritized by different groups (O'Brien, 2009). Recognizing potential value conflicts can help to identify how adaptation responses taken by one group may affect the vulnerability context of other groups. Strong vested interests within particular adaptation strategies may act as a barrier to sustainable types of adaptation. For example, the adaptive responses that distribute risk across market and subsistence production in Ghana may in fact prioritize the maintenance of the status quo for men, at the cost of women's self-determination (Carr, 2008). Sustainable adaptation may thus involve a more transparent political process that creates enabling conditions and access to information that supports decision-making

for adaptation. For example, linking democratization and empowerment efforts with those of adaptation can potentially address differing and often conflicting adaptation interests (Eriksen and Lind, 2009). The second principle involves recognizing differential interests and potential value conflicts, and identifying how these may influence outcomes, particularly for the most vulnerable.

3.2.1. Case study: including the adaptation interests of vulnerable groups in local government policy in Durban, South Africa

The case of Durban, exposed to both flooding and coastal erosion, illustrates how important it is to develop institutions (and how these institutions conceive climate change) that focus on social equity and vulnerability in order to achieve sustainable adaptation. In particular, prioritizing the needs of vulnerable groups in both development and climate policy processes is critical. Before the democratic transition in 1994, environmental concern at the local level was low in South Africa. The process of democratization resulted in a development agenda that focused on the need to address the social inequity created by the Apartheid regime, but with little connection to climate change (Roberts, 2008; Carmin et al., 2009). In the beginning, any climate change action was also largely disconnected from concerns about adaptation and vulnerability; for example, the Cities for Climate Protection campaign initiated in 2000 largely focused on developing mitigation-related policies (Roberts, 2008). Although important as a first step, the campaign failed to generate an institutional framework, knowledge about climate change and adaptation, or interest among government agencies or the population at large (Carmin et al., 2009).

The situation improved when programmes started to focus more specifically on vulnerability and climate protection, such as through convening a vulnerability assessment. This assessment served as an opportunity to engage different municipal stakeholders in climate change

discussions (Carmin et al., 2009), leading to recognition of the city's vulnerability and of existing initiatives through which adaptation could be facilitated. A second phase focused on key municipal sectors such as urban infrastructure, human health and disaster risk reduction (Roberts, 2008).

The case indicates that it is important not only to mainstream climate change responses into local government policies but also to consider it under a framework of social inclusion, justice and sustainable development. Not only could the interests of vulnerable groups be heard; by including vulnerable groups in the science-policy interface understanding of the implications of climate change in the local context was enhanced, generating local interest and policy action (Vogel et al., 2007). The case also exemplifies the importance of having local champions within government structures that can spearhead such engagement, an observation previously made in other contexts such as Norway, Sweden and the USA (Næss et al., 2005; Lowe et al., 2009; Sanchez-Rodriguez, 2009; Storbjörk et al., 2009). Such a dependence on individuals within government structures can nevertheless be a barrier to the social inclusion of vulnerable groups, since how (and if) processes are designed and which interests are heard are related to the particular knowledge, connections and orientation of an individual rather than institutionalized and democratic adaptation policy processes. The second principle suggests the need to ensure that representation of groups that are vulnerable to climate variability and change is institutionalized in formal government or development processes. It also requires that such processes analyse and recognize different interests and potential value conflicts up front, and identify how these may influence outcomes.

3.3. Key principle 3: integrate local knowledge into adaptation responses

Different groups and actors produce different knowledge on adaptation, and which source of

knowledge is recognized and used in decision-making is crucial in determining which interests or development paths are prioritized. Different approaches to adaptation often reflect varying approaches to knowledge and understandings of the local context, resulting in different diagnoses of both problems and solutions. Integrating local knowledge based on the experience of living in a risky place and of observing the natural environment is essential for sustainable adaptation to climate change (Olsson and Folke, 2001; Berkes, 2007). Community-based adaptation initiatives are increasing in response to the top-down, technical approaches promoted by the scientific discourse on climate change (Huq and Reid, 2007). In the dominant scientific discourse, practices of the poor have often been blamed for environmental degradation, and resource control has consequently been transferred from local populations to central governments or to private actors (Benjaminsen et al., 2006). The third principle of sustainable adaptation recognizes that successful responses involve integrating local knowledge with other sources of knowledge about climate change.

3.3.1. Case study: building on local knowledge and capacity in risk reduction in Concepción, Chile

The importance of existing local knowledge and capacity is particularly well illustrated by the case of Concepción, Chile.¹ Over time, vulnerable people have developed responses to disasters based on their knowledge and understanding of the conditions and environment where they live. The community of Agüita de la Perdiz consists of mainly informal and illegal settlements, built on landslide-prone areas on the 'Caracol hill', downtown of the second largest city in Chile, Concepción (Mardones and Vidal, 2001; Hauser, 2005).

Climate-related hazards, such as rainfall or cyclones, are expected to increase in frequency and magnitude because of climate change. However, there remains substantial uncertainty in the rate and behaviour of these changes (Christensen et al., 2007). Hence, timely and local

adaptation to 'new unknown severity and frequency of hazards' under a changing climate becomes imperative (Debels et al., 2009). In 2005, the community living in this area faced the most severe event in 142 years when 162.2 mm precipitation fell in 24 h. The material damages were massive, with 100 out of 282 houses partially or completely destroyed (DMC, 2005; ONEMI, 2005). What was remarkable for a disaster of this magnitude was that there were no deaths reported, and only a few injuries. In-depth interviews with people affected by the flood revealed that a crucial aspect that helped to protect what is most important – their lives – was the knowledge people had of their environment and vulnerability (Aldunce et al., forthcoming).

Recognizing and acting on an unusual level of rainfall, the community made use of both past experience and knowledge about which areas would be most exposed and which people would be hardest hit. Rather than waiting for external warning and help, people organized a refugee camp, evacuated vulnerable community members and took turns to protect houses against robbery (Aldunce et al., forthcoming). Faced with recurrent extreme events, the Agüita de la Perdiz community has shown itself capable of generating social learning, and the population has a high level of risk awareness and knowledge about the physical environment and potential vulnerability. This in turn has resulted in proactive behaviour in terms of well-organized community participation and leadership in disaster response, and improved capacity to adapt to climate extremes. The high degree of social learning enabled people of Agüita de la Perdiz to assist neighbouring communities in their response and recovery, both during the 2005 deluge and in other disasters. The key role of autonomous adaptation and local knowledge in adapting to climate variability and change has been frequently illustrated in rural contexts (Eriksen et al., 2005; Eakin, 2006; Reid and Vogel, 2006; Ziervogel et al., 2006). The case of Agüita de la Perdiz shows the more universal relevance of the third principle of

sustainable adaptation for both urban and rural contexts; that is, the importance of generating local knowledge and integrating it with other sources of knowledge in order to develop successful responses to climate change and empower local decision-making. Local knowledge in disaster risk management is critical for reducing vulnerability among the poorest, and can be combined with policy efforts to address social equity and vulnerability. Any policy intervention to strengthen adaptation and reduce risk would need to recognize community participation in disaster prevention and response and strategies for living with environmental variability (Wisner et al., 2004; Eriksen et al., 2005; Pelling and High, 2005; van Aalst et al., 2008).

3.4. Key principle 4: consider potential feedbacks between local and global processes

Adaptation responses may directly affect the vulnerability of local populations, but every response can also influence – or be influenced by – larger-scale processes. As Adger et al. (2009) pointed out, vulnerability is nested and tele-connected through environmental change feedbacks, economic linkages and global flows of resources, people and information. The possibility that feedbacks and linkages can influence both social justice and environmental integrity over both space and time raises questions about the sustainability of many adaptation responses. For example, adaptations often have significant implications for greenhouse gas emissions, water quality and access, and biodiversity. Likewise, adaptations can influence migration, trade patterns and urbanization processes. Mitigation of climate change is particularly important, as continued global warming can overwhelm local adaptive capacity. The fourth principle of sustainable adaptation hence focuses on the need for responses to recognize the interactions between local and global processes, which can create both positive and negative feedbacks.

3.4.1. Case study: linking adaptation with mitigation and transformations towards a resilient society in Norway

The importance of embedding local actions and adaptation in an understanding of climate change as a global concern is illustrated in the case of snow-dependent leisure activities in Oslo, Norway. For local adaptation efforts to be considered sustainable there is the need to consider the global effects of these efforts. For example, using low- rather than high-energy adaptation options would limit greenhouse gas emissions that contribute to global warming and increased risk elsewhere.

Winter sports and leisure activities such as skiing and skating are ingrained in the Norwegian national identity. A warming climate has led to deteriorating snow and ice conditions, especially since the 1970s. In the Oslo region, inhabited by a fifth of the country's population² and where an estimated 80% use the forests for recreation (Berg, 2004; Vaage, 2004), the number of days with skiing conditions are projected to decline by 40% from the 1981–1999 period to 2050 (Iversen et al., 2005). A transformation of recreational activities and ways of defining national identity may be required in the long term.

However, current adaptations in the face of warming conditions appear to focus on preserving existing activities through 'controlling' local environmental conditions in the short term in the face of changing weather conditions, often in ways that involve increased energy use. For example, the municipal authorities and sports clubs now produce large quantities of artificial snow and ice. In western Oslo, for example, there are now plans to construct the country's biggest artificial ice rink to enable people to skate despite warming winter conditions. Those opposed are concerned about local increases in traffic, noise and light pollution. Completely absent from the debate, however, are concerns about the global climate with respect to the increased emissions that result from the energy used in producing artificial ice. The main climatic consideration in the debate was the potential for

local cooling due to the artificial ice.³ At this instance, local adaptation is clearly not placed in a global context. There is little awareness on how the effects of local adaptation responses, through local and global linkages and feedback processes, in turn affect global warming.

Even if energy consumption is increasingly considered in the production of artificial snow and ice, there are nevertheless limits to such forms of adaptation. The production of artificial snow and ice can only support skating and skiing in isolated areas, while the loss of natural winter conditions and associated recreational activities could damage cultural and emotional attachment to the winter landscape, and potentially lead to a loss of values around national identity.

Sustainable adaptation in the case of Norway would involve both drastic cuts in GHG emissions to reduce future deterioration of snow conditions as well as transformation towards new types of recreation and cultural identities. In the current framing of the climate change problem, however, local weather and responses are treated as isolated from global changes. Such an approach may reinforce a dominant complacency regarding Norway's ability to adapt its way out of climate change (O'Brien et al., 2006) and stifle public and policy engagement for addressing climate change. The fourth principle of sustainable adaptation – recognizing the interactions between local and global processes – involves broadening responses from narrow short-term goals to instead helping to transform society through enhanced resilience and flexibility in the face of uncertainty, accommodating diverse needs (beyond skiing), and recognition of both positive and negative feedbacks from local measures.

4. Conclusions: practical and conceptual lessons regarding sustainable adaptation

Sustainable adaptation can be defined as a set of actions that contribute to socially and environmentally sustainable development pathways,

including social justice and environmental integrity. However, just as adaptation provides an opportunity to transform society towards sustainability goals, adaptation actions can also exacerbate greenhouse gas emissions, vulnerability to climate change and a number of development problems. In this article, we have outlined four principles that can guide adaptation responses in a manner that supports sustainability. Sustainable adaptation should (1) recognize the context of vulnerability, including multiple stressors, (2) acknowledge that different values and interests affect adaptation outcomes, (3) integrate local knowledge into adaptation responses and (4) consider potential feedbacks between local and global processes. An underlying premise for the four principles is that adaptation is not neutral, and not all adaptation will 'do good'; there will be trade-offs, feedbacks and negative consequences. Assessing and understanding these dimensions and moving towards sustainable development pathways requires a renewed focus on the consequences of adaptation actions, whether these actions are policy driven or autonomous, or involve social development, altered technology and practice, economic or institutional measures, legislation or infrastructure, or changes to political, structural or social relations.

The four case studies presented above illustrate different aspects of these principles. However, no single case illustrates a perfect or comprehensive example of sustainable adaptation. It is important to acknowledge that even if applied, the four principles alone do not guarantee sustainable adaptation. This article represents a first step in defining sustainable adaptation, and there is clearly a need for continued reflexivity, and what Tschakert and Dietrich (2010) refer to as 'anticipatory learning'. Furthermore, many gaps still exist between research and practice. How, then, can these principles be used to implement sustainable adaptation in practice? While answering this question is beyond the scope of this article, a few reflections are offered below.

Sustainable adaptation is likely to entail societal organization that is flexible in the face

of changing climatic conditions (rather than 'controlling' specific environmental conditions), while at the same time minimizing greenhouse gas emissions. It is important that adaptation actions do not lock people into high-emission and soon-obsolete technologies or practices, nor reinforce dependency relations. Instead, actions need to contribute to a cleaner, greener and more equitable society. Navigating the global long-term consequences of adaptation actions is complex. In the case of biofuel production, sustainability would entail promoting energy access and livelihood options by the poor in ways that enhance adaptive capacity, while avoiding production patterns that entrench dependency or create vulnerability, environment and land loss problems (African Biodiversity Network, 2008).

Sustainable adaptation also calls for a strengthening of social resilience. The case of Concepción underscores the importance of social capital and community empowerment as part of sustainable adaptation, through strong citizen participation, local identity and local organization. Social capital is made up of different norms and networks that enable people to act collectively (Woolcock and Narayan, 2000; Adger, 2003) and enable the knowledge sharing, spreading of risk and claims for reciprocity in times of crisis. Such networks are scale dependent and are associated with a flexible and adaptive society (Adger, 2003). A central challenge reflected in the cases, however, is that strengthening local capacity alone does not effectively reduce vulnerability. Increased sustainability can only be achieved if local capacity is combined with measures aimed at including socially marginalized groups, making the voices of vulnerable groups heard in decision-making processes that affect their adaptation interests and making these interests count in the face of pressures from economic development, such as physical development of lands that currently increase climate risk and reduce land rights of the poor.

The road to sustainable adaptation starts with the understanding that adaptation is a 'process' rather than a list of actions and measures that

address specific climate change impacts. Sustainable adaptation requires going beyond one-time climate proofing measures, and questioning the assumption that every adaptation to climate change will be beneficial. The consequences of actions and measures must be considered within the much broader social and environmental context; trade-offs and the potential for negative outcomes over space and time must be recognized. The normative principles of sustainable adaptation can be considered a first step in guiding responses towards social justice and environmental integrity.

Acknowledgements

This article is the result of discussions by a group of scientists from Asia, Africa, Latin America, North America and Europe at several meetings, including an International Human Dimension Workshop (IHDW) on Sustainable Adaptation held in New Delhi in October 2008, the IHDP Open Meeting in Bonn 2009, and the GECHS conference in Oslo, June 2009. We are grateful for support for these events from IHDP and the Research Council of Norway. Rafael D'Almeida Martins acknowledges the financial support of the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES) and the State of São Paulo Research Foundation (FAPESP) as well as the hospitality granted by the Department of Environmental Policy Analysis, Institute for Environmental Studies (IVM), Vrije Universiteit Amsterdam.

Notes

1. This case study draws upon on the research carried out by Aldunce, P. and Levín, V. between 2005 and 2007 (Aldunce et al., forthcoming).
2. Statistics Norway: www.ssb.no/utlstat/tab-2009-03-12-05.html, www.ssb.no/utlstat/tab-2009-0.
3. Newspaper articles: www.oslogk.no/Dokumenter/Bogstad%20vinterparadis%20faktaark.pdf; www.akersposten.no/apps/pbcs.dll/article?AID=/20081002/NYHETER/899389345/1052.

References

- Adams, W. M., 2009. *Green Development. Environment and Sustainability in a Developing World*. Routledge, London.
- Adger, W. N., 2003. Social aspects of adaptive capacity, climate change, adaptive capacity and development. *Climate Change, Adaptive Capacity and Development*, J. B. Smith, R. J. T. Klein and S. Huq (eds). Imperial College Press, London, UK.
- Adger, W. N., Eakin, H. and Winkels, A., 2009. Nested and teleconnected vulnerabilities to environmental change. *Frontiers in Ecology and the Environment*, 7(3). 150–157.
- African Biodiversity Network, 2008. Letter to Members of the Industry, Research and Energy Committee of the European Parliament: Renewable Energy Directive Must Not Promote Unsustainable Biofuels. *African Biodiversity Network*, 28 August.
- Aldunce, P., Levín, V. and León, A., forthcoming. Community participation: a bridge for disaster risk management and adaptation to climate change. *A Changing Environment for Human Security: New Agendas for Research, Policy and Action*, K. O'Brien and L. Sygna and J. Wolf (eds). Earthscan, London.
- Benjaminsen, T. A., Rohde, R., Sjaastad, E., Wisborg, P. and Lebert, T., 2006. Land reform, range ecology, and carrying capacities in Namaqualand, South Africa. *Annals of the Association of American Geographers*, 96(3). 524–540. doi: [10.1111/j.1467-8306.2006.00704.x](https://doi.org/10.1111/j.1467-8306.2006.00704.x).
- Berg, N., 2004. *Holdnings og brukerundersøkelse i Oslo kommune for Friluftsetaten. Utarbeidet for Oslo Kommune, Friluftsetaten (Survey of Attitudes and Users in Oslo Municipality)*. Oslo Municipality, Norway.
- Berkes, F., 2007. Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. *Natural Hazards*, 41. 283–295.
- Bizikova, L., Burch, S., Cohen, S. and Robinson, J., 2010. Linking sustainable development with climate change adaptation and mitigation. *Climate Change, Ethics and Human Security*, K. L. O'Brien et al. (eds). Cambridge University Press, Cambridge. 157–179.
- Burton, I., Huq, S., Lim, B., Pilifosova, O. and Schipper, E. L., 2002. From impacts assessment to adaptation priorities: the shaping of adaptation policy. *Climate Policy*, 2(2–3). 145–159. doi: [10.1016/S1469-3062\(02\)00038-4](https://doi.org/10.1016/S1469-3062(02)00038-4).
- Carmin, J. A., Roberts, D. and Anguelovski, I., 2009. Planning climate resilient cities: early lessons from early adapters. *Proceedings of the World Bank Fifth Urban Research Symposium on Cities and Climate*

- Change: Responding to an Urgent Agenda*, Marseille, France, 5–8 June.
- Carr, E., 2008. Between structure and agency: livelihoods and adaptation in Ghana's central region. *Global Environmental Change*, 18. 689–699.
- Christensen, J. H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R. K., Kwon, W.-T., Laprise, R., Magaña Rueda, V., Mearns, L., Menéndez, C. G., Räisänen, J., Rinke, A., Sarr, A. and Whetton, P., 2007. Regional climate projections. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L. Miller (eds). Cambridge University Press, Cambridge, UK and New York, NY, USA, 847–940.
- Cohen, S., Demeritt, D., Robinson, J. and Rothman, D., 1998. Climate change and sustainable development: towards dialogue. *Global Environment Change*, 8(4). 341–371. doi: [10.1016/S0959-3780\(98\)00017-X](https://doi.org/10.1016/S0959-3780(98)00017-X).
- Debels, P., Szlafsztein, C., Aldunce, P., Neri, C., Carvajal, Y., Quintero-Angel, M., Celis, A., Bezanilla, A. and Martinez, D., 2009. IUPA: a tool for the evaluation of the general usefulness of practices for adaptation to climate change and variability. *Natural Hazards*, 50. 211–233. doi: [10.1007/s11069-008-9333-4](https://doi.org/10.1007/s11069-008-9333-4).
- DMC (Dirección Meteorológica de Chile), 2005. *Boletín climatológico*, Vol. XXI(6), Junio de 2005. Gastón Torres (ed.). Santiago, Chile. 19 p.
- Eakin, H., 2006. *Weathering Risk in Rural Mexico. Climatic, Institutional, and Economic Changes*. The University of Arizona Press, Tucson.
- ENB, 2009. A brief analysis of the climate change conference. *Earth Negotiations Bulletin*, 12(459). 27–29. www.iisd.ca/climate/cop15.
- Eriksen, S., Brown, K. and Kelly, P. M., 2005. The dynamics of vulnerability: locating coping strategies in Kenya and Tanzania. *Geography Journal*, 171(4). 287–305. doi: [10.1111/j.1475-4959.2005.00174.x](https://doi.org/10.1111/j.1475-4959.2005.00174.x).
- Eriksen, S., Klein, R.J.T., Ulsrud, K., Næss, L. O. and O'Brien, K., 2007. *Climate Change Adaptation and Poverty Reduction: Key Interactions and Critical Measures*. Report prepared for the Norwegian Agency for Development Cooperation (Norad). GECHS Report 2007:1, University of Oslo. 42 p.
- Eriksen, S. and Lind, J., 2009. Adaptation as a political process: Adjusting to drought and conflict in Kenya's drylands. *Environmental Management*, 43(5). 817–835. doi: [10.1007/s00267-008-9189-0](https://doi.org/10.1007/s00267-008-9189-0).
- Eriksen, S. and O'Brien, K. L., 2007. Vulnerability, poverty and the need for sustainable adaptation measures. *Climate Policy*, 7(4). 337–352.
- Gbadegesin, A. S., Olorunfemi, F. B. and Raheem, U. A., 2010. Urban vulnerability to climate change and natural hazards in Nigeria. *Coping with Global Environmental Change, Disasters and Security – Threats, Challenges, Vulnerabilities and Risks*, H. G. Brauch, U. O. Spring, C. Mesjasz, J. Grin, P. Kameri-Mbote, B. Chourou, P. Dunay and J. Birkmann (eds), Hexagon Book Series on Human and Environmental Security and Peace, Vol. 5. Springer-Verlag, Berlin, 669–688.
- Hauser, A., 2005. *Informe geológico geotécnico, preliminar: sectores Agüita de la Perdiz y Cerro La Pólvora, Concepción, VIII Región*. SERNAGEOMIN. Santiago, Chile, 14 p.
- Huq, S. and Reid, H., 2007. *Community-Based Adaptation. A Vital Approach to the Threat Climate Change Poses to the Poor*. IIED Briefing Papers, IIED, London.
- Ijaiya, G. T. and Umar, A. C., 2004. The informal and formal sector inter-linkages and the incidence of poverty in Nigeria: a case study of Ilorin Metropolis. *Africa Development*, 29(3). 84–102.
- IPCC (Intergovernmental Panel on Climate Change), 2007. Climate change 2007: impacts, adaptation and vulnerability. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson (eds). Cambridge University Press, Cambridge, UK. 976 p.
- Iversen, T., Benestad, R., Haugen, J. E., Kirkevåg, A., Sortheberg, A., Debernard, J., Grønås, S., Hanssen-Bauer, I., Kvamstø, N. G., Martinsen, E. A. and Engen-Skaugen, T., 2005. *Norges klima om 100 år. Usikkerhet og risiko*. (Norwegian Climate in 100 years. Uncertainty and risk.) RegClim, Oslo. http://regclim.met.no/presse/download/regclim_brosjyre2005.pdf.
- Klein, R. J. T., Eriksen, S., Næss, L. O., Hammill, A., Robledo, C. and O'Brien, K., 2007. Portfolio screening to support the mainstreaming of adaptation to climate change into development. *Climatic Change*, 84(1). 23–44. doi: [10.1007/s10584-007-9268-x](https://doi.org/10.1007/s10584-007-9268-x).
- Leary, N. A., 1999. A framework for benefit–cost analysis of adaptation to climate change and climate vulnerability. *Mitigation and Adaptation Strategies for Global Change*, 4(3–4). 307–318. doi: [10.1023/A:1009667706027](https://doi.org/10.1023/A:1009667706027).
- Leichenko, R. M. and O'Brien, K. L., 2008. *Environmental Change and Globalization: Double Exposures*. Oxford University Press, New York, USA.
- Lowe, A., Foster, J. and Winkelmann, S., 2009. *Ask the Climate Question: Adapting to Climate Change Impacts in Urban Regions*. Center for Clean Air Policy, Washington, DC, USA.

- Mardones, M. and Vidal, C., 2001. La zonificación y evaluación de los riesgos naturales de tipo geomorfológico: un instrumento para la planificación urbana en la ciudad de Concepción. *EURE*, 27(81). 97–122. doi: [10.4067/S0250-71612001008100006](https://doi.org/10.4067/S0250-71612001008100006).
- Matthews, H. D. and Caldeira, K., 2008. Stabilizing climate requires near-zero emissions. *Geophysical Research Letters*, 35. L04705. doi: [10.1029/2007GL032388](https://doi.org/10.1029/2007GL032388).
- Mehrotra, S., Natenzon, C. E., Omojola, A., Folorunsho, R., Gilbride, J. and Rosenzweig, C., 2009. Framework for city climate risk assessment: Buenos Aires, Delhi, Lagos, and New York. *Proceedings of the World Bank Fifth Urban Research Symposium on Cities and Climate Change: Responding to an Urgent Agenda*, Marseille, France, 5–8 June.
- Munasinghe, M. and Swart, R. (eds), 2000. *Climate Change and its Linkages with Development, Equity and Sustainability*. Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland.
- Næss, L. O., Bang, G., Eriksen, S. and Vevatne, J., 2005. Institutional adaptation to climate change: flood responses at the municipal level in Norway. *Global Environmental Change*, 15(2). 125–138. doi: [10.1016/j.gloenvcha.2004.10.003](https://doi.org/10.1016/j.gloenvcha.2004.10.003).
- Nelson, D. R., Adger, W. N. and Brown, K., 2007. Adaptation to environmental change: contributions of a resilience framework. *Annual Review of Environment and Resources*, 32. 395–419. doi: [10.1146/annurev.energy.32.051807.090348](https://doi.org/10.1146/annurev.energy.32.051807.090348).
- O'Brien, K. L. 2009. Do values subjectively define the limits to climate change adaptation? *Adapting to Climate Change. Values, Thresholds, Governance*, W. N. Adger, I. Lorenzoni and K. L. O'Brien (eds). Cambridge University Press, Cambridge, UK. 164–180.
- O'Brien, K. L., Eriksen, S., Sygna, L. and Næss, L. O., 2006. Questioning European complacency: climate change impacts, vulnerability and adaptation in Norway. *Ambio*, 35(2). 16–22.
- O'Brien, K. L., St.Clair, A. and Kristoffersen, B., 2010. *Climate Change, Ethics and Human Security*. Cambridge University Press, Cambridge.
- O'Brien, K. L., Sygna, L., Leichenko, R., Adger, W. N., Barnett, J., Mitchell, T., Schipper, L., Tanner, T., Vogel, C. and Mortreux, C., 2008. *Disaster Risk Reduction, Climate Change Adaptation and Human Security. A Commissioned Report for the Norwegian Ministry of Foreign Affairs*. GECHS Report 2008:3, University of Oslo, Norway.
- Olorunfemi, F. B., 2008. Disaster incidence and management in Nigeria. *Research Review*, 24(2). 1–23.
- Olorunfemi, F. B. and Raheem, U. A., 2007. Urban development and environmental implications: The challenge of urban sustainability in Nigeria. *The Australasian Review of African Studies*, 28(2006/2007). 74–96.
- Olsson, P. and Folke, C., 2001. Local ecological knowledge and institutional dynamics for ecosystem management: a study of Lake Racken Watershed, Sweden. *Ecosystems*, 4(2). 85–104.
- ONEMI (Oficina Nacional de Emergencia, Ministerio del Interior), 2005. Informe consolidado. Sistemas frontales sucesivos: 10 Mayo–15 Julio 2005. Ministerio del Interior, Santiago, Chile. 30 p.
- Parry, M., Arnell, N., Berry, P., Dodman, D., Fankhauser, S., Hope, C., Kovats, S., Nicholls, R., Satterthwaite, D., Tiffin, R. and Wheeler, T., 2009. *Assessing the Costs of Adaptation to Climate Change. A Review of the UNFCCC and Other Recent Estimates*. International Institute for Environment and Development (UK), and the Grantham Institute for Climate Change, Imperial College London (UK), London.
- Pelling, M. and High, M., 2005. Understanding adaptation: what can social capital offer assessments of adaptive capacity? *Global Environmental Change*, 15(4). 308–319. doi: [10.1016/j.gloenvcha.2005.02.001](https://doi.org/10.1016/j.gloenvcha.2005.02.001).
- Reid, P. and Vogel, C., 2006. Living and responding to multiple stressors in South Africa – glimpses from KwaZulu-Natal. *Global Environmental Change*, 16(2). 195–206. doi: [10.1016/j.gloenvcha.2006.01.003](https://doi.org/10.1016/j.gloenvcha.2006.01.003).
- Roberts, D., 2008. Thinking globally, acting locally – institutionalizing climate change at the local government level in Durban, South Africa. *Environment and Urbanization*, 20(2). 521–537. doi: [10.1177/0956247808096126](https://doi.org/10.1177/0956247808096126).
- Robinson, J. and Herbert, D., 2001. Integrating climate change and sustainable development. *International Journal on Global Environmental Issues*, 1(2). 130–149.
- Sanchez-Rodriguez, R., 2009. Learning to adapt to climate change in urban areas. A review of recent contributions. *Current Opinion in Environmental Sustainability*, 1. 201–206. doi: [10.1016/j.cosust.2009.10.005](https://doi.org/10.1016/j.cosust.2009.10.005).
- Schellnhuber, H. J., 2009. Global warming: Stop worrying, start panicking? *PNAS*, 105(38). 14239–14240.
- Schipper, E. L. and Pelling, M., 2006. Disaster risk, climate change and international development: Scope and challenges for integration. *Disasters*, 30(1). 19–38.
- Smit, B., Burton, I., Klein, R. J. T. and Wandel, J., 2000. An anatomy of adaptation to climate change and variability. *Climatic Change*, 45(1). 223–251.

- Storbjörk, S., Lähteenmäki-Smith, K. and Hilding-Rydevik, T., 2009. Conflict or consensus: The challenge of integrating environmental sustainability into regional development programming. *European Journal of Spatial Development*, 34, 1–22.
- Tschakert, P. and Dietrich, K. A., 2010. Anticipatory learning for climate change adaptation and resilience. *Ecology and Society*, 15(2). 11. www.ecologyandsociety.org/vol15/iss2/art11/.
- Ulsrud, K., Sygna, L. and O'Brien, K. L., 2008. *More than Rain: Identifying Sustainable Pathways for Climate Adaptation and Poverty Reduction*. Report prepared for the Development Fund, Norway.
- Vaage, O. F., 2004, *Trening, mosjon og friluftsliv. Resultater fra Levekårsundersøkelsen 2001 og Tidsbruksundersøkelsen 2000. (Exercise, leisure and outdoors activities. Results from Living Conditions Survey 2001 and Time Use Survey 2000.)* Statistics Norway, Oslo/Kongsvinger. www.ssb.no/emner/07/02/50/rapp_200413/rapp_200413.pdf.
- van Aalst, M. K., Cannon, T. and Burton, I., 2008. Community level adaptation to climate change: The potential role of participatory community risk assessment. *Global Environmental Change*, 18(1). 165–179. doi: [10.1016/j.gloenvcha.2007.06.002](https://doi.org/10.1016/j.gloenvcha.2007.06.002).
- Vogel, C., Moser, S. C., Kasperson, R. E. and Dabelko, G. D., 2007. Linking vulnerability, adaptation, and resilience science to practice: Pathways, players, and partnerships. *Global Environmental Change*, 17(3–4). 349–364.
- Winkler, H. and Marquand, A., 2009. Changing development paths: From an energy-intensive to low-carbon economy in South Africa. *Climate and Development*, 1. 47–65. doi: [10.3763/cdev.2009.0003](https://doi.org/10.3763/cdev.2009.0003).
- Wisner, B., Blaikie, P., Cannon, T. and Davis, I., 2004. *At Risk: Natural Hazards, People's Vulnerability and Disasters*. Routledge, London, UK.
- Woolcock, M. and Narayan, D., 2000. Social capital: implications for development theory, research, and policy. *World Bank Research Observer*, 15(2). 225–249.
- Yohe, G. W., Lasco, R. D., Ahmad, Q. K., Arnell, N. W., Cohen, S. J., Hope, C., Janetos, A. C. and Perez, R. T., 2007. Perspectives on climate change and sustainability. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson (eds). Cambridge University Press, Cambridge, UK. 811–841.
- Ziervogel, G., Bharwani, S. and Downing, T. E., 2006. Adapting to climate variability: Pumpkins, people and policy. *Natural Resources Forum*, 30(4). 294–305. doi: [10.1111/j.1477-8947.2006.00121.x](https://doi.org/10.1111/j.1477-8947.2006.00121.x).