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Climate Change Adaptation and Development: Exploring the Linkages

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Summary

Successful human societies are characterised by their adaptability, evidenced throughout human existence. However, climate change introduces a new challenge, not only because of the expected rise in temperature and sea-levels, but also due to the current context of failure to address the causes of poverty adequately. As a result, policy supporting adaptation has been cast as a necessary strategy for responding to both climate change and supporting development, making adaptation the focus of much recent scholarly and policy research. This paper addresses this new adaptation discourse, arguing that work on adaptation so far has focused on responding to the impacts of climate change, rather than sufficiently addressing the underlying factors that cause vulnerability. While there is a significant push all around for adaptation to be better placed in development planning, the paper finds this to be putting the cart before the horse. A successful adaptation process will require adequately addressing the underlying causes of vulnerability: this is the role that development has to play. This work results from research aimed at exploring the international discourse on adaptation to climate change and the meaning of adaptation to climate change in the context of development.

Keywords: *Adaptation, Climate Change, Impacts, Vulnerability, Development, UNFCCC*

1. Introduction

As a result of evidence that human-induced global climate change is already occurring and will continue to affect society over the coming decades, a surge in interest in impact-oriented action is discernable since the beginning of the century, in contrast to efforts centred on prevention (Burton *et al.*, 2002). Frustration over the lack of progress and effectiveness of policy to reduce greenhouse gas emissions has contributed to this shift. *Adapting* to the changes has consequently emerged as a solution to address the impacts of climate change that are already evident in some regions. However, this course of action has not always been considered relevant within science and policy (Schipper, 2006a; Klein, 2003). Adaptation responds directly to the impacts of the increased concentrations of greenhouse gases in both precautionary and reactive ways, rather than through the preventative approach of limiting the source of the gases (this is known as 'mitigation'). This avoids the enormous political obstacles facing initiatives to curtail the burning of fossil fuels by factories, transport and other sectors. Adaptation to climate change is considered especially relevant for developing countries, where societies are already struggling to meet the challenges posed by existing climate variability (Yamin *et al.* 2005; Adger *et al.*, 2003; Handmer, 2003; Kates, 2000; Watson and Ackerman, 2000), and are therefore expected to be the most adversely affected by climate change (McCarthy *et al.*, 2001). The recent Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report makes clear that "adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions" (IPCC, 2007: 18). As such, it supports adaptation as a complimentary response strategy to mitigation.

Significantly, adaptation has been embraced not only by the climate change community, but also by the development assistance community (DFID, 2005; UNDP, 2004; Mathur *et al*., 2004; Simms *et al.*, 2004; AfDB *et al.*, 2003), and the disasters community to address the dynamics between risk and development (Helmer and Hilhorst, 2006; ISDR, 2003). But little research has examined whether empirical evidence or theory support a need for policy-implemented adaptation, or addressed the disparity between the discourses on adaptation to climate change and adaptation that is studied in other disciplines. Most importantly, work on adaptation so far has addressed the impacts of climate change, rather than sufficiently addressing the underlying factors that cause vulnerability to it. While there is a significant push all around for adaptation to be better placed in development planning, there is a missing step if vulnerability reduction is not considered central to this. A successful adaptation process will require adequately addressing the underlying causes of vulnerability: this is the role that development has to play.

This paper results from research aimed at exploring the international discourse on adaptation to climate change and the meaning of adaptation to climate change in the context of development. This work questions the emerging move towards policy-driven adaptation as a solution to address climate change impacts in the context of the UN Framework Convention on Climate Change (UNFCCC) and high-level statements such as by the G-8 and OECD by examining the development of relevant policy instruments and related theory. It discusses whether adaptation to climate change represents an emerging *paradigm* for 'climate proof' development, by presenting a critical review of adaptation as applied in research and practice. In particular, this work seeks to understand how adaptation is seen to bring the development agenda further, and asks whether 'adaptation' has simply become a platform for scientists and environmentalists concerned about climate change to voice their views on development, or whether there is indeed some value to calls to put a greater emphasis on adaptation within development processes. To this end, it examines whether adaptation indeed represents a "new opening to revisit some long-standing problems of environment and development in an innovative way", as suggested by Soussan and Burton (2002: 3), and examines options for reshuffling the current understanding to ensure that 'climate-proof' development involves reducing vulnerability, and not simply identifying responses to the impacts of climate change.

2. The Rise of Adaptation to Climate Change

Although adaptation to anthropogenic climate change may represent a new need, adaptation to take advantage of new opportunities and minimise adverse consequences of environmental change has existed

since the beginning of human presence on Earth (Smithers and Smit, 1997). Charles Darwin's 1859 *The Origin of Species* represents one of the roots of the concept of biological adaptation because his work provided evidence of evolution, which formed the basis for evolutionary biology. Adaptive strategies are also an integral element of the development of societies because they enable the management not only environmental variability, but also perturbations in social, economic and political variables (Pelling, 2003). As a result, numerous disciplines undertake to examine social, biological and cultural adaptation processes from a variety of perspectives, including anthropology, archeology, biology, ecology, geography, political ecology, psychology, and global environmental change science (Janssen *et al.*, 2006; Bock, 1980; Butzer, 1980; Alland, 1975). Ironically, many disciplines representing the conceptual roots of adaptation are seldom referred to in the climate change discourse.

What is particular about climate change is that adaptive processes will have to take into account not entirely understood, but certainly extensive, impacts on hydrology and water resources, agriculture and food security, terrestrial and freshwater ecosystems, coastal zones and marine ecosystems, human health, human settlements, energy and industry, and insurance and other financial services (Adger *et al.*, 2003). These impacts will have profound economic, social, demographic, technological and political implications (Pittock and Jones, 2000). Such impacts will be unprecedented in their scope and range, going beyond national boundaries and penetrating a broad array of policy and theory discourses because of the global nature of climate change. Aspirations for responding to such conditions could entail numerous strategies, however, not all responses will be beneficial to growth and development. Choices for responding to the changes, therefore, will require trade-offs and difficult decisions, because achieving successful adaptation in the future may not be the same as responding to existing conditions.

Adaptation to climate change as set out in the policy-oriented academic literature provides scarce practical guidance for policymakers, and raises numerous conceptual questions, not least whether the process of achieving adaptation is any different from the process necessary for sustainable development. There has also been evidence of lack of cohesion, dialogue and parallel between adaptation science and adaptation policy. Initially this could be explained by the two communities having different objectives (Schipper, 2006a). The growing theoretical adaptation literature remains focused on definitions[1], and yet the policy discourse on adaptation struggles to interpret these[2]. Inconsistency between the two requires clarity on adaptation in each discourse, and the conceptual linkages between them. Although scholars and policymakers have advanced in addressing these conceptual gaps in the last two decades, adaptation to climate change is driven by a community of practice that is using a discourse separate from related development frameworks for responding to risk (Thomalla *et al.*, 2006). As a result, it is necessary to examine the roots, meaning and implications of adaptation to climate change in the context of other theories in risk and development.

3. Definitions of Adaptation

Just as O'Brien and Holland note about adaptation in the evolutionary-biology literature, definitions of adaptation in the climate change literature "are so numerous that they would easily fill the space taken up by this paper" (1992: 38). Table 1 summarises some adaptation definitions that have emerged from scholarship primarily focused on climate change impacts. The variations in these definitions indicate the various approaches that are possible for understanding adaptation, even within the specialised climate change adaptation discourse. The definitions echo the evolutionary-biology definition of adaptation as "a process whereby the members of a population become suited over the generations to survive and reproduce." (Futuyuma, 1979: 308, quoted in O'Brien and Holland, 1992). The main difference in biological adaptation and climate change adaptation is the level of planning and consciousness by which adjustments are carried out. Thus, adaptation to climate change can be either deliberate or automatic; it can be imposed based on premeditated planning, or it can take place without specific policy frameworks to implement it.

As awareness of detrimental human impact on the environment as cause for risk to humans has replaced the idea that humans were at the mercy of the environment, adaptation has gone from being considered

[1] See recent papers in Number 3, Volume 16 of *Global Environmental Change*.
[2] See summary of UNFCCC Asian Regional Workshop on Adaptation, *Earth Negotiations Bulletin* Number 1, Volume 138, Page 3.

something done by plants and animals in evolution as a response to environmental changes, to being promoted as a concept for guiding policy to ensure sustainable development, reduce vulnerability and minimise risk to humans from climate change. Whereas biological adaptation "must be viewed in a historical sense" (O'Brien and Holland, 1992: 38), adaptation to climate change looks forward to the future changes in environment and attempts to make not reactive, but anticipatory adjustments. Although many climate change researchers have identified different adaptation typologies and presented a number of concepts and frameworks as bases for characterising different types of adaptation based on purpose, timing, duration and location (Smit and Wandel, 2006; Klein, 2003; Smit and Skinner, 2002; Fankhauser *et al.*, 1999; Smit *et al.*, 1999; Parry and Carter, 1998; Smith, 1997; Kates, 1985), the majority of scholarship currently aims to inform planned adaptation (Pittock and Jones, 2000), which is consequently what also interests policymakers.

Table 1. Summary of adaptation definitions

Source	***Definition***
Burton *et al.* (1998)	Refers to all those responses to climate change that may be used to reduce vulnerability.
Burton (1992)	Adaptation to climate is the process 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.
Downing *et al.* (1997)	Adaptation is synonymous with "downstream coping".
Füssel and Klein (2002)	All changes in a system, compared to a reference case, that reduce the adverse effects of climate change.
IPCC (2001)	Adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. This term refers to changes in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate. It involves adjustments to reduce the vulnerability of communities, regions, or activities to climatic change and variability.
Pielke (1998)	Refers to adjustments in individual, group and institutional behaviour in order to reduce society's vulnerabilities to climate.
Rennie and Singh (1996)	Adaptive strategies are ways in which local individuals, households and communities have changed their mix of productive activities, and modified their community rules and institutions in response to vulnerabilities, in order to meet their livelihood needs.
Scheraga and Grambsch (1998)	Adaptive actions are those responses or actions taken to enhance resilience of vulnerable systems, thereby reducing damages to human and natural systems from climate change and variability.
Smit (1993)	Involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events as well as longer term climate change.
Stakhiv (1993)	Means any adjustment, whether passive, reactive or anticipatory, that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change.

The different uses of adaptation affect how the concept might be applied in a practical way. Oliver-Smith (2004) speaks about adaptation based in discourses on society's domination over nature from an anthropological perspective. Adaptation here would include adjustments by humans of their surrounding environment, rather than changing their own behaviour. From the perspective of climate change researchers, such adaptation would require knowledge about the magnitude and dimensions of the changes, something that is currently not fully grasped (IPCC, 2007). This thus raises questions about whether a process of adaptation involves the development of technology or infrastructural changes that maintain existing livelihoods, or instead implies the actual behavioural adjustments needed to adapt livelihoods to new climatic conditions. The difference may be crucial in terms of the resources and scientific knowledge required. However, when technology or infrastructure become obsolete, individuals unaccustomed to the changes in climate that have been masked by these technical adjustments will struggle. In other words, some solutions may only be short-term, because they are limited by their own lack of flexibility, and effective adaptation must have a long-term goal.

In illustration, irrigation systems are characterised by their ability to increase resilience of farmers (Bruce, 1999) because they temporarily shield the system from the effects of reduced precipitation. In contrast, adaptation would entail permanently adjusting cultivation to changes in precipitation, for example through changing the types of crops planted or the timing of the planting season or even getting out of agriculture. Irrigation systems are only viable as long as surface or groundwater is available. Relying on technology to

build resilience as a solution does not mean that crops themselves will adjust to the change in climate, given the time scale. Instead, the production system will be viable until water resources are depleted, at which point farmers will have to face a changed water regime unadapted. Consequently, irrigation can be seen as a temporary solution to delay other changes in agricultural practice or livelihood, such as switching crops or taking up a different cultivation technique, or abandoning farming altogether. While irrigation would reduce vulnerability in the short term, it would not necessarily guarantee a long-term strategy to respond to variability, or change, in climate. As a response and planning strategy, adaptation is characterised by its objective to adjust human systems to a different set of external parameters in a sustainable and long-term manner that focuses on adjusting the entire system rather than simply those components of the system that are affected. This would imply an adjustment of farming practices accompanied by corresponding adjustments in the agricultural market. As such, a sustainable adaptation process appears to first require adjustments in policies, institutions and attitudes that *establish enabling conditions*, and second be accompanied by eventual technological and infrastructural changes.

An effective adaptation process would therefore hinge on the ability of livelihoods, which includes social networks, cultural traditions, and activities that provide food and income, to be sufficiently flexible so that no adverse impacts of climate change are discernable on the social system. Such enabling conditions would clearly facilitate a sustainable development process, but would also require overcoming factors that cause vulnerability to climate change, such as differential access to resources based on gender, age, belief systems or other characteristics, state of environment in which people live, viability of livelihoods in existing economic systems. Adaptation itself does not imply that the factors lying behind a society's vulnerability to climate change will even be affected, but in the long term, adaptation requires these factors to be addressed. Therefore, unlike Smit and Wandel's view that "adaptations…represent ways of reducing vulnerability" (2006: 286), this paper argues that vulnerability must be reduced first through targeted climate-aware development practice ('climate proof' development) in order for adaptation to take place. Creating enabling conditions for an adaptation process to take place implies reduction of vulnerability.

4. Adaptation: Whose Agenda?

As Smit and Wandel point out, "the whole point of the work on adaptation processes is to have risks (and opportunities) associated with climate change (or other environmental changes) actually addressed in decision-making at some practical level" (2006: 285). The main focus for this has been the UN Framework Convention on Climate Change (UNFCCC), where adaptation has been raised as the second response option, after abatement of greenhouse gas emissions ('mitigation'). Extensive examinations of various aspects of adaptation in the UNFCCC have been undertaken by Mace (2003) and Verheyen (2003a) (the legal framework for adaptation) and Huq and Burton (2003), Morita (2007) and Verheyen (2003b) (funding for adaptation) and Schipper (2006a) (the conceptual history). The emerging common conclusion is that adaptation has not been given a significant space within the UNFCCC, with differing perspectives as to whether this is positive or negative.

Other actors beyond those directly involved with the environmental aspect of climate change have also placed adaptation on their agendas. The disaster risk reduction community is one (see ISDR, 2006). In addition, development agencies have been flocking to incorporate or 'mainstream' adaptation into development planning, including the World Bank, and agencies from the UK, Germany, Netherlands, Sweden, Denmark, and the US among others, and scientists have been responding by providing tools for how to do this (Klein *et al.*, 2007; Huq *et al.*, 2003; Schipper *et al.*, 2003). As noted above, however, adaptation to climate change is not as simple as designing projects, drawing up lists of possible adaptation measures and implementing these. It requires a solid development process that will ensure that the factors that create vulnerability are addressed. This is not the same as the approach currently being taken by development agencies, who put adaptation forward as a means for reducing vulnerability, rather than vice-versa. Indeed, adaptation is a process for reducing impacts, not vulnerability.

These two approaches both recognise a relationship between adaptation and vulnerability to climate change and development. However, they represent two different starting points, with different understandings of the type of activities that need to be undertaken to achieve a sustainable adaptation process. In all cases, the

links between adaptation and development motivate numerous conceptual and practical questions about how to instigate an adaptation process in the context of development.

Links have been drawn between adaptation and sustainable development on theoretical and political levels (OECD, 2006a, 2006b; G8, 2005; Smit and Pilifosova, 2001; Burton, 2000). Clearly, both adaptation and development play a role in responding to risk. That climate change will affect developed and developing countries differently due to the differing capacity for responding to the changes is acknowledged both by theory and policy (IPCC, 2007; Downing *et al.*, 1997; Bohle *et al.*, 1994). But efforts to reduce poverty will not explicitly take climate change into account (Adger *et al.*, 2003; AfDB *et al.*, 2003; Gómez-Echeverri, 2000), which rationalises the calls for adaptation to be mainstreamed into development planning. In this view, adjusting to changes in climate is done with the specific goal of ensuring survival of livelihoods, lives, and cultures during environmental change, and can thereby be seen to aid progress in development by enhancing resilience to environmental fluctuations. From a policy perspective, adaptation has been stressed as "an integral and urgent part of overall poverty reduction strategies" (AfDB *et al.*, 2003: 1).

Another view holds that additional and explicit consideration of climate change may not be necessary, because "adequate development will automatically reduce the levels of relative or total risk" (Lavell, 2004: 73) and societies will eventually adapt as they face repeated extreme weather events (Adger and Brooks, 2003). This latter perspective underscores the importance of vulnerability as a determinant of risk. According to Srivastava and Heller (2003), vulnerability reduction is directly associated with sustainable development. This also resonates with the understanding that the ability to adapt is considered dependent on the state of development (Smit and Pilifosova, 2001). Thus, poverty and constraints to development fundamentally restrict adaptation (UNDP, 2002; Kates, 2000; Ribot *et al.*, 1996).

What implications do these observations have for the perspective that "adaptation represents a practical means of achieving sustainable development in the longer term" (Smit, 1993: 1)? Is it sufficient to conclude that adaptation and development are so strongly linked, that each processes supports the other? The discussion above has identified two tracks toward adaptation: an 'adaptation approach' to development, and a 'vulnerability reduction approach' to development (see Box 1). From a policy perspective, the adaptation approach to development is simpler: it centres around mainstreaming adaptation, which comes down to taking into account climate change in social, institutional and infrastructural development planning. As described above, bilateral and multilateral organisations and policymakers in the UNFCCC context have embraced the concept of mainstreaming adaptation into the existing development agenda. Even the Adaptation Policy Framework, developed by the UN Development Programme/Global Environmental Facility (Lim *et al.*, 2005) emphasises the mainstreaming approach, as do the National Adaptation Programmes of Action guidelines for least developed countries (UNFCCC, 2001). But mainstreaming will not be effective if existing development trajectories are inconsistent with the objectives of adaptation, i.e. if they explicitly contribute to vulnerability. This is particularly the case as adaptation remains seen as an outcome and an objective, rather than a process. The promotion of sustainable social and economic development may be a less conceptually problematic way to achieve adaptation eventually, particularly as the policy frameworks for such development are more explicitly elaborated and less dependent on uncertainties regarding climate change than for adaptation. This is also relevant as adaptation needs to confront the same constraints as those faced by development, and therefore an adaptation process is only possible if there is successful sustainable development to support it. However, for this to be successful, an awareness of climate change impacts and the needs for successful vulnerability reduction are imperative within the development process.

Consequently, it is vulnerability reduction that should be integrated into development policy, rather than the creation of explicit adaptation strategies. Focusing on adaptation before aligning development processes through the creation of enabling conditions for adaptation is like putting the cart before the horse. There is understandable urgency, as climate change will exacerbate problems already faced by developing countries – these problems are case-in-point that there is vulnerability. But often the reasons that people are vulnerable to climate change have nothing to do with the climate – and herein lies the crux of the vulnerability reduction approach: while the adaptation approach necessarily focuses on adjusting to reduce the specific impacts of climate change, the vulnerability reduction approach addresses the much more fundamental, underlying

series of issues that cause these impacts to be difficult to address, which mostly have little or nothing to do with climate. Watson and Ackermann underscore that the onset of climate change "does not call for a different or new strategy" for development, because the existing development problems will be the same as those problems created by climate change in general (2000: 24). Addressing risk, such as that related to food or nutrition security, is not a new aspect of development, either in planning or practice. Thus, "invulnerable development", as suggested by David McEntire (2000), is an appropriate paradigm.

Box 1. Different Approaches to Linking Adaptation and Development

Adaptation Approach

Adaptation to Climate Change Impacts → Vulnerability Reduction → Development

In this view, adaptation is carried out in response to the observed and experienced impacts of climate change on society (including ecosystems). These responses ensure that the vulnerability to the impacts is reduced. This in turn ensures that less is lost each time a climate-related hazard takes place, which means risk is reduced. With reduced risk, development can be more sustainable.

Vulnerability Reduction Approach

Development → Vulnerability Reduction → Impact Reduction → Adaptation

In this view, development processes help reduce vulnerability to climate change. By reducing the vulnerability, impacts of climate hazards are also reduced, as there is less sensitivity and exposure to the hazards. This translates into a process of adaptation to climate change.

The case of El Salvador is an appropriate illustration. In El Salvador the causes of social vulnerability are numerous, and linked inherently with development and environment issues in the country (for more details about this case study, see Schipper, 2006b). The agriculture sector is an example, whose stagnation is generating unemployment, and consequently poverty, which causes food insecurity. This stagnation also implies reduced technical support for production practices, which in turn also contributes to food insecurity. Focus on impacts of climate change alone would not contribute to facilitating development in the same way as would focus on vulnerability. In the case of agriculture, focus on impacts would examine the changes in crop yields resulting from more or less rainfall and the ways in which societies can adapt to these varying yields. This would not address related and dependent issues of unemployment, poverty, lack of technical support and ultimately food insecurity, which would be incorporated into a vulnerability approach. It appears clear from El Salvador that vulnerability reduction is a prerequisite for a process of adaptation. Whether the reduction of vulnerability is explicitly part of the objective of responding to climate change, however, is another question that has to be tackled. Adjusting to climate change in El Salvador, and many countries with similar conditions, will require and prompt significant social changes with extensive consequences. The implications are therefore that climate change adaptation will be facilitated by a focus on sustainable development and vulnerability reduction, with an explicit integrated approach that will account for factors such as globalisation, different belief systems, poverty and rural livelihoods.

5. A Development Agenda

This analysis describes vulnerability reduction and sustainable development as fundamental elements of adaptation to climate change. This is based on a specific understanding about the meaning of adaptation in the context of climate change. It contrasts with some of the views apparent in the policy and theory, where adaptation is seen as an outcome, and instead emphasises the continuous nature of adaptation. This vulnerability reduction approach appears more effective in impelling and facilitating a process of adjustment to climate change, because it avoids explicit adaptation measures that may be counteracted by parallel development processes. Rather than be viewed as mainstreaming, this approach is described as a new development paradigm.

Importantly, this approach also avoids seeing adaptation as an alternative to mitigation of greenhouse gases, because it focuses not on the specific impacts of climate change, but on the processes that are necessary to achieve sustainable adjustment to all factors contributing to risk. To this extent, adaptation incorporates an

aspect of vulnerability reduction associated with greenhouse gas mitigation. In this way, it represents a more holistic approach than is currently taken. Adaptation has been identified as a silver bullet, particularly within the climate policy community, but also to some extent in the development community for solving both development and climate change impact problems at once. Adaptation as a development paradigm avoids calls for separate policy provisions on adaptation, which have so far been shown to offer little.

Adaptation should therefore not be seen as a solution to existing development problems, or as an alternative path towards sustainable development. Instead, adaptation is understood to guide development successfully in light of increased risk from global environmental, social and economic change. Climate change will alter existing climate risks, and therefore a process by which vulnerability to existing risks is reduced can be seen as a step toward adaptation to future changes as well. This also overcomes the problematic posed by the UNFCCC's narrow definition of climate change – that does not include climate variability. To this end, policy calls urging funding for adaptation to be directed at development can instead be met through channels that already exist. It does not appear helpful to design a new adaptation policy model as a way to fund sustainable development – if that is indeed the goal. Instead, development activities should be concerned with reducing vulnerability and achieving sustainable development (see Box 1). This will ultimately provide the necessary structures for an effective adaptation process that will then overcome challenges posed by poverty and globalisation.

Adaptation could represent a new opportunity to revisit some long-standing problems of environment and development. However, there is a tendency in both the policy and theory discourses to perceive adaptation as something that is imposed, for instance through projects. This appears to contribute to taking focus away from the *process* of adaptation, and its building blocks, development and vulnerability reduction. Such a view may be a consequence of the general isolation of the new adaptation discourse, and of the view to address climate change from a global perspective. At the same time, the desire for a new adaptation agenda demonstrates a lack of understanding of how to incorporate vulnerability and risk aspects into development planning.

The popularity of adaptation as a policy objective is evidence that desire to identify a mechanism to bridge environment and development remains apt. With the emergence of clear evidence of climate change, adaptation appears as a tool to approach the new global environmental change agenda. Simultaneously, adaptation must also be able to deal with current and emerging development challenges, among which globalisation is of critical importance. Therefore, promotion of adaptation by policymakers can be seen as an attempt to integrate flexibility required for facing a changing environment into more demanding development processes. Numerous scholars have identified frameworks for development and environment that feature risk management or vulnerability reduction, but competing priorities need to be addressed in order for the adaptation process to be effective.

6. Conclusions

The international discourse on adaptation to climate change is sustained by progress in the climate change policy negotiations under the UNFCCC, as well as a growing amount of scholarly wisdom that has penetrated through by way of the IPCC. A separate agenda on adaptation to climate change is discernable, decoupled from analogous discussions on risk and hazards beyond the climate change context. This exclusive discourse appears to be on a self-limiting trajectory in that it portrays adaptation to climate change as a unique and tangible action that can be formalised through discrete adaptation measures, which can be identified and subsequently incorporated into existing development plans. On the other hand, close links between the adaptation discourse and that of other related concepts indicate that an effective adaptation process is not detached from those factors engendering vulnerability and challenging development. This implies that separate policy mechanisms to drive adaptation will be sidelined if they are not sufficiently inclusive. There are numerous factors determining vulnerability that cannot explicitly be affected by adaptation as suggested by the adaptation approach in Box 1.

Human social adaptation entails a process of sustainable and permanent adjustment to new or changing environmental circumstances in formal and informal institutions, behaviour and livelihoods. It is an on-

going process that has taken place since humanity's first appearance on Earth. An additional call for adaptation has been made recently to address increasing impacts of anthropogenic climate change and growing vulnerability to and risk of such impacts in developing countries. Adaptation has been identified as an appropriate response to these escalating contemporary phenomena, because it is associated with supporting development processes by facilitating the continuation and improvement of existing livelihoods. However, in order for an adaptation process to take place, it will be necessary to address those factors currently challenging progress in sustainable development and reduction of vulnerability; this cannot be expected of the adaptation process itself. To this end, proposed approaches to formalising adaptation policy are not sufficiently well-integrated with parallel processes addressing risk and development to affect development choices, particularly those approaches existing under the UNFCCC. Instead, it is more effective to view adaptation to climate change as a paradigm for development, where adaptation is fostered by a process of sustainable development and vulnerability reduction, rather than through explicit adaptation policies.

Adaptation to climate change has taken on its own discourse and science. So far, efforts to further adaptation have mostly focused on the impacts of climate change. Simultaneously, adaptation is seen as an important process to drive development, but how to do this has been unclear. This paper proposes a new interpretation of adaptation policy. A vulnerability reduction approach is identified as an effective framework for supporting the adaptation processes. The adaptation theory and policy communities have yet to reject fully a willingness to "reinvent the wheel", and need to look beyond the UNFCCC to understand how to facilitate adaptation. A disproportionate focus on the impacts of climate change are obscuring opportunities for addressing vulnerability reduction. An isolated adaptation discourse is unhelpful, and threatens to be insignificant if larger development issues are not considered. Therefore, rather than a view of "reducing the vulnerability of the poor through adaptation", as coined by the donor group (AfDB *et al.*, 2003), this paper argues for the perspective 'reducing the vulnerability of the poor through development' to adapt to climate change.

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References

Adger, W.N., S. Huq, K. Brown, D. Conway, M. Hulme (2003) 'Adaptation to Climate Change in the Developing World' *Progress in Development Studies* 3(3): 179-195.

Adger, N., N. Brooks (2003) 'Does Global Environmental Change Cause Vulnerability to Disaster?', in Pelling, M. (ed.) *Natural Disasters and Development in a Globalising World*, Routledge: London.

AfDB (African Development Bank, Asian Development Bank), UK Department for International Development, European Commission Directorate-General for Development, German Federal Ministry for Economic Cooperation and Development, The Netherlands' Ministry of Foreign Affairs Development Cooperation, Organization for Economic Cooperation and Development, UNDP, UNEP, The World Bank (2003) *Poverty and Climate Change - Reducing the Vulnerability of the Poor through Adaptation*, World Bank: Washington, D.C.

Alland, A. (1975) 'Adaptation' *Annual Review of Anthropology*, 4: 59-73.

Bock, W.J. (1980) 'The Definition and Recognition of Biological Adaptation' *American Zoology*, 20: 217-227

Bohle, H.G., T.E. Downing, M.J. Watts (1994) 'Climate Change and Social Vulnerability: Towards a Sociology and Geography of Food Uncertainty' *Global Environmental Change*, 4 (1) 37-48.

Bruce, J.P. (1999) 'Disaster Loss Mitigation as an Adaptation to Climate Variability and Change' *Mitigation and Adaptation Strategies for Global Change*, 4 (3-4) 295-306.

Burton, I., S. Huq, B. Lim, O. Pilifosova, E.L. Schipper (2002) 'From Impacts Assessment to Adaptation Priorities: The Shaping of Adaptation Policy' *Climate Policy* 2 (2-3) 145-159.

Burton, I. (2000) 'Adaptation to Climate Change and Variability in the Context of Sustainable Development' in Gómez-Echeverri, L. (ed.) *Climate Change and Development*, Yale School of Forestry and Environmental Studies & UNDP: New Haven and New York.

Burton, I. J.B. Smith, S. Lenhart (1998) 'Adaptation to Climate Change: Theory and Assessment' in Feenstra, J.F., I. Burton, J.B. Smith, R.S.J. Tol (eds.) *Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies*, Version 2.0, UNEP/RIVM: Nairobi and Amsterdam.

Burton, I. (1992) 'Adapt and Thrive', unpublished manuscript, Canadian Climate Centre: Downsview, Ontario.

Butzer, K.W. (1980) **'**Adaptation to Global Environmental Change' *Professional Geographer* 32(3): 269-278.

DFID (Department for International Development) (2005) Disaster Risk Reduction: A Development Concern. DFID, London.

Downing, T., L. Ringius, M. Hulme, D. Waughray (1997) 'Adapting to Climate Change in Africa', *Mitigation and Adaptation Strategies for Global Change*, 2 (1) 19-44.

Fankhauser, S. J.B. Smith, R.S.J. Tol (1999) 'Weathering climate change: some simple rules to guide adaptation decisions' *Ecological Economics* 30(1): 67-78.

Füssel, H-M., R.J.T. Klein (2003) 'Vulnerability and Adaptation Assessments to Climate Change: An Evolution of Conceptual Thinking' Paper presented at UNDP Expert Group Meeting "Integrating Disaster Reduction and Adaptation to Climate Change", Havana, Cuba, 17-19 June 2002, UNDP: Havana.

G8 (2005) 'Climate Change, Clean Energy and Sustainable Development' Agreement signed by G8 leaders in Gleneagles, June 2005.

Gómez-Echeverri, L. (2000) (ed.) *Climate Change and Development*, Yale School of Forestry and Environmental Studies & UNDP: New Haven and New York.

Handmer, J. (2003) 'Adaptive Capacity: What Does it Mean in the Context of Natural Hazards?' in Smith, J.B., R.J.T., Klein, S. Huq (eds.) *Climate Change, Adaptive Capacity, and Development*, Imperial College Press: London.

Helmer, M., D. Hilborst (2006) 'Natural disasters and climate change', *Disasters*, 30 (1): 1-4.

Huq, S., I. Burton (2003) 'Funding adaptation to climate change: What, who and how to fund?' Sustainable development opinion paper, IIED: London.

Huq, S., A. Rahman, M. Konate, Y. Sokona, H. Reid (2003) 'Mainstreaming Adaptation to Climate Change in Least Developed Countries' IIED: London.

ISDR (International Strategy for Disaster Reduction) (2006) 'On Better Terms: A Glance at Key Climate Change and Disaster Risk Reduction Concepts' Consultation version of booklet, ISDR: Geneva.

ISDR (2003) *Living with Risk*, ISDR: Geneva.

IPCC (Intergovernmental Panel on Climate Change) (2007) *Working Group II Summary for Policy Makers*, Cambridge University Press: Cambridge.

IPCC (2001) *Third Assessment Report of the IPCC*, Cambridge University Press: Cambridge.

IUCN (World Conservation Union, International Institute for Sustainable Development, Stockholm Environment Institute, Intercooperation (2004) *Sustainable Livelihoods & Climate Change Adaptation***,** IUCN: Geneva.

Janssen, M.A., M.L. Schoon, W. Ke, K. Boerner (2006) 'Scholarly networks on resilience, vulnerability and adaptation within the human dimensions of global environmental change' *Global Environmental Change*, 16(3): 240-252.

Kates, R.W. (1985) 'The Interaction of Climate and Society' in Kates, R.W. J.H. Ausubel, M. Berberian (eds.) *Climate Impact Assessments*, SCOPE No. 27, Wiley: UK.

Kates, R.W. (2000) 'Cautionary Tales: Adaptation and the Global Poor' *Climatic Change*, 45 (1) 5-17.

Klein, R.J.T. (2003) 'Adaptation to Climate Variability and Change: What is Optimal and Appropriate?' in Giupponi, C., M. Schechter (eds.) *Climate Change and the Mediterranean: Socio-Economic Perspectives of Impacts, Vulnerability and Adaptation*, Edward Elgar: Cheltenham.

Klein, R.J.T., E.L.F. Schipper, S. Dessai (2005) 'Integrating mitigation and adaptation into climate and development policy: three research questions' *Environmental Science & Policy* 8(6): 579-588.

Klein R. J., S. Eriksen, L.O. Naess, A. Hammill, T.M. Tanner, C. Robledo, K. O'Brien (2007) 'Portfolio screening to support the mainstreaming of adaptation to climate change into development assistance' Tyndall Centre Working Paper No. 102.

Lavell, A. (2004) 'The Lower Lempa River Valley, El Salvador: Risk Reduction and Development Project' in Bankoff, G., Frerks, G., D. Hilhorst (eds.) *Mapping Vulnerability: Disasters, Development and People*, Earthscan: London.

Lim, B., I. Burton, S. Huq, B. Doherty, E. Spanger-Siegfried, N. Adger, Y. Aguilar, R. Boer, H. Bosch, N. Brooks, C. Conde, T. Downing, K. Ebi, R. Jones, S. Rafi Khan, K. Lonsdale, E. Malone, L. Mearns, I. Niang-Diop, A. Patwardhan, R.T. Perez, E. La Rovere, J. Smith, G. Yohe (2005) *Adaptation Policy Frameworks for Climate Change*, Cambridge University Press: Cambridge.

Mace, M.J. (2003) 'Adaptation Under the UN Framework Convention on Climate Change: The Legal Framework' Paper presented at ZICER Seminar "Justice in Adaptation to Climate Change", 7-9 September, 2003, University of East Anglia, Norwich.

Mathur, A., I. Burton, M. van Aalst (eds.) (2004) *An Adaptation Mosaic: A Sample of the Emerging World Bank Work in Climate Change Adaptation*, World Bank: Washington, D.C.

McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken, K. S. White (2001) (eds.) *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, IPCC WG II contribution to the TAR, Cambridge University Press: Cambridge.

McEntire, D. (2000) 'Sustainability or Invulnerable Development? Proposals for the Current Shift in Paradigms' *Australian Journal of Emergency Management*, 15 (1) 58-61.

Morita, K. (2007) 'A Study of the Financing System Possibilities for Adaptation to Climate Change' Paper presented at the 2007 Amsterdam Conference on Human Dimensions of Global Environmental Change, 24-26 May 2007.

O'Brien, M.J., T.D. Holland (1992) 'The Role of Adaptation in Archaeological Explanation' *American Antiquity*, 57 (1): 36-59.

OECD (Organisation for Economic Co-Operation and Development) (2006a) 'Putting Climate Change Adaptation in the Development Mainstream' *Policy Brief*, March 2006.

OECD (2006b) 'Declaration on Integrating Climate Change Adaptation into Development Co-Operation' Declaration Adopted by Development and Environment Ministers of OCED Member Countries, 4 April 2006.

Okonski, K. (2003) (ed.) *Adapt or Die: The Science, Politics and Economics of climate change*, Profile Books: London.

Oliver-Smith, A. (2004) 'Theorising Vulnerability in a Globalised World: A Political Ecological Perspective' in Bankoff, G., G. Frerks, D. Hilhorst (eds.) *Mapping Vulnerability: Disasters, Development and People*, Earthscan: London.

Parry, M., T. Carter (1998) *Climate Impact and Adaptation Assessment: A Guide to the IPCC Approach*, Earthscan: London.

Pelling, M. (2003) 'Paradigms of Risk' in Pelling, M. (ed.) *Natural Disasters and Development in a Globalising World*, Routledge: London.

Pielke, Jr., R.A. (1998) 'Rethinking the Role of Adaptation in Climate Policy' *Global Environmental Change*, 8 (2) 159-170.

Pittock, A.B., R.N. Jones (2000) 'Adaptation to What and Why?' *Environmental Monitoring and Assessment*, 61 (1) 9-35.

Rennie, J.K., N.C. Singh (1996) *Participatory Research for Sustainable Livelihoods*, IISD: Winnipeg.

Ribot, J.C., A. Najam, G. Watson (1996) 'Climate Variation, Vulnerability and Sustainable Development in the Semi-Arid Tropics', in Ribot J.C., A.R., Magalhaes, S.S. Panagides (eds.) *Climate Variability, Climate Change and Social Vulnerability in the Semi-Arid Tropics*, Cambridge University Press: Cambridge.

Scheraga, J., A.E. Grambsch (1998) 'Risks, Opportunities, and Adaptation to Climate Change', *Climate Research*, 11(1): 85-95.

Schipper, E.L.F. (2006a) 'Conceptual History of Adaptation in the UNFCCC Process' *Review of European Community and International Environmental Law (RECIEL)* 16(1): 82-92

Schipper, E.L.F. (2006b) 'Climate Risk, Perceptions and Development in El Salvador' Tyndall Working Paper No. 93.

Schipper, E.L., Huq, S., Khan, M. (2003) 'An Exploration of "Mainstreaming" Adaptation to Climate Change'. Brief prepared for Adaptation Research Workshop, 9-12 November, New Dehli.

Simms, A., J. Magrath, H. Reid (2004) *Up in Smoke. Threats from, and responses to, the impact of global warming on human development*, New Economics Foundation: London.

Smit, B., M.W. Skinner (2002) 'Adaptation Options in Agriculture to Climate Change: A Typology' *Mitigation and Adaptation Strategies for Global Change*, 7(1): 85-114.

Smit B., O. Pilifosova (2001) 'Chapter 18: Adaptation to Climate Change in the Context of Sustainable Development and Equity' in McCarthy J.J. O. F. Canziani, N.A. Leary, D. J. Dokken, K.S. White (eds.) *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, Contribution of WG II to the TAR of the IPCC, Cambridge University Press: Cambridge.

Smit, B., I. Burton, R.J.T. Klein, R. Street (1999) 'The Science of Adaptation: A Framework for Assessment' *Mitigation and Adaptation Strategies for Global Change*, 4(3-4): 199-213.

Smit, B. (1993) 'Adaptation to Climatic Variability and Change: Report of the Task Force on Climatic Adaptation', Occasional Paper, Department of Geography, University of Guelph: Canadian Climate Program.

Smit, B. J. Wandel (2006) 'Adaptation, adaptive capacity and vulnerability' *Global Environmental Change* 16 (3) 282-292.

Smith, J.B. (1997) 'Setting Priorities for Adapting to Climate Change' *Global Environmental Change*, 7(3): 251-264.

Smithers, J., B. Smit (1997) 'Human Adaptation to Climatic Variability and Change' *Global Environmental Change*, 7 (2) 129-146.

Soussan, J., I. Burton (2002) 'Adapt and Thrive: Combining Adaptation to Climate Change, Disaster Mitigation, and Natural Resources Management in a New Approach to the Reduction of Vulnerability and Poverty', Paper

presented at the UNDP Expert Group Meeting, "Integrating Disaster Reduction and Adaptation to Climate Change", Havana, Cuba, 17-19 June 2002, UNDP: Havana.
Srivastava, L., T. Heller (2003) 'Integrating Sustainable Development and Climate Change in AR4', preparatory document for the drafting of the Fourth Assessment Report of the IPCC, IPCC: Geneva.
Stakhiv, E.Z. (1993) 'Water Resources Planning and Management Under Climate Uncertainty' in T.M. Ballentine, E.Z. Stakhiv (eds.) *Proceedings of the First National Conference on Climate Change and Water Resources Management*, U.S. Army Corps of Engineers Institute for Water Resources, Fort Belvoir, VA.
Thomalla, F., T. Downing, E. Spanger-Siegfried, G. Han, J. Rockström (2006) 'Reducing hazard vulnerability: Towards a common approach between disaster risk reduction and climate adaptation' *Disasters*, 30 (1): 39-48.
UNDP (UN Development Programme) (2002) Synthesis of UNDP Expert Group Meeting "Integrating Disaster Reduction with Adaptation to Climate Change", 17-19 June 2002, Havana, Cuba, UNDP: Havana.
UNDP (2004) *Reducing Disaster Risk: A Challenge for Development*, UNDP: Geneva.
UNFCCC (UN Framework Convention on Climate Change) (2001) Marrakesh Accords. In: *Report of the Conference of the Parties on its seventh session, held at Marrakesh from 29 October to 10 November 2001. Addendum. Part Two: Action taken by the Conference of the Parties.* Decisions 2-39/CP.7, (FCCC/CP/2001/13/Add.1-4.) UNFCCC, Bonn, Germany
Verheyen, R. (2003a) 'The Legal Framework' in Smith, J.B., Klein, R.J.T., S. Huq (eds.) *Climate Change, Adaptive Capacity and Development*, Imperial College Press: London.
Verheyen, R. (2003b) 'Adaptation Funding – Legal and Institutional Issues' Smith, J.B., Klein, R.J.T., S. Huq (eds.) *Climate Change, Adaptive Capacity and Development*, Imperial College Press: London.
Watson, R.T., R.O. Ackermann (2000) 'Poverty and Climate Change' *Environment Matters at the World Bank: Annual Review 2000*, World Bank: Washington, D.C.
Yamin, F., A. Rahman, S. Huq (2005) 'Vulnerability, Adaptation and Climate Disasters: A Conceptual Overview' *IDS Bulletin*, 36(4):1-14.

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- Barnett, J. (2001). **The issue of 'Adverse Effects and the Impacts of Response Measures' in the UNFCCC**, Tyndall Centre Working Paper 5

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- Berkhout, F, Hertin, J. and Jordan, A. J. (2001). **Socio-economic futures in climate change impact assessment: using scenarios as 'learning machines'**, Tyndall Centre Working Paper 3

- Hulme, M. (2001). **Integrated Assessment Models**, Tyndall Centre Working Paper 2

- Mitchell, T. and Hulme, M. (2000). **A Country-by-Country Analysis of Past and Future Warming Rates**, Tyndall Centre Working Paper 1

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