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Arun Malik, Xin Qin, and Stephen C. Smith
Department of Economics and
Institute for International Economic Policy
George Washington University
Washington DC 20052

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Institute for International Economic Policy
1957 E St. NW, Suite 502
Voice: (202) 994-5320
Fax: (202) 994-5477
Email: iiep@gwu.edu
Web: www.gwu.edu/~iiep

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1. Introduction

Study on climate change has long focused on mitigation. But regardless of how much mitigation is achieved or will be achieved, the climate is already changing, and significant change is expected in the coming decades due to past emissions of greenhouse gases. Therefore, adaptation has drawn more and more attention in recent years, and it is recognized that serious effort has to be made on this front in order to reduce our vulnerability to the changing environment. On the one hand, the fact that human society can, and does, adapt to climatic changes has implications for understanding the true impact of climate change and for designing optimal climate change strategies given uncertainty. On the other hand, given that some climate change is already inevitable, it is necessary to think about and act on adaptation now.

Adaptation can be classified either as planned adaptation or as autonomous adaptation. This review focuses on autonomous adaptation and it is organized as follows. Section 2 provides a conceptual framework for thinking about autonomous adaptation, including its definition, its relation and linkage with other types of adaptations, and the elements that will contribute to successful autonomous adaptation, including the role of the government and international development assistance in this regard. Section 3 reviews some empirical work, looking at various aspects of autonomous adaptation: perceptions of climate change, adaptation strategies, adaptation capacities, as well as the role of institutions. Section 4 puts forward some ideas for future research on autonomous adaptation.

2. Conceptual work

2.1 Definition of adaptation

The Intergovernmental Panel on Climate Change (IPCC) defines climate change adaptation as "adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities" **(IPCC, 2001)**. This is probably the most authoritative definition. However, there are other definitions that are also often used. Below are a few more examples:

> "A process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed and implemented" **(UNDP, 2005)**.

> Adaptation to climate change 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 (**Burton, 1992**, cited in **Smit et al., 2000**).
>
> Adaptation 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 (**Smit, 1993**, cited in **Smit et al., 2000**).
>
> The term adaptation means any adjustment, whether passive, reactive or anticipatory, that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change (**Stakhiv, 1993**, cited in **Smit et al., 2000**).
>
> Adaptation to climate change includes all adjustments in behavior or economic structure that reduces the vulnerability of society to changes in the climate system (**Smith et al., 1996**, cited in **Smit el al., 2000**)

Slight differences exist among these definitions and may have some practical implications under certain circumstances,[1] but they are minor for the purpose of this review.

2.2 Definition of "autonomous adaptation" and how it relates other types of adaptation

There are many ways to classify adaptation. The most commonly discussed classifications are listed below.

Based on intent/purposefulness:

- Autonomous adaptation: adaptation that does not constitute a conscious response to climatic stimuli, but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. It is also referred to as spontaneous adaptation **(IPCC, 2001)**. [2]
- Planned adaptation: adaptation that is the result of a deliberative policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, to maintain, or to achieve a desired state.

Based on timing:

- Anticipatory adaptation: adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.
- Reactive Adaptation—Adaptation that takes place after impacts of climate change have been observed.

Based on agents:

[1] See analysis in Levina and Tirpak, 2006.

[2] IPCC 2001: "Autonomous or spontaneous adaptations are considered to be those that take place—invariably in reactive response (after initial impacts are manifest) to climatic stimuli—as a matter of course, without the directed intervention of a public agency."

- Private Adaptation—Adaptation that is initiated and implemented by individuals, households or private companies. Private adaptation is usually in the actor's rational self-interest.
- Public Adaptation—Adaptation that is initiated and implemented by governments at all levels. Public adaptation is usually directed at collective needs.

Based on temporal scope:

- Short-Run Adaptation – The decision maker's response to climate change is constrained by a fixed capital stock, so that the principal options available are restricted to variable inputs to production (**Stern, 2007**).
- Long-Run Adaptation – The decision maker can adjust capital stock in response to climate change.

The most relevant to this review, of course, is the definition of autonomous adaptation. But it is important to note the connections between autonomous adaptation as defined above and the other types along different dimensions of classification. Autonomous adaptations are usually reactive. They are also widely considered initiatives by private actors instead of governments, thus autonomous adaptation corresponds to private adaptation, and planned adaptation to public adaptation (**IPCC, 2001**). However, some people believe private adaptation can be autonomous or planned, or some combination of the two (**Smithers and Smit, 1997**; cited in **Smit et al. 2000**). Short-run adaptation involves less uncertainty of climate impacts and the benefits are more predictable, so it is more likely to be driven by autonomous decisions. By contrast, adaptation in long-term investments (such as climate proofing of buildings) may prove difficult for private market due to the greater uncertainty (**Stern, 2007**).

The purpose of having these definitions and classifications is to help us frame the issues. In the real world, the line between autonomous and planned adaptation, or between private and public adaptation, is surely blurry. One can imagine many cases were adaptation takes place as a bottom-up process, with government stepping in to provide incentives. Or, government designs policies in response to people's concerns but the action of adaptation only begins with government policies in place.

So we can think of adaptation as a *continuum*. At one end is the "pure" spontaneous adaptation by private agents; on the other end is the pure planned adaptation by government, such as big infrastructure construction led by the government and regulations (change of building codes, for example). Between these extremes there are plenty of forms of adaptation that involve both the private agent and the government. While the focus of this review is on autonomous adaptation, one does not have to be a purist who considers an adaptation action as "autonomous" only if the government (or external actors like donor agencies, NGOs, etc.) is completely out of the picture.

Fankhauser et al. (1999) discuss the linkage between autonomous/reactive adaptation and planned/anticipatory adaptation as either being substitutes or complements. If autonomous adaptation increases the marginal benefit of planned adaptation and vice versa, they are considered complements. One example involves farmers responding to increasing temperature by planting new varieties

(autonomous adaptation) and government research institutes developing new heat resistant seeds (planned adaptation): farmers' willingness and ability to adopt the new seeds increase the marginal benefit of the research, and the availability of more varieties increases the marginal benefit for farmers changing to new seeds. On the other hand, if autonomous adaptation reduces the need for planned adaptation and vice versa, then they are substitutes. There are plenty of examples of this type of relationship. For instance, if the government, in anticipation of increased variability of precipitation, builds large reservoirs and irrigation systems (planned adaptation), farmers will have less need to make their own (autonomous) adaptations such as changing crops or conserving water**.**

2.3 Elements of successful autonomous adaptation and government's role

In a perfect world with no market failures, autonomous adaptation would be the best way to adapt to climate change and government involvement would be unnecessary. However, due to constraints with respect to information, resources, etc., autonomous adaptation alone may turn out not to be optimal, and governments have very important roles to play.

Fankhauser et al. (1999) argue that for autonomous adaptation to be effective, individuals must have the right *incentive, knowledge, resources and skills* to adapt efficiently. The government's role is to provide "a conducive environment" for adaptation, including the right legal, regulatory, socio-economic environment for autonomous adaptation. For example, the government needs to provide the right incentives to farmers for taking adaptive actions. If the government subsidizes certain crops heavily and farmers do not suffer losses from the changing climate, they will have no incentive to adapt by themselves. Governments also need to address all kinds of market imperfections related to climate change. The standard economic theory about government intervention is applicable here: government involvement is warranted only when the market cannot be expected to work properly in the given circumstances, such as in the presence of information asymmetry, externalities and public goods. Government intervention is needed, for example, when farmers adapt to droughts by using irrigation more intensively and thus incurring a depletion cost (a negative externality). Government involvement may also be needed to encourage people to make long-term investment on adaptation (imperfect information). The provision of goods and services of a public good nature, such as research and development and meteorological services are undoubtedly the government's responsibility and highly important to the success of autonomous adaptation.

Mendelsohn (2000) argues that as long as the cost and benefit of adaptation are borne by the same decision maker, private adaptation will occur and tend to be efficient. However, he also argues for government's involvement in adaptation on three grounds: externality, high information costs, and equity. The first two reasons are similar to Fankhauser (1999) and easy to see. The third one, equity, involves justice across different groups of people. The cost of private adaptation is borne by the victims of climate change, but equity means that polluters should pay for the damages of pollution. Government involvement may help shift the cost of adaptation from the victims to the polluters. In the context of adapting to climate change, this argument seems to fit better globally (industrial countries vs. developing countries) and across sectors (industry/energy sectors vs. agriculture) rather than locally. A

fourth type of adaptation that justifies government intervention is what Mendelsohn calls "joint adaptation", which resembles a "public good." For joint adaption, he points out, even with government intervention, it is very difficult to achieve efficient adaptation because: 1) the collective gain may not be perceived by every member of the group; 2) the collective body may not agree on the level of action; and 3) beneficiaries are more interested maximizing their own private gain than collective gain.

Aaheim and Aason (2008) also discuss the need for government involvement in adaption from the perspective of addressing market failures. Three classes of market failures are identified: 1) adaptation is a public good; 2) transaction costs are high; and 3) adaptation requires factors of production to be moved physically (immobility). As a result, the government is needed either to facilitate autonomous adaptation or to carry out the required adaptation directly (planned adaptation).

UKCIP (2005) distinguishes two adaptation processes: "building adaptive capacity" involves creating the information and conditions (regulatory, institutional, managerial) that are needed before adaptation actions can be taken, and "delivering adaptation actions" involves taking actions that will help to reduce vulnerability to climate risks, or to exploit opportunities. In this framework, autonomous adaptation could be thought of economic agents delivering adaptation actions, while governments play a major role in "building adaptive capacity."[3]

While recognizing government's role in promoting and facilitating autonomous adaptation, it also needs to be kept in mind that the process of autonomous adaptation and that of government adaptation are very different. As discussed in **Brooks (2003)**, for the former, adaptation will be determined by the agent's education, access to information, financial and natural resources, social networks, and the presence/absence of conflicts. For the latter, the adaptation process will depend on relationships between the government, the private sector and civil society, the regulatory environment and the effectiveness of state institutions, national wealth, economic autonomy and so on.

2.4 Development and adaptation

It is widely recognized that developing countries are more vulnerable to the impacts of climate and have less capacity to adapt. Therefore, adaptation to climate change has a growing profile in the international development community. IPCC TAR (2001) notes that "very little attention has been devoted to the interaction of adaptation to climate change with the ongoing development projects and programs" and that there is "surprisingly little recognition climate hazards and risks associated with climate change in established development projects and programs." This has changed very much over the last decade – at least in rhetoric: "mainstreaming" climate change adaptation has become a catchphrase in development projects. The World Bank devotes its 2010 *World Development Report* to the subject of development and climate change and calls for "integration of adaptation into climate-smart development" (World Bank, 2010).

[3] In UKCIP (2005), examples of "building adaptive capacity" include 6 types: research, data collection and monitoring, awareness-raising, changing standards and developing policy, organizational learning, and working in partnership.

A very basic question is the relationship between development and adaptation. **Schipper (2007)** identifies two approaches linking development and adaptation (Box 1). In the first approach, adaptation is carried out "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." As illustrated in the top half of the box, in this view, adaptation contributes to development. The contrasting view is that development leads to better adaptation, as illustrated in the bottom half of the box. This is the view expressed in IPCC TAR (2001), which suggests that the adaptive capacity is greater when the nation has "a stable and prosperous economy."

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.

*Reproduced from **Schipper (2007)**.*

Schipper (2007) argues that the "vulnerability reduction approach" to development is more desirable than the "adaptation approach." The "adaptation approach" translated into practice is "mainstreaming" – taking climate change into consideration for development planning. However, this may not be effective if the existing development strategies fail to address the underlying causes of vulnerability. Therefore, "*it is vulnerability reduction that should be integrated into development policy, rather than the creation of specific adaptation strategies*." Many people are vulnerable to the impacts of climate change for non-climate reasons. While the adaptation approach only focuses on climate impacts, the vulnerability reduction approach addresses the fundamental reasons for vulnerability, many of which are about broader development.

McGray et al. (2007) also note these two views of the relationship between adaptation and development: viewing adaptation as a means to achieve development and viewing development as a means to achieve adaptation. It suggests that a more useful way to characterize them is to think of them

as dual objectives rather than end and means. A development-adaptation continuum is proposed: on the one end is traditional development activities, which reduces overall vulnerability but do not consider any specific climate issues; on the other end are adaptation actions highly targeted towards specific impacts of climate change that are not included in conventional development. Between these two extremes are various forms of activities that place different emphasis on vulnerability and climate change impacts. Specifically, four categories of adaptation activities are identified:

- Addressing the drivers of vulnerability. This is the development end of the spectrum: activities that reduce poverty and other factors that lead to vulnerability.
- Building response capacity. These activities focus on building capacities for problem solving. Examples include improvement in communication systems, mapping, weathering monitoring, and resource management.
- Managing climate risk. In this category of activities, climate information is incorporated in decision making. Activities such as disaster response planning and growing drought-resistant crops fall into this category.
- Confronting climate change. These are actions that focus almost exclusively on responding to the impacts of anthropogenic climate change and are not generally included in conventional development, such as relocation of communities due to sea level rise.

(Adapted from McGray et al., 2007)

Adaptation and adaptive capacity in particular can also be analyzed with Amartya Sen's "capabilities approach."[4] In this approach, capabilities reflect various "functionings" a person can potentially achieve and require the access to "freedoms" – political freedom, economic facilities, social opportunities, transparency guarantees, and protective security (**Sen, 1999**). **Ospina and Heeks (2010)** argue that the growth of adaptive capacity itself is "developmental," regardless whether it is actually utilized. **Roy and Venema (2002)** apply this approach to examining Indian women's vulnerability to climate change, and argues that development efforts should be directed in the capabilities framework so that these women can improve their well-being, such as access to health care, literacy, and control over their own lives, hence acting more readily in response to climate change pressures.

It should be noted that for the discussion on development and adaptation, it appears that very often the authors have *planned* adaptation in mind, because the question at hand is about the deliberate planning of an adaptation strategy – usually by national governments or actors in the international development community. To some extent, however, the argument in Schipper (2007) can be seen as a case made for autonomous adaptation: "development" is to provide an enabling environment; once the environment is there, people would be able to adapt to whatever impact from climate change autonomously.

3. Empirical work - focusing on developing countries

[4] This approach is also often applied in discussions on climate justice (equity) and development opportunities. See **Halsnæs et al. (2007)**.

3.1 Overview. There have been some empirical studies on adaptation to climate change since the 1990s. The earlier studies seem to focus on developed countries, where data are more readily available and the challenges of adaptation were recognized earlier on as an important policy issue. The focus is on often on agriculture and infrastructure – sectors most exposed to climate change risks (e.g., Smit et al., 1997, Easterling et al., 1993, Yohe and Schlesinger, 1998. IPCC (2001) provides a comprehensive review of research up to that point.). Many studies look at the "planned adaptation" types of adaptation. For those that do study autonomous adaptation, such as adaptation in agriculture, very often the main interest is not on adaptation *per se*, but to understand what autonomous adaptation implies for the climate change impact. In other words, the negative impact of climate change on agriculture would be smaller if farmers adapt and the positive would be stronger. Therefore, autonomous adaptation by farmers is assumed (based on historical and cross-sectional observations) and adaptation behavior is not the focus of analysis.

In the last 10 years or so, interest in adaptation has grown in developing countries for reasons discussed above, and more studies have been carried out in Asia, Africa, and Latin America.

The various adaptations studied in the literature reviewed here are not necessarily fully consistent with the very narrow definition of adaptation or autonomous adaptation to anthropogenic climate change. For example, some research may be more accurately described as studying coping strategies, some adaptation actions are not made in response to climate change directly, but to existing natural disasters – but presumably such disasters might happen more frequently in the future as result of climate change. The intention is to keep the coverage broad enough so that ideas, analytical methods, and findings relevant to adaptation to climate change are included as much as possible.

For someone to take action to adapt to climate change autonomously, he has to recognize climate change first. It is thus important to have some understanding about the perception of climate change by people in developing countries. Another important aspect of adaptation is the specific strategies people use. Extremely relevant to policymakers are determinants of adaptation: which factors contribute to adaptation by the economic agents themselves and what factors are barriers to autonomous adaptation? This would provide useful information for better policymaking. And finally, what role do institutions play in autonomous adaptation? So this part of the review will examine these four main themes.

3.2 Perceptions of climate change

The Globe Environment Facility (GER)-funded project "*Climate, Water and Agriculture: Impacts on and Adaptation of Agro-ecological Systems in Africa*" is a large-scale quantitative research project in the field of climate change impacts and adaptation. Eleven African countries[5] with agricultural systems representative of all of Africa are included in the study, and the findings from this project are synthesized in **Dinar et al. (2008)**. Also generated from this project are a number of country case studies,

[5] Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa, Zambia, and Zimbabwe.

such as Deressa et al. (2008, 2009), Hassan et al. (2008), Kabubo-Mariara (2008), and Maddison (2006). For the "impact" part, the analytical method is based on Ricardian analysis, an approach similar to what is used in Mendelsohn (1994). To address the weakness of Ricardian models with respect to adaptation analysis, a special section of the survey includes specific questions about adaptation.

With regard to perceptions of climate change, the survey results show that a large number of African farmers have noticed some form of climate change. For example, more than half of the surveyed farmers Egypt, Ghana, Kenya, Senegal and South Africa believe the average temperature has increased, and more than half interviewed in these countries also claim they have observed decreased precipitation. A smaller but sizable portion in many countries notes changes in timing of rains. Most notably, in Kenya, all people interview say the frequency of droughts has changed. However, their perceptions are not always supported by meteorological records. For example, despite the perception of hotter weather by many respondents in Kenya, Senegal and South Africa, there is no evidence of such change in meteorological records. The same is true for the "less precipitation" perception for Egypt, Kenya and South Africa (**Dinar et al., 2008; Maddison, 2006**).

The study also uses a binary model to assess what kinds of farmers are more likely to perceive changes in climate. Variables considered include age, education, gender, marital status, whether he is head of household, distance to market, whether he has off-farm work, and country. It is found that more experienced farmers are more likely to perceive climate change. Distance to market is an important factor, presumably because farmers with easier access to market have better opportunity to exchange information with others (**Dinar et al., 2008; Maddison, 2006**).

Thomas et al. (2007) examine South African farmers' perception of and response to one particular change of the climate: precipitation. Through the use of focus groups, structured questionnaires, and semi-structured interviews, they collect data from three regions in South Africa. They find that a large portion of farmers have recognized changes in the precipitation pattern and, more importantly, their perceptions correspond to the actual changes reflected by the rainfall records. Most notably, people see drought and dry conditions as natural events; the main change perceived is increase variability and uncertainty of specific climate parameters, such as later start of the rainy season and changing distribution of rainfall over various months. In all three regions, over 70% of the respondents recognize increased climate variability. **Mertz et al. (2009)** examine farmers' perception of climate change in rural Sahel and also finds very strong recognition of the changing patterns and intensity of climate events.

By contrast, in a survey of small farmers in the Amazon, **Brondizio and Moran (2008)** find that memories of extreme weather events do not last long with these farmers. More than half of those interviewed in 2002 did not remember the drought in 1997-1998, one of the worst in history.

3.3 Adaptation strategies/methods

Depending on the how risks are reduced or avoided, five classes of adaptation strategies can be identified.

> *Mobility – pools or avoids risks across space*
>
> *Storage – It pools/reduces risks experienced over time*
>
> *Diversification – It reduces risks across assets owned by households or collectives.*
>
> *Communal pooling – It involves joint ownership of assets and resources; sharing of wealth, labor or incomes from particular activities across households, or mobilization and use of resources held collectively during time of scarcity. It reduces risks experienced by individual households.*
>
> *Exchange – It is usually viewed as a means to promote specialization and increase revenue flows, but it can equally substitute for the first four classes of adaptation strategies.*
>
> *(adapted from **Agrawal and Perrin, 2009**)*

The adaption methods discussed in most empirical literature fall into one of these five classes.

The GEF-funded research mentioned above (**Dinar et al., 2008, Maddison, 2006**) looks at agriculture only, so the adaptive strategies are mostly related to technical changes in farming practice. In nine out of the eleven countries included in the study, using different varieties of the same crop is one of the most important adaptation methods. Changing planting dates, adopting shorter growing season, increasing the use of irrigation, water conservation technique and soil conservation techniques are practiced in several countries. In addition to these technical adaptations, increased use of weather insurance is indicated by farmers in Egypt. Many of those surveyed in Egypt also adapt by moving to non-farming activities.

Eriksen et al. (2008) observe a number of "indigenous" adaptation strategies to climate change impacts in Eastern and Southern Africa: (1) Diversification. For example, fishers in Uganda also cultivate crops, raise livestock, collect firewood, and engage in trade and temporary migration. (2) Livestock herding is an important adaptation to frequent droughts in Namibia and Botswana. (3) Ecological diversification. Farmers in Mozambique have plots in high ground when there is a lot of rain and in low ground when there is little rain. Similarly, **Thomas et al. (2007)** find a large number of adaptation strategies by farmers in South Africa, such as changing farming practices (plant drought-resistant varieties, have more livestock and less crops, build cattle shelter), diversifying livelihood (get off-farm work, start a business) and forming networks (cooperatives, community horticultural projects). **Oxfam (2008)** reports several traditional and adaptation methods by pastoralists in Easter Africa, such as migration, diversification of herd animal mix, adjusting herd size, supplementing grazing with feed, and harvesting rain water as an alternative to the increasingly unreliable supply of groundwater.

Eakin (2005) studies adaptation to climate risks in three rural communities in Central Mexico. The focus is on the effect of social, political and economic conditions on farmers' adaptive capacities and their

selection of adaptation strategies. In particular, the analysis looks at how a number of institutional changes interact with farmers' ability to adapt to climate risks and their adaptation choice set. Planting maize is the core livelihood strategy for all farmers in this area, though maize is more susceptible to damage caused by changing climate patterns than alternative crops such as oat and barley. Farmers stick to maize because it provides subsistence while wheat and barley depend on the uncertain commercial market. For small farmers, meeting the subsistence need is the predominant concern in their livelihood strategy, which seriously limits their adaptation choice set. Only large farmers can diversify their crop mix. NAFTA provides a good opportunity for farmers to switch to the high-value vegetable production for export, which, theoretically, could be a desirable diversification strategy. However, market uncertainty in combination with climate events makes it a very risky strategy. Moreover, vegetable production requires more irrigation and technical service, and the lack of public support in these areas makes it very difficult for Mexican farmers to be competitive. Another means of adaptation is to diversify livelihood by off-farm employment. But this choice is constrained by farmers' own education level, the distance to industrial centers where such employment is available, and availability of public transportation.

3.4 Determinants of adaptation, barriers to adaptation, and adaptive capacity[6]

Dinar et al. (2008) find great difference among the eleven countries with respect to the adoption of adaptation practices. In several countries, more than one third of respondents take no adaptive action at all although they have perceived changes in the climate. By contract, almost all respondents in Egypt and Ethiopia report at least one adaptation. The specific reasons for this cross-country difference are not identified given the research design. However, at the individual level, this study suggests a number of factors affecting the probability of a farmer adapting to climate change. More experienced and better educated farmers are more likely to take adaptive measures. Being head of household also leads to higher probability of adaptation, presumably because he/she controls household resources. Farmers working on rented land are less likely to adapt.

In the frame field experiment in Costa Rica discussed in more detail below (**Alpizar et al., 2009),** a logit model is used to estimate what characteristics of coffee farmers are correlated with adaptation. It is found that male farmers are more likely to adapt than female ones (though no explanation is offered for this difference), and that those who have previously invested in soil conservation are also more likely to adapt to risks associated with climate change. On the other hand, big coffee farmers are less likely to adapt, probably because they have more resources to overcome the adverse effects from extreme weather events.[7] It is also found that age and education do not have any significant effect on adaptation decisions.

[6] According to IPCC, adaptive capacity is "the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change" (IPCC, 2001).

[7] The hypothetical scenarios in the experiment are set so that only incomes from coffee farms are affected. See below for more details.

Brouwer et al. (2007) look at vulnerability and adaptation to flooding in Bangladesh. By analyzing data from a household survey of residents living in the floodplain along the River Maghna, they are able to show the relationship between poverty, vulnerability[8] and adaptive capacity. The poorer live closer to the river, thus facing higher risks of flooding; at the same time, they have less capacity to take *ex ante* preventive measures against floods and less access to *ex post* disaster relief. The study also finds that more income sources result in lower damage costs from flooding; however, this strategy is primarily used by the wealthier households living further from the river. The poorest households, living closet to the river, have very few opportunities to diversify their income sources. This finding is similar to the pattern observed by **Eakin (2005)**: in the Mexican case, only larger farmers can diversify crops away from maize and have less climate sensitive crops such as oat and barley, and only the better-to-do households can invest in human capital, which, in turn, makes it possible to engage in other economic activities such as finding employment in the industrial parks. The poorest, with very small landholding, seems to be trapped in subsistence farming with high dependence on maize.

One feature of the **Brouwer et al. (2007)** study is that it looks at adaptation not just at the individual household level, but also at the community level. An important finding at the community level is that greater income inequality is associated with higher flood damage cost. Although no exact reason can be identified to explain this correlation, one possible explanation is that communities with more equal income distribution are more likely to pool their resources and spend on flood protection collectively. This would be true for both poor and rich communities.

Cinner et al. (2008) look at the response of artisanal fishers to a declining fishery. Though the decline in fish stocks may or may not be directly related to climate change, the issue studied – switching occupation/livelihood – is highly relevant. They examine the readiness to quit of 141 Kenyan fishers from 9 coastal communities in Kenya under hypothetical scenarios of declines in catch, and use a binary logit model to analyze how their decisions are influenced by their socio-economic conditions. The key finding is unsurprising: fishers from households with more material wealth (measured by household possessions or structure) and greater number of occupations are more likely to quit fishing when fishing stock decline. This again echoes the findings in **Eakin (2005)** and **Brouwer et al. (2007)**: poor people are unable to mobilize the resources required to overcome either shocks or chronic low-income situation. This is also consistent with the "poverty trap" discussion in the development literature.

Alpizar et al. (2009)[9] analyze farmers' adaptation to climate change through a framed field experiment with coffee farmers in Costa Rica. In a way, this study can be seen as examining the influence of people's own attitude towards risk and uncertainty as well as network effects on adaptation decision-making. The type of adaptation examined is solely adoption of new technologies. There have been studies in the

[8] Vulnerability has two aspects: exposure to risks on the one hand, and (the lack of) adaptive capacity on the other. Adger et al. (2007) defines vulnerability as: "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes."

[9] This research is included in this review largely for its field experiment method. Though the scenarios are all hypothetical, they are designed to be as realistic as possible. In addition, the study was conducted shortly after a major (and rare historically) storm, so the participating farmers could relate to the consequences of extreme climate events.

past on farmers' behavior in adopting new technologies in general – not related to climate change. The interest of this study is on three aspects: (1) how the level of income loss risks due to climate change affects farmers' willingness to adapt; (2) whether farmers are ambiguity averse (preferring known uncertainty over unknown uncertainty) and if this can explain their adaptation behavior; (3) whether farmers can coordinate adaptation efforts if there are economies of scope. The farmers are presented with a situation where their annual income from the coffee farm is 500,000 colones with no extreme climate event and 50,000 with such events, and the cost of adaptation is 200,000 colones. To test question (1), farmers are asked to decide whether to invest in adaptation when the risk of extreme event is 1%, 5%, and 10%, respectively. To test question (2), no exact risk level is given, and the farmers only know it could be 1%, 5% or 10% with equal probability (average=5.3%). To test question (3), the farmers are divided into groups of 3, and group members face risk level of 1%, 5% and 10%, respectively. They are told that if all three adapt, the cost of adaptation would fall to 10,000 colones; otherwise it would remain at 20,000.

As one would expect, the share of farmers that would adapt increase with the risk level: 31% would adapt when faced with a risk level of 1%, and this share increases to 77% and 95% for 5% and 10% risk levels, respectively. For the ambiguity aversion question, of those who choose not to adapt at the definite 5% risk level, more than half would adapt when faced with ambiguity (with average risk level at the comparable 5.3%), suggesting that farmers are ambiguity averse. With regard to coordination, it is found that the cost savings leads to more adaptation, and communication is a critical variable affecting the level of coordination.

3.5 Adaption and institutions

Institutions are "the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interactions," and they consist of both informal and formal constraints (**North, 1990**). Autonomous adaptation refers to adaptive actions by individuals and communities without deliberative government planning or intervention, but they do not act in isolation from the existing social, political, cultural and market institutions. Therefore, the role of institutions are touched upon in many studies on climate change adaptation, including some discussed above – such as the impact of NAFTA and economic liberalization on the adaptation choice set faced by farmers in Central Mexico (**Eakin, 2005**).

One line of research on (autonomous) adaptation exclusively focuses on institutions. **Agrawal (2008)** uses a comparison between two neighboring districts in India to illustrate the importance of various institutions to reducing vulnerabilities (**O'Brien et al., 2004**). Groundnuts farmers in both Anantapur District and Chitradurga District are exposed to risks due to economic liberalization as well as risks due to climate change (drought). In Anantapur, import competition and stagnant prices, in combination with droughts, seriously threaten farmers' livelihood. Switching to rain-fed fruit crops is difficult because it involves high investment, and the fruits' shelf-life is too short to be marketable. By contrast, farmers in the neighboring Chitradurga District reduce their vulnerability by taking advantage of a number of public

and market institutions, including subsidized drip irrigation, crop insurance, cheap credit, and contract with exporters to supply for the European market. Therefore, different institutions (or the absence of certain institutions) lead to very different levels of adaptive capacity and consequently levels of vulnerability.

Adger (1999, 2000) provides a description of institutional changes in Vietnam's transition towards a market economy and how they affect the country's management of environmental risks. The study was done in 1995-96 in the Xuan Thuy District in the Red River Region, which has a long coast line and typhoons and coastal storms are the major environmental risks. Building and reinforcing sea dikes is a major measure to manage the damages. During the collectivization period, members of communes were required to contribute a certain amount of labor to the task of sea dike maintenance. With Vietnam's market-oriented reform, this practice was replaced with a tax, and work of coastal protection has become increasingly professionalized (because the opportunity cost of farmers' time becomes higher) and paid for with the dike maintenance tax. However, the coastal communes to which this tax revenue is allocated may use it for purposes other than sea dike maintenance and reinforcement, such as road construction. As a result, the collective safety of the region is compromised. In this particular case, market oriented reform and decentralization result in some weakening of an important adaptation measure. However, as noted in the paper, this weakening may be offset by the reemergence of civil society and market institutions in the long run.

A very particular institution that could potentially play a major role in autonomous adaptation in the developing world is *microfinance*. As mentioned in Section 2, for autonomous adaptation to take place, economic agents need sufficient information, incentive and ability/resources. One key constraint facing the most vulnerable populations in the face of climate change is the lack of resources – this is why the international community as well as governments devotes much effort to assisting them in adaptation. Microfinance often targets the poor, and thus can potentially be a very effective mechanism channeling resources to the vulnerable groups that are in great need to take adaptive actions but otherwise lack the resource to do so.

Hammill et al. (2008) provide a systematic discussion about the linkage between microfinance and climate change adaptation. As they note, "the logic here is simple – the more assets and capabilities people have, the less vulnerable they are." Microfinance services provide the poor with a means of accumulating and managing the assets and capabilities needed to become less susceptible to shocks and stresses and/or cope with their impacts.

Agrawala and Carraro (2010) study the linkages between microfinance and adaptation in two countries highly vulnerable to climate change: Bangladesh and Nepal. The particular nature of microfinance lending – large volume, limited value loans, they observe, is "consistent with the fundamental nature of a majority of adaptation actions that will ultimately consist of thousands of decentralized actions by individuals, households and communities, as they continuously seek to internalize climate risks in their activities," i.e., engage in autonomous adaptation. More practically, microfinance can provide the

linkage between the macro-financing of adaptation in the international climate change regime and the adaptation activities at the grassroots.

Their review of microfinance lending in Bangladesh and Nepal find there is already significant overlap between microfinance and climate change. They review 226 microfinance lending programs (each program can have thousands of small loans) by 22 major microfinance institutions (MFIs) in Bangladesh between 2006 and 2008. These lending programs are divided into 10 categories: employment and income generating activities; agriculture, livestock, fisheries; forestry; water and sanitation; health; housing; education; renewable energy; information-technology transfer; disaster relief and preparedness. Programs for "agriculture, livestock and fisheries" account for 41% of the total number of programs, followed by employment-generating activities (19%), disaster relief and preparedness (11%), water and sanitation (7%), and health (5%). Given that OECD has identified Bangladesh's priority climate change risks as water resources (flooding), coastal resources, human health, and agriculture, the overlap between the microfinance programs and climate change adaptation needs is apparent.

Further, they examine the loan programs' connection with climate change adaptation and come up with three categories: no link, win-win, and climate-proofing. The "no-link" category includes programs targeted at purely income-generating activities – while these activities would ultimately reduce vulnerability and strengthening coping capacity, there is no direct link to climate change. The "win-win" category refers to "microfinance programs which, as currently structured, would automatically also contribute to adaptation to climate change." It includes programs on agriculture and water resources that are sound practices from the adaptation perspective. Also included are programs on disaster relief and preparedness. The "climate proofing" category refers to "activities that might need to be adjusted to take better account of the risks posed by climate change and/or to facilitate adaptation." Such activities may eventually lead to maladaptation to future climatic conditions or require adjustments to be more resilient to climate change. In this categorization, 44% of the programs reviewed fall under the "no-link" category, 43% are "win-win" and the remaining 13% are "climate proofing." Although only indicative, this finding is quite significant: with no explicit design centered on adaptation, 43% of the microfinance programs in Bangladesh are already supporting autonomous adaption[10] to climate change.

A similar but less strong linkage between microfinance and climate change adaptation is observed for Nepal. According to the authors' assessment, of the 82 lending programs offered by 22 MFIs from 2006 to 2008, 41% do not have a direct link to adaptation, 37% are "win-win," and 22% are "climate proofing."

Specific examples are provided to illustrate the specific ways through which microfinance facilitates adaptation: loans are provided to building stronger houses that can withstand bigger storms, loans that

[10] Many of the MFIs have received financial resources from donors and NGOs, and understandably the program design may reflect the goals and interests of these organizations. However, this does not change the "autonomous" nature of these adaptation activities since borrowers make their own decisions about the usefulness and benefit of participation. As a matter of fact, such microfinance programs, properly designed, can be viewed as effective tools to facilitate autonomous adaptation.

promote the adoption of new hybrid varieties that are tolerant to salt and water-related stresses, loans for improving water management and irrigation, and so on.

3.6 Summary

There are some common themes across the various case studies. In some way, they provide empirical evidence for the propositions in Section 2 regarding the government's role in facilitating autonomous adaptation. It is worthwhile to highlight a few key points.

- ✓ Provide/improve extension service
- ✓ Improve infrastructure, such as roads, irrigation infrastructure
- ✓ Provide local climate information
- ✓ R&D, especially developing new crop varieties
- ✓ The poorest are often the least able to adapt, which constitute a situation similar to "poverty trap." There are two ways to escape poverty traps: on the one hand, individuals could slowly building up assets so as to reach the threshold level required to escape the trap – this is often very difficult. The other way is to give a "big push," which implies government intervention.
- ✓ People are often faced with multiple stresses and risks in addition to the climate; focusing only on climate related issues is not enough.
- ✓ Some autonomous adaptation strategies actually increase people's exposure to climate risks[11] or other risks. This is true with the farmers in East African who diversify livelihood by commercialization, which exposes them to market risk. Better information, guidance and other forms of assistance from the government in such cases may be necessary.
- ✓ People have lots of possibilities to autonomously adapt. Governments should leave enough room for maneuvering to local populations, i.e., shifting away from adaptation policies that prescribe specific adaptation methods to those that provide enabling conditions for local populations to make their choices.

4. Future research (just some ideas)

- **McGray (2007)** identifies that additional research needed in development and adaptation: more case studies, quantitative and qualitative analysis of cases; development of decision tools in the development-adaptation continuum framework; development of case studies and models for adaptive policymaking.
- Costs and benefits of autonomous adaptation[12]

[11] For example, Pauliotte et al. (2009) reports that rice farmers in Subarnabad, Bangladesh adapt by switching from rice farming to shrimp farming, which is a successful for the rich few but complicates exposure to the poor.
[12] Definitions: adaptation benefit – the avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures; adaptation costs – costs of planning, facilitating, preparing for, and implementing adaptation measures, including transition costs (IPCC, 2001).

Existing cost-benefit analyses of adaptation are mostly at the macro scale – for a nation, a region, or a sector (see **Adger et al., 2007** for a review) and focus on planned adaptation. According to IPCC (2001), autonomous adaptation "forms a baseline against which the need for planned adaptation can be evaluated." "Autonomous adaptation is not only important for impact assessment; it also is a necessary ingredient in the 'base case,' 'reference scenario,' or 'doing nothing' option for evaluation of policy initiatives, with respect to both adaptation and mitigation." The same idea is stated in **Smit et al. (2000)**: "impact assessments focus largely, but not exclusively, on autonomous adaptations, whereas adaption evaluation and prescription necessarily deals with intentionally planned adaptive measures and policies."

So existing cost-benefit analyses are for purposes other than autonomous adaptation per se. Probably this is because, by definition, the cost and benefit consideration is private decision-making for autonomous adaptation.

It is important to understand the costs and benefits of autonomous adaption for its own sake, especially when autonomous adaptation provides a public good. **Kelly and Adger (2000)** perform an analysis of mangrove rehabilitation in three costal districts in Nam Dihn Province, Vietnam. Mangroves provide livelihood to households, but also help maintain dikes. The analysis shows that based on the personal benefit alone planting mangroves is a desirable investment. The social return is higher, of course, when the benefit of coastal protection is taken into account.

- Need to improve our understanding of the decision making process in autonomous adaptation, in particular people's attitude towards risks and uncertainty. **Alpizar et al. (2009)** show, in an experimental setting, that people demonstrate ambiguity aversion. What does it imply for policies?

Deleted:

- Policy guidance for supporting autonomous adaptation

  Existing efforts to evaluate adaptation seem to emphasize adaptation programs by international organizations and national governments, and these adaptation activities tend to fall into the "planned/public adaptation" category. Insufficient attention is paid to autonomous adaptation and the supportive, facilitating role of government (as opposed to government itself as the implementer of adaptation) in the process. For example, currently the most high-profile adaptation effort in least developed countries (LDCs) is represented by the National Adaptation Programs of Action (NAPAs) developed under UNFCCC. [13] Partly due to its project-based nature and its emphasis on the "urgent and immediate adaptation needs" of LDCs, activities identified are mostly public sector investment activities and do not address medium- and long-term policies for providing an enabling environment. In fact, a framework (guidebook) could be developed to guide governments at various levels to identify climate change challenges, understand the responses of the private sector, and set up their own priorities. Guidelines for climate change adaptation have been developed in OECD countries, such as *Canadian Communities Guidebook for Adaptation to Climate Change* (**Bizikova et al., 2008**) and *Preparing for Climate Change: A Guidebook for Local, Regional and State Governments* (**Snover et al., 2007**). However, they also tend to put more emphasis on the preparedness of the public sector.

[13] Forty-four LDCs have submitted their NAPAs to UNFCCC by March 1, 2010.

Rather, a more comprehensive guideline should include explicit explanation of the difference between public and private adaptation as well as appropriate policy instruments for addressing different types of adaptation challenges. In this regard, **Agrawala and Fankhauser (2008)** could potentially be a starting point (Table 3.1, page 90, in particular).

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