A Stitch in Time: Lessons for Climate Change Adaptation from the AIACC Project

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1. Introduction

We can adapt to climate change and limit the harm. Or we can fail to adapt and risk much more severe consequences. How we respond to this challenge will shape the future in important ways.

The climate is already hazardous and always has been. Variations and extremes of climate disrupt our production of food and our supplies of water, reduce our incomes, damage our homes and property, impact our health, even take our lives. Humans, in an unintended revenge, are getting back at the climate by adding to heat trapping gases in the Earth's atmosphere that are changing the climate. But the changes are amplifying the hazards to humans. We cannot in short order stop this. The physical and social processes of climate change have a momentum that will continue for decades and well beyond.

This undeniable momentum does not imply that efforts to mitigate climate change, that is to reduce or capture the emissions of greenhouse gases that drive climate change, are wasted. Nor is a call for adaptation a fatalistic surrender to this truth. The magnitude and pace of climate change will determine the severity of the stresses to which the world will be exposed. Slowing the pace of human caused climate change, with the aim of ultimately stopping it, will enable current and future generations to better cope with and adapt to the resulting hazards, thereby reducing the damages and danger. Mitigating climate change is necessary. Adapting to climate change is necessary too.

The challenges are substantial, particularly in the developing world. Developing countries have a high dependence on climate sensitive natural resource sectors for livelihoods and incomes and the changes in climate that are projected for the tropics and sub-tropics, where most developing countries are found, are generally adverse for agriculture. The means and capacity to adapt to changes in climate are scarce due to low levels of human and economic development and high rates of poverty. These conditions combine to create a state of high vulnerability to climate change in much of the developing world.

To better understand who and what are vulnerable to climate change, and to examine adaptation strategies, a group of case studies were undertaken as part of an international project, Assessments of Impacts and Adaptations to Climate Change (AIACC). The studies span Africa, Asia, Central and South America, and islands of the Caribbean, Indian and Pacific Oceans. They include assessments of agriculture, rural livelihoods, food security, water resources, coastal zones, human health and biodiversity conservation. Results from the studies about the nature, causes and distribution of climate change vulnerability are synthesized in a companion to this paper (see Leary et al, 2007). Here, in this paper, we synthesize findings and lessons about adaptation from the AIACC studies.

Comparison and synthesis of our individual contributions have yielded nine general lessons about adaptation, as well as many more lessons that are specific to particular places and contexts. The general lessons, formulated as recommendations, are: (1) adapt now, (2) create conditions to enable adaptation, (3) integrate adaptation with development, (4) increase awareness and knowledge, (5) strengthen institutions, (6) protect natural resources, (7) provide financial assistance, (8) involve those at risk, and (9) use place-

specific strategies. The lessons are briefly outlined below, followed by a more detailed examination of their nuances and supporting evidence from the case studies.

2. Nine adaptation lessons

2.1. Adapt Now!

The time-honored proverb "a stitch in time saves nine" means that immediate action to repair damage (to your clothing in the original context) can avoid the necessity to do much more later on, as much as nine times more. The expression captures one of the main findings of the AIACC program of studies. It can simply be stated as the injunction to adapt now.

Climatic variations and extremes cause substantial damages to households, communities, natural resources and economies. In many places the damages are increasing, giving evidence of an adaptation deficit, meaning that practices in use to manage climate hazards are falling short of what can be done (Burton, 2004). We find evidence in all our case study sites of an adaptation deficit that climate change threatens to widen. Climate change threatens to widen the deficit. Acting now to narrow the deficit can yield immediate benefits. It will also serve as a useful, even essential, first step in a longer-term process of adapting to a changing climate. Failure to tackle adaptation vigorously now likely would require many more than nine stitches in the future.

2.2. Create conditions to enable adaptation

In contrast to reducing emissions of the greenhouse gases that drive climate change, a policy that, in the parlance of economists, generates benefits that are substantially external, adaptation generates benefits that are largely internal. This means that the individuals, organizations, communities and countries that take action to adapt will capture for themselves most of the benefits of their actions, creating a strong incentive to adapt. This explains why we observe a wide range of practices being used to manage and reduce climate risks. But why then do we nonetheless observe adaptation deficits? Why doesn't self interest motivate people to do more to protect themselves from climate hazards?

There are numerous obstacles that are found to impede adaptation in our case studies. Common obstacles include competing priorities that place demands on scarce resources, poverty that limits capacity to adapt, lack of knowledge, weak institutions, degraded natural resources, inadequate infrastructure, insufficient financial resources, distorted incentives and poor governance. Obstacles such as these severely constrain what people can and are observed to do. Intervention by public sector entities, at levels from the local community to provincial, national and international can create conditions that better enable people to surmount the obstacles and take actions to help themselves. Enabling the process of adaptation is the most important adaptation that the public sector can make. Specific interventions to enable adaptation are addressed by some of the other lessons that follow.

2.3. Integrate adaptation with development

The goals and methods of climate change adaptation and development are strongly complementary. The impacts of current climate hazards and projected climate change threaten to undermine development achievements and stall progress toward important goals. Adaptation can reduce these threats. In turn, development, if appropriately planned, can help to enable climate change adaptation. Integrating adaptation with development planning and actions can exploit the complementarities to advance both adaptation and development goals. To be effective, integration needs to engage ministries that are responsible for development, finance, economic sectors, land and water management, and provision of public health and other services. It is in agencies such as these that key decisions are taken about the allocation of financial and other resources. And it is within these agencies and among their stakeholders where much of the sector-specific expertise resides that must be engaged.

2.4. Increase awareness and knowledge

Nearly all the case studies highlighted knowledge as a critical constraint on adaptation and rank efforts to increase and communicate knowledge as a high priority for adaptation. Stakeholders in many of the study areas complained of inadequate or lack of access to information about historical climate, projections of future climate change and potential impacts, estimates of climate risks, causes of vulnerability, technologies and measures for managing climate risks, and know-how for implementing new technologies. Uncertainty about the future and about the effectiveness and costs of adaptation options are common obstacles to action. Examination of these and other information problems in the case studies demonstrate the need for programs to help advance, communicate, interpret and apply knowledge for managing climate risks.

2.5. Strengthen institutions

Institutions are found to play important roles for enabling adaptation. Local institutions, including modern organizations, informal associations, kinship networks and traditional institutions, serve functions in communities that help to limit, hedge and spread risks. They do this by sharing knowledge, human and animal labor, equipment and food reserves; mobilizing local resources for community projects and public works; regulating use of land and water; and providing education, marketing, credit, insurance and other services. Provincial, national and international institutions aid by providing extension services, training, improved technologies, public health services, infrastructure to store and distribute water, credit, insurance, financial assistance, disaster relief, scientific information, market forecasts, weather forecasts and other goods and services.

In many of our case study sites, key functions for managing risks are absent or are inadequate due to weak institutions that are poorly resourced, lacking in human capacity, overloaded with multiple responsibilities, and overwhelmed by the demands of the communities that they serve. Strengthening institutions to fill strategic functions in support of adaptation is needed. In some instances, traditional institutions that have been diminished in role by socioeconomic changes and government policies provide a remnant framework that could be revitalized to facilitate adaptation and management of climate risks.

2.6. Protect natural resources

Developing countries typically are dependent on climate sensitive natural resources for a high proportion of their livelihoods, economic activities and national incomes. Too often these resources are in a degraded state from a combination of pressures caused by human use and climatic and environmental variation and change. Their degraded state makes these resources, and the people who are dependent on them, highly vulnerable to damages from climate change. Rehabilitating and protecting natural resources such as farm lands, grazing lands, forests, watersheds, wetlands, fisheries and biodiversity are a central focus of adaptation strategies in places as varied as the African Sahel, southern Africa, central Asia, southeast Asia, and south-eastern South America. Progress in many of these settings will require changes in incentives, reforms of tenure to land, water and natural products, education, training, and more vigorous enforcement of regulations. These in turn are dependent upon strong institutions and access to financial resources.

2.7. Provide financial assistance

Lack of financial resources is commonly cited as a major obstacle to adaptation. The constraint is particularly binding on the poor and the very poor, who typically are among the most vulnerable to climate change. Poor households and small-scale farmers and enterprise owners obtain finance through community and informal networks to recover from losses and make investments that reduce risks. But more adaptation could take place in impoverished localities and regions with greater financial assistance from provincial and national governments and international sources. Innovative ideas are needed for engaging the private sector in financing adaptation. Internationally, some financial assistance is being provided and acts as a catalyst for raising awareness, building capacity and advancing understanding of risks and response options. But the magnitude of financial needs for adaptation is much greater than the current level of assistance. Increased financial assistance over and above normal development assistance is needed. Ultimately, however, financing will need to come from multiple sources, including those internal to developing countries.

2.8. Involve those at risk

Involving persons at risk in the process of adaptation, the intended beneficiaries, can increase the effectiveness of adaptation to climate change. Many of our case studies involved at-risk groups in assessment activities. The experiences demonstrate the potential of participatory approaches to adaptation for focusing attention on risks that are priorities to the vulnerable, learning from risk management practices currently in use, identifying opportunities and obstacles, applying evaluation criteria that are relevant and credible to at-risk groups, drawing upon local knowledge and expertise for selecting and designing appropriate strategies, garnering support and mobilizing local resources and cooperation to assist with implementation. A common result of involving those at risk is that it forces climate risks to be examined in context with other problems and gives emphasis to solutions that can be combined to attain multiple objectives.

2.9. Use place-specific strategies

Adaptation is place-based and requires place-specific strategies. This fact has long been recognized in the climate impacts research literature. The general lessons outlined above conceal a much richer content of the case studies and risk presenting an oversimplified story. The ninth lesson is that there are many more lessons and that many are specific to particular contexts of particular places.

For example, in the lower Mekong River basin, rice farmers face similar risks from floods but rely on different strategies for managing the risks that reflect differences in the level of economic development of their surrounding community, strength of community institutions, locally available natural resources and differences in seasonal rain patterns (Chinvanno et al, 2007). Pastoralists in Mongolia, Sudan and Botswana share some strategies for coping with drought that have general characteristics in common, but there are significant differences too that derive from different traditions, resources and climates (Batimaa et al, 2007; Osman et al, 2007; and Dube et al, 2007). People living in the Caribbean and the highlands surrounding Lake Victoria both face health risks from mosquito-borne diseases that vary with the climate, but differences in public health infrastructure and access to health care contribute to differences in responses to the diseases (Taylor et al, 2007, and Yanda et al, 2007). General lessons can be applied in these different settings to help guide adaptive strategies, but details of the local context will determine the specific approaches and measures that will be most effective in each place.

3. Adaptation Now and in the Future

3.1. What is adaptation?

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects (Smit et al, 2001). It includes adjustments to moderate harm from, or to benefit from, current climate variability as well as anticipated climate change. Adaptation can be a specific action, such as a farmer switching from one crop variety to another that is better suited to anticipated conditions. It can be a systemic change such as diversifying rural livelihoods as a hedge against risks from variability and extremes. It can be an institutional reform such as revising ownership and user rights for land and water to create incentives for better resource management. Adaptation is also a process. The process of adaptation includes learning about risks, evaluating response options, creating the conditions that enable adaptation, mobilizing resources, implementing adaptations, and revising choices with new learning. We mean all these things by adaptation. But the conception of adaptation as a process is often the most important for formulating public interventions that will have lasting benefits..

3.2. Is adaptation new?

Adaptation to climate is not new. People, property, economic activities and environmental resources have always been at risk from climate and people have continually sought ways of adapting, sometimes successfully and sometimes not. The long history of adapting to variations and extremes of climate includes crop diversification, irrigation, construction of water reservoirs and distribution systems, disaster management and insurance, and even includes, on a limited basis, recent measures to adapt to climate change (Adger et al, 2007).

The AIACC case studies document a variety of adaptive practices in use that have reduced vulnerability to climate hazards. In most cases, these have been adopted in response to multiple sources of risk and only rarely to climate risk alone. One strategy commonly in use is to increase the capacity to bear losses by accumulating food surpluses, livestock, financial assets and other assets. Risks are hedged by diversifying crops, income sources, food sources and locations of production activities. Exposure to climate hazards has been reduced by relocating, either temporarily or permanently. Variability of production and incomes derived from natural resources have been reduced by restoring degraded lands, using drought resistant seed varieties, harvesting rainfall, adopting irrigation and using seasonal forecasts to optimize farm management. Prevention of climate impacts with flood control, building standards and early warning systems is practiced. Risk spreading is accomplished through kinship networks, pooled community funds, insurance and disaster relief. In many cases the capacity to adapt is increased through public sector assistance such as extension services, education, community development projects, and access to subsidized credit.

3.3. Is adapting to climate change different?

Is adapting to climate change different? Yes and no. Coping with and adapting to climate have always faced an uncertain future. Human societies have long coped with floods, droughts and other climate hazards without knowing when the next event would occur, how big it would be or how long it would last. Past experience provided a basis, albeit imperfect, for approximating the frequencies of events of different magnitudes and the likely range of conditions that might be encountered in the coming season, year or decade.

But climate change means that past performance of the climate is becoming a less reliable predictor of future performance. The frequency, variability, seasonal patterns and characteristics of climate events and phenomena will change. Phenomena once alien to a region could become regular features of its climate (for example, extra-tropical storm tracks are projected to move poleward, IPCC, 2007). An important consequence of climate change for adaptation is that the future climate will be less familiar and in key respects more uncertain.

Another important difference is that some climate parameters will change with predictable trends as a result of human-driven climate change. Globally averaged surface temperatures are projected to rise 1.1-6.4^{o}C by end of the 21st century relative to 1980-1999 temperatures (IPCC, 2007). Annual and monthly average temperatures can be expected to increase virtually everywhere with a very high degree of confidence. Trends in average precipitation are also projected but vary from decreases to increases depending on location and season. Confidence in predictions of precipitation trends is less than for temperature trends. However, some broad patterns do seem to be robust across climate model projections. For example, precipitation is very likely to increase in high-latitudes while decreases are thought likely in most subtropical land areas. Likely trends for extreme weather include more frequent hot days, heat waves and heavy precipitation events, more intense tropical cyclones with greater peak wind speeds and heavier precipitation, and increased summer drying and drought risk in continental interiors. The projected trends in temperature, precipitation, and extremes will push future climate variations and extremes beyond the bounds of what people and places have been exposed to and had to cope with in the past.

The implication is that current practices, processes, systems and infrastructure that are more or less adapted to the present climate will become increasingly inappropriate and maladapted as the climate changes. Fine tuning current strategies to reduce risks from historically observed climate hazards will not be sufficient in this dynamically changing environment. More fundamental adjustments will be needed. This will require recognizing what changes are happening, predicting the range of likely future changes, understanding the vulnerabilities and potential impacts, identifying appropriate adjustments, and mobilizing the resources and will to implement them.

The experience of Argentina in the last decades of the 20th century are instructive of some of the challenges (Barros, 2007). A number of climate trends are documented that began in the 1960s and 1970s. These include large increases in mean annual precipitation in southern South America east of the Andes Cordillera; increased flows and flood frequencies of the major rivers of the region, the Parana, Paraguay and Uruguay Rivers; more frequent heavy rainfall events in central and eastern Argentina resulting in localized flooding; more frequent *sudestadas* which bring winds from the southeast that cause high tides and flooding in Buenos Aires; and, in western Argentina, declining rainfall and stream flows.

The speed and effectiveness of adaptive responses to these trends varied. In each case there was a lag between the onset of the climate trend and recognition by affected persons, government agencies and the public. The lag varied depending on the perception of impacts, their magnitude, natural variability of the climate phenomenon, adequacy of observational data, and the difficulty of detecting trends in low frequency events. In all cases recognition was not immediate and the shortest lag time was roughly ten years. The quickest response came in the case of increased rainfall east of the Andes but west of the traditional crop farming areas. Farmers recognized and acted on the new opportunity created by the greater rainfall, as well as by high soybean prices in international markets, to profitably cultivate lands that were previously too dry for crop farming. This resulted in significant westward expansion of crop farming, particularly of soybeans. Less quick to act was the government, which failed to provide road and other infrastructure to support the westward expansion of crop farming.

Usually emphasis is placed on uncertainty of predicted climate change as a barrier to adaptation. Less appreciated is the barrier created by uncertainty in detecting changes that are already underway and likely to continue. The examples from Argentina demonstrate how delays in recognition and limited awareness of climate trends by key stakeholders delayed adaptive responses. They also suggest that those who have a direct self-interest in adapting may be more astute and quicker to respond.

Biodiversity conservation in southern Africa is an example where climate change will require a fundamental change in approach from current risk management (von Maltitz et al, 2007). In 50 years time, up to half of South Africa will have a climate that is not currently found in that country. With the changes, many species will need to move across the landscape to track climates that are suitable to their requirements. It will no longer be adequate to protect species where they are currently found – conservationists will have to aim for a moving target.

Some species will be able to tolerate the new climate in their current locations (persisters); some will thrive in new climate niches not currently available and expand their ranges (range expanders); some will no longer be viable in part or all of their current range and must disperse to new areas (partial and obligatory dispersers); and some will find no areas with suitable climate and will go extinct from the region (no hopers). Modelling of climate change impacts on *Proteaceae,* a surrogate for the highly diverse fynbos vegetation of South Africa, yields estimates that in 50 years 57 per cent of species would be persisters, 26 per cent partial dispersers, 6 per cent obligatory dispersers, and 11 per cent would be no hopers.

The no-hopers can be preserved only by *ex situ* conservation methods. Migration of the obligatory and partial dispersers over a mixed use, fragmented landscape to track a changing climate is not assured. And successful dispersal 50 years from now does not assure long-term survival, as the climate will continue to change. Multiple strategies will be needed to facilitate migration and minimize species loss. Adding to and reconfiguring land reserves are one element that will be needed, but it is a costly approach and the lands needing protection are a moving target. New and more aggressive strategies will be needed to make the landscape more permeable and biodiversity friendly, including private and communal lands that are not in formal reserves.

The terminology from the field of biodiversity conservation, obligatory dispersers and no-hopers, is stark. But are there analogous cases in other contexts? Will climate change make inhabitants of some small islands, coastal areas, and arid zones partial or obligatory dispersers? Is the hope for survival of some small island nation states and their cultures dependent on *ex situ* conservation? Do some livelihoods have no hope of persistence in a changing, more hazardous climate? The methods of adaptation to climate change will often be similar to, borrow heavily from and build upon current adaptation practice. But as these questions suggest, the challenges and stakes are getting higher.

3.4. Is current adaptation enough?

Adaptation to climate variation is a regular feature of our lives and, broadly speaking, we are adapted to cope with a wide range of climatic conditions. Indicators of successful adaptation include the increase in world food production in pace with population growth, increased life expectancy and decreased weather related deaths in developed countries (Schneider et al, 2007, and McMichael et al, 2001).

But variations and extremes do regularly exceed coping ranges, too often with devastating effect. Natural hazards, including weather related hazards, result in an average of more than 184 recorded deaths per day (Pelling et al, 2004). During the period 1980-2000, deaths from tropical cyclones, floods and droughts exceeded 250,000, 170,000 and 830,000, respectively, with the overwhelming majority of these deaths occurring in developing countries. Individual events can cause billions of dollars in damages. Economic and insured losses from natural catastrophes have increased more than 6-fold and 24-fold respectively since the 1960s (Munich Re, 2005).

While climate impacts can never be reduced to zero, the heavy toll of weather-related disasters and burden of less severe variations indicate that we are not as well adapted as we might or should be. All of the AIACC case studies give evidence of an adaptation deficit and identify measures that could reduce current losses. For example, greater reforestation efforts and enforcement of forest protection laws would reduce soil erosion and flood risks in the Pantabangan-Caranglan watershed of the Philippines (Lasco et al, 2007). In the Berg River basin of South Africa, allowing greater flexibility for water transfers or water marketing

would enable water to be allocated more efficiently during periods of drought (Callaway et al, 2007). A variety of underutilized options for reducing drought and flood risks are available to farmers in Argentina, Botswana, Cambodia, Egypt, Lao PDR, Mexico, Nigeria, Sudan, Thailand and Tunisia (Barros, 2007; Dube et al, 2007; Chinvanno et al, 2007; Mougou et al, 2007; Wehbe et al, 2007; Dabi et al, 2007; and Osman et al, 2007). In Jamaica, management of dengue fever risks are largely reactive and could be improved by proactive steps for education, elimination of breeding sites, and early warnings (Taylor et al, 2007). Building sturdier houses raised above ground level, improved control of river siltation and more regular dredging of rivers would reduce flood losses in coastal towns of Fiji (Mataki et al, 2007).

The current deficit in adaptation makes it imperative to adapt now. Doing so would have immediate benefits in reduced weather-related impacts and increased human welfare. The need to adapt is made more urgent by climate change, which is now upon us and is widening the deficit. Adapting to current climate is an essential step towards adapting to future climates.

3.5. What are the obstacles to adaptation?

People may not adapt, or adapt incompletely, for a variety of reasons. Climate may be perceived, rightly or wrongly depending on the context, to pose little risk relative to other hazards and therefore given low priority. Knowledge of options to reduce climate risks or the means to implement them may be lacking. Or their expected costs may exceed the expected benefits. The means or capacity to adapt may be lacking. Uncertainty about the future may make it difficult to know what to do or when to do it. Irreversible consequences of some actions may delay choices until some of the uncertainty is resolved. Incentives may be distorted in ways that discourage choices that reduce risks, or even encourage riskier choices. Sometimes the action of others, or inaction of others, can be an obstacle. Some may believe that reducing their own risk is the responsibility of others. All these are found to impede adaptation in one or more of the case studies.

The AIACC studies are all set in developing countries and most focus on places and households that are poor. Poverty, in human development as well as economic terms, is a major obstacle to adaptation in these study areas. Indicative of the constraint imposed by poverty is the high proportion of households in East Africa that do not use insecticide treated bed nets as a prevention against malaria, despite their effectiveness and seemingly low cost (Yanda et al, 2007).

The case studies of northern Nigeria (Dabi et al, 2007) and the states of North Kordafan, North Darfur and Red Sea in Sudan (Osman et al, 2007) are illustrative of the constraints faced by poor rural households. Households in their study areas, located in the dry and drought prone Sudano-Sahel zone, typically have low capacity to adapt because of very limited financial, natural, physical, human and social capital. They have little or no cash income, financial savings or access to credit with which to purchase seed, fertilizer, equipment, livestock or food. The lands from which they derive their livelihoods have poor fertility, are highly erodable and are degraded from heavy use, clearing of vegetation, declines in average precipitation and increasing frequency of drought. Physical infrastructure for transportation, communication, water supply, sanitation, and other services are lacking. People have knowledge of many traditional practices for coping with drought and other stresses, but often have little knowledge of new or alternate methods due to poor access to education, training or extension services. Kinship networks provide a safety net for food and other necessities in times of crisis, but sometimes a crisis such as drought or violence will strike many members of a network simultaneously. Local institutions for providing community services are generally weak, governance at provincial and national levels is ineffective, and violence and conflict have heightened vulnerability – with devastating impact in Darfur.

Lack of awareness, information and knowledge is a constraint on adaptation in all of the case studies. In Argentina, as noted previously, lags in recognition of climate trends that had begun in the 1960s and 1970s resulted in delayed and incomplete adaptive responses (Barros, 2007). Tunisian farmers are reluctant to change from inherited traditional practices because they lack knowledge and education to evaluate and implement new methods (Mougou et al, 2007). Similarly, in Tamaulipas, Mexico, *ejidatarios* and

smallholder farmers lack know-how for adopting irrigation (Wehbe et al, 2007). In Mongolia, herders voiced a strong need for education and training in methods for improving the condition and productivity of their rangelands and livestock (Batimaa et al, 2007). Participants in the artisanal fishery of the La Plata estuary need better information about the effects of variations in climate on movements of fish stocks and fish catch, forecasts of fishing conditions, and fishing methods and technologies for managing variability in the fishery (Nagy et al, 2007).

Seasonal weather forecasts and early warning systems are frequently suggested as useful for informing the management of climate risks. But, as shown by Adejuwon et al (2007), they require an effective knowledge network to deliver their promised benefits. Seasonal forecasts are made for West Africa and Nigeria, but few farmers use them. Their reliability is low, the variables forecast are not ones that are most relevant to farmers' decisions, and the spatial resolution of the forecasts is coarse compared to what farmers' need. The forecasts are poorly disseminated, are delivered only shortly in advance of the forecast period, do not regularly reach smallholder farmers, and are in forms that are not readily understood by farmers.

A number of steps can be taken to improve this knowledge network so that farmers are provided with forecasts that they would use. Agricultural extension agents, working with both farmers and forecasters, could help forecasters to focus on the climate variables and spatial resolutions that matter to farmers and provide feedback from farmers to the forecasters about the performance and utility of the forecasts. The extension agents, who are based in over 700 local government units and work in local languages, could develop methods for communicating forecasts to farmers in ways that are useful and understandable. They could assist farmers to interpret and apply forecasts for making decisions such as the timing of planting, choice of crops and crop varieties, and application of fertilizers, herbicides, pesticides and irrigation water. Success will be dependent on cooperation and coordination across the regional and national meteorological agencies, agricultural extension agency, local government units, and farmers' associations, which may require changes in responsibilities, accountability and incentives.

Scarce and degraded natural resources contribute to vulnerability and detract from the capacity to adapt in many of the case studies. Insufficient water supplies, and poor quality of existing supplies, prevent Tunisian farmers from expanding irrigation (Mougou et al, 2007). In some instances, treatment of a resource as an open access commons has contributed to its degradation and created disincentives for adaptations to protect the resource. Following the transition to a market economy in Mongolia, livestock ownership was privatized while pastureland remained state owned and access largely unrestricted (Batimaa et al, 2007). This has contributed to overstocking of animals, diminished seasonal migration of herds, and lack of investment in land improvements. This situation contrasts with earlier periods during which state collectives, and before that traditional family groups, controlled access to communal pastures.

Social capital, an important resource for coping with risk, has been eroded in many places by social and economic changes and by government policies. In the Limpopo Basin of eastern Botswana, the *Kgotla*, or traditional institution for local decision making and administration of justice, played a central role in adapting the local community to climate variability by regulating resource use and maintaining and disseminating traditional knowledge for the use of veld products (Dube et al, 2007). The *mafisa* system of lending cattle to poorer family members, the marriage institution and family-based user rights to land provided social security and income security that limited risks from climate extremes and other crises. These institutions were weakened during the 20th century, with the result that communities were alienated from decision making about local resource use, income poverty and capability poverty were deepened, and dependence on government interventions increased. This loss of social capital has reduced the capacity of communities to adapt and amplified their vulnerability to climate hazards.

Governance can either constrain or enable adaptation. Financial constraints, already mentioned for households, is one factor that prevents governance from playing a more positive role. Government agencies are often poorly resourced relative to the demands placed on them. Other impediments to government support for adaptation include lack of awareness, knowledge and staff with relevant skills, ineffective administration, poor coordination across departments, inadequate accountability and corruption. Also important is that persons who are most vulnerable to climate risks are often socially and politically marginalized and therefore unable to influence governments to act in their interest.

4. Climate and Development

4.1. What are the impacts of climate on development?

Weather-related disasters take lives, damage infrastructure and natural resources, and disrupt economic activities. Billions of people are exposed to natural disaster risk in more than 100 countries and more than 1 million people were killed by drought, tropical cyclones and floods during the period 1980-2000 (Pelling et al, 2004). Roughly 90 per cent of disaster victims live in developing countries. Economic losses from natural catastrophes are estimated to be US$575 billion over the period 1996-2005, with record losses of US$210 billion reported in 2005 (Munich Re, 2005). In the aftermath of disasters, human development in the impacted communities and wider region is setback and can take years to recover from the loss of housing, businesses, roads, water systems, schools, hospitals, farm fields and livestock. Events such as Hurricanes Mitchell, George and Katrina can cause economic losses that are a significant percentage of national or regional income. Repairing the damage can divert scarce capital from new development projects. Recurrent climate anomalies that do not rise to the level of natural disasters also adversely affect supplies of food and water, incomes, livelihoods, and health and place a drag on economic development.

The projected changes in climate, which include changes in average temperatures and rainfall as well as changes in climate extremes, will have wide ranging impacts. At risk from the projected changes are the productivity of agricultural lands, natural ecosystems and the livelihoods that are dependent on them. Also at risk are water supplies, human health and populations inhabiting low lying coasts, floodplains, steep slopes and other exposed locations (McCarthy et al, 2001). The AIACC case studies illustrate these and other climate risks at national and local scales in a variety of developing country contexts. Not all impacts will be negative. For example, a number of studies, including Travasso et al (2007), find that climate change and higher concentrations of carbon dioxide in the atmosphere are likely to increase yields of important crops in parts of South America. But most studies find that impacts will be predominantly negative in developing regions of the world (McCarthy et al, 2001).

Current climate hazards and the impacts of projected climate change threaten human development (African Development Bank et al, 2003). Climate is linked to all the Millennium Development Goals, but is most directly relevant to the goals to eradicate extreme poverty and hunger, reduce child mortality, combat disease, and ensure environmental sustainability (Martin-Hurtado et al, 2002). Agriculture, which is highly sensitive to climate and which is projected to be negatively impacted by climate change in much of the tropics and sub-tropics, is the direct or indirect source of livelihood for about two-thirds of the population of developing countries and is a substantial contributor to their national incomes. About 70% of the world's poor live in rural areas. Progress on all the Millennium Development Goals will be dependent upon progress in agricultural development and rural development. Management of climate hazards and climate change impacts in the agriculture sector and rural communities will be critical for success.

4.2. How does development affect vulnerability to climate?

There is a clear link between development level and vulnerability to climate and other natural hazards. Disaster risk is significantly lower in high income countries than in medium and low income countries. Countries classified as having high human development represent 15 per cent of the population that was exposed to natural disasters in 1980-2000 but account for only 1.8 per cent of the deaths (Pelling et al, 2004). In comparison, countries with low human development represent 11 percent of the exposed population but account for 53 per cent of the recorded deaths.

The association of poverty and low levels of development with high levels of vulnerability are borne out in the AIACC studies. Failures of development to raise people out of poverty causes people to occupy highly

marginal lands for farming and grazing, settle in areas susceptible to floods and mudslides, and live with precarious access to water, health care and other services. These conditions contribute to the high degree of vulnerability found among the rural poor of Botswana, Nigeria, Sudan, Thailand, Lao PDR, Vietnam, the Philippines, Argentina and Mexico. Squatter communities in Jamaica and the Philippines are more vulnerable than other communities because of lack infrastructure, access to basic services and social institutions to support collective efforts for reducing risks (Taylor et al, 2007, and Lasco et al, 2007).

Although much of the world continues to live in poverty and at high risk from hunger and disease, human development has greatly reduced vulnerability to climate-driven risks by increasing agricultural productivity, food production and trade, water storage and distribution systems, housing quality, transportation networks, health care, education and wealth. The Millennium Development Goals have set a challenge to expand the benefits of development to include those who continue to live in deep poverty. Moving forward, development that is focused on the poor can reduce vulnerability to climate and other stresses by improving the conditions and capacities of poor households, communities and countries so that they are more resilient to shocks and more capable of responding and adapting. If based on sound principles of resource management, development can improve resource-based rural livelihoods so that they are less sensitive to climate variations and more sustainable.

Development can, however, exacerbate pressures that add to the vulnerability of some. Past practice has given scant consideration to climate risks in planning development projects, resulting in greater vulnerability than what otherwise could have been achieved, even increasing vulnerability in some instances through maladaptive choices (Burton and van Aalst, 2004).

The uneven effects of development can also contribute to vulnerability. Trade liberalization has brought general increases in economic activity, lower prices, and greater overall wealth, but the benefits are unevenly distributed and some have suffered harm. Smallholder farmers and livestock raisers in Argentina and Mexico have struggled to compete as output prices fell relative to the costs of inputs, making them more vulnerable to climate shocks (Wehbe et al, 2007). Falling rice prices from greater productivity in Asia and liberalized trade caused rice farming to be abandoned in Navua, Fiji. The resulting loss of incomes and lack of maintenance of abandoned irrigation channels have raised vulnerability of inhabitants of the township to flood hazards (Mataki et al, 2007).

Development in the Heihe River basin of China has brought greater livelihood opportunities and incomes, but has also increased water demand in this arid basin to the point where water withdrawals are 80 to 120 per cent of average annual flows and conflicts have arisen between competing water users (Yin et al, 2007). Social and economic changes have driven rural-to-urban migrations, often concentrating poorer migrants in settlements that are prone to flooding, as is happening on the outskirts of metropolitan Buenos Aires (Barros, 2007). Increasing market orientation, movements of population and government policies have weakened community institutions and diminished use of collective strategies for managing climate risks in places such as Botswana (Dube et al, 2007), countries of the lower Mekong (Chinvanno et al, 2007), Mongolia (Batimaa et al, 2007), and Sudan (Osman et al, 2007). Development projects intended to benefit one group can have spillover effects that harm others, as is the case with the Khor Arbaat dam that is helping to solve water shortage problems in Port Sudan but at the expense of downstream traditional farmers who rely on the intermittent flow of seasonal streams (Osman et al, 2007).

4.3. Integrating adaptation with development

Sometimes climate change adaptation is seen as competing with the human and economic development needs of the world's poor. Development needs are immediate, the consequences of poverty in countries with low development are appalling, progress is less than desired and allocated resources too little. In comparison, climate change can be perceived as a problem distant in time, uncertain in its effects, and less consequential than present day poverty. Adaptation may therefore seem less urgent and less compelling than increasing development efforts for the world's poor. But, as argued above, climate hazards are

immediate, they are growing, they threaten the quality of life and life itself, and they directly impact on the goals of development.

In balancing needs for climate adaptation with those of development, it is critical to note that there is strong complementarity between their goals and methods. A society that is made more climate resilient through proactive adaptation to climate variations, extremes and changes is one in which development achievements and prospects are less threatened by climate hazards and therefore more sustainable. Development can repay the complement by creating conditions that better enable adaptation. This complementarity implies that integration of adaptation efforts with development can yield synergistic efficiencies and benefits that advance the goals of both agendas. This is not to deny that tradeoffs and hard choices may be required. That is the reality of pursuing multiple goals with limited resources. But there are sufficient complementarities to make integration a workable and desirable strategy.

Adaptation activities carried out in isolation from mainstream development and the functions of authorities responsible for managing economic sectors and natural resources may be pragmatic in some contexts. It can help raise awareness, allow experimentation with different methods, and provide proof of concept. But adaptation as a standalone function that is implemented by climate change experts will fail to mobilize the resources and engage the full range of actors that are necessary for success. To create a climate resilient society, adaptation as a process needs to be integrated into the processes of policy formulation, planning, program management, project design and project implementation of the agencies that are responsible for human and economic development, finance, agriculture, forestry, land use, land conservation, biodiversity conservation, water, energy, public health, transportation, housing, disaster management and other sectors and activities.

At the most basic level, integration would avoid maladaptive actions by development and other agencies that fail to account for climate-related risks and thereby unintentionally increase risks or miss easy opportunities to reduce risks. This could be achieved by subjecting policies, programs and projects to initial scrutiny for exposure to climate risks and modifying them accordingly, similar to assessments that are done for environmental impacts, gender equality and poverty reduction. A further step toward integration would be for public sector agencies to promote and support actions and behaviours by individuals, the private sector and civil society that would narrow the current adaptation deficit. Yet more ambitious, but ultimately essential, are development strategies that proactively create conditions to enable adaptation processes by enhancing the capacities of individuals, strengthening community institutions, removing obstacles and providing appropriate incentives.

Many of the AIACC studies demonstrate the need for comprehensive approaches to adaptation that are integrated with broader development strategies and examine how this might be done. They highlight several characteristics of development that would be complementary to the goals of adaptation. These include development that targets highly vulnerable populations, diversifies economic activities, expands opportunities for livelihoods that are less climate sensitive, improves natural resource management, encourages the development and diffusion of technologies that are robust across a wide range of climate variations and extremes, directs development away from highly hazardous locations toward less hazardous ones, and invests in expanding knowledge that is relevant to reducing climate risks.

An examination by Osman et al (2007) of community development efforts in Sudanese villages of Bara Province in North Kordafan, El Fashir in North Darfur and Arbaat in the Red Sea State demonstrate that development and adaptation to climate risks can be strongly complementary. Community development projects implemented in the villages integrated multiple strategies to improve livelihoods, the quality of life, and sustainability of resource use within a context of recurrent drought. Using measures of changes in household livelihood assets (human, physical, natural, social and financial capital), the holistic approach to development taken in the study areas are found to have succeeded in increasing the capacity of households to cope with the impacts of drought. Community participation in the projects and reliance on indigenous technologies for improving cultivation, rangeland rehabilitation and water management that are familiar to the communities are found to be important factors for success. The sustainable livelihood approach appears to be a viable model for integrating development and adaptation to climate hazards at the community scale.

Rice farmers in Thailand, Vietnam and Lao PDR rely primarily on their own capacity to implement strategies for coping with floods and mid-season dry spells, which is strongly limited by the social and economic conditions and natural resources in the surrounding community (Chinvanno et al, 2007). Once prevalent collective strategies to pool resources within their communities and provide buffers against food and income losses are much diminished, though still important in Lao PDR. National policies are in general not supportive of reducing the vulnerability of small rice farmers to climate hazards. A national strategy to integrate climate risk management with rural development, poverty reduction and farm policies is recommended for raising the capacity and resilience of farm households and rural communities. Opportunities for effective interventions by national governments include assisting farm households with financial resources, expanding off-farm income opportunities, marketing of farm products, improving access to water, protecting the natural resource base, developing and promoting new technologies to diversify farm incomes, improving seed varieties and providing information about current and changing climate hazards. Revitalizing community institutions is seen as important for enabling communities to benefit from national interventions.

An approach to integrating adaptation and development that is being embraced by Pacific Island Countries such as Fiji also combines top-down and bottom-up strategies (Mataki et al, 2007). Top-down actions would be taken by the national government to create incentives, enforce regulations, assist with capital financing and implement large projects that are beyond the means of local authorities to create a climate-proof society. These actions would encourage and enable development and settlement away from hazardous locations, building of flood-proof homes, purchase of insurance, better land-use practices, and river dredging and maintenance of irrigation channels and floodgates to control flooding. Bottom-up actions would draw on communal traditions of Pacific Island societies to engage members of the community to pool financial, human capital and other local resources and channel these in efforts to reduce climate related risks. The current political framework in Fiji does not provide an effective means for local communities to make their concerns felt at the national level and there is lack of communication and coordination across government departments. These obstacles will need to be overcome for the combined top-down and bottom-up integration to be effective.

5. Evaluating adaptation options

5.1. What to do, how much, when?

Adaptation decisions are made in a context of uncertainty and change. While we can be confident that the climate will change in response to greenhouse gas forcing, there is uncertainty about how it will change and how fast, particularly at the spatial scales that are relevant for adaptation. The impacts are also uncertain, partly because the changes in climate are uncertain, partly because the sensitivities of systems to climate stresses are uncertain, and partly because there is uncertainty about future demographic, social, economic, technological and governance conditions that will shape future exposures, sensitivities, capacities and vulnerabilities. There is also uncertainty about the potential performance of different adaptation options, their costs and possible unintended consequences.

Uncertainty makes it difficult to decide what to do, how much of it to do and when to do it. Many of the choices will have irreversible consequences, so choosing wrong can be costly, even deadly. This is just as true for deciding not to adapt, or to delay adapting, as it is for deciding to adapt now. Delaying adaptation will result in irreversible consequences that could be avoided by adapting now. But not all adaptations could or should be implemented now. Which are appropriate for immediate or near-term action and which should be delayed?

A number of factors are relevant to the selection of options for immediate action. These include the timing of benefits, the dependence of benefits upon specific climate conditions, irreversible consequences, option values, and thresholds for adverse impacts (Leary 1999). Characteristics of adaptation measutes that warrant consideration for early action include expectation of significant near-term benefits (for example in

narrowing existing adaptation deficits), performance that would produce benefits under a wide range of possible future climates, low capital costs, and minimal irreversible consequences. Also of interest for early implementation are actions that would preserve or expand options for future adaptation (for example purchase of development easements and capacity building), or counteract looming thresholds for adverse impacts (for example facilitated migration of species that are obligatory dispersers). Characteristics that would suggest delay of some actions while uncertainties are resolved include little near term benefit, future benefits that depend upon a narrow range of climate conditions, high capital costs and large irreversible consequences.

5.2. Evaluation of options by AIACC studies

Decision-making criteria for evaluating and selecting adaptation options vary from context to context. Criteria can vary depending upon who is making the decision, what stakeholders are affected by the decision, what role stakeholders have in the decision process, the objectives of decision makers and stakeholders, and characteristics of the decision such as the time horizon, uncertainty about outcomes, irreversibility of consequences and consequences of decision errors. Criteria applied in the AIACC studies include net economic benefit, timing of benefits, distribution of benefits, consistency with development objectives, consistency with other government policies, cost, environmental impacts, spill-over effects, capacity to implement and social, economic and technological barriers. In some cases the criteria are chosen by the investigators, in other cases they are chosen by stakeholders or based upon stakeholder input. Methods for their application include formal benefit-cost and multi-criteria analysis, expert judgment and participatory exercises with selected stakeholders.

Callaway et al (2007) apply formal benefit-cost analysis to decisions about building water storage and switching water allocation regimes for the Berg River basin in South Africa. The net benefits from choices of reservoir capacity are uncertain and vary depending on how the future unfolds with respect to climate, growth in water demand, and reliance on either the current regulatory regime or water markets for allocating water. The climate scenarios analyzed include no change in surface water runoff and reductions of either 11 or 22 per cent. Under the current regulatory regime for water allocation and water demand growth of 3 per cent per year, climate change would cause estimated damages with a present discounted value of 13.4 billion to 27.6 billion Rand, or roughly 15 to 30 per cent of the total net benefits of water use in the basin. Adapting by correctly anticipating and adjusting reservoir capacity to the optimal size corresponding to the change in climate would reduce the damages and yield net benefits, but the net benefits are modest and less than 2 per cent of the damages. In contrast, a switch from the current regulatory regime to allocation by water markets would yield net benefits of roughly 10 to 20 per cent by allowing efficient reallocation of scarce water.

Njie et al (2007) also apply benefit-cost analysis to evaluate adaptations to climate change. They investigate increased use of fertilizers and adoption of irrigation for growing cereals in the uplands of The Gambia. Climate change would cause estimated annual damages to cereal production of roughly US$150 million in 2010-2039 and in excess of US$1 billion in 2070-2079. Increased use of fertilizers would yield net benefits that would reduce climate change damages by 10 per cent or more. Irrigation, however, is found to yield negative net benefits in the 2010-2039 time frame and mixed results in the more distant future. For cereal production, the high cost of pump irrigation relative to cereal prices make irrigation an inefficient adaptation, at least in the near to medium-term.

Yin et al (2007) apply an analytic hierarchy process, a form of multi-criteria analysis, to evaluate adaptation options for the water sector in the Heihe River basin of north-western China. Stakeholder meetings and surveys were used to elicit judgments about the effectiveness of different options with respect to four decision criteria and the relative importance of the criteria. The criteria include water use efficiency, economic returns to water use, environmental effects and cost. The results rank intuitional options above engineering measures to increase water supply. Preferred options include economic reforms that would constrain sectors that are large water consumers, water user associations to share information and promote water conservation and transferable water permits for allocating water use.

Lasco et al (2007) perform a tradeoff analysis of effects of adaptations in one sector that spillover and impact other sectors in the Pantabangan-Caranglan watershed of the Philippines. Options are identified and examined for agro-forestry, water resources, and local communities. They find that spillovers are common because the shared water resource creates a high degree of interdependence among people, livelihoods, and biophysical resources located within the watershed. The spillovers include both positive as well as negative externalities. For example, many of the options identified for agro-forestry such as improving water use efficiency and controlling runoff and erosion have beneficial effects on the water sector and on local community institutions. But stricter enforcement of forest protection laws and reforestation to protect water resources can negatively affect incomes and livelihoods of some landowners and cause farmers in informal settlements with insecure land tenure to be forced from their farms. They find that these types of tradeoffs are seldom considered in planning new projects or revising policies, risking negative impacts on others, conflicts among stakeholders in the watershed, and missed opportunities for mutually beneficial actions.

In Mongolia, evaluation of adaptation options for the livestock sector applied a two-tiered screening process with participation from herders, scientific experts and authorities from local, provincial and national offices (Batimaa et al, 2007). In the first tier, options are screened for satisfying broad criteria for promoting both adaptation and development goals, consistency with government policies, and environmental impacts. Options that pass the first screening are then evaluated against a second tier of six additional criteria. These include capacity to implement, importance of climate as a source of risk, near-term benefits, long-term benefits, cost and barriers. Adaptation strategies that emerge as priorities from this process include measures that generate near-term benefits by improving capabilities for reducing the impacts of drought and hash winters as well as measures that produce long-term benefits by improving and sustaining pasture yields. Some of the specific measures identified as warranting further consideration include improving pastures by reviving the traditional system of seasonal movement of herds; increasing animals' capacity to survive winters by modifying grazing schedules, and increasing use of supplemental feeds; enhancing rural livelihoods by strengthening community institutions to regulate use of pasture and provide local services such as education, training, access to credit and insurance; and research and monitoring to develop and improve forecasting and warning systems.

In the study of dengue fever in the Caribbean, the investigators evaluate adaptation options for cost, effectiveness, social acceptability, environmental friendliness, promotion of local cooperation, and technical/socioeconomic challenges (Taylor et al, 2007). Three options of multiple measures are recommended based on these criteria. The first option would refocus current education, disease surveillance and vector control efforts to be more proactive and to address deficiencies in community involvement. Emphasis would be placed on education that stresses individual responsibility and community benefits of measures to reduce human-vector contact. The second option would combine the above measures with designing, producing and promoting the use of low-cost covered containers for storing rainwater. Discarded and uncovered oil drums are the most commonly used means of capturing and storing water and are ideal breeding sites for mosquitoes. The third option would include all the above plus development and implementation of an early warning system. Early warnings to give advance knowledge of the expected severity of possible disease outbreaks would enable responses to be calibrated to the anticipated threat level. Responses to an alert would include more frequent and extensive vector surveillance and control, stepped up education efforts tailored to the threat level, and more diligent efforts to eliminate breeding sites for mosquitoes.

6. Creating an Enabling Environment.

Many studies, including our own, identify numerous options for adapting to existing and changing climate hazards. Some are novel and untested, but many are based on current practices that are amply demonstrated to reduce risks. As we noted earlier, individuals, communities and nations all have a strong self-interest in adapting. Yet many options go unused, or are used much less extensively or intensively than their benefits would seem to warrant.

It is not for lack of options that adaptation lags. It is lack of determination, lack of cooperation and lack of means that impede adaptation. Deliberate and sustained efforts are needed to create an enabling environment for overcoming these obstacles and facilitating the process of adaptation. The efforts need to engage people, stakeholders and authorities from the many different economic sectors and spheres of activity that are affected by climate and should to link across local, provincial, national and international scales.

6.1. Creating the determination to adapt

A primary obstacle is a lack of will, or determination, to adapt. This can happen at the individual level (people failing to take simple actions to limit their own exposure to malaria and dengue), the community level (local authorities allowing new development in hazardous locations), the national level (ministries failing to consider climate risks in new programs and not being held accountable), and international (adaptation continuing to receive strong rhetorical support from international environmental and development communities but few resources).

The reasons for lack of will are varied. One is a problem of awareness and understanding. People lack knowledge about, or are uncertain or sceptical about, current climate risks, climate change, options for adaptation and the effectiveness, feasibility and cost of adaptation. Another important reason is that people have other objectives that compete with adaptation for attention, priority and resources. In essence, determination to adapt will not gain acceptance unless people find the evidence compelling that climate risks represent a substantial problem, that addressing the risks warrants priority on par with other objectives, that there are effective, feasible and affordable options and that we know enough to make wise choices.

Greater awareness and knowledge can help to create the determination to adapt. But it is not enough to simply create more knowledge. It needs to get into the hands, or the heads, of people facing decisions about how to allocate scarce resources to achieve their objectives, objectives that include, but are not limited to, reducing risks from climate and other sources. The knowledge needs to be relevant to the decisions being made and understandable to stakeholders and decision makers, who might be residents of hazardous places, resource users and owners, farmers, business operators, community leaders, or government officials. The knowledge also has to be seen as credible and untainted by bias or intent to manipulate.

The different types of knowledge, intended users and functions of knowledge creation, collection, communication, integration and interpretation are generally too many and varied to be done well by a single entity. Networks of knowledge institutions are needed that link between the scientist, practitioner and public; across economic sectors; and from local to national and international actors. In each of the AIACC study areas, knowledge networks are very incomplete and not well coordinated, resulting in substantial gaps in the awareness and understanding of climate hazards, climate change and adaptation among many key stakeholders.

This situation can be improved by strengthening knowledge networks. Investments are needed in scientific research, assessment and capacity in areas that are relevant to understanding climate risks and response options. Expanded efforts are needed to collect knowledge from the experiences and practices of at risk groups, including traditional knowledge. Mechanisms are needed to integrate, interpret and communicate the created and collected knowledge and to assist stakeholders to apply the knowledge in decision-making. Avenues are needed for stakeholders to give feedback about the information received and the information required, as well as to share their knowledge.

Participatory processes that engage stakeholders and attempt to link the different functions and components of knowledge networks can be effective at generating and communicating knowledge that is relevant, understandable and credible. The AIACC project is one example of such a process and similar projects have been initiated and are underway. Ultimately though, the generation and communication of knowledge

for supporting adaptation needs to be connected with and embedded in ongoing processes of human development, economic planning, poverty reduction and resource management.

6.2. Creating cooperation to adapt

What any one person or organization can do to adapt is very much constrained by what others do or don't do. Cooperation among members of a community can mobilize resources to reduce, hedge and spread risks beyond what individuals acting independently might achieve. Cooperation between local and national authorities can rationalize policies and plans so that they work toward common adaptation goals and not at cross-purposes. Cooperation among stakeholders and authorities from different economic sectors can increase positive spillovers and avoid negative spillovers of their sector-based strategies. And international cooperation can help to assure that actions are based on the best available science, that information about best practices is shared, that financial resources can be pooled and directed toward common goals, and that efforts under different international agreements contribute to adaptation objectives where possible.

Fostering cooperation on adaptation requires leadership within national governments. An environment or science ministry might play a useful role in raising awareness, sharing information about risks and adaptation options, supporting knowledge networks, assessing the implications of new legislation and policies for narrowing or widening the adaptation deficit, and monitoring overall progress on managing climate risks. But environment and science ministries typically lack the standing to marshal resources at the required scale or to compel other ministries to cooperate. The determination to adapt will need to permeate beyond environment and science ministries and be accepted by other ministries as important to their missions and objectives if there is going to be effective cooperation.

The intent of integrating or mainstreaming adaptation with development is to enlist the cooperation of these other ministries and associated stakeholders in making adaptation commonplace in economic and sector-, resource- and livelihood-based planning and programs at national to local scales. Cooperation is not forthcoming when actors and stakeholders in these different spheres of activity view climate change as immaterial to their main objectives and adaptation as a potential new mandate that will divert resources from their priorities. The experience of the AIACC case studies is that stakeholders from varied perspectives often are aware of climate threats to their interests and that, when put in a broad context of managing current climate hazards and not limited to only climate change, are willing to engage with others to assess threat levels and possible responses. Through their participation in an assessment process, many accept, or at least are willing to consider seriously, the need to adapt to narrow the existing adaptation deficit, to limit vulnerability to climate change in the near to medium-term future and to cooperate with others to move toward a climate-proof society.

6.3. Creating the means to adapt

Determination and cooperation to adapt are not sufficient by themselves. The means to adapt must also be available. Much of what needs to be done to adapt is at the level of the household and community. But for the most vulnerable households and communities, the means to adapt are in short supply. Often they do not have sufficient resources and know-how to implement measures that would reduce the risks that they face.

Targeting development to highly vulnerable populations to provide expanded and diversified livelihood opportunities and access to services such as clean water, health care, education, and credit can increase the assets of households and bolster their capacity to cope with and adapt to hazards of all types, including climatic hazards. Capacities that are specific to climate adaptation can be increased by providing information, training, technical advice and resources for adopting technologies and practices that can reduce climate driven damages and variability of production and income. Strengthening and supporting community institutions can increase the capacity for collective action to reduce, hedge and spread risks.

6.4. Financing adaptation

Financial resources are also an important part of the means to adapt. At the local level, many communities have been resourceful in operating village funds and other mechanisms to provide access to credit for small-scale farmers, enterprise owners and others that have proven useful for helping to finance risk-reducing investments or recover from losses. Private sector finance markets play an important role in financing investments by larger enterprises, for example for large-holder farmers to diversify farm operations, adopt new seed varieties and implement irrigation, and also to provide insurance against losses. Insurance needs particular attention as it is far less prevalent in developing countries than in developed, premium rates, already more than can be afforded by poor and vulnerable communities, are rising, and insurers are withdrawing from many markets where climate risks are high. Private sector innovations in micro-credit and micro-insurance can help to increase the access of the poor to financial resources. National governments also assist with direct financial payments and with subsidized credit and insurance, though in many places financial assistance from national governments to rural and urban poor is diminishing.

At the international level, financial assistance is being provided for adaptation through the Global Environment Facility under the United Nations Framework Convention on Climate Change (UNFCCC) as well as through development assistance from bilateral and multilateral aid agencies. The international funding is acting as a catalyst for raising awareness, building capacity, advancing understanding of risks and response options, and engaging developing country governments in prioritizing and assessing options. Recently, funding is also being made available for experimenting with and implementing selected measures for adapting to climate change.

But the magnitude of the adaptation problem and the likely financial needs in developing countries are far greater than current funding. Compelling arguments have been made that developed countries have a liability to help fund adaptation in developing countries that also exceed current contributions (see, for example, Baer, 2006). International financial assistance for adaptation does appear to be increasing. But it is not clear to what extent these are new resources or reallocations of limited development assistance funds, which is a source of tension for integrating adaptation and development. While the logic for integration is inescapable, there is legitimate concern that this will divert some funds away from critically important development objectives. Ultimately though, financing for adaptation will need to come from multiple sources, including developing country governments and their private sectors, as well as from foreign direct investment, international development assistance, and specialized funds under the UNFCCC and other multilateral sources.

7. A Final Word

Climate hazards exact a heavy toll, impacting most strongly on the poor and acting as a drag on development. The toll is rising as climate change widens the gap between our exposures to risks and our efforts to mange them. National governments are increasingly aware of the growing risks and are cooperating in the UNFCCC and other processes to cautiously consider how to respond. But there is not yet widespread determination to adapt.

The determination to adapt can be assisted by increasing recognition that closing the current adaptation deficit provides immediate benefits and is a first step toward adapting to climate change, that feasible, effective and affordable options are available, and that these options do not require certainty about how the climate will change to be effective. But beyond determination, the means to adapt need to be enhanced. Knowledge of climate risks and adaptation response strategies need to be increased. Capacities of at-risk households and community institutions need to be raised and access provided to improved technologies. Climate sensitive natural resources need to be protected and rehabilitated. Financial resources are needed. Most of all, adaptation needs to be integrated with development so that it becomes commonplace in each sector of human activity. The time to act, to make a stitch in time, is now.

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