

**ADAPTATION, MITIGATION, AND CLIMATE RISK:
A SYNTHESIS WITH EMPHASIS ON ASIA**

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Prepared for Policy Forum

*Agricultural and Rural Development
for Reducing Poverty and Hunger in Asia:
In Pursuit of Inclusive and Sustainable Growth*

**Session H on “Climate Change and Agricultural and Rural Development in Asia:
Impact, Mitigation, and Risk Management”**

**Organized by
International Food Policy Research Institute (IFPRI)
and Asian Development Bank (ADB)
ADB Headquarters, Manila, Philippines
August 9–10, 2007**

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A SYNTHESIS WITH EMPHASIS ON ASIA**

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July 31, 2007

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1. Introduction and Sign-post Paragraphs

Multiple changes are occurring simultaneously around the globe at an increasing pace. Energy and resource scarcities have emerged or intensified. Different trade regimes have evolved. New communication and information technologies have exploded into daily life. New human health issues have appeared, and old health issues have, in some cases, been exacerbated. Changes in global climate and associated patterns of extreme weather events must be added to this list, especially for the global poor whose very livelihoods depend on the use of natural resources. Indeed, it is far from clear how these changes will affect global agriculture and natural resources, what their impacts will be on the food and water security, how the poor particularly in developing countries will cope.

Appropriate climate change policies, if adopted now, can stimulate pro-poor investment. More specifically, they can increase the profitability of environmentally sustainable practices even as they generate income for small producers and create investment flows for rural communities. The Intergovernmental Panel on Climate Change (IPCC), in its recently released Fourth Assessment Report (AR4), has concluded that a portfolio of mitigation and adaptation will be required generally. In this paper, we argue that this conclusion applies to Asia, particularly when we focus attention on the poor who live there. We intend to argue that the determinants of the capacity, adapt and mitigate coincide with the precursors of sustainable development. It will follow immediately that policies designed to help the rural poor who rely on subsistence agriculture are both decent social policy and feasible climate policy.

We begin in Section 2 with a very brief description of the socioeconomic diversity displayed across the continent before devoting Section 3 to a summary of major observed and anticipated climate impacts as reported in the Contribution of Working Groups 1 and 2 to the AR4 of IPCC (IPCC 2007a; 2007b). The take-home message here will be that, indeed, both mitigation and adaptation will be required even if one takes an Asian perspective. Section 4 describes adaptation options, while Section 5 briefly examines the state of mainstreaming adaptation into development planning and implementation under the United Nations Framework

Convention on Climate Change (UNFCCC). Mitigation is the topic of Section 6, now making the case that the poor could, if policies were properly designed, benefit from their implementation. A final section offers a few concluding remarks on context.

2. The Current Situation

To state the obvious, Asia is a large and diverse continent. Table 2.1 offers a glimpse at this diversity by recorded in terms of major aggregated: population, per capita gross domestic product (GDP), area, arable land, forest coverage, water resources, cereal production and fish production (IPCC 2007b). These data are reported for nations; and so they mask an enormous amount of intra-national diversity particularly with respect to income and access to natural resources.

This second tier of diversity, for which data are generally less widely available and/or less reliable, is particularly important because it is widely accepted that vulnerability to climate change is exacerbated by exposure to multiple stresses. Chapter 10 in IPCC (2007b) reports that the Asian poor fall currently squarely in that category. Asia accounts for more than 65 percent of all people living in rural areas with incomes of less than US\$1.00 per day. They typically do not have access to proper sanitation. They are vulnerable to tuberculosis; and their children are underweight. Numbering nearly 2.5 billion, these people account for 60 percent of the world's malnourished people, and most of them live in South Asia. Coupled with illiteracy, poverty undermines their abilities to pursue sustainable practices, since their immediate goals involve meeting daily needs of subsistence. The poor tend to live in disaster-prone and ecologically fragile areas that are unproductive. It follows that their vulnerabilities are high because they are especially exposed to climate risks *and because* they faces the resulting stresses with severely limited adaptive capacity.

Table 2.1: Aggregate indicators on socioeconomics and natural resources in Asia

Country	Total population (1000 inhab) 2004	2004 GDP per capita (constant US\$2000)	Land area (1000 ha) 2002	Arable land and permanent crops (1000 ha) 2002	Arable land (1000 ha) 2002	Total forest area 2005 (1000 ha)	Percent of forest cover (FAO 2005)	Natural RWR 2002 (per capita m ³)	Water resources: Total renewable per capita (actual) (m ³ /inhab/yr) 1998-2002	Average production of cereals 2005 (1000 t)	Annual fish and fishery products (kg/capita) 2002
Reference	a	b	c			d		e		f	g
Afghanistan	24926	X	65209	8045	7910	867	1.3	2790	2835	4115	X
Bahrain	739	13852	71	6	2	X	X	X	164	0	X
Bangladesh	149664	402	13017	8429	7997	871	6.7	8444	8418	41586	11
Bhutan	2325	695	4700	128	108	3195	68	43214	43379	127	X
Brunei Darussalam	366	X	527	17	12	278	52.8	X	24286	1	X
Cambodia	14482	339	17652	3807	3700	10447	59.2	34561	34476	4458	28
China	1320892	1323	932743	154353	142618	197290	21.2	2186	2172	427613	26
India	1081229	538	297319	169800	160000	67701	22.8	1822	1807	235913	5
Indonesia	222611	906	181157	33700	20500	88495	48.8	13046	13070	65998	21
Iran, Islamic Rep	69788	1885	163620	17088	15020	11075	6.8	1900	2020	21510	5
Iraq	25856	X	43737	6019	5750	822	1.9	3111	3077	3934	X
Israel	6560	17788	2171	427	341	171	8.3	265	265	341	22
Japan	127800	38609	36450	4762	4418	24868	68.2	3372	3373	12426	66
Jordan	5614	1940	8824	400	295	83	0.9	169	165	83	5
Kazakhstan	15403	1818	269970	22799	22663	3337	1.2	6839	7086	13768	4
Korea, DPR	22776	X	12041	2900	2700	6	0.3	3415	3422	4461	8
Korea, Rep	47951	12752	9873	1863	1663	869	4.5	1471	1470	6776	59
Kuwait	2595	17674	1782	18	15	16142	69.9	10	8	3	9
Kyrgyz Rep	5208	325	1918	1363	1308	136	13.3	4078	4062	1625	1
Laos	5787	378	23080	1001	920	20890	63.6	60318	60327	2560	15
Lebanon	3708	5606	1023	313	170	10252	6.5	1220	1226	145	12
Malaysia	24876	4290	32855	7585	1800	32222	49	25178	24202	2290	57
Mongolia	2630	462	156650	1200	1198	0	0	13451	13599	75	0
Myanmar	50101	X	67658	10611	9862	3636	25.4	21358	21403	25639	19
Nepal	25725	231	14300	2480	2360	X	X	8703	8542	7577	1
Oman	2935	8961	30950	81	38	1902	2.5	364	356	6	X
Pakistan	157315	566	77088	22280	21608	29437	65	2812	1485	32972	2
Papua NG	5836	604	45286	870	220	7162	24	X	143394	11	X
Philippines	81408	1085	29817	10700	5700	X	X	6093	6096	19865	29
Qatar	619	X	1100	21	18	6265	63.5	X	88	7	X
Russia – E of Urals	142397	2286	1638098	125300	123465	808790	47.9	31354	31283	76420	19
Saudi Arabia	24919	8974	214969	3793	3600	2728	1.3	111	102	2590	7
Singapore	4315	24164	67	2	1	2	3.4	X	143	0	X

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Sri Lanka	19218	962	6463	1916	916	1933	29.9	2592	2644	3172	22
Syrian Arab Rep	18223	1115	18378	5421	4593	461	2.5	1541	1511	5620	3
Tajikistan	6298	223	13996	1057	930	410	2.9	2587	2579	859	0
Thailand	63465	2356	51089	19367	15867	14520	28.4	6371	6591	31490	31
Turkey	72320	3197	76963	26579	23994	10175	13.2	3344	3037	34570	7
Turkmenistan	4940	X	46993	1915	1850	4127	8.8	5015	5156	3035	3
U A E	3051	X	8360	266	75	312	3.7	56	51	0	24
Uzbekistan	26479	639	42540	4827	4484	3295	8	1968	1961	6182	0
Vietnam	82481	502	32549	8813	6600	12931	39.7	11109	11102	39841	18
Yemen	20733	534	52797	1669	1538	549	1	X	212	554	6

Source: IPCC 2007a.

This is the fundamental point of the volume of essays edited by Adger, et al. (2006). Taken together, this collection of work makes it clear that access to resources is an essential prerequisite for adaptation to any set of external stresses and that the capacity to adapt and equity are related through intricate webs of social, cultural, political, and economic connections. The capacity to adapt is, however, determined by a list of critical characteristics that includes access to possible adaptation options *and* access to the resources and decision-making processes that are required to begin and to sustain their implementation. These are, in short, prerequisites for effective adaptation to which the world's poor are, for all intents and purposes, currently denied. Since context can vary significantly from place to place, society to society, and time to time, of course, it is extremely difficult to tell an inclusive story about how equity and fairness should enter development plans. Since the capacity to adapt is so critical to promoting the well-being of the poor, however, these complexities cannot be used as an excuse not to act.

3. Impacts and Vulnerability to Climate Change

3.1. Observed Climate Change through 2007

The anthropogenic signal of climate change (particularly warming) has been detected in Asia with strong statistical significance. This signature conclusion of the Contribution of Working Group 1 to the AR4 is displayed in Figure 3.1 (IPCC 2007a). It is important here because it means that mitigation makes sense for the countries of Asia and so the discussion presented in Section 6 is germane. The manifestations of these observed changes have been noted in Asia. Tables 3.1 and 3.2 provide the evidence with respect to transient trends in specific physical impacts and the incidence of extreme events (IPCC 2007b). They focus on South Asia and China (where the highest concentrations of rural poor relying on agriculture reside), but they can be extended. The take-home message for present purposes is that impacts of climate impacts have already been observed in precisely the Asian regions where the poor reside.

Table 3.1: Observed past and present trends in climate and climate variability

Region	Country	Change in temperature	Change in precipitation	References
South Asia	India	0.68°C increase per century, increasing trends in annual mean temperature, warming pronounced during post monsoon and winter	Increase in extreme rains in northwest during summer monsoon in recent decades, lower number of rainy days along east coast	Lal, 2003; Lat et al., 2001; Lal et al., 1996; Kripalani et al., 1996; Singh and Sontakke, 2002
	Nepal	0.09°C per year in Himalayas and 0.04°C in Terai region, more in winter	No distinct long-term trends in precipitation records for 1948-1994	Shrestha et al., 2000; Bhadra, 2002; Shrestha, 2004
	Pakistan	0.6 to 1.0°C rise in mean temperature in coastal areas since early 1900s	10 to 15% decrease in coastal belt and hyper arid plains, increase in summer and winter precipitation over the last 40 years in northern Pakistan	Farooq and Khan, 2004
	Bangladesh	An increasing trend of about 1°C in May and 0.5°C in November during the 14-year period from 1985-1998	Decadal rain anomalies above long term averages since 1960s	Mirza and Dixit, 1997; Khan et al., 2000; Mirza, 2002
	Sri Lanka	0.016°C increase per year between 1961-90 over entire country, 2°C increase per year in central highlands	Increase trend in February and decrease trend in June	Chandrapala and Fernando, 1995; Chandrapala, 1996
SE Asia	General	0.1-0.3°C increase per decade reported between 1951-2000	Decreasing trend between 1961 and 1998; number of rainy days have declined throughout SE Asia	Manton et al., 2001
	Indonesia	Homogeneous temperature data were not available	Decline in rainfall in southern and increase in northern region	Manton et al., 2001; Boer and Faqih, 2004
	Philippines	Increase in mean annual, maximum and minimum temperatures by 0.14°C between 1971-2000	Increase in annual mean rainfall since 1980s and in number of rainy days since 1990s, increase in inter-annual variability of onset of rainfall	Cruz et al., 2005; PAGASA, 2001
East Asia	China	Warming during last 50 years, more pronounced in winter than summer, rate of increase pronounced in minimum than in maximum temperature	Annual rain declined in past decade in Northeast and North China, increase in Western China, Changjiang River and along south east coast	Hu et al., 2003; Zhai et al., 1999; Zhai and Pan, 2003

Source: IPCC 2007a.

Table 3.2: Observed changes in extreme events and severe climate anomalies

Country/Region	Key Trend	References
Heat waves		
China	Increase in frequency of short duration heat waves in recent decade, increasing warmer days and nights in recent decades	Zhai et al., 1999; Zhai and Pan 2003
India	Frequency of hot days and multiple-day heat wave has increased in past century; increase in deaths due to heat stress in recent years	De and Mukhopahyay, 1998; Lal, 2003
Southeast Asia	Increase in hot days and warm nights and decrease in cold days and nights between 1961 and 1998	Manton et al., 2001; Tran Viet Lien, 2002; Tran Viet Lien et al., 2005; Cruz et al., 2005
Intense rain and floods		
China	Increasing frequency of extreme rains in western and southern parts including Changjiang river, and decrease in northern regions ; more floods in Changjiang river in past decade ; more frequent floods in Northeast China since 1990s; more intense summer rains in East China; severe flood in 1999: 7-fold increase in frequency of floods since 1950s	Zhai and Pan, 2003; Zhai, 2004; Zhai et al., 1999; Ding and Pan, 2002
South Asia	Serious and recurrent floods in Bangladesh, Nepal and Northeast states of India during 2002, 2003, and 2004; a record 944 mm of rainfall in Mumbai, India on 26-27 July 2005 led to loss of over 1000 lives with loss of more than US\$250 millions; floods in Surat, Barmer and in Srinagar during summer monsoon season of 2006; May 17, 2003 floods in southern province of Sri Lanka were triggered by 730 mm rain	India Meteorological Department Reports 2002-06; Department of Meteorology, Sri Lanka, 2003
Southeast Asia	Increased occurrence of extreme rains causing flash floods in Vietnam; landslides and floods in 1990 and 2004 in the Philippines, and floods in Cambodia in 2000	FAO, 2004a; Tran Viet Lien et al., 2005 ; Cruz et al., 2005 ; FAO/WFP, 2000 ; Environment News Service, 2002
Droughts		
China	Number and intensity of strong cyclones increased since 1950s; 21 extreme storm surges in 1950-2004 of which 14 occurred during 1986-2004	Fan and Li, 2005
South Asia	Frequency of monsoon depressions and cyclones formation in Bay of Bengal and Arabian Sea on the decline since 1970 but intensity is increasing causing severe floods in terms of damages to life and property	Lal, 2001; Lal, 2003

Source: IPCC 2007a.

3.2. Anticipated Climate Change Impacts

Warming is generally anticipated across the continent, but it will be unevenly distributed. The general trajectory will depend dependent on global emissions scenarios, to be sure, but impacts will depend critically on local manifestations. Figure 3.2, for example, displays average results across a collection global circulation models in terms of global averages and the associated global distributions for three SRES (Special Report on Emission Scenarios) scenarios for the 2020's and the 2090's (IPCC 2007a). Table 3.3 translates these temperature portraits into subjective judgment of sectoral vulnerabilities for sub-continental regions distributed across Asia (IPCC 2007b).

Table 3.3: Sectoral vulnerability for key sectors for sub-continental regions in Asia

Sub-regions	Food and fiber	Biodiversity	Water resource	Coastal ecosystem	Human health	Settlements	Land degradation
North Asia	+1/H	-2/M	+1/M	-1/M	-1/M	-1/M	-1/M
Central Asia and West Asia	-2/H	-1/M	-2/VH	-1/L	-2/M	-1/M	-2/H
Tibetan Plateau	+1/L	-2/M	-1/M	N/A	No info	No info	-1/L
East Asia	-2/VH	-2/H	-2/H	-2/H	-1/H	-1/H	-2/H
South Asia	-2/H	-2/H	-2/H	-2/H	-2/M	-1/M	-2/H
Southeast Asia	-2/H	-2/H	-1/H	-2/H	-2/H	-1/M	-2/H

Vulnerability: -2 = Highly vulnerable
 -1 = Moderately vulnerable
 0 = Slightly or not vulnerable
 +1 = Moderately resilient
 +2 = Most resilient

Level of confidence: VH = Very high
 H = High
 M = Medium
 L = Low
 VL = Very low

Source: IPCC 2007b.

Of course, these sectoral vulnerabilities depend on changes in other key climatic variables, like precipitation; but the climate models do not necessary agree on even the sign of the change of precipitation or its character (e.g., annual precipitation in a specific region can increase because all storms are more intense or because there is an increased frequency of severe storms). Figure 3.3 indicates, for one SRES scenario with relatively high emission (along which the climate signal should be strongest) that precipitation across the globe in the 2090's could

increase or decrease by as much as 20 percent (IPCC 2007a). The subtle reflection of model agreement is perhaps more unsettling. Notice that more than 90 percent of the models agree on the sign of this change over a very small portion of Asia; conversely, less than 66 percent of the models agree on the sign over a much larger proportion of the continent. Since the lower bound for this proportion is 50 percent uncertainty around a critical threshold is profound. Clearly, the risk-management tools discussed in Section 4 will be essential in deciding how exactly to cope with these physical changes on a site by site and stress by stress basis.

The discussion thus far has focused attention on what we know about the physical manifestations of climate change with only passing mention to the activities that support human welfare. Given the uncertainty that is so evident, though, it is perhaps more productive to devote equal attention to sources of vulnerability that might be most significant. To that end, Figure 3.4 identifies the geographic distribution of some hot spots of critical vulnerabilities that the author team of the Asia chapter deemed to be most significant (IPCC 2007b). Notice that some of these key hot spots relate to agriculture. Are they realistic? Figure 3.5 suggests that warming could be beneficial up to certain thresholds for crops that are typical of subsistence agriculture across Asia (IPCC 2007b). It is therefore critical to note that these results depend on local temperature change and that the hot spots map indicates losses in yield in China and Southern Asia. Figure 3.2 suggests that these regions will experience warming in excess of 3 degrees by the end of the century – above the threshold of increase in all cases. Moreover, rice productivity in the tropics declines almost immediately, so the more modest temperature increases expected for the 2020's could still be troublesome.

Figure 3.5 also clearly indicates that adaptation can reduce crop sensitivity to temperature change. Table 3.4 lists some promising adaptation options for agriculture, but neither it nor its supporting text indicates which if any of them might be available to the poor without policy intervention (IPCC 2007b). Sections 4 and 5 will pay particular attention to this issue; but the previously mention collection of essays edited by Adger, et al. (2006) suggests that the news will be bleak and so the need to pay attention will be significant.

Table 3.4: Available adaptation measures in Asia

Sectors	Adaptation measures
Agricultural cropping	Choice of crop and cultivar: Use of more heat/drought-tolerant crop varieties in areas under water stress Use of more disease and pest tolerant crop varieties Use of salt-tolerant varieties Introduce higher yielding, earlier maturing crop varieties in cold regions Farm management: Altered application of nutrients/fertilizer Altered application of insecticide/pesticide Change planting date to effectively use the prolonged growing season and irrigation Develop adaptive management strategy at farm level
Livestock production	Breeding livestock for greater tolerance and productivity Increase stocks of forages for unfavorable time periods Improve pasture and grazing management including improved grasslands and pastures Improve management of stocking rates and rotation of pastures Increase the quantity of forages used to graze animals Plant native grassland species Increase plant coverage per hectare Provide local specific support in supplementary feed and veterinary service
Fishery	Breeding fish tolerant to high water temperature Fisheries management capabilities to cope with impacts of climate change must be developed
Development of agricultural bio-technologies	Development and distribution of more drought, disease, pest and salt-tolerant crop varieties Develop improved processing and conservation technologies in livestock production Improve crossbreeds of high productivity animals
Improvement of agricultural infrastructure	Improve pasture water supply Improve irrigation systems and their efficiency Improve use/store of rain and snow water Improve information exchange system on new technologies at national as well as regional and international level Improve sea defense and flood management Improve access of herders, fishers and farmers to timely weather forecasts

3.3 *The Joint Role of Adaptation and Mitigation*

It is now widely accepted that mitigation alone is not enough to solve the climate problem; nor is adaptation alone sufficient. Even together, they may not be sufficient. These points are illustrated in Figures 3.6 and 3.7 for 2050 and 2100. Replicated from Yohe, et al. (2006), both build from the intermediate A2 SRES emissions scenario if climate sensitivity turns out to be high; the regional distributions reflect climate impacts, calibrated in temperature change, for each country averaged across results derived from a collection of global circulation models. Panels A depict the global distribution of a vulnerability index without any specific climate policy intervention. Panels B display the implications of improving adaptive capacity so that, by 2100, developing countries achieve levels that are typical of developed countries at the turn of the 21st century. Notice the improvement almost everywhere, but particularly in China, in 2050; also, climate change overwhelms even enhanced adaptive capacity by 2100. The bottom two panels (C and D) bring mitigation into the mix by tracing the implications of pursuing a least cost path to limiting atmospheric concentrations of greenhouse gases to 550 parts per million in carbon-dioxide equivalents. Panels C capture only the effects of mitigation; Panels D add enhanced adaptive capacity to the mix. Again, there is some improvement in 2050, and the combination of the two approaches is most effective. Unfortunately, climate change again dominates nearly everywhere in southern Asia by 2100.

4. **Adaptation and Risk Management Strategies**

4.1. *The Adaptation Imperative*

The current scientific consensus that greenhouse gas emissions and atmospheric concentrations are set to increase for some decades to come and that global mean surface temperature (and hence climate change with the impacts described above) will continue to increase long after the peak of emissions is passed, will be the foundation of the impacts depicted in Section 3. Most but not all of the developed nations have agreed to take action in this direction and have signed and ratified the Kyoto Protocol. Progress in reducing emissions has nonetheless been slow, in large measure because some developed countries have thus far chosen

not to participate in the Protocol. In addition, some of the fastest growing countries (like China, India and Brazil) are among largest emitters of greenhouse gasses who have also refused to agree to any emission reductions. They are waiting for the developed countries to show “good faith” by substantially reducing their own emissions.

The rural and agricultural poor in Asia and elsewhere are powerless to stop this situation. They can and do demand through their national representation at the climate negotiations that those responsible for the continued growth in emissions take immediate steps to reduce those emissions, but they have no other choice but to do what they can to cope with climate change – in other words, they must adapt to climate impacts and try to manage the risks as well as they can. This is their adaptation imperative, and it must be viewed in the context of all of the other stresses that they currently face. This section focuses attention on how the rural and agricultural poor in South Asia can adapt to climate change and how they can be helped to do so, given that their adaptive capacity is low.

4.2. *The Adaptation Deficit*

As noted in Burton (2004) and Burton and May (2004), the challenge facing the global poor is greater than simply coping with the multiple manifestations of anthropogenic climate change because they are not even well adapted to their current everyday climate. The losses from floods, droughts, coastal storms and other impacts described above are already unacceptably large and are increasing. These impacts are not (yet) attributed to anthropogenic climate change, but that is immaterial. There is, quite simply, an *adaptation deficit* in relation to existing climate including its variability and extremes. This is a current development issue, to be sure. It follows that any efforts to improve adaptation or to take anticipatory adaptation to future climate change will have to be built upon present circumstances in the context of current development planning. More to the point, development and climate response programs must include ways of reducing the adaptation deficit even as we proceed to adaptation to future risks.

4.2.1. Types of Adaptation

Adaptation comes in many forms, and they all come to the table with their own strengths and weaknesses.

4.2.2. Measures

Most of the literature about adaptation is focused on adaptation “measures”. In agriculture, forestry, livestock operations, water resources management, public health, and other fields impacted by climate change, there are typically a multiplicity of adaptation measures that may be taken (see Table 3.5). In any given situation or context, though, the choice of adaptation measures may be difficult and constrained by their expense, the lack of knowledge on how to implement them, traditional beliefs and cultural practices and others. Notwithstanding these impediments, farmers and others at risk from climate change (and including variability and extremes) can be provided with external help in a number of ways: insurance or other forms of financial assistance and risk spreading; drought relief in the form of cash or kind; information and advice; information and guidance; free or cheap seeds or replacement seed for seeds consumed, and so on. These are actions that can be taken to reduce exposure or vulnerability or risk.

For example farmers in regions subject to drought can select the time of planting according to the arrival (or forecast arrival) of the monsoon or rainy season. They can also select different and more appropriate drought resistant crops or cultivars. This may entail some careful risk calculations (or external advice based on careful risk calculations) because drought resistant crops or varieties often have lower yields. This complexity adds another layer of difficulty. If a farmer plants drought resistant crops on the basis of externally provided information and there is an abundance of rainfall, the farmers may rightly feel that the precautions were unnecessary and that income has been lost in the process. On the other hand, if crops with high yields and lower drought tolerance were planted, serious crop failure and income or livelihood loss can occur as a result. Type 1 and Type 2 errors are rampant (jargon for either making a choice anticipating a new environment that does not materialize or making a choice anticipating the current

environment when a new one shows up), but there is no hope for a universally applicable decision rule. Natural and economic conditions are so varied from place to place and time to time that the relative likelihoods of making the wrong or the right choice are totally idiosyncratic.

4.2.3. Policies

Decision about what adaptation measures to adopt can be left to the rural and agricultural individuals, households or communities, but choices can also be shaped by public policy. For example, to cope the *ex post* mismatch of response and outcome just noted, the practice of providing daily and seasonal weather forecasts could be strengthened or intensified or made more effective. Publicly sponsored crop insurance programs (discussed at later section) may also be developed and implemented (or a system of crop insurance created and offered to rural farmers for an actuarially fair premium). Research on drought tolerant varieties could be accelerated and the resultant cultivars made available to farmers. Farmers can be instructed in the more effective and efficient use of irrigation water or other water management practices. Demonstration projects for any or all of these could be created.

Many of these policies represent things that need to be done. To strengthen these policies and their application may be a way of addressing the adaptation deficit and well as preparing to cope with climate change.

4.2.4. Strategies

Beyond the scope of specific policies, it is also important to think about the strategic aspects of adaptation. As the pattern of climate changes over the national territory of a country, it might be wise to encourage certain types of development (for example, dairy products, or fruit farming or cash crops) in some regions and not others. There might also be external factors to take into account in strategic development planning. For example, is climate change likely to facilitate production of certain types of agricultural produce elsewhere? Are some of countries' crops likely to face increased international competition perhaps from countries with greater

comparative advantage (as a result of climate change)? In short, effective adaptation requires the judicious selection of measures within a policy context and within a strategic development framework.

4.3. *Types of External Intervention*

High level external intervention by national governments trying to implement policies informed by well articulated strategies can be grouped into five types of activity.

4.3.1. Information and Advice

Government agencies can provide information about climate risks and about available adaptation or coping options. They can also provide advice, suggesting to farmers or other persons at risk from climate change, what actions to take. The risk is losing credibility by being wrong too often, of course, so a diverse portfolio of actions designed lower the variance of outcomes certainly makes sense.

4.3.2. Provide Guidance and Training

A step beyond the provision of information and advice is to move to a more pro-active stance by demonstrating how specific adaptation measures can be designed and implemented. This may require additional training or the supply of equipment; support for these programs is an excellent point of entry for international aid.

4.3.3. Promote Adaptation Measures

Governments themselves could take policy decisions on desirable adaptation measures and promote them with national or international resources. For example, the supply of diesel fuel for irrigation pumps in India is subsidized by governments to promote the use of irrigation from tube wells. Governments could also adjust water pricing to encourage the transfer of water from one use to another and thereby promote greater efficiency in water use.

4.3.4. Mandate or Require Adaptation

In some cases, the vulnerability of communities may continue to increase (and thereby increase the adaptation deficit) if natural constraints are not recognized; expansion of irrigation agriculture that exceeds the available water resources anticipated in the future is a perfect example (confounded, of course, by disagreement across climate models about whether precipitation will rise or fall as the planet warms). Also rural infrastructure (roads, bridges, communication and power lines) may be built at too low a standard unless codes and standards are set at a high enough level and enforced. In other words there is a role for government to require adaptation of some kinds in order to safeguard public safety.

4.3.5. Institutional Adaptation Capacity and Policy

The wide range of adaptation measures that might be adopted in different sectors of the economy and the need for policy guidance means that many different agencies of government should be involved. It is not unusual for climate change policy including adaptation to be managed and kept within the confines of one ministry or department. If adaptation is to be properly managed across all sectors and all risks then some form of interdepartmental cooperation is necessary. This may take different forms in different countries.

4.4. *Mainstreaming*

There has been some tendency to treat adaptation to climate change as a “stand-alone” activity. Countries have attempted to identify projects or other activities that are for adaptation to climate change and nothing else. As reported in IPCC (2007b, Chapter 20), this view is strongly rejected both by many scientists and by development specialists. Adaptation to climate change must be integrated into development projects, plans, policies, and strategies. Yohe (2007) argues that doing so should not be a problem if climate issues are viewed in terms of risk management because development ministries already speak that language. Indeed, adding future climate change to the list of risks on the decision-making table can, in many instances, simply add another good reason for doing something that was already being considered. This insight is

particularly important in confronting the “adaptation deficit” mentioned above. Adaptation to climate change should not be designed as a set of separate future activities; it should be built onto existing practices.

5. Mainstreaming Adaptation into Development Planning

Economic growth is necessary for poverty reduction and promoting adaptation to climate change. In this regard, ensuring energy services, promoting agriculture and industrialization, promoting trade and upgrading technologies appear on the front of development agenda. But growth cannot be sustainable over the long term on a planet committed to a changing climate without placing emphasis on making sure that emerging patterns of agriculture, industry and trade do not unduly impinge on ecological health and resilience. IPCC (Chapter 20, 2007b) argues, therefore, that development policy issues must inform the work of the climate-change community such that the two communities bring their perspectives to bear on the formulation and implementation of integrated approaches and processes that recognize how persistent poverty and environmental needs exacerbate the adverse consequences of climate change.

Although linkages between climate-change adaptation and sustainable development should appear to be self evident, it has been difficult to act on them in practice. However, as just noted, a significant adaptation deficit does exist in many developing countries, particularly those populated by the rural poor who rely on agriculture for their very subsistence. While mitigation within the UNFCCC includes clearly defined objectives, measures, costs and instruments, this is not the case for adaptation. Agrawala (2005) indicates that much less attention has been paid to how development could be made more resilient to climate-change impacts, and identifies a number of barriers to mainstreaming climate-change adaptation within development activity.

The existence of these barriers does not mean that the development community does not recognize the linkage between development and climate-change adaptation. Schipper and Pelling (2006) have noted that climate change has been identified as a serious risk to poverty reduction in developing countries, particularly because these countries have a limited capacity to cope with current climate variability and extremes not to mention future climate change.

Adaptation measures will need to be integrated into strategies of poverty reduction to ensure sustainable development, and this will require improved governance, mainstreaming of climate-change measures, and the integration of climate-change impacts information into national economic projections. Brooks et al. (2005) offer an extensive list of potential proxy indicators for national-level vulnerability to climate change, including health, governance and technology indicators. Agrawala (2005) describes case studies of natural resources management in Nepal, Bangladesh, Egypt, Fiji, Uruguay and Tanzania, and recommends several priority actions for overcoming barriers to mainstreaming. These include screening projects for climate-related risk, climate impacts in environmental impact assessments, and shifting emphasis from creating new plans to better implementation of existing measures and policies.

In recent years, new mechanisms have been established to support adaptation, including the Lesser Developed Countries (LDC) Fund, Special Climate Change Fund and the Adaptation Fund. Huq (2002), Brander (2003), Desanker (2004), Huq (2006) and Huq et al. (2006) trace their evolution. They have provided visibility and opportunity to mainstream adaptation into local/regional development activities. One critical problem with mainstreaming and the integration of adaptation to climate change with adaptation to existing climate has, however, surfaced. The boundary between normal or regular development assistance and the additional funds promised under the Climate Convention for adaptation gets lost. This ambiguity can require difficult decisions to be made about how much of an adaptation project or for regular adaptation, and how much specifically for adaptation to climate change.

This distinction is important because it carries implications about the distribution or allocation of costs for particular actions within UNFCCC mechanisms such as the Global Environmental Facility (GEF). For example, Burton (2004) and Huq and Reid (2004) note that the calculation of costs of adapting to future climate change (as opposed to current climate variability), as well as the local nature of resulting benefits, are both problematic *vis-à-vis* the GEF requirement for calibrating global environmental benefits. On the other hand, there are opportunities.

6. Pro-poor Mitigation Strategies

Carbon trading, now growing very fast from a small base as a fundamental building block of global mitigation strategies, will increase dramatically under present trends. However, two key constraints need to be overcome before significant benefits can be channeled to rural areas in developing countries:

- the rules of access, which still do not credit developing countries for reducing emission by avoiding deforestation and by improving soil carbon sequestration, must change; and,
- the operational rules of the game, with their high transaction costs, particularly for developing countries and small farmers and foresters, must be streamlined.

The innovative approach of the Chicago Climate Exchange (CCX) suggest that the technical reasons for excluding forestry conservation and soil carbon sequestration can be overcome and transaction costs reduced by simplifying the rules and using modern monitoring techniques. Pro-poor investments, community development, new research, and capacity building, can all help to integrate the agriculture, forestry, and land use systems of developing countries into the carbon trading system, generating both income gains and environmental security. To achieve this result will require effective integration throughout the process, from global governance of carbon trading, to sectoral and micro-level design of markets and contracts, as well as investment in community management. Streamlining the measurement and enforcement of offsets, financial flows, and carbon credits for investors is also required.

6.1. *Green House Gases (GHG), Land Use and Agriculture: The Big Picture*

Climate change is the result of an increase in the concentration of greenhouse gases (GHG) like carbon dioxide (CO₂), nitrous oxide (N₂O), and methane (CH₄). Rising GHG emissions are associated with economic activities including energy, industry, transport, and patterns of land use, including agricultural production and deforestation. Rich countries emit the majority of these gases while poor countries who are more vulnerable to the effects of these

emissions will suffer more of the negative impacts. Because of their location, their greater dependence on agriculture and natural resources, their larger variations in weather and temperature, and lower availability of critical resources like water, land, complementary inputs, capital, health, and other public services, developing countries are more vulnerable and less adaptable to these changing climatic conditions. The agriculture sector is the largest consumer of water resources, and variability in water supply is a major factor influencing welfare and health in poor areas. The inability of developing countries to respond and act immediately to lessen the impacts of climate change will have serious global economic consequence.

Figure 6.1 shows that land use change (18.2 percent) and agriculture (13.5 percent) together create nearly one-third of GHG emissions. Panel B of Figure 6.2 indicates that the share of these emissions is far larger in developing countries; and Panel C, that this share is larger still in the least developed countries. Achieving significant carbon mitigation in developing countries will need to tap carbon offsets from agriculture and land use change, including forestry, in these countries.

Table 6.1 shows the estimated potential annual carbon savings and costs from different activities. While not as large as the potential for savings from reducing the consumption of fossil fuels, the total potential savings from various agricultural and land use change activities is still very substantial and achievable at a competitive cost. With as much as 13 gigatons of CO₂ per year at prices of \$10-20 per ton, this represents potential financial flows of \$130-260 billion annually, comparable to annual official development assistance of \$100 billion and foreign direct investment in developing countries of \$150 billion.

Table 6.1: Estimated potential annual carbon savings and costs by sector

Sector	2050 Annual Emissions Savings (Gigatons of CO ₂)	Average Annual Cost per ton of CO ₂ (US\$)~2025-2050
Deforestation	3.5-5.0	2
Afforestation and Reforestation	1.0-2.0	5-15
Land management practices	1.0-2.0	20-27
Agriculture (methane and nitrous oxide)	1.0	27
Bioenergy	2.0-3.0	25
Waste and fugitive emissions, industrial processes	4.1	3-5
Fossil fuel related, excluding bioenergy	40.0	22-33

Source: Adapted from Stern 2006: 244-63.

There are two potential ways to enhance the pro-poor impact of climate change policy: first, by transforming climate change policy into a pro-poor development strategy to create value for small farmers and investment flows into rural communities in developing countries and secondly, by effectively integrating the carbon trading process from global governance of carbon trading through sectoral and micro-level design of markets and contracts into investment in community adaptation policies. There will be many benefits, environmental and economic, to adopting these new policies as producers and investors are provided incentives to improve agricultural practices and yields in sustainable ways, conserve watersheds to reduce erosion and enhance water filtration, and reforest denuded areas.

6.2. *Carbon Markets and the Clean Development Mechanism (CDM)*

Carbon markets are a prominent part of the response to climate change which gained global recognition in June 1992 when over 180 countries at the “Earth Summit” in Rio de Janeiro adopted the UNFCCC. The convention’s ultimate objective, enabled in 1994, was to stabilize “greenhouse gas concentrations at a level that would prevent dangerous anthropogenic

interference with the climate system” (Article 2 of the UNFCCC). In December 1997, under the Kyoto Protocol of the UNFCCC, signatories were required to reduce future GHG emissions (in 2008 to 2012) by an average of 5.2 percent from 1990 levels. If unable to reduce their emissions levels, the Clean Development Mechanism (CDM) allowed them to transfer Certified Emission Reductions (CERs) from developing country-based projects that did create measurable reductions of GHG emissions or sequestration of GHGs. Once verified and certified by a designated operational entity, such emission reductions (and removals) may be used by industrialized countries to meet their national target (World Bank 2003). This mechanism makes carbon markets a credible tool for future climate mitigation, particularly for developing countries.

A wide range of carbon sink activities, i.e., “any process, activity, or mechanism which removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas from the atmosphere” (UNFCCC 2007), were ruled eligible for credit in industrialized countries including afforestation, reforestation, forest management, agricultural management, and implicitly avoided deforestation, but sinks in developing countries through the CDM were limited to afforestation and reforestation. These types of activities became known by the acronym of LULUCF for “land use, land-use change and forestry” activities. Because GHG emissions from land systems can be reduced by protecting and conserving carbon in existing vegetation and soils, and additional carbon can be taken up from the atmosphere and stored through activities such as reforestation or revegetation, both forestry and agriculture become part of the solution through their potential to act as large carbon sinks. Carbon sink projects can counter the impacts of GHG and earn income for communities at the same time. Various agricultural and agroforestry activities, including reforestation, improved land and watershed management, and sustainable agriculture practices such as low or no-till farming create alternative sources of income from two sources: agricultural and forestry products and payments for carbon sequestered or conserved. Carbon payments (historically in the range of US\$ 3 - 4 per ton of carbon) can add significantly to a household’s monetary income, even if these prices are not sufficient to encourage huge shifts in land-use and forestry practices. (World Bank 2003).

6.3. CDM Conditions for Effective Offset Projects

A good sink project must meet a number of criteria: (i) additionality; (ii) measurability; (iii) permanence; (iv) leakage prevention; (v) social benefits; (vi) environmental benefits; and (vii) cost effectiveness:

6.3.1. Additionality

The concept of *additionality* requires demonstration that the carbon sequestration or emission reductions would not have occurred if it were not for the incentives provided by the existence of the Kyoto Protocol.

6.3.2. Measurability

Measurability means that it must be possible to quantify in advance and to monitor after that the carbon sequestration or emission reductions that occurred were a result of the project.

6.3.3. Permanence

A guarantee of *permanence* addresses whether sequestered carbon remains sequestered indefinitely (or at least for as long as an equivalent amount achieved by emission reductions).

6.3.4. Leakage

Leakage is the production of GHG emissions that result directly or indirectly from a climate change mitigation project, and can be hard to estimate in sink projects.

6.3.5. Social benefits

Verification and certification of *social benefits* that result from a sink project offers proof that it is meeting the CDM requirement to contribute to a country's sustainable development but also demonstrates *permanence* (noted above).

6.3.6. Environmental benefits

Carbon projects with inherent local *environmental benefits* are more likely to be sustainable. Such projects might include helping a community improve its degraded ecosystem

by replanting trees and establishing a new secure source of fuel wood and timber, by re-vegetating abandoned agricultural lands, or by adopting agricultural practices that conserve the soil.

6.3.7. Cost effectiveness

Finally, the *cost effectiveness* of LULUCF activities and monitoring is critical for effective implementation (World Bank 2003).

6.4. *Types of Carbon Transactions*

Carbon transactions can be grouped into two main categories:

- *Allowance-based transactions*, in which the buyer purchases emission allowances created and allocated (or auctioned) by regulators under cap-and-trade regimes. Examples are the Assigned Amount Units (AAUs) under the Kyoto Protocol, or European Union Allowances (EUAs) under the EU Emission Trading Systems (ETS). Such schemes combine environmental performance (defined by the actual level of caps set) and flexibility, through trading, in order for mandated participants to meet compliance requirements at the lowest possible cost (Capoor and Ambrosi 2007:8);
- *Project-based transactions*, in which the buyer purchases emission credits from a project that can verifiably demonstrate GHG emission reductions compared with what would have happened otherwise. The most notable examples of such activities are under the CDM and the Joint Implementation (JI) mechanisms of the Kyoto Protocol, generating CERs and emission reduction units (ERUs) respectively (Capoor and Ambrosi 2007:8). Others include projects capturing CH₄ and N₂O from animal waste, hydropower, biomass energy, and landfill gas capture.

Table 6.2 offers a glance at current activity in this market. Results of an analysis of carbon pricing for project-based assets in developing countries showed greater price stability and a steady growth in transacted volumes from 2005 to 2006 to US\$ 30 billion. All carbon funds

have grown sharply, but developing countries supplied only 450 MtCO₂e of primary CDM credits in 2006 for a total market value of US\$ 5 billion – a miniscule fraction of the total market. Average prices for CERs from developing countries were up marginally in 2006 at US\$10.90 per ton of carbon (with the vast majority of transactions in the range of US\$8-14).

Table 6.2: Carbon Market at a Glance, Volumes and Values in 2005-06

Type of carbon transaction	2005		2006	
	Volume (MtCO ₂ e)	Value (MUS\$)	Volume (MtCO ₂ e)	Value (MUS\$)
Allowances				
EU ETS	321	7,908	1,101	24,357
New South Wales	6	59	20	225
Chicago Climate Exchange	1	3	10	38
UK-ETS	0	1	na	na
Sub total	328	7,971	1,131	24,620
Project-based transactions				
Primary CDM	341	2,417	450	4,813
Secondary CDM	10	221	25	444
JI	11	68	16	141
Other compliance	20	187	17	79
Sub total	382	2,894	508	5,477
TOTAL	710	10,864	1,639	30,098

Source: Capoor and Ambrosi 2007: 11, 20.

Figure 6.3 shows that China continued to dominate the market-share of the CDM with 61 percent and set a relatively stable price floor for global supply of CERs. Figure 6.4 indicates, though, that agriculture and LULUCF (agroforestry) accounted for a miniscule 1 percent of CDM offsets. Hydrofluorocarbon (HFC-23) reduction and N₂O destruction projects accounted for approximately half of the market volumes, while renewable energy and energy efficiency transactions together accounted for nearly 21 percent of the CDM market over the same period.

6.5. *Pro-poor Mitigation: Constraints and Opportunities*

Currently, there are two major gaps in CDM that limit the scope of mitigation: prevented deforestation and soil carbon offsets. High transaction costs also delay the implementation of any carbon mitigation projects. This includes information about carbon benefits to potential buyers; obtaining information about project partners; organizing project participants; capacity building;

and ensuring parties fulfill their obligations. Transaction costs per unit of emission reduction are likely higher for projects involving many smallholders and forest communities while projects with smaller land areas may lack economies of scale.

6.5.1. Challenges for Carbon Mitigation in Developing Countries: LULUCF, Forestry, and Agroforestry

Carbon assets from LULUCF are low – roughly one percent of volumes transacted. Their regulatory complexity and restricted market access to the EU ETS limits their demand, at least from private compliance buyers and their intermediaries, although the proven community benefits and competitive cost may result in rising demand from public buyers, including European governments. Voluntary markets may find less complex and costly ways to manage permanence risk than the temporary credits currently used under the CDM. Large classes of LULUCF assets—soil sequestration, fire management, and avoided deforestation —remain attractive opportunities to promote sustainable development in Africa and in other natural resource-based economies, but are still systematically excluded from the CDM and other regulatory markets (CIFOR 2000).

Conservation forestry (prevention of deforestation) should be recognized and methods designed to determine dynamic baselines to accommodate prevention of deforestation should be developed. A proposal to CDM by Papua New Guinea on behalf of the Coalition of Rainforest Nations plans for a new approach to curb emissions from deforestation. It plans to establish a baseline rate of deforestation (converted into carbon emissions) for each country and to then negotiate a voluntary commitment to reduce emissions below the baseline. Countries would then receive carbon credits for the amount they reduce deforestation rates, and sell them on the international carbon market. Other innovative methods to assess deforestation credits on a project basis have been implemented (see below).

6.5.2. Challenges for Soil Carbon Sequestration

The feasibility of selling agricultural soil carbon within a market based credit-trading program is another major issue. Soil carbon is more difficult to measure than point-source industrial emissions or biomass in forests. Developing and managing systems to measure initial soil carbon levels, to verify increases in soil carbon, and to confirm its permanence, are all significant challenges. As noted by Antle (2000), citing IPCC (2000), improved crop management yields soil carbon sequestration rates vary according to climate and soil type; Table 6.3 characterizes this variance in general terms.

Table 6.3. Soil carbon sequestration rates by climatic conditions under improved crop management.

Climate type	Soil carbon sequestration rates (tons per hectare per year)
Dry temperate and tropical conditions	0.1 to 0.3
Wet temperate conditions	0.2 to 0.6
Wet tropical conditions	0.2 to 0.8

Source: Antle 2000.

Recent analysis of the possible market value of carbon found a range of \$10 per ton to \$100 per ton or more, depending on the assumption of each study (Antle et al. 1999; McCarl et al. 2000). Linking these two data sets suggests that if carbon were \$20 per ton, the annual per hectare values would range from a low of \$4 in temperate and tropical dry regions, to a high of \$16 in tropical wet regions. Carbon payments could represent an increase in income of 4 to 16 percent for poor farmers managing 3 hectare, with incomes in the range of \$300 per year.

The transaction costs in soil carbon sequestration include obtaining needed site-specific information to assess the baseline stock of carbon and the potential to sequester carbon. The transaction costs per ton of carbon associated with negotiating contracts will decline as the size of the contract increases, and a market for carbon credits is likely to operate for large, standardized contracts (e.g., 100,000 tons). For a typical, individual farmer who can sequester 0.5 ton per hectare per year, these transaction costs per ton will be too high.

Farmers and other producers may be more accurately seen as selling carbon sequestration *services* for a specified time period, rather than selling a commodity. There will be costs associated with monitoring compliance with carbon contracts, to verify the actual level of soil carbon, and to monitor compliance with specified management practices. The size of farm or land management unit also affects monitoring costs. Low-cost remote sensing methods may be used to monitor management features such as continuous cropping on large land units. To use these methods, poor farmers may need to link contiguous plots and manage them as a unit.

6.5.3. Innovative Approaches to Mitigation: Chicago Climate Exchange (CCX)¹

Chicago Climate Exchange (CCX) is the world's first and North America's only legally binding rules-based GHG emissions allowance trading system, and the only global system for emission trading based on all six GHG.² CCX operations demonstrate that the technical reasons for keeping prevented forestation and soil carbon out of the CDM can be overcome by simplifying rules and using modern monitoring techniques while simultaneously reducing transaction costs.

6.5.4. The CCX approach to Agricultural Soil Carbon Offsets

CCX has developed simple, standardized rules for issuing credits for agricultural carbon emission reduction and soil sequestration. Currently, eligible agricultural soil carbon sequestration projects include grass planting and continuous conservation tillage. The basic CCX specifications for soil carbon management Offset Projects include a minimum five-year contract, a tillage practice that leaves two-thirds of the soil surface undisturbed and two-thirds of the crop residue on the surface, conservation of between 0.2 to 0.6 mt of CO₂ per acre per year; enrollment through a registered Offset Aggregator, and independent verification. Effective use of Offset Aggregators as brokers for small projects is a crucial step in achieving economies of scale.

¹ Information presented in this section was collected from <<http://www.chicagoclimatex.com>> Accessed on July 2, 2007.

² The six are CO₂, CH₄, N₂O, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF₆).

6.5.5. The CCX Approach to Forestry Carbon Emission Offsets

CCX has also developed simple, standardized rules for issuing contracts for forest carbon sequestration. Eligible projects include forestation and forest enrichment, urban tree planting, and, in specified regions, combined forestation and forest conservation projects. Contracts are issued to forest enrichment projects on unforested or degraded forest land (including urban tree planting) at a rate based on the annual increase in the carbon stocks of above-ground, living biomass. In a key breakthrough, forest conservation credits for combined conservation and forestation projects on contiguous sites are credited on the basis of *avoided deforestation* rates specified for eligible geographic regions. Quantification methods for forest carbon stocks vary by project size to reduce transaction costs for smaller projects. Carbon in small to medium afforestation projects (under 12,500 mt of CO₂) is assessed through CCX carbon accumulation tables or uses of direct methods (direct in-field sampling and measurement). In large projects carbon accumulation is measured directly or determined by properly parameterized growth models.

6.5.6. Adopting Innovative Approaches to Developing Countries: Investing for the Poor

In addition to the crucial steps of including soil carbon offsets and avoided deforestation in the CDM, a number of other changes are needed. To ensure that these emerging carbon markets benefit developing countries, CDM rules should encourage the participation of small farmers, community forest and agroforestry producers, and protect them against major livelihood risks, while still meeting investor needs and rigorously ensured carbon offset goals. This can be supported by:

- 1) *Broadening the definition of afforestation and reforestation.* Agroforestry, assisted natural regeneration, forest rehabilitation, forest gardens and improved forest fallow projects should all be eligible for CDM, as they offer a low-cost approach to carbon sequestration, while offering fewer social risks and significant community and biodiversity benefits. Short-duration tree-growing activities should be permitted, with suitable discounting. Limiting project types would introduce forest product market distortions unfairly favoring large plantations.

2) *Promoting measures to reduce transaction costs.* Rigorous, but simplified procedures as typified by the CCX should be adapted to developing country carbon offset projects. According to the Marrakesh Accords, small-scale projects, whose annual emission offsets are less than 15,000 t CO₂, can benefit from simplified ways for determining baselines and monitoring carbon emissions. Agroforestry and community forestry projects should be eligible for simplified modalities. Simplified emission reduction credits can be calculated using standardized reference emission rates for different emission reduction/storage activities in specific locations, determined and verified by independent bodies and an uncertainty discount could be applied. These could significantly reduce the costs of community-based projects.

3) *Establishing international capacity building and advisory services.* The successful promotion of livelihood enhancing CDM forestry projects will require investment in capacity-building and advisory services for potential investors, project designers and managers, national policymakers and leaders of local organizations and federations. Regional centers could be established to assist countries and communities involved in forest carbon trading. Institutional innovations can provide economies of scale and specialization. Companies or agencies can provide specialized business services for low-income producers to help them negotiate deals or design monitoring systems. Locally accountable intermediary organizations can manage projects and mediate between investors and local people, e.g., the Scolel-Té project in Mexico.

The permanence requirement can also be addressed through innovative methods. Under ton-year carbon accounting, the carbon credits earned by a forestry project, for example, are calculated according to how long the carbon is stored or sequestered – i.e., how long the forest or its harvested products exist, even if the impact of the shift to cleaner energy sources lasts longer. The ton year approach pays by mass time units. CIFOR researchers explain that this system avoids the need for "locking up" land in forest land uses for prolonged periods because credits are calculated according to carbon storage duration. This flexibility is particularly valuable to small-holders as it enables them to change land use in the future if market or policy conditions change (CIFOR 2000: 11).

Such a system also compensates for projects that fail as a result of poor management or natural disasters. It would have the advantage of encouraging more local communities to participate and to enlarge the area in CDM projects reducing overall GHG emissions and increasing the proportion of benefits accruing to local communities (CIFOR 2000: 11-12).

Finally, further investment in advanced measurement and monitoring can dramatically reduce transaction costs. Measurement and monitoring techniques have been improving rapidly thanks to a growing body of field measurements and the use of statistics and computer modeling, remote sensing, global positional systems, and geographic information systems, so that changes in stocks of carbon can now be estimated more accurately at lower cost.

7. Conclusions

Climate change mitigation policies, if carefully designed, can create a new development strategy that encourages the creation of new value in pro-poor investments by increasing profitability of environmentally sustainable practices. To achieve this dual goal, it will be necessary to streamline the measurement and enforcement of offsets, financial flows, and carbon credits for investors. It is important to enhance global financial facilities and governance to simplify rules and increase funding flows for mitigation in developing countries.

Challenges and opportunities are not quite as clear when it comes to adaptation, however. If the truth be told, there is no single definition of what it means to adapt to a stress; and there are no firm quantitative measures for adaptive capacity. It is, though, widely accepted since Yohe and Tol (2002) that the underlying determinants of a high capacity to adapt (and to mitigate, for that matter), include routine access to resources, strong social and human capital, and routine access to risk spreading mechanisms. The rural poor are lacking in most of these factors, and thus their high vulnerability to climate change. Moreover, climate impacts vary over space and time – another source of complexity that has lead the Kyoto Protocol to rely on countries to define their own priorities in their National Adaptation Plans of Actions (NAPAs). As global adaptation funds become more solvent (as more members of the UNFCCC sign onto Kyoto),

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care must be taken to allow countries to follow their own particular approaches; but success across nations must be measured against consistent and as yet undefined standards.

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LIST OF ACRONYMS

AAU	Assigned Amount Units
CCX	Chicago Climate Exchange
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CFI TM	Carbon Financial Instrument
CIFOR	Center for International Forestry Research
ERPA	Emissions Reduction Purchase Agreement
ERU	Emission Reduction Units
ETS	Emission Trading Systems
EU	European Union
GHG	Green House Gases
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
LULUCF	Land use, land use change and forestry
NASD	National Association of Securities Dealers
PES	Payment for Environmental Services
WRI	World Resources Institute
UNFCCC	United Nations Framework Convention on Climate Change