

Adaptation to and mitigation of climate change

in the agriculture and forestry sector

- Collection of best practices -



SPC/GTZ REGIONAL PROGRAMME
ADAPTATION TO CLIMATE CHANGE IN THE PACIFIC ISLAND REGION

SPC Land Resources Division

gtz

Adaptation to and mitigation of climate change in the agriculture and forestry sector: Collection of best practices

By the Secretariat of the Pacific Community and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH

Programme on Adaptation to Climate Change in the Pacific Island Region







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Acronyms and abbreviations

ADPC – Asian Disaster Preparedness Center

ALM – Adaptation Learning Mechanism

BARI – The Bangladesh Agricultural Research Institute

CATHALAC – Centro del Agua del Trópico Húmedo para América Latina y El Caribe (Water Center for the Humid Tropics of Latin America and the Caribbean)

CFM – Community Forest Management

FAO – Food and Agriculture Organization of the United Nations

GEF – Global Environment Facility

GTZ – Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (German Technical Cooperation)

IASC – Inter-Agency Standing Committee

IIED – International Institute for Environment and Development

IUFRO – International Union of Forest Research Organizations

NAPA – National Adaptation Programmes of Action

PGRD-COPASA – Proyecto Gestión de Riesgo de Desastres con Enfoque de Seguridad Alimentaria de la Cooperación Peruana Alemana

REDD – Reducing Emissions from Deforestation and Forest Degradation

SFM – Sustainable forest management

SPC – Secretariat of the Pacific Community

UNDP – United Nations Development Programme

UNEP – United Nations Environment Programme

UNFCCC – United Nations Framework Convention on Climate Change

WB – World Bank

WRI – World Resources Institute

Foreword



Inoke Ratukalou

Acting Director, Land Resources Division

The devastating effects of cyclones on Pacific Island economies are just one example of how vulnerable our nations are to extreme weather events. For most Islanders the ocean and land are key sources of subsistence and commercial economic activities, and changes in climate and ecosystems will inevitable result in changes in livelihoods. The efforts in international negotiations to reduce greenhouse gas emissions have to be stepped up to limit global warming to a manageable level. But at the same time we have to start preparing now to be able to cope with climate change. The good news is that we are not alone in this task. Small island developing states around the world face the challenges of getting ready for a warmer world. International organisations and donors are devoting substantial sums to climate change projects in the Pacific. Likewise the agencies making up CROP (Council of Regional Agencies in the Pacific), such as the Secretariat of the Pacific Community (SPC), the Secretariat of the Pacific Regional Environment Programme (SPREP), the University of the South Pacific (USP) and others are developing services to support transformation processes at all levels of society.

At SPC the challenges of a changing climate are being taken up in many ways:

- The organisation's programmes are starting a process to assess if climate change can be usefully integrated into existing services.
- Databases will be established to provide stakeholders with state-of-the-art data on local effects.
- 'Climate ready' food crops which are resilient to marginal conditions are being collected, tested and stored.
- The SPC website has a new portal on climate change issues providing news and resources.
- The Regional Programme on Adaptation to Climate Change in the Pacific Island Region (ACCPIR), funded by the German government and implemented by GTZ (German Technical Cooperation) and SPC, is supporting the development of adaptation strategies and is running pilot projects helping communities increase their resilience to changing climatic conditions in the Pacific.

Global warming affects every country in the world. All over the world as people adapt to changing climates they are gaining experiences on how to cope with new challenges in natural resource management in tougher conditions. We can learn from these experiences – and we must if we want to have the chance to adapt fast enough.

This collection of best practices is part of a wider effort to cope with climate change. Multiple programmes planned and underway right now will produce numerous experiences from the region describing what works and what doesn't in the specific geographical, cultural and social situations on our islands. If we can manage to learn effectively from these experiences, Pacific Islanders will cope with this new challenge and keep their rich cultures and extraordinary ecosystems alive.



1. Introduction

The effects of climate change require strong actions from policy-makers, extension officers and communities to strengthen resilience to the expected negative impacts. Sea-level rise, changes in precipitation patterns and other effects cannot be avoided, but there are many means to reduce the vulnerability of communities. To equip the actors in this adaptation process with the right tools, the Regional Programme on Adaptation to Climate Change in the Pacific Island Region is setting up a knowledge management system including a database on climate change. A collection of best practices from the region and other parts of the world will be part of this venture. The collection of best practices from the region will be completed by the thematic teams of SPC Land Resources Division. This desk-study gathers examples from across the globe.

'Best practices' in this sense describe techniques, methods and activities that achieve a result in the most effective and efficient way. According to the United Nations Framework Convention on Climate Change (UNFCCC),

"Adaptation is a process through which societies make themselves better able to cope with an uncertain future. Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes." (UNFCCC 2007: 10).

Mitigation of climate change refers to the reduction of greenhouse gas emissions. While mitigation measures are included in the collection of best practices, the focus of this report is on adaptation. This reflects the priority given to adaptation rather than to mitigation by Pacific leaders, because of the low per capita and total emissions of Pacific Island countries.

Three methodological issues were encountered while collecting best practices for adaptation.

1. The first effects of climate change can be felt already. But these are minor given the predicted impacts for 2050 or 2100. This means that climate threats will increase in the next decades and that measures put in place today cannot be evaluated now, because they still have to prove their success in the future.

2. The need to adapt to climate change was recognized by the signatories of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, but only in recent years were programmes to adapt to anthropogenic climate changes planned, started and implemented. The number of examples of successfully implemented projects aiming specifically at adaptation to climate change is therefore limited.

3. The uncertainties about the exact changes caused by climate change at a local level can be significant. This means that adaptation measures often do not focus on specific climatic events but rather on the general coping capacities of institutions, communities and individuals.

These restrictions leave us only a limited amount of tested, best practice adaptation measures. Nevertheless many organizations like UN organizations, implementation agencies, development banks and international networks have published guides describing adaptation options and created databases with case studies of climate change projects.



Screenshot 1. FAO publications on climate change

This collection can only be a starting point as probably not all relevant documents have been found, and the body of literature and lessons learned is growing fast, because of the importance of climate change in international agendas.

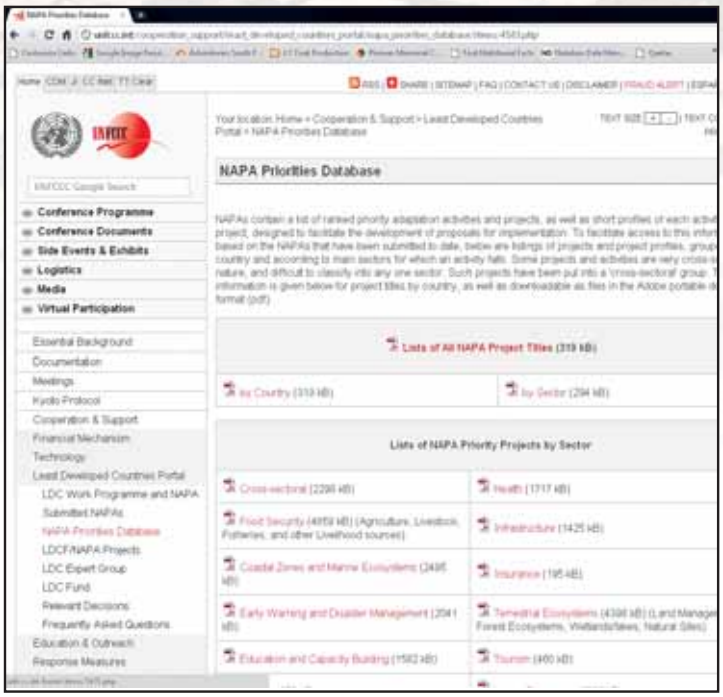
Some case studies and concrete examples of best practices published on climate change can be found in the boxes in this report. They provide examples of specific measures, show how these best practices are presented in the respective publication, and also show how many best practices are well known from classical development interventions before climate change was recognized as an important problem. The best practices are presented by the respective publishers as examples of adaptation to climate change because they increase resilience to its negative impacts, even if that is achieved with 'conventional' methods such as livelihood diversification or conservation farming.

The core of this collection are the tables in Annex 1 which lists a wide range of documents and databases, and features case studies, best practices and adaptation/mitigation options. Together with the currently collected local best practices, this collection could become part of the SPC Land Resources Division knowledge database on climate change adaptation.

2. Overview of databases

Many online databases and portals provide access to a variety of documents on climate change adaptation and mitigation. These include the climate change portal of the Food and Agriculture Organization (http://www.fao.org/climatechange/49391/en/), the World Bank (http://sdwebx.worldbank.org/climateportal/?page=display_projects&type=kundefined), the Global Donor Platform for Rural Development (a network of bilateral and multilateral donors) (http://www.donorplatform.org/component/option,com_docman/task,cat_view/gid,62/Itemid,98/) or the Climate change Adaptation portal of Eldis, a knowledge service from the Institute of Development Studies, Sussex (http://www.eldis.org/go/topics/dossiers/climate-change-adaptation).

The documents available on these websites usually cover different issues. Manuals for climate change mainstreaming, policy briefs and case studies can be found in these databases. Keywords and categories ease the search for the right information. Best practices can be found in some of these documents, but the quality and applicability varies considerably.



Screenshot 2. UNFCCC NAPA project database

A second group of online databases describes projects and programmes on climate change adaptation and mitigation. The UNFCCC hosts the Adaptation Practices database (http://unfccc.int/adaptation/nairobi_workprogramme/adaptation_practices_interface/items/4555.php?anf=&sorted=&seite=1&type=&region=&focus=&means=) which lists adaptation programmes in different regions and sectors. The National Adaptation Programmes of Action (NAPA) Projects Database is also hosted by the UNFCCC (http://unfccc.int/cooperation_support/least_developed_countries_portal/napa_project_database/items/4583.php). All the projects identified by NAPA are listed according to country and sector, including the sectors Food Security (Agriculture, Livestock, Fisheries, and other Livelihood sources) and Terrestrial Ecosystems (Land Management, Forest Ecosystems, Wetlands/lakes, Natural Sites).

The Vulnerability & Adaptation Database of the World Resources Institute (WRI) (http://projects.wri.org/adaptation-database) also belongs to this category. Abstracts of 135 adaptation projects and initiatives are categorized by country, region, scale, climate impact and strategy. While the databases describe the wide range of possible adaptation projects, and can provide valuable ideas for project design, the achievements, crucial success factors and lessons learned are not usually included in the descriptions.

The third group of databases deals with the distinct strategies and measures which can be taken to tackle climate change. The UNFCCC has set up the Local Coping Strategy Database (http://maindb.unfccc.int/public/adaptation/) which features a variety of best practices sorted by hazard (e.g. storm, drought), impact (e.g. soil erosion, water logging) and strategy (e.g. pest control, livelihood diversification). This might be the most useful database of best practices on adaptation to climate change. As explained above strengthening resilience to the effects of global warming does not necessarily require new approaches. Best practices from sustainable land use, agroforestry and so on, which diversify livelihood and protect natural resources, improve the capacities to deal with climate change. Therefore databases like FAO's Technology for Agriculture (TECA) (http://www.fao.org/sd/Teca/index_en.asp), which presents 'proven technologies for smallholders', as well as the World Overview of Conservation Approaches and Technologies (WOCAT) (http://www.fao.org/ag/agl/agll/wocat/wocatqt.asp) and the World Bank's Indigenous Knowledge Database (http://www4.worldbank.org/afr/ikdb/search.cfm) provide multiple examples of best practices to reduce the vulnerability of communities.



Screenshot 3. UNFCCC local coping strategies

The Adaptation Learning Mechanism (ALM) (http://www.adaptationlearning.net/) is an online repository of adaptation knowledge established by the United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), the World Bank and the Global Environment Facility (GEF). Every country has a vulnerability profile and a list of active programmes and case studies, and lessons learned can be submitted. A collection of adaptation tools is also available on the website. So far the amount of data is rather modest but this site could become a valuable resource in the future.

At a workshop in Berlin on Mainstreaming Adaptation Tools in May 2009 a number of aid agencies decided to build a new inter-agency database on climate change adaptation. This should be followed closely (GTZ 2009: International Workshop on Mainstreaming Adaptation to Climate Change Guidance and Tools).

BOX 1:

A FARMERS' GROUP RESPONSE IN SOUTH AFRICA

Men in KwaZulu Natal, who in the last three years returned from labouring on commercial farms, established a maize cooperative. The group has trialled short-growing resilient varieties and changed planting densities to minimise crop risk to increasingly variable weather. They have also benefited from shared resources and mechanisation. In the last two years, they organised the collective sale of surplus crop in order to compete in the rapidly changing local market. Establishing a spatial network of ties is therefore critical to innovation and collective action where no formal mechanisms exist. The highly variable and intense weather events in the area have also promoted the cooperative to introduce of con-servation practices (e.g. extensive contour stone bunding) for the first time by over a third of those interviewed in order to reduce soil erosion on the maize fields. The fields are especially vulnerable to sheet wash during heavy rainfall before planting or after harvest.

Source: Tyndall Centre for Climate Change Research. 2005. ADAPTIVE: Adaptations to climate change amongst natural resource-dependent societies in the developing world: across the Southern African climate gradient. p. 35.

3. Example publications and documents

Apart from the online databases a variety of publications deal with adaptation and mitigation in the agriculture and forestry sector. In the light of the problems mentioned above regarding the lack of proven success stories of adaptation, most of the documents either discuss strategies and options rather generally or describe programmes in the implementation phase. Thoroughly worked-out examples of best practices specifically about climate change are rare. Nevertheless many organizations recognize the importance of disseminating knowledge about climate change and coping strategies researched or implemented by them.

One example is **Climate variability and change: adaptation to drought in Bangladesh. A resource book and training guide, developed for the Improved Adaptive Capacity to Climate Change for Sustainable Livelihoods in the Agriculture Sector Project in Bangladesh** by FAO and the Asian Disaster Preparedness Center (ADPC). The manual is meant to enable extension workers and development professionals to guide communities through a vulnerability assessment and the identification of prioritized adaptation options. The guide is targeted at the context of Bangladesh, but the process orientation and training modules makes it a valuable resource for other countries, too. There are a few detailed best practices included as well (see Box 2: HOME GARDENS). Key factors for success include a thorough analysis of the current coping range and the identification of expected climatic changes which exceed the coping capacity of the farmers. While the farmers in the Barind area of Bangladesh use rice varieties with a shorter growing period to counter the drought at the end of the Monsoon season, climate change might alter precipitation in such a way that this coping practice to address climate variability will not suffice. The building of small irrigation ponds is an adaptation measure which would broaden the coping range of the farmers in Barind.

A project in the Caribbean to improve food security in hazard-prone areas documented 29 examples of best practices in Assistance to improve local agricultural emergency preparedness in Caribbean countries highly prone to hurricane related disasters published by FAO.

BOX 2:

HOME GARDENS

The indigenous knowledge of the local population regarding envi-ronmentally friendly land management needs to be encouraged. In the Barind Tract, tree species such mango, mahogany and jackfruit are being grown in uplands (chalas) around homestead, and are some times used for growing vegetables. The lowlands (baid) are generally used for growing paddy. This practice increases moisture retention, improves soil fertility and crop yield and reduces surface runoff , thus halting soil erosion. Home garden systems in drought prone areas provide healthy ecosystem for humans, animals, birds, livestock and miscellaneous flora and fauna. Homestead bamboos are also planted because these develop rapidly and are good soil binders. Use of homestead litter, ash supplements and organic matter in the soil keeps insects away. Homestead gardening helps produce vegetables for household requirements and sometimes for external marketing. Women are engaged in homestead gardening as an income diversification activity. As the rainfed Barind Tract is mostly dominated by rice during kharif II season, integration of homestead gardening within the household system provides var-ied nutrients and thus helps to ensure household nutrient security. Practicing homestead gardening in drought-prone areas helps integrate gender concerns within the climate change adaptation framework.

BARI has developed economically feasible homestead garden models for Barind Tract areas. The components of the homestead garden models include drought-resistant fruit trees and vegeta-bles.

Resources required: homestead land, propagation materials and seeds of drought resistant vegetable seeds.

Potential maladaptation: none.

Non-climatic benefits: gender integration in agriculture, nutritional security, year round income.

Source: FAO/ADPC. 2007. Institutions for Rural Development. Climate variability and change: Adaptation to drought in Bangladesh. A resource book and training guide. pp. 41–42.

The best practices are tested and rated which is an advantage compared with other collections where testing and successes are not documented. The following criteria were used to prioritize the adaptation measures: effectiveness in increasing resilience, cost effectiveness, sustainability, ease of implementation and replicability. In the regional context, diversifying cropping systems, integrating agroforestry practices, and soil erosion control structures, were considered to be three of the most relevant measures. The establishment of grass barriers as a means of erosion control was among the tested measures. To achieve the best results, selecting the species used is of vital importance. The selected species should be stress tolerant, not invasive, have a narrow leaf base that prevents insects from lodging and, ideally, also provide the farmers with an additional income.

Addressing the humanitarian challenges of climate change: Regional and national perspectives - Case studies on climate change adaptation (IASC 2010) provides examples of climate change adaptation projects from all over the world. The collection takes a humanitarian perspective but features examples from many related sectors such as disaster risk management, health and livelihood programmes. The activities and lessons learned are presented clearly. While many of the lessons presented depict well known principles of development projects (e.g. the need to adjust the project to the local and cultural context, taking a livelihood perspective, mainstreaming adaptation into national planning and policies), some successes are built on more specific insights. Useful experience was gained in a project for an early warning system for floods in West Africa, in which local volunteers operated a simple system of colour-coded poles along riverbeds – green for safe, yellow for danger and red for evacuation. However, the project concluded that weather forecasts should be treated with caution because 'below-average rainfall' forecasts do not exclude the possibility of intense rainfall events.

Weathering the Storm: Options for framing adaptation and development from the World Resource Institute (WRI) is based on the 135 case studies evaluated for this venture. These provide sufficient data to draw conclusions about the trend of adaptation projects and their relationship to 'traditional' development projects. The study found that almost half of the projects labelled 'adaptation' are in fact classical development projects aimed at reducing vulnerability. This should not be seen in a negative way, however, because the dual relationship of development projects (increasing resilience to climate change on the one hand and adaptation projects helping to meet development goals on the other) can be mutually supportive. A case

study of the Arid Lands Resource Management Project demonstrated the success of the combination of a suite of measures aimed at empowering local communities to manage climate risks.

A review of many examples of adaptation projects (WRI 2007: 21) has shown how analysis of historical, current and future climate information can help farmers make informed choices to reduce their risks:
"Climate and weather forecasts are being downscaled and communicated to farmers to help them select appropriate planting times. Local production systems are being diversified through the use of drought-tolerant crop varieties and better systems for collecting and storing seeds. Farmers have been trained in soil and water conservation; weather prediction and interpretation; selection of seeds to fit climatic and land conditions; and early land preparation and planting. As well, such technologies as sand dams and drip irrigation have been introduced to improve access to water. Credit systems are being strengthened, allowing community members to pursue diversified or alternative livelihood activities" (WRI 2007: 21).

Because of the uncertainty of climate predictions, and because climate change is only one factor in vulnerability, the study argues for a broad understanding of adaptation, "encompassing the full range of responses—from reducing poverty and building capacity, to managing risk and directly confronting climate change impacts" (WRI 2007: 37). The publication also includes non-agricultural and non-forestry practices, but the variety of projects is inspiring.

A comprehensive discussion of adaptation options is provided by **Climate change and agriculture: Review of impacts and adaptations**, published by the World Bank. While it lacks the detailed lessons learned from on-the-ground implementation, this literature review is a good starting point for considering the variety of options (a list with the adaptation measures is included in Annex II). One of the traditional measures discussed deals with drought in Sri Lanka, and suggests "that during times of drought and when water supplies from reservoirs are limited, the farming community temporarily ignores the individual boundaries of the farms and jointly cultivates land close



to the irrigation outlet in order to minimize losses from evaporation and movement of water. Each farmer cultivates an amount of the cultivable land that is in proportion to the amount owned" (Kurukulasuriya/Rosenthal 2003:47). The social cohesion of the community and the existence of traditional management practices can be a success factor for adaptation strategies. One of the findings of the study is the importance of addressing climate variability (like extreme weather events) and the impacts of slow climatic changes (like increasing temperatures and sea-levels) separately, because both aspects might need different solutions. The author concludes that policy makers should take care that incentives to adapt to climate change need to be incorporated into the project design of poverty reduction projects, and that site specific, dynamic adaptation measures should be promoted. While adaptation to climate change needs special attention, the review also affirms that the general development of the agricultural sector will also increase resilience in a changing climate (Kurukulasuriya/Rosenthal 2003:68–69).

Publications like this, which show the broad perspective of the effects of climate change and adaptation, should be complemented by detailed best practices which are not necessarily published under the climate change headline. If the vulnerability assessment considers soil erosion, for example, as a threat intensified by climate change-induced heavy rainfall, the FAO **Manual on integrated soil management and conservation practices** provides tested

and detailed easy-to-use measures on how to deal with erosion. Many best practices in agroforestry, cited as an adaptation option, have been described in the literature. The manual **Agroforestry: A better way to farming**, published by the Fijian Ministry of Agriculture, Fisheries and Forests, SPC and GTZ (Ratukalou 1999), provides techniques adapted to the pacific region like contour farming, intercropping, green manure management. A list of locally tested trees for agroforestry is included in the manual.

The paper **ADAPTIVE: Adaptations to climate change amongst natural resource-dependant societies in the developing world: across the Southern African climate gradient** from the Tyndall Centre for Climate Research stands out from the documents described so far for two reasons. First, the research paper describes adaptation practices which were not necessarily the result of externally driven interventions for adaptation to climate change, but also arose from everyday coping strategies and adapting capacities of communities in southern Africa. The second interesting aspect of this paper is the inclusion of institutional arrangements and social relationships in the analysis. The building of cooperatives and the role of reciprocity between different communities are important in coping with climate variability.

BOX 3:

MANGROVE REFORESTATION IN SOUTHERN THAILAND

– PROVIDING PROTECTION AGAINST STORM URGES AND ALLOWING FOR ADDITIONAL INCOME

Hazard(s): Storms

Impact(s): Coastal inundation/erosion

Strategy(s): Natural resource management

Summary

Mangrove forests are located in 23 coastal provinces in Thailand. These forests used to cover 368,000 ha in Thailand in 1961, but the area dropped to 240,000 ha by 2002. The major causes of the loss of mangrove forests are timber and charcoal industries, while some areas were converted for urbanization, agriculture, and aquaculture especially shrimp farms. In 2004, a five-year Action Plan for Mangrove Management in the Gulf of Thailand was established to preserve mangrove forests, as well as to promote the sustainable use of mangrove resources.

Following the 2004 tsunami, many local communities are interested in mangrove reforestation as protection against disasters such as storm surges. The Department of Marine and Coastal Resources established a program to conserve and rehabilitate mangrove forests. Four mangrove development stations are located in Trang to support the program's activities, including:

- Reforest and maintain mangroves
- Provide training to
- Build capacity for community forestry management and volunteer network
- Increase partnerships between the local community, the government, and NGOs
- Reduce illegal wood harvesting and land cultivation
- Set up Mangrove Protection Zones

The community mangroves operate with established rules. For example, wood can not be taken from protected areas (violators are fined 5-10,000 baht, or USD 125-250, depending on the amount taken). Villagers who need wood are able to present requests to the local committee and only those individuals who participate in conservation activities are allowed to present requests. However, locals are allowed to catch small aquatic animals such as fish, crabs, etc. So far, the Mangrove Protection Zones cover approximately 2,240 ha and provide habitats for protect and increasing biodiversity. The community nurseries have produced 225,000 mangrove seedlings, which serve government and NGO plantation activities and provide plants for reforestation. Families are able to supplement their incomes by catching and selling aquatic animals in the mangrove areas. The average household income from this activity ranges from 20,000 to 66,000 baht (USD 500-1,650) per year per household. They also earn income from gathering charcoal, fuel-wood, medicinal plants, tree bark for tanning production, and honey.

Resources required: Mangrove seedlings and expertise and mangrove forestry, tools, labour

Potential maladaptation: none

Non-climate benefits: improvements in biodiversty and livelihoods

Source: UNFCCC. Local Coping Strategies Database. http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.pl?id_project=154

One example of coping with frequent flooding in Mozambique is farming simultaneously in low- and highland areas. While the lowlands are fertile and provide more income, low-lying fields are also at risk of flooding. Families with only one plot formed informal farming associations to lobby successfully for the allocation of another piece of land to reduce the risks. Farming associations also play a decisive role in spreading knowledge about new varieties: "45% of those interviewed had changed to more drought resistant species of rice, maize, cassava and sweet potato at some point during the last 6 years as a direct result of the information exchange within and beyond the farming associations" (Tyndall 2005:16–17).

Key results from this research paper include:

- Reciprocity of actions between households and individuals proved to be very important in providing the means to cope at times of stress.
- Identification of the importance of collective action as a key to setting up new, often agriculturally based, opportunities to reduce vulnerability to the risks associated with climatic uncertainty. Both formal and informal institutions were critical aids to collective action. These institutions also facilitate the transfer of ideas and innovative actions by key individuals through the communities, especially access to external information and resources.
- Recognition that collective actions and community management of resources do not necessarily create circumstances for equitable adaptations among all households within a community.

The special Issue 60 of **Participatory Learning and Action: Community based adaptation to climate change** (IIED 2009) features a broad range of methods to engage communities in climate change adaptation activities. Its focus on applicability and the honest discussion of challenges make it useful guidance for implementing projects at grassroots level. Examples include the involvement of children in disaster risk identification through adapted methodologies. Experience revealed that children often have a broader understanding of global environmental problems as a result of school-based learning, and connect these problems to their own local experiences of disasters and extreme weather events.

Children were found to be excellent communicators and agents of change with a strong role as multipliers (e.g. with theatre performances or video clips) and implementers of specifically designed adaptation projects like child-led mangrove planting in the Philippines.

BOX 4:

INSURANCES IN INDIA

In India, changes in insurance regulations are giving rise to index-based weather risk insurance contracts as an alternative to tradi-tional crop insurance. Traditional crop insurance depends upon farm loss sampling after a given disaster. This means settling a claim can take up to a year, during which time farm families may suffer a loss of income. Private weather insurance contracts, on the other hand, can improve recovery times because they offer quick payouts triggered by independently monitored weather indices. These more innovative insurance mechanisms emerged in 1999, when India lifted its ban on private players in the insurance market. The resulting competition led to a series of pilot initiatives, through which companies tested a diversity of products and modes of delivery, often in partnership with state government or local development banks. At the same time, regulations required each company to provide some coverage in the rural sector, as well as for the "social sector," which includes unorganized or informal workers, as well as underprivileged or economically vulnerable classes. This directed innovation and market penetration toward agriculture. This example highlights a number of characteristics of adaptive policy. For one, the automatic adjustment feature of index-based insurance—triggered by climate information—provides a simple mechanism for managing insurer risk and determining farmer eligibility for benefit payments. It also passes along incentives for farmers to adjust to long-term change by providing signals calculated on the basis of actuarial risk. More generally, using pilot approaches has enabled policymakers and insurers to test key assumptions for iteratively refining program deliver, so as to better understand risk patterns and create awareness among farmers. The delivery of weather insurance through local microfinance institutions suggests the importance of two-way communication channels in fostering adaptive policy design by building in feedback mechanisms to respond to changing client needs or other condi-tions.

Source: IISD and TERI 2006; Cited from Weathering the storm (WRI 2007): p. 28.



4. Adaptation & mitigation options

As mentioned earlier, the amount of tested, genuine climate change adaptation is limited. Many publications instead depict the range of measures which can play a vital role in increasing resilience. Some are well known, best practices from the promotion of sustainable agriculture and forestry (e.g. contour farming) but some are also innovations which respond to climatic threats more specifically, like index-based insurances (see Box 4) or special dietary supplements to reduce the methane emissions of livestock (see below). All these measures taken together represent the response so far, to counter the expected effects. Lists of adaptation options for agriculture are discussed in the World Bank (2003) literature review, **Climate change and agriculture: Review of impacts and adaptations.** The measures discussed are farm-based, e.g. making use of the genetic diversity found in local seed banks. In Nigeria up to 12 varieties of pearl millet and 22 varieties of sorghum are used to counter pest and disease outbreaks in a changing climate. Breeding by the farmers themselves and exchange of seeds with neighbours is responsible for this agrobiodiversity, rather than the seeds handed out by extension services. Imported seeds are accepted when the advantages over indigenous seeds for changing climatic conditions are obvious (Kurukulasuriya/Rosenthal 2003:34). Other adaptation options discussed include migration and raising off-farm income to reduce dependence on agriculture.

Adaptation options for forests are described in **Adaptation of forests and people to climate change** (IUFRO 2009). One example of an adaptation by forest-dependent people in Latin America is the introduction of Community Forest Management (CFM). Enhancing local welfare through community-based forest management and restoration, agroforestry, use of non-wood forest products, availability of microfinance and support for women has had promising results in strengthening community resilience to climatic risks. Various factors have been contributing to this success:

- The local solutions required for the different natural and cultural settings of each community are being addressed.
- Local solutions have also been effective in entrepreneurial community level organizations: thus community companies, alliances or productive arms of political organizations can support the integration into markets.
- The integration of scientific and indigenous knowledge complies with the priorities of the community.
- The involvement and capacities for CFM are enhanced when forest organizations build on existing skills and regulations that govern social relations and natural resource use.

- Techniques developed for industrial settings are being adjusted to the needs of the community for successful implementation.
- External institutions (policy frameworks, markets) are being adjusted to support the inclusion of small producers.

Mitigation options for agriculture are discussed, inter alia, in a publication of the World Agroforestry Center (2007), **Opportunities for climate change mitigation in agriculture and investment requirements to take advantage of these opportunities.** The suggested mitigation measures include strategies like using less or organic fertilizers and the use of crops which require fewer chemical inputs. Other options require more work and management skills, e.g. the management of species composition to introduce more productive grass species with greater carbon allocation to the roots and nitrogen fixing legumes. Some of the options considered are currently under development, like adding "novel plant-derived compounds such as tannins, saponins, or essential oils" to the livestock diet to reduce methane (World Agroforestry Center 2007:67–69). Whether all these options are applicable in developing countries with non-intensive livestock systems is questionable.

Lists of the adaptation options discussed in publications are included as Annex II of this report. Typical recommended adaptation and mitigation options are:

Agriculture:

- sustainable farming practices, that is, reduced or no conservation tillage agriculture, contour farming, terracing, planting of hedges;
- changes in timing of farm operations;
- altering the intensity of fertilizers and pesticides;
- change in grazing management;
- water saving measures (increasing efficiency of irrigation, recycling of water, increasing water storage capacity);
- introduce irrigation;
- establish crop insurances;
- improve access to weather forecasts;
- improve storage facilities / food processing;
- relocate farms.

BOX 5:

ESTABLISH GRASS BARRIERS

Item	Description
Location where successfully applied	Pilot (Ludbur) and other sites
Suitability by hazard	Storms, floods & landslides
Environmental suitability	Flat and sloping land in most micro-climatic zones
Contribution to disaster risk reduction	Prevention and mitigation of hazard
Farming system	Mixed farming
Effectiveness Replicability Sustainability Contribution to LWM	o High o High o High o High
Implementation & maintenance requirement	Grass species: e.g. lemon grass, vetiver grass
Method of implementation	Grass barriers: Plant a suitable species of grass (e.g. Vetiver and Lemon grass) along the contour in the areas that needs stabilization. Optimal species should form an erect, stiff and uniformly dense hedge; should be able to survive stress with quick secondary growth; should not proliferate as a weed; and must require only a narrow width to be effective (The Australian Society of Agronomy, 1996).
Institutional requirement	Technical and financial support from Extension Division
Contribution to disaster reduction/prevention	Soil and water conservation

Source: Food and Agriculture Organization of the United Nations. 2007. Assistance to improve local agricultural emergency preparedness in Caribbean countries highly prone to hurricane related disasters. p. 32.

Forestry:

- protect forests through: law enforcement, sustainable forest management (SFM), community-based forestry, improve welfare of forest communities, protected area management, Reducing Emissions from Deforestation and Forest Degradation (REDD);
- afforestation;
- establish indigenous mixed-species stands for planted forests;
- improve fire management.

Agriculture and Forestry:

- mainstream climate change into agriculture and forest policies;
- crop and livestock diversification, including resilient crops/trees/livestock
- adopt agroforestry;
- watershed protection;
- make use of and document indigenous adaptation knowledge;
- control invasive species.

BOX 6:

TARA TREE CULTIVATION IN PERU

In 2003 risk analyses were conducted in Castilla Media that identified earthquakes, landslides and droughts as the major hazards. To reduce vulnerability to the two latter natural hazards, farmers began planting drought-resistant trees to stabilise slopes. The tara tree, a useful plant that is native to the region but had since almost sunk into obscurity, was considered especially suited to the planned purpose. It is well adapted to the prevailing conditions. It thrives on slopes, has low soil and water availability requirements, and has the great advantage that its pods and timber can be readily marketed. There is a strong demand for the seeds from its pods, from which fermenting and tanning agents can be obtained for use in breweries and the pharmaceutical industry. Alongside its protective function, the tara tree also provides an additional economic benefit. To implement the measure, committed farmers joined forces to form an association. PGRDCOPASA [Proyecto Gestión de Riesgo de Desastres con Enfoque de Seguridad Alimentaria de la Cooperación Peruana Alemana] supported it through organisational consultancy and targeted training measures. With financial support from GTZ, the members of the association established a small tree nursery where the young tara seedlings were nurtured. The labour performed there plus the administrative overheads were organised self-reliantly by the association. Once the young trees were large enough they were planted by the members along slopes susceptible to landslides. Planting was focused on those areas where landslides posed a constant threat to channels at the bottom of slopes. Results: A total of approximately 15,000 young trees were planted on eleven hectares of previously unutilised land. A cooperative now purchases and markets the pods of the tara trees (approx. 2.5 tons in 2006). This is also stimulating the cultivation of new tara trees at neighbouring locations, where the idea has been picked up and small tree nurseries have been established. The pods fetch a high price and the market forecast for tara is good, because it is anticipated that the demand – especially from the pharmaceutical industry – will rise.

Conclusions:

• The success of the measure was due the combination of risk-minimising measures with potential increases in income, as the farmers prefer to invest scarce resources in productive rather than preventive measures.

• The location of the tree nursery on the main road in the region raised the profile of the measure, and facilitated dissemination of the innovation.

• Initially it proved difficult to provide the needed irrigation for the planted trees. Slopes threatened by erosion are usually far away from irrigation channels, and are poorly accessible. Outside the rainy season, bucket-fed irrigation therefore requires a great deal of labour from the already overworked farmers, most of which is performed by women. Consequently, sealable clay vessels were sunk into the ground that feed the trees with moisture over a prolonged period, and only need to be filled with water sporadically.

(**Source**: GTZ 2008. Local capacity development for disaster risk management. Experiences of the Disaster risk management for food security in Arequipa project, Peru. p. 27.).

5. Conclusion

The majority of the available best practices for climate change adaptation are typical development measures from agroforestry, sustainable land use and so on. As the Report 'Weathering the storm' puts it:

"Rarely do adaptation efforts entail activities not found in the development 'toolbox.' The uniquely 'adaptive' elements of most efforts are those involved in defining problems, selecting strategies, and setting priorities—not in implementing solutions" (WRI 2007:1).

Most successful adaptation projects use a variety of strategies and components to deal with the multiple effects of climate change. The combination of measures to generally reduce vulnerability and to counter specific predicted impacts differentiates a climate change adaptation project from a classical development intervention in the agriculture sector. The predicted effects of climate change have two important attributes which have to be taken into account: first they are uncertain, depending on the reduction of greenhouse gas emissions and the actual changes (climate models are highly complex and therefore possibly imprecise). Secondly they focus on long term changes, from 15 to 100 years into the future. These characteristics should be factored in when developing an adaptation project.

The databases and best practices from long-established development areas (e.g. disaster risk management, sustainable forestry, water management, soil management, agroforestry, agricultural diversification) provide a valuable asset for climate change projects, because the knowledge and experiences generated in the last decades in these areas are well documented.

BOX 7:

SERVIR: ACCESSING CLIMATE INFORMATION FOR ADAPTATION IN CENTRAL AMERICA

Unlike their neighbors in North and South America, the countries of Central America do not have their own satellites or space agencies. They have traditionally had to make important decisions affecting their human and natural systems without the benefits of Earth observation data. This is changing, however, as these countries have started to leverage the satellite resources of other countries, such as the United States, to process Earth observation information through a system called SERVIR (the Spanish word for "to serve"). The system, which is based in Panama and serves all seven Central American countries and southern Mexico, uses this information to develop regional visualization and monitoring tools that ultimately enhance national and regional decision-making. The operational framework for SERVIR is relatively straightforward. Each participating country submits its own geospatial data to the central SERVIR hub in Panama, which is located at the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC). The SERVIR team then links this information to various types of satellite imagery for the region and disseminates the resulting data sets to decision-makers, researchers, educators, students, and the public via an Internet portal in both Spanish and English (http://www.servir.net). The portal offers online map viewing and free downloads of tools that help users understand the data. Additionally, CATHALAC provides training to environment ministries and meteorological services in the region for using SERVIR tools in their everyday work. SERVIR can generate different types of decision-support information. The system offers products for both monitoring and forecasting weather conditions on an hourly basis. Weather forecasters on the major television stations in Panama and El Salvador use SERVIR forecasts in their daily televised weather reports. The SERVIR system can also be used for disaster risk reduction measures, where computer-generated scenarios help identify vulnerable areas and populations. For example, during a November 2006 storm in Panama, SERVIR analysis was used as a basis for identifying, notifying, and evacuating inhabitants in areas vulnerable to flooding and landslides. SERVIR's Web Fire Mapper, which is implemented in partnership with the University of Maryland, detects burning fires and can send out e-mail alerts on the location of the fires. In Nicaragua, the forestry department sends out ground crews to assess the situation upon receipt of fire alerts from the system. Satellite data available through the SERVIR can also help governments monitor ocean tides, helping them warn fishermen of toxic algal blooms ("red tides"). These decision-support products and experiences all rely on regional data sharing, which SERVIR encourages. In fact, SERVIR allows for the standardization of disparate data sets from multiple sources. It is the first regional system of its kind in the world and is a testament to leveraging North–South and South–South collaboration for using Earth observations for the benefit of society.

Source: USAID/SERVIR 2007. Cited from 'Weathering the Storm' (WRI 2007): p. 29.

While the online databases for climate change practices are numerous, many lack the experiences and data needed to be useful and applicable. Positive examples are the databases set up by the UNFCCC, such as the Local Coping Strategies Database. As the UNFCCC is generally accepted as the leading international body on climate change issues, this is no surprise.

BOX 8:

AGROFORESTRY IN SRI LANKA – Cultivating crops in coconut plantations

Hazard(s): Drought/ aridity

Impact(s): Loss of crops

Strategy(s): Alternative cultivation methods

Summary

The wide range of traditional agroforestry (planting crops among trees) practices in Sri Lanka offers a promising solution to the ever-declining per capita availability of agricultural land. Coconut is the most widely planted agro-based industrial tree in Sri Lanka, covering 25% (419,200 ha) of the total cultivated area of the country.

On most coconut estates a variety of different crops are cultivated including food crops (such as tubers, cereals, legumes and fruits), spices and condiments (such as arecanut, betel leaves, chillies, ginger and turmeric), and cash crops (like black pepper, cacao, cinnamon, cloves, coffee and nutmeg). On some plantations pasture grass is grown in between coconut trees to allow cattle to graze. Bananas, black pepper, coffee, ginger, turmeric, betel, vegetables and pineapple are the preferred species because they can grow in shade and provide a good income. The most common crop mixtures in mature coconut plantations are coffee and banana; coffee and pineapple; pineapple and papaya; and banana, coffee and cacao. When farmers intercrop, the coconut trees benefit from the manure and fertilizers, weeds are eliminated, and the land is more productive.

Resources required: land, coconut palms, seeds or seedlings, labour. This mixed-cropping is a suitable technology for areas with declining per capita availability of agricultural land

Potential maladaptation: none

Non-climate benefits: enhanced productivity

Source: UNFCCC Local Coping Strategies Database. http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.pl?id_project=29

Some lessons learned were cited in multiple case studies:

- All development measures which reduce poverty and build capacities to deal with changing circumstances help to reduce vulnerability and thus adaptation to climate change. This can include, inter alia, poverty reduction, livelihood diversification, disaster risk management, and enabling access to information and capacity building.
- The integration of anticipated climatic changes in project planning leads to adaptation results which add value, compared with projects aimed at a broad reduction of vulnerability which do not take specific predicted changes into account.
- An adaptation project that offers additional benefits (for example increased income through higher yields) is attractive for the target community.
- Lessons learned from other development projects on the importance of taking local circumstances into account and achieving ownership through broad participation are obviously valid for climate change adaption projects as well.
- Local institutions and indigenous people are experienced in adapting to changing conditions. Building on their knowledge fosters participation and ownership, can be very profitable and eases the implementation
- Possible 'maladaptations' should be analyzed carefully, so that an intervention does not have unintended side effects which increase vulnerability. (For example, an agricultural policy might support a monoculture of high-value crops—e.g. through subsidies—with the objective of maximizing production and incomes. As a consequence, in the absence of insurance against yield losses, the farmers' income generation base becomes more vulnerable to climate variability, thereby lowering adaptive capacity.)
- Development programmes should integrate climate change adaptation into their planning process and make it an integral part of any project (mainstreaming climate change).

- Climate risk management should become part of the decision-making of farmers. Development programmes should provide incentives for this, e.g. by lower interest rates in micro-finance schemes if the investment takes climate change into account.





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BOX 9:

INSTITUTIONALISING DISASTER RISK MANAGEMENT IN MOZAMBIQUE

Mozambique is one of the countries in Africa most frequently and most seriously affected by natural disasters such as floods, cyclones and droughts. During the floods in 2000, over 700 people lost their lives, thousands became homeless, and altogether over 4 million people were affected. At the same time, Mozambique is one of the poorest and most vulnerable countries in the world, and there is a close link between poverty, vulnerability and disaster risk. Today, it is widely agreed that disaster risk management (DRM), poverty eradication and sustainable development are interdependent, and that DRM measures need to be integrated into the development planning of regions at risk. This includes both the vulnerable population at the local level as well as relevant actors at the different political and institutional levels.

The DRM component in the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH Programme for Rural Development in Central Mozambique (Programa para o Desenvolvimento Rural – PRODER) follows this idea. For the Búzi district, at first a participatory risk analysis was carried out, which identified approximately a third of the district's population as being endangered by the different types of disaster. Subsequently, different measures and activities from the 'disaster prevention' and 'disaster preparedness' components were implemented in order to reduce the vulnerability of the population and – where possible – the hazard risk as well, especially concerning the risk of floods and cyclones. These measures included the construction of new settlements on higher ground further away from the river, cyclone-resistant construction measures in the rebuilding of the damaged infrastructure, a disaster preparedness simulation and the implementation of early warning systems. A key factor was the sensitisation of the actors on different levels with regard to the topic of DRM and its advantages. This was achieved via numerous workshops, seminars and work meetings in Búzi and the endangered communities, which showed good success at the district level. Furthermore, the project provided the population at local level with a good basic and advanced training programme, based on GTZ's wide experience with DRM and flood early warning systems in Central America. Important progress was also made with training at the political level, and a concept to integrate DRM measures into the district development plan was formulated in close cooperation with the district administrator of Búzi, who has already presented the positive experiences of the project at international conferences.

The vulnerability of the population in the Búzi district with respect to the dangers of floods and cyclones has clearly been lowered by the implemented DRM concept, which represents an important contribution to sustainable rural development in the region. The selected methodology has proven successful and should be used in other disaster-prone districts.

Source: GTZ. 2005. Disaster risk management along the Rio Búzi. Case study on the background, concept and Imple-mentation of disaster risk management in the context of the GTZ-Programme for Rural Development page 4. (http://www.gtz.de/de/dokumente/en-mz-disaster-risk-management-rio-buzi.pdf)



Annex I: Collection of best practices

The documents reviewed so far and many more are presented in the attached tables. The first columns contain the title, the publisher, the URL and the date of publication as well as the number of pages, to provide some general information about the document. The next four columns are intended to help find the most suitable document. The following categories are used:

- *Adaptation and/or mitigation:* This refers to the goal of the measure. Is a reduction in vulnerability to climate change the expected result (adaptation), or will greenhouse gas emissions be reduced through the described measure (mitigation)?

- *Sector:* Agriculture, Forestry: Is the example from the agriculture or forestry sector or does it cover both (such as agroforestry etc)?

- *Level of Intervention:* research, policy and/or extension-services. Who is the target group of the document and how is it presented? The category Research refers to scientific articles and information, while policy is aimed at policy makers, governmental staff and agencies working on the level of policy formulation. Extension refers to concrete examples of measures which can be used directly by extension officers to advise farmers.

- *Keywords:* the keywords define the topic and content further. If a measure is designed to improve resilience to a specific climate impact, it is marked here as well.

- *Summary:* A short description of the listed document provides the user with additional information to decide whether the document might be relevant for his/her purpose.

Table 1 lists *documents* which feature adaptation and mitigation best practices. These are, for example, collections of best practices or project documents where a variety of interventions was tested, but also basic literature on adaptation where options are discussed.

Table 2 lists Internet Databases where a selection of best practices can be searched and found according to the interest of the user. Table 3 describes concrete measures and case studies of a specific adaptation/mitigation method.



Table 1. Compilation of Publications including Adaptation and Mitigation Measures in the Agriculture and Forestry Sector: Documents

Title	Publisher	URL	Published	No. of Pages	Adaptation/ Mitigation	Agriculture/ Forestry	Research/ Extension/ Policy	Keywords	Summary
How can smallholder tea and coffee growers cope with climate change?	GTZ	http://www.adapcc.org/download/Synthesis_Report_AdapCC_200804.pdf	2008	68	Adaptation	Agriculture	Extension	coffee, tea, smallholder farms, PPP	Description of GTZ projects supporting smallholder farmers to adapt to climate change in the tea and coffee sector. Adaptation options are identified and explained.
Climate change and agriculture: threats and opportunities	GTZ	http://www2.gtz.de/dokumente/bib/gtz2008-0555en-climate-change-agriculture.pdf	2008	36	Adaptation / Mitigation	Agriculture	Policy, extension, research		Exploration of adaptation and mitigation options including required policy changes.
Assistance to improve local agricultural emergency preparedness in Caribbean countries highly prone to hurricane-related disasters	FAO	http://www.fao.org/sd/dimpe4/docs/pe4_070402_en.pdf	2007	76	Adaptation	Agriculture	Extension	cyclone, storm, mudslide, flood, disaster risk management	Collection of a variety of best practices on how farmers in the Caribbean improve their resilience towards natural disasters.
Improved adaptive capacity to climate change for sustainable livelihoods in the agriculture sector	FAO / UNDP / DFID	ftp://ftp.fao.org/docrep/fao/010/i0481e/i0481e.pdf	2008	64	Adaptation	Agriculture	Extension	drought, dry spells, irrigation, adapted species	Project report from an adaptation project in Bangladesh describing potential adaptation options (such as home gardening, introduction of new species, composting) and lessons learned from a drought prone area.
No-tillage seeding in conservation agriculture	FAO / CAB	http://www.cober.org.pe/fao/docs/Agriculture/Excerpts%20of%20no-till%20farming.pdf	2007	15	Adaptation / Mitigation	Agriculture	Research	zero tillage, conservation agriculture	Article describing the advantages of no-tillage farming, and seeding for erosion control and emission reduction.
Climate variability and change: adaptation to drought in Bangladesh. A resource book and training guide	FAO / ADPC	ftp://ftp.fao.org/docrep/fao/010/a1247e/a1247e00.pdf	2007	66	Adaptation	Agriculture	Extension	drought, dry spells, irrigation, adapted species	Training manual on climate risk assessment and agricultural adaptation options.
Climate change and food security in Pacific Island countries	FAO	ftp://ftp.fao.org/docrep/fao/011/i0530e/i0530e.pdf	2008	280	Adaptation	Agriculture	Policy, extension	Pacific, institutions,	Case studies on the vulnerabilities and adaptation options for Vanuatu, Marshall Islands and Cook Islands. Some general lessons learned included effective participation, role of population growth, programme complexity.
Opportunities for climate change mitigation in agriculture and investment requirements to take advantage of these opportunities	World Agroforestry Centre	http://www.worldagroforestry.org/downloads/publications/PDFs/rp15435.pdf	2007	72	Mitigation	Agriculture	Research, extension	costs, livestock, crops, land use change, mitigation potential	Report for the UNFCCC on mitigation potential and costs in the agricultural sector. No case studies, but extensive list of mitigation options.
Agriculture. In climate change 2007: mitigation. Contribution of working group III to the fourth assessment report	IPCC	http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter8.pdf	2007	44	Mitigation	Agriculture	Research, extension	cropland management, grazing, livestock, rice, degraded land, manure management, mitigation potential, costs, agroforestry	IPCC report on mitigation in agriculture features options and bibliography.
ADAPTIVE: Adaptations to climate change among natural resource-dependent societies in the developing world: across the Southern African climate gradient	Tyndall Centre	http://www.tyndall.ac.uk/research/theme3/final_reports/t2_31.pdf	2005	47	Adaptation	Agriculture	Extension, policy	Institutions, networks, innovation, local knowledge, drought, flooding	Study of the coping and adaptation capacities of southern African communities with a focus on social relations and organization. Key findings are: formal farm associations enable knowledge transfer even in absence of extension officers; strong links between formal and informal structures enhance adaptive capacity; adaptation measures that fail to address the decision making context in the community are likely to fail.

Agricultural diversification for the poor. Guidelines for practitioners	World Bank	http://sdwebx.worldbank.org/climateportal/Knowledge%20Base%5CKB%20-%20Tools%5CAgricultural_diversification_for_Poor_Guidelines_2004_WB.pdf	2004	52	Adaptation	Agriculture	Extension, policy	cropping systems, erosion, no-till agriculture, diversification	Guide for diversification in agriculture. Includes concrete examples and case-studies. Not explicitly climate change though.
Manual on integrated soil management and conservation practices	FAO	http://sdwebx.worldbank.org/climateportal/Knowledge%20Base%5CKB%20-%20Biodiv%20and%20CC%5Cfao%20manual_soil_conservation.pdf	2000	228	Adaptation / mitigation	Agriculture	Extension	soil management, erosion control, zero-tillage, irrigation, green manure	Manual for sustainable agriculture focusing on soil management. In-depth description of different options. Climate change not mentioned explicitly.
The use of saline waters for crop production	FAO	http://www.fao.org/docrep/T0667E/t0667e00.htm	1992	?	Adaptation	Agriculture	Extension	irrigation, salinity, salt water	Publication elaborating the potential of salt water for agricultural production. Not climate change specific.
Electronic learning guidebook on participatory irrigation management	World Bank	http://sdwebx.worldbank.org/climateportal/Knowledge%20Base%5CKB%20-%20Tools%5CElectronic_Handbook_Participatory_Irrigation_Management_WB.mht	1998	?	Adaptation	Agriculture	Policy	irrigation, drought, water management	Guidebook on participatory irrigation management with case studies from Mexico, Colombia, Indonesia, Albania, Turkey and the Philippines.
Sharing lessons. Hazard risk preparedness in agriculture: good practice examples from South and South East Asia	FAO	ftp://ftp.fao.org/docrep/fao/010/ah831e/ah831e.pdf	2007	25	Adaptation	Agriculture	Extension	multi cropping, soil conservation, water management, mulching, erosion control, weather forecasting	Documentation of best practices for disaster risk management strategies in agriculture in Asia.
Caravan 25: Review of agriculture in the dry areas. Special issue on climate change	International Center for Agricultural Research in the Dry Areas (ICARDA)	http://www.icarda.cgiar.org/Publications/Caravan/Caravan25/Caravan25.pdf	2008	64	Adaptation / Mitigation	Agriculture	Research	plant breeding, livestock, water management, irrigation, organic soil matter	Special Issue of ICARDA's journal Caravan on climate change. The article focuses on current research about climate change-related topics but includes practical tips for climate change-proofing a farming system.
Policy and technological constraints to implementation of greenhouse gas mitigation options in agriculture	Smith et al	http://researchspace.csir.co.za/dspace/bitstream/10204/566/1/Smith_2007.pdf	2007	23	Mitigation	Agriculture	Research, policy	greenhouse gas, agriculture, mitigation, cropland management, grazing land, rice, livestock, carbon sequestration, policy	Scientific article about mitigation options in the agriculture sector, including obstacles and potential co-benefits.
Challenges and opportunities for mitigation in the agricultural sector	UNFCCC	http://www.donorplatform.org/component/option,com_docman/task,doc_download/gid,929/	2008	101	Mitigation	Agriculture	Policy, extension, research	livestock, manure management, agroforestry, policies	Technical paper on mitigation potential in the agriculture sector, including case studies and an extensive list covering the different options and barriers.
Climate change and agriculture. Review of impacts and adaptations	World Bank	http://www.c-ciarn.uoguelph.ca/documents/World_Bank_Paper.pdf	2003	106	Adaptation	Agriculture	Policy, extension	migration, insurance, cropping pattern, water management, trade, diversification, climate data, planning	Extensive discussion of a comprehensive collection of adaptation options, but without referring to proven examples.
Lessons learned in preparing national adaptation programmes of action in Eastern and Southern Africa	ECBI / GTZ	http://www.eurocapacity.org/downloads/ecbi_NAPA_PA_Project_2007.pdf	2008	42	Adaptation	all	Policy	NAPA	Survey of NAPA processes. Focus on decision making and structure, not on single adaptation measures. NAPAs are more than plans for action because the development of NAPAs creates awareness and capacities to prioritize adaptation measures if stakeholder participation is strong.

Adapting to climate change	GTZ	http://www2.gtz.de/dokumente/bib/07-1394.pdf	2007	36	Adaptation	all	Policy, extension	adaptation strategies, mainstreaming,	Description of GTZ adaptation projects covering different issues like water management, national adaptation strategies, insurances, disaster risk management.
Assessing carbon stocks and modelling win-win scenarios of carbon sequestration through land-use changes	FAO	ftp://ftp.fao.org/agl/agll/docs/carbonstocks.pdf	2004	166	Mitigation	all land uses	Research, extension	land use change, land use planning, land management, carbon stocks, biodiversity	Report on three projects using a sophisticated software developed by FAO to model the impacts of different land uses
Reducing emissions from deforestation in developing countries	GTZ	http://www.gtz.de/de/dokumente/en-climate-reducing-emissions.pdf	2007	32	Mitigation	Forestry	Policy	REDD	Overview of the international discussion about REDD as well as a review of pilot projects, addressing critical issues in concept design
Adapting to climate change. Unasylva no. 231/232, Vol. 60, 2009/1–2	FAO	ftp://ftp.fao.org/docrep/fao/011/i0670e/i0670e00.pdf	2009	92	Adaptation	Forestry	Research	forest health, science, pests, traditional knowledge, forest genetics	Issue of the scientific forestry journal of FAO focusing on adaptation to climate change. Many articles deal with non-tropical examples, but tropical forests are also dealt with. Best practices on indigenous knowledge about adaptation are described as well as general adaptation strategies.
Climate change and the forest sector. Possible national and sub-national legislation	FAO	ftp://ftp.fao.org/docrep/fao/007/y5647e/y5647e00.pdf	2004	75	Mitigation	Forestry	Policy	afforestation, reforestation, sequestration, carbon credits, CDM, legislation	Issue of the forestry journal of FAO focusing on legislation and policies for mitigation in forestry. Important issues as well as legislation on carbon rights from different countries are described.
Adaptation of forest ecosystems and the forest sector to climate change	FAO	ftp://ftp.fao.org/docrep/fao/008/J6525e/J6525e00.pdf	2005	98	Adaptation	Forestry	Policy	project planning, legislation, policy vulnerability assessment	Working paper covers the whole range of adaptation and forestry topics: from the international to the national level as well as categorizing different adaptation options at the project level. Some case studies are included as well.
Adaptation of forests and people to climate change	International Union of Forest Research Organizations (IUFRO)	http://www.iufro.org/download/file/3580/3985/Full_Report.pdf	2009	224	Adaptation	Forestry	Policy, extension	local knowledge, SFM, management strategies, forest health, pests, forest fires, water, governance	Extensive brochure about adaptation of forests (boreal, subtropical and tropical) to climate change, covering impacts, vulnerabilities, adaptation options, management, governance and policies for adaptation, including list of options and a few case studies.
Mangrove rehabilitation guidebook	Global Nature Fund (GNF)	http://www.mangroverestoration.com/pdfs/Brochure_Sri_Lanka_GNF.pdf	2007	68	Adaptation / Mitigation	Forestry	Extension	mangroves, coastal erosion,	Guidebook on rehabilitation and afforestation with mangroves. Includes best practices from projects in Sri Lanka after the tsunami
The role of local institutions in reducing vulnerability to recurrent natural disasters and in sustainable livelihoods development	FAO	ftp://ftp.fao.org/docrep/fao/007/ae190e/ae190e00.pdf	2004	72	Adaptation	misc	Policy, extension	disaster risk management, floods, mudslides, cyclones, early warning systems	Best practices from different countries on how local institutions can play a role in disaster management.
Technologies for adaptation to climate change	UNFCCC	http://unfccc.int/resource/docs/publications/tech_for_adaptation_06.pdf	2006	40	Adaptation	misc	Extension	inundation, irrigation, weather forecast	Few examples of successful adaptation technologies and projects.
Climate change: impacts, vulnerabilities and adaptation in developing countries	UNFCCC	http://unfccc.int/resource/docs/publications/impacts.pdf	2007	68	Adaptation	misc	Extension, policy	projects,	Brochure about impacts and adaptation with many short examples of best practices
Weathering the storm. Options for framing adaptation and development	WRI	http://pdf.wri.org/weathering_the_storm.pdf	2007	66	Adaptation	misc	Extension, policy	projects, insurance, institutions, water management, climate data, drought	Analysis of 135 adaptation projects with some best practice examples, discussion about the content of adaptation projects compared with normal ODA.
Adaptation policy frameworks for climate change. Section III: case studies	UNDP	http://www.undp.org/GEF/documents/publications/apf-sectionIII_case%20studies.pdf	2004	20	Adaptation	misc	Policy	programme, project, planning, water, maize, varieties, Kiribati	Case studies using the Adaptation Policy Framework of UNDP, focusing on the process of project planning and implementation and activities carried out.

Assessment of adaptation practices, options, constraints and capacity	IPCC	http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter17.pdf	2007	28	Adaptation	misc	Policy, research	economics, drought, sea-level rise	Chapter 17 of the 4th Assessment Report, covering adaptation options in different parts of the world and discussing briefly examples, opportunities and barriers.
Climate change. Adaptation and mitigation in development programmes	World Bank	http://siteresources.worldbank.org/EXTEEI/Resources/DCCToolkitCRAlores.pdf	2008	98	Adaptation / Mitigation	misc	Policy	sectoral reforms, crop diversification, drought resistant crops, irrigation, soil conservation, drought management, watershed management, seed banks, plantations	A practical guide to the links between the design of development programmes and the objectives of adapting to climate change and limiting emissions of greenhouse gases. Includes clear references to the agricultural sector and a list of policy options and corresponding indicators for climate change activities in different sectors.
Good practices for hazard risk management in agriculture. Summary report Jamaica	FAO	ftp://ftp.fao.org/docrep/fao/010/ai147e/ai147e00.pdf	2008	67	Adaptation	Agriculture	Extension	storm, flood, drought, landslides, soil conservation, irrigation, fire breaks, water storage, resilient crops,	Collection of good practices from a project to improve disaster risk management in Jamaica. About 20 different coping strategies were identified.
Reducing vulnerability, enhancing resilience. The importance of adaptation technologies for the post-2012 climate agreement	Caritas	http://www.caritas.org/includes/pdf/bonn09fullreport.pdf	2009	23	Adaptation	misc	Extension, policy	drought, early warning systems, diversification, afforestation, soil conservation, indigenous knowledge	Document describing adaptation projects, which discusses adaptation technologies in relation to to the post-Kyoto negotiations. Features an extensive list of adaptation options for different sectors.
Local capacity development for disaster risk management	GTZ	http://www.gtz.de/de/dokumente/en-pe-local-capacity-for-disaster-risk-management-2008.pdf	2008	36	Adaptation	Agriculture	Extension, policy	disaster risk reduction, food security, mainstreaming, landslides, diversification, irrigation	Documentation of experiences gained in a disaster risk management project in the Andes, Peru. Best practices on mainstreaming disaster risk management into planning processes and the education system are provided as well as examples from the agricultural sector (planting tara trees and improved livestock rearing).
Disaster risk management along the Rio Búzi. Case study	GTZ	http://www.gtz.de/de/dokumente/en-mz-disaster-risk-management-rio-buzi.pdf	2005	28	Adaptation	Misc	Policy	disaster risk reduction, flood, drought, cyclone, mainstreaming	Case study on the background, concept and implementation of disaster risk management in the context of the GTZ-programme for rural development in Mozambique.
Disaster risk management in a changing climate	Vulnerability and Adaptation Resource Group (VARG}	http://www.unisdr.org/eng/risk-reduction/climate-change/docs/DRM-in-a-changing-climate.pdf	2005	45	Adaptation	Misc	Policy, research	disaster risk reduction	Discussion oaper on the links between disaster risk management and climate change adaptation. The document includes case studies in which climate change adaptation and disaster risk management were successfully implemented in an integrated approach
Addressing the humanitarian challenges of climate change: regional and national perspectives – case studies on climate change adaptation	Inter-Agency Standing Committee (IASC)	http://www.humanitarianinfo.org/iasc/downloaddoc.aspx?docID=4862&type=any	2010	47	Adaptation	Misc	Extension	disaster risk reduction, flood, drought, community based adaptation	Collection of examples of climate change adaptation projects from all over the world. The collection takes a humanitarian perspective but features examples from many related sectors such as disaster risk management, health and livelihood programmes
Participatory learning and action no. 60: Community-based adaptation to climate change	IIED	http://www.iied.org/pubs/pdfs/14573IIED.pdf	2009	221	Adaptation	Misc	Extension	Community-based adaptation, tools, awareness raising, agriculture	Collection of experiences with a variety of participatory tools to engage communities in climate change adaptation activities. Its focus on applicability and the honest discussion of challenges provide useful guidance on implementing projects at grassroots level.

Table 2. Compilation of Publications including Adaptation and Mitigation Measures in the Agriculture and Forestry Sector: Internet Databases

Title	Publisher	URL	Adaptation/Mitigation	Agriculture/ Forestry	Research/ Extension/ Policy	Keywords	Summary
Vulnerability and Adaptation Database	WRI	http://projects.wri.org/adaptation-database	Adaptation	all	Policy, extension	projects, programmes, initiatives	Database with 135 case studies of adaptation projects, categorized by, e.g., region, impact, strategy employed.
Database of Indigenous Knowledge and Practices	World Bank	http://www4.worldbank.org/afr/ikdb/search.cfm	Adaptation	misc	Extension	agroforestry, livestock, forestry, pest management, post harvest, soil conservation, water management	Database featuring indigenous knowledge about different sectors, including agriculture and forestry.
Climate Change Data Portal	World Bank	http://sdwebx.worldbank.org/climateportal/?page=display_projects&type=kundefined	Adaptation	all	Research, policy, extension	crops, cropping pattern, drainage, drought, irrigation, land management, livestock, mangroves, pests, salinity, erosion	Database with documents and publications relevant to adaptation to climate change, not all of which targets direct adaptation but rather general increase of resilience.
NAPA Project Database	UNFCCC	http://unfccc.int/cooperation_support/least_developed_countries_portal/napa_project_database/items/4583.php	Adaptation	all	Policy, extension	NAPA, programmes, food security, agriculture, livestock, land management, forests, insurance, early warning systems	Lists of all NAPA projects categorized by sector with a description of the projects, inputs, risks, etc.
Local Coping Strategies Database	UNFCCC	http://maindb.unfccc.int/public/adaptation/	Adaptation	all	Extension, policy	erosion, waterlogging, land slides, inundation, forests, food security, livestock	Database of local coping strategies categorized by hazard, impact and coping strategies. Very useful project examples.

Funding for Adaptation	UNFCCC	http://unfccc.int/adaptation/implementing_adaptation/adaptation_funding_interface/items/4638.php	Adaptation	all	Policy	finance, funds, grants	Database of available funding mechanism for adaptation to climate change. Categorized by type of funding, region and sector.
Adaptation Practices	UNFCCC	http://unfccc.int/adaptation/nairobi_workprogramme/adaptation_practices_interface/items/4555.php?anf=&sorted=&site=1&type=&region=&focus=&means=	Adaptation	all	all	projects, programmes, initiatives	Database including a wide range of projects and initiatives tackling adaptation to climate change, often useful links.
Adaptation Learning Mechanism (ALM)	UNDP, UNEP, World Bank, GEF	http://www.adaptationlearning.net/	Adaptation	all	Extension, policy		Joint Database of UNDP, UNEP, GEF, World Bank which is providing country profiles, tools, case studies and lessons learned about adaptation projects. Unfortunately not very many entries yet. High potential.
WeAdapt	misc	http://www.weadapt.org/	Adaptation	all	all	projects, methods, tools, organizations	Portal including database and wiki for an exchange of experiences, tools and methods. The case study section is not very large yet. Focus is on Africa but will be extended.
Best practices and Policies Agriculture and Climate Change	Global Donor Platform for Rural Development	http://www.donorplatform.org/component/option,com_docman/task,cat_view/gid,62/Itemid,98/	Adaptation	Agriculture	all	projects, policy,	

Technology for Agriculture. Proven Technologies for Smallholders	FAO	http://www.fao.org/sd/Teca/index_en.asp	Adaptation / Mitigation	Agriculture / Forestry	Extension	livestock, cropping systems, horticulture, disaster risk reduction, forestry, agroforestry,	Database of the FAO providing multiple best practices from the agriculture sector, although not climate change specific.
World Overview of Conservation Approaches and Technologies	FAO	http://www.fao.org/ag/agl/agll/wocat/wocatqt.asp	Adaptation / Mitigation	Agriculture / Forestry	Extension	agroforestry, livestock, forestry, erosion control, soil conservation, water management	Database focusing on soil conservation and related technologies. No climate change focus.
FAO CC publications by topic	FAO	http://www.fao.org/climatechange/49391/en/	Adaptation and Mitigation	all	all		FAO publications sorted by topic, but not all FAO materials are included.
Linking Climate Adaptation	ELDIS (Institute of Development Studies)	http://www.eldis.org/go/topics/dossiers/climate-change-adaptation	Adaptation	all	all	organizations, projects, documents	Portal with an extensive database on climate change adaptation projects and studies.
Harmonisation Portal: Exploring Synergies between Climate Change Adaptation and Disaster Risk Reduction	ProVention Consortium	http://www.proventionconsortium.org/?pageid=95	Adaptation	Cross cutting	All	disaster risk reduction	Portal featuring country case studies of the integration of disaster risk and climate change adaptation and main actors in the field.
Disaster Risk and Climate Change	United Nations International Strategy for Disaster Reduction	http://www.unisdr.org/eng/risk-reduction/climate-change/climate-change.html	Adaptation	Cross cutting	all	disaster risk reduction	Portal on the links between climate change and disaster risk reduction.

Table 3. Compilation of Publications including Adaptation and Mitigation Measures in the Agriculture and Forestry Sector: Case studies

Title of case study	Published in	Publisher	URL	Case study on page number	Adaptation/Mitigation	Agriculture/ Forestry	Research/ Extension/ Policy	Keywords	Summary
Climate change in West Africa. Sahelian adaptation strategies	Online database	OECD	http://www.donorplatform.org/component/option,com_docman/task,doc_download/gid,997/	na	Adaptation	Agriculture	Extension	drought, erosion,	Case study from western Africa about adaptation techniques used by local farmers, including: building walls and earthen dykes, water pockets, improved clearing.
Drought in El Salvador: response and mitigation	Drought in El Salvador: Response and mitigation	Red Cross	http://www.ifrc.org/docs/pubs/disasters/reduction/ElSalvador-droughts-en.pdf	na	Adaptation	Agriculture	Extension	drought, food aid, diversification, irrigation, afforestation	Project dealing with droughts in El Salvador combining food aid and sustainable agriculture development.
Applying space-based assets to development assistance	Integrating climate change into development	USAID	http://www.donorplatform.org/component/option,com_docman/task,doc_download/gid,927/	7	Adaptation	Agriculture	Policy, extension		Description of a project using satellite visualization and a regional data hub to assist authorities and communities in disaster management, land use planning, fire prevention. etc.
Cropping system in Tamil Nadu, India	Online database	UNFCCC	http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.pl?id_project=42	na	Adaptation	Agriculture	Extension	drought, aridity, soil erosion, soil conservation, coconut	Innovation by Indian farmers to cope with wind erosion and loss of soil fertility through application of farm manure, earlier planting of coconut seedlings and introduction of new crops.
Climate proofing: practical tips on farm management	Caravan 25: Review of agriculture in the dry areas. Special issue on climate change	ICARDA	http://www.icarda.cgiar.org/Publications/Caravan/Caravan25/Caravan25.pdf	59	Adaptation	Agriculture	Extension	irrigation, reduced tillage, soil health, varieties, planting, rotation	Simple management methods to minimize the damage caused by extreme weather events
Community forest management as an option for adaptation of forest-dependent people in the tropical rainforests of Latin America	Adaptation of forests and people to climate change	IUFRO	http://www.iufro.org/download/file/3580/3985/Full_Report.pdf	137	Adaptation	Forestry	Policy, extension	SFM, community forest management, non-wood forest product	Case study of community-based management of forest resources in Latin America. Some success factors are described.

SERVIR: accessing climate information for adaptation in Central America	Weathering the Storm. options for framing adaptation and development	WRI	http://pdf.wri.org/weathering_the_storm.pdf	29	Adaptation	misc	Extension, research	climate data, meteorology, disaster risk management, satellite maps	Case study of a regional earth observation centre for Central America. SERVIR combines satellite and regional climate data to provide information for decision-making.
Insurances in India	Weathering the Storm. Options for framing adaptation and development	WRI	http://pdf.wri.org/weathering_the_storm.pdf	28	Adaptation	Agriculture	Policy	risk management, insurance, social security	Case study of index-based weather insurance for farmers, which allow lower costs and quicker transfers than traditional crop insurances based on farm loss sampling.
Floating agriculture in Bangladesh	Online database	UNFCCC	http://unfccc.int/resource/docs/publications/tech_for_adaptation_06.pdf	25	Adaptation	Agriculture	Extension	inundation, flooding, sea-level rise	Farmers in Bangladesh build floating gardens out of waterborne creepers as parts of the farmland are inundated for long periods.
Mulching and zero tillage in American Samoa	Online Database	UNFCCC	http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.pl?id_project=85	na	Adaptation, Mitigation	Agriculture	Extension	floods, soil erosion, soil conservation, zero tillage, taro	Methods developed in American Samoa to reduce the soil erosion on slopes used for cultivating taro. The measures proposed are: mulching with weeds, using a planting stick, planting legumes, and contour farming.
Agroforestry in Sri Lanka	Online database	UNFCCC	http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.pl?id_project=29	na	Adaptation	Agriculture	Extension	drought, agroforestry, coconut	Agroforestry in coconut plantations in Sri Lanka allows the cultivation of food and cash crops as well as providing pasture land, thus reducing the pressure on scarce arable land.
Mangrove reforestation in southern Thailand	Online database	UNFCCC	http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.pl?id_project=154	na	Adaptation / Mitigation	Forestry	Policy, extension	mangroves, afforestation, coastal rehabilitation, storm, inundation, coastal erosion	Case study from a mangrove rehabilitation project. Through the reforestation and maintenance of protected mangroves the coastal communities are protected against storm surges and derive income from collecting seafood.

Indigenous forecasting in Kenya	Online database	UNFCCC	http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.pl?id_project=113	na	Adaptation	Agriculture	Extension, research	drought, disaster risk management	This project tried to collect and re-establish indigenous weather forecasting knowledge and indicators to help farmers to respond in a timely manner to climatic events.
Reducing climate vulnerability through micro-credit in Nicaragua	Policy guidance on integrating climate change adaptation with development co-operation	OECD	http://www.oecd.org/dataoecd/26/34/42747370.pdf	169	Adaptation	Agriculture	Extension, policy	micro-credit, soil conservation	Summary of a micro-credit programme in Nicaragua which gives loans to farmers. If the farmers use the advice given by the lending institution and incorporate conservation activities and environmentally friendly agriculture (preventing soil erosion, reforestation), the interest rates are lower. This creates an incentive for the farmers to introduce resilience-enhancing activities.
Removal of foliage from immature bananas	Good practices for hazard risk management in agriculture. summary report Jamaica	FAO	ftp://ftp.fao.org/docrep/fao/010/ai147e/ai147e00.pdf	37	Adaptation	Agriculture	Extension	strong winds, cyclones	Farmers in Jamaica remove the foliage of immature bananas when a hurricane is approaching. The foliage will grow back afterwards.

Annex II: Adaptation options

Source: Climate change and agriculture. Review of impacts and adaptations (Kurukulasuriya / Rosenthal 2003, copyright by the International Bank for Reconstruction and Development, The World Bank).

Adaptation option:	*Purpose*	*Necessary supporting policies*	*Other prerequisites*	*Limitations*
Short term				
Crop Insurance Private/public programs Formal/informal schemes	Enabling improved risk coverage	Improving access Risk management through risk reduction and risk sharing Improving supervisory capacity Revising pricing incentives Improving affordability / availability of coverage for catastrophes	Synergies between govt. and private sector in bearing risks Minimizing information asymmetries Establishing enforcement mechanisms Introducing measures for the correct estimation of premiums Innovative schemes should be pursued (e.g. tradable financial assets; catastrophic bonds; weather markets	Risk averse communities/ insufficient collateral High opportunity costs of public funds High monitoring costs (institutional limitations) Adverse selection/moral Hazard Need to establish well functioning producer organizations
Portfolio (Crop/Livestock) Diversification Replacement of plant types, cultivars, hybrids and animal breeds with new varieties Alternative production techniques (adjustment of capital and labor inputs) Multi-cropping Mixed farming systems of crops and livestock	Risk-spreading/ promoting farm-level risk management Increasing productivity Defending against disease, pest	Availability of extension services Financial support/ alternatives should be provided by private and public sector Enable mobility of Activities Remove subsidies on certain crops/livestock production not conducive to changed climatic and resource conditions	Tenure reform to ensure property rights are established Land-use regulations need to be reviewed to enable diversification Education/training/ extension services need to be provided	Traditions, lack of awareness, and other limitations (high opportunity costs) may dampen willingness to diversify Over-dependence on government support mechanisms needs to be reduced Need alternatives that maintain quantity and income from production
Adjusting Timing of Farm Operations Adjusting cropping sequence	Reducing risks of crop damage/ maximizing output in light of new con-	Extension services/training is necessary	Mechanisms for the dissemination of agronomic and climate information	Investment in collection of climate data and disseminating information required

Adaptation option:	*Purpose*	*Necessary supporting policies*	*Other prerequisites*	*Limitations*
Adjusting timing of irrigation	ditions	Pricing policies have to be reviewed	Institutional support must be strengthened	Limitations of existing infrastructure
Changing Cropping Intensity Adjusting fertilizer and other inputs Changing land use practices Changing location of crop/livestock production Rotating or shifting production between crops and livestock Abandonment of land Changing the timing of activities (of sowing planting, spraying harvesting) Changing the timing of irrigation	Improving moisture and nutrient retention Reducing soil erosion Adjusting to changing length of growing season Increasing plant protection	Extension services must be improved Pricing policy adjustments for incentives to making adjustments	Location-specific solutions should be sought	Availability of cultivable land; availability of alternative lands Socioeconomic (financial) Conflicts with other farm operations at other times of the year Traditions, lack of awareness, and other limitations (high opportunity costs) may dampen willingness to diversify Concerns regarding maintaining similar production levels
Livestock Management Change in biological diversity, species Altering the breeding management program (i.e., changing composition, or species distribution) Change in grazing management (timing, duration, and location) Changing the location of watering points Changes in rangeland management practices Modifying operation production strategies Changing market strategies	Spreading risks; increasing productivity Adjusting to new climate conditions	Provision of extension services	Promoting investment in livestock management Institutional support	Tradition s, lack of awareness and other limitations (high opportunity costs) may dampen willingness to diversify

Adaptation option:	*Purpose*	*Necessary supporting policies*	*Other prerequisites*	*Limitations*
Implementing feed conservation techniques/ varying supplemental feeding				
Changes in Tillage Practices (Conservation Tillage) Land contouring and terracing Maintaining crop residues Fallow and tillage practices Planting of hedges Alternative drainage methods Construction of diversions and reservoirs and water storage Irrigation Reducing water use in land preparation	Conserving soil moisture and organic carbon contents and increased soil erosion maintain soil fertility and prevent erosion (nutrient management) Maintaining soil quality/provide protection against wind erosion Increasing production per unit of evapotranspiration Reducing water runoff/ improving water uptake Recharging water supply Reducing runoff and erosion Nutrient restocking Conserving water	Extension services need to support activities Pricing incentives to promote conservation	Investment Land tenure reform Indigenous knowledge	
Temporary Migration	Risk diversification strategy to withstand climate shocks and seasonal effects	Employment training/opportunitie	Institutional support	Availability of employment opportunities in urban areas; growth elsewhere in economy Skills and earnings potential High population density in cities
Short-Term Forecasts	Improve preparation for medium-term climatic impacts	Institutional support for collection and dissemination, information dissemination	Infrastructure for monitoring	Financial resources constraints
Food Reserves and Storage	Temporary relief		Delivery mechanisms	Expensive/complacency

Adaptation option:	*Purpose*	*Necessary supporting policies*	*Other prerequisites*	*Limitations*
Changing Crop Mix Adopting new crops Planting in different part of farm Converting land use	Spreading risk of damage Move away from unstable cash crop systems	Revising pricing; food importation policy Tenure; extension; pricing incentives Improving access and affordability Need viable alternatives (incomes)	Promoting investment Institutional support to administer Agricultural marketing policies Review of agricultural credit schemes	Institutional failures Acceptance of change gradual Economic failures (maintaining incomes) Knowledge
Irrigation	Increase productivity; withstand rainwater shortages	Investment by public and private sectors	Clear water management policy	Institutional support and enforcement mechanisms
Modernization of Farm Operations Research and development (biological and mechanical options Adoption of technology (e.g., use of sprinklers)	Increase productivity Withstanding climate effects	Promoting the adoption of technological innovations	Establishment of intellectual property rights Role of private multinationals	Conflicts between national/private objectives Maintaining similar production levels Subsidization programs may create perverse incentives
Permanent Migration	Diversify incomeearning Opportunities To overcome long lasting climate impacts	Education and training for alternative opportunities Retraining	Institutional support (property rights	Impacts on resource base Land pressure
Defining Landuse and Tenure Rights	Incentives to make necessary investments in agricultural land to withstand climatic impacts	Legal reform and enforcement		
Both short and long term				
Investment Promotion	Overcome financial limitations to adapt	Property rights; designing innovating financial tools Injection of initial capital		Social constraints against capital accumulation Reluctance of agricultural traders to offer inputs on credit
Develop Market Efficiency Pricing reform	Promote more efficient use of resources	Remove barriers Property rights; pricing policy	Institutional support The establishment of regional consultation centers	Poor transport infrastructure

Adaptation option:	*Purpose*	*Necessary supporting policies*	*Other prerequisites*	*Limitations*
Develop open markets Reform of agricultural markets		Adjustment of agriculture input subsidies that constrain adaptation Land use regulations	Impart knowledge on adaptation alternatives Legislative reform	
Adoption of Technological and Other Adaptation Measures	Increasing agricultural yields Reducing average fixed costs Reducing variable costs	Pricing incentives/ tax reform Extension services for training Finance schemes	Community management and cooperation programs	Natural constraints- if land is available Socioeconomic capacity to adapt Complete removal of government support Lower producer prices Lower world food prices Attitudes towards risk Level of uncertainty of the future availability of funds for investment Access to assets, capital, and credit High tariffs in export markets
Promoting Trade	Promoting economic growth Strengthening long-term food supply and production limitation Reducing risks of food shortages	Pricing and exchange rate reform and stabilization Adjustment of agricultural subsidies and tariffs	Social policy	Subsidies in developed markets
Developing Extension Services	Improve agricultural productivity Improve awareness and knowledge of measures	Role of private, non-governmental and co-operative agencies Ensuring sufficient agents per farmer/region	Ensure agents are productive through adequate incentives Limit/remove management failures Public organization, resources, and institutional support	

Adaptation option:	*Purpose*	*Necessary supporting policies*	*Other prerequisites*	*Limitations*
			Utilize indigenous knowledge	
Improving Forecasting Mechanisms	Assist planning Strengthen ability of to cope	Extension Institutional support (e.g. establishment of farmer cooperatives to spread knowledge)	Information needs to be distributed across all sectors Horizontal and vertical exchanges of information Ensure information is in a usable form	Financial Conflicts with traditional practices/ social conventions Skepticism
Institutional Strengthening and Decision-making Structures	To support long term planning Reduce vulnerability Provide information on the changing socioeconomic structure, demographics, technology, and public preference Improving organization capacity, responsibility and operational effectiveness	Reform existing institutions that support agricultural sector Pricing incentives; improving regulations and technology standards Legal infrastructure (reform) for stimulating domestic and international investment Changes in international and domestic competition Social policies Upgrading of current physical planning laws and regulations	Participation of keys stakeholders Requires integrated management practices; need to fit specific institutional settings Comprehensive multisectoral management plans Resilience; flexibility; public education program Remove inefficiencies Equally well institutions in other sectors Improve coordination between central and local government	Planning agencies formed by administrative resolution as opposed to being mandatory

