Brussels Rural Development Briefings

A series of meetings on ACP-EU development issues

Climate change, agriculture and food security:

Proven approaches and new investments

Prepared by Isolina Boto (Head of CTA Brussels Office), Ronalee Biasca and Filippo Brasesco (Young researchers at CTA Brussels Office)

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Climate change, agriculture and food security: Proven approaches and new investments

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This Reader does not intend to exhaustively cover the issue of the linkages between climate change, agriculture and food security, but to provide some background information and selected information resources, focusing on the implications for rural development. The Reader and most of the resources are available on http://brusselsbriefings.net

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1. Context

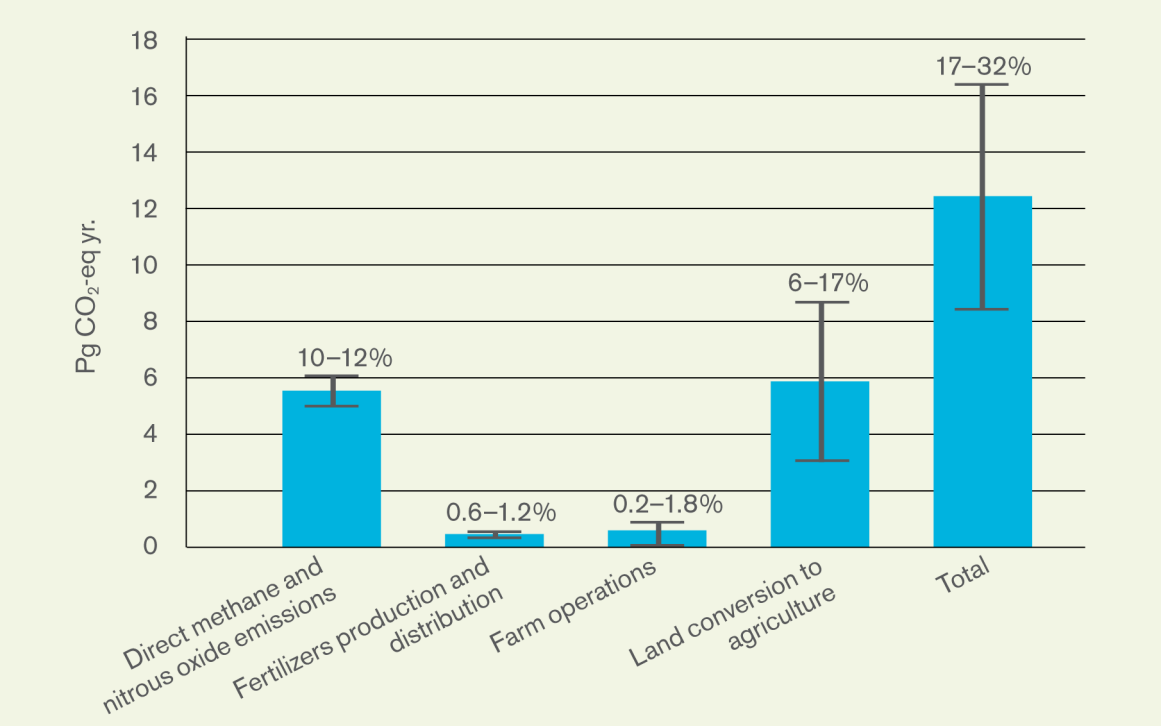
Climate change, food security and agriculture

Climate change - both natural and anthropogenic - will lead to significant changes at the global and local level. Its impact will be both short-term, resulting from more frequent and more intense extreme weather events, and long term, caused by changing temperatures and precipitation patterns.1 It is not possible to predict future climatic conditions with certainty, but the scientific consensus is that global land and sea temperatures are warming and will continue to warm regardless of human intervention for at least the next two decades,[2] under the influence of greenhouse gases (GHGs).

Climate change will affect agriculture through higher temperatures, greater crop water demand, more variable rainfall and extreme climate events such as heat waves, floods and droughts. Rising seas will lead to loss of territory and decline in agriculture affecting the 25% of global human populations who live in low-lying coastal areas. Especially vulnerable are island nations in the Caribbean, Pacific and Indian Oceans, and river deltas of the Nile, Ganges and the Mekong where food production is heavily concentrated.[3]

In 2007, the Intergovernmental Panel on Climate Change (IPCC) forecasted that global average temperatures could rise by 1.1°C to 6.4°C by the end of the 21st century. If the rise is at the lower end of the scale, the impact on agricultural systems may be modest; at the higher end however, it will almost certainly be disastrous. Even a 2°C rise by the end of this century – and this is an optimistic scenario – will lead to dramatic changes in patterns of land use.[4]

Figure 1: Total Global Contribution of Agriculture to GHG Emissions



Source: Garnett T. 2012. Climate Change and Agriculture, p. 13

Climate change, agriculture and food security

The International Energy Agency (IEA) has estimated that 80% of projected emissions from the power sector in 2020 are already locked in, as they will come from power plants that are currently in place or under construction today.[5] Further increase in emissions of GHGs resulting from human activities will exacerbate the impact of climate change on food production in the near future.

After a dip in 2009 caused by the global financial crisis, emissions are estimated to have climbed to a record 30.6 Gigatonnes (Gt).[6] According to IEA, global energy-related emissions in 2020 must not be greater than 32 Gt. This means that over the next ten years, emissions must rise less in total than they did between 2009 and 2010.

Agriculture is at the nexus of three of the greatest challenges of the 21st century - achieving food security, adapting to climate change, and mitigating climate change while critical resources such as water, energy and land become increasingly scarce.[7] Policymakers are therefore presented with a double challenge: to reduce agricultural emissions, and to help agriculture adapt to a changing climate.

Agriculture includes crop-, animal-, forestry- and fishery-based systems or mixed farming, including new emerging systems such as organic, precision and peri-urban agriculture. Agricultural systems range across the globe from intensive, highly commercialized large-scale systems to small-scale and subsistence systems. Although agricultural inputs and outputs constitute the bulk of world trade, most food is consumed locally and domestically. Agriculture is multifunctional as it provides food, feed, fibre, fuel and other goods. It also has a major influence on other essential ecosystem services such as water supply and carbon sequestration or release. Agriculture plays an important social role, providing employment and a way of life. Both agriculture and its products are a medium of cultural transmission and cultural practices worldwide. Agriculturally-based communities provide a foundation for local economies and are an important means for countries to secure their territories.[8]

Agriculture is crucial for food security and rural incomes, as well as other essential products, including energy, fibre, feed and a range of eco-system services. Agriculture accounts for approximately 30% of the gross domestic product (GDP) in developing countries and provides jobs for 60% of their populations.[9] In many countries, economic health is closely linked to the fortunes, or misfortunes, of farming communities. Agriculture accounts for a major part of the livelihood of 40% of the world's population and occupies 40% of total land area; 90% of farms worldwide have a size of less than 2 hectares.[10]

Agriculture is a significant cause of climate change, directly responsible for some 12-14% of GHG emissions[11] or 30% when considering land-use change, including deforestation driven by the agricultural expansion for food, fibre and fuel, which accounts for an additional 17% of emissions.[12] At the same time, agriculture is also a victim of climate change, with farmers around the world already facing an uncertain future as a result of rising temperatures, changing patterns of rainfall and the shifting distribution of pests and diseases.

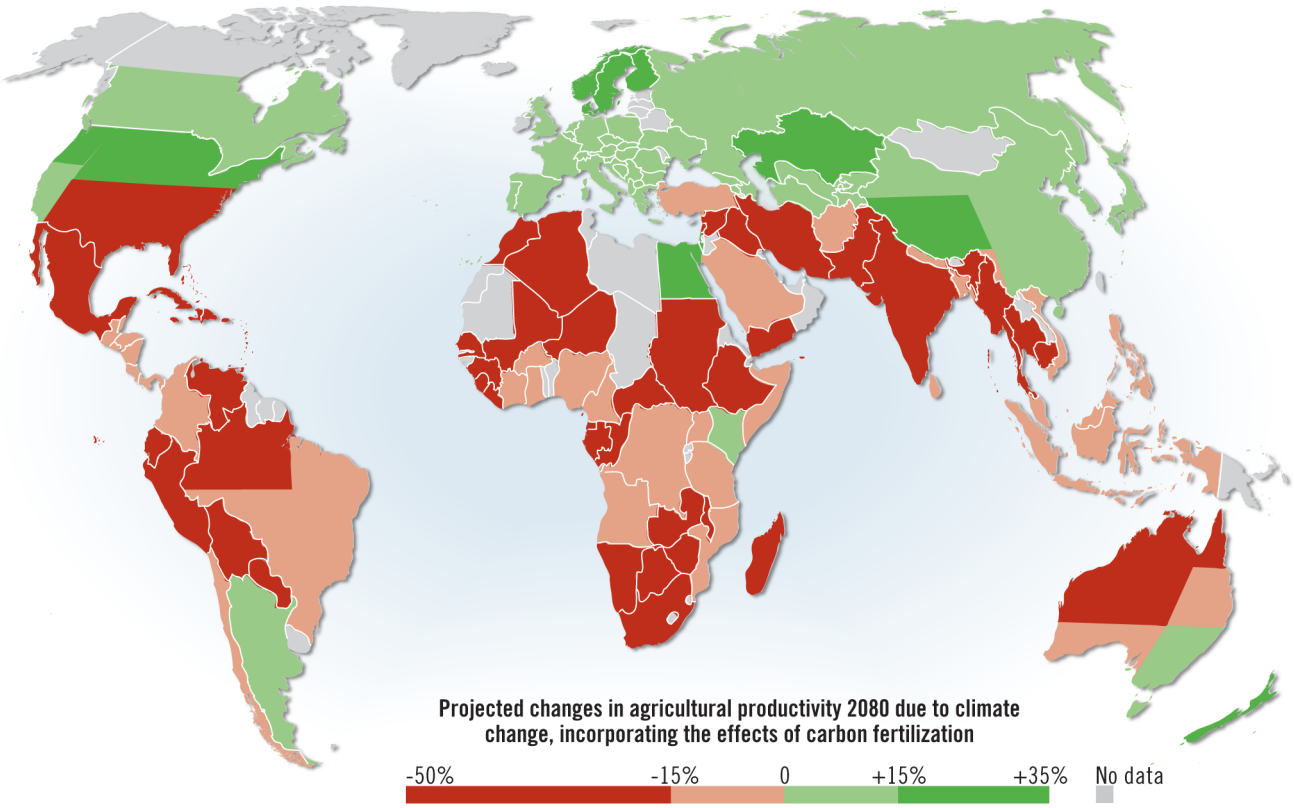
Sustainable agriculture simultaneously increases production and income, adapts to climate change and reduces GHG emissions, while balancing crop, livestock, fisheries and agroforestry systems, increasing resource use efficiency (including land and water), protecting the environment and maintaining ecosystem services. The goal for sustainable food production systems is to maximize productivity of both land and seascapes within humanity's 'safe operating space' for the planet– 'safe' from the perspective of achieving food security within the planet's safe environmental boundaries. Contexts will vary in different geographic regions and locations. Improvements to agricultural production systems should allow more productive and resilient livelihoods and ecosystems, contributing to a more secure, sustainable and safe food system and providing access to adequate food and nutrition, and allowing poor rural people to escape from and remain out of poverty. Sustainable agriculture lies at the heart of delivering poverty reduction.[13]

The global agricultural system faces great challenges today, as it has to confront climate change, loss of biological and agro-biological diversity, loss of soil fertility, water shortage and loss of water quality, and population growth. Sustainable

agricultural production is dependent on the effective management of a range of interdependent physical and natural resources -land, water, energy, capital and so on- as well as on full internalization of currently externalized costs.[14]

Adaptation to climate changes aims to mitigate and develop appropriate coping measures to address the negative impacts of climate change on agriculture. Although most agricultural systems have a measure of in-built adaptation capacity, known as autonomous or spontaneous adaptation,[15] the current rapid rate of climate change is expected to impose new pressures on the existing adaptation capacity, and undermine the ability of people and ecosystems to cope with and recover from extreme climate events and other natural hazards.[16]

Figure 2: Projected changes in agricultural productivity



Source: Beddington J, et al. 2012. Achieving food security in the face of climate change, p.12

At least 22% of the area under the most important crops in the world is expected to suffer negative impacts from climate change by 2050. In Sub-Saharan Africa and Asia, 56% and 21% of crops, respectively, are expected to be negatively affected.[17] Climate change will have an impact also on livestock production, with productivity losses (physiological stress) owing to temperature increases, and changes in the availability, quality, and prices of inputs such as fodder, energy, disease management,

housing, and water. Climate change is likely to impact fisheries in a number of ways.[18] Increasing ocean temperatures and acidification, and changing currents are projected to damage marine ecosystems, disrupt complex food webs and change fish distribution patterns. Fish and fishing are fundamental to life and culture in many parts of the world. Climate change seriously threatens the sustainability of the fishing industry and has the potential to undermine food security in a region strongly reliant on fish as a source of protein and the income derived from renting the sea to foreign fleets.

Farmers can significantly reduce climate change by selecting agricultural practices that reduce greenhouse gas emissions or store carbon. To encourage more farmers to use these practices, various incentives have been proposed, including payments for carbon credits. Yet in developing countries smallholder farmers' priorities are often to get immediate benefits from farming and ensure their own food security. Climate change mitigation among smallholders is thus more likely to occur where it is a co-benefit or outcome of practices that farmers pursue for improved income or reduced risk. In many cases these practices serve multiple goals, including increased yields, and improved ecosystem and livelihood resilience.[19]

Food security is the outcome of food system processes all along the food chain. Agriculture is important for food security in two ways: it produces the food people eat; and (perhaps even more important) it provides the primary source of livelihood for 36% of the world's total workforce. In the heavily populated countries of Asia and the Pacific, this share ranges from 40 to 50 percent, and in sub-Saharan Africa, two-thirds of the working population still make their living from agriculture.[20]

People who are already vulnerable and food insecure – more than 600 million according to FAO[21] - are likely to be the first to be affected. Climate change will affect all four dimensions of food security: food availability, food accessibility, food utilization and food systems stability. It will have an impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows.

Although the proportion of the world's population suffering from hunger has declined from 24% to 13% since 1970, largely as a result of dramatic increases in crop and livestock productivity, around 1 billion people still go hungry every day.[22] Climate change also represents an immediate and unprecedented threat to the food security of hundreds of millions of people who depend on small-scale agriculture for their livelihoods.[23] In countries where the economy is heavily based on agriculture, development of the agricultural sector is the most efficient poverty reduction measure.[24]

The majority of the world's poorest and hungry live in rural settings and depend directly on agriculture. Over 70% of the world's poor live in rural areas. These 2.1 billion people live on less than US$2 a day. This is not inevitable, and an improved economic environment and greater social equity at local, national, and global scales have the potential to ensure that agriculture is able to provide improved livelihoods.[25]

Reducing poverty and securing food to world's population while reducing GHG emissions will require a combination of technical, political and financial factors that will make climate change the biggest challenge for mankind in human history.

2. Potential to reduce emissions from the food system[26]

In all, the agricultural sector – and indeed the food chain as a whole – is a major global cause of greenhouse gas emissions. It contributes not only to carbon dioxide (through its role in land use change as well as from its use of fossil fuels) but also to methane and nitrous oxide emissions.

Much attention has focused on estimating the extent to which food system GHG emissions could be reduced. In summary, there are three key strategic approaches possible for reducing GHG emissions in the food system:

1 Measures to reduce agricultural emissions through better farm practices such as soil carbon sequestration, nutrient use efficiency, the management of manure and other outputs, and the use of renewable energy.

2 Measures to reduce emissions beyond the farm gate through the decarbonisation of energy inputs, energy efficiency and waste management (not examined here).

3 Measures to alter patterns of consumption, and in particular to reduce demand for meat and dairy products that are highly GHG intensive, combined with measures to encourage consumers to avoid wasting food.

Agriculture

Most of the mitigation potential identified is in developing countries, with soil carbon sequestration dominating as the key mitigation measure in these settings. This reflects the degraded state of soils in much of the developing world and hence the relatively greater gains that could be achieved through their remediation.

- *Enhancing carbon removal*: restoring degraded lands; afforestation; zero or minimum tillage; incorporating organic matter into soils; and managing aquatic plants and sediments.

- *Optimising nutrient use:* more precise dosage and timing for organic and inorganic fertilisers; incorporating nitrogen-fixing legumes into rotations; and better management of aquatic systems, including integration with agriculture.

- *Improving productivity:* increasing edible/ marketable output per unit of GHG generated (accounting also for non-consumed materials); crop and animal breeding for performance; optimising nutritional content of feeds; and pest and disease management.

- *Managing and incorporating secondary outputs*, including: manure and plant biomass, wastes and by-products from fish and other animals; product recovery, slurry and manure management; composting; and anaerobic digestion.

- *Reducing the carbon intensity* of fuel and raw material inputs through improvements in energy efficiency, selection of materials, and use of alternative fuels such as biomass, biogas, wind and solar power.

Beyond the farm gate

Another range of studies examines ways of reducing climate impacts from key post-farm gate sectors of the food system including transport, manufacturing, and retailing emissions (especially lighting and refrigeration). These again focus on measures such as improving energy efficiency, using less carbon-intensive materials, and using alternative fuels such as biomass, biogas, wind and solar power.

Consumption

There is a growing body of work that highlights the mitigation potential of changing consumption practices. There are two main strands: (1) shifting diets through a reduction in the consumption of meat and dairy products; and (2) reducing food waste. Wasted food represents a 'waste' of embedded emissions incurred during the production, processing and distribution of food – hence avoiding waste can, in theory, reduce GHG emissions.

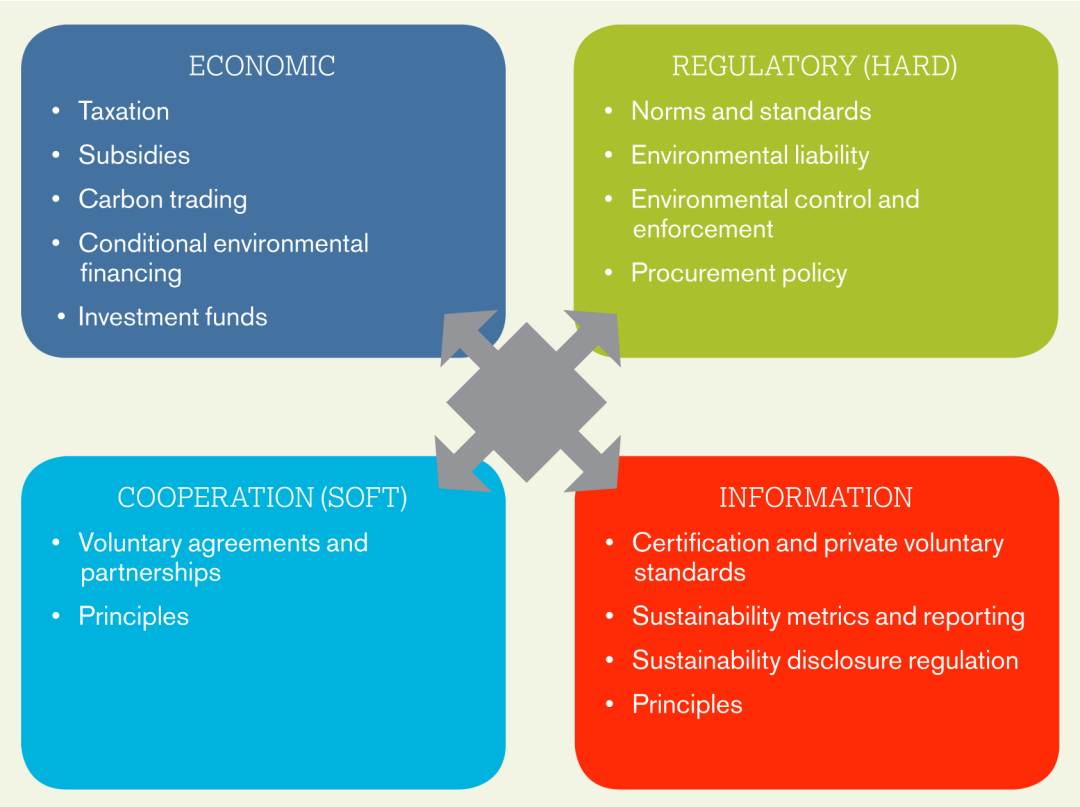
2.1 Market governance mechanisms

Market governance mechanisms (MGMs) operate through one or a combination of economic incentives and disincentives: regulatory measures (legal requirements or prohibitions); voluntary co-operation among stakeholders, often through partnerships; and information provision to potentially enable consumers, investors and producers to make informed and evidence-based choices.

There is growing interest by policymakers at both national and international levels in using market governance mechanisms – and market-based instruments in particular, such as emissions trading or payments for environmental services – as a tool for steering the global economy in less GHG-intensive directions.

To date, however, most of the focus has been on sectors such as transport and the built environment; agriculture has largely been neglected. This lack of policy action reflects the fact that in being essential to our survival, agriculture transcends any purely economic function. Agriculture is also multifunctional providing food and ecosystem services, for example, and is physically, socially and economically complex.

Figure 3: Market Governance Mechanism Typology



Source: Blackmore, 2011.

It is clear that no single measure will be effective in achieving emissions reduction. A mixture of approaches – regulatory, economic and voluntary, as well as labelling, information and awareness raising – are all essential and best undertaken in combination:

- Emissions related to production (agriculture) and consumption (dietary choices and waste) must be addressed together in order to reduce 'leakage'. If this is not done, emissions will not be reduced in absolute terms but simply displaced to other countries or regions. For example, action to reduce consumption in one country can lead to increases in meat and dairy exports to another.

- Regulation, in the form of a cap on emissions, is a 'precondition'

for other market governance measures (such as pricing) to operate effectively. In the absence of an agreed ceiling on emissions, economic, co-operative or other measures may simply improve the relative efficiency of production while failing to achieve absolute reductions.

2.2 Climate-smart agriculture

Conventional food production, rooted in the technical-scientific principles of the Green Revolution, depends on the intensive and systematic use of fossil fuels and natural sources of phosphates and potassium – resources that are now becoming scarce. Higher oil prices, caused by the growing depletion of the world's reserves, directly inflate food prices as a result of the importance of this energy source in the production of chemical fertilizers and pesticides, as well as in operating farm machinery and the processing, storage, refrigeration and long-distance transportation of farm produce.[27]

To successfully achieve agriculture that can adapt and mitigate the impact of climate change, it is important to work at the landscape level with an ecosystems approach and combine forestry, fisheries, crops and livestock systems. Early action is necessary to identify, pilot and scale-up best practices, strengthen institutional capacities and build experiences that support stakeholders when making informed decision for the transition to climate-smart agriculture.[28] How widespread these practices become will depend to a significant degree on the importance given to agriculture in international climate-change negotiations and national policymaking.[29]

What is climate-smart agriculture?

Climate-smart agriculture seeks to increase sustainable productivity, strengthen farmers' resilience, reduce agriculture's GHG emissions and increase carbon sequestration. By doing so, it strengthens food security and delivers environmental benefits.[30] Climate-smart agriculture should be seen as a pathway towards development and food security.[31] There are three pillars[32] of climate-smart agriculture:

- Increasing productivity and incomes
- Enhancing resilience of livelihoods and eco-systems
- Reducing and removing GHG emissions from the atmosphere

Figure 4: Three pillars of climate-smart agriculture

Source: FAO, Climate-Smart Agriculture, p. 2.

A transition from conventional, input-based agriculture to agricultural practices based on agro-ecological approaches will require a change in the current way of thinking about food production which is based on a globalized food system and on large-scale, input-based farming practices.[33] Sustainable intensification and productivity enhancement are key elements of climate-smart agriculture, but need to be combined with broader landscape restoration measures.[34]

Countries with a large share of their population engaged in agricultural production, high rates of food insecurity and poverty, and adverse impacts from extreme climate events are often obliged to take urgent and difficult policy decisions based on insufficient evidence.[35] Feeding people in decades to come will require ingenuity and innovation to produce more food on less land in more sustainable ways.[36] At the same time, it is necessary to look at solutions that are already available and recognize the potential of the alternative systems that have been developed over the years.[37]

Climate-smart agriculture includes proven practical techniques, such as mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management, agro-forestry, improved grazing and improved water management and innovative practices, for instance better weather forecasting, more resilient food crops and risk insurance.[38]

Figure 5: Options for climate change adaptation in the agricultural sector

Altering exposure	Reducing sensitivity	Increasing adaptive capacity
Assess impacts and map hazard zones	Develop or adopt suitable crop, plant and animal varieties	Develop adaptive strategies and action plans
Conduct proper land and water-use planning	Improve irrigation and drainage systems	Diversify sources of household income
Protect watersheds and establish flood retention zones	Enhance soil nutrition and on-farm water management	Improve water and other infrastructure systems
Resettle humans and restructure agriculture	Diversify cropping and agricultural activities	Establish disaster and crop insurance schemes
Change cropping patterns	Adopt disaster-prevention construction standards	Promote technical transfer and capacity building

Agricultural adaptation can occur in many ways, from the individual field - where a crop is grown, varieties are selected and management decisions such as tillage, fertilization, and pesticide application are made - through the farm level - where managers choose among crops, livestock, and other activities and capital investment decisions are made – to the landscape level, where decisions are made about management of water resources, biodiversity, forests and energy.[39]

2.2.1 Increasing productivity and incomes

The impact of climate change will continue and developing countries will be hit earliest and hardest, and are the countries with the smallest capacity to deal with climate change, often depending on natural resources – agriculture, forestry and fisheries.[40]

Crop rotation, cover crops, manuring and application of organic amendments are recommended

strategies to restore degraded soils and hence improve the livelihoods of rural populations affected by climate change. By restoring soil fertility, yields have been increased to a much greater extent at both farm and regional levels than by using purchased mineral fertilizers. Restoration of degraded land not only offers income opportunities for rural populations but also has a huge mitigation potential by increasing soil carbon sequestration.[41]

A review by Badgley et al. calculated average yield losses under organic management for developed countries of 0–20% and, in the case of developing countries, an increase of yield or hardly any yield reduction. In low external input systems, and especially in arid and semi-arid areas where most of the food-insecure live, organic yields generally improve up to 180%.[42] Higher yields in low-input systems are mainly achieved by the application of manure from integrated livestock production, composting and diversification. However, in an appropriate agro-forestry system, lower yields for the main crop are compensated by producing other foodstuff and goods. Agro-forestry systems are encouraged by different standards for organic agriculture. To be successful, organic agriculture must integrate plant and livestock production to the extent possible to optimize nutrient use and recycling.

By yielding a broad range of products, including fruits, fuel wood, timber and resins, agro-forestry farmers can diversify their incomes, which provides them with greater protection against market failures and fluctuations. The use of nitrogen-fixing trees and shrubs increases soil fertility and crop yields. Trees sequester much greater quantities of carbon than annual crops, and in some instances provide farmers with access to the carbon market. Trees also help farmers adapt to climate change, as perennial crops are better able to cope with droughts and floods than annual crops.

The use of external inputs is limited in organic farming systems. Synthetic inputs like mineral fertilizers and chemical pesticides are banned. The reduced dependency on energy inputs in organic agriculture reduces vulnerability to rising energy prices, and hence volatility of agricultural input prices. Nitrogen fertilizer prices rose by 160% during the first quarter of 2008,[43] and price hikes are expected to recur with peak oil and climate change, further limiting the access for poor rural populations to agricultural inputs.

Water management is a critical challenge in water stressed countries. Measures to enhance agricultural water productivity are often most helpful if combined with measures to support broader economic diversification.[44] According to the FAO, conservation agriculture reduces water needs of crops by 30%, lowers energy needs by 70%, and sequesters significant amounts of carbon. It also helps farmers adapt to climate change as the perennial cover of organic matter protects the soil from high temperatures, desiccation and erosion.[45]

The Pacific and Caribbean regions have uniquely fragile water resources due to their small size, lack of natural storage, competing land use and vulnerability to natural and anthropogenic hazards, including drought, cyclones and urban pollution. In addition, water service providers face challenging constraints to sustaining water and wastewater provision due to the lack of both human and financial resources bases.[46]

Forests and trees provide important staple crops worldwide. Trees have long played a pivotal role in traditional agro-forestry systems by providing shelter, shade and protection against the ravages of wind, salt spray and sun. Mangrove forests and other coastal trees also play multiple roles in protecting coastlines, buffering wind and wave action, and contributing to food webs.[47]

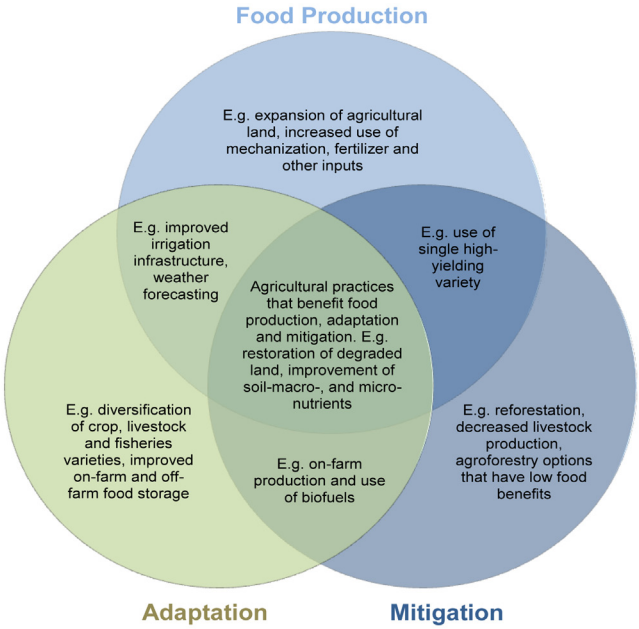
According to a survey conducted by Jules Pretty, professor at the University of Essex, more than 1.4 million farmers across the world have adopted agro-ecological approaches. His study identified average increases of 100% in the productivity of hundreds of projects after adoption of these principles with records of 400% increases in more advanced agro-ecological systems. Should all farming be managed organically, the current annual production of 100 megatons of nitrogen in mineral fertilizers and the corresponding N2O emissions would fall off.[48] Reduced use of synthetic fertilizers is believed to result in lower yields per land unit, depending on the level of intensity of the previous management system. The main challenge to widespread adoption of agro-ecological approach is not technical but political.[49]

2.2.2 Enhancing of livelihoods and eco-systems

Africa is considered to be the most vulnerable continent because most Africans, particularly those from Sub-Saharan Africa, live in dry or sub-humid agro-ecological zones. The vulnerability of African populations is expected to rise not only due to high poverty levels, but, for instance, also due to the ongoing degradation of natural resources as a result of unsustainable resource management practices, low GDP per capita, weak institutions, low levels of education and primary health care, a lack of consideration of women and gender balance in policy planning, poor infrastructure and technology.[50] Organic agriculture can be a promising approach to sustaining food security by supplying alternatives to agricultural inputs.

In countries most highly exposed to climate variability and change, disaster management and a climate resilient, diverse agricultural sector are closely linked.[51] Farming now occupies almost 30% of the global land area and has a bigger impact on natural ecosystems than any other human activity. Of the 8.7 billion hectares used for crop production, pasture and forests, 2 billion have been degraded since the end of the Second World War. Farming consumes 70% of all water utilized by humans.[52]

Figure 6: Potential synergies and trade-offs among food production, mitigation and adaptation



Source: Campbell B. et al. 2011. Agriculture and Climate Change A Scoping Report, p. 16.

Rural communities are on the front-line of efforts to mitigate climate change. Often depending on subsistence farming and on products and services provided by forest ecosystems, they are the groups most vulnerable to potential climate change impacts. However, rural communities are also in a strong position to address these challenges. The most poor and potentially vulnerable communities tend to be important stewards of global environmental resources, particularly forest ecosystems and the services they provide, which over and above climate regulation include watershed services, soil stability and conservation of biodiversity.[53]

Agro-ecology is defined as a science

that applies ecological concepts and principles to the design of sustainable agro-ecosystems. Agro-ecology emphasizes the development and maintenance of complex ecological processes capable of enhancing soil fertility, as well as the productivity and health of crops and livestock.

The vast majority of world's farmers – who are small-scale farmers - could benefit the most from agro-ecology as a healthy food production system is the basis for sustainable development.[54] Growing different assemblages of crops in time and space seeks to enhance the agro-ecosystem resilience to external shocks such as extreme weather events or price variation, which are all risks that are most likely to increase as the climate changes. Currently, most small-scale farmers are net buyers of food and, thus, highly vulnerable to volatile food prices.[55]

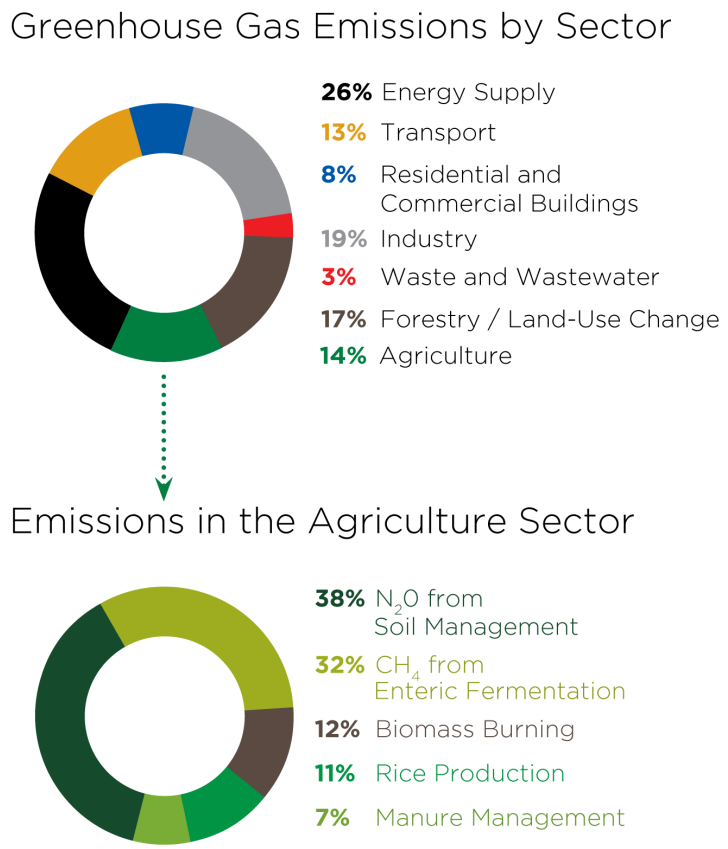
More diverse plant communities are more resilient to environmental perturbations derived from extreme climatic events. Undoubtedly, crop diversification represents a viable long-term strategy for farmers experiencing erratic weather. The use of diversification within agricultural production systems can significantly reduce their vulnerability and protect their livelihoods.[56]

2.2.3 Reducing and removing GHG emissions from the atmosphere

The organic matter in the top 30 cm of the Earth's soil contains almost as much carbon as there is in the entire atmosphere. When poorly managed, soils not only provide meagre crop yields, they release significant quantities of carbon. In sub-Saharan Africa, for example, 500 million ha of agricultural land is moderately or severely degraded: this is a disaster for both food security and the climate. Farming also has the potential to sequester huge quantities of carbon through practices such as conservation agriculture, which improves the nutrient- and water-holding capacity of the soil.[57]

Within agriculture, the production of synthetic nitrogen, the use of concentrated feed made with raw materials that come from far away and fuel consumption, account for almost 90% of energy consumption. If we want to substantially reduce the energy cost of feeding world's population we need a form of agro-ecological management that closes the cycles and uses local and renewable sources of energy.[58]

Figure 7: Total GHG emissions



Source: The World Bank. 2010. Climate-Smart Agriculture A Call to Action, p. 3.

Soil carbon sequestration involves transferring carbon dioxide from the atmosphere into the soil in a form that is not immediately re-emitted. This is achieved by incorporating carbon-rich matter in the soil, encouraging agricultural practices that 'lock' carbon into the above- and below-ground biomass, and minimising soil disturbances.[59]

Excessive nitrogen in the soil and water system is caused by applications both of synthetic nitrogen fertiliser and of manure. These nutrient surpluses give rise to leaching and eutrophication, ammonia emissions and, as is now increasingly recognised, to emissions of nitrous oxide, a greenhouse gas. Measures to address nitrogen overload therefore have a part to play in reducing agricultural GHG emissions.[60]

As of 2000, the livestock sector has been estimated to account for 18% of man-made GHG emissions. Other authors instead suggest that this value is largely underestimated, as livestock production seems to make up 51% of total GHG emissions. In any case, the livestock sector is a major contributor of GHG emissions and therefore one of the targets of any mitigation policy. In addition, the livestock sector absorbs 58% of direct human appropriation of biomass, 70% of agricultural land (from which 33% is designed to feed crop production) and 30% of land globally.[61]

A wide range of measures are required to reduce the livestock sectors' climate-change footprint. These include improving production and feed systems, developing new

breeds of ruminant which produce less methane, introducing methods of manure management which reduce emissions, and integrating livestock with crops in order to reduce waste and improve soil fertility. Better grazing management could also do much to improve animal nutrition and reduce greenhouse gas emissions.[62]

2.2.4 Climate-smart practices from ACP countries

Africa

To increase agricultural productivity and encourage private investment in agricultural enterprises, the Kenyan government has implemented the *Kenya Agriculture Carbon Project*, which also includes carbon sequestration activities, including reduced tillage, an increase in cover crops, residue management, mulching, composting, green manure, targeted application of fertilizers, reduced biomass burning and agro-forestry. The project provides technical support to about 60,000 farmers aggregated in farmer groups, managing a total of 45,000 hectares in the Nyanza and Western provinces of Kenya, and implemented by the Swedish Cooperative Centre, ViAgroForestry, an NGO well-known in the Lake Victoria Basin for participatory approaches leading to increased farm productivity and sustainable management of natural resources.[63] Expected outcomes include the access to the carbon market by smallholder farmers and for them to receive additional carbon revenue streams through the adoption of productivity enhancing practices and technologies. The main benefits will be increased yields and productivity, additional income sources due to payment for environmental services, and overall enhanced resilience to climate vulnerability and change.[64]

The *Land Husbandry, Water Harvesting and Hillside Irrigation* project in Rwanda seeks to improve the management of rainfall to cause less hillside erosion through terracing, improving the soil under cultivation, managing water runoff and, in some cases, developing irrigation systems. It also seeks to empower farmers by helping them develop farmer groups, which are rare in Rwanda, and gain access to credit. The project was first piloted in the Karongi district and local farmers were employed to build terraces. They reported an increase in yields and income with more than 65 percent of the first potato harvest having been sold on the market, compared to the 10 percent that used to be sold. In June 2010, the project received a US$50 million commitment from the Global Agriculture and Food Security Program (GAFSP) to scale up and replicate achievements in other regions together with a range of development partners. The Rwandan government seeks to scale up the program to over 100 watersheds countrywide to create a more resilient rural economy that can withstand the population and climatic pressures.[65]

In Ethiopia, over-exploitation of forest resources has left less than 3% of the country's native forests untouched. Under the Humbo Assisted Natural Regeneration Project, developed by World Vision and the World Bank, seven forest cooperatives were established on the Humbo Mountain to sustainably manage and reforest the surrounding land. More than 90 percent of the Humbo project areas has been reforested using the Farmer-managed Natural Forest Regeneration technique, which encourages new growth from tree stumps previously felled but still living, and has resulted in increased production of wood and tree products, such as honey and fruit to contribute to household budgets. Improved land management has also stimulated grass growth, providing fodder for livestock that can be cut and sold as an additional source of income. Furthermore, the regeneration of the native forest is expected to provide an important habitat for many local species and reduce soil erosion and flooding. The protected areas of forest now act as a 'carbon sink', absorbing and storing GHG from the atmosphere to help mitigate climate change. The project is the first large-scale forestry project in Africa to be registered with the UNFCCC.[66]

The Caribbean

After several years of intensive grazing in Costa Rica and Nicaragua, pastures were degraded, erosion was accelerating and livestock productivity was falling. A pilot project was launched between 2001 and 2007, which introduced silvopastoral techniques to 265 farms on 12,000 hectares. A payment scheme for environmental services – carbon sequestration and biodiversity conservation – was introduced as an additional income stream for livestock production. Silvopastoral techniques are used to transform degraded lands with mono-cultures of one grass species

into more complex agro-forestry systems that may include forest fragments, live fences, riparian forests and trees dispersed in pastures. These techniques have been shown to enhance biodiversity and sequester appreciable amounts of carbon while reducing methane production of livestock under increased tree cover. The techniques ranged from planting trees, to natural pastures, to highly intensive fodder shrub plantations. Results showed an annual sequestration of 1.5 MT of CO2-equivalent was accompanied with increases of 22 percent in milk production, 38 percent in stocking rate and 60 percent in farm income. The methane emission per product kilogram decreased while biodiversity (measured by the number of bird species and water quality) increased. The project is currently being scaled up in Colombia through the Global Environment Fund (GEF) and private sector funds.[67]

The Pacific[68]

Recent studies by FAO and UNICEF suggest that several Pacific Island Countries and Territories (PICTs), such as Nauru, Kiribati, Tuvalu and the Republic of the Marshall Islands, are particularly vulnerable to food insecurity. Their extremely limited soil and water resources and heavy reliance on fishing and imports create major challenges. Addressing food security in the region requires a multi-pronged approach that explores the linkages among factors such as long- and short-term climatic variability, food procurement and trade modalities, poverty disparities between rural and urban communities, issues contributing to sustainable livelihoods, nutrition and health, and viable agriculture, forestry and fishing practices.[69]

The Pacific HYCOS program provides support to the National Hydrological Services in the region and is building their capacity in flood and drought forecasting as well as in basic monitoring of water resources. The need for a thorough analysis of hydro(geo) logical information and water quality, as well as water quantity data, is frequently overlooked by adaptation programs which sometimes make assumptions on the impacts of climate on water resources without adequate research. There is a need to mainstream risk management into water supply and water resources management, building on the integrated approaches adopted by Pacific and Caribbean island countries and territories such as Drinking water Safety Planning (DWSP) and Integrated Water Resources Management.[70]

The Pacific Islands Climate Change Assistance Programme (PICCAP) was developed to assist with the reporting, training and capacity-building required under the United Nations Framework Convention on Climate Change (UNFCCC), in order to improve investments in adequate water resources monitoring and assessments to be able to cope with climatic extremes, both droughts and flooding, as well as increase awareness of the effects of floods and droughts on drinking water.[71]

In the context of the GCCA, the Solomon Islands have been supported through the Solomon Islands Climate Change Assistance Programme (SICAP), a 4-year project to contribute to climate change adaptation and reduction of vulnerability, support the Government in the areas of policy enhancement, coordination and implementation of its national Climate Change strategy.[72]

3. Policy frameworks and initiatives favourable to climate change and agriculture

3.1. International negotiations on climate change

There are two currently existing international agreements on climate change. The first is the 1992 UN Framework Convention on Climate Change (UNFCCC) that contains no concrete policy obligations. The second treaty is the 1997 Kyoto Protocol to the UNFCCC that specifies binding targets for emission reductions in industrialized countries and economies in transition. The Kyoto protocol came into force in February 2005 and effectively expires in 2012 when its first "commitment period" ends.[73]

The Copenhagen Conference (COP15)

The Copenhagen conference took place in December 2009 and was a turning point in climate negotiations. The outside world expected a global climate treaty but inside negotiators did not regard this as a viable option, except island nations who pursued it faithfully to the end. Several issues proved impossible to resolve in Copenhagen, including the number of international agreements to be negotiated, the future of the Kyoto Protocol, and collective emission reduction targets. Negotiations came to a complete stalemate on the second day when developing countries presented a hard ultimatum: negotiate Kyoto 2 or leave empty-handed.[74]

The Copenhagen Accord committed developed countries to provide US$30 billion in fast-start financing from 2010 to 2012 (divided equally between adaptation and mitigation) and set a goal to mobilize US$100 billion by 2020 in the context of mitigation. Pledged resources for fast-track financing are estimated to be between US$27.9 billion as of August 2010, however past performance on climate financing shows large gaps among resources pledged, deposited and disbursed.[75]

The conference produced two document outputs: the Copenhagen Accord and the continuation of UN negotiations. The Copenhagen Accord is a political agreement among the heads of state of certain countries. The Accord was not formally adopted and the official decision of the Conference of the Parties was a single sentence that reads: "The Conference of the Parties takes note of the Copenhagen Accord of 18 December 2009". The text does not include a specific deadline for capping global emissions, rather than "we should cooperate in achieving the peaking of global and national emissions as soon as possible".[76]

Generally, the Copenhagen Accord is considered a weak agreement designed to deal with global climate change. However, climate policy around the world is making considerable progress. While the UN negotiations process is deadlocked, multilevel climate governance is thriving.[77]

The Durban Conference (COP17)

Despite its significance for climate change, attempts to include agriculture in the text of international negotiations failed in 2009 and 2010. However, there was a breakthrough in December 2011, when the 17th Conference of the Parties (COP 17) to the UNFCCC met in Durban, South Africa. Following intense deliberations, delegates agreed to include agriculture in future negotiations and it was referred to the Convention Subsidiary Body for Scientific and Technological advice (SBSTA) for detailed discussion.[78]

The Durban conference on climate change took place in November and December of 2011. After two weeks of negotiations world leaders agreed to a number of decisions including the Durban Platform, which contains some provisions for adaptation, progress on a green climate fund, and a deadline for governments to adopt a new universal legal agreement on climate change by 2015. The outcomes from Durban do not go far enough to hold global temperatures at a two-degree warmer world, nor is there sufficient finance or appropriate mechanisms

in place to tackle the major adaptation challenges faced by least developed countries. But there were at least some outcomes that may eventually help poor farmers deal with climate change.

For agriculture there were some positive steps and it was the first time that UNFCCC had adopted a decision on agriculture. Although many agricultural organizations had pushed for a separate work program on agriculture to be set up, this was not achieved. Instead, the Conference of Parties' Ad Hoc Working Group on Long-term Cooperative Action (LCA) concluded that a decision on agriculture will be made at COP18 which will take place in November 2012 in Qatar. Negotiations on REDD+ made significant progress on technical issues, although a decision on financing was deferred to the Qatar meeting. Agriculture is an important part of the REDD+ discussions in the UNFCCC negotiations. However, the incredibly drawn out decision-making process has no clear path beyond COP18, and agriculture could get sidelined should the negotiations in Qatar fail.[79] Governments also agreed to a second commitment period of the Kyoto Protocol from January 2013 and decided to adopt a universal legal agreement on climate change no later than 2015. A significantly advanced framework for the reporting of emission reductions for both developed and developing countries was also agreed, taking into consideration the common but differentiated responsibilities. Furthermore, governments agreed on the full implementation of the package to support developing nations, agreed last year in Cancun, Mexico. The package includes the Green Climate Fund, an Adaptation Committee designed to improve the coordination of adaptation actions on a global scale, and a Technology Mechanism, which are to become fully operational in 2012.

The COP18/CMP8, will take place on 26 November to 7 December 2012 in Qatar, in close cooperation with the Republic of Korea.[80]

While agriculture's progress in COP has been slow, some significant advances were made under the Kyoto protocol, notably the agreement on rules for accounting for emissions and removals from the land use sector for Annex 1 parties under the Kyoto protocol.[81]

RIO+20

Rio+20 is the short name for the United Nations Conference on Sustainable Development which took place in Rio de Janeiro, Brazil in June 2012 – twenty years after the landmark 1992 Earth Summit in Rio. At the Rio+20 Conference, world leaders, along with thousands of participants from the private sector, NGOs and other groups, came together to shape how we can reduce poverty, advance social equity and ensure environmental protection on an ever more crowded planet. The official discussions focussed on two main themes: how to build a green economy to achieve sustainable development and lift people out of poverty; and how to improve international coordination for sustainable development. According to many, Rio+20 did not produce any breakthrough agreements or commitments, but it provided an international platform to shed light on pressing issues in the quest to secure global sustainable development. On the financial side, at Rio+20 more than USD 513 billion was pledged to build a sustainable future.[82]

3.2. National Action Plans for Adaptation (NAPAs)

Climate change policies at the national level are expressed through the National Action Plan for Adaptation (NAPAs) and the Nationally Appropriate Mitigation Actions (NAMAs), also national or regional climate change strategies. Agricultural development and food security plans are expressed in national development strategies and poverty reduction strategy papers (PRSPS). In the case of African countries, agricultural development and investment strategies are developed under the Comprehensive African Agricultural Development Programme (CAADP) umbrella.

Effective agriculture and climate change policies can protect the environment and contribute to the eradication of poverty. Aligning strategies and policies with enabling measures, incentives and institutional support mechanisms is key to the success of climate-smart agriculture. The sustainable utilization of natural resources will require management and governance practices based on ecosystem approaches that involve

multi-stakeholder and multi-sectoral coordination and cooperation.[83]

Policy leaders must adopt an integrated approach to food security, poverty and climate change to include the integrated planning of land, agriculture, forests, fisheries and water at all levels, and to ensure that synergies are properly taken advantage of, promoting activities that increase carbon storage, combine animal husbandry and trees with food production, and are geared towards improving soil fertility, reducing a variety of emissions from agriculture such as nitrous oxygen from fertilizer application, livestock emissions and methane from rice cultivation among others.[84]

Better integration of food security, safety nets and adaptation policies offers the potential to reap significant benefits. Better use of climate science information in assessing risks and vulnerability and then developing the safety nets and insurance products as an effective response is already being piloted in some areas with fairly positive results. Policies related to price stability are also key to both adaptation and food security, including the use of buffer stocks of food.[85]

The quality of public policies and support measures is as important as the quantity. Public support should focus on raising the resilience of the most vulnerable farmers and consumers, including through social protection and safety nets, development of climate-smart institutions and technologies, investments in soil and water conservation, value chain development, and incentives to improve diets and reduce waste. Inter-sectoral approaches and consistent policies across the agricultural, food security and climate change sectors are necessary at all levels.[86]

Patterns of public support which focus on research, support for investments in soil and water conservation, weather and climate services, land tenure, technology and value chain development rather than on commodity or input support are generally more effective, benefit more farmers and are more sustainable in the long run.[87]

It is also important that policy supports the development of sound risk insurance and risk management strategies that include safety nets that reach the poorest farmers, the dissemination of climate information to farmers and the monitoring of local outcomes of different actions, building on the traditional knowledge of farmers, and tailoring techniques to shifting climatic conditions without harming ecosystems.[88]

The key requirements to ensure an enabling policy environment that promotes climate-smart smallholder agricultural transformations are greater coherence, coordination and integration between climate change, agricultural development and food security policy processes. Policies in all three of these areas have impacts on smallholder production systems and GHG emissions.[89] To avoid solving a problem while exacerbating another, policy leaders should take an integrated approach to food security, poverty reduction and climate change. These approaches include:[90]

- Integrated planning of land, agriculture, forests, fisheries and water at local, watershed and regional scales, to ensure synergies are properly captured
- Promoting activities that increase carbon storage, combine animal husbandry and trees with food production, and are geared towards improving soil fertility
- Reducing a variety of emissions from agriculture such as nitrous oxygen from fertilizer application, livestock emissions and methane from rice cultivation
- Exploring carbon finance as a "lever" to promote sustainable agricultural practices that have many other direct benefits for smallholder farmers and the environment
- Diversifying income sources and genetic traits of crops to help farmers hedge against an uncertain climate
- Developing sound risk insurance and risk management strategies as well as resilience building strategies including safety nets that reach the poorest farmers

National early-action policies and measures might include: building a country-specific evidence base that could generate the required information, data, and knowledge to identify climate-smart agricultural practices as well as constraints to their adoption; more integrated and innovative policy design to overcome adoption barriers; institutional

and financing arrangements; and formulation of implementation strategies. These activities should also contribute to capacity building, consolidation of country ownership, and confidence-building; they could all benefit from consultation with stakeholders.

Policies on food security, development, and climate change adaptation and mitigation tend to be formulated separately, with little thought given to linkages across these policy areas. They are also often influenced by policies outside these areas, such as those relating to environmental and energy issues or finance and trade. Better aligned policies could help to overcome policy fragmentation and encourage more coordinated action that is required for synergy building, agriculture and climate change management of difficult trade-offs, and avoidance of perverse outcomes, which climate-smart agriculture seeks to address.[91]

Strategies and policies need to be adapted to country circumstances and provide incentives for responsible private sector investment both large-scale and small-scale. Successful programs need a long term commitment and strong local ownership, through bottom-up approaches.[92]

At the international level, better integration of food security, agricultural development and climate change policies and financing are also needed. Two parallel global dialogues on reducing food security and responding to climate change have until now had remarkably little substantive integration of issues under construction. Likewise the agricultural community has only recently become active in the discussions and negotiations of international climate change policies that could have profound impacts on the sector. The creation of mechanisms that allow dialogues between food security, agricultural development and climate change policy-makers is fundamental.[93]

3.3 Institutional support

Institutional support for climate smart agriculture has increased, as global and regional institutions encourage the inclusion of climate smart practices into development agendas, the scale-up of best practices, the strengthening of capacity building and increasing the knowledge base to successfully achieve climate smart agriculture. Institutions are needed to improve access coordination and collective action. In many cases, local institutions exist to govern collective action and access to collective natural resources, but they are often under increased pressure due to population growth, conflicts, changes in market patterns and state intervention.[94]

Institutions are needed to improve access coordination and collective action. In many cases, local institutions exist to govern collective action and access to collective natural resources, but they are often under increased pressure due to population growth, conflicts, changes in market patterns and state intervention. Effective systems of use and access rights and, in general, property rights are essential to improve management of natural resources including land, water and genetic resources. In many cases these rights are poorly specified, overlapping or not formalized. Improving them is a priority for providing farmers – especially women – with the incentives needed to make long term investments in transformations. However, formalizing rights does not necessarily improve the security of overall resource access since ambiguous rights often serve as an insurance mechanism, especially important where other safety nets are not available – and likely to become even more important as weather becomes more variable.[95]

Programme on Climate Change, Agriculture and Food Security (CCAFS)

The Consultative Group on International Agriculture Research (CGIAR) launched a 10-year program, the Challenge Program on Climate Change, Agriculture and Food Security (CCAFS)[96] to explore new ways of helping vulnerable rural communities adjust to global changes and generate new knowledge and tools that explain changes in climate and forecast what the changes might be, leading to a better awareness of the implications of actions that could be taken to adapt to climate change or mitigate climate change. New knowledge and predictive models will help policy-makers and farmers to understand the inevitable trade-offs. Modelling and scenarios will help them to weigh up compromises and make decisions based on the best available data.[97]

It is a response to accumulating evidence that the food security and livelihoods of hundreds of millions of people who depend on small-scale agriculture are under significant threat from climate change. The goal of CCAFS is to overcome the additional threats posed by a changing climate on attaining food security, enhancing livelihoods and improving environmental management. The aim of the program is to strengthen food security, enhance rural livelihoods and improve environmental sustainability in the context of the challenges arising from current climate variability and progressive climate change. [98]

The UN-REDD Program

The UN-REDD Program[99] is a collaborative partnership between FAO, UNDP, UNEP that supports countries to develop their capacity to reduce emissions from deforestation and forest degradation (REDD), which includes the conservation and sustainable management of forests and enhancement of forest carbon stocks. To protect the natural resources base, realize mitigation potentials and enhance output from production systems, the forestry and agriculture sectors need to coordinate their planning, policies and strategies, using a landscape approach.

The Partnership and Sourcebook on Climate-smart Agriculture is a joint FAO, WB, CGIAR, IFAD, WFP, UNEP and the Global Mechanism collaboration to coordinate action relating to climate-smart agriculture. For interventions to have sustainable impacts there is a need for leadership in bringing together practitioners, farmers and decision-makers on a strategic level to enable early action and broad involvement of stakeholders. One of the first elements is the development of a Sourcebook and knowledge platform on climate-smart agriculture. The sourcebook will describe how climate-smart agriculture simultaneously addresses food security and livelihoods, and climate mitigation. It aims to help stakeholders to plan climate-smart production systems and landscapes by providing an overview of key principles, areas of interventions and good practices in management and governance. The online Knowledge Platform will build on the content of the sourcebook and provide more detailed information on technologies, case studies and other ongoing initiatives.[100]

UNEP

The United Nations Environmental Programme (UNEP), in partnership with Standard Bank and with funding provided by the German government, introduced the *Africa Carbon Asset Development Initiative (ACAD)* in 2009, which supports projects with grants for early stage costs, technical assistance for local project developers, carbon finance training for local financial institutions. It aims to support highly replicable demonstration projects by reducing the early-stage investment risks associated with African carbon projects. Afforestation and reforestation projects are excluded from this initiative.[101]

The Mitigation of Climate Change in Agriculture[102] (MICCA) Program seeks to build the knowledge base on climate change mitigation in agriculture by conducting life cycle analyses of agricultural production chains, analyzing global mitigation potentials and costs, and reviewing opportunities and obstacles for mitigation at the farm level and also supports decision-making by analyzing policy options and farmer decision-making processes, and by supplying information to the UNFCCC negotiations. It generates reliable data by addressing the large variations and gaps in data related to GHG emissions from agriculture and forestry and strengthens countries' capacity to carry out their annual GHG inventories, and carries out pilot projects to produce quantifiable evidence that CSA practices can mitigate climate change, improve farmer livelihoods and make local communities better able to adapt to climate change.[103]

FAO's Forest and Climate Change Programme10[4] seeks to strengthen national and international actions on forests and climate change adaptation and mitigation. The program seeks to raise awareness, strengthen technical capacities, create an enabling policy environment for action and encourage cross-sectoral and landscape approaches to climate change. One of the key activities is to work with countries and other partners to develop two specific tools to assist countries mainstream climate change into the forest sector at both the policy and forest management levels. The first tool is designed to assist forest policy makers develop strategic goals and operational actions to integrate climate change into forest policy,

legislation, governance arrangements and institutional frameworks; enhances capacity, research, information, communication and financing in forest and climate change. The second tool consists of a set of guidelines to assist forest managers adjust to forest management practices to improve climate change adaptation and mitigation.[105]

The *FAO EX-ACT106 (EX-Ante Carbon Balance Tool*) is a tool developed by FAO to provide ex-ante estimations of the impact of agriculture and forestry development projects on greenhouse gas emissions and carbon sequestration and indicate their effects on the carbon-balance. It is a tool intended to improve the accuracy of accounting or greenhouse gas emissions and mitigation potential from agricultural productions systems and processes. It is designed to help farmers, practitioners and policy makers make more informed decisions and facilitate the transition to climate smart agricultural systems. By contributing to improved greenhouse gas accounting, EX-ACT also supports investments in climate smart agriculture. The tool was tested in project case studies in 2009 and peer reviewed in early 2010. FAO, in partnership with WB, the International Fund for Agricultural Development (IFAD), the AfDB, the German Agency for International Cooperation (GIZ) and others organizations, has started to pilot up-scaling. It is currently being used in 19 countries.

The International Assessment of Agricultural Science and Technology for Development (IAASTD) was initiated in 2002 by the World Bank and the FAO as a global consultative process to determine whether an international assessment of agricultural knowledge, science and technology was needed. The main goal of IAASTD is to provide decision makers with the information they need to reduce hunger and poverty, improve rural livelihoods, and facilitate equitable, environmentally, socially and economically sustainable development through the generation of, access to and use of agricultural knowledge, science and technology (AKST).[107] In 2008, the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) was concluded. This four-year process, initiated by the World Bank and the United Nations, saw more than 400 scientists from various disciplines evaluate the state of agriculture worldwide.
The report called for a paradigm shift in agricultural policies and practice, and expressed a need to strengthen support for small-scale farmers. The IAASTD did away with common concepts of agriculture, redefined which farming systems are sustainable and offered options for action in order to achieve sustainable agricultural development.[108]

4. Financial support to climate-smart agriculture

Institutional and financial support are needed for farmers, fishers and forest-dependent people to make the transition to climate-smart agriculture. Climate change mitigation, adaptation and climate-smart agriculture will require combined action on food security, development and climate change and large-scale investments to meet the projected costs. Urgent action and financing are necessary, as there have been large financing gaps - the share of agriculture in official development assistance declined from 19% in 1980 to 3% in 2006, and in 2010 was around 6%. Meeting the challenge to finance these changes will require innovation, cooperative action, political will and the use of multiple funding sources, as well as an improvement in connecting action to financing.[109]

Serious investments in building knowledge capacity and developing technology are necessary, in order for the climate-smart practices that are effective to be scaled-up. These investments have to link finance opportunities from both the public and private sector and also integrate climate finance into sustainable development agendas. Investments must be made in education, capacity development and communication.[110]

One recent study estimates that the annual global cost of adapting to climate change in the agricultural sector could amount to US$7 billion a year. The UNFCCC has come up with a figure of double that. It has also calculated that the additional investment and financial flows needed in developing countries for mitigation activities in the agricultural sector will amount to US$12.25–14 billion a year by 2030. This does not appear to include the cost of soil carbon sequestration.[111]

According to the IPCC, US $30 billion could be obtained annually through agricultural mitigation from the estimated total annual value of the four major mitigation categories (crops, grazing land improvements, organic soil and degraded land restoration) in non-OECD countries – approximately 15% of the overall agricultural investment required for food security. However, assuming that agricultural investment can leverage five times its value in carbon revenues, carbon finance may provide incentives to leverage US$150 billion worth of climate-smart agricultural investments in developing countries. Mitigation finance could thus provide significant incentives to leverage agricultural investments that generate productivity increases, reduction/removal of GHG and increased climate resilience. [112]

As overseas development aid (ODA) is not intended for financing agricultural adaptation or mitigation, a more synergistic use is needed and it could be used, for example, to provide budget or sectoral financing support for capacity building, access to information and technologies or to cover initial expenses that are needed to make changes in agriculture production systems that support both food security and climate change objectives. This would help to agricultural systems to meet multiple objectives relating to food security and agricultural development goals, while making these systems more resilient to climate change over the longer term. [113]

To ensure investments are sufficient to make the transition to climate-smart agriculture, financial mechanisms are needed that can combine and coordinate funding from several different sources, including public, private, agricultural development and climate financing.[114] As climate change has moved up the agenda, finance mechanisms have multiplied. In 2010, about 20 different climate change-related finance initiatives existed. In 2007 alone, 14 new initiatives were launched. This proliferation of new financing mechanisms has raised concerns about fragmentation, with high transaction costs (each initiative has its own governance structures and regulations), which in turn can reduce capacity to avoid duplication and inefficient allocation of resources. Strengthening national ownership, transparency and accountability will be important for international mechanisms as well as for national mechanisms receiving resources, including through direct access. [115]

For agriculture, coordination across different financing mechanisms is needed in order to reach the scale required to meet agricultural production and climate change challenges, and to ensure an adequate link between national action and international support. National funds, such as Brazil's Amazon Fund, the Indonesian Climate Change Trust Fund (ICCTF) or the proposed national Mexican Green Fund, provide opportunities

for greater national ownership and better integration with national policies and programs.[116]

4.1 Financial tools

Solutions to support the long term transitions are needed, and financing is clearly one key aspect in the form of providing credit, insurance, social safety nets and payments for environmental services.[117]

Providing Credit

The United Nations Framework Convention on Climate Change (UNFCC) has established a loan scheme[118] at the request of the Parties to the Kyoto Protocol, which provides zero per cent interest loans to cover expenses associated with the Clean Development Mechanism. To be eligible for a loan, projects must have a high probability of getting registered with the UNFCCC and generate at least 7,500 Certified Emission Reductions (CERs) per year for projects in LDCs, and 15,000 CERs per year in non-LDCs.[119]

Financing and technology transfer as well as capacity building supported under the Convention may assist in overcoming financial and non-financial barriers to the adoption of agricultural practices that increase climate-resilience, mitigate GHG emissions, and enhance food security. The types and extent of such barriers depend on the context, culture, and capabilities of countries, regions, or even farming systems, and on labour availability. Financial support related to covering only incremental or abatement costs is unlikely to trigger changes in agricultural practices; support is more likely to be effective if it improves adaptation while maintaining production.[120]

Insurance mechanisms

Index insurance programs are one potential response to the insurance gap in agriculture in developing countries to insure against an objectively-measured index – such as rainfall deficit. Many of the insurance mechanisms that already exist in rural communities have high opportunity costs in the form of foregone development. Some examples of insurance mechanisms that may constrain development are:

- Selection of less risky, but less profitable crop varieties
- Under-use of fertilizers
- Engaging less household labor in farming enterprises
- Shifting from productive to liquid assets as precautionary savings

Contract design and transactions costs are important issues in program effectiveness and have implications for the design of appropriate institutional settings. Index-insurance programs can be managed through social safety net programs or commercial financial institutions, but in either case capacity building is required. Index-based insurance reduces the problems of moral hazard and adverse selection, and generates greater willingness of lenders to extend credit to farmers.[121]

Index insurance is a financial product linked to an index highly correlated to local yields. There are several advantages to index insurance. Since all buyers of the same contract pay the same premium and receive the same indemnity per unit of insurance, regardless of their actions, index insurance avoids the problems of adverse selection and moral hazard. Thus, a farmer with rainfall insurance possesses the same economic incentives to manage her crop as an uninsured farmer. Index insurance also has its disadvantages. It is expensive to launch: significant resources and technical expertise are required to conduct the initial research and development, build the capacity of local insurers and others in the delivery channel, effectively raise the awareness of potential clients and market the product, and, in some cases, access data.[122]

Banks and other financial service providers are often reluctant to lend in rural areas or for agricultural activities because they perceive them to be risky. Private insurers have typically been reluctant to insure crop and livestock yields. Moral hazard and inadequate risk assessment information make product design difficult. The high frequency and covariate nature of certain risks can expose insurers to large payouts. As a result, premium rates are often too expensive for many farmers to afford without subsidies. Governments and relief agencies frequently intervene where losses have a catastrophic impact and the local coping capacity is weak or non-existent.[123]

Social Safety Nets

Social safety nets are a form of social

insurance consisting of programs supported by the public sector or NGOs that provide transfers to prevent the poor from falling below a certain poverty level. These programs include cash transfers, food distribution, seeds and tools distributions, and conditional cash transfers. Several new initiatives for safety net programs have emerged.[124] This program targets people facing predictable food insecurity and offers guaranteed employment for five days a month in return for transfers of either food or cash – US$ 4 per month for each household member. The purpose of the program is to build resilience to shocks amongst vulnerable HH and differs from other programs in that the transfer is predictable and regular.[125] There has been a continuing debate about the role of such programs regarding development activities. However, recent evidence indicates tradeoffs between protection and development are not pronounced. Instead, safety net programs can actually be a form of social investment into human capital (for instance nutrition, education) and productive capital (allowing households to adopt higher risk and higher productivity strategies).[126]

Payments for Environmental Services

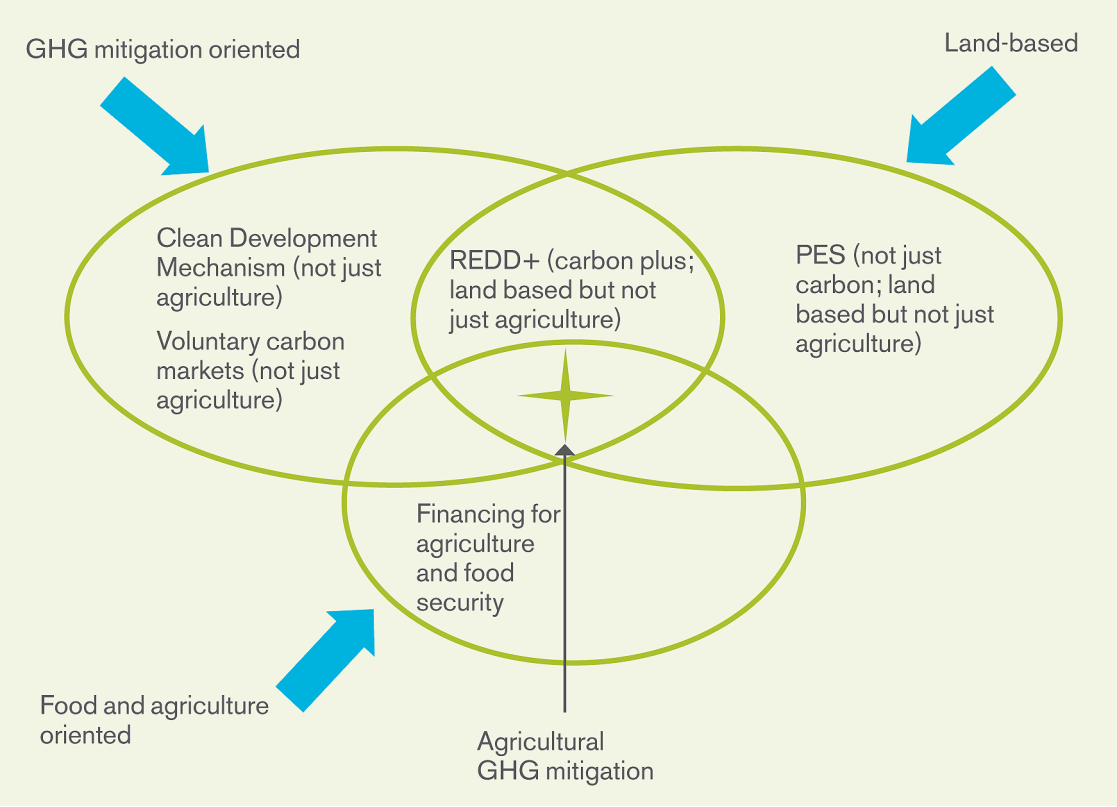
A potential source of alternative financing for agricultural transitions are payments for environmental services, mitigation of climate change being one of them that smallholders can provide and is often synergistic with improvements in agricultural productivity and stability. Emerging carbon markets and payments for emissions removals or reductions have attracted much interest and anticipation of such financing as a source of income for some agricultural activities and producers. However, high transaction costs, as well as low potential mitigation benefits in many smallholder systems seriously limit the potential of carbon market offsets to smallholders. Public financing for mitigation at a sub-sectoral or regional level is more likely to have an impact on smallholder agriculture in the near future.[127]

The Voluntary Carbon Market (VCM) has afforded communities some opportunities to access funds through selling 'voluntary emissions reductions' (VERs), but in practice, the proportion of carbon finance reaching community-led projects is small, even though the offer of ecosystem services and additional social and environmental benefits is high. Although the VCM has experienced slower activity since 2008, transactions within this market have still increased massively over the last two decades. In 2008, an amount of 123.4 million metric tonnes of MtCO2e was traded.[128]

Carbon financing

Support for measures to improve global food security is also relevant to discussions on carbon financing in agriculture. The FAO argues that an annual US$210 billion in private and public investment in developing country agriculture is needed to achieve food security for all by 2050. Of this, it estimates that around 15 per cent can be gained through carbon finance geared towards reducing GHG emissions.[129] All developing countries are eligible for support via the CDM, although in practice the majority of projects can be found in the rapidly industrializing economies of China (over 60%), India (11%) and Brazil (5%).[130]

Figure 8: Role of different financing mechanisms in agricultural GHG mitigation



Source: Garnett, Tara. 2012. Climate Change and Agriculture, p. 19

To date, there have been very few specifically agriculture-related CDM projects – currently less than 4% of the total. Until recently there have been two routes through which agriculture could be eligible for CDM payments: through the development of biogas schemes that use manure or agricultural by-products as feedstock (which avoids fossil fuel use), or through practices that sequester carbon in soils.

Since 2009, the UNFCCC has also approved projects that substitute biological nitrogen fixation for synthetic fertiliser. However the design of projects eligible for carbon credits through this route is still at the conceptual stage. Biogas has had more success than carbon sequestration, since there are inherent complexities in measuring and monitoring GHG 'savings' from soil carbon sequestration. As a result, agricultural land use projects that reward soil carbon sequestration are scarce, even in voluntary markets outside the Kyoto Protocol, where they face fewer restrictions.

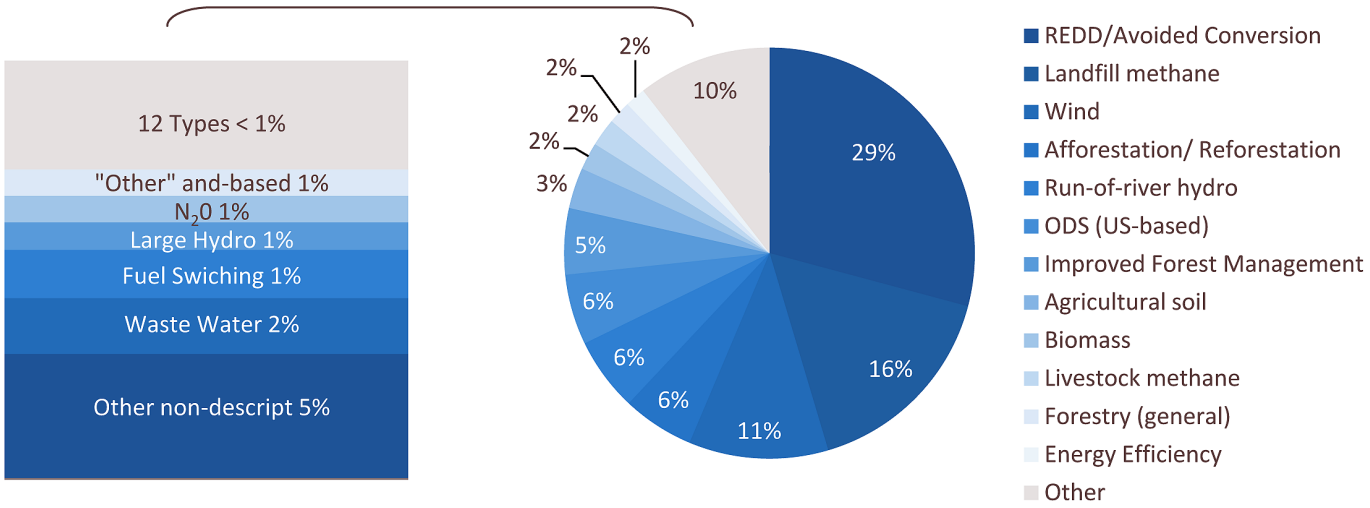
The technical problems relating to measuring and monitoring soil carbon sequestration are likely to be addressed over time. It has been argued that broadening carbon markets post-2012 to include agricultural carbon sequestration could enable agriculture-based countries in sub-Saharan Africa and other regions to participate in and benefit more fully from the financing available. Payments can also potentially gain in other ways. Measures to build carbon can improve soil quality and water retention, thereby increasing food productivity and enabling farmers to adapt to environmental stresses caused by climate change. In practice, however, as well as the

scientific difficulties associated with measuring soil carbon, particular challenges arise when designing schemes aimed at benefiting small scale farmers. For owners of very little land, the increases in soil carbon that each landholding can achieve will be limited and transaction costs will be high. There can be an 'opportunity cost' in terms of foregone land for food production in some cases, and these costs will be higher for poorer farmers. Studies suggest that farmers are more likely to participate in such schemes where they perceive there to be concrete benefits, not only in terms of income but also higher yields.

Voluntary carbon markets

As in the CDM market, there are very few agriculture-related projects within the voluntary carbon markets. In 2010, agricultural soil projects made up 3% of the total market, and livestock methane projects represent 2%.

Figure 9: Transaction volume by project type in 2010



Source: Peters-Stanley. 2011.

4.2. Support from development partners

4.2.1 The European Union

The EU has placed climate change at the top of its external relations' priorities by supporting developing countries at different levels – ranging from political dialogue with its partners to ad-hoc support for climate change, and integrating climate change aspects into its development cooperation activities and other policy areas. It is the largest contributor of climate finance to developing countries and the European Commission alone has provided official aid funds for climate change-related interventions of around EUR3.3 billion since 2002, not including significant direct contributions from EU Member States. Support has focused on energy, forestry, water resources, biodiversity, including protected areas and disaster risk reduction.[131] As of August 2011, EUR 4.68 billion have been mobilized as part of the EU Fast Start Financing scheme, which includes finance to support capacity building and the development and transfer of technologies for adaptation,

mitigation and reductions in emissions from deforestation and forest degradation in developing countries – in 2011, EUR 50 million, EUR 33 million and EUR 17 million respectively. The aim is to commit to mobilizing US$100 billion per year by 2020.[132]

The European Commission supports the Global Index Insurance Facility (GIIF), launched in December 2009, with EUR 24,5 million to expand the use of index-based insurance as a risk management tool in developing countries and especially in ACP countries. This tool is considered an effective instrument in reducing risks related to natural disasters or catastrophic events and assist in preserving livelihoods and preventing a fall into poverty. Index-based insurance pays out benefits on the basis of a parameter or a pre-assigned value for losses resulting from weather and catastrophic events, irrespective of the actual loss. Thus, beneficiaries, including smallholders, are guaranteed rapid payments following natural disasters once a pre-determined index (for instance centimeters of rainfall) has been triggered. The GIIF provides financing for advisory services to generate increased levels of awareness of index insurance, improved technical and commercial capacity to develop and market index-based insurance products and improved legal and regulatory capacity.[133] The project is implemented by the International Finance Corporation of the World Bank Group.[134]

Strengthening the knowledge base through assistance to developing countries through climate research is also necessary. Further knowledge is needed to better understand the climate system, evaluate the impacts of climate change and identify and assess options for mitigation and adaptation. The EU's 7th Framework Programme for Research and Technological development (FP7) for the period 2007 – 2012, provides a key framework for international collaborative research in the field of Environment and Climate Change. "Horizon 2020", the future EU-funding programme for research and innovation for the period 2014 – 2020 is currently under development and will continue to give priority to climate change and resource efficiency. Numerous projects carried out under the EU's research programmes concern global or regional climate change questions of relevance to developing countries. The results are also an important contribution to the Intergovernmental Panel on Climate Change's (IPCC) work on assessing climate change.[135]

The Global Climate Change Alliance (GCCA)

The GCCA is an initiative of the European Union (EU) launched in 2007 to strengthen dialogue and cooperation on climate change with developing countries most vulnerable to climate change. The GCCA focuses on the Least Developed Countries (LDCs) and the Small Island Developing States (SIDS), which are often the most affected by climate change but have the fewest resources to tackle it. The GCCA fosters dialogue and exchange of experiences between the EU and developing countries on climate policy and on practical approaches to integrate climate change into development policies and budgets. It is supporting adaptation programs in climate sensitive sectors such as agriculture, coastal zone protection and land and water management. GCCA is also active in the fields of forestry, DRR, and clean energy.

The GCCA provides technical and financial support to developing countries to integrate climate change into their development policies and budgets and to implement adaptation and mitigation interventions. The technical and financial cooperation in turn informs the dialogue and exchange of experiences between the EU and developing countries. From 2008 to 2011, the GCCA has committed and engaged over EUR 200 million in support of 31 programmes across the world while an additional 11 countries and regions are expected to benefit from the initiative in 2012-2013.[136] By the end of 2011, the GCCA will have national programmes in 25 countries in areas like climate change mainstreaming (Bhutan, Cambodia, Ethiopia, Laos, Mozambique, Nepal, Seychelles, Solomon Islands), adaptation in climate sensitive sectors like agriculture (Uganda), coastal zone management (Gambia, Guyana, Senegal), land (Rwanda), and water (Belize, Samoa), and both at the national level (Vanuatu) and at the local level (Tanzania). The GCCA is also active in the fields of clean energy (Mauritius), forestry (Mali, Benin, Sierra Leone, and DRC), disaster risk reduction (Jamaica), and adaptation or mitigation more generally (Bangladesh, Maldives, Vanuatu).[137]

Investments from the EU in Africa

The EU cooperates with Africa through the Africa-EU Strategic Partnership on Climate Change and Environment, for example including supporting the ClimDev-Africa project. Zambia, a country which suffers from poor yields due to low use of inputs, overdependence on climate conditions and a lack of improved crops varieties, is being supported by the EU in collaboration with FAO – EUR 16.9 million have been given to a conservation agriculture (CA) project, which aims to produce resource-saving agricultural crops and boost small farmers' food production through improved access to agricultural inputs and the promotion of CA principles.[138]

Furthermore, the EU is funding a EUR 1.4 million project for the Great Green Wall for the Sahara and Sahel Initiative (GGWSSI), an African-owned program aligned with TerrAfrica and seeks to unite the countries of the Sahara and the Sahel to not only adapt to climate change but also ensure they benefit from the post-Kyoto climate agreement, gaining recognition for the fact that there are huge opportunities for low-cost carbon storage in dryland soils. The EU-funded project focuses capacity development for the planning and implementation of best practices at the local and international level, establishing a networking platform for knowledge sharing and technology transfer, developing a harmonized strategy for the GGWSSI and setting up a platform for partnership and resource mobilization. The EU contribution to TerraAfrica is EUR 10 million.[139]

The EU has also provided EUR 8 million to the Kenyan Agricultural Research Institute (KARI) for the Kenya Arid and Semi-Arid Research program (KASAL), which focuses on developing site-specific agricultural technologies which help farmers and livestock keepers in the region adapt to climate change. Arid and Semi-Arid Lands (ASALs) of Kenya experience high poverty rates (between 60 – 80%), as the ASALs maize fails every three out of five seasons. This has led to food insecurity and the dependence of thousands of people on food relief. The program funded by the EU has developed models for private and public sector players to work together to assist the farmers and livestock keepers to produce and market drought-tolerant crops (sorghum, cassava and amaranth grain) and appropriate animals (indigenous chicken and camels).[140]

Investments from the EU in the Caribbean

In Guyana, mangroves contribute substantially to sea defence by damping wave actions and protecting coastal banks against the effect of heavy storms, thus playing an important role in disaster risk reduction. They also provide a number of ecosystem services essential for human populations, including food and wood sources, water sanitation and waste absorption, also acting as nurseries for many species of tropical fish, providing a complex habitat that attracts food and creates refuge from predators. As 90% of the population in Guyana lives in the low-lying coastal area, the coastal ecosystem, especially the mangrove forests, is threatened. The National Mangrove Management Action Plan includes public awareness activities, replanting, research, monitoring and development of a code of practice and constitutes the reference document of a recent EU-funded program. In the context of the GCCA, the EU is providing EUR 4.2 million for an innovative Sector Budget Support for sustainable coastal zone protection through mangrove management in Guyana with the objective being the mitigation of climate change through carbon sequestration, as well as through sea defence and biodiversity protection. The results foreseen include rehabilitation of mangrove fields, mapping of existing mangroves for a better monitoring, mainstreaming mangrove issues in the national Forest Plan and raising awareness, involvement of local communities living close to mangroves. Until now, Guyana has planted 200,000 mangrove seedlings in an area of 4,5 km along different sections of the coastline ; surveys of project sites designs for hard structures to increase sedimentation in selected areas has been undertaken; and a mangrove ranger unit to monitor and protect the mangroves that have been established.[141]

Investments from the EU in the Pacific

In the Pacific, many high-level meetings and workshops took place in 2010 relating to EU-Pacific relations, with the support of the Global Climate Change Alliance[142] (GCCA) – an EU initiative to increase dialogue and cooperation with developing areas, which provides technical and financial support to developing countries to integrate

climate change into their. Between 2008 and 2011, over EUR200 million were allocated by the GCCA in support of 31 programs in 25 countries across the world and an additional 11 countries and regions are expected to receive funds in 2012 – 2013.[143]

4.2.2 ACP support

The African Development Bank (AfDB), African Union (AUC) and UN Economic Commission for Africa (UNECA) have committed EUR144 million for 2012 – 2014 to the Climate for Development in Africa (ClimDev-Africa) Program, which aims to improve the provision and use of appropriate climate information to promote planning for sustainable development in Africa. The ClimDev-Africa Special fund (CDSF) was established within the program. The objectives are to pool resources to contribute to sustainable development and poverty reduction by preparing and implementing climate-resilient development programs that mainstream climate change information at all levels in Africa, and to strengthen the institutional capacities of national and sub-regional bodies to formulate and implement effective climate-sensitive policies. The ultimate beneficiaries of this project are rural communities i) with climate-sensitive livelihoods b) that are vulnerable to climate-sensitive diseases c) that are dependent on uncertain water and other natural resources d) at risk of disasters e) with poor energy access. The fund has not become effective yet, but steps are underway to operationalize the fund. Once it has become effective, the EUR144 million will finance and manage 72 projects.[144]

The Global Environment Facility (GEF) is a collaboration between UNEP, WB and UNDP and provides grants to developing countries for projects that benefit the global environment and promote sustainable livelihoods in local communities. Assessments of impacts and adaptations to climate change (AIACC) was one of GEF's key initial adaptation programs. AIACC consisted of a global initiative developed in collaboration with the UNEP/WMO IPCC and was funded primarily by the GEF to advance scientific understanding of climate change vulnerabilities and adaptation options in developing countries. The total budget was around US$8 million. It was introduced in 2002 and final reports were submitted in 2006 – 24 regional assessments were carried out, covering 46 countries, of which 17 African countries. The AIACC climate change assessments engaged effectively with policy processes, but, at the same time, the final report is said to fail to recognize the need for the further engagement of stakeholders in the design and start-up phases of the projects.[145]

The World Bank Group has become increasingly involved in international climate discussions, demonstrating the institution's desire to play a greater role in climate finance in developing countries. At the same time, however, it has been accused of supporting fossil fuel projects that are harmful to the climate and lock developing countries into energy models that are both dangerous and expensive, and of its failure to approve a climate-sensitive energy strategy. Nearly half of its lending – more than US$15 billion has gone to fossil fuels in the last four years – is spent to fund these projects. An example is support to a coal project in Kosovo, which will contribute to the most heavily polluting form of coal (lignite).[146]

4.3. Initiatives from the private sector

Cargill

Cargill, one of the world's largest privately held companies with more than US$100 billion in annual sales, has been investing in projects to improve food security in Africa. Some recent examples from this year: In June 2012 Cargill revealed plans to develop industrial palm-oil and processing facilities in the Ivory Coast within the next five years and may invest up to US$380 million in the project. Cargill is one of the biggest cocoa exporters in the West African nation, the world's top grower of the crop.[147]

In May 2012, Cargill announced they would invest US$3 billion in a 5-10 year program with the government of Mozambique to make farming in Africa commercially successful, as part of the New Alliance for Food Security and Nutrition. Along with other multinational corporation, small African businesses, advocacy groups, banks, African governments the goal is to raise 50 million Africans out of poverty within the next decade and to transform Africa into a major food exporter. Cargill's specific role will be to increase the soybean or corn production of roughly 16,000 farmers operating on small land holdings in Mozambique. The move into

Mozambique is a first step for Cargill, a company that currently employs 5,000 people in nine other African countries in operations focused mainly on growing or processing cocoa, grain, oil seed and cotton. Previously, in November 2011, Cargill had made the largest single food gift in history to the Horn of Africa, sending 10 metric tons of rice on a tracked ship. However, Cargill seeks to do more than provide relief and to give African farmers the tools to survive.[148]

General Mills

General Mills is one of the world's leading food companies, operates in more than 100 countries and markets more than 100 consumer brands. In 2011, General Mills officially launched the non-profit organization 'Partners in Food Solutions' together with others (Cargill, DSM, TechnoServe, USAID, PEPFAR) as a hunger-fighting non-profit that seeks to bring food production and food processing expertise to small and medium-sized food processors in African nations. The aim is to use the deep food processing expertise and the technical leadership skills necessary to transfer critical knowledge to food processors in Africa who can then increase production and fight food poverty. Local food processors can then source more ingredients from local small-holder farmers, many of them women, creating an important and stable outlet for their crops. In the year of the launch, Partners in Food Solutions had already begun working with 15 food processors on about 40 projects in Kenya, Zambia, Tanzania and Malawi, impacting 60,000 farmers. Until 2016, they aim to broaden the program to include as many as 10 corporate partners working with 200 food processors and 1 million farmers in 14 African nations with work ranging from new product development to packaging, from plant design to fortification.[149]

Mars, Incorporated

The African Orphan Crops (AOC) consortium was initiated by Mars, Incorporated, NEPAD and WWF in 2011 to improve the productivity of Africa's most important food crops, while making them more nutritious and more robust in the face of weather disasters, pests and disease. Per capita food yields have been declining in Africa for decades, resulting in stunting among one-third of African children. Furthermore, the IPCC reports that by as early as 2020, global warming may reduce rain-fed crop yields in some African countries by as much as 50%. The crops in question are grown in all parts of Africa, but are referred to as "orphan crops" because they have largely been ignored by science and big seed companies. This includes cassava, palm oil, peanuts, sorghum, African eggplant, baobab and many others. As population and consumption in Africa are increasing and 21st century technology allows faster improvements of annual crops, tree crops and perennial crops propagated without seeds, demand for these crops is increasing. The consortium has also begun to sequence winter-thorn acacia, a tree that can be used for nitrogen fixation, carbon sequestration and erosion control. It has edible seeds sheds its leaves in the rainy season, allowing it to be grown among field crops without shading them.[150]

4.4. Public-Private Partnerships

Public private partnerships (PPP) present an opportunity for financing. Expanding and diversifying the sources that are used could provide greater flexibility and the opportunity to tap into additional sources of funding.[151]

Some trade-offs when investing in agricultural changes to mitigate climate change may occur, for example crop and grassland restoration often take land out of production for a significant period of time, reducing cultivated or grazing land available in the short run, but leading to overall increases in productivity and stability in the long run. A different type of trade-off may occur with incorporating crop residues that are expected to increase soil fertility and water retention capacity, thereby increasing yields at least over the medium-long term.[152]

The EU acknowledges the use of grants to leverage additional contributions from the private sector to fully meet the financial needs to mitigate the impacts of climate change. Instruments that foster and strengthen Public Private Partnerships (PPPs) need to be scaled up to meet the long-term commitments of developed countries for climate change finance. The European Commission has, thus, established 'Climate Change Windows' in existing financial instruments, which are designed to leverage loans and private investments and is planning to continue doing so for future instruments and mechanisms.[153]

The *Global Energy Efficiency and Renewable Energy Fund154 (GEEREf)* is an innovative Public Private Partnership initiated by the European Commission and managed by the European Investment Bank group to transfer clean and renewable energy technologies to developing countries. GEEREF finances a range of energy efficiency and renewable energy projects and technologies and also enables the transfer of low-carbon technologies in targeted regions. It has invested more than EUR 45 million in four regional funds, covering Southern Africa, East Africa, South Asia and Latin America. The European Commission, Germany and Norway are the current investors of the GEEREF.[155]

5. The Way Forward

The Green Revolution has performed well in areas with a stable climate, adequate water supply and access to inputs and cheap energy. But the necessary fertilizers, pesticides, farm equipment and fuel are derived from dwindling and ever more expensive fossil fuels. Detailed analyses of agricultural performance after extreme climatic events have revealed that resilience to climate disasters is closely linked to the level of on-farm biodiversity.[156] Increasing organic matter in soils in cropping systems will be critical to retain water, increase yields and reduce risks in rain-fed agriculture while sequestering carbon.[157] Nevertheless, agriculture can present the solution to help people to feed themselves and adapt to changing conditions while mitigating climate change.[158]

It will be important to have consistent policies that support and strengthen tools, programs and knowledge sharing, and provide financial mechanisms and funds for agricultural investments. The mitigation of climate change, the support for sustainable agricultural development and the implementation of adaptation measures are key to successful climate smart agriculture.[159]

As the world seeks solutions for facing the reality of changing climates, the importance of mitigating the effects of greenhouse gas (GHG) emissions becomes increasingly significant, especially in the agriculture sector which both emits and sequesters GHGs.[160] In the food and agriculture sector, adaptation and mitigation often go hand in hand, so adopting an integrated strategic approach represents the best way forward.[161]

Farmers who are the 'agricultural stakeholders' must adapt to and mitigate the impacts of climate change simultaneously. Sufficient funding is of utmost importance, as adaptation and mitigation measures are not cheap and more investments need to be made to increase farmers' resilience to climate change through a) technology, for example crop breeding for new climate, rural electrification b) management, such as farming systems that use water more efficiently c) institutions, for instance market and tariff structure). Many adaptation measures can be win-win, for example drought-proofing for present weather can increase resilience to effects of a long-term drying trend.[162]

For agriculture to be part of the solution to climate change, while continuing to contribute to development and food security, it needs to (i) be eligible to receive resources from existing and future climate financing mechanisms, (ii) have its specificities taken into account for effective allocation and use of resources and (iii) allow rewards for agricultural producers who adopt practices that generate multiple benefits for climate change, development, and food security. Coordination across different financial sources is needed to mobilize the scale of finance required to meet agricultural production and climate change challenges.[163]

Action on multiple fronts – agriculture, rural development, trade, social welfare, land rights, gender equity, education and knowledge management – can come together to ensure that humanity operates in a "safe space" that provides sufficient food for all without compromising environmental limits. Indeed, the international community needs to demonstrate commitment to the multiple agendas of food security, adaptation and mitigation by stepping up investment support to climate-smart agriculture and scaling up of best practices and technologies. Considerable finance will be needed to rapidly implement proven programmes. Placing a greater emphasis on agriculture in negotiations on climate change, as in the development of national policies, will ensure that agriculture fully contributes to efforts to adapt and mitigate without undermining food production and the fight against poverty.[164]

According to IFOAM, operators shall take measures to maintain and improve landscape and enhance biodiversity. This may include extensive field margins, hedges, trees or bushes, woodlands, waterways, wetlands and extensive grasslands. The integration of landscape elements is mentioned as an effective mitigation strategy by the IPCC, due to its multiple adaptation effects. For example, hedges and trees are useful to reduce erosion, which is expected to be aggravated by climate change. The adaptation effects of landscape features are particularly important in those areas where the strongest impacts of climate change are expected.[165]

Necessary improvements for financing

While a number of existing financing mechanisms have been instrumental in mobilizing resources for climate change mitigation and adaptation, FAO has underlined that the main mechanisms have generally not

enabled agriculture (or forestry) to contribute fully to adaptation and mitigation efforts, in accordance with its potential. The Clean Development Fund (CDM) largely excludes agriculture, as soil carbon sequestration (representing 89% of agriculture's mitigation potential) is not eligible. The EU Emissions Trading Scheme (EU-ETS) also excludes agriculture. This contrasts with voluntary carbon markets and the WB's BioCarbon Fund which include soil carbon sequestration. Although 4.49% of all registered CDM projects are designated as relating to agriculture, these mainly address energy (bioenergy) through the use of agricultural residues, bio-fuels from crops and manure management. CDM's project-based and offset approaches may be inadequate to generate the breadth and scale of incentives required for agricultural mitigation. CDM incentives appear too weak to stimulate transformation in the economy and have not enabled developing countries to move towards low-emission development pathways that do not threaten economic growth. CDM projects also tend to have high transaction costs for many developing countries, long approval periods and a narrow geographic spread. Efforts to correct these weaknesses are under discussion and implementation.[166]

The *Adaptation Fund* has recently become operational and ten projects have been submitted, of which only two are related to agriculture, one by WFP on building climate resilience in Uganda's fragile ecosystems and the other by UNEP on vulnerability of the rice sub-sector to climate variability and projected climate change. Furthermore, developing countries, especially LDCs, have complained that accessing resources from the GEF has been complicated and project approval takes a long time. They have indicated that this has inhibited the implementation of NAPAs and the preparation of national communications. They have also drawn attention to under-funding of the Special Climate Change Fund and the LDC Fund which are funded on a voluntary basis.[167]

Finding ways to overcome what is sometimes a false dichotomy between adaptation and mitigation (which can be the case with agriculture, especially where soil carbon sequestration is concerned), as well as the integration of adaptation and mitigation finance with agricultural development financing channels and activities, will be a challenge faced by financing mechanisms in the future. Broader approaches that look beyond current silos to forms of financing that could support high productivity/resilience and low emission agricultural development and development/food security-responsible climate change responses will be needed. Mechanisms must also be flexible enough to fund options adjusted to the specific agro-ecological, institutional and technological situations of different countries, including their different capacities. They may also be called upon to address the potential for establishing long-term and reliable funding sources, rewarding synergies and resolving potential conflicts or trade-offs due to multiple fund objectives. [168]

Adequate investment in national climate-smart agricultural policy formulation, research and extension, including related capacity building, is important in supporting action by farmers. Ministries of Agriculture, national research institutes and extension systems in many cases need to be built back following the decline in resources allocated to agriculture both internationally and domestically. Nationally-owned instruments that can promote coherence and coordination in priority setting for climate-smart agriculture action and financing may be useful to governments.[169]

A key issue associated with financing for mitigation is measurement, reporting and verification (MRV) of emission reductions and removals, as well as of international support provided. There is currently no consensus on the specific parameters of MRV for international financing, but eventual decisions in this regard could affect the costs and viability of different agricultural mitigation activities. Developing countries and farmers are more likely to undertake action to build MRV capacity, where there is confidence and direct access to adequate and predictable financing for capacity building, and technology development/transfer. More robust measurement of soil carbon sequestration may require combining actual soil samples, with modelling and/or default values for emission-reducing/removing activities.[170]

Further steps for ACP countries

For Africa, the continent that highly depends on agriculture and is the most vulnerable to the impacts of climate change, there is no single best option for the integration of various methods, but the most important ones are:

- The Adaptation fund policy: since Africans are most affected and least able to cope with the impacts of climate change this should be the priority, and show how financing can be done, sources of funding, directives for use, monitoring and evaluation
- Integrating climate change adaptation measures in other long-term planning through other development policies, for example by incorporating climate change measures in poverty alleviation strategies
- Building a resilient society by integrating climate change measures with a combination of learning alliances, innovation systems and a sustainable livelihood framework
- Strengthening and supporting the National Adaptation Plans of Action (NAPA)
- Capacity building, policy-increasing awareness and knowledge about climate change impact, vulnerability and adaptation
- Technology transfer policy, which provides access for the poor to utilize environmentally friendly technology as an open resource
- Policy to strengthen environmental governance from the local to the national level
- Strengthening information and communication, especially for weather forecasting
- Policy which supports crisis, disaster and risk early warning and response system[171]

It is important that governments and institutions act now, as early action is needed to identify and scale up best practices, to build capacity and experience and to help clarify future choices. Considerable finance will be needed to rapidly implement programs and support poverty alleviation and food security goals in a changing climate.[172] Integration of the productivity, adaptation and mitigation agendas remains a challenge and must be addressed if climate-smart agriculture is to achieve the triple wins, both in strategies and in financing mechanisms.[173]

Responses aimed at adapting to climate change may have negative consequences for food security, just as measures taken to increase food security may exacerbate climate change. This complex and dynamic relationship between climate change, agriculture and food security is also influenced by wider factors. Agricultural and food systems are heavily influenced by socioeconomic conditions, which are affected by multiple processes, such as macro-level economic policies, political conflict, the spread of infectious disease etc. Thus, concerted action is urgently needed to address this complex challenge. Although climate change is a long-term phenomenon, the actions taken over the next 10 years will be critical. The foundations must be built for responsive, adaptive agricultural technologies and policies that help people reduce their vulnerability to climate variability, while at the same time paving the way for the successful management of long-term changes.[174]

One key role of institutions is the production and dissemination of information, ranging from production and marketing conditions to the development of regulations and standards. It will be critical that national and international agricultural research programs focused on developing countries incorporate climate change into their programming.[175]

Improving the use of climate science data for agricultural planning can reduce the uncertainties generated by climate change, improve early warning systems for drought, flood, pest and disease incidence and thus increase the capacity of farmers and agricultural planners to allocate resources effectively and reduce risks.[176]

A human security-based approach to strengthening international institutions in the area of sustainable development and defining new global sustainable development goals could help give priority to the needs of poor and vulnerable countries.[177]

Glossary

Adaptation

The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.[178] The core factor of adaptation should involve building resilience, which is the ability of countries, communities, households and individuals to cope with climate change[179] and 'tolerate disturbance without collapsing into a qualitatively different state'.[180]

Autonomous Adaptation

Adaptation that does not constitute a conscious response to climatic stimuli, but rather is triggered by ecological changes in natural systems and by market or welfare changes in human systems. It is also referred to as spontaneous adaptation.[181]

Agriculture

For the purposes of this report, the term agriculture is used to include all land-use activities involving the cultivation, production, and processing of food, fuel, and fiber. Where needed, sections of the report refer to specific types of agriculture and to the interface between certain land uses.[182]

Biomass

Materials that are biological in origin, including organic material (both living and dead) from above and below ground, for example, trees, crops, grasses, tree litter, roots, and animals and animal waste.

Biosphere

The part of the Earth system comprising all ecosystems and living organisms, in the atmosphere, on land (terrestrial biosphere) or in the oceans (marine biosphere), including derived dead organic matter, such as litter, soil organic matter and oceanic detritus.

Carbon capture and storage

The collection and transport of concentrated carbon dioxide gas from large emission sources, such as power plants. The gases are then injected into deep underground reservoirs. Carbon capture is sometimes referred to as geological sequestration.

Carbon dioxide (CO2)

A common gas formed by the combination of carbon and oxygen. A by product of the combustion of fossil fuels and a key component of the carbon cycle. It can trap heat within the earth's atmosphere giving it a so-called "global warming potential". All other greenhouse gases' warming potentials are measured relative to CO2.[183]

Carbon dioxide equivalent (CO2e)

CO2e is an indicator that converts the six greenhouse gases that exist into one carbon dioxide equivalent quantitative measure. This is the standard international way of reporting on greenhouse gas emissions. PG stands for Petajoule – an international unit of energy, work, and heat equal to 1015 joules.[184]

Carbon Footprint

The total amount of greenhouse gases that are emitted into the atmosphere each year by a person, family, building, organization, or company. A persons carbon footprint includes greenhouse gas emissions from fuel that an individual burns directly, such as by heating a home or riding in a car. It also includes greenhouse gases that come from producing the goods or services that the individual uses, including emissions from power plants that make electricity, factories that make products, and landfills where trash gets sent.

Carbon market

A popular (but misleading) term for a trading system through which countries may buy or sell units of greenhouse-gas emissions in an effort to meet their national limits on emissions, either under the Kyoto Protocol or under other agreements, such as that among member states of the European Union. The term comes from the fact that carbon dioxide is the predominant greenhouse gas, and other gases are measured in units called "carbon-dioxide equivalents."

Carbon sequestration

The uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide, release the

oxygen and store the carbon. Fossil fuels were at one time biomass and continue to store the carbon until burned. See also Carbon sinks.[185]

Certified Emission Reduction (CER)

A greenhouse gas trading credit, under the UN Clean Development Mechanism program. A CER may be earned by participating in emission reduction programs - installing green technology, or planting forests - in developing countries. Each CER is equivalent to one tonne of carbon dioxide.

Clean Development Mechanism (CDM)

A mechanism under the Kyoto Protocol through which developed countries may finance greenhouse-gas emission reduction or removal projects in developing countries, and receive credits for doing so which they may apply towards meeting mandatory limits on their own emissions.

Climate

Climate refers to the characteristic conditions of the earth's lower surface atmosphere at a specific location; weather refers to the day-to-day fluctuations in these conditions at the same location. The variables that are commonly used by meteorologists to measure daily weather phenomena are air temperature, precipitation (e.g., rain, sleet, snow and hail), atmospheric pressure and humidity, wind, and sunshine and cloud cover.[186]

Climate Change

According to the IPCC, climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. In the Framework Convention on Climate Change, the term has a different definition and refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.[187]

COP17

The official title of the Durban conference. Alternatively, it can be called the 17th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

Deforestation

Those practices or processes that result in the conversion of forested lands for non-forest uses. Deforestation contributes to increasing carbon dioxide concentrations for two reasons: 1) the burning or decomposition of the wood releases carbon dioxide; and 2) trees that once removed carbon dioxide from the atmosphere in the process of photosynthesis are no longer present.

Desertification

Land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities. Further, the UNCCD (The United Nations Convention to Combat Desertification) defines land degradation as a reduction or loss, in arid, semi-arid, and dry sub-humid areas, of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation. Conversion of forest to non-forest.

Food Security

FAO's vision of a world without hunger is one in which most people are able, by themselves, to obtain the food they need for an active and healthy life, and where social safety nets ensure that those who lack resources still get enough to eat.[188]

Fossil Fuel

A general term for organic materials formed from decayed plants and animals that have been converted to crude oil, coal, natural gas, or heavy oils by exposure to heat and pressure in the earth's crust over hundreds of millions of years.

Global Environment Facility (GEF)
The GEF is an independent financial organization that provides grants to developing countries for projects that benefit the global environment and promote sustainable livelihoods in local communities. The Parties to the Convention assigned operation of the financial mechanism to the GEF on an on-going basis, subject to

review every four years. The financial mechanism is accountable to the COP.

Greenhouse Effect

Trapping and build-up of heat in the atmosphere (troposphere) near the Earth's surface. Some of the heat flowing back toward space from the Earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other gases in the atmosphere and then reradiated back toward the Earth's surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere will gradually increase

Green Revolution

The Green Revolution was the technological response to a world-wide food shortage which became threatening in the period after WWII.[189] The term Green Revolution refers to a series of research, development, and technology transfer initiatives, occurring between the 1940s and the late 1970s, that increased agriculture production around the world.

Intergovernmental Panel on Climate Change (IPCC)

Established in 1988 by the World Meteorological Organization and the UN Environment Programme, the IPCC surveys world-wide scientific and technical literature and publishes assessment reports that are widely recognized as the most credible existing sources of information on climate change. The IPCC also works on methodologies and responds to specific requests from the Convention's subsidiary bodies. The IPCC is independent of the Convention.

Kyoto Protocol

The first binding deal on emissions reductions named after the host city of the 1997 UNFCCC meeting where it was signed. Rich countries agreed to enter into a carbon cap and trade system with targets on greenhouse gas cuts written into international law. The fate of a second phase of cuts based on the Kyoto rules remains undecided.[190]

Market governance mechanism

A market governance mechanism (MGM) is defined as a set of formal or informal rules consciously designed to change behaviour – of individuals, businesses, organisations or governments – so as to influence how markets work and their outcomes.[191]

Organic Agriculture

According to the Codex Alimentarius Commission, organic agriculture is a holistic production management system that avoids use of synthetic fertilizers, pesticides and genetically modified organisms, minimizes pollution of air, soil and water, and optimizes the health and productivity of interdependent communities of plants, animals and people.[192]

Mitigation

A human intervention to reduce the human impact on the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.

REDD

Reducing Emissions from Deforestation and Forest Degradation.

Renewable Energy

Energy resources that are naturally replenishing such as biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action.

Vulnerability

The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, the sensitivity and adaptive capacity of that system.[193]

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IPCC - Intergovernmental Panel on Climate Change
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IDS - Institute of Development Studies
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NRI - Natural Resources Institute
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Acronyms

AAUs	Auctioning of Allowances
AF	Adaptation Fund
AfDB	African Development Bank Group
AGF	African Green Fund
AIACC	Assessments of impacts and adaptations to climate change
AMIS	Agriculture Market Information System
AOC	African Orphan Crops
AUC	African Union Commission
AusAID	Australian Government Overseas Aid Program
CA	Conservation Agriculture
CAADP	Comprehensive African Agricultural Development Programme
CARIFORUM	Caribbean Forum
CCAA	Climate Change Adaptation in Africa
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CGIAR	Consultative Group on International Agricultural Research
CCCCC	Caribbean Community Climate Change Centre
CDC	Centres for Disease Control
CDM	Clean Development Mechanism
CDSF	ClimDev-Africa Special fund
CEHI	Caribbean Environmental Health Institute
CERs	Certified Emission Reductions
CGIAR	Consultative Group on International Agriculture Research
CILLS	Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel
CIMH	Caribbean Institute for Meteorology and Hydrology

CO2	Carbon dioxide
CO2e	Carbon dioxide Equivalents
COMESA	Common Market for Eastern and Southern Africa
COP	Conference of the Parties
COP17	17th Conference of the Parties to the UN Framework Convention on Climate Change
DWC	Dialogue on water and Climate
DWSP	Drinking Water Surveillance Program
ECOWAS	Economic Community of West African States
EU-ETS	EU Emissions Trading Scheme
EX-ACT	Ex-Ante Carbon-balance Tool
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign direct investment
FFS	Farmer Field Schools
FP7	EU's 7th Framework Programme for Research and Technological development
GAFSP	Global Agriculture and Food Security Program
GCCA	Global Climate Change Alliance
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEEREf	Global Energy Efficiency and Renewable Energy Fund
GEF	Global Environment Fund
GEF	Global Environment Facility
GGWSSI	Great Green Wall for the Sahara and Sahel Initiative
GHG	Greenhouse gas
GHGAP	Greenhouse Gas Action Plan

GIIF	Global Index Insurance Facility
GIZ	German Agency for International Cooperation
GT	Gigatonne
HH	Household
INRA	Institut Scientifique de la Recherche Agronomique
ICCTF	Indonesian Climate Change Trust Fund
IDRC	Canada's International Development Research Centre
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
KARI	Kenyan Agricultural Research Institute
LCA	Long-term Cooperative Action
LDCs	Least Developed Countries
LEAP	Livelihoods Early Assessment Protection
MICCA	FAO's Mitigation of Climate Change in Agriculture
MRC	Mekong River Commission
MRV	Measurement, reporting and verification
NAMA	Nationally Appropriate Mitigation Actions
NAPA	National Action Plan for Adaptation
NGOs	Non-governmental organizations
NZAID	New Zealand Agency for International Development
ODA	Overseas Development Aid
OECD	Organisation for Economic Co-operation and Development
PICCAP	Pacific Islands Climate Change Assistance Programme

PICTs	Pacific Island Countries and Territories
PPP	Public Private Partnerships
PRSPSs	Poverty reduction strategy papers
PSNP	Productive Safety Net Program
REDD	Reducing Emissions from Deforestation and Forest Degradation
SBSTA	Subsidiary Body for Scientific and Technological advice
SICAP	Solomon Islands Climate Change Assistance Programme
SPC	Secretariat of the Pacific Community
UNCTAD	United Nations Conference on Trade and Development
UNECA	UN Economic Commission for Africa
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USP	University of the South Pacific
WFP	World Food Programme
WRAP	Waste and Resources Action Programme
WTO	World Trade Organization

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