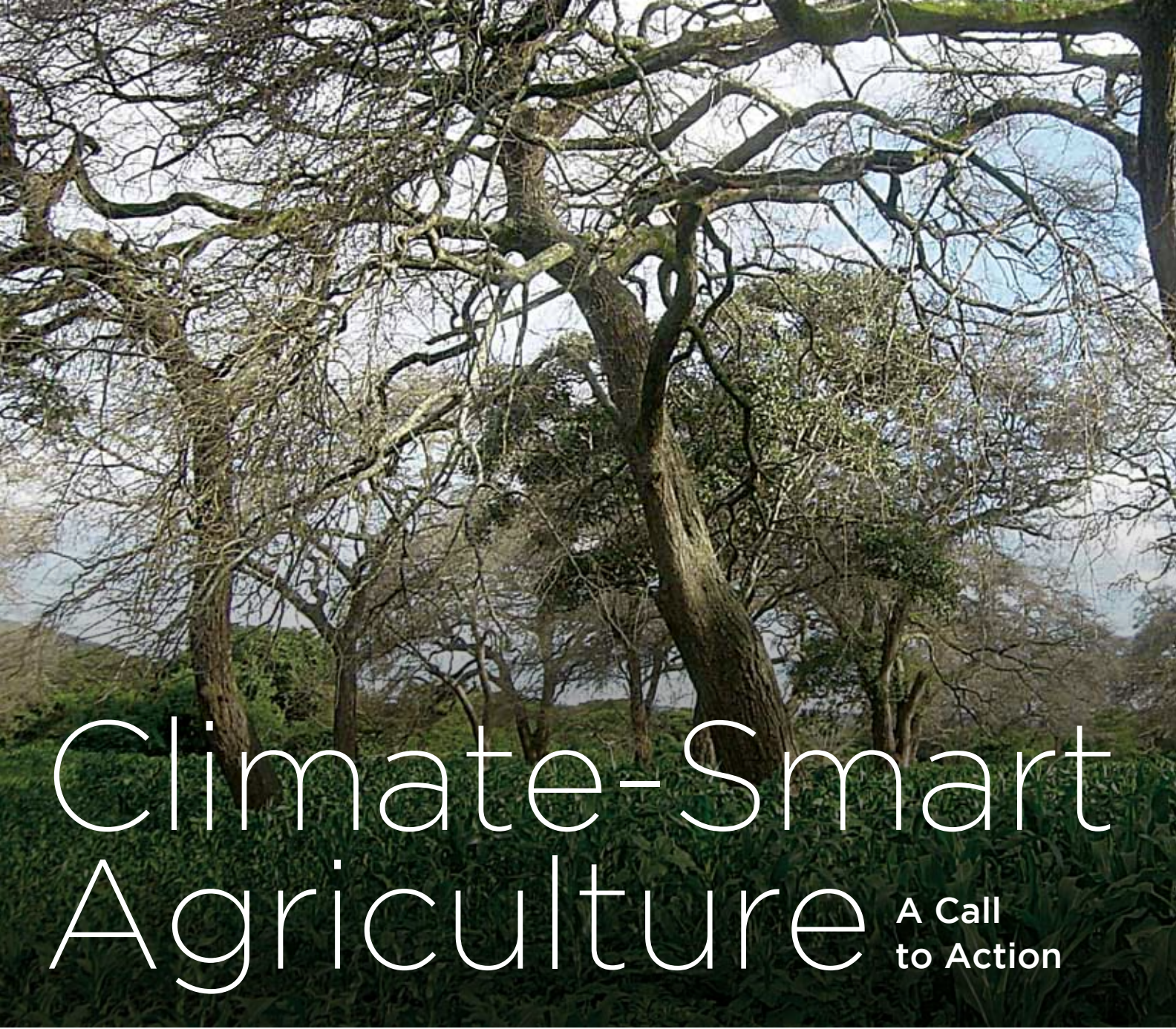




Climate-Smart Agriculture

A Call
to Action



THE WORLD BANK

Climate-smart agriculture

seeks to increase sustainable productivity, strengthen farmers' resilience, reduce agriculture's greenhouse gas emissions and increase carbon sequestration. It strengthens food security and delivers environmental benefits. Climate-smart agriculture includes proven practical techniques — such as mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management, agroforestry, improved grazing, and improved water management — and innovative practices such as better weather forecasting, more resilient food crops and risk insurance.



Foreword

Feeding people in decades to come will require ingenuity and innovation to produce more food on less land in more sustainable ways. Climate change will exacerbate already tight resource constraints by making weather more extreme and variable and by decreasing average yields worldwide. Population growth, changing diets and land and water scarcity are also long-term trends that threaten our shared vision of a more prosperous future in which well-fed people everywhere are able to achieve their full potential without damaging their environment. Already, these pressures are forcing farmers and researchers to reassess mainstream farming techniques and consider alternative approaches to securing food, including conservation agriculture, integrated crop-livestock management, intercropping and agroforestry.

The good news is that there is no shortage of women and men ready to take the last century's agricultural advances into a new era of opportunity. Collectively, we can tap into well-proven production practices, information technology and scientific findings, to rapidly scale up policies and practices that achieve the triple win of food security, adaptation and mitigation. That goal is within reach if we build on our successes and create the right incentives for site-specific sustainable land management practices around the world.

“To feed the continent’s 900 million people, Africa needs its own food security. This can only be achieved through a uniquely African Green Revolution. It must be a revolution that recognizes that smallholder farmers are the key to increasing production, promotes change across the entire agricultural system, and puts fairness and the environment at its heart”

Kofi A. Annan, Chair of the Board of the Alliance for a Green Revolution in Africa (AGRA, 2010)

Left: A girl stands among the sorghum crops protected by trees in Niger. Photo: Petterik Wiggers/Panos.

The Global Challenge

Close to 1 billion people went hungry in 2010 according to the Food and Agriculture Organization (FAO) of the United Nations. In 2011, hunger plagued the Horn of Africa, hit by the worst drought in 60 years. The future is daunting too: food needs are projected to increase by 70 percent by 2050 when the global population reaches 9 billion, while climate change is projected to reduce global average yields.

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. Marginal areas, where low yields and poverty go hand in hand, may become even less-suited for agriculture as a result of land degradation through deforestation, wind and water erosion, repetitive tillage and overgrazing. Many impact studies point to severe crop yield reductions in the next decades without strong adaptation measures — particularly in Sub-Saharan Africa and South Asia, where rural households are highly dependent on agriculture and farming systems are highly sensitive to temperature increases and volatile climate. One assessment, based on a pessimistic assumption about global warming, estimates that by the 2080s world agricultural productivity will decline by 3-16 percent. The loss in Africa could be 17-28 percent (Cline 2007).

While agriculture is the sector most vulnerable to climate change, it is also a major cause, directly accounting for about 14 percent of greenhouse gas emissions, or approximately 30 percent when considering land-use change, including deforestation driven by agricultural expansion for food, fiber and fuel (IPCC 2007). And yet, agriculture can be a part of the solution: helping people to feed themselves and adapt to changing conditions while mitigating climate change.

THE CHALLENGE IN AFRICA

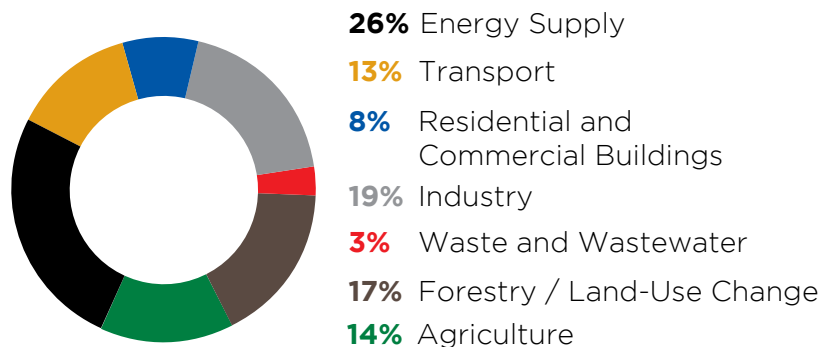
Climate projections for Africa (IPCC 2007) include a likely average temperature increase of 1.5 to 4° C in this century, higher than the global average. Assuming even moderate temperature rises, warming and drying could reduce crop yields by 10–20 percent by 2050 in Africa (Jones and Thornton, 2009). This overall projection translates into much more severe losses in certain places and does not account for extreme events: pests and diseases; droughts, heat stress and floods.

In Sub-Saharan Africa, 250 million people went hungry in 2010 – almost a third of the population. Hunger is particularly prevalent in arid and semi-arid lands, where soil quality has been decreasing for several decades. Chronically poor crop performance

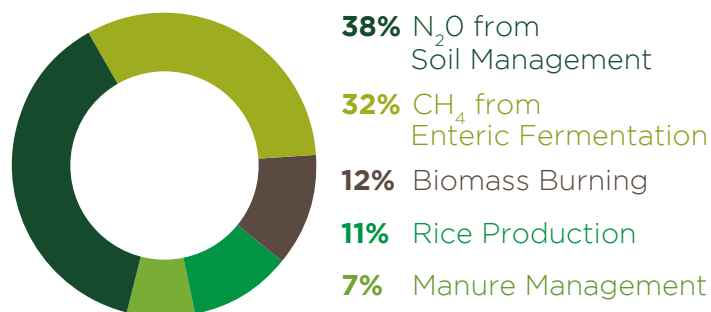
and a high risk of crop failure in these systems, combined with low levels of rural development, have acted to dissuade farmers from investing in soil fertility improvements. From 1945 to 1990, soil nutrient removals (without replenishment with fertilizers or manure) and other forms of soil degradation reduced agricultural productivity in Africa by an estimated 25 percent (UNEP 1990).

Increasing organic matter in soils in cropping systems will be critical to retain water, increase yields and reduce risks in rainfed agriculture while sequestering carbon. The Global Partnership on Forest Landscape Restoration estimates that over 400 million hectares of degraded forest landscapes in Africa offer opportunities for restoring or enhancing the functionality of “mosaic” landscapes that mix forest, agriculture and other land uses. A range of well-established restoration options can improve human livelihoods, repair ecosystems and increase the resilience of both people and landscapes to climate change.

Greenhouse Gas Emissions by Sector



Emissions in the Agriculture Sector



Source: IPCC 2007; Smith et al. 2007.

How Climate-Smart Agriculture Can Help

In countries where the economy is heavily based on agriculture, development of the agricultural sector is the most efficient poverty reduction measure. Yet agricultural expansion for food production and economic development which comes at the expense of soil, water, biodiversity or forests, conflicts with other global and national goals.

For example, forest loss undermines efforts to reduce emissions from deforestation and forest degradation and has negative repercussions on livelihoods and sustainable agriculture because of the many ways in which trees produce goods (fruits, energy, fodder, timber), mitigate poverty in times of stress, and provide vital ecosystem services (whether by regulating water, housing pollinating bats and bees, or maintaining soil fertility and erosion control). The loss of tree cover also increases people's exposure to violent weather, depletes biodiversity and alters micro climates.

To avoid solving a problem while exacerbating another, policy leaders should take an integrated approach to food security, poverty and climate change.

These approaches include:

- 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 oxide 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.
- Adaptive management that disseminates timely climate information to farmers and monitors the local outcomes of different actions, builds on the traditional knowledge of farmers, and tailors techniques to shifting climatic conditions without harming ecosystems.

Right: Woman with a seedling, part of an NGO-funded reforestation project in Malawi. Photo: Mikkell Ostergaard/Panos.



Sustainable intensification seeks to increase yield per unit of land to meet today's needs without exceeding current resources or reducing the resources needed for the future.

Carbon sequestration is the process by which atmospheric carbon dioxide is taken up by plants through photosynthesis and stored as carbon in biomass and soils.



Climate-Smart Agriculture in Action

Country Examples

Agricultural Carbon for Smallholder Farmers in Kenya

Agriculture contributes more than 27 percent to Kenya's GDP. Yet the sector is affected by widespread land degradation, due in part to rising population density and continuous cultivation, and is threatened by recurrent droughts and floods. The Government is seeking to increase agricultural productivity and encourage private sector investment in agricultural enterprises. The Kenya Agriculture Carbon Project builds on this approach but adds a carbon component. Carbon sequestration activities include reduced tillage, cover crops, residue management, mulching, composting, green manure, targeted application of fertilizers, reduced biomass burning and agroforestry. The project seeks to provide technical support to about 60,000 farmers aggregated in farmer groups, managing a total of 45,000 hectares in the Nyanza and Western

provinces in Kenya. It is implemented by the Swedish Cooperative Center, ViAgroforestry, an NGO well-known in the Lake Victoria Basin for participatory approaches leading to increased farm productivity and sustainable management of natural resources. The project uses a simple activity-based carbon-accounting methodology that could become a model for similar soil carbon projects elsewhere in Africa once it is approved. Improved agricultural practices have the potential to sequester about 60,000 tons of CO₂-equivalents per year, while simultaneously increasing crop yields, diversifying income sources and reducing the vulnerability of small farmers to climate change. The BioCarbon Fund, a public-private initiative administered by the World Bank, has agreed to purchase carbon credits generated by this project.

Left: Terraced watersheds at Loess Plateau in China are a successful example of climate-smart agriculture. Photo: Erick Fernandes/The World Bank.

Improving Hillside Productivity in Rwanda

Rwanda's Land Husbandry, Water Harvesting and Hillside Irrigation Project seeks to better manage rainfall so that it causes 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 (rare in Rwanda) and gain access to credit. In the Karongi district, where the project was first piloted and local farmers were employed to build terraces, farmers reported an increase in yields and income: more than 65 percent of the first potato harvest was sold in the market (after satisfying people's own food needs) whereas only 10 percent used to be sold in the past. Erosion control means

fertilizer and crops are less likely to be washed downhill. The incorporation of fodder trees also raises the possibility of adding livestock to the farmers' activities — although buying cows is still a challenge for many. This project received a \$50 million commitment from the Global Agriculture and Food Security Program (GAFSP) in June 2010 to scale up and replicate achievements in other regions together with a range of development partners. The Government's vision is to scale up the program to over 100 watersheds countrywide. Such practices will create a more resilient rural economy that is better able to withstand population and climatic pressures.

Natural Regeneration of Agroforestry Systems in Niger

In Niger, a Sahelian country with highly variable rainfall, 84 percent of the population depends on land-based activities for survival and half the population suffers periodically from food insecurity (witness the famine associated with the 2009-2010 drought). Given the key role of agriculture and the impact of climate on development and human welfare, the Government is actively seeking to intensify agriculture on the most productive lands, and improve land and water management to address soil fertility, erosion and run-off issues. Niger is also home to a tree expansion program that has spread organically from village to village and farmer to farmer and resulted in a major transformation of landscapes, especially in the Maradi and Zinder regions. Rules regulating the use of trees on farms were revised in 1993, giving

farmers a freer hand and stronger incentive to grow trees. After more than two decades, the results have been phenomenal, with over 5 million hectares of rejuvenated “parklands,” an indigenous agroforestry system, benefitting 4.5 million people. The practice mainly involved the selection and protection of tree species that were regenerating naturally from seed or roots in the soil. A range of species, including the signature species *Faidherbia albida*, now provide improved soil fertility, fodder, wood and fuel, and a variety of fruits and foods, thereby diversifying farmers’ incomes and providing alternatives to famine in case of drought. Benefits associated with increased tree cover have increased sorghum yields by 20-85 percent and millet yields by 15-50 percent in participating areas.

Greening Ethiopia

The over-exploitation of forest resources in Ethiopia has left less than 3 percent of the country's native forests untouched. In Humbo, a small town nestled against the rocky slopes of Ethiopia's Great Rift Valley, deforestation threatens groundwater reserves that provide 65,000 people with potable water, and has caused severe erosion resulting in floods and in some cases deadly mudslides. Climate change is likely to compound Humbo's vulnerability to natural disasters and consequent poverty. With a population that depends heavily on agriculture for its livelihoods, increasing droughts and floods will create poverty traps for many households, thwarting efforts to build up assets and invest in a better future. 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 area has

been reforested using the Farmer-Managed Natural Forest Regeneration technique, which encourages new growth from tree stumps previously felled but still living. The regeneration project has resulted in increased production of wood and tree products, such as honey and fruit, which 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 greenhouse gases from the atmosphere to help mitigate climate change. The project is the first large-scale forestry project in Africa to be registered with the United Nations Framework Convention on Climate Change (UNFCCC).

Right: Farmland north of Lalibela in Ethiopia.
Photo: Sven Torfinn/Panos.



Linking Weather Risk Management with Social Protection in Ethiopia

Extreme weather and natural disasters such as drought and floods can have a devastating impact on food security as well as the social and economic development of poor rural households. Climate change threatens to increase both the frequency and the intensity of these events. By combining different risk management approaches, including early warning, weather index insurance, contingency planning, contingent financing, and social protection, it is possible to shift from managing disasters to managing risks in a more cost-effective manner.

Ethiopia has been able to improve the financial sustainability and effectiveness of its Productive Safety Net Program (PSNP) by taking into account weather risk. The program's core target group are the poorest people who face ongoing food insecurity whatever the weather. However the ranks of hungry people needing emergency assistance can swell by some 5 million people when a drought occurs in Ethiopia. The

Government of Ethiopia with support from the World Food Programme and the World Bank has developed a program called LEAP (Livelihoods - Early Assessment - Protection) which combines early assessment, early warning, contingency planning and capacity building with contingent finance and a software platform that provides an estimate of the funding needs in the event of a weather shock. The software uses ground and satellite rainfall data to calculate weather-based indices for the whole of Ethiopia (even where there are no weather stations). The agro-meteorological information is integrated with livelihoods and vulnerability data at local and regional levels. These indices are used to trigger contingent finance to scale up the PSNP, enabling earlier responses that protect livelihoods and reduce the need for more costly emergency assistance. LEAP is currently being refined to integrate a flood index and a climate change and seasonal forecast component.

Conservation Farming in Zambia

Conservation farming is a package of agronomic practices that have been promoted in Zambia by a coalition of stakeholders from Government, donors and the private sector, since the mid-1990s. The system is comprised of dry-season land preparation using minimum tillage methods, utilizing fixed planting stations (small shallow basins); retention of crop residue from the prior harvest in the field or use of other mulches/ground covers; and rotation of crops in the field. Over 180,000 farmers used this system at the end of 2010, and this figure was projected to rise to 250,000 farmers by 2011 — representing some 30 percent of the population of small-scale farmers in Zambia. The scaling up program has

recently added a tree component — the planting of *Faidherbia albida* — to provide mulch and nutrients. These practices have been found to be highly profitable and not only because of their impact on soil health. By eliminating the need for laborious land preparation, farmers adopting the system have been better able to plant close to the onset of the rains. That alone has had a significant impact on yields which have doubled for maize and increased by 60 percent for cotton using conservation farming, compared to conventional plowing systems. The program has thus been able to achieve the triple win of enhanced productivity, resilience and carbon sequestration.

Restoring Vietnam's Mangrove Buffer

Vietnam is one of the countries most exposed to climate change; floods, storms, typhoons, and longer-term sea level rise pose risks to low-lying coastal areas, including the agricultural heartland of the Mekong Delta. The rapid decline of Vietnam's mangrove forests has had a serious impact on the productivity of coastal fisheries and the rural economy of the Southern Mekong Delta. Mangrove forests act as breeding grounds for aquatic organisms, a cleansing system for sediments and nutrients in estuaries, and provide buffer zones against typhoons and floods. The Coastal Wetlands Protection and Development Project (1999-2007) adopted a comprehensive, long-term approach to the protection of coastal wetlands in four Mekong provinces. In addition to planting trees to fight erosion and defining full protection and buffer zones, the project sought to tackle some of the causes of environmental degradation. It worked to improve incomes in adjoining communities to reduce destructive

practices through a combination of resettlement activities, extension services, vocational training, and credit and social support. The project also introduced policy and contractual measures that give local communities incentives to protect the coast's growing mudflats and biodiversity. As a result, pressure on coastal mangrove ecosystems has been reduced, erosion has declined and livelihoods have improved for coastal communities who have witnessed a resurgence of aquatic resources such as crabs and clams. Combined with other forestry activities implemented by the Government of Vietnam in the project area, more than 95 percent of barren areas in the full protected zones have now been reforested. Experience gained in planting trees in challenging environments should be especially valuable at a time when climate change puts coastal communities at greater risk of natural catastrophes.

Right: Farmer with mangrove seedling in Vietnam. Photo: Jim Holmes/Panos.



Community Managed Sustainable Agriculture in India

Andhra Pradesh is one of India's major producers of rice, cotton, groundnuts and lentils. Most farmers in the state practice conventional, input-intensive farming that relies on the periodic purchase of high-yielding seed and the continual application of chemical pesticides and fertilizers that account for as much as 35 percent of their cultivation costs and generate tremendous pressure to borrow to pay for inputs. As a result of debt and uncertain profit potential, agricultural growth began to stagnate in the 1990s. By the early 2000s, farming was no longer a sustainable livelihood. Many farmers used their land as collateral and became tenant farmers or wage laborers on their own land. In 2005, 82 percent of farm households in the state were in debt — the highest rate in India.

In 2005-06, building on successful efforts by NGOs like the Centre for Sustainable Agriculture, the Society for Elimination of Rural Poverty began supporting a program of non-pesticide agricultural management on just 162 hectares benefiting 350 farmers. Encouraging results led to a scale up of community managed sustainable agriculture (CMSA) with seed networks, soil management practices and ultimately

conservation furrows, trenches and farm ponds to increase water for crops. Together with inter-cropping, multi-cropping, improved planting techniques, and increased on-farm water capture, non-pesticide management makes CMSA farms more resilient to climate shocks. CMSA farmers are growing more food, and a wider variety of food both for themselves and for sale to local markets, with positive effects on nutrition and food security. By 2009-10, CMSA and non-pesticide management was being implemented on 715,314 hectares and benefiting 738,000 farmers. Farmers have lowered the cost of cultivation while maintaining yields, which means more profit to invest in livelihood assets. Many have reclaimed their mortgaged land. To manage labor costs, farmers work together to manage pests and increase soil fertility. New local enterprises producing bio-pesticides and leasing farm implements are emerging to meet growing needs. Moreover, pesticide-free groundwater and soil have also had a positive impact on community health and biodiversity. The Government of Andhra Pradesh recently announced its intention to scale up this approach to make the state entirely free of chemical pesticides.

Using Weather Index Insurance to Improve Relief Efforts in the Event of Drought in Mexico

Although at initial stages, weather index insurance programs are taking off as a more promising way to adapt to extreme weather conditions than selling assets, digging wells which drain water tables, or queuing up for food aid after disaster strikes. Since 2002-03, Mexico has used an insurance scheme managed by a government-owned insurer (AGROASEMEX) to improve public relief efforts in the event of drought. Federal and state governments purchase Catastrophic Agricultural Insurance to manage the risk they face from making payments to rural households affected by drought. Part of the appeal of the program is to put relief funding on a more predictable footing and to transfer part of the risk to the international reinsurance market. More compelling still is the ability to provide

households timely and assured access to funds when they need it most. Vulnerable smallholder farmers are identified in advance and payments can be made as soon as a predetermined threshold is crossed (using a weather-based index which correlates local rainfall with crop yields) rather than waiting for relief agencies to raise funds for a given catastrophe (when farmers may have already sold productive assets). This leaves farmers better equipped to recover when the weather improves. In 2010, the program covered potentially 3.2 million low-income farmers in 30 out of 33 states in Mexico. The availability of reliable weather databases and weather stations in the field is one of several factors constraining the spread of this model.

Erosion Control in China

Addressing the environmental footprint of agriculture is a major challenge for China. The agricultural sector accounts for 15 percent of national greenhouse gas emissions, mostly from livestock and paddy rice, and has become the largest source of water contamination. In the last two decades, China has spearheaded a major reforestation program to protect its watersheds. It has also successfully implemented one of the world's largest erosion control programs which has returned the devastated Loess Plateau to sustainable agricultural production, improving the livelihoods of 2.5 million people and securing food supplies in an area where food was sometimes scarce in the past. Thanks to the program, grain production increased from about 1 mt per household, which left a food gap of approximately 2 to 3 months a year, to 1.3 mt and more, covering

basic requirements. The project encouraged natural regeneration of grasslands, tree and shrub cover on previously cultivated slope-lands. Replanting and bans on grazing allowed the perennial vegetation cover to increase from 17 to 34 percent between 1999 and 2004, sustaining soil fertility and enhancing carbon sequestration. Together with terracing, these measures not only increased average yields, but also significantly lowered their variability. Agricultural production has changed from generating a narrow range of food and low-value grain commodities to high-value products. As a result, the evolution of farm and family incomes has shown a steady increase. The program has effectively addressed the triple win of climate-smart agriculture. It is estimated that as many as 20 million people have benefited from the replication of the Loess Plateau approach throughout China.

The Three Rivers in China – Sustainable Grazing and Carbon Credits

The Three Rivers Project, situated in Qinghai province, northwest China, is a pilot project using carbon financing to facilitate grassland restoration and increase livestock productivity. Potential benefits are expected to be higher productivity and profitability of herding operations and thus poverty alleviation and enhanced food security, greater resilience to droughts from improved vegetation cover and soils, and emission reductions through soil carbon sequestration and reduced livestock methane emissions.

Carbon finance from a voluntary scheme will be used to compensate costs and foregone income during a transition period and to increase productivity. The pilot, jointly supported by the Food and Agriculture Organization of the United Nations (FAO), the Chinese Ministry of Agriculture and Qinghai Province Government, offers a combination of restoration of degraded grasslands and stocking-rate management in an incentive-based system. In the first project years, tackling overstocking (currently at about 45 percent) will translate into income losses which will be mitigated

through improved productivity and product marketing. Incentive payments will encourage herders to overcome risk barriers. Overall, after the first decade of the project, households will have fewer but more productive livestock, and be engaged in more profitable value chains.

After 10 years, it will be possible to increase herd size on the restored grasslands while continuing with sustainable grazing management. Increased availability of forage will enable more productive livestock and higher incomes, providing an incentive for long-term sustainable land management. It is hoped that this model can break the vicious cycle of overstocking and land degradation and demonstrate sustainable management options, while generating a reduction of approximately 500,000 tons of CO₂-equivalent, over 10 years. It also aims to address some of the key barriers to smallholder access to carbon finance, which include the lack of appropriate carbon accounting methodologies and cost-effective measuring, reporting, and verification.

Cooking with Biogas in China

Methane, which is released from animal manure, is 22 times more damaging than carbon dioxide. By turning human and animal waste into methane for lighting and cooking, a project of the International Fund for Agricultural Development (IFAD) in China's Guangxi Province is reducing poverty and also helping reduce methane's more damaging global warming effects.

Each household involved in the project has built its own plant to channel waste from domestic toilets and nearby shelters for animals (usually pigs) into a sealed tank where waste ferments and is naturally converted into gas and compost. As a result of the project, living conditions and the environment have improved. Forests are protected, reducing GHG emissions from deforestation. A large amount of straw, previously burned, is now put into biogas tanks to ferment. This further reduces air pollution

from smoke and helps produce high-quality organic fertilizer. In addition, the project has resulted in better sanitary conditions in the home.

Families, especially women, save 60 work days per year by not having to collect wood and tend cooking fires. This additional time is invested in raising pigs and producing crops. With more time to spend improving crops, farmers in Fada, a village in the project area, increased tea production from 400 to 2,500 kilograms a day over a five-year period. Average income in the village has quadrupled to just over a dollar per day. This is significant in a country where the poverty line is 26 cents per day. And as a result of the project, 56,600 tons of firewood can be saved in the project area every year, which is equivalent to the recovery of 7,470 hectares of forest.

Right: Farmer with drought tolerant maize variety in Tanzania. Photo: Anne Wangalachi/CIMMYT.

Research Benefits: Drought Tolerant Maize

Maize is life to more than 300 million of Africa's most vulnerable people, and is a critical part of the fight against poverty in Africa. Maize is both an important source of home-produced food and an important cash crop for farmers. The open-pollinated modern maize varieties are particularly valuable for resource-poor farmers, as they do not have to buy fresh seed each season.

In the early 1980s erratic rainfall and drought began to reduce crop production in much of Sub-Saharan Africa and the development of drought tolerant maize varieties became a priority for both scientists and farmers. Since then, the scientists of the Consultative Group on International Agricultural Research (CGIAR) have been conducting extensive research in partnership with national research institutions to develop improved drought tolerant varieties that deliver higher and more stable yields despite variable rainfall, benefitting hundreds of thousands of people each year. It is estimated that in West and Central Africa alone improved maize varieties have lifted more than one million people out of poverty each year since the mid 1990s.



Silvopastoral Approaches in Costa Rica and Nicaragua

After several years of intensive grazing in Costa Rica and Nicaragua, pastures were degraded, erosion was accelerating and livestock productivity was falling. To address these challenges a pilot project introduced silvopastoral techniques to 265 farms on 12,000 hectares between 2001 and 2007. 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 agroforestry 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. In Costa Rica and Nicaragua, the techniques ranged from planting trees, to natural pastures, to highly intensive fodder shrub plantations. Sequestered carbon was paid for at a rate of \$2 per ton of CO₂-equivalent.

Farmers had a very positive reaction to the initiative. Results showed a typical win-win situation: 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 Global Environment Fund (GEF) and private sector funds.

Right: Silvopastoral techniques are used at Reserva Natural El Hatigo, familia Molina Durán, near Palmira, Colombia. Photo: Neil Palmer/CIAT.



Next steps

- Early action is needed to identify and scale up best practice, to build capacity and experience and to help clarify future choices.
- Considerable finance will be needed to rapidly implement proven programs and support poverty alleviation and food security goals in a changing climate.
- COP 17 in Durban offers a unique opportunity for Africa to shape the global climate agenda and establish an agriculture work program that is informed by science and covers adaptation and mitigation.

“Millions of hungry and starving individuals have their hopes vested in us. Despite our serious global challenges, we still have hope. We need your support to elevate agriculture to achieve global climate change goals and the triple win of enhanced agricultural productivity and incomes, climate resilience and carbon sequestration. It is vital to include agriculture, food security and land in the climate change negotiations.”

Tina Joemat-Pettersson, Minister: Agriculture, Forestry and Fisheries, South Africa.

Photo: Woman in southwestern Uganda.
Credit: Neil Palmer/CIAT.





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Cover photo: Maize and other crops grow under *Faidherbia albida* trees in Tanzania. Agroforestry is the most effective method of sequestering carbon. Photo by World Agroforestry Centre.