SUCCESS STORIES

Climate-smart agriculture
SUCCESS STORIES
FROM FARMING COMMUNITIES AROUND THE WORLD

“To ensure a food-secure future, farming must become climate resilient. Around the world, governments and communities are adopting innovations that are improving the lives of millions while reducing agriculture’s climate footprint. These successful examples show the many ways climate-smart agriculture can take shape, and should serve as inspiration for future policies and investments.”

Michael Hailu,
CTA Director

Bruce Campbell,
CCAFS Director

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Climate-smart agriculture and the future of food production

The world's climate is changing fast, and will continue to do so for the foreseeable future, no matter what measures are now taken. For agriculture, change will also be significant, as temperatures rise, rainfall patterns change and pests and diseases find new ranges, posing new risks to food and farming. Until recently, agriculture has tended to be on the sidelines of discussions concerning human-induced climate change, and has generally been seen as the 'victim'. There is now, however, a growing recognition of agriculture's contribution to climate change, past and present, and of the means by which farming systems can adapt to cope with the changes, as well as the potential of agriculture to mitigate our climate impact. This recognition has led to the concept of 'climate-smart agriculture'.

The Food and Agriculture Organization of the United Nations (FAO) defines climate-smart agriculture as consisting of three main pillars:

- sustainably increasing agricultural productivity and incomes (food security);
- adapting and building resilience to climate change (adaptation);
- reducing and/or removing greenhouse gas emissions (mitigation), where possible.

There are many projects that are testing or promoting climate-smart agriculture, but few have shown widespread uptake. This booklet showcases 16 initiatives that are having a widespread impact on food security, adaptation to climate change and climate change mitigation, covering large areas of land and improving the lives of millions of people.

With examples from both the developed and developing world, the initiatives include innovative agricultural interventions (*Chapter 1 in this booklet*), initiatives that address climate-related risks (*Chapter 2*) and policies and institutions that underpin adaptation to and mitigation of climate change (*Chapter 3*). In some cases, particularly in the policy domain, the support for climate-smart agriculture is a side-benefit rather than the core objective of the initiative; in others, it is the main focus. But ultimately, all the cases meet the three-part goal of improving resilience to climate change, enhancing food security and livelihoods, and reducing agriculture's climate footprint.

These 16 initiatives show the potential of agriculture to adapt to a changing climate, to be more resilient and protect farmers against future changes in weather patterns, pests and diseases, and to slow the rate of climate change. The challenge now is to promote widespread adoption of climate-smart agricultural interventions around the world. A recent publication[1] from the CGIAR Research Program on Climate Change, Agriculture and Food Security shows how widespread adoption might be achieved, drawing lessons from the 16 initiatives presented in this volume. ■

1 *Large-scale implementation of adaptation and mitigation actions in agriculture. Working Paper No. 50.* Cooper PJM, Cappiello S, Vermeulen SJ, Campbell BM, Zougmoré R, Kinyangi J. A publication of the CGIAR Research Program on Climate Change, Agriculture and Food Security, Copenhagen, 2013. Available from http://cgspace.cgiar.org//bitstream/handle/10568/33279/WorkingPaper50.pdf

Guddi Bai Verma gathers wheat during the harvest in Madhya Pradesh, India, where agriculture has been described as a gamble on the monsoon.

A few scattered trees can make all the difference in the Sahel, providing wood for fuel, food for people and animals, a home for beneficial insects and birds, protecting the soil from wind erosion and bringing many other benefits.

Agricultural innovation for climate change resilience and mitigation

While the impact of climate on agriculture has been recognised for as long as people have been farming, climate change has highlighted this dependence like never before. Temperatures are rising, rainfall is increasing in some areas and declining in others, seasonal patterns and pest and disease distribution are changing, and extreme weather events are becoming more frequent and severe.

But there is now an increasing awareness of the impact that agriculture has on climate, particularly through production of methane and nitrous oxide—potent greenhouse gases. Agriculture produces nearly half of all methane generated by human activity, and nearly 60% of nitrous oxide emissions.

Rather than dealing with short-term weather events—droughts, floods, heat waves and cold spells—farmers must now respond to climatic changes that will alter the way they farm irrevocably.

Around the world, farmers urgently need innovations that will enable them to produce enough to support themselves and the ever-growing global population. Their added challenge is to do so in ways that will protect the environment, especially soil and water, and minimise agriculture's contribution to climate change. This section presents examples of how this is already being done. ■

There is growing recognition of agriculture's contribution to climate change, past and present, and of the means by which farming systems can adapt to cope with the changes, as well as the potential of agriculture to mitigate our climate impact

STORY 1

Bringing back the Sahel's 'underground forest'

Over 5 million ha of degraded land in the Sahel have been restored through a practice known as 'farmer-managed natural regeneration', increasing the food security of millions of people and enhancing their resilience in the face of climate change.

For centuries, farmers in the Sahel grew their crops in fields scattered with trees that were selected and nurtured. But, by the 1980s, almost all of these trees had disappeared, falling victim to drought, increasing population pressure and modern forestry and agricultural advice that dictated that trees should not be left to grow in crop fields. Farmers were told that trees on farmland were 'weeds' that competed with their crops for light, water and nutrients.

This drastic loss of trees had devastating consequences. Stripped of its cover, land was exposed to sun and wind, reducing the fertility of the soil and its ability to absorb and retain water. Crops were shredded and buried by wind-blown sand. Insects and birds that used to help protect crops from pests lost their habitat and their populations declined, leading to plagues of pests and crop losses. Crop and livestock yields fell, contributing to chronic hunger and periodic acute famine. Women and children were forced to walk ever further in search of firewood, and turned to burning manure and crop residues instead, removing farmers' only source of fertiliser.

Spurred by severe famine in the 1970s, development efforts targeted reforestation as a way to stop desertification and restore agricultural yields. These efforts relied on 'modern' approaches, growing seedlings of exotic species such as eucalyptus in nurseries and planting them out in windbreaks and woodlots. But with little buy-in from local communities, and a national forestry policy that denied farmers ownership of trees on their land and fined them for cutting trees, few of these efforts survived when project funding ended.

However, in the early 1980s, people working on a rural regeneration project in the Maradi region of Niger realised that the stumps of many indigenous trees were still present in farmers' fields and sent up shoots each year—which the farmers routinely slashed and burned. Studies showed that, far from being 'useless bushes', as had been assumed by many development practitioners, these indigenous trees could provide a wide range of goods and services, including timber, firewood, fodder, fibre, medicines, fruits, edible leaves and nuts, fodder, dyes and many environmental services.

In 1984, the Maradi Integrated Development Project (MIDP) introduced 'farmer-managed natural regeneration' (FMNR), under which farmers allowed the stumps to regenerate, as part of a 'food-for-work' programme targeting 95 villages in Niger's Maradi region. Initial results were promising, with crops growing well among the trees. But, as often happens with food-for-work programmes, when the incentive of food was withdrawn at the end of the famine, many of the farmers reverted to their normal practice and cleared the tree regrowth. Two-thirds

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Firewood is an increasingly scarce and valuable commodity in the Sahel. Farmers who allow trees to regenerate on their land have a ready source of fuel for their own use and for sale, and are able to leave crop residues in the field, building up organic matter in the fragile soil.

of the half million trees that had been allowed to regenerate were cut down the following year.

Those farmers who retained their trees, however, rapidly realised the benefits: more firewood, fewer pests and diseases, less soil erosion, rising water tables and higher crop yields. More wood meant that farmers were able to leave crop residues on their land, to be incorporated into the soil or grazed by livestock, thereby improving soil fertility and structure. A recent study by the World Agroforestry Centre shows that FMNR more than tripled yields of millet, from 150 kg/ha to 500 kg/ha. Overall, the changes brought about by FNMR, including improved soil fertility and increased supply of food, fodder and firewood, have been estimated to be worth at least US$56 per ha each year.

More than 5 million ha of land have been restored, with over 200 million trees re-established or planted. This has resulted in an additional half a million tonnes of grain production each year and enough fodder to support many more livestock. It has improved the food security of about 2.5 million people so far

More farmers quickly adopted the practice, and from those first 95 villages, FMNR has now spread across southern Niger and even into neighbouring countries, including Burkina Faso, Mali and Senegal. More than 5 million ha of land have been restored, with over 200 million trees re-established or planted. This has resulted in an additional half a million tonnes of grain production each year and enough fodder to support many more livestock. This has improved the food security of about 2.5 million people so far.

The environmental impacts of FMNR are clear: the structure and fertility of the soil has improved, rain soaks into the soil more readily and water tables have risen in some places, making water more accessible available to plants and people alike. Together, these changes have increased the resilience of farming systems to extreme weather events, diversifying sources of food and income and protecting land and water resources. Anecdotal evidence suggests that FMNR also contributes to climate change mitigation, by sequestering large amounts of carbon in the soil, and in tree roots and wood.

These benefits might never have been achieved, however, without the flexibility of the Maradi Forestry Department. Back in the mid-1980s, all trees in Niger were the property of the state, and farmers were fined or even imprisoned for cutting them down. Following discussions with MIDP staff, the local forestry department agreed to relax these rules, converting trees (in farmers' eyes) from a nuisance to a cash crop. Finally, in 2004, the Government of Niger changed the law, giving farmers ownership of trees on their land. The World Agroforestry Centre now estimates the value of tree products at about US$1000 per year to each household practising FMNR. ■

Sustainable intensification of rice production in Vietnam

More than 1 million smallholder farmers in Vietnam are benefiting from a package of rice production practices that boost yields, reduce water demand, enhance the environment and mitigate climate change.

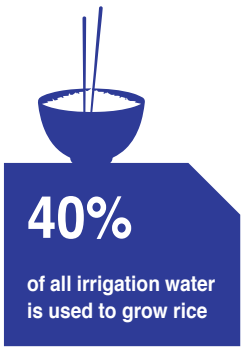
Rice is the staple food of over half of the world's population—more than 3.5 billion people depend on rice for at least a fifth of their daily calories. More than 1 billion depend on rice farming for their livelihoods.

But rice farming has some serious drawbacks. Paddy rice consumes more water than any other crop, and globally, nearly 40% of all irrigation water is used to grow rice. Globally, flooded rice fields also produce about 10% of all the methane produced by human activities, with methane 25 times more potent than carbon dioxide as a greenhouse gas. Paddy fields are also a significant source of nitrous oxide, from the breakdown of excess nitrogen in the soil. Excessive use of inorganic fertilisers and agrochemicals in rice production are also responsible for environmental damage, such as pollution of water bodies.

The 'System of Rice Intensification' (SRI) is a set of agronomic practices developed in the 1980s in Madagascar to help smallholder farmers grow more rice in a sustainable way, using less water and other inputs. Since then, SRI has been demonstrated in more than 45 countries throughout the tropics and subtropics.

Key practices recommended in SRI include alternate wetting and drying (AWD) of the soil during grain filling rather than continuous flooding, and application of organic fertilisers, such as manure, rather than synthetic fertilisers. Allowing the soil to dry out intermittently lets air in, preventing build-up of anaerobic bacteria responsible for methane production; this has been shown to reduce methane emissions from rice paddies by up to 90%. AWD also reduces the amount of water farmers have to apply to their fields by up to 40%. However, AWD may increase production of nitrous oxide, so careful fertiliser management is needed to reduce excess nitrogen in the soil and thus reduce nitrous oxide emissions. Using organic fertiliser rather than synthetic fertiliser can help in this respect, as well as improving soil structure and water-holding capacity and sequestering carbon as organic matter builds up in the soil. Changes in the way the crop is planted and managed—with seedlings more widely spaced in a grid pattern—allows the plants to make best use of the light, water and nutrients available to them and ensures good yields. Integrated pest management completes an environmentally friendly package.

Vietnam supplies more than a fifth of the rice consumed worldwide, but millions of smallholder farmers in the country grow barely enough rice to meet their own needs.



Farmer transplanting rice, a staple food of over half of the world's population.

More than 9 million farmers in Vietnam own less than half a hectare of paddy rice land. Faced with the effects of climate change—declining rainfall, unpredictability of rains and salinisation of groundwater as a result of rising sea levels—and increasing prices of inputs like fertiliser and agrochemicals, they are increasingly struggling to meet even their own bare subsistence requirements.

This is where SRI comes in. Smallholder farmers in neighbouring Cambodia have been using SRI since 1999, with impressive results: yields from 'mixed' SRI plots (combining organic fertiliser and synthetic fertiliser) are commonly double those of traditionally managed plots, while cash expenditure has been reduced by up to 95%. Yields and returns to SRI plots using only organic fertiliser have been even higher. While farmers using traditional practices have made losses from growing rice, those using SRI have netted incomes ranging from US$100 ('mixed' SRI) to US$700 per household (fully organic SRI).

In 2006 SRI was tested in Dai Nghia commune in the northern Vietnamese province of Ha Tay by the national Plant Protection Department, with funding from Oxfam. The results were so good that the Ministry of Agriculture endorsed SRI in 2007, and in the same year the approach was rolled out across 17 provinces. A wide range of extension approaches was used, including intensive farmer field schools and farmer-to-farmer training. By 2011, more than 1 million farmers in 22 provinces were practising SRI on 185,000 hectares. Interestingly, women - who made up 70 per cent of farmer field school participants - shared their new knowledge much more widely than men did: on average, women helped five to eight other farmers to adopt SRI, compared with only one to three other farmers helped by men.

The results of SRI adoption have been impressive. On average, farmers using SRI have increased their yields by 9–15% and used 70–75% less seed, 20–25% less nitrogen fertiliser and 33% less water than farmers following conventional practices. This has boosted their income by US$95–US$260 per hectare in each cropping season. Farmers have also reported positive changes to the environment and their health as a result of using fewer pesticides, herbicides and synthetic fertilisers.

Yields from 'mixed' SRI plots are double those of traditionally managed plots

So far, very few studies have been conducted in Vietnam on the effects of SRI on methane and nitrous oxide emissions, but field trials in Cambodia indicate that organic and mixed SRI have reduced emissions by over 20%, while studies in India have shown a 62% reduction in methane emissions.
So, SRI brings immediate benefits to smallholder farmers in terms of increased yields, it builds long-term resilience by reducing the amount of water they use and enhancing long-term soil fertility, and helps mitigate climate change by reducing emissions of greenhouse gases and sequestering carbon in the soil. Truly a win-win-win proposition. ■

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Canola stretching as far as the eye can see in Alberta, Canada. Herbicide-tolerant canola allows farmers to reduce tillage, reducing carbon dioxide emissions by 94,000 tonnes between 1994 and 2006, and sequestering about 1 million tonnes of carbon each year.

STORY 3

Herbicide-tolerant crops contribute to climate change resilience and mitigation

Herbicide-tolerant (HT) and pest-resistant crops boost the climate resilience of farming systems and their capacity to mitigate climate change. HT crops, for example, reduce the need for ploughing and other types of mechanised weed control, reducing fuel consumption by up to 44% in maize and 60% in soybean. Both HT and pest-resistant crops reduce the amount of chemicals farmers need to apply, and the chemicals they use are less toxic than previous generations of herbicides and pesticides. Reduced tillage helps to preserve soil structure, reducing erosion and increasing infiltration and retention of water, and leads to a build-up of organic matter in the soil. Such benefits protect the environment and increase the resilience of farming systems, while also reducing the contribution of agriculture to climate change.

A great advantage of HT varieties is that they facilitate weed control under reduced tillage, as they are not harmed by broad-spectrum herbicides. For example, HT canola—a variety of oilseed rape—was introduced in Canada in 1995, and now accounts for about 95% of the national crop—some 6 million ha. Grown under reduced or zero tillage, HT canola has been credited with reducing the amount of fuel used to grow the crop by over 31,000 tonnes a year, and reducing carbon dioxide emissions by 94,000 tonnes between 1996 and 2004. Adoption of reduced and zero-tillage for canola has led to the build up of organic matter in the soil, resulting in around 1 million tonnes of carbon being sequestered or no longer released into the atmosphere each year . Soil structure has also been improved, reducing vulnerability to wind and water erosion and increasing the availability of water to plants—all of which are vital for sustainable agriculture on the prairies. And beyond the environmental gains, farmers are also receiving immediate benefits in the form of higher yields, lower costs and greater returns. ■

Adoption of reduced and zero-tillage for canola has led to the build up of organic matter in the soil, resulting in around 1 million tonnes of carbon being sequestered or no longer released into the atmosphere each year

STORY 4

Drought-tolerant maize boosts food security for millions of African farmers

© CIMMYT

There is not much to eat on this maize, suffering from severe drought. Climate change is increasing the risk of drought across sub-Saharan Africa, and drought-tolerant maize is throwing farmers a lifeline.

Maize is a staple food for more than 300 million people in Africa but, by the 2030s, drought and rising temperatures could render 40% of the continent's current maize-growing area unsuitable for maize varieties available today. Maize production in southern Africa, for example, may fall by 30% or more. New, drought- and heat-tolerant varieties will have to be developed quickly and be growing in farmers' fields in the next few years if we are to avoid widespread famine in Africa.

Since 2006, more than 100 new, drought-tolerant maize varieties and hybrids have been developed and released across 13 countries by the Drought Tolerant Maize for Africa Initiative (DTMA), funded by the Bill & Melinda Gates Foundation, the Howard G. Buffett Foundation, USAID and the UK Department for International Development (DFID). Each of these new varieties is adapted to local requirements, including cooking and milling properties and pest and disease resistance. In on-farm trials, the new varieties have yielded up to 35% more grain than those grown previously by farmers'; the best hybrid out-yielded even the most popular commercial variety by 26%. More than 2 million smallholder farmers in sub-Saharan Africa are now growing these new varieties and hybrids, some of them in countries not directly involved in the DTMA—a sure sign the initiative is on the right track. Farmers are reporting yields 20–30% above what they would have got with their traditional varieties, even under moderate drought conditions.

Key to the success of this initiative is the way it has brought together a wide range of partners, including publicly-funded research organisations, public and private seed producers, varietal certification agencies and farmer groups. This has helped avoid the bottlenecks so common in efforts to get improved crop varieties into the hands of farmers. Farmers themselves guide the breeding efforts, making sure the varieties developed meet their requirements. Certification agencies have been engaged in the process from the beginning, so their staff are up to speed on what the initiative is trying to achieve and the new varieties can move efficiently through the certification process. Seed companies are geared up and ready to produce seed as soon as it is ready for release. Engaging the private sector has helped to ensure that farmers have access to both inputs and markets for their produce.

In March 2012, DFID won the Best Technological Breakthrough award for its support of the project at the UK Climate Week Awards. ■

Farmer in the Loess Plateau.

STORY 5

Paying for ecosystem services is good for the environment and people

In China, during the 1990s, more than a million hectares of land became eroded each year. By 2009, 38% of the country's total land area was considered badly eroded, with more than 2 billion tonnes of silt entering the Yangtze and Yellow rivers each year, two-thirds of this from farmed hillsides.

China's 'Grain for Green' programme (GGP), initiated in 1999 and implemented countrywide in 2002, was designed to reduce erosion in river catchments and to alleviate poverty in poor and remote areas. Based on paying farmers not to cultivate steep slopes and to restore forests on hillsides and eroded grasslands, GGP is one of the most ambitious conservation set-aside schemes in the developing world. Farmers are supplied with tree seedlings and receive annual grain and cash payments for each hectare of set-aside land that they plant with trees. With a budget of around US$40 billion, nation-wide the scheme aimed to convert about 15 million ha of farmland into forest and grassland, and 17 million ha of eroded wasteland (grassland) into forest by 2010.

The Loess Plateau, in the upper and middle reaches of the China's Yellow River, was identified as a GGP priority region. In recent years, increasing population pressure and overexploitation of the land, including overgrazing, have led to severe degradation on over 60% of the land area. The Plateau's climate is also warming and drying: between 1951 and 2008, average temperature increased by 0.02°C per year and precipitation declined by an average of 0.97 mm annually.

The impact of the GGP has been considerable. Over 2.5 million households have participated, converting 2 million ha of cropped hillside to grassland or forest. In Ansai County, Shaanxi Province, for example, the forested area (both old forest and newly forested land) grew from 12.4% in 1995 to 37.7% in 2010. The new forests and grassland sequester over 700,000 tonnes of carbon (2.5 megatonnes of carbon dioxide equivalents) annually across the whole Loess Plateau—equivalent to removing nearly 800,000 cars from the road. Soil erosion has been reduced by up to 26%.

As a result of GGP, total grain production on the plateau was only slightly reduced, largely because the land converted to forest was marginal for cropping and yields here were low. Farmers were able to increase yields on their remaining land by concentrating their efforts and resources on these more fertile areas, boosting food security. Household income also increased, largely because farm workers were able to take up gainful off-farm employment, broadening their livelihoods base and increasing resilience. ■

STORY 6

Water harvesting boosts yields in the Sahel

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Millet Zai pit : farmers in the Sahel traditionally plant sorghum and millet in zai pits—shallow pits that are filled with compost and manure—that concentrate nutrients and rainfall. These work well in combination with contour bunds.

The Sahel—the belt of land that stretches across Africa below the Sahara—has always been a tough place to farm, and climate change is set to make matters worse. Rainfall is sparse and intermittent, and droughts are frequent. When rain does fall, it is usually in short, intense downpours. After the long dry season, the hard-baked surface of the soil is largely impermeable, and the rain runs off to be carried away in streams and rivers, along with valuable topsoil. As a result, both people and plants are deprived of the water they need.

Changes in land management can greatly improve yields

Constructing stone bunds along contours has proved to be an effective way of reducing runoff. These loose 'walls', 20–30 cm tall and spaced 20–50 metres apart, slow the runoff, allowing more of the water to soak into the soil and trapping silt and organic matter that would otherwise have washed away. Combined with other changes in land management, such as digging *zai* pits—shallow bowls filled with compost or manure in which crops are planted—the bunds markedly increase cereal yields. Sorghum and millet yields of more than 1 t/ha have been reported, double the yield achieved on unimproved land. The benefits of contour bunds should also be future-proof: if the climate becomes wetter, the bunds will alleviate runoff erosion, and if it becomes drier they will contribute to water harvesting.

Contour bunds have been established on some 200,000 to 300,000 ha of land across the Sahel. Assuming a yield increase of 400 kg/ha, this implies 80,000 to 120,000 tonnes more cereal grain being produced each year, enough to feed 500,000 to 750,000 people.

Tree cover and diversity have also increased on the rehabilitated areas, increasing the supply of fuelwood. As a result, more manure is being applied to fields instead of being used as fuel, further increasing soil fertility and crop yields. Groundwater levels are rising, and farmers have started growing vegetables on small plots near wells, thereby increasing both their income and the diversity of their diets. Health benefits from this are likely to be significant, although have yet to be measured.

The primary constraint to widespread adoption of stone bunds is their high initial cost: constructing the bunds on a single hectare requires 30 to 50 tonnes of stone at a cost of around US$200 and up to 150 person-days of labour. Farmers therefore require external support—from government, extension services or non-governmental organizations—to take on such projects, even if the long-term benefits make them financially attractive. ■

500,000

to 750,000 people are fed with yields increasing thanks to contour bunds

Managing climate risks

Agriculture will always be largely at the mercy of the climate. Too much rain, too little rain, or simply rain at the wrong time can devastate a farmer's crop. An intense downpour may wash away newly planted seed, leaving the farmer with the prospect of no crop or the expense of replanting. Warm, humid spells increase the danger from fungal diseases, and such weather-inflicted losses are not only experienced in the developing world. Droughts in the USA's Corn Belt in 2012 caused US$20 billion of damage to crops. In early 2013, freezing temperatures and snow in the UK killed tens of thousands of lambs across the country, driving many farmers to the brink of bankruptcy. What's more, the frequency and severity of such extreme weather events, along with changes in seasonal patterns and distributions of pests and diseases, are predicted to increase in future years.

Faced with these seemingly endless risks posed by the weather, resource-poor smallholder farmers are reluctant to gamble on investing in inputs such as improved seeds and fertiliser. In a good season, these could boost their yields and bring them extra food and income. But a hail storm, drought or disease outbreak could wipe out their crops or livestock, leaving them with nothing to eat, a large debt to repay, and no way of rebuilding their livelihoods.

Insurance policies have the potential to markedly increase food production by reducing the risk farmers face from investing in inputs such as improved seeds and fertiliser. With climate change, insurance is also invaluable in protecting the food security of farming families

Farmers in the developed world have long had access to safety nets and insurance that helps them survive tough times. Now, innovative approaches are being tested throughout the developing world. Examples found in this chapter include a programme in Ethiopia that is helping resource-poor farmers to rebuild their resources and boost their food security, and a weather-based insurance scheme in India that is encouraging smallholder farmers to take judicious risks to raise their production. Ultimately, such systems are helping farmers move to new production systems that can meet the demands imposed by future climate scenarios. ■

© Reuters

A farmer looks towards the sky while standing amongst his drought-stricken crop.

STORY 7

Weather-based insurance helps farmers evade the poverty trap

Weather-index-based crop insurance is encouraging farmers in India to invest in their crops, boosting food security and the resilience of smallholder production systems.

Small-scale farmers, especially poor subsistence farmers, are loath to take risks: they cannot afford to. If a gamble does not pay off—and, in the context of uncertain physical and financial climates, investing in improved seeds, fertilisers and other inputs is a gamble—their lives and those of their families are at risk. This is one reason why smallholder farmers are often trapped in poverty—they do not have the resources to invest in the inputs that would help boost their yields and give them a surplus for sale. And unfortunately, climate change is only increasing the levels of risk for those who choose to gamble.

Over two-thirds of agricultural land in India is rainfed and, as a result of climate change, droughts are increasingly frequent. The major river valleys in the north of the country—the Ganges-Brahmaputra and Indus river systems—have always been prone to flooding, but the area of land affected by floods has more than doubled in recent decades, from 19 million ha in the 1950s to 40 million ha in 2003. Between 1801 and 2002, India suffered from 42 serious droughts that reduced agricultural production. In early 2013, parts of western India were suffering from the worst drought in more than 40 years. Indian agriculture has been described as 'a gamble on the monsoon.'

India has a long history of agricultural insurance schemes, starting with a pilot programme for cotton farmers in Gujarat in 1972. This led to the Comprehensive Crop Insurance scheme in 1985, which was subsequently replaced by the National Agricultural Insurance Scheme (NAIS) in 1999. NAIS is based on an 'area yield index': yields are independently checked each year on a sample of farms within a sub-district and farmers receive a pay-out if the yield falls below a certain percentage of the long-term, average yield for the area. The scheme works reasonably well for widespread events such as drought and is relatively cheap to run, as yields do not have to be checked on each farm. However, payouts tend to be delayed, taking up to 2 years to reach affected farmers.

Introduced as a pilot in 2003, the Weather-Based Crop Insurance Scheme (WBCIS) was adopted by the government in 2007 as an alternative to the existing 'yield index' insurance. The weather index includes rainfall (high or low, length of wet or dry periods etc.), temperature, humidity, wind speed, and a combination of these as a proxy for disease risk, and is based on measurements taken at official weather stations around the country. Pay-outs are triggered automatically without the need for farmers to formally file a claim, reducing transaction costs and resulting in rapid pay-outs, usually within 30 days of

A woman farmer works in a paddy field in the eastern Indian state of Orissa.

the index trigger. The system also has the advantage of avoiding fraudulent claims by those insured.

All farmers who borrow money from financial institutions are required to take out insurance (including NAIS or WBCIS), while those who do not take out loans are still able to insure their crops if they wish to. Voluntary purchases account for about 15% of policies sold. The insurance premium for NAIS and WBCIS is subsidised by central and local government. WBCIS policies are offered by both public- and private-sector insurance companies.

The number of farmers insured under WBCIS is increasing dramatically year on year, from only 1,000 in 2003/04 to nearly 12 million in 2011/12. Interestingly, the value insured per policy declined from about US$590 in 2007/08 to US$340 in 2010/11, suggesting that more small-scale farmers are beginning to take out loans and insurance. Premiums paid (including farmer premiums and government subsidies) increased from less than US$100,000 in 2003/04 to US$370 million in 2011/12, and pay-outs from less than US$100,000 in 2003/04 to US$125 million in 2010/11.

12 million

Indian farmers insured in 2011/2012 under the WBCIS

These insurance policies have the potential to markedly increase food production, by reducing the risk farmers face from investing in inputs such as improved seed and fertiliser. With climate change bringing increasing variability of rainfall and temperature and greater risks from pests and diseases, insurance is also invaluable in protecting the food security of farming families. By helping raise productivity of cropland, it also helps indirectly to mitigate climate change by reducing the pressure to bring more land under cultivation.

But there are still a number of issues that need to be addressed to make weather-index-based insurance more effective in India. Weather-index-based insurance requires a dense network of weather stations to gather data; India needs to double the number of weather stations if it is to support reliable weather-index-based insurance. More research is also needed to improve the indexes used, to ensure that they accurately gauge the impacts of weather on crop yields. Recent research shows, for instance, that the average WBCIS payment is only 12% of the sum insured when conditions have caused complete crop failure and yet payments of up to 6% of the sum insured have been made when yields were double the historical average. Finally, the cost of weather-index-based insurance will increase as the effects of climate change start to be felt more widely. WBCIS and similar products use historical weather data to predict the frequency of adverse weather; however, climate change is expected to increase the frequency and severity of these events and hence the size and frequency of pay-outs, driving up insurance costs. ■

Safety net programmes boost food security and climate change resilience in Ethiopia

Ethiopia's Productive Safety Net Programme and Household Asset Building Programme have improved the food security and resilience to climate change of nearly 8 million households across the country.

Ethiopia's millions of smallholder farmers—who account for some three-quarters of the country's population—largely practise low-input, low-output, rainfed, subsistence agriculture. As a result they are vulnerable to the vagaries of the weather in the short term and will be hard hit by climate change in the longer term.

Ethiopia has a long history of droughts and famines, but they are becoming more frequent. Throughout much of the twentieth century, the country suffered from droughts that caused widespread food shortages about once every 10 years, but such droughts are now occurring every three years or so, and almost constantly in the southern Borana rangelands. Average temperatures in the Horn of Africa increased by 1.3°C between 1960 and 2006.

The increasing frequency of drought has depleted the asset base of smallholder farmers. They and their families commonly go hungry for several months even in 'normal' years, and famine is just one failed rainy season away. And every time the rains fail or crop yields are low, they are forced to sell off their livestock, ploughs, tools, and even their seeds, just to make ends meet.

In 2005, the Ethiopian government introduced the Productive Safety Net Programme (PSNP) to improve the food security of people who suffer from chronic food shortages and live in areas that are prone to drought. The programme is almost fully funded by external donors, including Canada, Denmark, Ireland, the Netherlands, Sweden, UK, USA, EU, the World Bank and the World Food Programme. However, the Ethiopian Government is the driving force behind the programme and has had strong ownership of it from the beginning.

Households that have experienced food shortages for at least three months each year in the previous three years and have no external social support—relatives working in towns and cities who send remittances, for example—receive payments in cash, food or a mix of the two in exchange for six months' work on public works projects. Households that cannot provide labour, such as those headed by disabled or elderly people, receive the payments as grants. About 85% of beneficiaries are engaged in 'workfare' projects. These are chosen through a participatory approach based on local authority development plans and include such things as enclosing protected areas, esta-

75%

of the population in Ethiopia are smallholder farmers

The Household Asset Building Programme in Ethiopia is helping farmers invest in increasing their agricultural production.

Ethiopia's Productive Safety Net Programme means that many farmers no longer have to sell off their productive assets, such as their livestock, when drought or other calamities hit. The programme provides cash or food in exchange for work on public works projects.

blishing woodlots, constructing hillside terraces, shallow wells and ponds, and diverting streams for irrigation.

A complementary programme, the Household Asset Building Programme (HABP), has provided access to agricultural credit and similar services to help people build up their productive assets and increase their agricultural production. Households' food situation is monitored regularly and, once they are deemed to have achieved an acceptable level of food security and no longer need external support, they 'graduate' from the PSNP. Between 2008 and 2012, almost 500,000 households graduated from the programme.

In 2012, the programme was supporting nearly 8 million people (9% of the country's population) across seven of the country's 10 regions. A study published in 2011 showed that the PSNP reduced the 'hunger gap'—the period during which households ran short of food—in beneficiary households by just over a month (29%) and improved child nutrition . The HABP reduced the hunger gap by an additional 17 days. Households enrolled in the programme showed a steady increase in livestock holdings (up 11% between 2006 and 2010) and the value of tools—hoes, sickles and ploughs—they owned. In contrast, households not enrolled in the programme saw their livestock holdings and assets fluctuate widely over the same period. Distress sales—selling off livestock and productive assets to meet immediate needs—also declined markedly, from 51% of households at the beginning of the programme to 34% of households reporting distress sales in 2010.

There were strong synergies between the PSNP and HABP. Households enrolled in both programmes were 19 percentage points more likely to use fertiliser on their crops than households enrolled in only the PSNP, and 21 percentage points more likely to use fertiliser than households that were not enrolled in either programme. Similarly, households enrolled in both programmes were more likely to invest in stone terracing, which improves productivity by conserving topsoil. As a result of such measures, those enrolled in both programmes produced 147 kg more grain per household than those enrolled only in the PSNP.

The Productive Safety Net Programme improves the food security of people who suffer from chronic food shortages and live in areas that are prone to drought. It reduced the 'hunger gap' - the period during which households ran short of food - in beneficiary households by just over a month and improved child nutrition

Working together, the PSNP and the HABP have improved the immediate food security of households, strengthened their resilience to shocks such as droughts and floods, and increased their ability to adapt to longer-term climate change. There is anecdotal evidence that the PSNP and the HABP have increased tree planting by beneficiaries and suggestions that agricultural practices adopted are likely to increase carbon sequestration, but these have not been measured or even estimated. ■

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India's Integrated Agrometeorological Advisory Service is helping farmers get the most out of their crops, warning of impending severe weather or conditions that might provoke a disease outbreak, for example, and giving advice on what action to take to protect their crops.

STORY 9

Weather-based agricultural advice boosts crop and livestock production in India

Nearly 70 years ago, All India Radio started broadcasting a farmers' weather bulletin. These bulletins and the subsequent TV show, *Krishi Darshan*, played a vital part in promoting the uptake of improved production technologies by smallholder farmers and enabling them to respond to demands imposed by the weather.

Such advisory services have come a long way. The latest iteration, the Integrated Agro-Meteorological Advisory Service (IAAS) was introduced in 2007. The service involves a wide range of partners, including the India Meteorological Department (IMD), the National Centre for Medium Range Weather Forecasting (NCMRWF), the Indian Council for Agricultural Research (ICAR), state departments of agriculture and agricultural universities, several government ministries, media organisations, non-governmental organisations and private sector bodies.

The meteorological services provide weather data and five-day forecasts. Specialists from ICAR, state departments of agriculture and the universities translate these into agricultural advisories, to alert farmers to weather-related events that are likely to affect their agricultural operations, such as strong winds, low temperatures or periods of humid weather, which can increase the risk of disease outbreaks. They also provide advice on what actions farmers should take. Field units at the agricultural universities relay these advisories to farmers in local languages using a variety of channels, including SMS messages on mobile phones, local radio and newspapers, and face-to-face advisory and extension services.

The IAAS also provides national-level and state-level advisory bulletins, used for planning by national and state governments and the agro-input supply industry.

The agricultural advisories currently reach some 2.5 million smallholder farmers across India. Studies have shown that farmers receiving IAAS advisories have yields that are 10–15% higher, and costs that are 2–5% lower, than farmers not receiving the advisories, largely as a result of using more modern agricultural production technologies and practices, having better irrigation and pest/disease management and improved postharvest technologies. Since it started in 2007, the service has had an estimated economic impact of more than US$10 billion.

The IAAS has clearly helped farmers cope with current, short-term climate-induced risk, but may do little to help them adapt to longer-term climate change. More will need to be done, to build on the foundation of farmer engagement and to help farmers make the changes necessary to cope with uncertain future climate scenarios. ■

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A farmer works in a sunflower field in Khatihari village, India.

3

A farmer watches as grain is harvested in Hurup, Jutland, Denmark.

Policies and institutions: foundations of climate-smart agriculture

Time and again, promising technical interventions in agriculture have failed to deliver the benefits they promise. Often, this proves to be because the policy environment does not encourage farmers to take up these interventions, or institutions such as land or tree tenure mean that farmers would not reap the gains from their labours. Inappropriate policies and weak institutions may result in farmers adopting practices that are unsustainable or actively degrade the environment. Resource-poor smallholder farmers live a hand-to-mouth existence. They typically lack the resources to invest in potentially life-changing interventions—even simple ones like improved seeds, fertiliser, pesticides, herbicides or improved livestock—or are reluctant to do so because of the risks to their lives and livelihoods if their crops fail or their livestock die.

The difficulties facing farmers are being compounded by climate change. Extremes of weather are increasingly common, making farming a more and more risky business in the immediate term. But in the longer term, farmers will have to make major changes to the way they farm, and even what crops and livestock they keep, if they are to continue to derive their livelihoods from the land in a sustainable way.

The impact of agriculture on the environment is unquestionable. It is responsible for up to 25% of all greenhouse gas emissions. Policies must be implemented worldwide to help mitigate climate change and raise farmer incomes

This section highlights policy approaches from around the world that are helping farmers adapt to climate change, reduce some of its impacts and contribute to its mitigation while boosting their income and protecting their livelihoods. ■

STORY 10

Reducing Danish agriculture's contribution to climate change

Denmark's Green Growth policy has helped reduce the agriculture sector's carbon footprint while ensuring the sector remains vibrant. Smart measures, such as improved use of manure and a 40% reduction in the use of inorganic fertiliser, have contributed to a 28% reduction in greenhouse gas emissions between 1990 and 2009.

Agriculture is responsible for up to a quarter of all greenhouse gas emissions worldwide, and Denmark' agricultural sector is no exception. Denmark is one of the world's most intensively farmed countries and a leading exporter of pig and dairy products. Denmark's agricultural sector is the country's third largest source of greenhouse gas emissions after the energy and transport sectors, contributing 17% of emissions.

Agricultural production in Denmark is based on intensive, specialised farms, with large-scale pig, poultry, beef and dairy units and arable farms common across the country. Such intensive agriculture places considerable demands on the environment, and Denmark has a long history of efforts to reduce the environmental impact of agriculture. In 1989, for example, the government introduced the Action Programme for Joint Biogas Plants, which explored the use of liquid manure in large-scale biogas plants as a way to reduce emissions and improve manure management in the country's intensive livestock industries. The programme was backed up by action plans to reduce agricultural contamination of water courses. The Action Plan for Sustainable Agriculture, launched in 1991, tightened controls on the use of manure on farmland, and was followed by a further action plan in 2001, to improve manure handling and reduce the amount of ammonia released into the atmosphere.

All of these measures were aimed at reducing the impact of agriculture on the environment, including nitrogen pollution of groundwater and release of greenhouse gases—methane and nitrous oxide in particular—to the atmosphere.

The Agreement on Green Growth, signed by all of Denmark's major political parties in 2009, builds on these measures and aims to ensure that protection of the environment and the climate goes hand-in-hand with modern and competitive agriculture and food industries. The Agreement includes measures to promote organic farming, re-establish wetlands, encourage environmentally sound farming practices and reduce use of pesticides and nutrients. It also focuses on efficiency in resource and energy use and the application of environmental technologies that reduce input use, energy consumption and emissions, recover valuable by-products, and minimise waste disposal problems. One of the specific aims of the

© Reuters/Bob Strong

Young calves at a dairy farm in Brundy, Denmark, where agricultural production is based on intensive, specialised farms.

Agreement is to reduce greenhouse gas emissions from Danish agriculture by 800,000 tonnes of carbon dioxide equivalents per year by 2015, half of which will come from reducing the amount of nitrogen applied as manure or inorganic fertiliser.

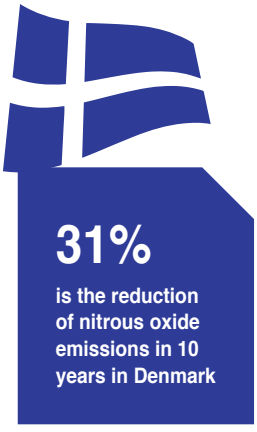
The Agreement on Green Growth, signed by all of Denmark's major political parties in 2009, aims to ensure that protection of the environment and the climate goes hand-in-hand with modern and competitive agriculture and food industries

A key climate-change mitigation element of the Agreement is its target to use half of all manure produced in the country to produce biogas by 2020—a 10-fold increase from 2009 levels. Production of biogas will reduce methane emissions from manure and reduce the country's dependence on fossil fuel—both of which will help bring down Denmark's carbon footprint. The use of catch crops and establishment of perennial plants such as willow for biomass, mandated under the Agreement, will sequester considerable amounts of carbon in organic matter and woody species.

With a budget of some US$2.4 billion for 2009–15, the Agreement provides funding for several initiatives that will contribute to climate-change mitigation. These include the development of common, centralised biogas plants, farm-level investments for connecting to these plants and planting of perennial energy crops, such as willow. Planting these crops has also been made tax-deductible, to encourage uptake by farmers.

Such initiatives are balanced by policy measures aimed at ensuring the continued health and vibrancy of the agricultural sector, which is a vital part of Denmark's economy, accounting for 3% of gross domestic product and employing 8.5% of the country's labour force. Many of the changes are aimed at simplifying the policy environment in which agriculture operates, in order to reduce farm overheads and increase the efficiency of production.

To date, the various measures have had considerable impact: Denmark's greenhouse gas emissions declined by up to 28% between 1990 and 2009 (from 18.7 to 13.4 million tonnes of carbon dioxide equivalents). Much of this decline came from a 31% reduction in nitrous oxide emissions, due to improved use of manure and a 40% reduction in use of inorganic fertiliser between 1990 and 2000. Studies suggest that greenhouse gas emissions from Danish agriculture could be cut by a further 50–70% without reducing food production, and that increases in biogas production from manure could result in a positive energy balance for the agricultural sector as a whole. ■



STORY 11

Carbon farming initiative boosts climate change mitigation in Australia

An initiative launched by the Australian Government in December 2011 to generate carbon credits for trading or to satisfy mandatory or voluntary carbon commitments is already showing benefits in terms of climate change mitigation and raising farmer incomes.

The Carbon Farming Initiative (CFI) allows farmers to earn 'carbon credits' by implementing practices that sequester carbon or reduce greenhouse gas emissions. The credits may then be sold by farmers to individuals and businesses that want or need to offset the greenhouse gas emissions of their business operations, creating additional income for Australian farmers and land managers and boosting resilience of Australian agriculture to climate change.

Eligible activities for reducing emissions include altered livestock management, increasing fertiliser use efficiency and improved savannah fire management. Activities to increase carbon sequestration include managing for increased soil carbon and reforestation and revegetation. Such sequestration activities must demonstrate that they will deliver genuine and lasting reductions in greenhouse gas emissions.

To be eligible to participate in the CFI, farmer projects have to meet a number of criteria, including applying a government-approved methodology for implementing and monitoring specific carbon farming activities and generating carbon credits. So far, four methodologies have been approved, covering environmental planting of native species, burning savannah in the early dry season, destruction of methane generated from manure in piggeries, and capture and combustion of landfill gas. New methodologies are being developed by private bodies, industry associations and the Department of Climate Change and Energy Efficiency.

By July 2013, 69 projects had been declared as eligible under the CFI, including 10 related to early burning of savannah to reduce carbon emissions, 10 involving reforestation and afforestation and three reducing methane emissions from manure from piggeries.

Benefits to the farms can be impressive. A pig farm in New South Wales that invested in a biogas generator went from paying US$15,000 a month for electricity to earning US$5,000 a month from the surplus electricity generated. The farm is burning some 2400 cubic metres of methane every day, saving the equivalent of 32 tonnes of carbon dioxide. At A$15 (US$13.80) per tonne, the carbon credits the biogas digester is generating are expected to be worth around US$160,000 a year.

One possible drawback of the scheme, however, is that the high up-front costs of getting a project approved may discourage smallholders from getting involved, as the pay-back from small-scale operations may be too small to justify the investment; smallholders account for 86% of agricultural and forestry businesses in Australia. ■

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Australia's Carbon Farming Initiative allows farmers to earn carbon credits for changes in land management that sequester carbon or reduce emissions, such as improved pasture management.

The most dramatic way to see the extent of deforestation in the Amazon rainforest is from the air.

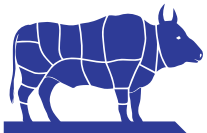
STORY 12

Persuading Brazil's farmers to adopt low-carbon agriculture

The Government of Brazil has introduced a US$1.6 billion fund to encourage farmers to introduce climate-smart agricultural practices that will boost production and reduce the country's greenhouse gas emissions.

The Brazilian Government launched a plan to promote sustainable agricultural systems and practices to reduce greenhouse gas emissions, increase the efficiency of agricultural activities and boost the resilience of rural communities

As in many developing countries, agriculture in Brazil is the second largest source of greenhouse gases after the energy sector. But there are clear opportunities in the country to mitigate agriculture's contribution to climate change. For example, Brazil has about 40 million has of degraded pasture. Restoring these pastures could increase beef yields six-fold, from around 30 kg/ha per year to 180 kg/ha, reducing the pressure to expand agriculture into the Amazon region. Well-managed pasture also sequesters more carbon than degraded pasture.



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Restoration of pastures could increase beef yields six-fold

In 2010, the government initiated the Low-Carbon Agriculture (ABC) Plan, which aims to promote sustainable agricultural systems and practices to reduce greenhouse gas emissions but also increase the efficiency of agricultural activities and boost the resilience of rural communities. The Plan's credit arm, the ABC Programme, provides low-interest loans for sustainable agricultural practices such as: no-till agriculture; restoration of degraded pasture; integration of crops, livestock and forest; planting of commercial forests; biological nitrogen fixation; and treatment of animal wastes.

The goals are ambitious, including rehabilitating 15 million ha of degraded pastures and increasing the area under zero-tillage from 25 million ha to 33 million has by 2020. The target is to reduce Brazil's direct farm carbon dioxide emissions by more than 160 million tonnes a year, and save as much again by curbing the invasion of rainforests by farmers. Initial uptake was slow, with only five projects totalling US$1.7 million approved in the first year, but over 2,000 projects were approved in 2011/12 with a total value of US$251 million—still way short of the US$1.6 billion target. Uptake has been constrained by a number of factors, including shortage of people able to evaluate proposals, both among producers and at the banks, lack of information about the technical and financial performance of some proposed interventions, and excessive bureaucracy. The government is working to reduce the red-tape, including relaxing some of the environmental controls, but it is too soon to tell if the initiative will achieve its ambitious goals. ■

STORY 13

Kenyan farmers sell carbon credits to BioCarbon Fund

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Farmers participating in the Kenya Agricultural Carbon Project are earning carbon credits for implementing land management practices such as mulching that reduce carbon emissions while at the same time boosting crop and livestock production.

In November 2010, the Kenya Agricultural Carbon Project (KACP) became the first soil carbon project in Africa to sign an Emissions Reduction Purchase Agreement (ERPA) with the World Bank's BioCarbon Fund.

The project is operating in the Kisumu and Kitale districts of Western Kenya, which are dominated by subsistence farms with an average of less than one hectare of highly degraded land. Implemented by Vi Agroforestry, a Swedish non-governmental organisation, the project is helping these farmers adopt sustainable agricultural land management (SALM) practices, such as reduced tillage, use of cover crops and green manure, mulching, targeted application of fertilisers and agroforestry. The project is following the World Bank's 'Adoption of Sustainable Agricultural Land Management' methodology, which uses land management practices as a proxy for carbon stock changes. A survey of agricultural practices at the start of the project provides the baseline against which adoption of SALM practices is monitored.

A key feature of the World Bank methodology is the bottom-up approach to monitoring (with farmer groups directly engaged in monitoring of the adopted activities), which helps boost awareness and understanding of the practices among participating farmers and promotes buy-in. A sample of participating farmers completes an Activity Baseline and Monitoring Survey each month, and these are independently audited to estimate the reduction in greenhouse gas emissions. Vi Agroforestry then sells the greenhouse gas gains to the BioCarbon Fund. The revenue from carbon credits is distributed between farmer groups (60%), Vi Agroforestry extension operations in the project area (30%) and Vi Agroforestry headquarters in Stockholm to cover administrative costs (10%).

To date, some 15,000 farmers in 800 farmer groups have adopted SALM practices, which have been applied to around 12,000 ha of degraded land. The project's target is to enrol a total of 60,000 farmers and apply SALM practices on around 45,000 ha by 2016. Vi Agroforestry estimates that this would result in reducing greenhouse gas emissions by over 60,000 tonnes of carbon dioxide equivalents each year, while also restoring degraded land, boosting crop yields and reducing the vulnerability of the farmers to the effects of climate change. According to the World Bank, the project will bring direct benefits of US$350,000 to local communities. Payments from the BioCarbon Fund will provide additional income to participating farmers until 2025. ■

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Local women at a community meeting in Dan Bako Village, Niger.

STORY 14

Bottom-up development planning in Niger

Local communities in Niger have been playing a leading role in the country's development, with support of a Community Action Plan (CAP) financed by the World Bank, the Global Environment Facility (GEF) and the International Fund for Agricultural Development (IFAD). Many of the initiatives implemented have contributed to mitigating climate change and enhancing the resilience of the country's agriculture to the effects of climate change. Initiated in 2003, CAP has improved the capacity of two-thirds of Niger's local governments to design and implement development plans using small capital grants. In this locally owned process, villagers agree on a list of projects to be implemented, with backstopping from local technical experts from decentralised offices of national ministries.

Sustainable land management practices have increased agricultural productivity, vegetative cover and carbon sequestration, and reduced water erosion

While many of the projects have focused on health and education, the programme has also financed more than 1,000 income-generating micro-projects in agriculture, fisheries and livestock, which have benefited an estimated 100,000 people, 80% of whom are women. More sustainable land management practices have been implemented on nearly 9,000 ha, increasing agricultural productivity, vegetative cover and carbon sequestration and reducing water erosion on 88% of sites.

Now, the Community Action Project for Climate Resilience (CAPCR)—part of the government' Strategic Programme for Climate Resilience—is building on CAP, focusing on making sure that climate resilience is incorporated into development programmes and investment plans across the economy and improving the resilience of agricultural, agroforestry, agropastoral and pastoral production systems to climate change. There are already many good practices in sustainable land and water management known in West Africa, such as soil/moisture conservation methods, water harvesting, reduced tillage, agroforestry and nutrient-enhancing rotation systems, and the project will support initiatives to roll these out across the country. The project will also support social protection measures, such as cash transfers, seasonal labour-intensive public works programmes and safety nets for the most vulnerable households.

It is too early to say how much impact these programmes will have on climate-change mitigation or resilience, but the bottom-up approach augurs well for both sustainability and beneficiary buy-in. ■

STORY 15

Plan Maroc Vert gets climate change makeover

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A town above a palm plantation.

Launched in 2008 to boost market-oriented agriculture in the country, the climate change credentials of Plan Maroc Vert (Green Morocco Plan) were strengthened in 2011 with the launch of a project on 'Integrating Climate Change in the Implementation of the Plan Maroc Vert'.

The objective of the original Plan Maroc Vert was to revitalise and reform Morocco's agriculture and transform it into a driving force for broad-based economic and social growth in rural areas. The targets are ambitious: increase production of olives four-fold; more than double citrus production; double or treble the income of 3 million rural workers; and create 1.5 million new, permanent jobs in the agricultural sector. The plan has two pillars, one focused on promoting modern, competitive, market-oriented agriculture, the second dedicated to combating rural poverty by increasing the agricultural incomes of the most vulnerable farmers in marginal areas. The measures proposed could reduce greenhouse gas emissions by 63.5 million tonnes of carbon dioxide equivalents over 20 years, largely though sequestration of carbon in the soil as a result of improved agronomic practices.

So far, the Plan has delivered impressive results. By 2011, production of olives had nearly tripled relative to 2005–07, citrus production was up 20%, cereal production was up 52%, date production up 45%, and red meat production was up 48%.

However, the 2010 World Development Report identifies Morocco as one of the countries that will suffer the most as a result of climate change. Changes in rainfall patterns are likely to increase the risk of poor harvests, or even crop failure, especially for small-scale farmers who depend on low-input, rainfed agriculture.

Such concerns are being addressed by the new project, 'Integrating Climate Change in the Implementation of the Plan Maroc Vert', co-financed by the Special Climate Change Fund of GEF, which will finance climate change adaptation measures in 10 pilot projects (involving around 2500 small-scale farmers in five regions of Morocco), and mainstream climate change adaptation across the whole Plan.

Smallholder farmers should thus benefit from higher incomes and greater resilience to climate change, while the changes brought in will also contribute to climate change mitigation. ■

Engaging local communities in forest management is promoting a sense of shared ownership and responsibility within the communities. Deforestation and forest degradation is less in community-managed forests than in forests managed by central authorities.

STORY 16

Bringing forest management back home

Forests play a vital role in the livelihoods of millions of Tanzanians, but uncontrolled exploitation of the country's forests in the 1990s and early 2000s led to over 400,000 ha of forest being lost each year.

Tanzanian authorities recognised that they did not have the resources—money or people—to protect all the country's forests. Villagers were using the forests as an open access resource, indiscriminately gathering fuelwood, forest fruits and vegetables, medicinal plants and building materials for their own use, and cutting trees for timber or to make charcoal for sale.

Participatory forest management (PFM) was seen as a way of getting local people to take responsibility for managing the forests themselves. The Forest Policy of 1998 and the Forest Act of 2002 provided a legal basis for communities to own and manage forest resources on village lands and jointly manage forest resources in government forest reserves.

By the end of 2011, more than 2 million ha of forest were under community-based management and more than 1.6 million ha were under joint management, involving over 1,800 villages—17.5% of all the villages in the country. The impact on deforestation and forest degradation is promising. The size and volume of trees are increasing in forests under PFM, but are continuing to decline elsewhere; cutting of poles and timber harvesting are lower in the PFM forests than in traditionally managed forests. However, there is some evidence that villagers are harvesting wood from other, non-protected areas, so the overall impact on deforestation may not be as great as hoped for. The impact on livelihoods is also mixed, with community-based forests contributing more to livelihoods than the jointly managed forests, with their more-restrictive protection rules.

More needs to be done to capture benefits of forest management for local communities, including payments for environmental services and income from eligible afforestation/reforestation projects under the Kyoto Clean Development Mechanism or the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD). ■

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Farmer Remy Temba, who practices eco-friendly farming methods, pruning a coffee crop along the foothills of Kilimanjaro.

A farmer sifts his wheat crop at a farm on the outskirts of the Indian city of Ahmedabad.

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Climate-smart agriculture helps millions of people adapt to climate change, while reducing agriculture's climate impact

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