Working with farmers for agricultural innovation and climate adaptation

Working Paper No. 77

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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Alex Wynter

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Abstract

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), in common with other CGIAR research programs, understands that farmers are at the centre of agricultural innovation and adaptation. This publication describes some of the many ways in which CCAFS works with farmers and farmers' organizations to solve problems generated by climate change. Recognizing the importance of participatory knowledge systems involving farmers, scientists, and other stakeholders in responding effectively to climate change, this document seeks to provide an overview of the many ways CCAFS collaborations with farming communities work in practice – and how this can serve as a springboard for more effective dialogue and planning, leading ultimately to better outcomes for farming in a climate-constrained world.

Keywords

Farmers; Agriculture; Climate change; Participatory knowledge

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Introduction

The actions, values and knowledge of farmers are pivotal to achieving future food and nutrition security under climate change. This publication describes some of the many ways in which the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) works with farmers and farmers' organizations to solve problems generated by climate change.

Etrida Luhanga, a smallholder from Malawi, had the final word at the 2013 'Dublin Conference on Hunger - Nutrition - Climate Justice' on behalf of fellow farmers, pastoralists, and fishers. Addressing the assembled policy-makers, she said: *"*In the past, you've been talking to people who do not know anything about farming…But we are the owners of this work."

Rural households have indeed managed the vagaries of local climates and environments for millennia. CCAFS, in common with other CGIAR research programs, understands that farmers are at the centre of agricultural innovation and adaptation. Climate change is altering agricultural conditions at an alarming rate, and in times of such rapid change, farmer-led research to reduce exposure to climate risks provides an alternative to approaches driven entirely by 'experts'.

On the other hand, within the next century climate change may push many habitats and farming systems outside all previous experience. Thus science has a valuable role to play in helping farmers plan for completely new conditions.

Participatory knowledge systems involving farmers, scientists, and other stakeholders, will be key to responding effectively to climate change. These systems may cost more but they can trigger and disseminate innovation faster and more widely and equitably than either farmers or scientists alone. Science and farming need to work together.

In this document we give practical examples of the work of CCAFS with farmers. We hope it will give farmers and our other partners a good overview of the many ways our collaborations with farming communities work in practice – and how this can serve as a springboard for more effective dialogue and planning, leading ultimately to better outcomes for farming in a climate-constrained world.

SCIENCE AND FARMING NEED TO WORK TOGETHER

Helping farmers adapt: objectives and approaches

Even without the rising uncertainties and risks of which climate change is the progenitor worldwide, farmers in the poor South would face a daunting challenge over the next few decades, struggling by some estimates to produce as much as 70 percent more to feed a growing population.

Farming systems all over the developing world face being destabilized in even the most conservative climate scenarios examined by the Intergovernmental Panel on Climate Change (IPCC). Agriculture will have to contend with substantially modified environments, rising global temperatures, unpredictable seasons, altered precipitation patterns, and rising sea levels that threaten, especially, coastal communities – all spawning additional stressors for farmers.

Put at its simplest, most farmers in most countries rely on rain-fed agriculture; this makes them very vulnerable to topsy-turvy seasons and the vagaries of precipitation under climate change. As yields decline, so does the chance of generating a surplus that can be invested in the technologies and practices that might help – like rotating crops, or mixing familiar varieties with new drought-resistant ones, for example, or integrating crops and livestock.

A key objective for CCAFS, therefore, is to help reinforce the ability of farmers and fishing

communities to *adapt* – researching and deploying a wide range of strategies, from product diversification to better institutions and policies. It will be important to do this without disrupting fragile livelihoods; holistic approaches are needed that consider how technical and policy sectors interact.

At the outset, it's clear that there are significant gaps in people's knowledge about what adaptation options are even available, what a cost-benefit calculation for them might look like, when and where they should be deployed, and what learning processes can support widespread change amid an uncertain and risk-laden future.

The main objectives of CCAFS research are threefold. The first action we need to take to adapt farming systems to the world of 2030 is to *close the yield gap* –the difference between what farmers actually harvest and what they could get under more favourable or better-managed conditions – by effectively using current technologies, practices, and policies. We model different approaches through field-based research to test their effectiveness in relation to expected future climatic conditions.

Secondly, we can *develop breeding strategies* for the improvement of crops and make varieties available that can stand up to the many challenges of the future climate.

And thirdly we will enable policies and institutions, from the farm to national level, to *promote change*. We investigate the social, institutional, and policy environments required for adaptation options to bear fruit, so that together they can be used to establish effective agricultural adaptation plans and strategies.

Our partners: the rural poor on three continents

All over the world it is possible to take 3 categories of rural people and observe a high degree of overlap between them: the poor, the food-insecure, and smallholders. Belonging to of one of these groups is a good predictor of membership of at least one of the other two.

Almost all African farms are small-scale; a majority of the population of sub-Saharan Africa rely on subsistence agriculture for survival; typically, the people who till, sow, hoe and pick are *women*, without easy access to machine tools, fertilizer, pesticides or artificial irrigation.

In the CCAFS East Africa region (Ethiopia, Kenya, Rwanda, Tanzania and Uganda) agricultural systems are highly vulnerable to frequent, severe climate shocks like drought, floods and extreme temperatures. The West Africa region (Burkina Faso, Ghana, Ivory Coast, Mali, Niger, Senegal) encompasses a diverse agricultural base spread over a wide range of agro-ecological zones, yet with significant potential for improved productivity.

Latin American countries are highly vulnerable to climate change due to their socioeconomic, geographic and institutional characters. Agriculture, in particular, is highly sensitive to climate variations. The CCAFS region (Colombia, El Salvador, Guatemala, Honduras, Peru) has also faced human and biodiversity losses from extreme-weather events. Most of the impacts of climate variability have been in Central America and along the Andes mountain range.

Southeast Asia (Cambodia, Laos, Vietnam), the newest region in the CCAFS system, is also exposed to climate impacts because of the interaction between disasters and population density. It contains important biodiversity – the world's second largest rainforest after the Amazon – and the huge rice bowls of the Mekong and Red River deltas, themselves at risk from extreme weather and rising sea-levels.

South Asia overall is home to nearly a quarter of the world's population, yet it has only 2.4 percent of global land surface area, making it the most densely populated region of the world. It has achieved

tremendous progress in last four decades in food, yet a quarter of the world's hungry and 40 percent of malnourished women and children live there. The region is prone to climate impacts like floods, droughts, cyclones and heatwaves – all projected to intensify. CCAFS works in Bangladesh, India and Nepal.

TYPICALLY, THE PEOPLE WHO TILL, SOW, HOE AND PICK ARE *WOMEN*

Stages of CCAFS engagement

Farmer baselines

CCAFS has been developing baseline surveys and 'participatory diagnosis' to determine farmers' household and agronomic starting points – figuring out exactly where you are *today* helps to plot a course toward a better future.

Through its partners and starting in 2010, CCAFS engaged in 15 baseline surveys at household, village, and organizational levels in locations across 3 target regions in East and West Africa and South Asia. The challenge was to design new tools for data collection of the highest standard, to allow for comparisons to be made between sites on different continents but facing many of the same issues.

The surveys were designed to develop simple indicators of food security, assets, crop diversity, farming practices and gender indicators, for which changes can be evaluated over time. They were conducted in (alphabetically) Bangladesh, Burkina Faso, Ethiopia, Ghana, India, Kenya, Mali, Nepal, Niger, Senegal, Tanzania, and Uganda. The exercise covered just over 4000 households in 206 villages.

The plan is to revisit these households and villages, where many partners have already been working, after 5 years and again in 10 to monitor progress. The goal – through participatory diagnosis – is to assess what changes have occurred and whether they are helping households adapt to and mitigate climate change.

This first set of 15 sites may be added to as new opportunities emerge; some may receive more attention than others; some sites may even phase out. Additional sites and partners will be added as research priorities for CCAFS are developed with partners. Work is also underway to define locations for 'climate analogues', where the climate projected for 2030 at one geographical location matches the climate now at another. This approach enables farmers to visualize what their future might look like and what options they need to consider.

Land use is another important issue for which a baseline needs to be drawn.
CCAFS and its local partners have identified blocks of 10 square kilometres where researchers can integrate socioeconomic and land-use factors into a 'big picture', also including, for example, carbon measurements from satellite images. In some African countries, blocks 30 kilometres square were chosen because of lower population densities, ensuring the criteria for household sampling were met everywhere.

The first baseline indicator is *food security*. For years when there was neither drought nor exceptional rainfall, households were asked, firstly, whether the food they accessed month by month came from their own supplies or other sources, and, secondly, which months of a typical year they struggled to feed their families, from whatever source.

The baseline surveys revealed the highest incidence of food insecurity in Ethiopia, Ghana and Tanzania. Over half of the Ethiopian households surveyed experienced more than 6 'hunger months' a year; 60 percent of Tanzanian households reported more than 5 in an average year; 47% percent of

Ghanaian households surveyed reported more than 5. In Kenya, however, it is rare to find households that experience more than 4 hunger months.

Men and women

Understanding how climate variability affects rural men and women in different regions is difficult. Men, women, and children are all placed differently to respond to climate change.

The CCAFS baseline surveys picked out female-headed households, allowing patterns to be discerned in areas where there were significant proportions of such households. We also itemized agricultural labour inputs by gender, and highlighted some of the differences in levels of access to climate-related information reported by men and women.

Farm labour tends to be differentiated by gender. Women had no power over cash crops such as rice in the Bangladesh sites, for example, because their domain is the kitchen garden; in Uganda, women could not make decisions about the precious coffee and banana crops (*see below*) because of insecure land tenure. In Ghana, women had more say over improved crop varieties, but less with staples such as cereals and legumes.

'Participatory video' can give women a voice to share perceptions and knowledge of the climate issue with a larger, online audience.

Oh beloved mother, why are you making us work every day?
Why are you not sending us to school at all?
All the children of the village go to school, except me
When I see my friends going to school, I feel like crying
You sell all the goats to send my brother to school
Oh beloved mother, why are you stopping me from going to school?

The song above features in a 2012 CCAFS-funded participatory video directed by 12 women on the Thadhi Jhijha village development committee (VDC), in southern Nepal's Dhanusha district. They were given 3 days' training in production techniques and spoke (and sang) about how climate has affected their livelihoods.

Like many of the village's men, Dhanmanti Pradhan's husband works abroad and she's left to cultivate their fields alone with her children and hired labour when she can afford it. The climate impact this year, bedevilling the entire area's agricultural effort, is drought.

"In my childhood there was a lot of rain," she recalls, standing in the middle of one of her parched paddy fields. "Now we irrigate using boreholes. This is winter time. But look at how strong the sun is, like summer."

The 2012 drought – which the Thadhi Jhijha women contrast to the stormy, rainy weather of the previous year – is having other, more insidious effects than just the withering of various vegetables crops they need to celebrate Baisakh, the Nepalese New Year. Drought is conducive to *pests*.

"Earlier when there was rain we didn't have to use as much pesticide as we do now," says Dhanmanti. "It is not good. It affects our health badly."

The women must pay for water from privately owned boreholes: the rupee equivalent of up to 4 US dollars an hour, further sapping families' reserves for things like school fees. Says Dhanmanti: "We only water plants every 15–20 days. Look how many have died."

Her VDC colleague Sabitri Sah, a mother of three, always liked to put on a good spread of vegetable dishes for Baisakh (April–May), using plants like *mooli* (radish) and *bantha* (eggplant).

"Toor lentils are OK with less rain," she says, "but everything else has been affected. The lack of rain has caused many people's paddies to go bad, and the potatoes didn't germinate in the ground. Now I live from selling buffalo milk."

The Dhanusha participatory video project was implemented by the Nepal Forum of Environmental Journalists (NEFEJ) and the country office of the International Water Management Institute (IWMI). The NEFEJ adapted the videos for broadcast on the Nepal's Image Channel, starting last July.

'THIS IS WINTER TIME. BUT LOOK HOW STRONG THE SUN IS, LIKE SUMMER'

'Climate-smart villages': a concept for the 21st century

What practical steps can smallholders take to adapt farming to secure the food supply? Might those also mitigate greenhouse gas (GHG) emissions? In its search for answers, CCAFS is working with a wide range of partners to test interventions in 'climate-smart villages' – a concept that is surely apt for the 21st century, given the latest IPCC forecasts (Working Group I, 2013) for the future of our climate.

The project launched in 2011 with 15 climate-smart villages in the West and East Africa and South Asia regions; 22 are now taking part, with more planned for other CCAFS regions. All are in areas likely to suffer most from a changing climate, where partners have already established links with local communities.

After a site is selected, a steering group of community members and researchers identify climate-smart options in a fully participatory process. These might include climate-smart technologies, climate information services, local development and adaptation plans or supportive institutions.

In Kenya's Lower Nyando valley, farmers are discovering the value of 'agroforestry' – maize, sorghum and other crops sown between rows of trees that stabilize and enrich the soil. The demand for trees has led to nurseries springing up to supply seedlings, and these are becoming an important source of income, particularly for women, who own more than half the nurseries now thriving in Lower Nyando. Farmers have been encouraged to incorporate poultry, sheep and goats into their farms, generating additional income and food.

Other activities focus on the management of natural resources. In Bihar state in northern India, where soils are prone to water-logging, new drainage techniques get rid of floodwater more rapidly and recharge aquifers at the same time. In dryer villages in India and Kenya, rainwater harvesting is important. More effective management of soil carbon, precise application of fertilizers, and energy-efficient machinery all play a part.

In addition to farm practices, farmers in climate-smart villages are also testing climate-smart services such as tailored weather-forecasts to plan planting and harvesting. These may come by SMS, and mobile phones are also being used to enable farmers to buy insurance cover against extreme weather.

Another project that comes under the general heading of 'site-level participatory action research' is underway in Uganda, which in 2008 was the second-largest banana producer and the eleventh-largest coffee producer in the world. However, with a growing population farmers are increasingly short of space – both crops tend to grow at around the same altitude, from 800 to 2300 metres.

The old colonial-era system – of separate cropping areas for coffee and bananas – is still in use today, for lack of an obviously better option. But new research by the International Institute for Tropical

Agriculture in Kampala and other CGIAR centres shows how growing bananas and coffee together leaves yields virtually unaffected but greatly increases the value of a single plot of land.

Including bananas in the coffee system also alleviates risk for the farmer. If one crop fails they can still harvest the other. Ugandan farmers say shade from bananas also decreases coffee's susceptibility to drought and extreme weather. The residue from the trees provides mulch which would otherwise cost time and money to acquire, and they say bananas also motivate them to manage coffee better during the early unproductive years, because bananas produce even when coffee is not. This is especially true for women, who often do not see the proceeds from coffee sales but can use the banana harvest for home consumption.

There are trade-offs, of course. 'Intercropping' places a greater burden on the soil and the system may require larger inputs of labour and capital at the outset. More work needs to be carried out to identify constraints and develop ways of addressing them.

GROWING BANANAS AND COFFEE TOGETHER GREATLY INCREASES THE VALUE OF A SINGLE PLOT OF LAND

Farmers learning from farmers

"During the winter we used to see snakes fall off roofs due to the severe cold," says Horil Singh, a farmer in the Rajapakar, Bihar, who almost quit farming in 2008 due to a cluster of difficulties – not least the changing climate around him. It's the kind of telling local detail that often gets picked up in 'participatory video' productions.

"We have seen the weather change to a great extent," he continues. "Earlier we saw rainfall in June and July. Not any longer. Low or delayed rainfall has become the norm."

Singh is speaking in one of a series of participatory videos shot for CCAFs in Rajapakar and two other climate-smart Bihari villages, Bhattadasi and Mukundpur, all in Vaishali district, to help spread the word about effective new farming technologies and methods.

"We have benefited from these interventions," says Parmanand Singh, standing in his paddy in Rajapakar East village. "We have progressed, making use of the best farm practices. Many programs have also helped us to get updates on new methods."

Uma Kant Singh, another Rajapakar farmer, who has insured his rice crop as a member of a new association, adds: "This year, we would insure our wheat crop. Our risks are covered and our claims for damages are settled."

Levelling fields by lasers, zero tillage (which leaves crop residue and other organic matter to decompose in the soil), vertical drainage (into underground wells rather than surface channels), index-based insurance that gives famers some protection against climate impacts like drought and floods, and agricultural advisories by SMS, have all been explored in these Hindi-language videos aimed at a local audience.

Shanti Devi, like other Rajapakar farmers, used to just 'eyeball' how much nitrogen fertilizer to spread on her rice and maize fields. They had no way of judging it systematically, until CCAFS and its partners helped the Indian Farmers Fertilizer Cooperative introduce new leaf-colour charts for assessing fertilizer loads properly.

"The first colour is yellowish and requires two kilos of nitrogen," says Shanti Devi, standing almost waist-high in her now very healthy-looking crop. "The second colour indicates the need for one kilo

of fertilizer. The third and fourth colour indicate half a kilo. And the last two dark green colours don't require any application."

'Climate analogues' also support policy recommendations with field tests, and as well as climate can encompass soils, crops and socioeconomic factors. The CCAFS 'Farms of the Future' project will use the climate analogues to connect farmers to their possible climate futures through farm visits; key outputs are networks of farmers who can go on to use participatory diagnosis to design adaptation strategies for their own communities.

Farms of the Future will improve understanding of local practices and tools. Once refined, the methodology will be global enough to be implemented anywhere, giving scientists the ability to test – and hopefully validate – their models against real-world assessments.

Knowledge is power: climate services

Down the ages, farmers have used traditional knowledge and coping strategies to adapt to changes in the weather and climate. They can predict the arrival of the rainy season by a change in wind patterns, for example. However, climate variability has now intensified to the point where they struggle to keep up.

Agricultural research, extension systems, and NGOs are all affected by climate uncertainty because it limits the back-up they can offer; it has a negative impact on providers of credit and markets.

Climate information (or 'climate services'), on the other hand, reduce uncertainty and can help farmers make better use of seeds and new technologies; they enable better decision-making, especially when reinforced with communications and training. With pilot projects in several African countries, CCAFS is tapping farmers' memories of rainy seasons, dry spells and planting dates. This helps researchers map the probable future and provide better seasonal forecasts.

But to be effective, climate services rely on data tailored to farmers' needs, and under-resourced national meteorological services need support to supply information applicable to large areas.

Mobile phones and radio have been used to convey weather information to a very large audience, even if personal interactions remain probably the most effective way of communicating complex messages about climate. CCAFS is building connections between national meteorological services and local organizations that have access to farmers *and* good information-technology skills.

In Senegal, CCAFS and its local partners are developing new ways of reducing the risks farmers face. Farmers have been involved every step of the way, helping meteorologists and other specialists package information useful to them.

"Our biggest challenge was explaining [the concept of] probability to farmers, and also how to help them interpret the forecasts into action – for example, when to plant," according to Ousmane Ndiaye, Head of Climate and Society with the Senegal National Meteorological Agency, interviewed about the CCAFS work in Kaffrine, on the northern Gambia border.

But he added: "The farmers were very keen and enthusiastic. And after the training they shared the information…and we felt we were filling an actual gap that exists. We built trust by trying to connect our climate information to things that are well-known to farmers."

In East Africa – in the districts of Lushoto in Tanzania and Rakai and Hoima in Uganda – CCAFS partners include the Sokoine University of Agriculture and the Tanzania Meteorological Agency, and the National Agricultural Research Organization and Makerere University in Uganda.

CCAFS researched the integration of indigenous knowledge with scientific weather forecasting and early-warning systems to sharpen farmers' and policy-makers' decision-making. In Lushoto, seasonal drought occurred most often compared to other extremes. Farmers in Rakai and Hoima districts planted early-maturing crops such as beans and sweet potatoes and drought-tolerant varieties of cassava.

Local communities identified a 'good' season by watching for signs from birds, insects and animals, plants, the moon, winds and air temperature, and making decisions such as field preparation, dry planting, purchasing seed, and deciding on types of crop. The goal now is to evaluate the scientific basis of this traditional knowledge and link it to forecasts to reach a consensus.

'WE BUILT TRUST BY CONNECTING CLIMATE INFORMATION TO THINGS THAT ARE WELL-KNOWN TO FARMERS'

ICT and 'index-based' insurance: the example of India

CCAFS has been working with farmers in India to maximize the benefit they can derive from information and communication technology (ICT) – especially 'advisories' about crop markets and weather via SMS, and index-based insurance schemes. Our researchers have also been looking at ways farming communities can record crop losses using modern ICT.

India's agriculture depends heavily on the annual monsoon, which has become increasingly uncertain in onset and intensity. Unpredictable monsoons can account for half or more of the fluctuations in the country's harvests. Under these conditions, index-based insurance against weather shocks buffers farmers from losses. It uses a simple, measurable weather *index* such as rainfall to determine payouts, which can be made more quickly and with less fuss than conventional insurance.

India has seen the widespread adoption of index-based insurance schemes, with the private sector playing a leading part in devising affordable policies for smallholders that are reliable, transparent, fast and less susceptible to fraud.

Insurance companies don't need to visit the policyholder to assess damage and arbitrate claims. If recorded rainfall is below an agreed threshold, the insurance pays out automatically. Faster payouts mean farmers don't have to sell their assets to survive, and the need for emergency food aid is reduced.

In many Indian states, public and private programmes now offer index-based insurance contracts for a variety of crops, providing cover against excessive rainfall or drought, temperature extremes and high winds. The index is based on measurements taken at weather stations around the country. By 2012, up to 12 million farmers growing 40 different crops over 15 million hectares were insured against weather losses.

To achieve its full potential, index-based weather insurance needs to reach a much higher proportion of India's 1.2 billion people, 60 percent of whom depend – directly or indirectly – on agriculture. To help meet that goal, CCAFS is investigating the behavioural and economic constraints that limit uptake by smallholder farmers.

We are also working with the Agricultural Insurance Company of India to design schemes better suited to farmers' needs. This means, for example, ensuring payments match losses. CCAFS researchers are combining crop models with climate data to identify payment-triggers for various crops.

Finally, through climate-smart villages, CCAFS is working with farmers to test tools and technologies

such as water management and soil conservation. When combined with insurance, these can produce long-term benefits for farmers and help them become more resilient.

In Bihar, for example, the 2012 monsoon was late, leading to delayed planting and losses in the rice crop. But in the Vaishali climate-smart villages, where more than 200 farmers had crop insurance, they got their first payment soon after the rains failed, enabling them to quickly invest in new seeds and re-plant.

There are also synergies between insurance and *credit*. With insurance, farmers may be happier to borrow and banks more willing to lend, enabling farmers to invest in new technology.

Conserving biodiversity for adaptation

Agriculture is sometimes considered to be 'climate-smart' when it contributes to food security, adaptation and mitigation in a sustainable way. That may simply be through an otherwise disparate collection of practices, like water management or being more strategic about grazing.

But now CCAFS and experts at Bioversity International – who research the role of agriculture and forest biodiversity in a nutritious, resilient and adaptable future – are evolving a broader concept of climate-smart agriculture; one that not only stays within the limits of ecological systems but actually enhances them. Biodiversity gives farmers *options*, helping them minimize the risks associated with climate change.

This work – which includes local vulnerability, adaptation planning and seed systems – contributes to CCAFS programs and the CGIAR Research Program on Dryland Systems. Bioversity International's 'Seeds for Needs' projects, for example, are based on the premise that with an array of different crops, farmers are more likely to cope with unpredictable weather.

The program introduces farmers to different crop varieties and strengthens their seed systems so they can move with the climate. For example, wheat is particularly sensitive to heat and dries out quickly when it flowers; if farmers plant different varieties that flower at different times, they are less likely to suffer losses from sudden hot weather.

"It is definitely getting hotter. This has been the situation for the last five years," says Mamta Kumari, a farmer and a member of Bhatadasi Ladies' Group, in Bihar, India. "But when we talk about the weather now, both summers and winters are getting extreme."

One answer is to take varieties from other locations that are likely to thrive in the prevailing conditions. Jacob van Etten, a Senior Scientist with Biodiversity International, explains the process: "We make a shortlist of varieties that we think are going to do well. Then we make a smaller set for farmers so they can get access to diversity, do some systematic observation, collect the information" and share it.

Mamta Kumari was pleased with the results: "They [Biodiversity] helped select the varieties of wheat to grow this year and last year also. The trial was a big hit. Farmers came from far-off places to see this."

In Papua New Guinea, another Seeds for Needs country, together with local implementing partners, the National Agricultural Research Institute (NARI), the program is identifying models for taro and sweet potato for current and future climatic conditions. The project is also expected to develop "an improved seed multiplication and delivery system, leading to improved genetic production potential of staple crops in Papua New Guinea," according to NARI.

Seeds for Needs started in Ethopia in 2009 with barley and wheat; as well as in India and Papua New Guinea, it also works on bean varieties in Honduras, Rwanda and Uganda; and on sorghum, pigeon pea and cowpea beans in Kenya and Tanzania. Additional projects in Cambodia and Laos are expected to start in 2014.

'WE MAKE A SHORTLIST OF VARIETIES WE THINK ARE GOING TO DO WELL'

New approaches to extension

In India, the CCAFS site in the Indo-Gangetic plains lies in an agriculturally vibrant region playing a vital role in the food security of the country. Since the mid-1960s, increases in agricultural productivity, rapid industrial growth and expansion of the informal rural economy have quadrupled per capita GDP and significantly reduced poverty.

But now a host of factors threaten future progress: soaring food and fuel prices, volatile markets, the global economic downturn, depletion of water resources, diversion of human capital from agriculture, soil degradation, indiscriminate use of chemical inputs, shrinking farm sizes, and the overarching effects of the climate change that is projected to lead to uncertain monsoons and more frequent weather-extremes.

Significant efforts are being made through various institutions on the development and dissemination of new technologies, including climate-smart practices, but large-scale adoption is sluggish. Scaling-up climate-smart agricultural systems and other knowledge-intense technologies and practices has turned out to be more difficult than were 'green revolution' methods like new seeds, fertilizers and irrigation.

One major bottleneck centres on the increasing average age of farmers, lingering traditional mind-sets, and the loss of young people who move out of farming. Discussing with communities ways to break the impasse, the Mexico-based International Maize and Wheat Improvement Center (known by its Spanish acronym, CIMMYT) decided to undertake technology development with young farmers in the belief that engaging them in a community-based approach will facilitate adaptation and adoption of new technologies.

CIMMYT also recognised the advantage of bringing young farmers together to influence policymakers to support the promotion of technologies, targeting not only adaptation and mitigation but also farm profitability and generating alternate employment for rural youth through technology-led business opportunities. The other benefit was to evolve institutional mechanisms for buying and sharing assets such as expensive farm machinery, for real-time decision-making, and for using resources more effectively at community-level.

CCAFS decided to interact with a group of young farmers from Taraori village, in the Karnal district of India's Haryana state. The response was overwhelming: farmer groups showed a keen interest in new-generation technologies to help with problems like: sowing rice with less labour; surface levelling to save irrigation water; residue management for more healthy soil; eliminating burning and tillage to save fuel, energy and water; more efficient use of nutrients; and general adaptation to climatic risks.

The enthusiasm was so great that a group of 20 young people formed the 'Society for Conservation of Natural Resources and Empowering Rural Youth'. A community-based movement led by young farmers was born. Now more than 4000 people including senior policy-makers have visited these innovative farmers to learn more about resource-efficient, climate-smart and profitable technologies.

As farmers' participation in technology and adaptation is critical, a new research platform was established with CCAFS at this village cluster to build awareness of different stakeholders including

farmers, extension agents, students, scientists and policy-planners. Through capacity-building, different climate-smart technologies were demonstrated to large number of farmers in the CCAFS cluster as well as farmers and extension agents in other areas.

The new society has also been publicizing the technologies through print and electronic media, including national newspapers and television and international conferences. The chief minister of Haryana announced incentives for community-based climate-smart and resource-efficient technologies – primarily conservation agriculture and 'smart' mechanization.

This became a model for rural youth and communities, with 5 more young-farmer cooperatives in the clusters of CCAFS climate-smart village.

Metrics

Agriculture contributes as much as 24 percent of man-made emissions of GHG globally and is an important driver of deforestation. Yet it also offers opportunities to mitigate climate change through, for example, enhancing soil carbon, planting trees, improving livestock management, and more efficient uses of nitrogen fertilizer and energy.

What are the relationships between emissions reductions, food and energy security, climate change adaptation and other environmental goals? Which agricultural systems and geographical regions have the largest potential for mitigation? How can we create incentives for lower-emissions food systems around the world? How can GHG in smallholder systems be quantified? CCAFS research seeks to answer these and other questions.

We use a variety of *metrics* – many of them highly innovative – such as farm emissions measurement, systems analysis, remote sensing, modelling and socioeconomic analysis. We test practices such as agroforestry, efficient use of nitrogen fertilizer, alternate wetting and drying (AWD) of rice paddies, improved livestock management, minimum tillage and more.

In a project called Standard Assessment of Mitigation Potential and Livelihoods in Smallholder Systems ('SAMPLES') that started in 2012, CCAFS researchers are using the irrigated area of Bulacan province in the Philippines to test new metrics for emissions, and comparing mitigation options in smallholder agriculture.

The project promotes mitigation in smallholder agriculture by developing a protocol for modelling and field-testing mitigation options and building local capacity for analyzing data. The subsequent protocol will be a tool for scientists and decision-makers who want to analyze low-emissions agriculture in smallholder systems.

Scientists associated with SAMPLES are also testing methods and collecting data in Kenya and Vietnam, where field sites cover a range of smallholder systems including rice, rice-wheat rotations, and mixed systems of maize, sugarcane, livestock and vegetables. The research will provide a full year of data on low-emissions strategies.

The sites are also serving as a classroom for more than 20 research fellows – building in-country capacity for implementing the strategies being tested.

Rice farmers in Bulacan are even more concerned about water than they are about climate. Their irrigation reservoir has been steadily depleting for at least 30 years due to droughts and the demand from the capital, Manila; another issue is that Philippine law prioritizes domestic over agricultural use of water.

CCAFS researchers and their partners have been testing an AWD solution. This allows paddies to dry until the water table is below the soil surface before irrigating again. Compared with maintaining paddies in a continuously flooded state, it can lower water use by 25 percent and reduce energy used for pumping.

The assessment process demands accurate measurement of emissions reductions associated with AWD – difficult because methods for doing so in smallholder systems have not yet been well defined.

RICE FARMERS IN BULACAN ARE EVEN MORE CONCERNED ABOUT WATER THAN THEY ARE ABOUT CLIMATE

The private sector

Investment by the public sector in adaptation is rising but it will be largely the *private* sector – from small-scale farmers to multinational companies – that will lead adaptation of global food systems to achieve food security under climate change. The important thing will be to identify areas where companies' vital interests in adaptation overlap with opportunities for building adaptive capacity among vulnerable agricultural communities.

Of 72 companies surveyed by the UN in 2010, 86 percent reported that climate change adaptation presents new opportunities; other studies indicate a large variety of motives that encompass both exploitation of emerging opportunities and management of growing threats. Incentives for engaging in adaptation can be summarized as: gaining competitive advantage; 'climate-proofing' future business; social responsibility; and compliance with regulation.

The development by seed companies of crop varieties that have strong defences again drought, flood, salinity and pests clearly brings down farmers' vulnerability to climate risks. But their success is highly dependent on local factors. Drought Tolerant Maize for Africa, for example, a project led by CIMMYT, is developing maize cultivars that produce up to 50 percent higher yields in drought conditions. It has released 105 drought-tolerant varieties and seed production has risen from 700 tonnes in 2009 to 30,000 tonnes in 2011–12 in 13 African countries.

The Stress Tolerant Rice in Africa and South Asia project, led by the International Rice Research Institute (IRRI) and AfricaRice – both CGIAR affiliates – has, for 6 countries, developed 10 rice varieties that tolerate floods, droughts and increases in salinity. One has survived being completely submerged for nearly 3 weeks and is spreading across Bangladesh, India and Nepal, reaching nearly 4 million farmers in 2012.

IRRI and AfricaRice share an extensive network of partners from public and private sectors, NGOs, seed companies and farmers' organizations, through which these new products can be disseminated.

Index-based insurance (*see above*) is also used in the arid rangeland areas of northern Kenya. To help pastoralists cope with climate change, CGIAR's International Livestock Research Institute (ILRI) and partners launched the Index-Based Livestock Insurance (IBLI) product in the Marsabit district. The average client has about 50 cows, camels, goats or sheep, or a combination.

Unlike weather-based insurance, IBLI is based on a *vegetation* index; some 3000 pastoralists have bought cover. ILRI provides technical support while the private sector builds relationships with pastoralists and tries to overcome the problems of remoteness with SMS transactions.

The most visible impacts of these developments and others like them are on farmers' assets; their ability to expand adaptive capacity depends on whether they can afford the goods and services on offer, and whether companies can engage in outreach when transaction costs are high or

communications poor. As climate change develops, more companies are likely to respond to risks and market opportunities alike, which may provide farmers and herders with more options.

Local people, local solutions

In Phu Tho, two hours from the Vietnamese capital, Hanoi, where the Red River Delta meets Vietnam's northern mountains, lies a small family farm which shared its experience of 'Vuon Ao Chuong' (VAC) agriculture with CCAFS researchers busy planning our expansion into Southeast Asia.

The scene that met the researchers was a testament to the success of VAC (which translates as 'garden-pond-pen') agriculture in Vietnam: dozens of sows and piglets grunting happily in their pen; a fish pond with resident ducks flapping on the water; bamboo beehives scattered around the property; about 100 chickens; workers tending a rice paddy. At the back of the property, a small wood provided much-needed shade.

All these uses of land were being managed in the intensive but sustainable VAC system, in which nutrients from the pond fertilize rice and maize, while livestock manure generates biogas for cooking. The farm produces enough rice to feed a family of six and generates steady income through the rest of its products, allowing the family to invest in education, materials, and possible new ventures.

It's experience and local wisdom like this farm and hundreds of others like it that CCAFS will attempt to harness as it rolls out climate-smart villages across Cambodia, Laos and Vietnam. Integrated and intensive systems like Vuon Ao Chuong already give farmers an edge in the race against climate change: *they do not rely on a single crop*; GHG are reduced thanks to nutrient cycling and the use of intensification rather than just expansion.

There is concern that climate impacts such as rising sea-levels threaten to erode the region's agricultural land and contaminate supplies of fresh water for agricultural production in a region responsible for much of the world's rice. Combined with rising salinity, which damages fertility and stunts rice and other crops, researchers warn that the region's huge deltas – the Red River, Mekong and Chao Phraya – and the millions who live on them, are at risk.

The villages to be located in Vietnam, Laos, Cambodia, Myanmar and the Philippines will be "learning laboratories where multiple partners – researchers, government agencies, the private sector, farmer groups, civil society organizations – come together to trial integrated solutions to climate change," according to Bruce Campbell, who led a 'convergence meeting' in Bangkok in December to build a climate-smart road map with local CGIAR partners.

The program will not be without its challenges. "Do you know how difficult it is to ask farmers to change their crop?" says Dr Leocadio Sebastian, CCAFS Regional Program Leader for Southeast Asia. "It's like asking someone to change their career. It's not something they can do overnight."

"It will require change in attitudes and acquisition of new knowledge, skills and practices and links to new markets."

Buy-in from local partners will be crucial to identify target villages and the climate challenges to be tackled in them. "Local ownership is very important," Dr Sebastian adds. "Local people need to be part of local solutions."

Farmers' voices in policy

CCAFS does more than just gather evidence of the effects of climate change and agriculture on each other; it also strives to ensure each realm is understood in the other, requiring constant effort to engage at all levels with national decision-makers. Making sure farmers' voices are heard in the highest arenas, that is.

CCAFS research shows how adaptation and mitigation are mutually supportive, with better-adapted agriculture leading to reduced emissions and greater food security. A cornerstone of this effort has been the Commission on Sustainable Agriculture and Climate Change, whose 2012 report, *Achieving Food Security in the Face of Climate Change*, informs the global conversation with recommendations for integrating food security and sustainable agriculture into policy.

CCAFS researchers also produced a report on the impacts of climate change on more than 20 important commodities as well as agroforestry, forests, and water, detailing implications for food security. It identified gaps such as yam and cassava, important to food security but barely studied in relation to climate.

The UNFCCC's decision to hold the 17th Conference of the Parties ('COP 17'), in Durban, South Africa, provided a platform for sub-Saharan agriculture. CCAFS helped the South African Confederation of Agricultural Unions brief its 16 member organizations in 12 countries. SACAU's decision to include mitigation in its pitch went counter to many African governments. But the farmers, like CCAFS researchers, felt it was essential because agriculture accounts for as much as 24 percent of global emissions. The position paper helped persuade African negotiators to endorse this view.

COP 17 wanted the UNFCCC's Subsidiary Body for Scientific and Technological Advice to discuss a work programme on agriculture – the first step to admitting agriculture to its official agenda. But the following COP in Qatar dodged the issue and pushed it on to 2013, when CCAFS partnered with the Common Market for Eastern and Southern Africa and the African Climate Policy Centre to organize preparatory workshops in Johannesburg and Arusha.

While UNFCCC negotiators continue to be wary of agriculture, their meetings help keep it in the climate spotlight. In collaboration with leading agriculture, forestry and rural development organizations, CCAFS has facilitated side-events at major forums such as the annual UN climate talks (the COPs) and the 2012 'Rio+20' meeting, where farmers, policy-makers, researchers and others come together to share examples of climate-smart agriculture and often win headlines.

Global negotiations are immensely complicated and move with glacial slowness, but positions *are* shifting. The push for a work programme on agriculture resulted in new CCAFS research on better metrics for GHG, and the research will feed into policy decisions. Despite delays in the global policy process, many countries are forging ahead with agricultural development that also leads to adaptation and mitigation.

CCAFS ambitions in the age of social media

Social learning

'Social learning' plugs scientists and other stakeholders into the knowledge of communities so that poor farmers are empowered and research agendas become more relevant and nuanced. At CCAFS, a new but rapidly growing body of work is encompassing the potential of this concept.

Social learning works in 'loops' of action and reflection: the first loop is simple dissemination of information; the second is reflection about what activities allow us to be more effective; and the third is transformative change.

For example, the Coffee Under Pressure project with smallholder producers in Central America and Mexico has brought sophisticated modelling of climate impacts to the community in a context that is relevant and useful for farmers. 'Double-loop' learning is emerging as scientists react to the resulting demands for information.

Recent studies show that climate change threatens coffee systems, with impacts on yields, quality, and pests, among others. These findings have been extensively covered in the media, and now a round-table dialogue is planned in Nicaragua, new research is being funded, and the largest US coffee roasting company is considering investing in adaptation by smallholder farmers upstream in its supply chains.

Social learning has become important to CCAFS under its mandate to rethink agriculture and food security in a warming world. Strategies for addressing climate change ultimately depend on local contexts, so it is critical to link knowledge with action and explore tools for local decision-making.

We are trying to help policy-makers, development partners, researchers and farmers make choices with a greater understanding of the many factors involved – local conditions and knowledge, national policies and programmes, international development paradigms, and the increasingly diverse drivers of global change. To support this process, CCAFS research and the tools it produces have to be based on the needs and knowledge of *local* actors.

The CCAFS 'Integration for Decision-Making' team are looking at how social learning might help, and we are interested in learning from innovative work across the CGIAR network; in the next few years, we will mainstream new ways of working in climate, agriculture and food security.

But we need new models for scaling-up and changes in institutional culture to spread social learning through research and development. We also face methodological issues such as learning how to work with different social groups and power structures, and reconciling stakeholders' varying timescales.

There is also plenty of evidence that 'top-down' approaches to designing and communicating research do not work. Even though the impacts of CGIAR research are measured in billions of dollars a year, scientific advances of recent decades have largely by-passed the world's poorest and most vulnerable areas. CGIAR is committed to development outcomes, and to make a difference we will have to experiment with new pathways. Evidence suggests that social learning methods are among the most promising possibilities.

'COFFEE UNDER PRESSURE' IN CENTRAL AMERICA BROUGHT MODELLING OF CLIMATE IMPACTS TO THE COMMUNITY

Crowdsourcing: the 'citizen scientist'

In the CCAFS climate-smart villages in Bihar in 2012, we started an innovative approach to testing crop varieties: 'crowdsourcing', *writes Jacob van Etten, a Senior Scientist leading Bioversity International's climate change adaptation work.*

The idea is to involve farmers in evaluating varieties as 'citizen scientists'; each farmer grows a combination of 3 varieties drawn from a broader set of 10. The farmer then ranks them according to characteristics like vigour, yield and grain quality.

Things are made as easy as possible for the farmers; then we, the researchers, use nifty statistical methods to combine the rankings and share the results with them. With this information, farmers can identify the best varieties for their conditions and preferences.

Farmers become scientists, actively contributing to science with their time, effort and expertise. In India, around 800 farmers are now testing wheat varieties as citizen scientists.

It was a lot of fun to visit the plots and talk with the farmers. Each had its own story: wheat growing in an orchard or next to a cooperative, women's groups getting involved, etc. One thing we wanted to test is whether this approach is more cost-effective and less complicated than the usual demonstration plots or participatory trials. In the new set-up, logistics are simpler because the seed comes to the farmer; the farmer doesn't need to go to the demonstration plot.

As the plots are smaller (with only 3 varieties from 120 grams of seed), they are easier to accommodate. In extreme cases, you can always just "pull out the radishes," as one farmer put it.

Also, the varieties farmers are testing have become the new local favourite topic of conversation, as farmers feel they are fully involved in the scientific process. We are also starting to test if they can report their results using a mobile phone.

An important aspect of this work is the collaboration with national and local organizations; the litmus test will be whether the approach is picked up by our partners after their first experience of it.

In Vaishali, our partner organizations liked the approach a lot. They found it practical and clearly saw its value for getting varieties to farmers. They were, however, a bit worried about how *scientific* it really was. But I believe that after going through the whole cycle with them (including applying the statistical methods mentioned above), they will be more confident about the scientific value of the exercise, explains van Etten.

And if the approach is successful, we would not only make the crop improvement process cheaper but also *faster* – important given the speed of climate change.

The crowdsourcing approach could make it possible to scale-up this effort to even larger areas – involving thousands of farmers, increasing productivity and decreasing climate risk. Encouraged by the experience in Vaishali, we'll soon be starting similar tests in East Africa and Central America.

IN THE NEW SET-UP, LOGISTICS ARE SIMPLER BECAUSE SEED COMES TO THE FARMER

Target half a billion

Climate change affects not just a few thousand farmers, pastoralists and fishers, but all of them – half a billion people or more. CCAFS harbours ambitious targets for reaching large numbers of farmers in the regions where we work. With the collaboration of partners, some of this ambition is beginning to be realised.

The local government of Maharashtra in India, for example, is looking to scale-up CCAFS's climate-smart villages to at least 1000 across the state, concentrated in the most disadvantaged and vulnerable areas. Almost 100,000 women and men farmers will be involved, with secure government funding to support their efforts to manage the growing climate risks they face.

Working with farmers is critical to CCAFS in achieving its long-term goals for poverty reduction, better nutrition, environmental benefits and fair outcomes for women and men. CCAFS seeks to be as strategic as possible in its partnerships with farmers and farmers' organizations, and this means:

- Improving policy-makers' understanding of the issues.
- Listening to farmers' priorities, ideas and proposals.
- Building the capacity of farmers to deal with climate risks.
- Enabling learning on climate change across farming communities.
- Ensuring farmers can access and utilize knowledge.
- Empowering farmers to drive research and policy.
- Amplifying farmers' voices in all policy arenas.

The role of governments, NGOs, businesses and research agencies is to support the true "owners of this work", as Malawian smallholder Etrida Luhanga put it in Dublin, to provide the services, infrastructure and incentives that enable farmers to manage and build agriculture under climate change.

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The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is a strategic initiative of CGIAR and the Earth System Science Partnership (ESSP), led by the International Center for Tropical Agriculture (CIAT). CCAFS is the world's most comprehensive global research program to examine and address the critical interactions between climate change, agriculture and food security.

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