Supporting agricultural extension towards Climate-Smart Agriculture
An overview of existing tools

©FAO/Giulio Napolitano / FAO

Compendium

The Compendium provides examples of more than 20 different approaches of how agricultural extension can support climate-smart agriculture, with contributions from seventeen institutions and over 30 contributors worldwide.

GACSA
GLOBAL ALLIANCE FOR CLIMATE-SMART AGRICULTURE

Simone Sala, Federica Rossi, Soniia David (editors)

SECTIONS

1 Approaches

2 Technology and innovation

3 Knowledge and Participation

Table of Contents

1. Approaches

1.1 Extension & CSA: introduction – Soniia David (FAO)

1.2 Agrometeorology: useful tools for extension in light of CSA – Federica Rossi (IBIMET)

1.3 The Farmer Field School approach: how can it boost CSA? – Julian Schnetzer, Marta Gomez San Juan and Janie Rioux (FAO)

1.4 Science Field Shops approach for extension services for CSA – Yunita Winarto & Kees (C.J.) Stigter (Universitas Indonesia)

1.5 New Extension approaches to build Climate Smart Farmers in India – K. N. Shelat (National Council for Climate Change Sustainable Development and Public Leadership, NCCSD)

1.6 Overview of interesting extension services for CSA in West Africa – C. Kénou (Young Pioneers for Development)

1.7 Scaling up climate smart information services to guiding climate risk management by farmers in Senegal – R. B. Zougmoré (CCAFS-CGIAR) and O. Ndiaye, (ANACIM)

1.8 The CSA Prioritization Framework: an innovative planning tool to prioritize CSA practices – A. Nowak (CIAT), C. Corner-Dolloff (CIAT), M. Lizarazo (CIAT), D. Martinez Baron (CCAFS)

2. Technology and innovation

2.1 Technologies for extension services in CSA sector - Dai Peters (Catholic Relief Service)

2.2 Data products/services for CSA - Sylvaine Delerce (CIAT)

2.3 Promising innovative extension approaches for CSA - L. Heeb & W. Jenner (CABI Switzerland) D. Romney (CABI Africa)

2.4 Citizen science for Climate Smart Agriculture – J. Van Etten (Bioversity)

2.5 Lessons learned from the application of the CSA Prioritization Framework in Guatemala – A. Nowak (CIAT), C. Corner-Dolloff (CIAT), M. Lizarazo (CIAT), D. Martinez Baron (CCAFS)

2.6 Sustainable intensification of smallholder rice production: lessons from Asia – M. Commons (Earth Net Foundation)

2.8 Government-led early warning systems: the case of Karamoja, Uganda – L. Abura, (Kotido District Local Government Uganda)

3. Knowledge and Participation

3.1 Participatory Video & CSA – R. Ghandi & A. Dunlop (Digital Green)

3.2 Communication tools for gender-inclusive CSA – S. Russo, C. McOmber, S. McKune, E. Poulsen (University of Florida)

3.3 Farmer to farmer extension services – S. Franzel, E. Kiptot, J. Kirui, (ICRAF)

3.4 Improve training tools for extension agents – K. (C.J.) Stigter (Agromet Vision)

3.5 Farmers' organizations and CSA: a case study from Vietnam – E. Simelton (ICRAF)

A special dedication

This Compendium is dedicated to the loving memory of Professor Cornelis Johan (Kees) Stigter, former president of the WMO Commission for Agricultural Meteorology and founder of the International Society of Agrometeorology (INSAM).

Professor Stigter contributed to the Compendium with two pieces and, moreover, to the broad CSA community with enduring efforts throughout his life. He passed away on May 19th 2016 in Indonesia, having felt ill during his mission to train farmer facilitators in Indramayu regency to enable them to facilitate their fellows' understanding about climate change and its consequences on agriculture.

Foreword[1]

Ensuring that agriculture becomes climate smart is a priority for addressing the need for adequate, nutritionally balanced food for a growing and more demanding population in a situation of resource limitations, and climate change and variability. Despite the recognized importance of Climate-Smart Agriculture (CSA) by the Global Alliance for Climate Smart Agriculture (GASCA) and a range of international and national initiatives, the dissemination and uptake of climate smart technologies, tools and practices is still largely an ongoing, challenging process. Barriers at different levels must be overcome in all countries and solutions to these challenges must respond to specific local needs.

The development and dissemination of CSA technologies and practices is challenging for several reasons. Firstly, CSA is not a simple ensemble of actions. Crop surfaces are complex systems that must be understood in connection with their climate, weather and atmospheric drivers. This means a strong interdisciplinary vision. Secondly, there must be adequate capacity at different levels to perform the actions and changes needed, and political will to support the implementation of climate-smart actions. This implies engaging multi-actors' interest and, above all, promoting their active involvement. As broadly recognized, all stakeholders – including governments, producers and buyers – should act as one to address the increasingly negative impact of climate change by securing adequate policies, technical and financial conditions for increased productivity, building resilience and the capacity to adapt, and seeking opportunities to mitigate emissions of greenhouse gasses.

Relevant knowledge is widely available, and CSA provides a great opportunity to make the science that is still confined among the boundaries of scientific literature move into operational action – with particular regards to mitigation actions, Carbon (C) stocks, and novel technologies able to support resilience and reduce climate change-related threats. Moreover, CSA embeds high-value traditional agriculture skills and tools, easily recognized and accepted by farmers.

The adaption of climate related knowledge, technologies and practices to local conditions, promoting joint learning by farmers, researchers, rural advisor and widely disseminating CSA practices, is critical. This compendium brings together a collection of experiences from GACSA members related to the role of agricultural extension and rural advisory services in supporting CSA. The contributions are not intended to be state-of-the art academic articles but thought pieces or work in progress. The compendium itself is a "living" document which will be revised periodically.

Agricultural extension and rural advisory services, as used in this document, refer to any organization in the public or private sectors (e.g. NGOs, farmer organizations, input suppliers, etc.) that provides information and advice to farmers and other rural actors. Described as the "synapses that bring information from research to end-users", "the new extensionist has now mutated from a production centred role to an integrated

[1] Foreword prepared by the Compendium editors: Simone Sala, Federica Rossi, and Soniia David

cross-sectorial function of the extension ecosystem" (see section 2.3), key actors in their own right who have a unique role to play in achieving CSA.

The approaches and tools available in the Compendium span from face-to-face technician-farmer dialogues to more structured exchanges (such as on-line or off-line e-learning), but in every case it is clear that each process must be tailored to local expectations and needs. In particular, the voice of farmers must be actively taken into account as they are the key actors to promote sustainable agriculture, and their issues need to be prioritized. Furthermore, the advantages linked to the adoption of climate smart management tools and approaches should be clearly identified and shared, and ad hoc indicators of "smartness" also still need to be properly defined. Other papers in the Compendium showcase examples and case studies where participation and inclusion have been integrated into extension approaches for the ultimate benefit of farming communities that were part of CSA initiatives. It is clear from the various contributions that a successful CSA implementation involves effective and efficient extension providers and systems, which will require major organization and institutional reforms in most countries as well as capacity building at organization and individual levels.

Section I - Approaches

1.1 Climate smart agriculture: what role for rural advisory services?[2]

Introduction

It is widely recognized that climate change will pose one of the most significant challenges to humankind because of the global nature of the problem, its potential catastrophic impacts and the unknown nature and unpredictability of its onset. Agriculture, as both an area of human activity at risk from climate change as well as a driver of climate and environmental change, features prominently in the global climate change agenda. To alleviate some of the complex challenges posed by climate change, agriculture (including forestry and fisheries) has to become "climate smart", that is, sustainably increase agricultural productivity and incomes, adapt and build resilience to climate change, and reduce and/or remove greenhouse gases emissions, where possible (FAO, 2013). In short, agriculture systems have to become more efficient by using less land, water and inputs to produce more food sustainably, and along with the people who manage them, be more resilient to changes and shocks (FAO, 2013). The case studies in this document show some of the ways rural advisory services (RAS) contribute to achieving climate smart agriculture (CSA) by disseminating climate information (Stigter and Winarto) and technologies and information on production practices for climate adaption through innovative approaches, such as plant clinics and participatory video (CABI, Digital Green, case from India). In many low income countries, however, RAS have relatively limited involvement in climate change adaptation and mitigation efforts and relatively few national providers have initiated specific programs in this area (Simpson and Burpee, 2014). This paper discusses the contributions RAS and the broader system within which they operate can help to achieve CSA, not just as "implementing" partners, but as key actors in their own right who have a unique role to play. It also highlights the changes needed and challenges involved in mainstreaming the CSA approach into RAS. The terms rural advisory services and extension are used interchangeably in this document to refer to any organization in the public or private sectors (e.g. NGOs, farmer organizations, input suppliers, etc.) that provides information and advice to farmers and other rural actors.

The complexities of climate change and the role of RAS in achieving CSA

The wide-ranging impacts, current and predicted, of climate change on agriculture and food security are well documented (IPCC, 2014). Changes in rainfall patterns, higher mean temperature, increased variability in both rainfall and temperature, changes in water availability, a rise in sea levels, increased salinization, changes in the frequency and intensity of extreme weather, among other changes, will have and are already having adverse effects on the farming, fishery and forestry sectors. The uncertainty of climate change impacts, which are linked to the timing, intensity and combination of changes, coupled with the consequences on multiple interrelated sectors beyond agriculture

[2] Contribution prepared by Soniia David, Agricultural Extension Officer, FAO.

(e.g. health, energy, economy, migration, etc.) contribute to a highly complex, challenging and continuous process. Additionally, broadly speaking it is expected that climate change may lead to an increase in crop and livestock productivity in mid to high latitudes (IPCC, 2014) and a decrease in tropical and sub-tropical areas, home to most of the poorest populations. This implies that the changes precipitated by climate change are likely to exacerbate competition between the interests and values of different social groups at global and national levels (e.g. rich and poor, rural and urban communities, farmers and pastoralists, etc.).

CSA, an integrated approach to addressing the interlinked challenges of food security and climate change, focuses on three objectives: sustainably increasing food security by increasing agricultural productivity and incomes; building resilience and adapting to climate change; and developing opportunities to reduce greenhouse gas emissions from agriculture. Achieving these objectives requires changes in the behaviour, strategies and agricultural practices of farming households by: improving their access to climate-resilient technologies and practices, knowledge and information for increasing productivity, inputs and market information; information and assistance with income diversification; as well as organizing themselves better for collective action. Changes in the extension landscape since the 1980s, notably the involvement of a broader range of rural advisory service providers beyond the public sector (private sector actors, NGOs and producer organizations) and a wider focus beyond production issues, have created opportunities for RAS to contribute to achieving the three objectives of CSA. Extension providers can play a major role in supporting these objectives through the following: technology development and information dissemination, strengthening farmers' capacity, facilitation and brokering, and advocacy and policy support. While RAS have a comparative advantage in these functions and are already actively engaged in these roles more broadly, to improve their effectiveness with regard to CSA will require capacity development at individual and organizational level and institutional reform at the systems level.

Sustainably increasing productivity and enhancing adaptation through technology development and information dissemination

In response to the changing nature of agriculture and farmers' needs, the focus of extension in the past three decades has shifted away from transferring skills, technologies and knowledge related to the production of crops, livestock and forestry products from research to farmers, to developing technologies with farmers and catalyzing and facilitating innovation processes. This shift in focus is in alignment with the need for site-specific assessments to identify suitable agricultural technologies and practices needed for CSA. Extension providers in many countries have proven highly successful in using participatory methods and approaches such as participatory technology development, enabling rural innovation and innovation platforms to develop and disseminate technologies and encourage innovation through multiple stakeholder engagement (see for example, Kaaria et al., 2007; Nederlof and Pyburn, 2012). RAS also have a wealth of experience in disseminating technologies, information and practices with a range of approaches including traditional extension modes (e.g. interpersonal interaction, demonstrations, field days, printed materials, etc.), ICTs (radio, mobile phones, video, social media) (e.g. Ghandi et al., 2009 on the use of video; Vignare, 2013), rural resource centres (see Takoutsing et al., 2014 for an example from Cameroon; Degrande et al., 2015), farmer-to-farmer extension (see Kiptot and Franzel, 2014 for a Kenyan experience; Simpson et al., 2015) and farmer field schools (see Waddington and White, 2014 for a review of experiences), among others. For example, climate change experts can learn from the experience of RAS in areas such as using ICTs for information dissemination.

While technology and information dissemination are traditional extension activities, RAS providers face challenges in coming up with and disseminating climate-resilient technologies and practices. Determining what types of adaptive changes farmers need to make and when to make them, and ensuring that relevant technologies and modes of dissemination keep up with the need for ever changing climate change adjustments (Simpson and Burpee, 2014) are two key inter-related challenges for RAS providers. In addition to collaborating with researchers to come up with practices to address climate change, rural advisers will need to be more involved in looking for technological solutions than they currently are by searching for good practices in adapting to climate change from historical experiences and identifying lessons from other regions (at national or international level) that are already affected by adverse climatic conditions. To find technical solutions for boosting agricultural productivity sustainably, rural advisors will need new capacities and skills (discussed below) and rural service providers will have to undergo institutional changes. Developing closer linkages between agricultural researchers and extension providers than currently exists in most countries is critical because of the strong need for researchers to tap local knowledge, have a clear understanding of farmers' needs and problems as well as obtain feedback on how technological interventions are working. Because climate change adaptation calls for changes in managing natural resources at the landscape level, RAS providers will need to move beyond their typical focus at household/farmer level to working at other scales. A greater focus on natural resources management (NRM) will require changes in the institutional set up of public extension in many countries, away from a system of separate extension services for agriculture, forestry, fisheries and environment found in most countries, to a unified system or better alignment between sectoral extension services provided by public and private sectors.

Building resilience through developing farmers' human and social capacity and providing support services

To manage the uncertainties and risks associated with climate change, diversify their agricultural and income options and become more resilient, farmers need to draw on local and scientific knowledge, sharpen their observational and experimental skills and improve their critical thinking and problem solving abilities to be able to make their own decisions about appropriate practices and diversified and resilient income opportunities from a menu of options. RAS have a wealth of experience with non-formal education and experiential learning approaches (e.g. farmer field schools and farmer learning groups and local agricultural research committees) that focus on enhancing farmer experimentation and problem solving abilities to encourage uptake and decision making regarding knowledge intensive agricultural practices (Braun, 2000; Waddington et al., 2014). To promote livelihood diversification, some RAS have adopted a market-oriented approach to extension by supporting farmers in the area of marketing, value addition and enterprise skills development. Often being the only agencies operating after disasters, RAS also build resilience after extreme climate events by working closely with humanitarian agencies to distribute seeds and inputs (Christoplos, 2010). Although the role of RAS in building resilience has not been widely documented (Davis et al., 2014), it is clear that strengthening the role of RAS in this area will typically require new skills and capacities at the organizational and individual levels. For example, for RAS providers who are more used to providing technology "packages" and blanket recommendations, building farmers' decision-making and problem solving capacity will require a shift in approach. The need to improve the capacity of rural advisors themselves in "soft" skills (e.g. communications, facilitation, co-learning, sensitivity to gender and diversity issues, managing power and conflict dynamics, etc.) and in specialized areas such as marketing, must also be recognized, along with the importance of including these competencies in extension education curricula.

Supporting climate change adaptation and mitigation through facilitation and brokering

One of the traditional roles of extension organizations is a "bridging" function, linking farmers to other rural stakeholders and service providers. More recently, RAS providers in many countries have been supporting agricultural innovation systems (AIS) by playing various roles in the establishment of multi-stakeholder innovation platforms. These include acting as the main innovation broker (the organization that catalyzes the innovation process and brings the actors together), functioning as a "bridging" organization facilitating interaction between actors, coordinating and creating networks, supporting actors, facilitating access to information, knowledge and expertise, and providing technical backstopping (Sulaiman and Davis, 2012). Innovation platforms are one kind of institutional innovation that can contribute towards adaptation to, and mitigation of, climate change (Leeuw and Hall, 2013) and are an area where RAS can play a critical facilitation and brokering function for various activities, such as bringing farmers together to develop adaptation practices with researchers and designing climate service tools. Extension providers can contribute to mitigation efforts by, for example, strengthening farmer groups and rural organizations and linking them to voluntary and regulated carbon markets and supporting payment for ecosystem services programs. Besides strengthening existing linkages between farmers and their conventional partners (research, NGOs, traders, input suppliers, credit institutions), rural advisers can also facilitate engagements with new types of institutions related to climate change, such as insurance companies, humanitarian agencies and meteorological services. To support innovation processes, RAS and advisors need skills in areas they typically do not have, such as network building and brokerage, process facilitation and process monitoring. The Global Forum for Rural Advisory Services (GFRAS), FAO and other institutions are in the process of developing capacity development materials for "the new Extensionist" (Sulaiman and Davis, 2012).

Monitoring, advocacy and policy support

RAS providers are ideally placed to undertake a number of functions in support of CSA actions. Given the critical need for more information on the effects of climate change on agriculture, RAS should be actively involved in monitoring the effects of climate change on agriculture and the progress of CSA efforts in close collaboration with farmers and scientists. Although RAS are not typically mentioned as part of the "climate change advocacy coalition" (i.e. environmental advocacy groups, scientists, journalists, agency personnel, legislators, leaders in renewable energy technologies), they can play an important advocacy role at the local level in decentralized governance structures to ensure climate change remains high on the policy agenda and funds are allocated for CSA programs. As one of the key ways policy makers learn about and respond to problems is through dramatic events (Pralle, 2009), by virtue of working closely with farmers and communities, RAS are uniquely placed to highlight the outcomes of climate related events to policymakers and advocate for policy change and investment in CSA. Enlisting farmers, pastoralists and others directly affected by changing climate as spokespeople to put a human face to the problem, highlighting potential solutions and proving feedback on policies and progress are some ways RAS can contribute to keeping climate change and CSA high on the policy agenda (Pralle, 2009). Rural advisors can also play a role in explaining climate change policies to rural communities.

The need for extension reform and challenges of developing pluralistic, climate-smart rural advisory systems

As the above discussion highlights, the broadened scope of purpose of rural advisory services, from serving as an intermediary between research and farmers to functioning as nodal points bringing together and facilitating multiple stakeholders to address complex problems and situations, is in effect in most developing countries. However, the de-facto pluralistic "extension systems" found in most countries tend to be weak and unsystematic, characterized by short-term projects, a lack of coordination between providers, limited financial and human resources (particularly for public sector agencies) and advisers who lack the knowledge and skills to address the new demands. Despite recognition of the need to reform agricultural extension since the 1980s, few developing countries, notably India, China, Senegal, Mozambique and Kenya, have made significant strides in developing and financing demand-driven, pluralistic agricultural advisory systems. To handle the complexity of achieving CSA and to ensure the efficiency of the range of actors involved in pluralistic rural advisory landscapes, there is need for effective rural advisory systems; this encompasses the organizations and actors involved in providing extension and closely related services (education, research, agri-business support, etc.), the regulatory and policy structures that govern how the system operates, and the enabling environment. While the role of public sector extension in rural advisory systems will vary in different contexts, governmental agencies will typically provide some form of leadership or coordination role, particularly in the area of policy and regulatory frameworks. Moving ahead with extension reform is a major and challenging undertaking that will take strong political will, a willingness to make major changes, and significant financial investments by governments and donors. Alongside the long term process of reforming and strengthening rural advisory systems, some immediate priority actions for developing climate-smart rural advisory systems and services include: establishing local level platforms/mechanisms for better alignment and collaboration between public sector advisory services working on agriculture, water, environment, forestry, fisheries and livestock; strengthening the capacities of RAS and other stakeholders to support innovation processes at organizational and individual levels; and improving the capacity of service providers to identify and use a range of extension methods and approaches appropriately for sharing CSA technologies and practices with farmers.

References

Braun, A.R., Thiele, G. & Fernández, M. 2000. *Farmer field schools and local agricultural research committees: complementary platforms for integrated decision-making in sustainable agriculture.* London: ODI.

Christoplos, I. 2010. *Mobilizing the potential of rural and agricultural extension*. Rome, Italy: FAO.

Davis, K., Babu, S. & Blom, S. 2014. Building the resilience of smallholders through extension and advisory services. *In* Fan Shenggen, R., Pandya-Lorch, & Yosef, F. Eds. *Resilience for food and nutrition security*, pp 127-136. Washington, D.C., International Food Policy Research Institute.

Degrande, A., Tchoundjeu, Z., Kwidja, R. & Fongang Fouepe, G. 2015. Rural Resource Centers: a community approach to agricultural extension. *GFRAS Global Good Practices Note* no. 10. Lindau, Switzerland.

FAO, 2013. *Climate smart agriculture: a source book.* Rome, Italy.

Gandhi, R., Veeraraghavan, R., Toyama, K & Ramprasad, V. 2009. Digital Green: participatory video & mediated instruction for agricultural extension. *Information Technologies and International Development,* 5(1): 1–15.

IPCC, 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. *In* Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R. & White L.L. (eds.) *Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kaaria, S., Sanginga, P., Njuki, J., Delve, R., Chitsike, C. & Best, R. 2007. Enabling Rural Innovation in Africa: an approach for empowering smallholder farmers to access market opportunities for improved livelihoods. *In Farmer First Revisited Conference, Future Agricultures Consortium*. Sussex, UK, Institute of Development Studies (IDS).

Kiptot, E. & Franzel, S. 2014. Volunteerism as an investment in human, social and financial capital: evidence from a farmer-to-farmer extension program in Kenya. *Agriculture and Human Values*, 31: 231–243.

Leeuw, C. & Hall, A. 2013. Facing the challenges of climate change and food security: the role of research, extension and communication for development. *Occasional Papers on Innovation in Family Farming*. Rome, Italy, FAO.

Nederlof, E.S. & Pyburn, R. 2012. *One finger cannot lift a rock. Facilitating innovation platforms to trigger institutional change in West Africa*. Amsterdam, Royal Tropical Institute.

Pralle, S. 2009. Agenda setting and climate change. *Environmental Politics*, 18(5): 781-799.

Simpson, B., Franzel, S., Degrande, A., Kundhlande, G. & Tsafack, S. 2015. Farmer-to-Farmer Extension: Issues in Planning and Implementation. *MEAS Technical Note*. University of Illinois-Champaign.

Simpson, B. & Burpee, G. 2014. Adaptation under the new normal of climate change: The future of agricultural extension and advisory services. *MEAS Brief no. 3*. University of Illinois-Champaign.

Sulaiman, R. & Davis, K. 2012. *The new "Extensionist": Roles, strategies and capacities to strengthen extension and advisory services*. Landau, Switzerland, GFRAS.

Takoutsing, B., Tchoundjeu, Z., Degrande, A., Asaah, E. & Tsobeng, A. 2014. Scaling-up sustainable land management practices through the concept of the rural resource centre: reconciling farmers' interests with research agendas. *International Journal of Agricultural Extension Education*, 20(5): 463–483.

Vignare, K. 2013. Options and strategies for information and communication technologies within agricultural extension and advisory services. *MEAS Brief no. 1*, University of Illinois-Champaign.

Waddington, H. & White, H. 2014. Farmer field schools: from agricultural extension to adult education. *Systematic Review Summary 1*. London, International Initiative for Impact Evaluation. 15pp.

1.2 Agrometeorology: useful tools for extension in light of CSA[3]

Overview of agrometeorological-based tools for CSA

There is a long list of agrometeorological-based tools that have be considered as fundamental drivers of CSA implementation. National Meteorological Hydrological Services (NMHSs) provide, at different levels of detail, a range of weather/climate information for farmers (real time weather data, weather short-medium-long range forecast), on-line climate normal, and climate forecast that provide basis for tactical and strategic adaptation. When, and if, properly tailored to farmers needs and expectances, including providing an indication of their use/consequences, they may be extremely valuable in the implementation of CSA.

Climate advisories for agriculture facilitate the adaptation to climate variability and change by stimulating technological innovation, such as in the fields of genetics (i.e. the adoption of "state of art" biotechnologies) and agro-techniques (tillage, irrigation, weeding, crop protection, soil cultivation and protection, etc.), including early-warning and decision support systems. Climate services and tools may support the solution to specific field problems by addressing "on-farm" management options, such as use of mulches (e.g. for mitigating temperatures, reducing evaporation, hindering soil erosion, improving soil fertility), trees (e.g. for wind protection, sand flow prevention/reduction, microclimate modification), water (e.g. for irrigation, frost protection), shade and/or other forms of modification to the growing environment. Crop/forest/husbandry modelling (e.g. of yield, pest and diseases, crop quality, prices, etc.) integrate weather-climate inputs to monitor and forecast production, vulnerability and resilience. Communication of agrometeorological information and tools is operated with different degrees of penetration to stakeholders in various countries.

In some countries, co-creation of climate services for agriculture is carried out through the dialogue between farmers and extension/scientists. The farmers' perceptions support the development of proper tools, such as daily rainfall on-farm measurements, daily agro-ecological observations, impacts on yield quantity/quality, and seasonal rainfall scenarios. Such services lie within the service provider's capacities and farmers' adaptation potentials and include early warnings on droughts, floods, heat waves and heavy precipitation, with explanations and dialogues on prevention and/or protection measures that can be taken.

Particularly, bulletins, internet based communication, radio and broadcast, face to face and group meetings and dialogues, seminars and technical meetings are among the main tools used to disseminate agrometeorological information. These tools can provide final users (farmers, actor of the value chain, technical and support services) with proper weather and climate information that is tailored to specific needs, as well as supporting the

[3] Contribution from Federica Rossi, Senior Researcher CNR IBIMET & VicePresident Commission Agricultural Meteorology WMO. Supported by Josè Luis Camacho Scientific Officer Agricultural Meteorology Programme WMO- Geneva, and Kees Stigter Founding President International Society of Agricultural Meteorology.

implementation of activities under the various CSA pillars.

National Meteorological and Hydrological Services (NMHSs) and international research organizations have been at the forefront of the application of agrometeorological tools. Among the most interesting applications of agrometeorological tools is an experience in Indonesia where they have learned to distinguish first class climate services for agriculture, to be established with farmers, that results in a substantial increase in understanding and consciousness of what happens and is going to happen in their agricultural environment. In China, crop and/or locality specific climate services proved to be effective in increasing adaptation to unfavourable events. WMO CAgM METAGRI projects have also shown that farmers have the ability to determine when to sow their plantation based on "on-farm" rainfall data recorded by farmers themselves using rain gauges.

These approaches can contribute to CSA in several ways. For example, they can help in: reducing energy demands, and consequently produce lower amounts of GHG emissions during crop management; requiring less water for irrigation; putting in place prevention measures; strategic decisions; and increasing efficiency.

It should be noted that the effectiveness of implementation is generally high, but there is still much room for improvement. It follows from the above that specific training/capacity building for extension intermediaries in agrometeorology is necessary for making them able to play a buoyant role. Implementation will be effective in training farmers to become climate smart practitioners and/or in making meteorological products more client-friendly by offering solutions to farmers' problems.

These tools show a high scaling-up potential, at the condition of a better diffusion at local-global level and ability to focus and implement the most proper tools to be boosted in the process of innovation. Transfer has been in place for many decades, the main issue now is a proper tailoring to farmers and CSA targets. A good upscaling is also envisaged when services/tools embed the recovery of traditional techniques.

Finally, it should be underlined that there are no risks that could arise from correct interpretation of climate/weather information. Few risks may come from overconfidence, given that there are uncertainties that may still be intrinsic to some tools, such as long-term seasonal forecast. What is sure is that there are no alternatives to the introduction of climate/weather information, and related tools into CSA.

A look at WMO roving seminars

Roving seminars have been applied as support services by CagM, Wmo, METAGRI (2008/9-2011) & METAGRI OPERATIONAL (2012-2015). Approximately 160 to 190 roving seminars (with a total number of 13 500 farmers trained, of which only 10 percent were women) were organized to increase the interaction between the NMHSs and rural farmers and artisanal fishermen.

The contents of the seminars were adapted to the local conditions of the country and region. The Roving Seminars were of one-day duration and brought together farmers from a group of villages in a given region to a centralized location. Due to the success of a similar activity in Mali, that country has supplied a total of 7 000 rain gauges to be distributed at each of the seminars (20 per seminar) that were organized. A national focal point, supported by regional expertise in the form of support documentation, training and joint regional workshops, prepared agrometeorological advice that was used in conjunction with the rain gauges.

Roving seminars were organized in many African countries, specifically in West Africa: Mali, Senegal, Niger, Burkina, Mauritania, Gambia, Cabo Verde, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Benin, Togo, Nigeria and Chad. Based on the experiences in these countries, it can be said that there are no specific initiatives for CSA, and that the extension services have limited capacity for addressing climate smart management. Among the services that have been employed for CSA are local radios: in the Sahel radios help in disseminating climate/weather and agriculture information in local languages. NGOs also play a supportive role in some countries, such as World Vision, CARE, and international agencies, such as FAO, which in Liberia has supported the Ministry of Agriculture to develop extension services jointly with Meteorological Service.

Roving seminars can contribute to CSA pillars by helping to implement crop strategies according to rainfall observed and early/right/late rainy season onset, as well as disseminating seasonal rainfall forecasts. This specifically targets the sustainable increase in agricultural productivity and incomes.
Furthermore, roving seminars have been supporting smallholder farmers to reduce vulnerability to climate and weather related hazards, particularly by improving information flows and community strategies towards more resilient solutions as well as adapting traditional knowledge to changes. Roving seminars have also been helpful in reducing and/or removing greenhouse gases emissions, wherever possible.

Although there have been significant challenges encountered in the application of roving seminars for CSA, the high participation and interest from smallholder farmers and fishermen should be underlined as a major achievement. Simple practices based on crop models and simple observation tools proved to be an effective approach to promote CSA. However, it should also be noted that there is a large gender unbalance in access to climate and weather information, as well as to decision making tools.

When considering the potential barriers to successful application of roving seminars, it is important to take into account the need to share knowledge in local languages and integrating traditional knowledge to broaden the dissemination of knowledge with farmers. Most knowledge sharing initiatives tend to provide farmers with overly technical information that is not easy understandable. Within this framework, the use of mobile phone technologies and rural radios, building on traditional knowledge, would be an effective strategy to overcome existing obstacles. Training on basic technical tools, such as crop models, remote sensing and field observations, would be effective in bridging existing gaps.

Finally, roving seminars have helped to highlight that governmental support is often channeled into cash crops, reducing available resources to support production of staple crops.

1.3 The Farmer Field School Approach: how can it boost CSA?[4]

Overview of the Farmer Field School approach

The Farmer Field School (FFS) is a participatory, non-formal extension approach based on experiential learning that puts farmers and their demands at the centre (FAO, 2002). It provides farmers with a low-risk setting to experiment with new agricultural management practices, discuss and learn from their observations, which allows them to develop new practical knowledge and skills, and improve their individual and collective decision-making (Settle et al., 2014). The approach was originally developed by FAO and partners in response to unsustainable pesticide use promoted in many South-East Asian countries in the context of the Green Revolution and was first applied in Indonesia in 1989 to demonstrate the potential of natural enemies to regulate pest populations in irrigated rice systems and introduce the concept of Integrated Pest Management (IPM) to farmers (FAO, 2002). Since then FFSs have been used in around 90 countries, initially in South-East Asia and later also in Sub-Saharan Africa, South America and the Caribbean, Near East and North Africa, Central Asia and Eastern Europe (Braun and Duveskog, 2008), and adapted to different crops, production systems and topics, including sustainable agro-ecosystems management of vegetable crops, cereal and root crops (FAO, 2014), cotton-based systems (Settle et al., 2014), integrated rice-aquaculture systems (Geer et al., 2006), livestock and agro-pastoral systems (Dalsgaard et al., 2005; Okoth et al. 2013), tree crops, climate change adaptation, nutrition, linking to value chains, credit and savings or life skills.

A typical FFS consists of a group of 20-25 farmers from the same community who meet weekly throughout one or more growing seasons at a test field (on communal or farmer land) – or around aquaculture systems or animals – where they set up and run experiments comparing conventional and new, innovative production and management practices on separate plots. The FFS is guided by a facilitator trained in technical topics as well as facilitation skills. Facilitators are typically extension workers, NGO workers, farmer organization staff or trained farmers, for example, former FFS participants or champion farmers. Over the course of the cropping season or production cycle, farmers learn about new topics and practices in synchrony with the growth stages of the examined crops (or animals), document their observations, and at the end of the season organize a field day to share their findings and experiences with other farmers or herders from their own or neighbouring communities, local government officials and civil society (Settle et al., 2014).

FFSs often incorporate topics beyond the scope of technical issues in agricultural production, for example, book keeping, marketing, processing, monitoring, nutrition, health, HIV/AIDS, and family planning. They can further contribute towards building human empowerment and social capital in the FFS communities and foster the creation and strengthening of local networks, e.g. among FFS alumni in the same area and farmers' organizations (Braun and

[4] Contribution from Julian Schnetzer, Marta Gomez San Juan and Janie Rioux
Climate and Environment Division, Food and Agriculture Organization of the United Nations (FAO)

Duveskog, 2008). For the creation of local networks, it is important to strategically cluster FFSs in an area. This allows for mutual visits between FFSs and also enhances the adoption of new practices by non-FFS participants through farmer-to-farmer diffusion (Settle et al., 2014).

Over the last couple of years, FFSs have also integrated elements of climate change adaption, such as the FAO FFS program on Integrated Plant and Pest Management (IPPM) that promoted improved and adapted varieties and agroforestry practices in Mali and Niger (FAO, 2015). Climate Field Schools in Indonesia raised awareness of climate change and promoted solutions to cope with changing rainfall patterns, such as recording and interpretation of on-farm rainfall measurements and in-field water harvesting (Winarto et al., 2008).

Experiences with FFS specific to the promotion of Climate-Smart Agriculture have been gathered through the FAO's Mitigation of Climate Change in Agriculture (MICCA) pilot project in Tanzania (FAO MICCA series 11, in preparation).

FFS for promotion of CSA – an example from Tanzania

MICCA partnered with CARE International in the Hillside Conservation Agriculture Project (HICAP) in the Uluguru Mountains in eastern Tanzania and with the World Agroforestry Centre (ICRAF) to integrate climate change adaptation and mitigation within agricultural development activities with smallholder farmers between 2011 and 2014. Agriculture in the project area is characterized by slash-and-burn and rotational fallow systems on hill slopes with high rate of land degradation through soil erosion combined with poor agronomic practices, leading to low productivity.

Figure 1. (a) Degraded hillside in the Uluguru Mountains.

Figure 1. (b) Hill slope cleared by slash-and-burn in the Uluguru Mountains.

The objectives of the MICCA-HICAP project were to improve food security and livelihoods among the project village communities by supporting conservation agriculture (CA) and by introducing agroforestry and soil and water conservation (SWC); it was assumed that these combined practices would lead to increased yield and reduced erosion on existing farmland and consequently reduce slash-and burn and deforestation. An initial socio-economic survey, capacity assessment and carbon-balance analysis were conducted and combined with stakeholder consultations to help in the identification and selection of the CSA practices, to ensure their suitability and their potential to reduce GHG emissions. It was estimated that the combined HICAP and MICCA project CSA activities would create a sink of 1.7 t CO_2 eq/ha/year over the next 20 years, compared to a source of 0.8 t CO_2 eq/ha/year in the baseline scenario (FAO, 2012).

CA was considered a suitable CSA practice as its positive effect on soil nutrient intake and soil moisture conservation helps increase and stabilize yield thus mitigating the risks of changing rainfall patterns observed by local farmers, and because of the reduced GHG emissions from avoided slash-and-burn practices and soil carbon storage. Besides CA, the project identified other complementary practices to support CSA: SWC practices, such as terracing (including fanya juu and fanya chini), trenches, ridges, and trash lines (depending on the slopes) to reduce soil erosion and increase water infiltration and retention; agroforestry for livelihoods diversification, income (especially through fruit and spice trees) and increased landscape resilience; and construction of improved cooking stoves to save fuel wood and reduce GHG emissions and pressure on forests. The improved cooking stoves reduced wood use by 50 percent, from six pieces to three pieces per day, thus reducing the workload on women who had to fetch fuel wood and potentially reducing pressure on the forest, although this is hard to assess in a short time frame, considering other uses for wood, such as in brick making. Moreover, slash and burn agriculture decreased from 55 percent to 39 percent at the end of the project but it is recognized that this could be a temporal coincidence instead of a longer term trend initiated by the project. CA as part of the CSA approach was promoted through the FFSs, while the other practices were promoted through targeted demonstrations and practical training sessions for interested farmers (often among the FFS participants).

Awareness meetings on climate change, CSA and related issues such as gender and land tenure were held in eight villages and involved farmers, village leaders and ward officials. Interested farmers were invited to join the FFS. The FFSs were led by trained local farmers, so called contact farmers, who set up the experimental plots in their own fields and received an initial training by an FFS master trainer. Project staff and extension staff from the District Agriculture Office also provided continuous support to contact farmers throughout the duration of the FFS and assisted during many training sessions.

The core principles of CA, as promoted by the FFSs, were (i) minimum tillage (after double digging is done to break the hard pan from repeated tillage); (ii) permanent soil cover by leguminous cover crops and mulches (as there was no competition with livestock in the area over crop residues); and (iii) crop rotation without the use of slash and burn. The FFSs also encouraged the combination of CA with SWC practices and agroforestry.

Throughout the MICCA project duration of three years, a varying number of FFSs (between five and nine per year) were active, reaching a total of 22 FFSs and about 650 FFS members. Moreover, when accounting for the CSA/CC awareness sessions, a total of 1418 farmers (41 percent women) were reached, around 100 experimental plots were established and 11 tree nurseries (and tree nursery management groups) were set up in the area. The tree nurseries were to provide farmers with seedlings for SWC measures and agroforestry, offering a range of tree species to satisfy different demands and uses: spices, fruit, timber, fuel wood, construction material and nitrogen fixing species. Nursery managers trained by ICRAF provided guidance on tree planting and agroforestry to farmers upon provision of seedlings. In addition to FFSs and targeted training sessions, exchange visits were organized, taking farmers from one village to another in- or outside the project area where the adoption of the promoted practices was further advanced. These exchange visits served also as a reward mechanism for champion farmers and to keep interest and motivation among the FFS.

Figure 2. (a) Experimental plot in the project area.

Figure 2. (b) FFS contact farmer interacting with project extension staff.

At the end of the project the community-level adoption of CSA practices was evaluated through five focus group discussions (FGD) formed of different local stakeholder groups (from six to nine members each), which included: contact farmers, trained farmers, trained women farmers, non-trained farmers, and village leaders. The perception of the adopters of CA was that their maize yields increased by more than 100 percent and allowed them to generate extra income by integrating high value crops such as pineapples on their newly established terraces. All adopters had received training, which show-cases the importance of capacity building through FFSs and other extension methods. However, many FFS participants adopted only a subset of CA practices or they applied the different practices to different plots but not as a combination in one single plot. This illustrates that it can be difficult to achieve adoption of a complex farming practice or system in the way preconceived, but also shows how farmers use their newly acquired knowledge and skills and adapt the practice to their specific situation and needs, which is exactly the purpose of FFS.

Generally, farmers considered the presence of contact farmers as an important element for the adoption of CA and other CSA practices and underlined the value of their knowledge, which will remain in the village beyond the project period and can further support the promotion of CSA. This demonstrates that the FFS approach and CSA have been positively perceived in the targeted communities. Crucial for the acceptance and adoption of a new practice was the demonstration that they actually bring higher yields.

Opportunities	Challenges
- Presence of trained farmers with knowledge - Presence of farmer field schools and groups - Productivity potential of the practice	- Poor governance (leaders neither practiced CA nor formulated by-laws to enforce it) - Insecure land tenure (tenant farmers had no incentives for uptake of CA, as if yield increased, the landlord would claim back the land) - Reluctance of people to change

Table 1. Opportunities and challenges of conservation agriculture adoption raised in the FGD with farmers

The poor governance at village-level and the lack of by-laws to promote the new practices were cited as barriers during the group consultations. Insecure land tenure was identified by the farmers, especially women, as a major barrier to the adoption of CA and other CSA practices, in particular terracing and agroforestry. Some farmers were reluctant to invest in labour-intensive new practices, such as double digging for CA or terracing, because of the risk that their landlord would take back the land after seeing improvements. These challenges show that even at the lowest organizational level, FFSs must be linked with governance, gender and tenure issues.

Scaling up potential

FFSs generally have a great potential for up-scaling, as the contents of an FFS can easily be adapted to the location-specific needs of farmers. An additional challenge in the context of CSA, however, is the identification and prioritization of the practices with the greatest climate change adaptation and mitigation benefits in a specific location by FFS participants and other local stakeholders. A thorough initial assessment and identification of recommended practices is therefore required when transferring an FFS model to another agro-ecological context.

General concerns about the sustainability of project-based FFS programs may be addressed by measures such as (i) focusing on local farmers as facilitators because they know the local conditions, can connect to and mobilize local people more easily, and ensure that the transmitted knowledge and skills remain in the area, which also increases the potential of self-initiated farmer-to-farmer FFS beyond the scope of a project (FAO, 2015; Braun and Duveskog, 2008); (ii) linking FFS work to national policies to ensure institutional support or transforming FFSs into small cooperatives; (iii) reaching out to other projects that can benefit from the FSS infrastructure to ensure continued financial support and consolidation of the FFS structures (Settle et al., 2014); and (iv) addressing land tenure issues in an early project stage to guarantee tenant farmers a sufficient time horizon to benefit from practice change and avoid land lords claiming back land after successful establishment of new practices.

As the experience from Tanzania shows, a challenge for FFSs on CSA is to achieve the adoption of complex production systems or practices as preconceived, as this requires continuous support over a long time period to ensure the barriers to adoption are addressed alongside. At the same time, the example of farmers picking the components they deem suitable and adapting them to their specific situation underlines the principles of the FFS approach and demonstrates its potential to support farmers and other agricultural sector producers to create locally adapted solutions for CSA.

References

Braun, A. & Duveskog, D. 2008. The Farmer Field School Approach – History, Global Assessment and Success Stories. *Background paper for the IFAD Rural Poverty Report 2011*.

Dalsgaard, J.P.T., Minh, T.T., Giang, V.N. & Riise, J.C. 2005. Introducing a farmers' livestock school training approach into the national extension system in Vietnam. *Agricultural Research & Extension Network. Network Paper No. 144*.

FAO. 2002. *From farmer field school to community IPM – Ten years of IPM training in Asia*. Bangkok, Thailand.

FAO. 2012. Assessing the climate change mitigation potential of the HICAP-MICCA pilot project with the Ex-Ante Carbon Balance Tool (EX-ACT). *Mitigation of Climate Change in Agriculture (MICCA) Programme Background Report 5*. Rome, Italy. (Available at http://www.fao.org/fileadmin/templates/ex_act/pdf/case_studies/tanzania-micca.pdf Accessed on Oct 13, 2015)

FAO. 2014. Transboundary Agro-Ecosystems Management Project for the Kagera River Basin. *Project Newsletter, Issue 3, March 2014*. Rome, Italy. (Available at http://www.fao.org/3/a-au254e.pdf Accessed on Oct 13, 2015)

FAO. 2015. *Building resilient agricultural systems through farmer field schools – Integrated Production and Pest Management Programme (IPPM).* Rome, Italy.

Geer, T., Debipersaud, R., Ramlall, H., Settle, W., Chakalall, B., Joshi, R. & Halwart, M. 2006. Introduction of Aquaculture and other Integrated Production Management Practices to Rice Farmers in Guyana and Suriname. *In FAO Aquaculture Newsletter No. 35*. FAO.

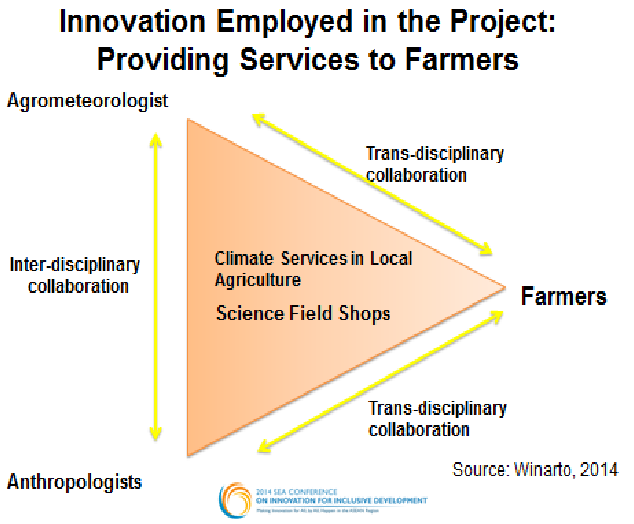
Okoth, J.R., Nalyongo, W., Petri, M. & Ameny, T. 2013. *Supporting communities in building resilience through agro pastoral field schools*. Rome, Italy, FAO.

Settle, W., Soumaré, M., Sarr, M., Garba, H. & Poisot, A.S. 2014. Reducing pesticide risks to farming communities: cotton farmer field schools in Mali. *Phil. Trans. R. Soc*. B 369: 20120277. (Available at http://dx.doi.org/10.1098/rstb.2012.0277)

Winarto, Y.T., Stitger, K., Anantasari, E. & Hidayah, S.N. 2008. Climate Field Schools in Indonesia: Improving "response farming" to climate change. *Leisa Magazine, 24*.

1.4 Science Field Shops Approach[5]

Introduction



Inter-disciplinary science (Anthropology and Agricultural Climatology) and Trans-disciplinary collaboration (Farmers and Scientists) form our approach used in establishing climate services in local agriculture. The objective is agrometeorological learning of all involved in exchanges of traditional and more recent empirical knowledge and scientific knowledge between farmers, extension intermediaries (where available, recently trained or to be trained) and scientists. The approach involves holding regular Science Field Shops (SFSs, meeting at least once a month in farmer villages) that are attended by all parties.

Agrometeorological learning means policy changes (of agreements on how to act, live, work) in beliefs, attitudes, behaviours and goals of farmers in reaction to new meteorological and climatological knowledge relevant to production. For scientists, new knowledge is the traditional and more recent empirical knowledge of farmers.

This approach is used in Indonesia and contemplated in Lesotho.

Farmers, as well as extension intermediaries not yet trained on the consequences of climate change for local agriculture, are targeted with SFSs. In the course of time farmer facilitators are selected by the farmers and more intensively trained to act as extension, locally and in upscaling. This will be an auxiliary, rather than core, function where well trained extension intermediaries exist.

The main players are thus: (i) farmers; (ii) scientists (assisted by students) wanting to bring new knowledge (with climate change as a driver) to farmers; as well as (iii) extension intermediaries, both in SFSs and/or with separate training of such intermediaries in Climate Field Schools.

Implementation of Science Field Shops

Local climate services using the SFS approach, established with farmers in their fields, have been implemented in villages in Indramayu, NW Java, since 2010, after trials in Gunungkidul, Yogyakarta, from 2008 till 2009. Lombok has also been involved since 2014. We will discuss their impacts below. For this we first list the climate services concerned:

1. proposing and jointly organizing the SFSs to discuss the issues below and the results obtained;
2. guiding daily rainfall measurements in farmers' plots by all SFS participants;
3. guiding daily agro-ecological observations (soil, plants, water, biomass, pests/diseases, climate

[5] Contribution prepared by C. (Kees) J. Stigter and Yunita T. Winarto (Department of Anthropology, Faculty of Social and Political Sciences, University of Indonesia, Depok, Indonesia)

extremes) by all SFS participants in their fields and training on the ways to document the rainfall data and agro-ecological observations;

4. assisting focus onto measured yields and explaining the differences from measurements, observations, amounts and timing of inputs available, and affordable and used inputs (e.g. varieties, water, fertilizers, pesticides, labour, machinery, knowledge, etc.);
5. developing and exchanging monthly updated seasonal climate predictions in the form of seasonal rainfall scenarios;
6. delivering new knowledge related to the above, including the provision and discussion of answers to all questions raised by participants throughout the year; and
7. guiding the establishment of farmer field experiments to get on-farm answers to urgent local questions, heavily discussed in the SFSs (e.g. suggestion by some farmers that it was worthwhile to reduce methane emissions by improved water and biomass management).

This approach contributed to CSA because the above climate services provided the farmers with current daily rainfall data, current agro-ecosystem data, related yield discussions on causes of yield differences, a monthly seasonal rainfall scenario and other new knowledge that provided answers to urgent questions. The on-farm field experiments have started to show that CSA have adaptation, as well as mitigation, potential. Adaptation and building resilience to climate change is therefore definitely taking place.

Because they are not scientific experiments, we have no data on sustainably increasing agricultural productivity and income. However, given the new dangers of heavier rains, floods, droughts and heat waves, the impression of the farmers is that the reason yields are not yet reducing is due to our joint efforts. The present El-Niño may however reduce yields unprecedentedly and in some cases lead to harvest failures if there are no other water resources available. The Lombok farmers have the advantage of a water storage reservoir for each field or combined between some fields and also the advantage of many more trees being used there.

As to reduction and/or removal of greenhouse gas emissions, where possible, the above mentioned need for attention on water management due to intermittent drying and flooding of the soil in irrigated rice has been a start. Also, composting and direct seeding has been experimented with. The decision was taken that only in win-win situations, that is farmers and the environment both gain from the new management, are farmers willing to contribute to mitigation.

The effectiveness of implementation of SFSs has been well established on the small scale in villages in Indramayu. Farmers are happy with the interactions and exchanges bringing new knowledge and understanding of the present and the uncertain future. The present El-Niño shows how vulnerable the lowland tropical rice farmers remain under conditions of extreme weather.

Lessons learned

The following four main lessons were learned throughout the process:

1. The earliest classes of climate services for agriculture to be established with farmers in SFSs do result in a substantial increase in understanding of what happens and is going to happen in their agricultural environment (see our seven climate services in the previous section);
2. This is due to strongly increased anticipation of power and leads to improvements in decision making as a consequence of the SFSs;
3. Better understanding of a conglomerate of yield determining factors makes farmers less vulnerable; and
4. What is absent in Indonesia is an extension service with intermediaries that have been sufficiently trained and updated to assist farmers properly.

The key challenge is to maintain SFSs season after season, with increasingly better trained extension (and the withdrawal of scientists) to develop new problem solving services.

The first two sections of this contribution have shown that SFSs are suitable in the context of CSA. The SFS contents are dialogues between participants and the components discussed are new strategies, technologies and goals that provide new knowledge that can be used to tackle the vulnerabilities of local farmers and address related questions.

The best practices are the use of the seven climate services for agriculture that were developed and established to fight yield diminishing climate factors (see the previous section for further references).

Farmer to farmer transfer takes place during SFSs. We are using farmer facilitators, selected by the farmers themselves and preliminarily trained as trainers, to facilitate transfer.

Scaling up of SFSs is possible and necessary and we have started to work with satellite villages. However, we need facilitators there first and they have to be groomed.

The risks/limitations/constraints lie more in the sustainability of the approach to maintain SFSs under the absence of strong extension services and management capabilities of local agricultural officials. The farmers themselves may also lack funds/logistics/training and political will to use a "farmers first" paradigm.

Farmers are happy with their active role as "researchers" and "decision makers", and prefer this to a top-down, one-way communication of knowledge transfer and provision of services. Given the goal of facilitating knowledge transfer, there are few alternatives to an SFS approach.

1.5 On New Extension Approach-Building of Climate Smart Farmers[6]

Overview of innovative approaches in extension

The importance of agricultural research and extension cannot be overemphasized, especially with the increasing recognition of value-added technical services for the direct benefit of farmers and farming systems. This is true the world over.

Inclement weather has compounded the spread and depth of challenges.

The 12th 5–year Plan of the Government of India recognized the imperative of resilience and harmonized governance including public policies. Within this framework, the principal objective is to design and implement an inclusive engagement strategy to help the farming community, reduce related vulnerabilities and sustain development. Community level institutions and public leadership are central to the success of this initiative.

A recent analysis by Wesley & Faminow (2014), the Montpellier Panel Report 2015 with a special focus on farms in Africa as a sequel to the Proceedings of the Joint FAO/OECD 2012 Workshop on resilience in agriculture, called for a special focus on: smallholder systems; drudgery faced by women farmers in particular; and integrated engagement processes to improve preparedness of stakeholders to tackle challenges in a timely manner. The large number of countries that employ decentralized approaches to deliver locally relevant information and action support create and build on community initiatives. They focus on such cross cutting aspects as soil health, water quality and access, temperature regimes and crop patterns/cycles, natural enemy complexes, post-harvest losses, capacities to assess and engage in preventive action, and knowledge enrichment for sustainable livelihoods.

The target population of extension services in India is the farming community, especially poor farmers and women farmers in particular, along with elected and non-elected leaders of public governance system at local level. A wide range of stakeholders are engaged in the outreach and engagement process, signified by the soil health scheme in particular and related climate resilient agriculture initiative. Stakeholders include public administration mechanisms and decision makers at the national, State, district and village levels, extension workers, civil society members, cooperatives and farmers. Agriculture and animal resources are covered with equal emphasis.

Implementation and impact issues

A new extension approach was deployed in 2004 in India through the initiative known as "Festival of Agriculture", 'KRISHI MAHOTSAV'. This was a door step approach, followed by special capacity building programmes on Climate Smart Agriculture (CSA), to provide guidance to farmers at village level prior to onset of monsoon. It introduced Soil Health Card – crop selection and soil management based on soil health analysis, for each individual farmer. It identified the 15 poorest farmers or animal holders and made available appropriate certified seeds, pesticides, fertilizer mix and sprayer, limited to Rs.1500 per farmer.

---

[6] Contribution by Dr. KIRIT N. SHELAT, IAS (RTD) Executive Chairman-National Council for Climate Change Sustainable Development and Public Leadership (NCCSD)

The village community undertook a participatory approach, using check dams and village ponds for water conservation. Farmers were encouraged to adopt micro irrigation. Mapping was done based on satellite imagery. The process involved a visit to each village by a team of agriculture scientists, along with an agricultural extension team, and interaction with farmers to provide agro-advisory prior to onset of monsoon. This was mainly implemented through a mass communication approach with the involvement of: elected head of state government, namely the Chief Minister; the farmers and elected head of local village council, known as Sarpanch; and president of district council, along with entire district administration and state-level administration.

This is a replicable model. Indeed, the Indian Government has already introduced a programme of "Soil Health Card" and Integrated Irrigation Water Management Scheme across India in 2015. It is, however, essential to enhance engagement with elected and non–elected public leadership to sustain this momentum.

Contribution to CSA

The Gujarat state increased its growth rate significantly to eight percent at constraint prices over the period 2005 to 2013 and the total income of the agriculture sector doubled. The income of farmers and the growth rate was sustained despite erratic monsoon and drought in some years.

Farmers selected crops based on soil capacity and that sustained their crops, reduced use of fertilizer and pesticides and, most importantly, increased the seed replacement ration. Indirectly it enhanced management of landscapes, reducing the greenhouse gas burden, further supported by water conservation that reduced energy use due to tapping water.

The Krishi Mahotsav approach created the context and was successfully built on. A paper published recently by Dr. Nikulsinh M. Chauhan (2015) confirmed the relevance and robustness of the initiative. He particularly highlighted its timeliness, content and benefits due to practicing approaches for crop and animal husbandry proposed therein. These outcomes are also discussed in a blog of a leading newspaper and are poised to benefit several other States across the country.

There are indeed gaps in extension services and problems due to the overlapping of multiple messages by different agencies provided to farmers. The challenges for CSA include: an inadequate portfolio, and demonstration, of techniques/alternatives that are feasible for implementation even in small farms; and the delivery services on a sustained basis.

Opportunities to transfer extension services to CSA in India in particular need a mass multiplier model to reach out to all farmers in all districts with the involvement of local level agriculture extension administration. Local level community institutions can be suitably aligned to complement such engagement activities.

Some additional threats to the extension services for CSA include the difficulties of re-aligning all players for a common objective and the wealth of technical input needed to be provided to farmers. Risks can clearly arise from overstating benefits. Alternative approaches should be indeed centred on: clear statements of limits and limitations of alternatives; rewards to communities for their knowledge inputs and building capacities to assess related parameters; and seamlessly integrating agriculture and socio-economic development agendas.

References

Mahotsav, K. 2015. A new TOT tool in Gujarat for Extension Management, *International Journal of Innovative Science, Engineering & Technology*, 2(1): 9 – 21. (Available at www.ijiset.com)

Modi, N. 2015. *"CM blogs on Krishi Mahotsav – Agro-revolution by reaching farmers at their doorsteps."* May 17, 2012. (Available at http://blogs.timesofindia.indiatimes.com/narendra-modisblog/krishi-mahotsav-agro-revolution-by-reaching-farmers-at-their-doorsteps/ Accessed on 19 Nov 2015)

The Hindu Times. 2015. *"Soil Health Card scheme takes off gingerly."* New Delhi, July 17, 2015. (Available at http://www.thehindu.com/news/national/soil-health-card-scheme-takes-offgingerly/article7431232.ece Accessed on 19 Nov 2015)

1.6 Overview of interesting extension services for CSA in West Africa[7]

Introduction

Agriculture is the main industry in sub-Saharan Africa, employing 65 percent of Africa's labor force and accounting for about a third of its gross domestic product (World Bank, 2008). It is reported that the situation of the agricultural sector will be exacerbated by climate change, which will have significant impacts on the various dimensions and determinants of food security. Climate Smart Agriculture (CSA) has been identified as an alternative that can increase agricultural productivity in the region, while at the same time mitigating the multiple effects of climate change. Gradually the approach of CSA is gaining ground in the agricultural sector in Africa. This consequently places enormous demands on extension services which have a crucial role to play in promoting agricultural innovation to keep pace with the changing context. It is therefore important to explore to what extent extension services are used to improve the implementation of CSA across West African countries.

This contribution examines the interesting extension services for possible CSA implementation in West Africa. It is divided in two main sections: the first focuses on the evaluation of existing extension services to CSA implementation and the second on the challenge and opportunities of extension services approach in supporting the potential of CSA practices in West Africa. The contribution considers evidence from a range of bibliographic databases and specialist collections.

Different types of extension approaches are being practiced in various parts of the world. Each approach reflects a particular set of objectives, aims and sociocultural setting. Extension services in West African countries are carried out by state institutions, agricultural training institutions, advisory services, private sector agencies, non-governmental organizations (NGOs), farmer organizations and farming communities. Extension services are delivered not only by extension agencies but also by farmers, scientists, commercial companies and mass media organizations, among others.

Key facts on agricultural extension services.

In developing countries, most of the extension services are carried out by public institutes. However, the private sector and civil society organizations are playing an increasingly important role in carrying out specific extension/advisory services because most public extension systems are still top-down in structure. Information, knowledge and skills for CSA are delivered through three extension methods: mass communication methods, individual methods and group methods. For each method, different tools and approaches have been used. This could involve technologies such as radio, podcasts, mobile phones and video programmes, as well as the ways in which new knowledge and skills are shared with farmers, such as model farmers, farmer field schools, village information centres or question-and-answer services.

Many approaches, such as the market day approach, the teacher-student approach, field school approach in Burkina Faso, the village level

[7] Contribution by Christel Kénou, Young Pioneers for Development

participatory approach (VLPA) in Benin, adaptation (modification) for adoption in Nigeria, radio and TV, have been used to promote agricultural development. Some of these extension services have focused on information provision and training of farmers. In West Africa, one of the common approaches is Farmer Field School (FFS). It is a participatory method of technology development and dissemination whereby farmers are given the opportunity to make a choice in the methods of production through a discovery based approach based on adult learning principles and experiential learning (FAO, 2001). It reflects the four elements of experiential learning cycle, namely: concrete experience, observation and reflection, generalization and abstract conceptualization, and active experimentation.

This approach challenges farmers to learn how to organize themselves and their communities. Then, the farmers are sensitized in new ways of thinking and solving problems. Through participation in FFS, farmers develop skills that allow them to continually analyse their own situation and adapt to changing circumstances (Madukwe, 2006). FFS is seen to be a good approach that tends to be participatory and demand-led. In other words, it is ideal to sensitize smallholder farmers to include climate factors in production; to promote the economic value of agriculture to youth; and to improve local practices to use seeds that adapt to climate variation.

On the other hand, radio and TV are a powerful communication tool. Experience with rural radio and TV have shown the potential for agricultural extension to benefit from both the reach and the relevance that local broadcasting can achieve by using participatory communication approaches (Chapman et al., 2013). Rural radio can be used to improve the sharing of agricultural information by remote rural farming communities. Video is effective as a training method for providing information and knowledge on complex technical topics for farmers. Video, which combines both visual and verbal communication methods, appears to be an appropriate extension tool for less developed countries as this medium is suited for the transmission of skills, information and knowledge (David & Asamoah, 2011). However, video has been underutilized in Africa as a tool for disseminating technical agricultural information to farmers.

Challenges and perspectives

Africa needs to harness opportunities arising from South-South cooperation and regional integration in fostering partnerships and building capacity in CSA. The dominant top-down 'transfer of technology' model has largely excluded farmers from the development and dissemination of new technologies and led to low adoption of CSA technologies. The main challenges facing CSA in terms of dissemination of farming technologies are the perception that the technology is expensive to adopt, training of extension agents, unwillingness of farmers to accept the technology, inadequate funding, high illiteracy levels among farmers, incompatibility of the technology, inadequate and inexperienced extension workers, limited farmer participation and the gender dimension. In addition, lack of adequate knowledge of farm management skills, such as correct land preparation, timely planting, pest and diseases and their control, timely weed control to bypass the critical period of weed competition, knowledge on nutrient deficiency symptoms and how to correct them and keeping farm records, are some of the constraints faced by farmers in adopting new technologies related to CSA practices. An inclusive approach to CSA is needed, one that both empowers women and generally reflects differing gender roles, and deliberately aims to involve Africa's rural youth. An 'innovation system' approach should be taken that encompasses not only the introduction of new technologies, but also organizational and behavioural changes.

References

FAO. 2001. *Farmer innovation and new technology options for food production, income generation and combating desertification*, Rome, Italy, 99 pp.

World Bank. 2008. The Growth Report: Strategies for Sustained Growth and Inclusive Development. *Commission on Growth and Development*, Washington D.C., World Bank.

Madukwe, M.C. 2006. Delivery of Agricultural Extension Services to Farmers in Developing Countries. CTA publications, Wageningen, Netherlands, 1-3 pp.

David, S. & Asamoah, C. 2011. Video as a tool for agricultural extension in Africa: a case study from Ghana. *IJEDICT*, 7(1): 26-41.

1.7 Scaling up climate smart information services to guiding climate risk management by farmers in Senegal[8]

Extension services in Senegal

Senegal, with 90 percent rain-fed agriculture, is subject to rainfall variability, especially in the northern region where crops are particularly exposed to erratic rainfall and long drought (Khouma et al., 2013). These are becoming more frequent with climate change, which may lead to frequent crops failures during the one, short rainy season per year. Indeed, extreme climate events can undermine agriculture and rural development. Even in years when extreme events do not occur, the uncertainty of results due to climate-related risk is an impediment to sustainable intensification of agriculture and adoption of climate-smart agricultural (CSA) production practices.

In an era of more frequent and more extreme weather events and climate shocks, enhanced early warning systems provide a key opportunity to curb erosion of development progress in rural sectors. Allowing farmers to base farm management decision-making through tailored and salient climate information along the cropping cycle may help them reduce climatic risk and avoid regular food insecurity. With the support of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), vital downscaled seasonal rainfall and long term weather forecasts are reaching around three million people across Senegal, helping smallholder farmers to make better-informed decisions about agricultural management in a changing climate. By doing so, the provided climate information services (CIS) have allowed farmers to improve their adaptive capacity and increase farm productivity. In addition, an institutional behavioural change has been operated by the Senegalese Ministry of agriculture who now consider CIS as an agricultural input for their yearly agriculture action plan development and implementation.

CCAFS scientists worked with the national meteorological agency, Agence Nationale de l'Aviation Civile et de la Météorologie (ANACIM), to develop downscaled seasonal rainfall forecasts, and to raise capacity of partners to do longer-term analysis and provide more actionable information for farmers. The forecast information includes the total rainfall, the onset and end of the rainy season, plus a 10-day forecast across the rainy season. The information is conveyed to farmers as an agrometeorological advisories package that are tailored to meet the local needs expressed by farmers themselves through discussion groups. While this approach has been piloted in the Kaffrine region since 2011, the geographical scope has now been widened through a partnership with the Union des Radios Associatives et Communautaires du Sénégal (URACS), an association of 82 community-based radio stations promoting economic development through communication and local information exchange[9]. The union spans all 14 administrative regions of Senegal and operates in all local languages, giving it significant adoption potential by local farmers to transform their lives through reliable information. Following training of the 82

[8] Contribution prepared by R. Zougmoré, Regional Program Leader (WA), CCAFS, (r.zougmore@cgiar.org) and O. Ndiaye, Head of Department Research/Development, ANACIM, Dakar, Senegal (ousmane.ndiaye@anacim.sn)

[9] For further information see: http://uracsenegal.org/

radio journalists on the jargon of climate and on the understanding of the seasonal forecast, climate information services across the rainy season are now transmitted as special radio programs in the 14 administrative regions of Senegal. The interactive nature of the radio program allows listeners to reply with their feedback, including additional information, views, and requests of clarification. Moreover, the widespread use and coverage of mobile phones and radio have made it possible to convey climate information to a very large audience and to upscale the project to the rest of the country. This scaling up of CIS has been possible thanks to the partnership between CCAFS, ANACIM and URACS with each stakeholder playing a specific enabling and complementary role.

Local extension services and Climate Information Services

Seasonal forecasts must reach remote rural communities in time for farmers to make use of them. To this end, ANACIM produces CIS during the rainy season and is responsible for transmitting it directly to the MWG, rural radios, the Rural Development Departmental Services (SDDR) and farmers. In addition, ANACIM organizes a seminar at the beginning of each rainy season to inform farmers of the major trends. The seminar is also an opportunity to collect farmers' forecasts based on their traditional knowledge. At the very beginning of the project, climate information was disseminated in Kaffrine by the SDDR. Following an internal evaluation conducted in 2011, the farmers suggested the use of community radio stations to disseminate CI since they have a large audience in rural areas. In 2012, ANACIM signed a collaboration agreement with the Union des Radios Associatives et Communautaires du Sénégal (URACS). These stations operate in Senegal's local languages. The radio programs are interactive and farmers are able to provide feedback. Capacity enhancement workshops were organized to enable radio broadcasters to easily understand and assume ownership of the jargon used by ANACIM forecasters. While rural radio proved to be an important communication pathway for men, it was found that women often receive climate information through personal contacts at strategic places, such as local boreholes where they gather water every day.

Farmers also play an active role in the dissemination of CI within their community. Through their network of social relationships, they facilitate access to CI for other farmers. A study conducted in the project areas revealed that individuals who did not have a strong social network were less likely to receive climate information and therefore could not take proactive steps to alleviate negative impacts of climate change (Lynagh et al. 2014; D'Auria Ryley 2014). Apart from radio, SMS is widely used for CI dissemination. The very broad cellular coverage allows for access in rural areas. In every rural household there is at least one mobile phone, which is often used by many people. When farmers and extension agents receive climate information, they relay it to other farmers by SMS. This creates a multi-branching distribution chain. Instant information is usually disseminated through this channel.

The extension agents are at the centre of the entire dissemination system. They receive the CI via SMS from ANACIM and relay this to the village level through SMS, phone calls or "word of mouth". Their interpretation of the forecast and related advice on fertilizer use, pesticide application, seed selection, etc. renders the CI actionable.

Through a combination of these different channels, between 2011 and 2014, up to 3.9 million rural people (not all farmers) were potentially reached with climate information in the project areas (Lo and Dieng, 2015). Indeed, the widespread use and coverage of mobile phones and radio have made it possible to convey climate information to a very large audience and to upscale the project to the rest of the country. In 2015 a total of 7.4 million rural people, among which there are about 740 000 agricultural households, were potentially reached with climate information across all 14 administrative regions of Senegal, via 82 rural community radios and SMS (ANSD, 2013; CCAFS, 2015).

Lessons learned

There have been three important challenges during the scaling up process.

First of all, *gaps in long-term series of climate data* for all sub-national level administrative zones did not allow ANACIM to design the downscaled seasonal rainfall forecast information; this has consequences for the production of enough accurate climate information. Confidence in early warning systems (EWS) is influenced by the quality of data. Quality is often compromised because EWS is based on multiple streams of information; investments in quality and streamlining can help increase confidence. In the case of meteorological data, the ENACTS product helps create high spatial and temporal resolution rainfall and temperature data through blending of observations and satellite data. This complements and fills the gaps in the ground historical climate database, as with ENACTS: (1) climate data are available for each 10 km by 10 km grid in West Africa, (2) Data are available online and any user can therefore access them at any time, (3) Usage of data and products from ENACTS is easy, provided weather services and users are trained.

Secondly, there was insufficient coverage of local multidisciplinary working groups (GTPs) across the country. This constitutes the institutional bodies translating the climate information into agro-advisories for farmers and disseminating the information through various channels; the local GTPs are in principle setup in each district through ANACIM. However, the latter doesn’t have the required funds to cover their operational costs (meetings, transport, etc.) rendering it difficult to cover the whole country with such an important entity in the scaling up process. Using context specific partnerships to play the role of GTPs appears relevant as this was demonstrated in the case of Bambey district by the existence of a powerful farmers’ organization. In these kinds of public-private partnerships, the added value is that the private sector, because of its interest in the produced CIS, will also support the scaling up process. And as members of the local GTPs where they contribute to the development of the agro-advisories, the vast network of rural radios can easily understand the messages to be largely disseminated through their radio broadcast programs.

The third and final issue was the lack of financial resources to operationalize training plans, capacity building of GTPs and URACS journalists, and communication among actors, among others. Our proposed approach of public-private partnership to develop more local GTPs across the country will allow rationalization of the financial resources needed to capacitate all actors involved in the scaling up process, including ANACIM, the local GTPs and the 82 rural radios of URACS. In Louga, for instance, a bank (Crédit Mutuel du Sénégal) that was part of the scaling up process led by ANACIM strongly expressed its willingness to base its loans on the forecast. The bank was therefore ready to support (financially) the development of the CIS and in 2014 the bank already sponsored the development of the CIS bulletin by the national GTP. This, in addition to the government support through major rural development projects and through dedicated allocation of public funds to strengthen the capacity of key actors (ANACIM, Extension services, URACS, etc.), will sustainably operationalize the scaling up process.

References

ANSD. 2013. Rapport Definitif RGPHAE 2013. *Agence Nationale de la Statistique et de la Démographie (ANSD)*. (Available at http://bit.ly/1NrlekU Accessed on 25 Nov 2015)

CCAFS. 2015. *Scaling up climate advisories in Senegal and Colombia*. (Available at http://bit.ly/1NrlCjv Accessed on 23 Nov 2015)

D'Auria Ryley, T. & McKune, S. 2014. *Climate change and social networks in Senegal's peanut basin*. CCAFS. (Available at http://bit.ly/1Kc3nvL Accessed on 23 Nov 2015)

Khouma, M., Jalloh, A., Thomas, T.S. & Nelson, G.C. 2013. Senegal. *In IFPRI*, pp.291-322.

Lo, H.M. & Dieng, M. 2015. *Impact assessment of communicating seasonal climate forecasts in Kaffrine, Diourbel, Louga, Thies and Fatick (niakhar) regions in Senegal*. CCAFS. (Available at http://bit.ly/1ifHC3P Accessed on 29 Nov 2015)

Lynagh, S., Tall, A. & Jay, A. 2014. *One size does not fit all: considering gender, equity and power in climate information services*. CCAFS. (Available at http://bit.ly/1Q3blaG Accessed on 19 Nov 2015)

1.8 The CSA Prioritization Framework: an innovative planning tool to prioritize CSA practices[10]

Developing an evidence-based framework for prioritizing investment in CSA

Researchers from the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and the International Center for Tropical Agriculture (CIAT) have taken on the challenge of developing a framework for prioritizing investment in CSA that is evidence-based, yet realistic in that it can move forward in the face of data and resource constraints. The CSA Prioritization Framework (CSA-PF) is a participatory process that links multiple analytical tools and methodologies to assess CSA practices, including: methods to identify climate-vulnerable agriculture regions and production systems; expert-led quantitative and qualitative assessments of context-specific outcomes of CSA practices and technologies, based on the three CSA pillars (adaptation, productivity, and mitigation); cost-benefit analysis for CSA practices adoption; and assessment of opportunities and challenges to adoption.

The main objective of the CSA-PF is to provide decision-makers at various levels (national and local governments, donors, non-governmental actors and the private sector) with a variety of tools that can assist them in planning processes, thus contributing to more informed decision-making. Priority CSA actions (or CSA investment portfolios), established at different operational levels (national, regional, local), are a key output of the framework. To achieve this, the CSA-PF constitutes multi-phase participatory processes that combine expert evaluations with national and local actor feedback to ensure alignment of priorities with contextual realities and needs. The phases are additive in order to refine previous outputs and guide stakeholders through filtering a long list of applicable CSA options into portfolios of priority practices. The process generally takes between six and twelve months, and can be simplified and still provide valuable inputs into investment decision-making.

In an initial phase, CSA-PF users identify the scope of the study, based on which a long list of potential CSA options is developed and then assessed using CSA-related indicators. In a second step stakeholders (academics, producers, donors and government decision-makers, among others), explore the results and tradeoffs between different CSA options in order to identify a shortlist of high-interest practices for further investigation. The economic costs and benefits of the practices are then thoroughly assessed in a third phase. Stakeholders gather in a final phase to discuss the results from the entire process and prioritize CSA practices for investment portfolios.

The CSA-PF has been used in planning processes from local to national levels, with pilot studies completed in Colombia (local level), Guatemala (national/sub-national), and Mali (national/sub-national) and ongoing use in Ethiopia (national/sub-national), Ghana (national/sub-national), Nicaragua and the Trifinio region (regional/national/subnational), and Vietnam (national). The Ministry of Agriculture and Livestock (MAGA) in

[10] Contribution prepared by Andreea Nowak (CIAT), Caitlin Corner-Dolloff (CIAT), Miguel Lizarazo (CIAT), Deissy Martinez Baron (CCAFS)

Guatemala was the first to utilize the framework and assist in adjusting the participatory process and phases to the context and stakeholders, including government, academia, research centres and productive sectors. The pilot in Guatemala focused on the prioritization actions, and next steps would include implementation, Monitoring & Evaluation (M&E), and adjusting of national plans.

Methodology and impact

The prioritization processes embedded in the CSA-PF are aimed at building up the conversation on CSA, the benefits, uses, and gaps of such an approach, engaging a variety of actors in these discussions to ensure mainstreaming. More specifically, they seek to identify priorities for targeting investments that aim to address CSA goals now and in the future. The methodology allows for the integration of the CSA concept into agricultural and climate change planning through expanding potential entry points for action and cooperation among actors working on any of the CSA goals (productivity, adaptation, mitigation). That said, the framework can also be tailored to specifically focus on adaptation or mitigation options in the agricultural sector.

The CSA-PF has proved effective in contributing to the co-development of a vision that is shared by actors belonging to the public, private and not-for-profit sectors, which is oriented towards medium- and long-term agricultural development planning, and which takes into account multiple investment dimensions (CSA pillars). However, one critical success factor of this initiative is the stakeholders' commitment to stay engaged in the process and willingness to proceed with the on-ground implementation of the portfolios. Action plans and joint programming can be options for ensuring that these efforts are continued.

Implementation of the CSA-PF

Piloting the CSA-PF in contexts where socio-economic, cultural, politico-institutional, and agri-environmental conditions are different, has highlighted some important characteristics of the process: flexibility, adaptability and scalability. Users can decide which phases to use and when, what activities to be adapted and added, depending on the needs and resources available. For instance, working with farmer and indigenous communities in Colombia as next users required adding extra activities to the process, offering local people the chance to be engaged in the methodology development (e.g. indicators and metrics to use for the practices' assessments) and implementation (community leaders were in charge of collecting required data through "community dialogues"). This created local ownership of not only the data collected and analyzed, but of the entire process.

Moreover, the prioritization activities are designed in such a way to allow the selection of the most appropriate practices or approach to invest in agriculture according to national/local contexts and environmental and socio-economic challenges. The list of CSA indicators used for assessing the practices from multiple points of view, as well as the CBA methodology, are broad enough to allow for their use in different contexts and by different users. This makes the framework, but not the results, replicable in other countries, regions, and around the world.

Another lesson learned indicates the importance of linking analytical tools with participatory processes for both national and local-level planning. While analytical tools increase the evidence that decision-makers have to plan actions, decisions are not made in a vacuum. The CSA-PF process is structured around the recognition that analytic tools can be useful, but will not capture all variables decision-makers weigh up, and therefore participatory design of tools (e.g. selection of indicators for assessment of options) and participatory evaluation of results and final selection of actions for investment or inclusion in policies is critical.

It has also been observed that priority CSA options vary considerably based on the context in which they are being applied. The scope of assessments and descriptive characteristics must be clearly defined and utilized to tailor analyses to local realities. Moreover, diverse stakeholder representation is imperative to ensure that the concerns of various actors are considered and addressed during planning processes.

Main results and lessons learned

Results from the pilots have also revealed that uptake of practices promoted as national CSA priorities is occurring, but not always with high rates of adoption. Some CSA practices are priorities to policy makers and funders, yet many farmers face technical and financial barriers to adoption. Local actors' and farmers' priorities should be included early in decision making processes to identify adoption barriers as well as expected impacts of practices in specific contexts. Likewise, CSA policies should promote both practices and services, such as financial services (crop insurance, subsidies, credits, etc.) and strategies for knowledge sharing and management (strengthening of extension services, early warning system, etc.).

Many farmers implement two to three practices simultaneously, indicating that CSA investments need to refer to technological packages, rather than isolated solutions. Moreover, prioritization of investments should include explicit discussion of tradeoffs between practices related to outcomes of interest across time, and clarify who is benefiting and losing related to different priorities.

Last but not least, operationalizing CSA into strategies and concrete actions requires adequate, rigorous information. Adaptation planning, as well as CSA, require assessment of impacts across social, environmental, and economic aspects of socio-ecological systems. The CSA-PF emphasizes this by assessing CSA practices using indicators of changes across sectors, such as yield, income, ecosystem services, water and soil use and quality, emissions, etc. However, such assessments, and CBA exercises in particular (an important component of the CSA-PF), are often challenged by the lack of data available at local level and by the difficulty in assessing certain benefits (externalities) that practices have, such as health or environmental benefits. More research efforts are needed towards the creation/strengthening of frameworks, methodologies and information systems, to make sure economic analyses are comprehensive and rigorous enough to serve for decision-making.

Section II – Technology and Innovation

2.1 Technologies for extension services in CSA sector: examples from Kenya[11]

Extension services in Kenya

The Extension Department of the Kenya Ministry of Agriculture oversaw the extension services provided by approximately 6 000 field agents (of which crop agents account for 5 000 and livestock, fisheries and veterinarian together account for the remaining 1 000 agents) throughout the country until 2014 when these responsibilities were devolved to the newly formed 47 counties. Until the devolution, crops, livestock, fisheries and veterinarian were separate departments and operated independent extension services. The devolved governments integrated these various departments under the same umbrella of the extension services of each county. The devolved county political structure mirrors that of the central government and each county has a ministry of agriculture with the structure as in the central ministry.

Immediately prior to the devolution, the ministry launched the new e-Extension program which mandated that all extension services be modernized. The plan was to purchase a 'computer set', consisting of a mini laptop, a modem, and a rudimentary smart phone, for each of the extension agents. This was to be implemented for the 5 000 agents in the Crops Department first. In 2013-14, prior to the implementation of devolution, 645 sets were purchased and distributed to crop agents, with the understanding that the remaining would be distributed until all agents were outfitted. With the devolution, all funds and responsibilities were handed to the counties, while the ministry was left with only the authority of oversight and guidance for all agriculture activities. The counties are now in charge of all agriculture extension, for both conventional and CSA activities.

Rolling out the e-Extension system

The e-Extension methods introduced by the government were not fully automated systems from data collection to storage and display although it was certainly a step up from the traditional pencil-and-paper system. By and large, the county extension offices do not have access to any e-Extension tools to perform this newly mandated task. During 2013-14, Catholic Relief Services (CRS) embarked on a collaborative initiative with Kenya Ministry of Agriculture to modernize its extension program. The first wave of this initiative introduced the SMART Skills on ePlatform developed by CRS on a small pilot scale to the extension agents in two counties. Appropriate training is both a gap and an opportunity to transfer extension services to CSA. The appropriate training refers to both the material/content, and the training approach. SMART Skills (Skills for Market and Rural Transformation) approach aims to strengthen all the skills farmers need in order to create effective and sustainable linkages to markets. The SMART Skills curriculum presents an integrated and sequential approach to strengthening the capacity of farmers to link with markets and manage their resources. The SMART Skills stress sustainable resources management and effective market engagements. Natural Resources Management (NRM) is a central theme to sustainable production, taking into consideration conservation agricultural practices as a way to build resilience to

[11] Contribution by Dai Peters, Catholic Relief Services (CRS)

climate change. More importantly, recognizing that NRM production practices are but one aspect of CSA considerations, SMART Skills incorporate the other essential skills for farmers to succeed, which include group management, financial management, innovation, and effective market engagements.

SMART Skills are created in two formats to best facilitate scaling extension efforts:

1. Paper manual format.

These manuals are complete with laminates as visual aids to facilitate training in the field. These manuals are best suited for field agents to use in the training of farmer groups.

2. Digital eLearning format.

The ePlatform is designed to scale by facilitating independent study by project staff, local partner staff and field agents. This format contains the following features:

- interactive and animated with voiced narration;

- ability to be viewed on both computers and mobile devices;

- ability to be studied online on computers;

- ability to be studied both online and offline on OS (Android Tablets) and iOS (Apple iPads) devices;

- complete with a fully functioning Learning Management System (LMS), both online and offline, to facilitate managers/supervisors monitoring and managing the learning progress of their staff; and

- offline function feature allows the field agents to study and take quizzes offline. The study and quiz records can later be uploaded for managers to view when the agents synch the device via network connection.

The two formats of these SMART Skills are available in three languages: (a) English; (b) French; and (c) Spanish. In addition to disseminating this curriculum to Kenya MoA and the counties, this curriculum has been introduced to other countries to be used for both projects within and outside of CRS. CSA is now a signature program in CRS and the SMART Skills curriculum is a central tool to promote best practices and scale up extension services.

The introduction of the SMART Skills sparked considerable interest in the ministry as one of the methods to launch their e-Extension program. The next logical tool to introduce to the ministry was Map & Track, which consists of data collection forms to register extension agents, farmers, and farmer groups, and to track agents' extension service deliveries to the farmers or farmer groups. National extension services need more extensive CSA modeling and mapping so that extension competencies can be deployed accordingly in the future. The registration of the agents would fill the role of modeling and mapping of the extension competencies across the country. Registering farmers and farmer groups would provide baseline data of farmers' crops and their agricultural practices into a database system for extension services specifically targeted for resilience to climate change.

These data collection forms are built on iFormBuilder platform and loaded on smart phone, which functions both online and offline to facilitate agents working in the field where there is no network connection. The registration and service delivery tracking data collection can both be stored on the phone while functioning offline and synced to the cloud and into data storage whenever the agents have network access.

These extension tools — the SMART Skills eLearning and data collection forms — require the use of mobile devices, such as smartphones or tablets. Only a fraction of the extension agents in Kenya has been allocated a rudimentary smartphone that barely meets the requirements of the iFormBuilder; this seriously compromised the counties' ability to employ these tools to provide extension services for CSA in Kenya. In this case, the traditional extension methods must be employed, which significantly hampers the extension effort for CSA.

2.2 Can data products/services contribute to meet the goals of CSA?[12]

What are data products/services?

Data have always been the base for research processes, including in agronomy where experimental designs coupled with statistical analysis have achieved great progress in the understanding of the complexity of cropping systems. Nevertheless, nowadays the sources, amounts, nature, property, uses and users of the data are all rapidly evolving. What has been called the revolution of big data has brought a change of paradigm in many sectors of the society (Mayer-Schonberger & Cukier, 2013), and emphasized new opportunities.

Today farmers of the developed countries routinely generate yield maps at very high resolution, using GPS sensors plugged into their combines. Simultaneously, automatic weather station networks are collecting climate data and making it available through web platforms in real-time thanks to cloud computing. In the near future, agriculture is anticipated to produce even more data thanks to the generalization of drones, remotely connected sensors, advances in satellite products and the generalization of the internet.

Compared with the experimental data that have been commonly used, these streams of information are observational data – they comes from operating commercial farms. This means that it captures the whole diversity of geographical contexts in which a crop is grown, as well as the variations of climate, soils and management in time. The management decisions that are made on the farms to cope with each particular situation are also recorded. This embedded knowledge can be extracted using data mining techniques to learn from the data at a site-specific scale. This, at the time, can provide farmers and agronomists with highly relevant site-specific information to enrich their knowledge basis and support more accurate decisions.

This enabling environment creates a great opportunity for agriculture to start collecting, storing, combining and analyzing observational data, and make value of it.

Making sense of every bit of data

What can be called *data-driven agriculture* is the approach in which technical decisions made on farms or recommended by extensionists are supported by the analysis of large amounts of observational data.

Farmers' data describing the management of crops, yields and crop status are pooled and combined with weather records and soils data at field level to finely characterize the actual conditions in which the crop grew and the production it achieved. Empirical modelling techniques are then used to mine the databases for correlations and/or patterns that inform about the response of crops to the variability of environmental conditions, main limiting factors and optimal management practices in each context. Typically, clustering, PCA, regressions and machine learning approaches, such as artificial neural network and classification and regression trees, are part of the portfolio of techniques that can be employed and may overcome the additional challenges that this kind

[12] Contribution by Sylvain Delerce (CIAT)

of data brings (noisy, sparse, all factors varying at the time, etc.). The process can be described as a wide scale benchmarking where the performances of the crops are compared among groups of fields that share similar environmental conditions. The approach is very versatile in terms of the data sources it can use and the variables it assesses.

The approach brings several opportunities:

- It allows the exploitable yield gap (van Ittersum et al., 2012) existing between best and worst actual yields achieved in similar environmental conditions to be quantified.

- It provides detailed understanding of the response to different weather factors at site-specific scale of the different cultivars of a crop. This allows the farmers to learn more about the cultivars' behaviour under changing weather patterns in a faster way; the data helps them to record everything that happened, and, once analyzed, reveals weather factors associated with high or low productivity.

- Cropping events can be classified according to the weather pattern they experienced. This allows identification of favourable/unfavourable weather patterns. Then, results can be combined with forecasts to look for analogues in the historical data according to the classification. Farmers can then replicate management practices that were successful in the past with similar conditions and avoid the ones that were associated with crop failure.

- Detect optimum management practices in each group of homogeneous environmental conditions. Comparing the management between farms with similar climate and soils at broad scale, one can detect which combinations of practices work and which do not.

The idea is to take advantage of every bit of data generated on farms, climate stations, research and plant breeding plots, to analyze it, and make sense of it to guide farmers' decisions.

The generated information can be used by different stakeholders:

Farmers can take into account the results of the analysis to modify their management optimizing inputs level, cultivar choice, sowing dates and other practices. The characterization of favourable/unfavourable climate patterns and their probability to occur is also of great interest for them to anticipate their crop rotation and manage the risk. The outputs of the approach are especially useful for smallholder farmers who do not have access to extension services.

Extensionists and rural advisors may be the most interested actors. It is a new tool for them to monitor crop response to climate, soil and management at large scale. Indeed, the system basically replicates the thinking of an agronomist, but with the precision and infallible memory of a computer. They will use it to enrich their recommendations, based on actual measurements from many farms.

Plant breeders can use the output of the analysis as a direct feedback on the performance of the different cultivars in commercial conditions. This is of great help for them to adjust their breeding strategies according to the actual performance of the cultivars, but also to design more site-specific cultivars better adapted to each context.

Finally, *agricultural organizations* can gain much information on crop growth in order to plan harvest, logistics and commercialization. This is the case for the example of coffee, where post-harvest actors need to know when the plants will flower to schedule their operations.

In turn, the input data needed also comes from different stakeholders:

Farm records of management and yield can be provided by *farmers*, *farmers' associations* and *processing industries*, depending on the structure of the value chain.

Weather data usually comes from *national climate institutions* or agriculture supporting organizations' weather stations networks. When there is low availability from such sources, alternatives are secondary databases such as Worldclim[13], CRU[14], SHIRPS[15]… and satellite products such as TRMM[16] and NASA POWER[17].

For soil data, sources are usually national soil/geological institutes for traditional soil maps. Nevertheless fuzzy logic data products[18] offer more possibilities and are progressively replacing traditional maps. In some countries, local maps are available. When not, global products are already available, like the ISRIC's World Soil Information system[19].

Quick expansion of data-driven approaches

Such approaches have already been tested and/or implemented in several parts of the world. Academic studies were published for China (Tao et al., 2016), Colombia (Jiménez et al., 2016), France (Delmotte et al., 2014), Iran (Shekoofa et al., 2014), Kenya (Tittonell et al., 2008), USA (Rosenheim & Meisner, 2013), among others. But some countries also report concrete implementations under varying business models, like Argentina[20], Colombia[21], Mexico[22], Nicaragua[23], Uruguay[24] and USA.

Private companies have already started to develop solutions and services. Subscribed farmers provide their data through Internet based technologies and receive personalized reports on the status of their crops and recommendations on the actions to be taken to make the best of their crops.

This is the case for Climate Corporation in the USA, for example. The company uses publicly available daily weather data to generate contextualized weather forecasts and management recommendations for members' farmers[25].

The Farmer Business network offer similar services, but invite farmers to be part of a community in which farmers

[13] Web site: http://worldclim.org/
[14] Web site: http://www.cru.uea.ac.uk/data
[15] Web site: http://chg.geog.ucsb.edu/data/chirps/
[16] Web site: http://trmm.gsfc.nasa.gov/data_dir/data.html
[17] Web site: http://power.larc.nasa.gov/common/php/POWER_ParametersAgro.php
[18] Web site: http://www.purdue.edu/newsroom/releases/2014/Q3/purdue-mapping-technology-could-help-farmers-better-understand-their-soils-functionality.html
[19] Web site: http://www.isric.org/

[20] See http://inta.gob.ar/servicios/frutic-fruticultura-de-precision-0
[21] See http://blog.ciat.cgiar.org/los-gremios-colombianos-entran-a-la-era-de-los-datos/?lang=es
[22] See http://masagro.mx/index.php/en/
[23] See http://www.laprensa.com.ni/2015/10/22/economia/1922896-tecnologia-puede-revolucionar-el-agro
[24] See http://ricetoday.irri.org/a-date-with-big-data-in-uruguay/
[25] See https://climate.com/

share their data anonymously to build a huge knowledge database from which each member can learn, benchmarking his management with millions others'[26].

Today, every John Deere machine includes a SIM card for live transfer of the operating data to the company. Machines measure the time in operation, breakdowns frequency, engines performances and many other factors that give information on everything about machine operation. The company collect and analyze these data to provide its customers with reports on the status, the profitability of the machines, as well as recommendations on how to improve the management of the fleet. Furthermore, the company is also entering the field of agronomic advice based on farmers' data.

Research institutes also seized the topic:

- CGIAR centres are developing several initiatives to harness the benefits of farmers' data, and trying to democratize its use. Among them are the AEPS team at CIAT and the Mas Agro project at CIMMYT. A cross-cutting platform dedicated to big data is also planned to start in 2017.

- Rothamsted Institute in England has made large investments to harness big data opportunities in the agro sector.

Other private initiatives can be mentioned, such as: AgroappGrade[27] and APPgro[28] (both based in Argentina), WeFarm[29], and aWhere[30].

[26] See https://www.farmersbusinessnetwork.com/
[27] Web site: http://www.agroappgrade.com/
[28] Web site: http://www.appgro.com.ar/
[29] Web site: http://wefarm.org/services/
[30] Web site: http://www.awhere.com/

Data products/services across the main pillars of CSA

In many parts of the world, agriculture is still producing far less than it could, mainly because of sub-optimal management and lack of opportunities for farmers to modernize their tools. This yield gap is called Exploitable Yield gap (van Ittersum et al., 2012) and it is a key element to increase global food production in a context of low availability of new suitable lands for farming.

The wide deployment of data-driven agriculture can simultaneously (i) generate updated granular data on actual farms' yields that allow better estimation of the exploitable yield gap and (ii) provide the required insights on main limiting factors and optimal management practices at site-specific level to accelerate the closing of these gaps.

The approach also indicates which crops are suited to each environmental condition. There are still many farms that grow crops using tradition rather than technical criteria. It is important to correct that to avoid chronic low yields and to make the most of land. Thus the implementation of this approach can boost food production on existing farmland and contribute to meeting world demand.

Farmers are challenged by changing weather patterns and unpredictable climate. Traditional calendar landmarks are no longer useful and new and more dynamic information sources are needed to maintain farming productivity and profitability in such contexts.

By combining farmers' crops data with daily weather data series, analysts can characterize in detail the response of each cultivar to the different weather patterns that occurred in each region. This in turn allows farmers to adapt the cultivar choice, the sowing date and the management of irrigation to each pattern, avoiding mistakes. They also get information on the actual expected yields under each condition based on historical records.

This additional knowledge enables agriculture to understand how climate is changing, how crops are responding to it, and therefore to take tactical decisions to avoid losses and manage the risk level.

The impact of data products/services on greenhouse gases emissions is indirect: the tool allows the farmer to optimize the input level, avoiding unnecessary applications and at a larger scale, by closing the yield gap, agriculture can become more efficient and mean that less land is needed to produce the required amounts of food, avoiding deforestation (as suggested in Aramburu Merlos et al., 2015).

Potential impact of data on CSA

According to the *Global Yield Gap Atlas project*[31] (van Ittersum et al., 2012), Exploitable Yield Gap for corn reaches 80 to 90 percent (expressed as a percentage of 80 percent of the Yw) in Africa, 40 to 50 percent in Latin America, and 2 to 65 percent in Europe (selected countries). For irrigated rice in Africa, it is 40 to 60 percent.

These important gaps are the results of suboptimum management of the crops. The implementation of data products/services can help to identify optimum management for each location.

Losses due to climate variability: At a global level, inter-annual climate variability has been found to explain between 32 and 39 percent of yield variability (Ray et al., 2015), and the El Niño/Southern Oscillation (ENSO) alone has been shown to modify by 5 percent the average yields of major crops (soybean, maize, rice, wheat).

Climate will remain an uncontrollable factor for farmers, but if they have a better understanding of how their crops respond to each weather pattern and what are the best options to cope with them, the current impact of climate variability can be lowered.

Based on the references and analysis above, it is estimated that proper use of data products/services can rapidly achieve an average of 10 to 20 percent improvement in yields, although this is highly dependent on the initial conditions of the farms.

The way forward: scale up

Data products/services have a very good potential to contribute to the goals of CSA, along with other advantages to the modernization process and the efficiency of agriculture. Moreover, the framework implemented for data products/services offers the opportunity to monitor the changes on farms towards CSA with quantified data.

The approach requires analytical abilities, as well as computing infrastructure, and is based on pooling many data. Therefore, it is not meant to be a personal tool that each farmer can use on their own. The service has to be provided by some organization that gather farmers.

But the implementation of the approach requires only a few people and some

[31] See http://www.yieldgap.org/web/guest/home

cloud computing power, for which costs are dropping. The software can be entirely based on open source, avoiding licensing cost barriers.

At the same time, cheap sensors are spreading; remote sensing makes it possible to capture more and more data without any human intervention. Datasets are being released by national institutions in line with open-access policies and new generations of farmers are used to ICTs tools. Therefore, more data are available, it is easier and cheaper to process, and end-users are being more receptive to the results.

Thus the approach is highly suitable to scale up, it basically depends on existing data and capacity to capture data. Farmers' associativity is also very important to centralize efforts and reach required amount of data.

Data products/services and CSA: challenges

The main risk of this approach is the misuse of farmers' data, as it needs to be compiled at some point. Data privacy and farmers' willingness to share their data is already a challenge. In developed countries the debate is well settled[32]: should farmers trust the big companies and go for the additional benefits they promise, or should they take extra care when sharing their data? And what is the real value of farmers' data? Companies have different approaches to the problem and offer varying guarantees to their customers. Others call for stronger regulation of these activities, but at the same time, the revolution of big data seems to overpass our traditional regulation schemes and may require more innovative solutions for fair use of the data. Meanwhile it is important that the users of the tool can understand it, at least to a certain extent, especially because their personal data are involved in the process.

Observational data are powerful as they depict the reality of operating commercial farms. But the collection of this kind of data is challenging. Few farmers capture data routinely, and when they do, data are often sparse and of varying quality. For those data to be useful, it is necessary to aim for standardization of variables and units, consistency in time and wide-scale capture. Also, the level of precision of the results/recommendations directly depends on the level of detail available in the input data. For that reason, the data capture scheme should include the exact date of every operation on the crop (sowing, harvest, pesticides/fertilizers applications, irrigation, etc.), the name and amount of inputs used. The use of ICT is a clear opportunity to solve many problems of the data capture, and to accelerate it to meet the requirements of the analysis in terms of volume. Unfortunately, the deployment is slow and highly disparate between advanced farmers and smallholders. The renewal of farmers' generations will strongly help to smooth the transition but in the meanwhile efforts are needed to democratize the use of those tools.

The access to public climate data can also hinder the implementation of the approach in some countries where institutions responsible for the public climate stations network and data still do not comply with open-access policies. There is an interesting trend for countries to release the climatic

---

[32] See http://www.economist.com/news/business/21602757-managers-most-traditional-industries-distrust-promising-new-technology-digital

datasets which we advocate for (e.g. USA and Colombia, among others).

Finally, farmers' willingness to share their data may be a limitation when there is limited confidence in the agriculture supporting organizations. Extensive work to explain the approach is then required and a neutral entity might be created specifically for the purpose, to avoid pre-existing political barriers.

Data driven agriculture can take time to reach the critical data amounts that allow analysis. While the data capture grows, there already exist similar approaches that rely on much simpler information but use the same conceptual approach: Cropcheck in Chile[33], CREA in Argentina[34], or CETA in France (Gerbaux & Muller, 1984).

Those tools are based on the co-construction of collective knowledge through the benchmarking of the performance members' farms.

References

Aramburu Merlos, F., Monzon, J.P., Mercau, J.L., Taboada, M., Andrade, F.H., Hall, A.J., et al. 2015. Potential for crop production increase in Argentina through closure of existing yield gaps. *F Crop Res.*, 184: 145–54. (Available at http://dx.doi.org/10.1016/j.fcr.2015.10.001 Accessed on 19 Nov 2015)

Delmotte, S., Tittonell, P., Mouret, J-C., Hammond, R. & Lopez-Ridaura, S. 2011. On farm assessment of rice yield variability and productivity gaps between organic and conventional cropping systems under Mediterranean climate. *Eur J Agron.,* 35(4): 223–236. (Available at http://linkinghub.elsevier.com/retrieve/pii/S1161030111000724 Accessed on 19 Dec 2015)

Gerbaux, F. & Muller, P. 1984. La naissance du développement agricole en France. *Econ Rural*, 159: 17–22.

van Ittersum, M.K., Cassman, K.G., Grassini, P., Wolf, J., Tittonell, P. & Hochman, Z. 2012. Yield gap analysis with local to global relevance — A review. *F Crop Res* (Available at http://linkinghub.elsevier.com/retrieve/pii/S037842901200295X Accessed on 19 Dec 2015)

Jiménez, D., Dorado, H., Cock, J., Prager, S.D., Delerce, S., Grillon, A., et al. 2016. From Observation to Information: Data-Driven Understanding of on Farm Yield Variation. *PLoS One,* 11(3): e0150015. (Available at http://dx.plos.org/10.1371/journal.pone.0150015 Accessed on 19 Dec 2015)

Mayer-Schonberger, V. & Cukier, K. 2013. *Big Data: A Revolution That Will Transform How We Live, Work and Think*. 242 p.

Ray, D.K., Gerber, J.S., Macdonald, G.K. & West, P.C. 2015. Climate variation explains a third of global crop yield variability. *Nat Commun* 6: 1–9. (Available at http://dx.doi.org/10.1038/ncomms6989 Accessed on 28 Nov 2015)

Rosenheim, J.A. & Meisner, M.H. 2013. Ecoinformatics can reveal yield gaps associated with crop-pest interactions: a proof-of-concept. *PLoS One*, 8(11): e80518. (Available at http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3829906&tool=pmcentrez&rendertype=abstract Accessed on 11 Dec 2015)

Shekoofa, A., Emam, Y., Shekoufa, N., Ebrahimi, M. & Ebrahimie, E. 2014. Determining the most important physiological and agronomic traits

[33] See http://www.fch.cl/en/iniciativa/foods-and-biotechnology-aquaculture/primary-productivity/
[34] See http://www.crea.org.ar/

contributing to maize grain yield through machine learning algorithms: a new avenue in intelligent agriculture. *PLoS One* 9(5): e97288. (Available at http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4022653&tool=pmcentrez&rendertype=abstract Accessed on 19 Nov 2015)

Tao, F., Zhang, Z., Zhang, S., Rötter, R.P., Shi, W., Xiao, D., et al. 2016. Historical data provide new insights into response and adaptation of maize production systems to climate change/variability in China. *F Crop Res* 185: 1–11. (Available at http://linkinghub.elsevier.com/retrieve/pii/S037842901530071X Accessed on 18 Nov 2015)

Tittonell, P., Shepherd, K., Vanlauwe, B. & Giller, K. 2008. Unravelling the effects of soil and crop management on maize productivity in smallholder agricultural systems of western Kenya—An application of classification and regression tree analysis. *Agric Ecosyst Environ,* 123(1-3): 137–50. (Available at http://linkinghub.elsevier.com/retrieve/pii/S0167880907001648 Accessed on 4 Dec 2015)

2.3 Promising Innovative Extension Approaches for Climate-Smart Agriculture: The Plantwise Example[35]

The important role of extension services

Climate-Smart Agriculture (CSA), as an idea, is a success story and has been rapidly taken up by the international community because of its potential to address the urgent needs of climate mitigation, adaptation and resilience, and food security. While lack of location-specific tools, long-term experiences and a favourable enabling environment are barriers to CSA implementation, there are a number of climate-smart technologies and practices that are known and available. Unfortunately, few have shown widespread uptake. One reason for limited uptake and implementation is the difficulty of sharing information and knowledge on effective CSA practices emerging from research.

National agricultural advisory services can be considered as representing the synapses that bring information from research to the end users, namely farmers. But these advisory services suffer in many developing countries from chronic understaffing, limited operational funds and weak linkages to other players, such as research. Evidence from Africa, for example, shows that the numbers of farmers served by each extension worker is 950 in Kenya, 2 500 in Uganda, and 3 420 in Nigeria (Sones et al., 2015). This situation leads to underperformance of extension systems, limited reach and impact and presents the main challenge for CSA implementation. These systemic constraints can lead to an inability to respond quickly to changing climatic environments with adaptation strategies and are thus a threat for agriculture-based economies.

Extension services were traditionally conceived as the mechanism to put research-based knowledge into use with a strong focus on increasing agricultural production. GFRAS (2012) argues that new global challenges such as declining water availability, increasing soil degradation and changing and uncertain climate and markets means today's role of extension systems has drastically changed. Addressing these global challenges requires generation, adaptation and use of new knowledge, which involves interaction and support from a wide range of organizations. These new challenges also mean that extension systems need to tackle a diversity of objectives that include, but go well beyond, transferring new technology. This encompasses the need to: link more effectively and responsively to domestic and international markets (food, feed, fibers, etc. and/or carbon); reduce the vulnerability and enhance the voice of the rural poor; promote environmental conservation; build linkages between farmers and other agencies; and institutional and organizational development to support the bargaining position of farmers by, for example, forming farmer groups (Davis, 2009; GFRAS, 2012). The new extensionist has therefore mutated from a production centred role to an integrated, cross-sectorial function of the extension ecosystem. Today, extension comes "in many sizes and shapes" (FAO, 1998) and a distinction between the extension approaches as such (e.g. participatory training approach, training and visit approach)

[35] Contribution by Luca Heeb and Wade Jenner (CABI Switzerland), and Dannie Romney (CABI Africa)

or the main underlying principles of the advice (e.g. organic production, integrated production) is not absolute. However, all extension systems share the common challenge of how to best respond to climate change. This is amplified by the fact that CSA considerations in extension strategies can still be considered as new. The need for a shift from a food security focus to an integrated view taking into account both synergies and trade-offs between the three components of CSA is, and will be, a major barrier to CSA implementation and will require considerable investments to develop knowledge and capacities both at extension and farmer level.

Agricultural extension has proven to be a high pay-off public investment in many countries. It is reported in a review of 48 impact studies that 75 percent of extension projects showed significant positive results with rates of return ranging from 13 to 500 percent (Birkhaeuser et al., 1991). A more recent review in sub-Saharan Africa reported similar findings, with 71 percent of the assessed impact evaluations reporting positive impact (Taye, 2013). Therefore, a functional, climate-smart, sensitive and responsive extension system can be considered as an efficient and cost-effective tool that can play an important role in addressing climate change.

Complementary extension approaches for climate-smart agriculture

Based on the previously mentioned challenges, this review has two objectives. Firstly, it shall illustrate how complementary extension approaches can contribute to putting CSA research into use and address climate change mitigation and adaptation based on their reach and impact potential. Secondly, it will show that extension approaches with two-way information flow are particularly valuable to address climate change adaptation because they collect real-time agricultural information and are able to detect effects of climate change on a local scale that can be used for decision makers to react to threats to agriculture. The extension approaches explained hereafter include two approaches taken from Plantwise, a multi-partnership global programme on plant health system development rolled out in over 30 developing countries in Africa, Asia, and Central and South America that provides a mechanism to deal with numerous challenges resulting from climate change (Romney et al. 2012) and one example from a scale-up campaign approach being implemented by the Africa Soil Health Consortium.

There are several ways that extension systems can contribute to CSA. However, the philosophy used (e.g. demand vs. supply led, one-to-one interaction vs. mass extension) and specific approaches suit different types of messages to farmers and provide different possibilities to collect information from farmers' fields. In addition, reach and impact potential, two negatively correlated indicators, are of primary importance and differ between extension approaches: i.e. generally the higher the reach, the smaller the impact and vice-versa (figure 1). Mass media often suits simpler messages while intensive interactions through farmer field schools can be more effective for complex knowledge. Choice of approach combinations can influence the ability of extension services to contribute to food security and income, adaptation and resilience, and climate change mitigation. In the following paragraphs, three extension approaches will be briefly explained and assessed from their CSA perspective, considering primarily their reach and impact potential.

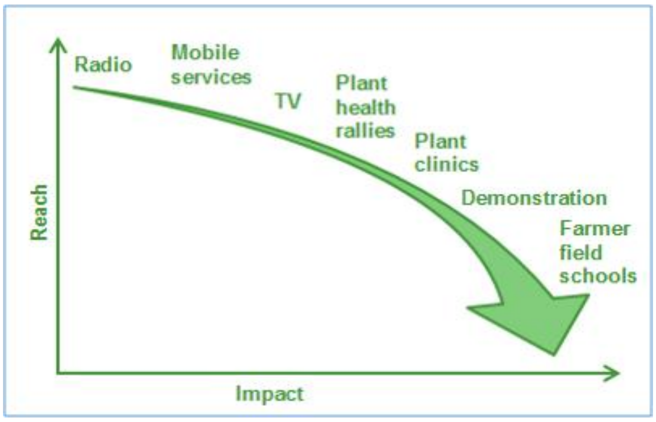


Figure 1 Complementary extension approaches (CABI)

The plant clinic approach to extension works in a similar way to human health clinics; they are the frontline contact point of the national extension system and allow direct information exchange between extension workers and farmers on "any problem and any crop". Plant clinics (figure 2) are a channel for facilitating face-to-face exchange and two-way-flow of knowledge and information between extension workers and farmers and link to other components of a plant health system (Boa et al., 2015). They respond to the immediate needs of farmers, offering advice on demand, and are owned by national and local bodies and run on a regular basis in public places that are best suited to meeting farmers. So far over 1 600 plant clinics have been established in 33 developing countries in Asia, Africa, and the Americas, where farmers can and do ask for assistance on any plant health problem affecting the crops they grow. The various crop problems brought to plant clinics can be related to either abiotic factors (e.g. nutrient deficiency, water-logging, chemical misuse, etc.) or biotic factors (e.g. pathogens, insects, rats, etc.). Farmers then receive practical advice from the extension workers who run the plant clinics. At the same time, the extension workers complete a so-called prescription form, either in printed form or by using a hand-held digital device, to record information about the plant health problem and the advice given. Data about each farmer's visit are held within a central repository and are a goldmine of real-time information. For instance, based on the information on what crop problems farmers face in a certain region, response strategies can be initiated or the suitability of the advice given can be assessed and, if needed, corrective action can be taken.

Figure 2 Plant clinic in Nepal
(Photo by Janny Vos, CABI)

In many countries around the globe, the plant clinic approach has passed its proof of concept phase and national extension systems are now scaling up this innovative extension method. Sri Lanka, as an example, has already implemented the plant clinic approach in 16 out of 25 districts, with over 290 operating plant clinics. Due to its nature of face-to-face exchange and demand-driven service, plant clinics are the ideal approach to transfer messages with a high degree of complexity (e.g. management responses to devastating emerging pests, such as tomato leafminer/tuta absoluta in Kenya) that require direct interaction with farmers. One limitation of the approach is the number of farmers reached due to the need for physical interaction between extension workers and farmers.

Plant clinics can contribute and have contributed in various ways to all three pillars of CSA, both directly and indirectly. Undoubtedly, plant clinics contribute to food security (both in terms of physical and economical access to food) when the targeted advice gives results in reduced crop losses and increased yield. Evidence from a recent study shows that 82 percent of farmers visiting plant clinics in Pakistan, Sri Lanka, Rwanda, Malawi and Ghana reported increasing crop yields due to plant clinic visits (Williams, 2015). Increased crop yields resulting from better crop management practices mostly implies an increase in production efficiency due to a better use of available resources (mostly land and inputs such as fertilizers, pesticides and seeds). This therefore contributes to climate change mitigation directly (more carbon sequestration in soils, less nitrous oxide and methane emission per volume of food) and indirectly (higher yield can lead to less conversion from forest or grassland to annual cropland and therefore less CO2 emissions due to land use change). The role of plant clinics in climate change adaptation is two-fold. On the one hand, climate change causes new problems to emerge at an increasing rate and plant clinics, linked to other plant health systems stakeholders, provide a mechanism to respond quickly to new problems brought by farmers (Romney et al., 2013). For example, drought or salinity resistant varieties, or management responses to new pests, can be promoted via plant clinics, thereby decreasing the vulnerability of farming communities to the effects of climate change. On the other hand, plant clinics can play a key role in terms of surveillance. There is a consensus in literature that developing and rolling-out location specific adaptation measures to climate change is difficult because models cannot project climate change effects precisely, neither in time nor at the local scale needed. Through the data collected systematically at plant clinics, unexpected crop production problems due to climate change can be detected. This enables governments to develop response strategies (via plant clinics or other extension approaches) on how to best cope with problems such as emerging pests, increased temperature, or a shift in the growing season. Plant clinics can also play an important role in building resilience of entire farming systems since their advice focuses on Integrated Pest Management principles. This whole farm approach leads to a decreased dependence on farm inputs (e.g. fertilizers, pesticides), which enables a faster economic recovery for smallholders after price hikes of these inputs.

The plant health rally approach is an extension method for quickly raising awareness about major agricultural risk or threats on important crops, to promote the use of improved agricultural practices, and to collect feedback from farmers on major issues which affect production. The plant health rally approach (figure 3), first described by Bentley et al. (2003), is complementary to the plant clinic approach as it differs in terms of reach, impact and complexity of the messages that it can transmit. Similarly to plant clinics, plant health rallies are run by local extension workers. They are usually held in public spaces and are open to everybody. A plant health rally may be spontaneous, attracting people with a banner and other announcements, or may target farmers who have been specifically mobilized for the event. Every rally begins with a short explanation of the selected topic and then people (mostly farmers) can ask questions and are given factsheets with validated recommendations. Different synergies between plant clinics and plant health rallies can be identified. The most evident is that data collected at plant clinics can be used to identify topics for plant health rallies, thus making the approach an extremely responsive and powerful extension tool.

Figure 3 Plant health rally in Tanzania (Photo by Eric Boa)

As of the end of 2014, almost 290 plant health rallies had been conducted in 14 different countries reaching over 21 000 farmers with targeted messages. Especially in countries like Malawi, Uganda and Zambia this approach has been used by the public extension system and is valued for its ability to reach a high number of people in a targeted area within a short time (Mur et al., 2013). Experiences from Malawi show that in two days, 34 plant health rallies were held and more than 4 000 farmers were reached with management tactics on important pest and diseases, such as cassava mosaic virus or witchweed, both a big threat to food security.

Plant health rallies and plant clinics share common goals and thus contribute in a similar way to CSA objectives. Nonetheless, while the plant clinic approach has its focus mainly on responding to emerging problems (and surveillance) and contributing to food security and mitigation via targeted demand based advice, plant health rallies have a stronger emphasis on awareness raising and prevention. Since the plant health rally approach does not imply/allow a face-to-face interaction between individual farmer and extension worker like at a plant clinic, the level of complexity of the information to be transmitted to farmers decreases but the number of farmers reached rises. Due to its hybrid nature between mostly supply led approaches such as classical mass media approaches and two-way, demand driven approaches such as plant clinics, rallies best suit building awareness of climate change and its related implications for farming. The approach can also contribute to climate change mitigation; for example, plant health rallies would find perfect fit as a vehicle for putting mitigation research, such as urea deep placement technology in rice production, into use and thus reducing greenhouse gas emissions from paddy rice.

Plant clinics and plant health rallies, though reaching many farmers, still reach only a modest proportion of farmers. The mass extension campaign approach, in contrast to plant health rallies and plant clinics, delivers targeted messages to thousands of farmers through relevant media such as radio, television, mobile phones and print media, including newspapers and youth targeted publications (figure 4).

Major constraints of national extension systems are shortage of field extension personnel and limited resources to reach large numbers of farmers if spread widely across geographical areas. To tackle these constraints, extension can be more efficiently performed using mass media; for example, in Myanmar the Ministry of Agriculture and Irrigation runs a farmer channel aimed at informing and educating the farming community. Extension with mass media can also be run by non-extension players (e.g. radio or television) with technical inputs on messaging from extension workers, for awareness creation or simple information delivery. However, one must consider that although the high reach of mass extension campaign approaches is very attractive, impact can be limited. Also, there is a risk of exclusion of certain population groups whose accessibility to a certain information channel is not guaranteed or that this largely supply led approach might not respond to real farmers' needs. Plantwise aims to address this by linking mass media with plant clinics so that messaging is informed by the problems brought to clinics and by working with different mass media approaches in order to reach different types of household and different family members.

The use of mass extension campaigns is a relatively new concept in Plantwise (from where this contribution takes its examples). Therefore, evidence of successful implementation and impact cannot be assessed yet. However, there are examples from other projects that have shown suitability of mass extension using mass media approaches in the frame of climate-smart agriculture. A participatory mass extension campaign in Malawi, for example, has shown positive impact of radio messages on farmers' understanding of climate change and its effects, on how to produce high quality compost or about the importance of compost for building resilience (Mloza Banda, 2014). This example also shows that extension approaches that are best suited for awareness raising have the potential to contribute to climate mitigation, adaptation and increase food security.

Figure 4 "Shujaaz" comic storyline developed for the Maharage Bingwa (Champion bean) scale-up campaign coordinated by the Africa Soil Health Consortium in Tanzania (Well Told Story 2015)

Concluding remarks

Successfully rolling-out CSA will require considerable efforts from a variety of stakeholders. Extension services are, and will be key players because of their key role in knowledge transfer and their vicinity to farmers' fields. The correct mix of different extension approaches will largely depend on factors such as: the complexity of the extension messages, the target population and its geographical spread, the available technology, the type and variety of data to be collected from farmers, and lastly on the financial means available for extension as such. On-the-ground implementation of extension also needs to go hand in hand with advocacy and awareness raising of decision makers on the imminent threat of climate change for agriculture in order to make extension more responsive to climate change and contribute to address the triple challenge of food security, adaptation and mitigation.

References

Bentley, J.W., Boa, E., Van Mele, P., Almanza, J., Vasquez, D. & Eguino, S. 2003. Going Public: A New Extension Method. *International Journal of Agricultural Sustainability,* 1(2): 108-123.

Birkhaeuser, D., Evenson, R.E. & Feder, G. 1991. The Economic Impact of Agricultural Ex-tension: A review. *Economic Development and Cultural Change*, 39(3): 607–640.

Boa, E., Danielsen, S. & Haesen, S. 2015. Better Together: Identifying the Benefit of a Closer Integration Between Plant Health, Agriculture and One Health. *In One Health: The Theory and Practice of Integrated Health Approaches*, Chapter 22, pp. 258-259.

Davis, K. 2009. Agriculture and Climate Change: An Agenda for Negotiation in Copenhagen. The Important Role of Extension Systems. *International Food Policy Research Institute, Brief 11, Focus 16*. (Available at http://www.asb.cgiar.org/content/agriculture-and-climate-change-agenda-negotiation-copenhagen-important-role-extension-system Accessed on 19 Nov 2015)

FAO. 1988. *Definition of Several Extension Approaches*. (Available at http://www.fao.org/docrep/v9122e/v9122e02d.htm Accessed on 1 Nov 2015)

GFRAS. 2012. The "New Extensionist": Roles, Strategies, and Capacities to Strengthen Ex-tension and Advisory Services. *Global Forum for Rural Advisory Services, 1-3*. (Available at http://www.g-fras.org/en/157-the-new-extensionist.html Accessed on 19 Nov 2015)

Mloza Banda, B.C. 2014. *E-adaptation to Climate Change in Malawi, ICT Update 78*. (Available at www.cta.int/images/iyff/ict4ag-78-en.pdf Accessed on 9 Nov 2015)

Mur, R., Williams, F., Danielsen, S., Audet-Bélanger, G. & Mulema, J. (eds). 2015 Listening to the Silent Patient. Uganda's Journey towards Institutionalizing Inclusive Plant Health Services. *CABI Working Paper 7*, 224 pp.

Romney, D., Boa, E., Day, R., Negussie, E., Reeder, R., Rehman, A. & Simons S. 2012. *Solving the problem of how to solve problems: Planning in a climate of change*. Presented at Planet Under Pressure Conference, March 26-29, 2012, London. (Available at https://elsevier.conference-services.net/reports/template/onetextabstract.xml?xsl=template/onetextabstract.xsl&conferenceID=2808&abstractID=573499 Accessed on 17 Nov 2015)

Romney, D., Day, R., Faheem, M., Finegold, C., LaMontagne-Godwin, J. & Negussie, E. 2013. Plantwise: Putting Innovation Systems Principles into Practice. *Agriculture for Development,* 18: 27-31.

Sones, K.R., Oduor, G.I., Watiti, J.W. & Romney, D. 2015. Communicating with Small-holder Farming Families - A Review with a Focus on Agro-dealers and Youth as Intermediaries in sub-Saharan Africa. *CAB Reviews, 2015*, 10(030): 1-6.

Taye, H. 2013. Evaluating the Impact of Agricultural Extension Programmes in sub-Saharan Africa: Challenges and Prospects, *African Evaluation Journal* 1(1), Art. #19. (Available at http://dx.doi.org/10.4102/aej.v1i1.19 Accessed on 10 Nov 2015)

Williams, F. 2015. *Plantwise Rapid Satisfaction Survey*. Unpublished internal document, CABI.

2.4 A citizen science approach for Climate Smart Agriculture: triadic comparisons of technologies (tricot)[36]

An introduction to triadic comparisons of technologies (tricot)

Triadic comparisons of technologies (tricot) is an approach that applies citizen science and crowdsourcing methods to evaluate climate-smart technologies on-farm in a way that facilitates joint learning across different sites. The tricot citizen science approach is participatory in nature and scalable to include many farmers. The approach makes it feasible to evaluate options with many farmers by using a simple format for technology evaluation. Each farmer receives three technologies (new seeds, inputs, etc.) and gives feedback about which is the best and worst technology of the three from the farmer's perspective. Information is collected using an Android app or through (automatic) mobile phone interviews. As each farmer receives a different combination of three technologies, it is possible to evaluate a large set of options. By combining the farmer-generated data with data from other sources, especially climate, soil and socio-economic conditions, the approach generates information about interactions of technologies with their environments and their potential contribution to Climate-Smart Agriculture (CSA). The information serves to inform farmers about the options, through field activities, and to inform researchers and input and service providers.

[36] Contribution prepared by Jacob Van Etten (Bioversity)

The approach has been designed through extensive testing in India, East Africa and Central America in projects led by Bioversity International for contribution to the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS). A large number of organizations have now implemented the approach, including CATIE (Central America), NARI (Tanzania), Mekelle University (Ethiopia), ICAR and a large number of Krishi Vigyan Kendra KVK farm science centres, which have on-farm testing as part of their mandate (India). A number of other organizations are also preparing or considering tricot trials.

Contribution to CSA

The tricot approach has already contributed to CSA through applications to drought-tolerant crops, such as sorghum and pigeon pea, and by introducing drought-tolerant varieties of staple crops. Also, other CSA practices can be evaluated with the tricot approach. Through the approach, farmers can systematically compare their on-farm observations. As many farmers share insights arising from their test plots, they can jointly infer from the spatial variability how the different options do under different conditions.

Tricot trials can contribute to increasing productivity by introducing improved technology, and to adapting to future climates by recurrently evaluating new options under changing conditions. To contribute to the third pillar of CSA, a specific focus on greenhouse gas emission reducing technologies would be necessary, for example the introduction or expansion of legumes. This could be combined with citizen science observations of soil carbon in order to quantify the contribution of these technologies to carbon sequestration.

The approach is being supported by an online platform (ClimMob.net) that supports the design of tricot trials, data collection and analysis. A mobile app for Android systems supports data collection in the field. A number of training materials are available, including instructional videos and manuals. At the moment (May 2016), Bioversity International is adding the possibility to gather feedback from farmers using interactive voice response through automated phone calls.

The effectiveness of the approach has already been demonstrated in a number of contexts. Tricot provides a time-saving and cost-effective approach compared to other on-farm participatory approaches that are more labour-intensive and require close supervision from trained professionals. Still limited evidence is available, however, about farmer adoption of technologies and practices introduced into local farming systems using the tricot approach.

Way forward

At the moment of writing, farmer research networks with several thousands of farmers are using the tricot approach. The ClimMob platform (ClimMob.net) makes it relatively easy to implement a new tricot trial. The approach is relevant in the context of CSA. CSA will require a fast-paced change in technologies in ways that take local conditions into account. The low skill-requirement of tricot trials facilitates transfer of the approach to many situations.

A challenge is the design of appropriate experiments for different technologies. A number of design choices need to be made, for example about sample size (e.g. number of participants, number of technologies to be tested). Some experience has already been accumulated in this regard. Design of tricot citizen science experiments also involves the creation of visual materials to support the on-farm trials and these materials are tailored to local language and production systems. Over time, best practices should emerge for different types of CSA technologies in relation to the variables that participating farmers can observe, how to motivate farmers to participate, and the design of communication materials.

Scaling the tricot approach requires adoption by national institutions and enterprises. Some institutional adjustments and investments will be needed to achieve this. A closer collaboration between research institutions and technology providers on the one hand, and agricultural extension and farmer organizations on the other, will be needed to provide the necessary institutional conditions to implement tricot trials at scale. Also, research organizations and technology providers will need to be prepared to receive farmers’ feedback on their technologies, even if this feedback is negative.

The relative advantage of the tricot approach would be its scalability. It is less suitable for gathering new insights or detailed feedback. It therefore does not replace other participatory research methods but does provide a useful addition to the toolbox of CSA.

2.5 The CSA Prioritization Framework in Guatemala - lessons learned[37]

Extension services in Guatemala

Guatemala's agriculture sector contributes 11.5 percent to the national economy and generates a third of the total employment (World Bank, 2016). Recurrent, severe droughts over the past two years have heavily affected crop subsistence farmers in the country's dry corridor. The prolonged dry spell in 2014 resulted in harvest losses of about 70 percent for beans (equivalent to 70 000 tons) and 80 percent for maize (200 000 tons), compared to 2013 yields, affecting more than 250 000 inhabitants of the region. These losses were evaluated at US$ 58 million and have had important consequences on regional and local food reserves, people's nutrition and health, including access to drinking water (OCHA, UNETE, 2014).

Previous studies identified a variety of public and private actors working towards diminishing the impacts of such climate threats to the country's social and economic development and ensuring national food security. Initiatives have come in the form of research, capacity building and extension, technology transfer and rescue of traditional knowledge and practices, and policy development. The National Policy for Climate Change, the Framework Law for regulating activities on climate change vulnerability, adaptation and greenhouse gas mitigation (2013) and the National Policy for Integrated Rural Development (2009-2016) are some examples of efforts that have contributed to the creation of a favourable policy environment for CSA in the country (Bouroncle et al., 2015; CCAFS, 2014).

In 2014, the Ministry of Agriculture, Livestock and Food (MAGA) of Guatemala worked closely with the International Center for Tropical Agriculture (CIAT) and the CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS) to analyze opportunities for CSA investments in Guatemala's dry corridor region. The "Climate-Smart Agriculture Prioritization Framework (CSA-PF)" initiative sought to identify and prioritize CSA practices that contribute to enhancing the food security and livelihoods of vulnerable farmers in the region. Previously that year, the Government had designed an emergency plan (Bouroncle et al., 2015) to support drought-affected families in the dry corridor. The CSA-PF aimed to build on this effort and generate a process that combines quick responses to climate risks with long-term planning for building the adaptive capacity of populations exposed to changes and variability in climate.

The plan, "Del corredor seco a corredor de Oportunidades: Plan de atención a familias afectadas por canícula prolongada de 2014" (Bouroncle et al., 2015), consisted of several components: food assistance (rations) for the households willing to adopt soil and water conservation practices aimed at increasing agricultural system's resilience to future climate threats, the establishment of community markets, as well as long-term investments in conservation strategies.

[37] Contribution by Andreea Nowak (CIAT), Caitlin Corner-Dolloff (CIAT), Miguel Lizarazo (CIAT), Deissy Martínez Barón (CCAFS)

Linking local extension services to CSA with CSA-PF

This joint effort between MAGA and CIAT/CCAFS was built on the principles of inclusive planning and knowledge co-creation, with the aim of building understanding and capacity to prioritize investments that echo the three CSA pillars (productivity enhancement, resilience building and low-emissions agricultural development). The CSA-PF facilitated the creation of a decision-making forum for actors to narrow down long lists of CSA options into portfolios for promotion and scaling out.

In Guatemala, the prioritization process was developed into four main phases, between 2014 and 2015. In a first step, a team of experts from MAGA's Climate Change Unit, the main user of the process, defined the objectives and the scope of the prioritization. The team then developed a list of potential (vulnerable) regions of focus, production systems and related CSA practices (long list). External experts evaluated the impacts of these practices on indicators of adaptation, mitigation, and productivity, with the aim of highlighting those practices that have the highest aggregate benefits to CSA. All these results were then discussed and validated by a wider variety of stakeholders (government decision-makers, academics, donors, producer organizations, etc.) during a participatory workshop (phase two), to ensure usability and consistency with actors' agendas. As a result of discussions, the focus of the process was narrowed down to CSA practices (short list) relevant for small-scale maize and beans farmers in the dry corridor region.

In a third phase, the costs and benefits of these short-listed practices were calculated using a combination of economic analysis, expert interviews, literature review and household surveys. In a subsequent step (phase four), the results of the cost-benefit analysis were brought back to the stakeholders' table for discussion, validation and definition of next steps. With multiple sets of results from the different phases, which were considering different CSA dimensions (adaptation, productivity, mitigation) and angles (social, economic, environmental, policy and institutions), stakeholder groups then grouped practices into CSA portfolios that would be consistent with their investment priorities in the area.

One of the major achievements of the process has been the development of CSA investment portfolios, the result of a thorough analytical, expert-led process and reflective of stakeholders' different priorities for the dry corridor region. While farmers and the non-governmental sector prioritized practices with higher rates of return on investments, the research and academia group opted for investments with higher positive impacts on productivity and environmental indicators (conservation agriculture, crop rotations). Less barriers to adoption and adoption feasibility for small-scale farmers were additional criteria that governmental actors used for building their suggested portfolio (water and soil conservation practices). In general, actors looked at high-interest practices not just from a technical, agro-environmental feasibility perspective, but also from the point of view of the socio-cultural appropriateness of a practice (cultural acceptance of a practice by a farmer).

Likewise, the CSA-PF generated capacity to analyze and interpret information to support decision-making. Applying a variety of analytical frameworks – vulnerability assessments, CSA impact assessments, economic analysis, participatory assessments of barriers and opportunities – governmental actors were able to assess and validate practices that had been previously incentivized in the dry corridor (through the drought emergency policy) and fill information gaps. They identified new practices to be adopted and scaled out with extension offices, based on the new information generated through the process (especially related to social and economic costs and benefits of implementation). Moreover, national stakeholders gained more knowledge and understanding of the CSA concept and its relevance for Guatemala's agricultural sector.

The prioritization process facilitated the shaping of a more long-term, integrated vision of agriculture investments for food security that is no longer focused exclusively on boosting productivity, but also on building farmers' resilience and contributing to low emissions agricultural development. It also created momentum for aligning actors' agendas to the commonly-agreed goals for Guatemala's dry corridor. By actively participating in the various project stages, either through sharing, co-creating or validating knowledge and information, stakeholders demonstrated a first ambition to work together towards shared objectives. However, offshoot efforts are needed to transform this impetus into concrete actions on the ground, where farmers can seize the benefits of such processes. Such follow-up options would include the design of joint investment action plans and collaborative proposals for further financing of CSA work in the region, among others.

Lessons learned

The CSA-PF also enabled mechanisms for higher integration between actors working on CSA-related topics in Guatemala, from ministries to experts and researchers, private sector entities and farmers representatives. Identifying stakeholders and analyzing the key contributions to CSA promotion and scale out helped maximize their effective participation in subsequent phases. Dynamics between actors were generated and they were based on the principles of information sharing and knowledge co-creation, core aspects of a sustainable learning process. However, more efforts need to be directed towards recognizing and operationalizing linkages between agriculture and sectors immediately related to it (forestry, environment, health, rural development, among others). A first step to making this integration viable would be through effective engagement and equitable participation in the entire process, from scope definition, to portfolio creation.

The CSA portfolios that stakeholders in Guatemala built do not constitute silver-bullet solutions to the drought that threatens thousands of households in the dry corridor region, but rather a pallet of options that take into account different dimensions and respond to different uses and needs. Investment portfolios were tailored to the stakeholder groups' agendas, to their capacity to invest and available resources, as well as local realities. This is to say that, while all portfolios selected have high adoption and scale-out potential to national or regional AEZs with similar conditions, one needs to bear in mind that this prioritization is highly dependent on various factors: the investment perspective, local socio-cultural contexts, and institutional capacity to operationalize changes. In

Guatemala, strengthening the mechanisms and capacity to diffuse information generated from the CSA-PF is key for the continuity of the efforts. Local extension offices need to be able to operationalize portfolios with the adequate financial, technical, and human resources.

The success of the CSA-PF in general, and in Guatemala in particular, relies heavily on stakeholders' commitment to the commonly defined objectives and their willingness to collaborate, both from a financial and a political-institutional perspective. Political will is particularly important for legitimizing the process, but also for creating a favourable environment where the potential of the CSA portfolios to influence national policies and strategies can be effectively tapped. Without further commitment of the stakeholders (direct and indirect users of the results) to remain engaged in the process, either through planning policies and strategies or through financing CSA investments, the likelihood of those prioritized interventions to be operationalized may be at risk.

References

Bouroncle, C., Imbach, P., Läderach, P., Rodríguez, B., Medellín, C., Fung, E., Martínez-Rodríguez, M.R. & Donatti, C.I. 2015. La agricultura de Guatemala y el cambio climático: ¿Dónde están las prioridades para la adaptación? Copenhagen, Denmark: *CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)*.

CCAFS. 2014. Estado del Arte en Cambio Climático, Agricultura y Seguridad Alimentaria en Guatemala. March 2014. Copenhagen, Denmark: *CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).*

OCHA, UNETE. 2014. *EMERGENCY RESPONSE PLAN; Extended dry spell / drought 2014 in Guatemala*, 25 pp.

World Bank. 2016. *World Development Indicators*. (Available at http://databank.worldbank.org/data/reports.aspx?source=2&type=metadata&series=NV.AGR.TOTL.ZS Accessed on 19 Nov 2015)

2.6 Sustainable intensification of smallholder rice production: lessons from Asia[38]

Rice Chain Climate Chain Adaptation Project

The project focused on participatory research and climate change resilience tool development with farmers in rice-based farming systems of Thailand. It was supported by HIVOS, Netherlands, in partnership with Earth Net Foundation, Thailand (acting as the coordinating partner), along with Sahaja Samrudha and Kudumbam (India), VECO and FIELD (Indonesia), SEARICE (Philippines), CEDAC (Cambodia), and Janathakshan and FFCTSAR (Sri Lanka).

While this 3-year project has yielded many identified climate resilient methods, tools and varieties, it is the overall approach and methodology that may be the most interesting to apply and adapt to other situations.

While each partner has its own experience and there is some variation, the general collective approach has been as follows.

1. The target group is small-scale farmer groups and/ or communities.

With facilitation normally by extension staff, the process starts with a review of actual climate change and experienced climate related stress and disasters. Actual climatic information can be provided by the meteorological department as well as other resources. This information however needs to be converted into a form that is clear and usable by the farmers involved. A good choice is to convert it into graphs for norms of temperature and rainfall 30 years ago and at present. This then shows the general shift from past to present.

2. Conversion of climate information

As all partners have identified rainfall as the most critical factor, and changes in the rainfall pattern causing major stress, the information is converted to look at rainfall shifts in 15-day (half month) periods. In the Indian context these periods correspond to "Rain Stars." So for any given 15-day period, one can see if the trend is an increase in rainfall, reduction in rainfall, or similar rainfall.

3. Crop calendar

An additional tool that is collectively developed is a crop calendar of key crops, including rice. The crop calendar, as it overlaps the rainfall calendar and shift in rainfall, shows where a lack or excess of rainfall may be a problem, and then can lead to choices for testing, such as a change of variety (shorter duration), a change in planting date or even a shift to another crop.

4. Participatory mapping of crops and areas of climatic stress and disaster

With the easy availability of aerial imaging, such from services like Google Maps and vinyl printing, one can print out a large map of a community at quite a low cost. The farmers participating then use coloured markers to identify different agriculture zones, roads, waterways, structures, and areas where climatic stress/disaster occurs. From this process we can see where different crops are grown and where the greatest risks of flooding and drought stress are. These maps often reveal that what is perceived as climatic stress is an interaction of climatic changes with land

[38] Contribution prepared by Michael Commons, Earth Net Foundation (michael@greennet.or.th)

use changes. Roads and canals become barriers to water flow, exasperating flooding. Drought stress may be a problem for a high water use crop where for another crop there is no issue.

Earth Net Foundation, which also had good support from the SEA START Regional Center to generate climatic projections based upon the leading scenarios for specific areas, additionally provided graphs for expected climate norms and rainfall shifts 30 years into the future. Unfortunately, most other partners could not obtain such information. Nonetheless, starting from clarity of what the climatic norm was, what the current climatic norm is, changes in rainfall and then seeing what crops this has affected and where climatic stress and disaster has been most problematic, all gives a clear basis to evaluate the situation.

5. Farmer-based identification of climate risks

At this point, the farmers involved identify what the climate related risks are. Common risks for partners include: delay of rain; dry spells within the rainy season; flooding during different periods; and rains during the harvest period when it should be dry. For some areas salt infiltration and typhoons were important climatic risk factors.

FIELD-Indonesia developed a very simple but effective tool for weighing the importance of these risks by plotting them on a two axis chart. One axis is frequency. The other axis is severity. More frequent risks with greater severity of damage deserved the most attention.

Thus from this process the group could decide the priority risk for their community, such as dry spells during the rainy season.

Reviewing this risk, the group then would look at identified resistance as well as consider other possible measures to test. Identified resistance are cases in the community or area that performed in spite of climatic stress. Certain varieties (like a drought tolerant traditional variety) may have performed better. Certain planting practices (like SRI) may have performed better. Water management practices (like a farm with a pond) may have performed better. Aside from what is identified to have resistance, they or the facilitator may know of other varieties, crops, tools and practices that have shown resistance elsewhere.

6. Identification of resilient practices and tools

From this process the group/community identifies one or more practices, tools or varieties to test for resilience. Then whether collectively (like FFS) or individually, they test this variety, method or tool. Amongst many of the better farmer researchers (and sometimes other supporting entities) they also start to do regular weather information collection of low and high temperature, precipitation, and in the case of at least one farmer scientist in Indonesia, evaporation. Observations during and at the end of the crop cycle, when combined with such information, present a clear picture of what climatic stress has occurred and how the method/variety being tested is performing.

As with any such research, and in our experience as well, the test scenario often does not sufficiently fit the actual climatic scenario for that season. If one tests for resistance to dry spells, yet there is no major break in the rainy season, then one cannot get good information on that point in that season. However, over a number of seasons, one is sure to eventually get a match. More important, however, was generating and supporting this process of farmer research, observation and sharing. While the testing sometimes did not result in clear information, as farmers consciously observe performance and share experience of what they are doing, they may identify and share other resilient varieties, crops, and methods beyond what was chosen for research.

Concluding remarks

With climate change there is no silver bullet and in all of the project partner areas increased climate variation and variability is the trend. Scientific research and projections show that climate change will continue long into the future, so the present norms and the situation 10, 30 or 50 years into the future may be very different. Thus the objective of the project was not to find any one solution but first to develop communities and groups of farmers into active researchers. Then this active research and exchange of knowledge and experience on different levels has created a sort of climate resilience tool box that can be dipped into to try and test and adapt in new situations. Again it is not viewed that any crop, variety, method, or tool will necessarily work for a given new situation; they must be tested and fit within other constraints such as culture and market demand.

If and as this sort of methodology spreads and more communities become active researchers of climate resilience tools, methods, and varieties, this collective body of knowledge will increase. The method itself is very empowering for farmers and communities to take an active role in developing their own resilience capacity. It does not require significant outside resources. With farmers (as in our cases) who already see that climate change and variability is damaging their crop performance, incomes, and livelihoods, they have an interest to reduce these risks. Most of the effort and process is done by the farmers. Once the farmers become farmer researchers, then they tend to continue observing and experimenting. The external investment is in the facilitation process, particularly this initial awareness process and evaluation of risks and choice of what to test. Most partners did this process in one to two days. Then to better share knowledge, someone from outside (extension staff) can help to document and share the experiences, making the knowledge available to other communities.

In some cases, academia and local governments have seen the value of this process and are continuing to link with farmer researchers to help document their work and spread their knowledge. Where farmer research may not be given credit, the academic link can then give more scientific weight to what has been learned, allowing for easier promotion in policy circles.

2.8 EARLY WARNING SYSTEMS AND THEIR ROLE TO SUPPORT GOVERNMENT ON CSA[39]

Introduction

Kotido has been having drought, insecurity and food insecurity for several years, which has affected the people and also services, such as: health; water availability for both humans and livestock; diseases and pests for crops and livestock; insecurity; environment degradation; and many others. In an effort to assist the community there was a need to develop a system that would increase their resilience to the weather pattern, food insecurity and give timely information to the farmers on the impending disaster.

Early warning system

An Early warning system was designed for the whole of Karamoja region by ACTED in collaboration with the Local and National governments, UN agencies, like FEWSNET/IPC/CEWARN, and development partners. This is being implemented under the existing structure of the Local and National Government. A Non-Governmental Organization called ACTED, in collaboration with the Office of the Prime Minister and Ministry of Agriculture, has been offering technical and financial support for the process.

Methodology

This system consists of collecting and analyzing data monthly, scrutinizing the information generated and disseminating it to the community who is at risk in the region/district/sub-counties. This information, which is related to the level of vulnerability and the pending risk, is delivered in a timely manner. By monitoring selected indicators, the district authorities can predict in advance the risk of drought, famine, disease and pest outbreaks, marketing, water availability for humans and livestock insecurity, etc.

The system therefore acts as an alert signal to the communities, the relevant district departments and the development partners, on time, whenever a risk of disasters is rising and to initiate the implementation of preparedness measures in order to minimize the impact on the population. The Heads of Departments in the district can give recommendations to the various stakeholders on the best strategy to follow to help the communities get prepared.

[39] Contribution prepared by Levi Abura, Kotido District Local Government (Uganda)

Section III – Knowledge and Participation

3.1 Digital Green: Participatory video as a promising tool for extension in the field of CSA

Overview and Background

Digital Green began in 2006 as a research project in Microsoft Research's Technology for Emerging Markets group, motivated by understanding how information and communication technologies could support small-scale farming systems. Digital Green tested multiple extension approaches and compared use of posters, audio messages and videos to conventional extension methodologies, such as Training & Visit (where extension agents visit farmers and provide in-person training on improved practices) and Farmer Field Schools (using demonstration fields to provide hands-on training and demonstration of the improved practices). These experiments led to the development of Digital Green's approach, which involves partnering with existing public, private and civil society organizations involved in extension and layering technology to amplify their efficacy and efficiency. Digital Green became an independent non-profit organization in 2008 and is adapting and scaling its approach to engage more than 800 000 farmers (80 percent women) across India, Ethiopia, Afghanistan, Ghana, Niger, Papua New Guinea and Tanzania.

Digital Green uses a participatory approach to train extension agents and peer farmers to produce short videos featuring local farmers demonstrating improved agricultural practices or sharing testimonials using low-cost pocket video cameras, microphones and tripods. The videos are distributed using mobile, battery-operated projectors among small groups of farmers. An extension agent or peer farmer facilitates a discussion among the group viewing the video and records data on farmer feedback, their questions and level of interest and which practices they adopt. Data and feedback informs the production and distribution of the next set of videos in an iterative cycle that progressively better addresses the needs and interests of a community. In a controlled evaluation, the approach was found to be seven times more effective in terms of adoption of new practices and ten times more effective on a cost-per-adoption basis (Ghandi et al., 2009).

Participatory video is the core delivery mechanism for Digital Green's approach; however, Digital Green also uses other communication channels, such as broadcast television, radio and mobile applications and IVR, to disseminate and reinforce extension messaging and link farmers to markets. Digital Green has found that different modes of communication can complement one another across the awareness-knowledge-adoption-productivity continuum of agricultural extension. Farmers are most open to information when it comes from sources similar to themselves in contexts with which they can identify. Digital Green is also using videos to build curricula that are incorporated into the training regimes of extension agents.

Climate Smart Agriculture

Digital Green's model promotes the adoption of climate-smart agriculture (CSA) practice in India and Africa, with the effect of sustainably increasing agricultural productivity and incomes. Most of the content of the videos produced and disseminated to farmers is focused on boosting farm productivity with improvements in farm management and agronomic practices, rather than the "technology transfer" of traditional extension, which often focuses on supplying improved inputs, including harmful synthetic pesticides and fertilizers. It also reduces cost and increases resilience of farmers, reducing their risk to climate and market shocks. The focus emphasizes taking advantage of locally available, endogenous knowledge and resources and those that show the strongest constraint on yield, including water, soil management and pest management (Hengsdijk & Langeveld, 2009).

The Government of India's National Rural Livelihood Mission (NRLM), for instance, is leveraging Digital Green's approach to promote the adoption of improved rice production practices including seed nursery raising and transplantation in paddy cultivation, weeding and water management, and seed treatment. These practices follow the government-approved environmental guidelines, which include pest management, disease management, soil nutrient management, cropping patterns in rain-fed areas, and soil and moisture conservation. Following these guidelines is an important part of Digital Green's approach to work with existing systems since setting up parallel systems limits the long-term viability of the approach.

In addition to rice, Digital Green promotes practices to improve productivity in teff in Ethiopia, wheat in India, pulses, oilseeds, and vegetables. This includes methods to enable farmers to apply fewer seeds, grade and treat seeds, sow with wider spacing, use organic manuring, intercropping, optimizing water management, and using organic fertilizers and pesticides. This approach reduces the consumption of chemical inputs and water, increases overall agronomic productivity, and increases farmers' resilience and incomes. Promoting yield-boosting practices lies in the farmers' natural interests and they are also less harmful to soil and the surrounding environment. Rather than convincing farmers to adopt complex practices that require additional, sometimes costly inputs, the content of Digital Green practices rely on endogenous knowledge that is relevant to the local context.

In addition to the practices themselves, the Digital Green approach to improving agriculture extension also helps to promote CSA. For instance, videos feature local individuals and contexts that viewers are able to relate to and then are encouraged to adopt new practices, increasing their skills and experience with adaptation. Videos feature a variety of different farmers in different conditions adapting and applying practices, which is critical with increased climate variability. Self-efficacy among farmers is often increased as they see peers as role models whom they can aspire to become (Bernard et al., 2014), in part by adopting new practices and realizing the benefits to themselves and their families. Perceptions of risk are reduced by seeing farmers apply practices from start to finish. The videos also provide insight on how to access products, services and resources that might be needed to take action on them. Data collected and feedback at an individual level helps to identify weather, pest, disease constraints or other climate issues that may be an effect of climate change. These data can add insight to climate variability in different regions, show how climate patterns affect some farmers more than others, and allow for better targeting of extension programs.

The approach includes a robust data collection and monitoring system that enables governments to track the adoption of new practices, so governments can implement and track the implementation of CSA practices. Digital Green developed an open-source data management system, called Connect Online Connect Offline (COCO) (Shah and Joshi, 2010) to collect information related to the adoption of improved practices. Extension agents, for example, can access the system on- and offline to easily and accurately enter data about video screenings, interest and questions from farmers, and adoption of technologies promoted in the videos, providing feedback that informs future content. These data are publicly available on Digital Green's analytics dashboards (analytics.digitalgreen.org), videos library (digitalgreen.org/discover), and Farmerbook (farmerbook.digitalgreen.org) platforms to drive knowledge sharing and increase the accountability of extension through transparency. Digital Green has partnered with national agriculture research systems and international CGIAR centres, like IRRI and CIMMYT, to contribute technical input and review farmer feedback and adoption data to inform research agendas. Digital Green also used the data sets to conduct social network analyses to identify influencers and other factors that drive adoption on new practices among farming populations.

Lessons learned

Digital Green works with government partners to institutionalize the core components of the approach into permanent programming, providing opportunity for making CSA practices standard. Risks of the approach include shifting political dynamics that can affect CSA programming and the lack of technical expertise on climate smart practices. Working through government systems requires a reliance on existing staff capacity of extension workers and limited measures to ensure accountability. Digital Green is working to mitigate these risks by providing outside technical expertise to provide additional technical support, where needed, and using data and feedback at the level of individual extension agents to promote accountability.

Digital Green achieves scale through two channels: integration with host-country systems, and the replication of the approach through partner organizations. Since the approach is integrated with government and private extension systems, it can be scaled up to work with additional locations and with a greater number of farmers with low incremental cost. In India, NRLM has invested considerably in supporting the expansion to more than 5 000 villages across the country through the purchase of equipment, compensating staff, and supporting training. As aspects of the approach (video production, dissemination, and data collection) become institutionalized, Digital Green's role shifts to one focused on providing technical assistance and overseeing quality assurance.

Digital Green's franchisee model enables replication of the approach, supporting public or private partner organizations to replicate it through (1) online and in-person training and accreditation on community facilitation, video production, and data management techniques via Digital Green's Virtual Training Institute (VTI)[40]; (2) access to Digital Green's

[40] VTI is a standardized curriculum to enable increased training on the Digital Green approach of producing and disseminating

open source technology stack, with technical assistance as needed; and (3) links to the content library and knowledge partners that are able to provide relevant inputs to franchisees. In addition to areas of current operations, Digital Green is expanding its model to Bangladesh and Malawi.

References

Bhardwaj, N. & Seth, Y. 2013. Identification of highly influential individuals in a rural social network. *In Proceedings of the 3rd ACM Symposium on Computing for Development* p. 47. ACM.

Bernard, T., Dercon, S., Orkin, K. & Seyoum Tadesse, A. 2014. *The Future in Mind: Aspirations and Forward-Looking Behaviour in Rural Ethiopia*. (Available at http://www.worldbank.org/content/dam/Worldbank/Feature%20Story/Africa/afr-tanguy-bernard.pdf Accessed on 5 Nov 2015)

Gandhi, R., Veeraraghavan, R., Toyama, K. & Ramprasad, V. 2009. Digital Green: Participatory video and mediated instruction for agricultural extension. *Information Technologies and International Development*, 5(1): 1-15.

Hengsdijk, H. & Langeveld, J.W.A. 2009. Yield trends and yield gap analysis of major crops in the world; *Wageningen, Wettelijke Onderzoekstaken Natuur & Milieu*, WOt-werkdocument 170 blz. 57; fig. 15; tab. 13; ref. 40; bijl. 2.

Shah, S. & Joshi, A., 2010, December. COCO: A web-based data tracking architecture for challenged network environments. *In Proceedings of the First ACM Symposium on Computing for Development,* p. 7. ACM.

videos, capturing and reporting data and information.

3.2 GACSA CIS and Gender Analysis[41]

Overview

The approach presented here synthesizes research results from several years of activities in three African countries working on climate change adaptation with the Climate Change, Agriculture and Food Security (CCAFS) research program in the CGIAR (Consultative Group on International Agricultural Research). Our efforts focused on gender analysis of climate information services (CIS), the producers of the climate and weather information and the users of that information. Our approach was to work with existing CCAFS programs that delivered climate and weather information, observing their approaches, trainings, materials, partners and results, and interrogating those efforts regarding gendered impacts. The three countries where we (the University of Florida faculty and graduate students) conducted gender analyses were Kenya, Tanzania, and Senegal. Three sets of questions were developed, focusing on access to and use of CIS, knowledge of climate smart agriculture (CSA) and food security. In all cases, we worked with CCAFS partners (agricultural extension, country meteorological office and local NGOs).

Approach and Implementation

Men and women have different vulnerabilities to climate change and different adaptive capacities[42]; it is therefore imperative to recognize what those differences are and how to improve access to information and services for farmers in the face of climate change. Qualitative and quantitative methods can be used to understand how household and community power is negotiated between and among men and women; this is critical to understand how climate information is accessed and utilized by rural farmers. Women often raise their own crops and have their own fields but they may have to work on their husbands' crops and fields before their own. As for extension, today's extensionists work better with farmers who can access information. Information access can be a problem for women farmers. Research indicates that women farmers are not reached by extension services, that having more female extension officers means more women are reached, and that women prefer female extension officers (Doss, 2001). Further, extensionists are less likely to reach poor farmers who have less land, capital and do not use inputs (Doss, 2001); women are more likely to be poor than men. Finally, in terms of access to information, women have less access to mobile phones and are less likely to be able to read or read in the national language. For these reasons, it is necessary to find other ways to reach women farmers.

From the gender analyses conducted and the investigation of ways to reach women farmers with CIS, we have noted that using a hybrid approach to information sharing that includes traditional methods (e.g. community meetings, social networks, and community radio) combined with newer methods (e.g. text messaging, co-production of knowledge with communities) reaches not only women farmers but reaches more farmers. When more than one avenue of

[41] Contribution by S. Russo, C. McOmber, S. McKune, E. Poulsen (University of Florida)
[42] For further reference see: https://ccafs.cgiar.org/themes/gender-and-social-inclusion

information is used, more people "travel" along that avenue. The more people/farmers who get climate and weather information in a timely manner, in words they understand, in contexts that are specific to their needs, the more they are able to adapt to climate change and weather risks. Gender analyses allows us to pinpoint how best to reach women farmers in specific contexts, for example, location, culture, differential access, varying quality of extension and climate information providers, etc.

Lesson Learned

Our gender analyses confirmed, in Senegal, that men and women access CIS differently. When it was learned that only men have mobile phones, a deliberate effort to put at least one phone in the hands of a woman in each project village resulted in more climate and weather information being available to the entire village. When both men and women had access to the same information, they could jointly decide how to prioritize planting of their respective fields and not assume that the men's fields would be planted first. We also learned that when extension, meteorologists, and farmers jointly discuss the kinds of information needed by the farmers, the providers of information respond and provide what is needed. It is in the absence of discussion, we found, that weather and climate information is simply "shot out" to extension and falls short of reaching farmers.

Challenges

Even though gender analysis helps the knowledge producers and distributers better understand the needs of their intended audiences, few have the time, skills, or will to conduct a gender analysis. They perhaps also do not realize that there are real differences between men and women farmers in their access to knowledge and the types of information they need. Sometimes steps are taken but these are not enough, for example, identifying and training female extension agents in CSA but not following up to see if they understood the training and have implemented the knowledge. In one case, the meteorological service had a dysfunctional server for months and relied on mailing weather information to extension agents. Getting extensionists, who are already overburdened, and meteorologists, who focus on the message and not the recipients, to work together with farmers remains the biggest challenge. The information is there; getting it out on time to as many people as possible is the issue.

Best Practices

Our results show that a hybridization of communication methods (McOmber et al., 2013) is the best way to ensure that women farmers are reached. Using multiple methods to send out the same information is essential. Participatory dialogue with farmers, meteorologists, and extension is essential for co-production of knowledge. In the Kaffine district of Senegal, village women who received CIS as text messages (ICT) from the agricultural meteorology service (working in collaboration with extension and CCAFS) would tell their neighbours (social networks), and post the news on a village blackboard and at the field entrances (community networks). Extension would use meetings (social networks) and community radio (community networks) to distribute information and discuss CSA practices.

Scaling Up

Recent research, conducted with health clinics and community health workers in the Kaffrine district, was carried out to ascertain whether climate and weather information could be posted at health clinics and distributed by the health workers. The response was overwhelmingly positive. Thus, text messages, blackboards at community health clinics and social networks, that now include health workers, can be used to deliver weather information, benefiting an even larger number of people. As the community health workers told us, weather and climate change impacts their clientele as well. The challenges to including health workers are less about financial resources and more about including them in the CIS programmes so that they get the messages in a timely manner.

References

Doss, C.R. 2001. Designing Agricultural Technology for African Women Farmers: Lessons from 25 Years of Experience. *World Development*, 29(12): 2075-2092.

McOmber, C., Panikowski, A., McKune, S., Bartels, W. & Russo, S. 2013. *Investigating climate information services through a gendered lens*.

3.3 Farmer-to-farmer extension[43]

Introduction

Farmer-to-farmer extension (F2FE) offers great promise for effectively scaling up climate smart agriculture (CSA). F2FE is "the provision of training by farmers to farmers, often through the creation of a structure of farmer promoters and farmer-trainers" (Scarborough et al., 1997). In this contribution, we use the term "farmer-trainer" as a generic term for farmers involved in farmer-to-farmer extension, though we recognize that different labels (e.g. lead farmer, community knowledge worker) often have implications for the exact roles and tasks of the farmers involved.

The objectives of F2FE programs are to increase coverage of large areas and numbers of farmers reached and to enhance sustainability of extension efforts. Lukuyu et al. (2012) showed that volunteer activities in western Kenya continued three years after projects supporting farmer trainers ended. The approach empowers farmers as change agents and helps to increase adoption because farmers are more willing to learn from their colleagues than from extension staff (Franzel et al., 2015).

F2FE programs are common throughout the tropics and are used by many different types of extension providers, including government, NGOs, producer organizations and private companies. A survey of 37 major extension providers in Malawi found that 78 percent used F2FE (Masangano & Mthinda, 2012). The Ministry of Agriculture in Malawi alone has 12 000 lead farmers. A survey of 151 extension programs across seven regions of Cameroon found that 31 percent used F2FE (Tsafack et al., 2014).

F2FE programs are actively involved in promoting CSA; 23 percent of a sample of 30 organizations in western Kenya and 24 percent of a sample of 25 in Malawi using F2FE used it to promote CSA practices (Kundhlande et al., 2014; Franzel et al., 2014). F2FE programs contribute to all three pillars of CSA, that is, they help improve productivity, build resilience and reduce greenhouse gas emissions. A case in point is the East Africa Dairy Development Project, a project led by Heifer International which has had over 4 000 volunteer farmer-trainers across Kenya, Uganda, Tanzania and Rwanda since 2008. Farmer-trainers have been instrumental in promoting practices that increase milk production. In Uganda for example, the trainers are a main reason why over 40 percent of farmers have adopted seven improved feeding practices, such as sweet potato vines and fodder shrubs (because the project covers different agro-ecological zones, few practices are appropriate for more than half of the farmers) (Kimaiyo et al., in press). Certain of these practices, such as fodder shrubs, help build farmers' resilience, because they are deep-rooted, drought resistant and evergreen; thus providing high protein feed during the dry season, when high-quality feed is scarce. By promoting adoption of perennial fodders such as fodder shrubs, Rhodes grass and Napier grass, farmer-trainers and the project are helping farmers to conserve their soil and reduce greenhouse gas emissions.

[43] Contribution by Steven Franzel, Evelyne Kiptot, and Josephine Kirui (ICRAF)

Farmer-trainers are active in promoting conservation agriculture as well. In Zambia, lead farmers working with the Ministry of Agriculture, NGOs such as the Conservation Farming Unit and projects such as the Conservation Agriculture Program, have played a critical role in the uptake of conservation agriculture (FAO, 2012). Similarly, in Zimbabwe lead farmers working with the Department of Agricultural, Technical and Extension Services have successfully promoted conservation agriculture in a number of areas of the country (FAO, 2012). In Kenya, volunteer farmer-trainers working with Vi Agroforestry, CARE, VIRED and other NGOs assisting farmers to plant trees on their farms and adopt other climate change adaptation practices.

F2FE has been shown to have great potential for facilitating the uptake of CSA practices. Costs are fairly low, with costs/farmer-trainer/year ranging from US$ 100 (Wellard, 2013) to US$ 160 (Kiptot et al., 2012).

Simpson et al. (2015) and Franzel et al. (2015) highlight several limitations of the F2FE approach as well as several ways to make it more effective. Concerning limitations, farmer-trainers need coaching and technical backstopping; without these they may perform poorly. Some programmes appear to recruit more farmer-trainers than they are able to effectively backstop, reducing overall performance of the programme. If extension staff perceive farmer-trainers as a substitute, rather than a complement, to their own services, conflicts between farmer-trainers and extension staff may occur. As low-cost as F2FE programmes are, they may not be sustainable following the end of a project if no local institution agrees to support and backstop them. Finally, F2FE may not be appropriate for promoting complex practices such as ration formulation, disease management or what are essentially permanent decisions, such as siting of water control structures. The approach also appears to be less suited to high-income, commercial systems or to areas of low population density, where transportation is a constraint.

On lessons learned and ways to improve effectiveness, extension managers need to understand farmer-trainers' motivations to volunteer and to implement low-cost incentives to reward them, especially those not paid for their services. For example, for those farmer-trainers motivated by helping others and social status, contests, certificates, t-shirts and community recognition are important. For those interested in gaining knowledge, the offer of increased training opportunities, exchange visits and tours are important incentives. For those who have entrepreneurial skills, giving them business training and linking them to markets to sell their inputs, such as seed, would greatly enhance their effectiveness. The ability of the F2FE approach to include more women (or other marginalized groups) in extension roles and to reach more female farmers is clearly evident (Simpson et al., 2015). However, to recruit more women as farmer-trainers, pro-active efforts are needed, such as setting guidelines that stipulate that as many women as men are nominated to be farmer trainers. Another important consideration is that farmers and local institutions (e.g. producer organizations or village councils) play a key role in selecting farmer-trainers and monitoring and evaluating them. This provides a sense of ownership and helps make the programmes more accountable to the community or organizations that they serve. Finally, whereas selection criteria for farmer-trainers need to be agreed on between the facilitating organization and the community, one common weakness is that excellent farmers are selected to be farmer-trainers, regardless of their interest and skills in communicating with others. The ability and interest in training others has to be an important criterion for selecting farmer-trainers, in addition to being a good farmer.

References

FAO. 2012. *Conservation Agriculture Extension and Promotion approaches for smallholder farmers in southern Africa: Evaluating their role and impact*. Johannesburg, FAO Regional Office for Southern Africa.

Franzel, S., Degrande, A., Kiptot, E., Kirui, J., Kugonza, J., Preissing, J. & Simpson, B. 2015. Farmer-to-farmer extension. *Note 7. GFRAS Good Practice Notes for Extension and Advisory Services*. Lindau, Switzerland, Global Forum for Rural Advisory Services. (Available at http://www.g-fras.org/en/download.html)

Franzel, S., Sinja, J. & Simpson, B. 2014. Farmer-to-farmer extension in Kenya: the perspectives of organizations using the approach. *ICRAF Working Paper No. 181. Nairobi, World Agroforestry Centre*. (Available at http://www.worldagroforestry.org/downloads/publications/PDFs/WP14380.PDF)

Kimaiyo, J., Kiptot, E., Mwambi, M. & Franzel, S. (in press). Assessing the effectiveness of volunteer pros in disseminating livestock feed technologies in Uganda vis a vis other information sources. *ICRAF Working Paper. Nairobi, World Agroforestry Centre*.

Kiptot, E., Franzel, S. & Kirui, J. 2012. Volunteer farmer-trainers: improving smallholder farmers' access to information for a stronger dairy sector. *Policy Brief No. 13. Nairobi: World Agroforestry Centre*. (Available at: http://www.worldagroforestry.org/downloads/publications/PDFS/PB12236.PDF)

Kundhlande, G., Franzel, S., Simpson, B. & Gausi, E. 2014. Farmer-to-farmer extension approach in Malawi: a survey of organizations. *ICRAF Working Paper No. 183*. Nairobi, World Agroforestry Centre. (Available at http://www.worldagroforestry.org/downloads/publications/pdfs/WP14391.PDF)

Lukuyu, B., Place, F., Franzel, S. & Kiptot, E. 2012. Disseminating improved practices: are volunteer farmer trainers effective? *Journal of Agricultural Education and Extension* 18: 525–540.

Masangano, C. & Mthinda, C. 2012. Pluralistic extension system in Malawi. *IFPRI Discussion Paper 01171*. Washington, D.C., International Food Policy Research Institute (IFPRI). (Available at http://www.ifpri.org/publication/pluralistic-extension-system-malawi)

Scarbourough, V., Killough, S., Johnson, D.A. & Farrington, J. (eds.). 1997. *Farmer-led Extension: Concepts and Practices*. London, Intermediate Technology Publications.

Simpson, B., Franzel, S., Degrande, A., Kundhlande, G. & Tsafack, S. 2015. Farmer to farmer extension: Issues in planning and implementation. *MEAS Technical Note*. Modernizing Extension and Advisory Services, USAID (Available at http://agrilinks.org/sites/default/files/resource/files/MEAS%20TN%20Farmer%20to%20Farmer%20-%20Simpson%20et%20al%20-%20May%202015.pdf)

Tsafack, S., Degrande, A., Franzel, S. & Simpson, B. 2014. Farmer-to-farmer extension in Cameroon: a survey of extension organizations. *ICRAF Working Paper No. 182*. Nairobi, World Agroforestry Centre. (Available at http://www.worldagroforestry.org/downloads/publications/PDFs/WP14383.PDF)

Wellard, K., Rafanomezana, J., MNyirenda, M., Okotel, M. & Subbey, V. 2013. A review of community extension approaches to innovation for improved livelihoods in Ghana, Uganda and Malawi. *The Journal of Agricultural Education and Extension*, 19(1): 21–35.

3.4 Improve training tools for extension agents[44]

Improved training for improved agrometeorological extension

Education/training of intermediaries for (in thise case agrometeorological) extension has been proposed to be in two steps for two kinds of intermediaries (e.g. Stigter and Winarto, 2013). The first kind of such extension intermediaries would be working and trained within the centres where the (in this case agrometeorological) knowledge useful for decision-makers in agricultural production is generated. We called them "product intermediaries". They should basically be specially trained members of staff in the National Weather Services, and at extension departments of Universities and Research Institutes which give contents to the scientific support systems of response farming (Stigter et al., 2013, **(C)** in Figure 1).

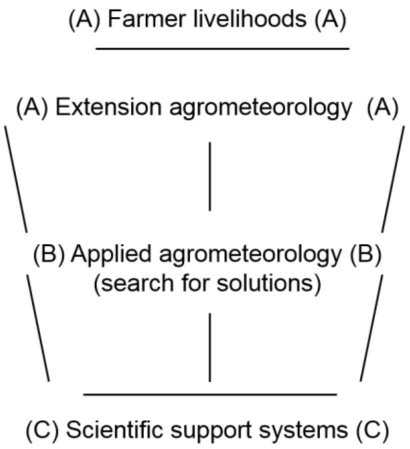


Figure 1. Layered levels of science. Support systems are the fundamental basis for any scientific work (level **(C)**) that supports the search for solutions in the fields of applied science (for example applied agrometeorology, level **(B)**). Extension agents trained at level **(B)** may be called "product intermediaries". They should themselves be "trainers of trainers" in (here) extension agrometeorology that takes place at the level of and within farmers' livelihoods (level **(A)**). The extension intermediaries trained at that **(A)** level, train the farmers and establish climate services for agriculture with the famers in their fields.

Forecasts of weather and climate, monitoring and early warning products for drought, floods or other calamities, advisories for agrometeorological services that could increase the preparedness of farmers long in advance, have to be made into client-friendly products that can be absorbed and used advantageously in a rural response to climate change (e.g. Stigter et al., 2013). This response farming has to be developed at the level of applied sciences where the search for solutions to farmers' problems should be carried out (**(B)** in Figure 1). For training, such "product intermediaries" requires a good education in farmers' needs as well as in how (in this case) agrometeorology can be used in problem solving in extension, using knowledge from applied agrometeorology, to which their work should be close.

The second kind of extension intermediaries should be closest to the farmers and operate exclusively at the level **(A)**. They should learn to articulate the needs of farmer communities better and seek for (agrometeorological) components that need attention. They should match this with what is or should become available as (agrometeorological) services, in strong contact with the product intermediaries. From the training point of view this should look like Figure 2.

[44] Contribution by K. (C.J.) Stigter, Agromet Vision

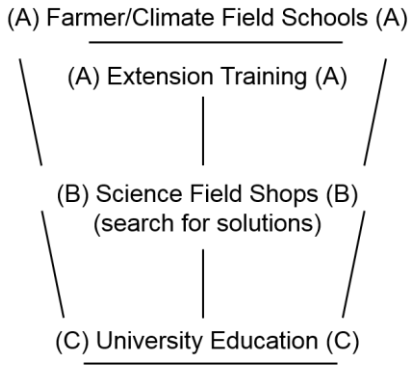


Figure 2. Layered fields of education/training. University education is the fundamental basis for any scientific education (level **(C)**) that supports the training in searching for solutions at extension level **(B)**), for which Science Field Shops were established (e.g. Stigter and Winarto, 2013). Extension agents trained at level **(B)** may be called "product intermediaries". They should themselves be "trainers of trainers" that act at the level of and within farmers' livelihoods (level **(A)**). The extension intermediaries trained at that **(A)** level, for example in Climate Field Schools, train the farmers, for example in Farmer Field Schools (Integrated Pest Management Farmer Field Schools as an existing but deteriorated example), and establish climate services for agriculture with the famers in their fields.

What has been exemplified for agricultural meteorology above holds, *mutatis mutandis*, also for fields like agricultural hydrology, agricultural entomology, agricultural pest management, crop management (including inputs), farm management, etc. The earlier composed syllabi of Appendix I show how wide the extension agrometeorology is taken to include basics in all these fields that can then be emphasized where necessary in practice (Stigter et al., 2013). Very few attempts have been made to work with material such as that in Appendix I. In Indonesia we trained "farmer facilitators" selected by the farmers from within the farmers. Those that did by far the most in that direction, working for CCAFS, have warned that a large proportion still has to be locally collected everywhere (e.g. Hansen et al., 2013).

Appendix I - Syllabi for training Extension Intermediaries (WMO, 2009; Stigter, 2010)

1. An agrometeorology related syllabus for in-service training of farmer trainers

Elementary

Review of local administrational context issues: functions and responsibilities. Review of local climate issues, including traditional knowledge. Review of farming systems in the sub-region/country/region/continent concerned. Production constraints of farming systems reviewed. Fields of agrometeorology relevant to local agriculture (choice from INSAM [www.agrometeorology.org] categories for example). Agrometeorological components of production constraints identified. Assessments of needs as seen by the farmers in the various systems.

[Practicals possible with farmers on the last two subjects and additional ones with "trainers of trainers". Results of such practicals could be discussed with "trainers of trainers" in joint classes.]

Advanced

Review of processes of change (economical, social, environmental, etc.) taking place in the sub-region/country/region/continent concerned. Extension approaches suitable in the farming systems reviewed for the production constraints identified. Policies of existing extension and their decentralization. Extension agrometeorology locally available to meet assessed needs. Agrometeorological services already applied or tried. New extension agrometeorology possible. Constraints in applying extension agrometeorology through agrometeorological services and their relief solutions.

[Practicals possible with farmers on last three subjects and additional ones with "trainers of trainers" as indicated below. Results of such practicals should be discussed with "trainers of trainers" in joint classes.]

2. An agrometeorology related syllabus for in-service "training of trainers" (extension agrometeorology within NMHSs, Research Institutes, Universities)

Elementary

Needs assessments of farmers and farming systems for agrometeorological products. Available products from weather services, research institutes and universities directed at farming systems in the sub-region/country/region/continent concerned. Client friendliness of those products as assessed by users. Documented or remembered use of such products, successes & failures and assessment of their causes.

[Practicals possible together with the "trainers of trainers" on last two subjects. Results to be discussed in joint classes.]

Advanced

Needs for additional products from weather services, research institutes and universities. How to commission such products in these organizations. How to make such products most client-friendly for the farming systems concerned. Discussions on potential new products with potential users. Bringing new products into new or existing agrometeorological services.

[Practicals possible together with the trainers of farmers on the last two subjects. Results to be discussed in joint classes.]

References

Hansen, J., Tall, A. & Jay, A. 2013. How can we reach a million farmers with climate services? (Available at https://ccafs.cgiar.org/blog/how-can-we-reach-million-farmers-climate-services#.VkLc3_1zNLN Accessed on 19 Dec 2015)

Stigter, C.(K.)J. (Ed.). 2010. *Applied Agrometeorology*. Springer. Heidelberg, New York, xxxviii + 1101 pp.

Stigter C.(K.)J. & Winarto, Y.T. 2013. Science Field Shops in Indonesia. A start of improved agricultural extension that fits a rural response to climate change. *J. Agric. Sc. Appl*., 2(2): 112-123.

Stigter, K., Winarto, Y.T., Ofori, E., Zuma-Netshiukhwi, G., Nanja, D. & Walker, S. 2013. Extension agrometeorology as the answer to stakeholder realities: Response farming and the consequences of climate change. *Special Issue on Agrometeorology: From Scientific Analysis to Operational Application. Atmosphere* 4(3): 237-253.

WMO. 2009. Guidelines for curricula in agricultural meteorology. *Supplement No. 2 to "Guidelines for the education and training of personnel in meteorology and operational hydrology", Vol. 1*, WMO 258, Geneva. (Available at https://www.wmo.int/pages/prog/dra/etrp/documents/258_vol1_Supp_2_1.pdf Accessed on 10 Dec 2015)

3.5 Farmers' organizations and CSA: a case study from Vietnam [45]

Setting

Vietnam has made a remarkable journey to ensure food security for 90 million people while increasing forest cover. Since the 1980s, it has become an exporter of rice, coffee, rubber, cashew, black pepper, wood and aquaculture products.

Over two-thirds of the population live in rural areas and depend at least partly on agriculture for their livelihoods. Challenges are low profit margins, high labour inputs due to outdated equipment, small and dispersed fields, poor infrastructure and investment options, and weather-related stresses.

Extension services

Vietnam has two major systems: 1) public extension through the Ministry of Agriculture and Rural Development (MARD). Remote areas often have only one extension officer for an entire commune. 2) The Farmers' Union (FU), a civil society organization under the Party and People's Committee. Its capacity varies across the country.

An increasingly popular activity among farmers and extensionists is private extension linked to selling inputs, such as seed and fertilizers.

Climate-smart initiatives

MARD has been involved in CSA since 2010, hosting the Second Global Conference on Agriculture, Food Security and Climate Change in Hanoi in 2012. A key outcome was establishment of the Global Alliance for Climate-Smart Agriculture (GACSA) in 2014. MARD sees participation in GACSA as adding value and sustainability to agriculture. For example, FAO's Economics and Policy Innovations for CSA programme worked with MARD on CSA value chains of indigenous products. Agriculture and forestry feature strongly in the Intended Nationally Determined Contributions to UNFCCC. CSA initiatives include rice in the delta regions — sustainable intensification and alternate wetting and drying (Siopongco et al., 2013) — and forestry through Payments for Forest Environmental Services (PFES) (MARD, 2012).

Climate-smart villages

Climate-smart villages (CSV) were introduced through the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) in 2014. Six villages were selected, representing different climatically-exposed agroecosystems: three in Vietnam; two in Lao; one in Cambodia. The CSVs are test sites for scalable CSA technologies and build on partnerships between CGIAR and local agencies (CCAFS, 2015).

My Loi CSV in Ky Anh District, Ha Tinh Province represents upland farming in central Vietnam that is exposed to temperature and water stresses, strong föhn winds and tropical storms. My Loi CSV is coordinated by the World Agroforestry Centre (ICRAF Vietnam) in collaboration with Ha Tinh provincial FU and the Department of Agriculture and Rural Development. This case study draws on this collaboration (Simelton et al., 2015a).

[45] Contribution by E. Simelton (ICRAF)

Collaboration in CSV

ICRAF has worked with FU in Ha Tinh Province since 2008. FU staff enrolled as group facilitators, interviewers and translators of local and scientific ecological knowledge. There have been concrete benefits from the collaboration.

1. During interviews and meetings, FU staff address farmers' questions, while learning about climatic impacts and local adaptation (Simelton et al., 2013).

2. FU staff joined meetings to make inventories and prioritize CSA interventions. Although not called CSA, farmers were implementing practices to sustain yields during extreme weather, such as intercropping, rotation and mulching.

3. FU generally has more female staff than the public extension service. Female farmers were generally less aware than men of climate change; one reason being that male extensionists tended to talk to men. Through a gender-sensitive selection process, some of the needs of women are now raised. Women in My Loi CSV preferred interventions in livestock and home gardens; men favoured forestry; and both wanted intercropping. Women having a longer daily schedule and want to use time more efficiently (Simelton et al., 2013a)

4. Among the low-cost, gender-equal, CSA interventions at the CSV are school vegetable gardens, vermiculture and a village weather station that monitors deviations from centralised forecasts.

5. A cooking competition helped everyone realize the diversity of vegetables and fruit that could be included in the CSA portfolio.

Challenges for CSA

Among the various challenges for CSA in Vietnam, the three main ones have been described.

1. CSA has different interpretations. First, some equate food security with quantity of rice, meaning that they do not identify a problem. This disregards the that over 10 percent of children under five years-old are malnourished and that many households struggle to survive from agriculture. More flexible interpretations of CSA are reduced yield variability or losses as a result of adaptation (and mitigation) interventions. Second, non-climate-related environmental services lack a clear objective in CSA. This causes contradictions when introducing PFES and for reducing pesticide use. Third, there are no indicators for evaluating "smartness", such as co-benefits, landscape-level, non-economic or longitudinal benefits.

2. Supporting policies. ICRAF and MARD have run policy dialogues since 2013 on overcoming barriers to agroforestry. Among the barriers are separated policies and land use for agriculture and forestry. Similarly, extensionists receive training in either agriculture or forestry. Furthermore, awareness of climate change is limited among farmers and leaders; this increases the risk of maladaptation, particularly if the CSA priority is yield increase (Simelton et al., 2013).

3. Gender. Without reducing women's work it will be difficult to release time for women to join training courses, field trips and community activities.

Opportunities

Four main opportunities can be identified for follow up actions.

1. Export crops are grown mainly as monoculture or short-term rotations but all can be grown in integrated systems (ICRAF, 2015).

2. "Smartness" indicators can be developed with extensionists and farmers to monitor adaptation to reduce or stabilize yields and improve incomes. The indicators can also monitor extension demonstrations. Research with FU shows that agroforestry reduces the period of economic recovery after natural disasters (Simelton et al., 2015a).

3. With 3 to 4-year projects with rotating staff it is vital to work with those who stay — FU and extension staff — and who learn to generate resources. Moreover, FU members can request training and support for demonstrations.

4. The FU is vital for expansion and MARD for policies enabling expansion.

References

CCAFS. 2015. (Available at: https://ccafs.cgiar.org/climate-smart-villages Accessed on Oct 25, 2015)

ICRAF. 2015. *Spatially Characterised Agroforestry Database (SCAF)* (Available at http://worldagroforestry.org/regions/southeast_asia/vietnam/products/databases/SCAFS Accessed on Nov 4, 2015)

MARD. 2012. (Available at http://www.isgmard.org.vn/News.asp?Status=1&InfoID=889 Accessed on Oct 13, 2015.)

Simelton, E., Dam, V.B. & Catacutan, D. 2015a. Trees and agroforestry for coping with extreme weather events - experiences from northern and central Viet Nam. *Agroforestry Systems* doi:10.1007/s10457-015-9835-5.

Simelton, E., Dam, V.B., Lasco, R. & Finlayson, R. 2013. *The Talking Toolkit. How smallholding farmers and local governments can together adapt to climate change*. World Agroforestry Centre (ICRAF), Ha Noi, Viet Nam. (Available at http://www.worldagroforestry.org/regions/southeast_asia/vietnam/products/tools/talking-toolkit Accessed on Oct 25, 2015)

Simelton, E., Catacutan, D., et al. 2015b. Agroforestry - a policy imperative for Vietnam. *Policy Brief VN No 1*. Hanoi, Viet Nam, World Agroforestry Centre (ICRAF).

Siopongco, J.D.L.C., Wassmann, R. & Sander, B.O. 2013. Alternate wetting and drying in Philippine rice production: feasibility study for a Clean Development Mechanism. *IRRI Technical Bullettin No 17*. Los Banos, Philippines, International Rice Research Institute (IRRI).

Acknowledgment

GACSA deeply thanks all the authors and their institutions, who kindly contributed to the development of the Compendium.

Agromet Vision

Government of Uganda

Disclaimer

The views expressed in this Compendium are those of the authors and are not necessarily endorsed by or representative of GACSA, Agromet Vision, ANACIM, Bioversity International, CABI, CCAFS, CIAT, CRS, DigitalGreen, Earth Net Foundation, FAO, Government of Uganda, IBIMET, NCCSD, Universitas Indonesia, University of Florida, World Agroforestry Centre, Young Pioneers for Development or of the cosponsoring or supporting organizations.

Further reading

Grist, N. 2015. Topic Guide: Climate change, food security and agriculture. Evidence on Demand.

Nelson, S. & Huyer, S. 2016. A Gender-responsive Approach to Climate-Smart Agriculture Evidence and guidance for practitioners. GACSA Practice Brief.

Richards, M., Sapkota, T., Stirling, C., Thierfelder, C., Verhulst, N., Friedrich, T. and Kienzle, J. 2016. Conservation Agriculture: Implementation guidance for policymakers and investors. GACSA Practice Brief.

Richards, M.B., Butterbach-Bahl, K., Jat, M.L., Lipinski, B., Ortiz-Monasterio, I. and Sapkota, T. 2015. Site-Specific Nutrient Management: Implementation guidance for policymakers and investors. GACSA Practice Brief.

Richards, M. and Ole Sander, B. 2016. Alternate Wetting and Drying in Irrigated Rice. GACSA Practice Brief.

Roobroeck, D., Van Asten, P., Jama, B., Harawa, R. and Vanlauwe, B. 2015. Integrated Soil Fertility Management: Contributions of framework and practices to climate-smart agriculture. GACSA Practice Brief.

Teenstra, E., Andeweg K. and Vellinga, T. 2015. Manure helps feed the world - Integrated Manure Management demonstrates manure is a valuable resource. GACSA Practice Brief.

van Asten, P., Ochola, D., Wairegi, L., Nibasumba, A., Jassogne, L. and Mukasa, D. 2015. Coffee-Banana Intercropping: Implementation guidance for policymakers and investors. GACSA Practice Brief.

COMPENDIUM ON CLIMATE-SMART AGRICULTURE & EXTENSION

The Compendium seeks to provide an overview of approaches and practical tools to support extension services in the field of climate-smart agriculture.

Please visit GACSA website for more information: www.fao.org/gacsa/en/

Editors

Dr. Simone Sala is a researcher and practitioner in the area of innovation and ICT for agriculture and rural development at FAO.

Dr. Federica Rossi is Senior Researcher at CNR IBIMET & Vice President of the Commission for Agricultural Meteorology at WMO.

Ms. Soniia David is Agricultural Extension Officer, FAO.

Publishing date: June 2016