Agriculture *for* Development

Tropical Agriculture Association

Special issue on climate-smart agriculture (CSA)

CSA strategies, policies, partnerships and investments

'CSA-Plan': strategies to put CSA into practice

The mitigation pillar of CSA

Agricultural diversification as an adaptation strategy

Climate services and insurance: scaling CSA

Closing the gender gap in agriculture under climate change

How can the Data Revolution contribute to climate action?

Climate change and CSA in the current political climate

No. 30, Spring 2017

Guidelines for Authors
Agriculture for Development

The editors welcome the submission of articles for publication that are directly related to the aims and objectives of the Association. These may be short communications relating to recent developments and other newsworthy items, letters to the editor, especially those relating to previous publications in the journal, and longer papers. It is also our policy to publish papers, or summaries, of the talks given at our meetings.

Only papers written in English are accepted. They must not have been submitted or accepted for publication elsewhere. Where there is more than one author, each author must have approved the final version of the submitted manuscript. Authors must have permission from colleagues to include their work as a personal communication.

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- A short biographical note about the author(s) is included, preferably with a photograph of the author(s). If still working, indicate your position and email address. If retired, your previous job (*eg formerly Professor of Agriculture, ABC University*).
- For papers longer than 1,500 words, a short abstract (summary) of 150-200 words.
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- Sources of funding should be listed in the acknowledgements.

References

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Book: Brammer H, 2012. The physical geography of Bangladesh. Dhaka, Bangladesh: University Press Ltd.

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Conference proceedings (published): McIntosh RA, 1992. Catalogues of gene symbols for wheat. In: Miller TE, Koebner RM, eds. *Proceedings of the Seventh International Wheat Genetics Symposium*, 1987. Cambridge, UK: IPSR, 1225–1323.

Agency publication: Grace D, Jones B, eds, 2011. *Zoonoses (Project 1) Wildlife/domestic livestock interactions*. A final report to the Department for International Development, UK.

Dissertation or thesis: Lenné JM, 1978. *Studies of the biology and taxonomy of Colletotrichum species*. Melbourne, Australia: University of Melbourne, PhD thesis.

Online material: Lu HJ, Kottke R, Martin J, Bai G, Haley S, Rudd J, 2011. Identification and validation of molecular markers for marker assisted selection of Wsm2 in wheat. In: Plant and Animal Genomes XIX Conference, abstract W433. [http://www.intl-pag.org/19/abstracts/W68_PAGXIX_433.html] . Accessed 20 April 2012.

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- Self-explanatory with an appropriate legend above the table, without abbreviations.
- Number with arabic numerals, *eg* Table 2.
- Refer to tables in the sequence in which they are presented.
- Use lower-case letters, *eg* a, b and c, for footnotes to tables.

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- Self-explanatory with an appropriate legend below the figure, without abbreviations
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Your paper should be submitted ready for editing and publication.
Accepted text file types: Word (.DOC or .DOCX), Rich Text Format (.RTF) or Postscript (.PS) only.
Accepted figure file types: .TIF, .EPS or .PDF.
No lecture notes or PowerPoint presentations, please. If the paper is a presentation from a TAA meeting, please let us have this or as soon as possible afterwards so that there is no last minute rush in trying to meet the next publication deadline.

Send submissions via e-mail to coordinator_ag4dev@taa.org.uk preferably in an attached file.

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Cover photograph: Multipurpose trees in Lower Nyando, Kenya. CCAFS is working with partners in East Africa to empower communities to manage climate risk. Agro-forestry, land and water management are among the mitigation interventions employed to reduce greenhouse gas emissions in the Nyando basin. Tree nurseries, some owned by self-help groups, have produced more than 50,000 high-quality tree seedlings, and 23,500 multipurpose trees have been planted on homesteads, with a 75 percent survival rate. (Photo: K Traumann).

Special Issue on Climate-Smart Agriculture

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The TAA is a professional association of individuals and corporate bodies concerned with the role of agriculture for development throughout the world. TAA brings together individuals and organisations from both developed and less-developed countries to enable them to contribute to international policies and actions aimed at reducing poverty and improving livelihoods. It grew out of the Imperial College of Tropical Agriculture (ICTA) Association, which was renamed the TAA in 1979. Its mission is to encourage the efficient and sustainable use of local resources and technologies, to arrest and reverse the degradation of the natural resources base on which agriculture depends and, by raising the productivity of both agriculture and related enterprises, to increase family incomes and commercial investment in the rural sector. Particular emphasis is given to rural areas in the tropics and subtropics and to countries with less-developed economies in temperate areas. TAA recognises the interrelated roles of farmers and other stakeholders living in rural areas, scientists (agriculturists, economists, sociologists etc), government and the private sector in achieving a convergent approach to rural development. This includes recognition of the importance of the role of women, the effect of AIDS and other social and cultural issues on the rural economy and livelihoods.

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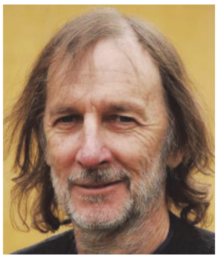
Editorial

Directions for climate action in agriculture



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A triple challenge. Agriculture and food systems stand at the nexus of three of the greatest challenges of the 21st century: food insecurity is still widespread and there is need for significantly more food in the decades ahead; agriculture is the sector which will be hit hardest by climate change; and food systems contribute up to a third of greenhouse gasses and have to be part of the solution to reducing global warming (Vermeulen *et al*, 2011). In response, there are many major research and development initiatives dealing with climate change, agriculture and food security. There is, of course, much to build on as farmers have always been at the mercy of the weather, but now there are significant new challenges, such as greater frequency and/or intensity of extreme events; more unreliable weather patterns; and/or managing for a new dimension: greenhouse gases.

It is for these reasons that a major movement has arisen around 'climate-smart agriculture' (CSA). In his article, *The rise in CSA strategies, policies, partnerships and investments across the globe*, Dhanush Dinesh (University of Copenhagen) and colleagues describe the mushrooming of strategies, policies and alliances around CSA. At the regional level, the news from the field on *Climate-Smart Agriculture across scales in Latin America*, by Ana María Loboguerrero Rodríguez (CIAT) and Deissy Martinez-Baron (CIAT) highlights the challenges and opportunities for implementing CSA. One of the many programmes that are being initiated on CSA – *VUNA* – is featured in the newsflash from Christopher Muller.

But what exactly is CSA? CSA is focussed on three pillars: productivity (sometimes interpreted more broadly as food security), adaptation (usually including both longer-term adaptation as well as managing climate variability) and mitigation (reducing emissions). Lipper *et al* (2014) provide a comprehensive discussion of CSA. The development of the CSA concept and its relationship with climate change and agriculture development is addressed in the new book, *Climate change and agricultural development: improving resilience through climate smart agriculture, agroecology and conservation*, edited by Udaya Sekhar Nagothu, and reviewed as part of this issue.

As with many emerging concepts, CSA tends to have multiple interpretations. While some focus on a target of win-win-win on the three pillars, others rather focus on 'considering' all three dimensions and then implementing actions that are appropriate for a specific context, actions that may, for example, be win-win-lose, but are appropriate for this particular time in this particular space. As Todd Rosenstock from the World Agroforestry Centre (ICRAF) states, *"Many practices can be CSA somewhere but none are likely to be CSA everywhere"*. Thus we need context specific research in multiple global locations to pinpoint what exactly should be prioritised in the name of CSA. This has led to 'CSA-Plan', a comprehensive approach to prioritisation and implementation of CSA options. CSA-Plan is described in the second article of this issue: *'CSA-Plan': strategies to put CSA into practice*, by Evan Girvetz (CIAT), Caitlin Corner-Dolloff (US Department of Agriculture), Christine Lamanna (ICRAF) and Todd Rosenstock (ICRAF).

One of the three pillars of CSA focuses on mitigation. This is particularly challenging in most developing country contexts, where food security and adaptation are the main priorities. In addition, in many countries fertiliser application is well below levels needed for sustainable (higher) production, and needs to increase. This will usually lead to a rise in greenhouse gas (GHG) emissions, but hopefully we can put agriculture on a trajectory towards minimising GHG emissions per unit of yield ('emissions intensity'). In the third article, *The mitigation pillar of CSA – targets and options*, Lini Wollenberg, from the University of Vermont, argues that it is critical to put agriculture in the developing world on a low emissions development pathway. She justifies a mitigation target for agriculture and demonstrates how we will need transformative actions to achieve the target. Measuring GHG emissions in agriculture is complicated and expensive, but progress is being made to develop simple and cost effective methods: the new book by Rosenstock *et al* on *Methods for measuring greenhouse gas balances and evaluating mitigation options in smallholder agriculture*, is reviewed under *Bookstack*.

Silver bullet approaches and/or single commodity focussed research for development (R4D) is still widespread in the agricultural community. Take three researchers from different commodity research agencies to a particular location, and their solution to the problems will invariably be focussed on their commodity of interest. We need to listen to the farmers and apply the comprehensive approach of CSA-Plan to select priorities. Crops are often the focus, but we must think beyond technologies and beyond specific crops – livestock, fisheries, agroforestry, value chains, services, policies, food systems and diversification strategies. In the fourth article, Isabel López Noriega (Bioversity International) and colleagues take a look at diversification as a response to climate change, in their article *Agricultural diversification as an adaptation strategy*. The role of participatory approaches and development of context specific portfolios are highlighted in news from the field from East Africa, South East Asia and South Asia.

Coming from the agricultural community, we often do not give enough attention to working with those from the climate science community, and in particular with the meteorological agencies that can potentially empower farmers with climate information and, through linking to the agricultural community, with climate-informed advisories. Climate information services are a crucial part of the CSA concept, and are tackled by Ana María Loboguerrero Rodríguez (CIAT) and colleagues in the fifth article entitled *Climate services and insurance: scaling CSA*. Taking a regional perspective, the news from the field by Samuel Tetteh Partey (ICRISAT) and colleagues highlights the role of climate information in risk management in West Africa.

Differentiation and inequality within communities has to be considered in the selection of actions for climate change. Mary Nyasimi (CIAT) and Sophia Huyer (Women in Global Science and Technology, WISAT) tackle the topic of *Closing the gender gap in agriculture under climate change*. They show how research needs to change, and identify some focus areas in the sixth article. This is a particularly under-researched area.

Can 'big data' help us to devise solutions? We have previously estimated that we need to reach 750 million farmers as early as 2030 if we are to combat climate change (Campbell & Thornton, 2014) – but also if we are to achieve the Sustainable Development Goals. Can emerging techniques of machine learning and citizen science, help us to achieve scale and deliver information to millions of farmers on options to tackle climate change? Jacob van Etten (Bioversity International) and colleagues argue that this is a key innovation area. The case studies they describe in the seventh article – *How can the Data Revolution contribute to climate action in smallholder agriculture?* – demonstrate the vast possibilities for the Data Revolution to provide solutions to climate change challenges which smallholder farmers face.

While significant advances are being made in tackling climate change in the agricultural sector, these advances are at risk as a result of an uncertain political climate. Philip Thornton (International Livestock Research Institute, ILRI) provides an opinion piece on what an era of post-modernist politics means for climate change and CSA.

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This Special Issue on Climate-Smart Agriculture is guest edited by Dr Bruce Campbell and Dhanush Dinesh. The *Ag4Dev* Editorial Team are very grateful to Bruce, Dhanush, and their CCAFS colleagues for planning, commissioning, and delivering an outstanding selection of articles, news from the field, and book reviews on the theme.

The rise in Climate-Smart Agriculture strategies, policies, partnerships and investments across the globe

Dhanush Dinesh, Pramod Aggarwal, Arun Khatri-Chhetri, Ana Maria Loboguerrero Rodríguez, Catherine Mungai, Maren Radeny, Leocadio Sebastian and Robert Zougmoré

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Abstract

Since the term 'climate-smart agriculture' (CSA) was coined in 2010, a growth in strategies, policies, partnerships and investments in the area has been observed. Here we have summarised key CSA efforts globally and in South Asia, Southeast Asia, East Africa, West Africa, and Latin America. We have interpreted CSA in the broad sense, including efforts which may not mention CSA but implicitly contribute to CSA pillars. We note that many international and regional organisations, and countries, are implementing policies and programmes promoting and upscaling CSA. While the growth in strategies, policies, partnerships and investments is positive and creates a favourable enabling environment for CSA, these need to be complemented with targeted implementation on the ground, sustainable financing, institutional coordination and metrics to measure the efficacy of interventions.

CSA strategies, policies, partnerships and investments at the global level

At the global level, the United Nations climate summit in 2014 saw the launch of several key efforts, including the *Global Alliance for Climate-Smart Agriculture (GACSA)* – a platform for knowledge exchange and inter-regional cooperation on CSA with over 140 members including governments, research institutions, farmers' organisations, the private sector, and NGOs. The World Bank committed to make its US$ 8 billion annual spending on agriculture, climate-smart by 2018 (UN, 2014). The International Fund for Agricultural Development (IFAD) also committed to include an element of climate risk screening in all its operations by 2018 (UN, 2014). In 2015, the private sector, under the umbrella of the World Business Council on Sustainable Development (WBCSD), committed to reduce by 50 percent the greenhouse gas (GHG) emissions from agriculture and land use by 2030, while making 50 percent more nutritious food available, and strengthening the climate resilience of agricultural landscapes and farming communities (WBCSD, 2015). Members of WBCSD, including *Olam*, *Pepsico*, *Monsanto*, and *Wal-Mart*, have launched their own respective actions in support of these global commitments. The rise in usage of 'CSA' can be seen in the phenomenal increase in the number of publications which refer to CSA (Figure 1), indicating the growing knowledge base on the topic.

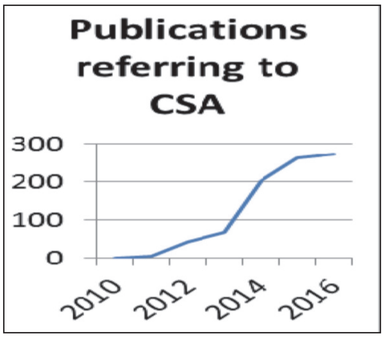

Figure 1. Numbers of publications referring to CSA (based on a search for the term in Google Scholar).

Table 1. CSA strategies, policies, partnerships and investments globally.

Global Alliance for Climate-Smart Agiculture	A voluntary coalition of over 140 members including governments, research institutions, farmers' organisations, the private sector, and NGOs, for knowledge sharing and cross-regional collaboration on CSA .
The World Bank: *Scaling up CSA for Impact*	Mainstreaming CSA across its entire annual agricultural portfolio of US$ 8 billion.
IFAD: *Small Farms, Big Impacts: helping smallholder farmers adapt to climate change*	Mainstreaming climate change considerations into all its new investments by 2018.
CGIAR Research Programme on *Climate Change, Agriculture and Food Security (CCAFS)*	Committed to reach 11 million farm households with CSA by 2022, in collaboration with partners.
'4 per 1000' initiative	Aims to increase soil carbon sequestration, and support the transition towards a productive, resilient agriculture.
FAO	Supporting member countries in CSA implementation through technical assistance, and through targeted programmes.
Climate and Clean Air Coalition (CCAC)	Reducing methane and black carbon emissions from key agricultural sectors, and enhancing food security and improving livelihoods.
Food Security Climate Resilience Facility	Multilateral, multi-year, replenishable fund developed by the World Food Programme to build climate resilience.
Pilot Programme on Climate Resilience (PPCR)	Sectors of focus under this US$ 1.2 billion funding window includes agriculture and landscape management (25%), water resources management (18%), and climate information services and disaster risk management (17%) (PPCR, 2016).
Building Resilience and Adaptation to Climate Extremes and Disasters	United Kingdom Department for International Development (DFID) funded programme which supports actions in South and Southeast Asia, and the African Sahel to increase resilience to climate change impacts.
WBCSD CSA Initiative	Aims to reduce by 50% the GHG emissions from agriculture and land use by 2030, while making 50% more nutritious food available, and strengthening the climate resilience of agricultural landscapes and farming communities.

These efforts by global players (Table 1) are in direct response to the high priority accorded to agriculture by countries in their Nationally Determined Commitments (NDCs) to the Paris Climate Agreement. Twenty-nine countries explicitly highlighted CSA in their NDCs and 119 countries identified climate change mitigation in agriculture to be a priority. Of the 138 countries which included adaptation actions, 127 indicated agriculture as a priority sector (Richards *et al,* 2016).

CSA strategies, policies, partnerships and investments in South Asia

There is a growing emphasis on CSA in Asia, for example, the Asian Development Bank (ADB) committed to double its annual climate financing to US$ 6 billion by 2020, of which US$ 2 billion is allocated for adaptation, including through CSA (ADB, 2015). In South Asia (Table 2), countries which have piloted and scaled-up CSA include India, Bangladesh and Nepal. In India, the *National Mission for Sustainable Agriculture (NMSA)* is one of the eight key Missions outlined under the *National Action Plan on Climate Change*. It aims to enhance agricultural productivity, especially in rain-fed areas, through integrated farming, water use efficiency, soil health management and resource conservation. The *National Innovations on Climate Resilient Agriculture (NICRA)* programme supports nationwide effort through research and piloting, and has established over 150 Climate Resilient Villages across the country (Rao *et al*, 2016). In Nepal, the new *Agriculture Development Strategy* aims to promote a range of CSA technologies through its extension system. In Bangladesh, a national work-plan for scaling up *Alternate Wetting and Drying*, a CSA practice, has been produced. Bangladesh will engage a World Bank US$ 214 million agricultural technology programme, involving 1 million farmers, in implementation of the work-plan.

The concept of Climate-Smart Villages (CSVs) – portfolios of CSA technologies, practices and services promoted in collaboration with the local community and organisations – is gaining traction in the region. The Indian states of Haryana, Maharashtra and Madhya Pradesh aim to scale up CSVs in over 2000 villages. In Nepal, the Government has highlighted implementing the CSV concept as part of national efforts to adapt to climate change.

Table 2. CSA strategies, policies, partnerships and investments in South Asia.

Asian Development Bank	Committed to double annual climate financing to US$ 6 billion for Asia-Pacific by 2020, US$ 2 billion will be for ad aptation including through CSA.
National Mission for Sustainable Agriculture, India	Supports climate change adaptation and mitigation research, pilot and model projects, to develop climate-smart management practices and integrated farming system models suitable to specific agro-climatic conditions.
National Innovations on Climate Resilient Agriculture, India	Aims to enhance resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration.
Climate-Smart Villages (CSVs) in India and Nepal	CSVs are being scaled-up in over 2,000 villages in the Indian states of Haryana, Madhya Pradesh and Maharashtra. The Government of Nepal has started to pilot and scale- out the CSVs approach in different agro-ecological zones from 2016.
National Solar Mission of India	Targets renewable energy generation of 175 gigawatts by 2022. Also supports the replacement of fossil fuel based water pumps for agricultural use to solar pumps.
Renewable Energy Promotion Policy in Nepal	Aims to provide support for water pumping systems in irrigation managed by individuals, a community or a private company.
Agriculture Development Strategy of Nepal	Aims to improve capacity of extension staff and farmers in CSA practices.

CSA strategies, policies, partnerships and investments in Southeast Asia

In Southeast Asia (Table 3), the Association of Southeast Asian Nations (ASEAN) Ministers of Agriculture and Forestry (AMAF) have taken the lead by endorsing regional guidelines for promoting CSA in 2015. These guidelines provide an enabling framework for implementing CSA in the region, and are supported by national and local efforts. Countries including Cambodia, Myanmar, Philippines and Vietnam, have adopted national CSA related policies and programmes. The shared vulnerability to the effects of climate change of many Southeast Asian countries is encouraging cross-country and inter-regional collaboration and knowledge exchange. Regional effort and knowledge exchange on CSA is being facilitated by the *ASEAN Climate Resilience Network*. The Southeast Asian Regional Centre for Graduate Study and Research in Agriculture (SEARCA) has also developed a framework programme for partners (*eg* the *Southeast Asian University Consortium for Graduate Education in Agriculture and Natural Resources (UC)*).

Table 3. CSA strategies, policies, partnerships and investments in Southeast Asia.

ASEAN *Regional Guidelines for Promoting CSA Practices*	Provides voluntary guidelines for countries in Southeast Asia for scaling-up of CSA practices.
ASEAN *Climate Resilience Network*	A platform for regional exchange, particularly for sharing information, experiences, and expertise on CSA.
SEARCA *Climate Change Adaptation and Mitigation Programme for Agriculture and Natural Resource Management in Southeast Asia (SEARCA's CChAM) Umbrella programme*	SEARCA's *Climate Change Adaptation and Mitigation (CChAM) Framework* is envisioned to contribute to the twin goals of food security and poverty reduction through ensuring climate change resilience in the agricultural production and sustainable natural resources management in Southeast Asia.
Myanmar *Climate-Smart Agriculture Strategy*	Focuses on technical, policy and investment conditions to achieve sustainable agricultural development for food security and nutrition through climate-resilient and sustainable agriculture.
Vietnam *20-20-20 programme*. Reduction of GHG emissions in agriculture and rural areas by 2020	Issued in 2012, the programme aims to reduce total GHG emissions from agriculture and rural development sector by 20% by 2020, while growing the sector's productivity and reducing poverty through the application of CSA.
Cambodia's *Climate Change Priorities Action Plan for Agriculture, Forestry and Fisheries 2014-2018*	Promoting and scaling-up CSA is part of the priority actions identified in the plan. The plan is currently being implemented with support from multi-sectoral partners and donors.

CSA strategies, policies, partnerships and investments in East and Southern Africa

In East and Southern Africa (Table 4), a number of CSA initiatives are closely linked with continent-wide initiatives. The *New Partnership for Africa's Development (NEPAD)* agency is leading the implementation of the African Union-NEPAD *Agriculture Climate Change Programme*, which aims to have 25 million farm households practising CSA by 2025 (GACSA, 2016). A key continental initiative supporting this effort is the Africa CSA Alliance, a partnership between NEPAD Agency and five international NGOs (CARE, Catholic Relief Services, Concern, Oxfam, and World Vision), and linking closely with previous continental initiatives to transform agriculture in Africa, such as the *Comprehensive Africa Agriculture Development Programme (CAADP)*. The Alliance aims to reach at least 6 million farm households with CSA thus contributing to NEPAD's 2025 goal of reaching 25 million farm households (GACSA, 2016). The *Africa Climate Business Plan (ACBP)* launched at COP 21 in Paris represents the World Bank's contribution to reduce Africa's adaptation gap by deploying technical expertise, mobilising financing and facilitating the engagement of stakeholders towards climate action. By 2026, the ACBP aims to support the adoption of CSA practices by 25 million African farmers, on 3 million hectares of farmland, and improve CSA policy implementation capacity in at least 20 countries (World Bank, 2015).

Recently a new CSA programme, now known as *VUNA* ('harvest'), has been initiated in East and Southern Africa. *VUNA* is a £23 million DFID-funded programme that aims to transform agricultural systems in East and Southern Africa to be suitable for the changing climate (*Editor's note: see also Newsflash 1*). *VUNA* supports smallholder farmers to adapt to climate change, and also supports achievement of national and regional priorities to transform agriculture in the face of climate change, which aligns with the CAADP pillars.

The three Regional Economic Communities, Common Market for Eastern and Southern Africa (COMESA), East African Community (EAC), and Southern Africa Development Community (SADC) collaborate on a project that is supporting adoption of conservation agriculture, supporting investments in national CSA programmes, and addressing the linkages between agriculture, forestry and land use and *Reduced Emissions from Deforestation and Degradation (REDD)*. The goal is to bring significant livelihood and food security benefits to at least 1.2 million small-scale farmers.

At the national level, Kenya, Uganda, Tanzania, Botswana and Namibia have developed *CSA Framework Programmes (CSA-FPs)*, a joint initiative supported by CCAFS, the World Agroforestry Centre (ICRAF), the International Centre for Tropical Agriculture (CIAT), NEPAD and COMESA. The *CSA-FPs* aim to support countries to synergise their *National Agricultural Investment Plans (NAIPs)* and agricultural sector programmes with national

Table 4. CSA strategies, policies, partnerships and investments in East and Southern Africa.

AU-NEPAD *Agriculture Climate Change Programme*	Aims to have 25 million farm households practising CSA by 2025.
Africa *CSA Alliance*	Supports the scaling-up of CSA practices to at least 6 million farming households.
Africa Climate Business Plan (ACBP)	Supports the adoption of CSA practices by 25 million African farmers, on 3 million hectares of farmland, and improve CSA policy implementation capacity in at least 20 countries.
VUNA	£23 million DFID-funded programme that supports smallholder farmers to adapt to climate change. Initial focus on Malawi, Mozambique, Tanzania, Zambia and Zimbabwe.
Adaptation of African Agriculture Initiative	Aims to mobilise US$ 30 billion for adaptation in the agriculture sector in Africa. Focal areas include management of soils, agricultural water and climate risks.
African Development Bank *Feed Africa strategy*	Focuses on providing funds to support climate-smart agricultural practices.
Climate Resilient Green Economy (CRGE) Strategy, Ethiopia	Through this strategy, Ethiopia aims to achieve carbon-neutral middle-income status before 2025. The strategy aims to improve crop and livestock production.
Uganda *Climate-Smart Agriculture Programme (2015-2025)*	The vision for this programme is climate-resilient and low-carbon agricultural and food systems contributing to increased food security, wealth creation and sustainable economic growth in line with the *National Vision 2040*.
Agriculture Climate Resilience Plan (ACRP) 2014-2019, Tanzania	The ACRP addresses increasing economic, social and climatic impacts accelerated by climate change, and invokes CSA as a central approach to increasing yield and mitigating economic shocks at the smallholder farm level.
Country Climate-Smart Agriculture Framework Programmes (CSA-FP)	Identifies strategic priorities for agricultural development and growth in a changing climate, and aligned with the AU/NEPAD *Comprehensive Agriculture Development Programme (CAADP)* and national strategies and policies.

climate change strategies and action plans in order to ensure a common and holistic approach. In addition, Kenya and Tanzania are also in the process of developing national CSA strategies. In Ethiopia, climate change has been mainstreamed into various national policies, strategies and programmes. In particular, the *Climate Resilient Green Economy (CRGE)* initiative, which is supported by the *Green Economy Strategy (GES)* and the *Climate Resilience Strategy (CRS)* focuses on improving crop and livestock production practices for greater food security and better income for farmers, while reducing emissions.

CSA strategies, policies, partnerships and investments in West Africa

In addition to the continental initiatives outlined above, in West Africa (Table 5), the *West African CSA Alliance (WACSAA)* was established by the Economic Community of West African States (ECOWAS) in 2015 to support efforts in the region. The *Promotion of Smart-Agriculture towards Climate Change and Agro-ecology transition in West Africa* is a regional initiative led by ECOWAS and covers 15 countries. The initiative aims to ensure adoption of CSA practices by 25 million households by 2025, and includes two steps: firstly, the spread of best practices through public policies (involvement of public services in charge of agricultural and environmental policies) and, subsequently, farmers' training and support by NGOs and producers (involvement of producer organisations and operators).

Regional efforts are complemented by national and local efforts. These include efforts by Senegal to provide better climate information to farmers, Ghana's *National CSA action plan*, and Nigeria's *National Agricultural Resilience Framework*.

CSA strategies, policies, partnerships and investments in Latin America

During COP21 in Paris, the Central American Agricultural Council, represented by the Ministers of Agriculture of Costa Rica and Guatemala, declared its full commitment to promote CSA as the approach to face climate challenges in agriculture in the region. As a result of the commitment, a *CSA Strategy* is being formulated for eight countries in Central America and the Caribbean. This *CSA Strategy* is being articulated with the *Central America Climate Change Regional Strategy*, which was formulated in 2010, in order to address threats and promote opportunities that climate change and variability are imposing on the population. The *Climate Change Strategy* also constitutes a guiding mechanism to implement complementary measures and actions at regional level that add value to national initiatives.

In addition to regional efforts (Table 6), national initiatives include Colombia's efforts to enhance the competitiveness of its agricultural sector. By working hand-in-hand with research institutes and the private sector, the government of Colombia has avoided 30 percent of total losses (US$ 50 million) in crops such as rice and maize due to climate variability. In Brazil, their *Low-Carbon Agriculture (ABC) Plan* aims to rehabilitate 15 million hectares of degraded pastures and to increase the area under zero tillage from 25 million hectares to 33 million

Table 5. CSA strategies, policies, partnerships and investments in West Africa.

AU-NEPAD *Agriculture Climate Change Programme*	Aims to have 25 million farm households practising CSA by 2025.
Africa CSA Alliance	Supports the scaling-up of CSA practices to at least 6 million farming households.
Africa Climate Business Plan (ACBP)	Supports the adoption of CSA practices by 25 million African farmers, on 3 million hectares of farmland, and improves CSA policy implementation capacity in at least 20 countries.
Scaling out CSA in Senegal using climate information services	Innovative dissemination of climate information through community radio and SMS text messages.
West African CSA Alliance	Aims to increase productivity and farm incomes sustainably and equitably, to enhance adaptation and resilience to climate variability and change, and control and/or reduce GHG emissions wherever possible and appropriate.
Adaptation of African Agriculture Initiative	Aims to mobilise US$ 30 billion for adaptation in the agriculture sector in Africa. Focal areas include management of soils, agricultural water and climate risks.
National Agricultural Resilience Framework of Nigeria	Seeks to minimise climate risks associated with Nigeria's ambitions to promote rural development through export led agriculture.
National Climate-Smart Agriculture and Food Security Action Plan, Ghana	Aims to translate the national goals and objectives on CSA, into action on the ground, through sound implementation of programmes in the respective agro-ecological zones and in various districts.
Promotion of Smart Agriculture Towards Climate Change	A regional initiative led by ECOWAS and covering 15 countries. Aims at the adoption of CSA practices by 25 million households by 2025.

Table 6. CSA strategies, policies, partnerships and investments in Latin America.

Climate-Smart Agriculture Strategy for Central America and Dominican Republic	A *CSA Strategy* is being formulated for eight countries in the region.
Climate Change Regional Strategy	An initiative that seeks to combine efforts in Central American countries to face current and future climate challenges.
Climate and the Colombian Agriculture Sector: Adaptation for a Productive Sustainability	Seeks to enhance the competitiveness of the Colombian agricultural sector through the implementation of policy instruments, strengthening the investment of resources for research, technological development and innovation.
Brazil's *Low-Carbon Agriculture (ABC) Plan*	Credit initiative that provides low-interest loans to farmers for CSA practices such as no-till agriculture, restoration of degraded pasture, treatment of animal wastes and the integration of crops, livestock and forest.

hectares by 2020. It also intends to reduce its emissions by 160 million tonnes of CO_2 equivalent annually, before 2020.

Conclusions

A number of strategies, policies, partnerships and investments have been initiated to put the CSA concept into practice, at the global, regional and national levels. Many of these efforts are in early stages and their impacts cannot yet be fully quantified, however, some general lessons can be drawn to ensure the success of these efforts.

Firstly, the experiences from Africa, Southeast Asia and Latin America show that regional cooperation and knowledge exchange between countries is key to success. Efforts to foster regional cooperation, particularly through South-South cooperation, should be pursued further.

Secondly, CSA actions are context-specific and will vary depending on regional, national and local priorities. For example, in South Asia, the key areas of emphasis include scaling-up CSVs and renewable energy, whereas in East and West Africa, there is greater emphasis on increasing resilience of smallholder farmers. Therefore, effective targeting and prioritisation is needed to ensure success of CSA strategies, policies, partnerships and investments.

Thirdly, success of these efforts will depend on the sustainability of financing. Although several major commitments have been made by international financial institutions, the private sector, development agencies, and national governments, many of the efforts are funded for short periods only (two to five years). A long-term view is needed to allow farmers to grasp concepts fully, as well as to realise the benefits of these interventions.

Fourthly, while private sector efforts are prominent at the global level, they are limited at the regional and national levels, with most efforts led by Governments or international organisations. There is a need for more involvement of the private sector at the regional and national levels, including with small and medium enterprises and micro-insurance schemes.

Lastly, while the interest in CSA is extremely positive and provides a favourable enabling environment for scaling-up CSA, success should be measured using rigorous metrics, and sound monitoring and evaluation approaches need to be integrated into implementation efforts.

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News from the Field

Climate-Smart Agriculture across scales in Latin America

The implementation of climate-smart agriculture (CSA) in Latin America presents interesting challenges and opportunities, especially when considering the region's agro-biodiversity, natural resources, and socioeconomic and cultural contexts.

Collaboration amongst many agencies in Latin America has brought significant advances in CSA. One notable development was the declaration of Central American countries during an event at COP21 in Paris to promote CSA (Figure 1). During the event, Ministers of Agriculture of Costa Rica and Guatemala reaffirmed that CSA provides a robust framework to transform agriculture in the region to become a resilient and sustainable source of development. Some of the main reasons to promote CSA, stated by the members of this declaration, included: i) Central America suffers measurable impacts from climate change evidenced in increased drought intensity in the Dry Corridor and intensive floods on the Atlantic Coast of the region; ii) the region needs to move from relief and emergency actions towards adaptation to climate change and therefore resilience; and iii) common vulnerabilities in the rural areas of Central American countries need to be addressed through collaborative action in order to increase productivity, efficiency and development for current and future generations. In addition, according to Costa Rica's Minister of Agriculture, Central America aims to serve as a demonstrative laboratory of the effectiveness of CSA, becoming an example to other regions.

Figure 1. Regional declaration to promote Climate-Smart Agriculture in Latin America, on day 2 of Global Landscapes Forum, Paris, France. (Photo: P Valbuena (CIFOR))

The strong commitment of the region to promote sustainable production and development through CSA has led to the formulation of a CSA strategy for Central America and the Dominican Republic, with the CGIAR's programme on Climate Change, Agriculture and Food Security (CCAFS) leading the technical support. The strategy will enable the region to have robust guidelines that will allow countries to learn from their neighbours' successful experiences, but also to acknowledge what might work best considering context-specific challenges and opportunities given a changing climate. The expected outcomes of the regional strategy include: improving the livelihoods of the region's approximately 14 million smallholder farmers (BID, 2014); increasing productivity in relevant sub-sectors of the regional economy, such as livestock, while reducing their contribution to climate change; and increasing food security, as well as competitiveness through climate-smart value chains in coffee and cocoa using a *knowledge intensive approach*. The latter activities imply not only exchange of experiences but also applied research and thus generation of knowledge by and for the region.

The knowledge intensive approach promoted through the Central America CSA regional strategy already has significant advances to build on, especially regarding the coffee sector (Figure 2). Coffee is one of the most important products of the region (approximately 67 percent of the world's coffee is produced in Latin America (FAO, 2015)). Research conducted by CIAT, suggests that by 2050 there will be substantial decreases in the total area suitable for coffee production in Nicaragua, and predicts that climate change will shift the altitude range for coffee to higher elevations over time, with the optimal altitude shifting from 1,200 m at present to 1,400 m in 2020 and 1,600 m in 2050 in Central America (Laderach *et al,* 2011).

Figure 2. Mr José Luis's coffee farm in a Climate-Smart Village in Santa Rita, Copán (Honduras). (Photo: O Bonilla (CCAFS))

CIAT's research also established that climate pressure might lead farmers to move from coffee into other crops such as cocoa in the near future (Bunn *et al*, 2015). Coffee in Central America remains susceptible to leaf rust, with large-scale impacts such as increases in input costs, both for fertilisers and for rust control application, while coffee prices continue to remain far below historic peaks. Today's impacts on coffee yields, pests and diseases, will be intensified by future climate changes. Bunn *et al* (2015) state that in this scenario cocoa is a feasible option for business diversification, given that it adapts well to the emerging climate. Under both current and future scenarios, CSA options such as diversification are providing a way out of negative impacts on farmers' income. Governments and the private sector have used this information to take action and collaborate in order to promote and implement CSA measures in the coffee sector. For example, Nicaragua's government, with IFAD's support, is promoting coffee diversification with cocoa to gradually transform agricultural landscapes. Also, companies such as *Root Capital* are investing in supporting their coffee suppliers, most of them small coffee cooperatives, to become more climate-smart by implementing practices such as diversification, efficient use of nutrients and inputs to reduce pest and disease damage, and associated practices to seek balance on quantity and quality characteristics that can provide differentiated added value.

Finally, Latin America is an example where CSA has become part of the global action translated into the National Determined Contributions (NDCs). In Colombia, CCAFS developed an approach to support the decision making process of the agricultural sector regarding climate at local scale. This approach is called *Local Technical Agro-climatic Committees (LTACs)* and it constitutes a dialogue between three types of communities: climate scientists, agro-climatologist scientists and local communities (Figure 3).

Figure 3. Local Technical Agro-climatic Committee in Montería, Colombia. (Photo: JL Urrea (CCAFS))

These communities interact in order to understand the erratic changes in climate and to provide possible answers that can help to manage local climate risk in agricultural production. As part of the process, capacity building in local and sectoral institutions is carried out in order to make the initiative sustainable in the long term. The LTACs facilitate knowledge exchange and promote the implementation of adaptation actions according to agro-seasonal forecasts which can enhance productivity. These adaptation actions include decisions on best planting dates for each agricultural season, more suitable seeds, as well as the desirable amount and frequency of irrigation and use of fertiliser. At the same time, the latter contributes to GHG emissions reduction. Given the success of this initiative, and the urgency to address agro-climatic risks, especially at the local level, while reducing GHG emissions, the Government of Colombia has decided to include in its NDCs the establishment of at least 15 LTACs as a measure to promote food security, enhance adaptation and reduce GHG emissions.

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‘CSA-Plan’: strategies to put Climate-Smart Agriculture (CSA) into practice

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Abstract

Large-scale investment is needed to create climate-smart agriculture (CSA) systems. While many government and development agencies are integrating CSA into their policies, programmes, plans and projects, there is little guidance for operational planning and implementation on ways to be climate-smart. Here we present ‘CSA-Plan’. CSA-Plan frames actions needed to design and execute CSA programmes into four components – (i) situation analysis, (ii) targeting and prioritising, (iii) programme design, and (iv) monitoring and evaluation. Each component yields concrete information to operationalise CSA development, separating it from traditional agriculture development. Already, CSA-Plan has shown the capacity to change the discussion around CSA implementation. With iterative co-development, the approaches will become ever more useful, relevant and legitimate to governments, civil society and the private sector alike.

Introduction

Climate-smart agriculture (CSA) is an approach to agriculture that promotes three objectives: sustainably increasing productivity; building the resilience of farming systems; and reducing greenhouse gas emissions, where possible (FAO, 2013). CSA does not prescribe interventions: instead, climate risks are addressed through tackling trade-offs and synergies between the three objectives (Rosenstock *et al,* 2016). This then separates CSA from other approaches to agricultural development that either specify practices or technologies, such as conservation agriculture or agroforestry. Thus, CSA requires identifying what is climate-smart for the biophysical, agricultural, and socio-economic context of a given place.

Major development investors are rallying behind CSA, with large investments being planned or made by the international financial institutions and aid organisations, including the *Green Climate Fund*, the International Fund for Agricultural Development (IFAD), and international aid agencies such as the United Kingdom Department for International Development (DFID) and the United States Agency for International Development (USAID). National governments and their development partners are looking to move forward with large-scale CSA implementation. The private sector is also recognising the importance of making their supply and value chains climate-smart, as evidenced by the engagement of the World Business Council for Sustainable Development in

CSA. New multi-sector CSA partnerships have formed, such as the Global Alliance for Climate Smart Agriculture (GACSA) and seven regional/national alliances, with goals of sharing knowledge, supporting investments, and scaling-up implementation.

Putting CSA into practice requires knowing what is climate-smart in different locations and designing projects to fit the context for implementation. What works for one type of farmer may not work for another (*eg* related to labour availability), and a CSA practice with desirable outcomes in one location does not necessarily deliver desirable outcomes under all agro-ecological conditions. There are often trade-offs amongst the three goals of CSA – sustainable productivity, resilience, and mitigation – so stakeholder priorities are important to consider when selecting which CSA practice to implement. There is a need for assessing value-for-money, climate-smartness, development impact, and scaling potential to establish effective CSA programmes. One major problem is that decision-makers do not have frameworks in place that link science and stakeholder engagement to plan, implement, and monitor CSA to achieve impact at the scale needed.

This paper presents an operational guide for putting CSA programming into practice – 'CSA-Plan' – which contains four main components for CSA planning and implementation (Figure 1): (i) situation analysis; (ii) prioritising interventions; (iii) programme design and implementation; and (iv) monitoring, evaluation, and learning. A suite of approaches are available for each component, and can be used to answer specific challenges that obstruct planning and progress. The components of CSA-Plan can be implemented sequentially or by themselves depending on stakeholder needs. Underlying CSA-Plan is a suite of CSA indicators to provide an evidence base to the decision-making, implementation, and monitoring components. Moreover, given the participatory nature of the approaches, capacity strengthening is critical for success and broad use.

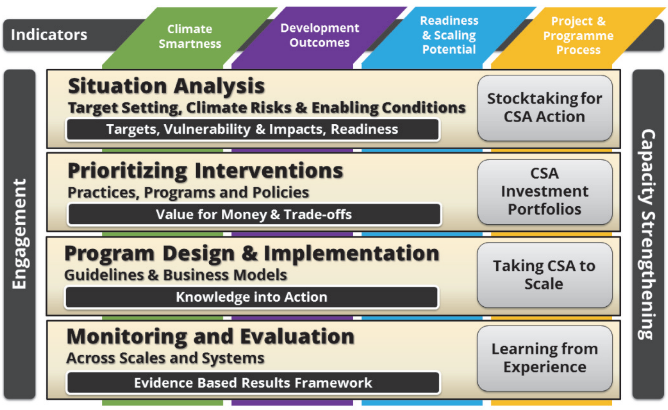

Figure 1. CSA-Plan Framework includes Situation Analysis, Prioritising Interventions, Programme Design and Implementation; Monitoring and Evaluation. Different types of Indicators are important to utilise across the CSA-Plan components to measure climate-smartness, development outcomes, readiness and scaling potential, and project/programme process. Engagement and capacity strengthening are needed for application of the CSA-Plan information and approaches within the context of agricultural development.

Situation Analysis

Before any decisions can be made on CSA programmes, policies, and initiatives, a fundamental understanding is needed of the context where they will be implemented. This includes not only information on the farming activities, but on stakeholders' goals, constraints, livelihood strategies, *etc*. A CSA situation analysis should provide information on the climate risks and impacts, but more widely the agricultural, political, social, and economic conditions for which CSA actions are being taken. The situation analysis specifically identifies the entry points for CSA actions by looking at: (i) the importance of agriculture in society; (ii) risks and vulnerabilities of the agricultural sector; (iii) existing and promising CSA practices and services; (iv) institutional and policy environment related to CSA – both barriers and enabling; and (v) finance opportunities and challenges for CSA initiatives. An engagement plan is needed to ensure key stakeholders are part of the process from the beginning, and that it is inclusive. At this stage, a long list of current and promising CSA practices and services relevant to specific agricultural systems and agro-ecological conditions can be identified for further analysis. Identification of finance mechanisms and institutional and policy entry points demonstrates current alignment with public and private sector policies and investment plans with CSA. A range of different specific CSA approaches that have been/can be used for situation analysis include the International Centre for Tropical Agriculture (CIAT)/CCAFS *CSA Profiles*, which summarise the CSA context at national or sub-national levels (World Bank & CIAT, 2015) and FAO's *scoping studies for CSA East Africa* (FAO, 2015), among many others. The commonality being that they provide a foundation for CSA actions that can address climate risks, engage stakeholders, and enable further analyses and planning (Figure 2).

Figure 2. National stakeholder workshop in Nairobi on responding to climate shocks at community level. New climate-smart profiles offer Kenya a roadmap to implement climate-smart agriculture at country level. (Photo: Georgina Smit (CIAT))

Targeting and prioritising to identify CSA investment portfolios

A range of technological, institutional, and policy options for climate-smart interventions exist that have varying impacts on the CSA goals and economic costs and benefits. CSA-Plan's targeting and prioritising component builds on this premise by using advanced analytical techniques, nested within participatory processes, to narrow down an extensive list of possible practices, services, and policies to a range of best-fit options that provide value for money and can be scaled-out. The outcome of this step is a stakeholder-selected and evidence-based portfolio of high-interest CSA options.

CSA-Plan puts forward a general prioritisation approach based on the CIAT/CCAFS *CSA Prioritisation Framework* (Campbell *et al,* 2016; Sain *et al,* 2016; Corner-Dolloff *et al,* 2017). Stakeholders first assess the context for the CSA intervention in question and set criteria for prioritisation. This includes a set of specific measurable indicators under each of the three CSA goals. A long list of potential CSA interventions – practices, services, and policies – is then established to provide a starting point for prioritisation. Next, through stakeholder and expert interrogation of indicator analyses of the potential outcomes of CSA interventions, the long list is narrowed down to a short list of high interest interventions for further analysis. Then, the selected practices are evaluated for their economic costs and benefits, implications for gender and social inclusiveness, adaptability, and scalability. And finally, through stakeholder and expert input, ensuring inclusivity, investment portfolios are developed either for different farmer types, different implementers, or different scales, aiming to maximise or minimise specific synergies and tradeoffs across the portfolio.

A range of specific CSA prioritisation tools and approaches have been developed that can be used (Shikuku *et al,* 2017; Mwongera *et al*, 2017; Notenbaert *et al*, 2017). Different tools and processes can be used for different types of stakeholders and levels of decision-making (*eg* national *vs* community), allowing implementers to tailor their prioritisation approach and successfully engage target stakeholders.

Programme design and implementation

Programme design and implementation supports taking prioritised CSA actions to scale. It provides specific information that underlies the implementation of the interventions selected. It is important to have a 'theory of change' for how the intervention will lead to positive impact; a common pitfall is to simply come up with a list of interventions rather than strategically designed interventions that can be scaled-up to many beneficiaries. The diversity of products, users, and implementation conditions dictates equally diverse approaches and models. Principles of co-design can be useful to innovate in product design, iterate with end-users to field test, refine and improve materials, and share products on learning platforms to facilitate access by others.

There are a range of approaches and tools to use for programme design and implementation, including climate-smart value chain models, outgrower models, extension, farmer field schools, early-warning systems, financial mechanisms, weather-based insurance, and technical guides for technology implementation, among others. For example, the *Link 2.0 methodology* (Lundy *et al,* 2014) is one such approach that has been used for designing innovative and inclusive climate-smart value chain business models. Financial savings approaches, such as village savings and loan associations (Allen & Staehle, 2007), provide simple savings and loan facilities in a community that can provide a mechanism for facilitating uptake of CSA interventions. Innovative agricultural business models, such as outgrower or contract farming schemes, can be a mechanism for scaling of CSA interventions, such as has occurred in Kenyan tea outgrower schemes (Milder *et al,* 2015). Climate services, warning systems, and agro-advisory services provide means for providing timely and site-specific information to farmers to help them respond to weather and climate (Hewitt *et al,* 2012). Technical guides and manuals for implementation are needed for guiding development projects in how to implement interventions on the ground under different conditions (Rioux *et al,* 2016). Climate risk can be offset using weather-based index insurance products for crops and livestock (Miranda & Mulangu, 2016). Depending on the social, environmental and economic context of the location, different programme models and tools will be useful or not. All in all, programme design is a wide area of work focused on engaging stakeholders in designing interventions that work for them.

Monitoring, evaluation, and learning

CSA-Plan's monitoring, evaluation, and learning (ME&L) component develops strategies and tools to track progress of implementation, evaluate impact, as well as facilitate iterative learning to improve CSA planning and implementation. CSA-Plan's ME&L delivers processes and products to support achieving and documenting programme goals and adaptively managing implementation. However, there are many challenges in measuring CSA. It has multi-objective complexity, given the multiple goals of CSA. The scale of impact can range from the farm to the national or international level. There are often multiple institutions involved in ME&L, each of whom might bring their own priorities and approaches.

The CSA-Plan approach considers various aspects of ME&L to address these challenges. The programme and stakeholder priorities are used to determine specifically what the ME&L is addressing. Then specific indicators must be selected and linked to priority outcomes using tools such as the *CSA Indicators Database* (Quinney *et al,* 2016). There are *CSA outcome indicators* needed to measure medium/long-term impact on the three CSA objectives – sustainable productivity, adaptation/resilience, and greenhouse gas mitigation. There are indicators related to *broader development outcomes* (*eg* Sustainable Development Goals), such as incomes, nutrition, markets, *etc*. There are *readiness and scaling potential indicators* reflecting the capacity to plan, implement and monitor investments and activities related to CSA implementation that help measure the ability for the intervention to be scaled-up. Finally, there are *project and programme process indicators* to monitor programmes for meeting implementation process objectives. It is important to note that even though indicators clearly are important for the ME&L, these indicator sets are important across the different components of CSA-Plan.

Specific tools and instruments have been developed for monitoring sets of indicators. The CGIAR-CCAFS *Monitoring Instrument for Resilience* can be used for tracking changes in resilience in agricultural projects and programmes (Hills *et al,* 2015). Operationalising the concept of resilience (*ie* the ability to withstand change, stresses and shocks) is a challenge, and this tool demands tracking and reporting changes efficiently and using the information commonly available within development initiatives. Similarly, the *Toolkit for the indicators of resilience in socio-ecological production landscapes and seascapes* provides practical guidance for engaging local communities in adaptive management and can increase their capacity to respond to pressures and shocks. Monitoring CSA can also be done in a holistic, multi-objective way. For example, the *Rural Household Multi-Indicator Survey (RHoMIS)* provides a rapid and cost-effective instrument to track changes in poverty, gender equity, nutrition, climate and productivity outcomes – all measures of climate-smartness (van Wijk *et al,* 2016). *RHoMIS* is modular, so implementers can select or add indicators which fit their context and needs, and has been used in Africa, Latin America and Asia. Specific attention should be paid to gender, a critical cross-cutting part of CSA, and monitoring can also be done using approaches such as the *Woman's Empowerment in Agriculture Index* (Johnson & Diego-Rosell, 2015).

Engagement and capacity strengthening

Engagement and capacity strengthening are critical to help governments and others implementing agricultural development to integrate CSA into their policies, programmes, plans and projects (*eg* National Agriculture Investment Plans, Nationally Determined Contributions, and Climate Change Action Plans). CSA-Plan provides operational approaches that can be directly integrated into the planning processes, but the CSA-Plan process must be owned by the stakeholders and decision-makers involved.

Capacity strengthening is also critical for mainstreaming CSA, and the CSA-Plan approach, in institutions, policies and businesses across levels (community to national to global). This can be accomplished by working through the National Agriculture Research Systems (NARS), through academia, government, NGO, or the private sector. There are various alliances forming to provide formal engagement, knowledge, and training, for example GACSA and the Africa CSA Alliance. The bottom line is that without good engagement and capacity strengthening, CSA-Plan lacks purpose.

Conclusions

With the growing demand by governments, NGOs, and the private sector for integrating climate into agricultural development, there are many opportunities for CSA-Plan components to be applied from regional to sub-national levels. The CSA-Plan components – situation analysis, prioritising interventions, programme design and implementation, and monitoring, evaluation, and learning – have already been applied in many countries with partners including the World Bank, USAID and DFID, among others. For example, climate risk profiles are being developed for 24 Kenyan counties to provide technical support to the US$ 250 million *World Bank Kenya CSA Project*. Prioritisation of CSA intervention areas is then being developed within counties, and specific interventions being designed and implemented within the county Common Interest Groups and Public-Private Partnerships developing innovative implementation plans.

Responding to the needs of the stakeholders and decision-makers is critically important if evidence is to be translated into policies and programmes, but this is also a challenge to accomplish. Each set of stakeholders requires slightly different information and processes. For this reason, the CSA-Plan components are not static, but rather CSA-Plan provides a range of information, tools, and approaches that can be modified to address the needs of the specific stakeholders, with new tools and approaches added as they become available. Capacity strengthening of key institutions is also needed as evidence presented is only helpful if decision-makers are able to use it. Training manuals and workshops are useful starting points for capacity building interventions. Given that famers and others at the local level are the ones actually taking decisions, there is a need for information, tools and approaches to be accessible across levels to operationalise mainstreaming of CSA into both on-farm business planning and larger-scale investments aimed at catalysing action. While the number of examples is growing, there is great opportunity for increased uptake of the CSA-Plan approach by governments, NGOs, and the private sector to mainstream CSA into agricultural development globally.

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News from the Field

Climate information use implications for climate risk mitigation in West Africa

The necessity for climate information services in West Africa

With projections of a 70 percent increase in demand for staple cereals by 2050 in order to feed the growing human population (FAO, 2010), combined with the current declining per capita food production and a dwindling natural resource base, 'feeding West Africa' and increasing the resilience of livelihood systems may be well beyond reach. This has been attributed to multiple factors such as land tenure challenges, declining soil fertility, poor markets, climate hazards and variability, inadequate funding and poor infrastructural development (Ouedraogo *et al*, 2016; Partey *et al*, 2016). The current state of food insecurity and poor rural livelihoods are expected to be further exacerbated by climate change and variability which has emerged as one of the major threats to development in West Africa (Zougmoré *et al*, 2016).

While the Paris Agreement places great emphasis on reducing greenhouse gas emissions and creating carbon sinks, the impact on climate change mitigation will not be seen immediately even if the most effective mitigation measures are implemented.

As vulnerable farmers in West Africa experience greater climate variability (Cooper *et al*, 2008) it is important that climate-smart agricultural (CSA) technologies that reduce vulnerability to climate risks are prioritised. The establishment of the *Global Framework for Climate Services* (WMO, 2013) by the World Meteorological Organisation (WMO) clearly confirms climate information services (CIS) as one opportunity for managing climate change and variability risks. With increased drought, unpredictable rainfall patterns, destructive flooding and the growing evidence of climate change negatively impacting farm production systems, access and use of climate information should help farmers make crucial decisions that enable them to adopt strategies that have the potential to reduce crop failure, improve efficient use of farm resources, and ensure profit (Roudier *et al*, 2014).

CIS initiatives and impact in West Africa

In the quest to improve the capacity of farmers to better manage climate-related risks and build more resilient livelihoods in West Africa, there have been several initiatives focusing on: (i) designing tailored climate information services and (ii) communicating the results appropriately to farmers for their farm management decision-making (CCAFS, 2015).

Since 2011, substantial successes have been achieved, particularly in Senegal and Ghana. In Senegal a collaboration between scientists, the national meteorological agencies and 82 rural community-based radio stations, resulted in the promotion of economic development through communication and local information exchange, and seasonal forecasting, which is now reaching about 750,000 rural households across 14 administrative regions (CCAFS, 2015). Climate information has benefited fisher-folks, pastoralists and crop producers in managing farm-related, and other livelihood, activities.

In Ghana, through a private ICT-based platform, market price alerts, climate-smart agricultural advice, weather forecasts and voice messages on CSA practices are sent out to farmers in Northern Ghana in the local language. This platform has so far trained about 1,000 farmers (of whom 33 percent are females) (ICRISAT, 2015). A recent survey (Zougmoré *et al*, 2016) showed how access to and use of climate information resulted in increased yield of crops as farmers used seasonal forecasts to make strategic decisions such as when to start land preparation, when to plant, selection of crop varieties, and when to apply manure or chemical fertilisers.

Furthermore, *ROPPA*, the West Africa farmers' organisations network, and the agricultural value chain programmes initiated by CCAFS in Burkina Faso *(PROFIL)* and Senegal *(PAFA)*, also disseminated seasonal forecast information and climate-smart agricultural options to farmers from various agricultural sectors as well as throughout their national constituencies (Ouédraogo *et al*, 2015). A cost-benefit analysis in Burkina Faso showed that farmers exposed to climate information used less local seed and more improved seed for cowpea and sesame production (Ouédraogo *et al*, 2015). They also used less organic manure and more fertilisers for sesame production. Cowpea producers exposed to climate information obtained higher yields and, at the same time, lower input costs. Their gross margins were therefore found to be higher compared to non-exposed farmers.

A *Participatory Integrated Climate Services for Agriculture (PICSA)* approach – designed by the University of Reading – is also being tested in Burkina Faso, Ghana, Mali and Senegal to equip agricultural extension staff, and other intermediaries, to work with groups of farmers to understand climate information and incorporate it into their planning. The *PICSA* approach involves agriculture extension staff working with groups of farmers ahead of the agricultural season to analyse historical climate information and use participatory tools to develop and choose crop, livestock and livelihood options best suited to individual farmers' circumstances. Then, before and during the season, extension staff and farmers consider the practical implications of seasonal and short-term forecasts on farmers' plans.

Conclusions

Farmers and policy-makers have long sought reliable regional and local climate projections to provide a solid basis for guiding their actions. With climate information services in West Africa, farmers are able to plan their planting dates and make projections about rainfall distribution patterns. These guide farm decision-making and have helped farmers increase yield, reduce costs of production and improve the use of farm inputs (such as manure and inorganic fertilisers).

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Newsflash

Vuna is set to help farmers in East and Southern Africa battle the impacts of climate change

In many languages in East and Southern Africa, the word "*vuna*" means harvest, reaping or redeeming a crop from bad weather. It is also associated with the coming together of people and tackling joint challenges. This is what *Vuna*, a DFID-funded climate-smart agriculture (CSA) programme implemented by *Adam Smith International*, is inspired by. Our work in Malawi, Mozambique, Tanzania, Zambia and Zimbabwe, to help build the climate resilience of smallholder farmers in the region, is achieved by working together with the private sector, governments, civil society and smallholder farmers.

Since the three-year programme was launched in 2015, *Vuna*'s objective has been to contribute to transformative change of the agriculture sector in the region, so that the majority of smallholder farmers are climate-resilient. We do this in three ways: increasing the availability and use of CSA evidence, assessing and co-creating strategic actions to improve the enabling environments for CSA, and testing and promoting innovative business models that help the delivery of CSA.

At *Vuna*, we understand that we are not the only organisation working in CSA and that three years may not be enough time to drive this 'transformative change'. In our initial programme period, *Vuna* is laying the foundation for work that will have bearing on the continent in the long-term. Our three work-streams illustrate this understanding:

Increasing the availability and use of CSA evidence

Vuna commissions research on key issues that affect farming in East and Southern Africa: climate risk and trends and their impact on farming in the region; the financial viability of weather-based index insurance; analyses of agricultural drought; seed systems and models for reaching farmers with high quality seed varieties; and developing frameworks for assessing CSA delivery models and how to scale them up. In 2017, *Vuna* will publish these findings on its website, social media, journals (where possible) and disseminate widely to funders, investors, governments, civil society organisations, research institutes and agribusinesses.

Assessing and aiming to improve the enabling environments for CSA

We conduct analyses on key CSA-enabling environment issues, engage with national governments, civil society and regional climate change organisations such as the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS) regarding findings and country CSA-enabling environment priorities, and implement activities that aim to produce useful and practical CSA actions. In our five target countries, *Vuna* works to support the development of national CSA strategies or policies, effective coordination mechanisms, as well as monitoring, reporting and verification (MRV) of organisations that promote and implement CSA initiatives. We also work to assist governments to access climate finance and support the development of CSA implementation instruments such as CSA manuals.

Testing and promoting innovative business models that help the delivery of CSA

Vuna is piloting ways to link farmers and private companies in sustainable agricultural value chains. We partner with agribusinesses from various sectors across the region, to test and scale-up sustainable CSA delivery mechanisms. We work in a number of themes: (i) seed systems to improve access to drought tolerant seed (especially legumes); (ii) strengthening agribusiness outgrower extension systems to deliver CSA to smallholder farmers; (iii) developing financial systems to support smallholder farmers access to finance; (iv) strengthening smallholder livestock production systems and linkages with commercial off-takers.

We are also implementing a robust results management system to document the evidence of how such innovation models leverage additional investment and close the gender transformation gap in agriculture. Over the next year, *Vuna* will publish and share its findings widely on the evidence of these innovative business models.

Christopher Muller

Communications Manager, *Vuna*

Vuna is a DFID-funded, regional climate-smart agriculture programme, implemented by Adam Smith International. Read more on www.vuna-africa.com or follow Vuna's social media: Facebook, LinkedIN and Twitter.

The mitigation pillar of Climate-Smart Agriculture (CSA): targets and options

Lini Wollenberg

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Abstract

The need to prioritise food security in the face of a changing climate raises the question of how much agriculture should contribute to global mitigation targets. A global target for reducing methane and nitrous oxide emissions from agriculture of ~1 gigatonne of carbon dioxide equivalent per year ($GtCO_2e/yr$) by 2030 would limit warming in 2100 to 2°C above pre-industrial levels. Yet low emissions development (LED) in agriculture, based on available technologies and policies, will deliver only a portion of the needed mitigation. More transformative options will be needed, including carbon sequestration, reduced food loss and waste, and shifts in consumption.

Introduction

The potential for agriculture to contribute to climate change mitigation globally is well-documented (Smith *et al*, 2007). However, the threat of food insecurity in the face of a changing climate raises the question of how much agriculture should contribute to global mitigation targets, if at all. Most developing countries, especially those most vulnerable to climate change, are focused on adapting to climate change, rather than reducing it.

Growing evidence suggests reducing emission in the industrial, energy or transport sectors will not be enough to limit warming in 2100 to 2°C above pre-industrial levels, the target set by the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement. As emissions in other sectors decrease, agriculture-related emissions will become the largest source of surplus emissions by 2030, so the pressure and need to mitigate emissions in agriculture will increase (Bajzelj *et al*, 2014; Gernaat *et al*, 2015). In addition, the Paris Agreement states the aim of achieving *"a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century…"*. Agriculture's potential to store carbon in the soil, and in above- and below-ground biomass, means that it could be a major contributor to negative emissions. For many countries, mitigation of agricultural emissions is an opportunity to meet national mitigation targets. For the Paris Agreement, 119 countries pledged to reduce their agricultural greenhouse gas (GHG) emissions (Richards *et al,* 2015b). Agricultural emissions contribute an average of 35 percent of emissions in developing countries and 12 percent in developed countries (Richards *et al*, 2015a).

Given the need to meet the global 2°C warming limit, how can agriculture best contribute to mitigation in ways that also meet food security goals? Also, since three-quarters of agriculture's emissions of 5.0 to 5.8 gigatonnes of CO_2e per year originate in developing countries (Smith *et al*, 2007), what are the implications of a mitigation target for places that are the most vulnerable to food insecurity and need to prioritise adaptation?

To address these questions, I present a 2°C-linked target for mitigation in agriculture and discuss the potential and limitations of low emissions agriculture as an option to meeting climate change and food security goals.

A mitigation goal of 1 gigatonne CO_2e per year

Estimates suggest that in 2030, global anthropogenic emissions of 68 gigatonnes CO_2e (all sectors) will need to be reduced by 26 gigatonnes CO_2e to meet the 2°C limit (New Climate Economy, 2014). Can this global goal be allocated across sectors to estimate a sectoral goal for agriculture? Having such a goal would help to guide ambition and assess the relevance of mitigation contributions.

To develop such a goal, experts from twenty universities, research institutes and other organisations, collaborated to consider the emissions reductions necessary in agriculture in a 2°C world (Wollenberg *et al,* 2016). The scope of agricultural emissions considered included methane (CH_4) and nitrous oxide (N_2O) emissions. Carbon sequestration resulting from the production of crops, livestock and agroforestry on farms was not included due to the models available. Other agriculture-related emissions not included in the study due to the available models were emissions in the supply chain (transport, processing, fertiliser production, post-harvest loss), and those related to land use change or consumption (diet and food waste).

The team examined the 2°C target using the Representative Concentration Pathway (RCP) 2.6 scenario prepared for the Intergovernmental Panel on Climate Change (IPCC). We identified the mitigation needed by comparing this reduced budget with the scenario's baseline, business-as-usual emissions. The RCP 2.6 scenario represents conditions expected to limit emissions to 450 ppm of CO_2e in 2100, which results in a 66 percent or 'likely' chance of staying below the 2°C warming limit (van Vuuren *et al*, 2011). We examined the same scenario using three different integrated assessment models: Integrated Assessment of Global Environmental Change (IMAGE); Global Change Assessment Model (GCAM); and the Model for Energy Supply Strategy Alternatives and their General Environmental Impact (MESSAGE).

The comparison showed that, on average, agricultural emissions would have to be reduced by 1 gigatonne of CO_2e per year by 2030 to stay within a 2°C emissions budget of 6 to 8 gigatonnes CO_2e for agriculture (Figure 1). This would reduce agricultural emissions by 11-18 percent in 2030, contributing 4 to 5 percent of the mitigation needed across all sectors in 2030 to achieve the 2°C limit.

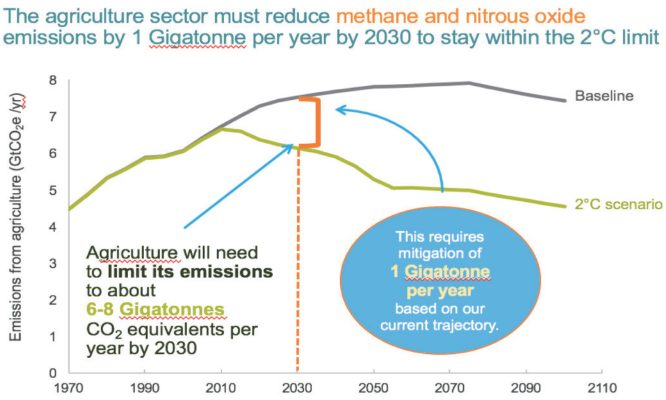

Figure 1. Mitigation needed in agriculture to achieve the 2°C target in 2030.

Mitigation in agriculture would need to increase in 2050 to 2.5 to 2.6 gigatonnes CO_2e per year, reaching a maximum of 2.9 to 4.2 gigatonnes CO_2e in the period between 2070 to 2100. These estimates indicate that significant reductions in agricultural emissions will be necessary in the decades to come.

Since developing countries will need to focus on food security and climate change adaptation, what would be their contribution to this target? Social justice considerations suggest that the burden for mitigation should be carried by the more industrialised countries. However, if the priority is meeting the 2°C goal in conjunction with food security, scenarios show that the mitigation burden needs to be shared among all countries, including developing countries. Kleinwechter *et al* (2015) found that mitigation in agriculture was most efficient for food production when based on a policy regime of full global collaboration rather than exemptions of the least developed countries or developing countries. The implication is that new approaches to agriculture will be needed everywhere, including developing countries. Mitigation measures thus need to be introduced in the context of agricultural development.

Low emissions development (LED) in agriculture

LED is the emerging paradigm for mitigation in agriculture in developing countries. LED in agriculture can be defined as sustainably advancing human well-being and agroecological productivity and sustainability in ways that also reduce agricultural GHG emissions. Reductions in emissions should be compared to what emissions otherwise would have been with conventional agricultural development or based on the projection of current practices. LED puts the need to produce food and other goods for human needs first, and mitigation second (Nash *et al,* 2015).

LED differs from mitigation-driven approaches. Mitigation-driven planning identifies practices that deliver the largest reductions in emissions at the least cost (usually expressed in monetary terms, but can also be in terms of food security losses, see Kleinwechter *et al*, 2015) and then seeks the policy incentives enabling adoption of these practices. An LED approach instead identifies agricultural development goals and then develops mitigation practices compatible with these goals. Farmers are assumed to shift to LED practices because the practices also best meet their own goals.

GHG-efficiency is the guiding principle of LED. Practices should be sought that minimise the GHG emissions per unit of yield or what is called 'emissions intensity'. Many agricultural development practices already seek to increase input efficiencies, such as improved feed digestibility for cattle, reduced water use for paddy rice or efficient use of nitrogen fertiliser (see for example CSA practices https://ccafs.cgiar.org/publications/csa-practices-and-technologies or Gerber *et al*, 2014 on livestock), which often also reduce emissions per unit yield. Improved GHG-efficiency in LED does not however guarantee reductions in emissions compared to the present. It only guarantees the reduction of future emissions relative to a business-as usual baseline based on present practices.

LED agriculture ideally also contributes to enhanced productivity, adaptation and mitigation, the three pillars of climate-smart agriculture. The challenge is in ensuring optimal multiple benefits to the farmer and optimal reductions in emissions, while also meeting other development goals. Meeting multiple public and private objectives in agriculture will become increasingly necessary, but trade-offs are inevitable. For example, sequestering more carbon in the soil can enhance productivity and resilience to drought, but also increases methane emissions during flooding in paddy rice. Traditional livestock breeds are often more resilient to extreme weather conditions and produce lower emissions than more productive breeds that will also produce lower emissions per kg of meat.

Can we meet the goal?

LED in agriculture seems like a reasonable way to pursue mitigation, but is the amount of mitigation that it can provide enough? The 1 gigatonne goal allows us to assess the significance of different options for achieving LED.

Sustainable intensification of food production provides one example of the mitigation possible as a co-benefit of development. According to projections from the FAO, intensified food production from 2005 to 2050 will come mostly from increased yields (73 percent), and somewhat from expanded area for cultivation (21 percent) and increased cropping intensity (6 percent) (see http://www.fao.org/fileadmin/templates/esa/Global_persepctives/world_ag_2030_50_12_rev.pdf). FAO statistics project that intensification will reduce emissions in 2030 by about 0.4 Gt, or 7 percent of expected emissions – a significant amount of mitigation, but short of the goal.

Intensification along the food supply chain can also provide mitigation benefits, although 2°C-linked goals for specific supply chains need to be calculated to assess their significance. Some food supply companies are already exploring goals for their sectors (Smith *et al,* 2017). Gerber *et al* (2013) provided a comprehensive review of the opportunities for mitigation associated with intensification of production and increased efficiency of livestock products. They estimated that the livestock supply chain's emissions could be reduced by 1.8 gigatonnes CO_2e/yr, or about 30 percent (Figure 2), if all producers shifted their practices to those used by the 10 percent of producers with the lowest emission intensity. This number indicates the scale of mitigation possible in the supply chain.

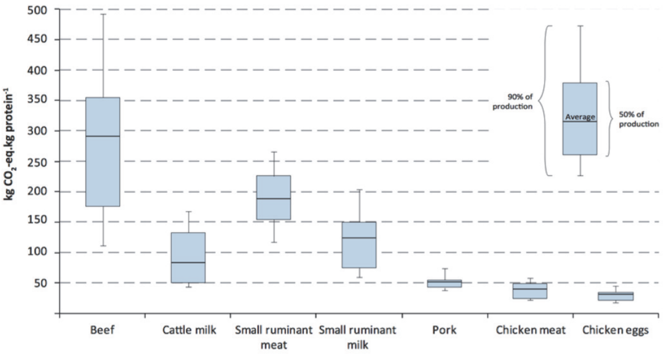

Figure 2. Global emissions intensities of livestock products (Source: Gerber *et al*, 2013).

Using future scenarios, Valin *et al* (2013) showed that reducing the yield gap in agriculture by 50 percent for crops and 25 percent for livestock by 2050 would decrease agriculture and land use change emissions by 8 percent overall, with the outcomes depending on the approach used. For example, emphasising crop yield increases would achieve a larger increase in food production, while livestock productivity gains would achieve the most mitigation of GHG emissions. Valin *et al* (2013) conclude that productivity should be increased in both sectors to best achieve both food security and mitigation.

Other estimates of the impacts of LED agriculture benefits also fall short of the goal. Using the best global evidence available, our team examined what could feasibly be achieved by (i) summing the impacts of all mitigation practices compatible with food production using IPCC data (Smith *et al*, 2008, 2014), and (ii) examining increases in production efficiency based on trade, improved production techniques and shifting the location of production designed to also yield mitigation co-benefits (Havlík *et al*, 2014). Both approaches used relatively low carbon prices of US$ 20 per ton of CO_2e. Assuming realistic rates of change and projecting impacts to 2030, these approaches provided only 21 to 40 percent of the mitigation needed in 2030 (Wollenberg *et al*, 2016).

Our projections of what is needed in the 2°C world, and what is possible, therefore reveal a major gap. Countries want to take action on agriculture, but the options currently available will not make the impact needed to meet the global target agreed to in Paris. We need a much bigger and better menu of technical and policy solutions with major investment to bring them to wider scale.

Two degree Centigrade-linked mitigation goals are not currently available for carbon sequestration associated with agriculture or changes in consumption, but estimates of aspirational goals possible in 2030 suggest that significant mitigation of absolute emissions, rather than emissions intensities, could occur with these interventions (Wollenberg *et al,* 2016):

- Soil carbon sequestration – 1.2 $GtCO_2$e/yr at US$ 20 per tCO_2e (Smith *et al*, 2014);
- Reduced land use change due to clearing for agriculture – 1.71 to 4.31 $GtCO_2$e/yr at US$ 20/tCO_2e (Carter *et al*, 2015);
- Decreased food loss and waste by 15 percent (estimates vary from 30 to 50 percent for total lost or wasted food) – 0.79 to 2.00 $GtCO_2$e/yr (Stehfest *et al*, 2013);
- Shifted dietary patterns, based on the diet recommended by the World Health Organisation (Stehfest *et al*, 2013), or in response to increases in carbon prices (Havlík *et al*, 2014) – 0.31 to 1.37 $GtCO_2$e/yr.

These interventions reinforce the need for reducing agriculture as a driver of deforestation, and addressing the potential for mitigation through changes in food loss and waste, and consumption. Agroforestry practices can be expected to have significant impacts as well. A recent analysis of tree cover on agricultural land indicated increases in biomass carbon stocks between 2000 and 2010 of more than 4.6 percent (2 PgC) (Zomer *et al*, 2016) (see also http://www.worldagroforestry.org/global-tree-cover/data-download.html).

A review of USAID's portfolio of sustainable agriculture investments in 2015-2016 further reinforces the importance of carbon sequestration in achieving mitigation. The USAID portfolio reflects realistic bundles of practices that countries currently want and that donors are promoting. The analysis examined 25 agricultural development projects involving dozens of LED practices across 15 countries in 3 continents. These often involved multiple interventions across a landscape and along value chains. The analysis estimated emissions using the *Ex-ACT* tool over a twenty-year period. Field-level practices included:

- Land use change, including avoided deforestation and afforestation/reforestation (low value agricultural or degraded lands changed to forest);
- Crop transitions to perennial crops or agroforestry or from flooded rice systems to other crops such as wheat;
- Management practice improvements: (i) Rice crops – alternate wetting and drying, urea deep placement, short duration rice; (ii) Crops – soil, manure and water management improvements, including crop residue burning reduction and perennial management; (iii) Fertiliser – increased use and increased efficiency; (iv) Livestock – including herd size management, feed quality and breeding improvements, and increases in grassland.

The major sources of emissions across the portfolio were from increased fertiliser use and livestock intensification, but these were easily offset by carbon sequestration. Overall, carbon sequestration exceeded increases in emissions of the 25 projects by more than two times (Nash *et al*, in press). Further reductions due to reducing post-harvest loss were also possible (Nash *et al*, in press). While this analysis does not provide an estimate of the mitigation possible in 2030 globally, it does suggest that bundles of interventions that include carbon sequestration associated with land use change already occur and have the potential to achieve net reductions in emissions.

Tweaks or transformation?

The evidence suggests that LED can make progress towards achieving the 2°C goal. We need to continue to scale-up available options for LED through intensification and GHG-efficiency gains at field levels and in supply chains. Just tweaking current agricultural intensification will not be enough to achieve policy targets.

More transformational, high-impact technical and policy interventions are needed, including options that meet the needs of farmers in the developing world. If such radical measures are not pursued, we risk increasing the cost of mitigation by having to mitigate more in other sectors or exceeding the 2°C limit. Promising innovations include recently developed methane inhibitors that reduce dairy cow emissions by 30 percent without affecting milk yields; breeds of cattle that produce lower methane levels; and varieties of cereal crops or pasture grasses that inhibit nitrous oxide emissions associated with fertiliser or animal waste. Policies that support more ambitious mitigation include more rigorous carbon pricing, taxes and subsidies; sustainability standards that include reduced emissions in agriculture; and improving the reach of technical assistance for farmers on locally relevant mitigation options through web-based information portals.

Sequestering soil carbon, reducing deforestation due to agriculture, increasing agroforestry, decreasing food loss and waste and shifting dietary patterns will all contribute significantly to mitigation, but we do not yet have a target for assessing their significance. In the meantime, expanding these practices, particularly as part of LED packages, will help offset expected increases in emissions.

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News from the Field

Managing climate risks through small ruminants in Kenyan climate-smart villages

Small ruminants in Kenya

Small ruminants (goats and sheep) play an important role in rural livelihoods. About one third of the total red meat consumed in Kenya comes from small ruminants (GoK, 2015a). Small ruminants are easier to de-stock and re-stock due to their small body size, higher birth rate, and shorter generation intervals compared to large stock. *Kenya Vision 2030* is the country's development programme from 2008 to 2030, and has agriculture as a key economic pillar. Within agriculture, small ruminants have been identified as a priority sector in contributing to food security in a changing and variable climate.

Climate-related risks in Nyando, western Kenya

The Nyando basin in western Kenya is one of the most highly populated areas in East Africa, with a population density of more than 400 persons per square kilometre. About 40 percent of the Nyando basin landscape is highly eroded with deep gullies (Macoloo *et al*, 2011). Agriculture is the main source of livelihood, where local zebu cattle and local East African sheep and goats are kept alongside local poultry. The onset of the seasonal rainfall has become more variable and long dry periods can be expected whenever the rains start earlier than predicted. Dry periods reduce the length of the main growing season, and thus farmers rely more on livestock to address the risk. However, some of the local breeds have low productivity and are more susceptible to drought and disease. In 2011, about 81 percent of the families experienced 1-2 hunger months in a year, while 17 percent of the families experienced 3-4 hunger months – a period when they are unable to produce food from their own farm (Mango *et al*, 2011).

Improved small ruminants in Nyando

Through participatory action research, the International Livestock Research Institute (ILRI) and local community-based organisations (CBOs) have, from 2013, upgraded the local breeds of small ruminants through crossing with resilient breeds of *Galla* goats and *Red Maasai* sheep, and coupled this with better livestock management practices. The improved small ruminants are able to better cope with the disease burden, better withstand heat stress, better utilise low quality herbage, recover from drought due to faster compensatory growth, and mature to market weight in shorter periods (Ojango *et al*, 2015). *Galla* goats are adapted to drylands, with a longer productive life, good milking ability, a high level of twinning, high growth rate, and an earlier maturing age – up to six months compared to the local small East African goat. The *Red Maasai* sheep is reared for meat, and is renowned for withstanding drought and heat stress, resistance to internal parasites, and faster growth as compared to the small East African sheep. More than half of the households (57 percent) across the Nyando climate-smart villages (CSVs) currently own either pure- or cross-bred *Galla* goat and *Red Maasai* sheep (Ojango *et al*, 2016).

Farmers were trained on basic sheep and goat husbandry, housing, and fodder development, conservation and utilisation, prior to receiving the improved goats and sheep. Farmers trained to be breeders received pure-bred *Galla* does and bucks, and *Red Maasai* ewes and rams, which formed breeding units for the community crossbreeding. In 2013, 100 breeding units of *Galla* goats and *Red Maasai* sheep were established, and after one year, a total of 1,506 crosses were registered, representing one third of the total 4,336 sheep and goats in seven test villages (Kinyangi *et al*, 2015). It is anticipated that it may take 10 years to replace the current population of 38,725 sheep and goats in Nyando villages with the new *Galla* and *Red Maasai* crosses, and hence bring the benefits of resilience.

The impacts of the initiative are at both individual and community level. Individual farmers are able to own the assets (sheep and goats), and obtain goat milk for home consumption, resulting in improved household nutrition. Small ruminants are popular with women, as they have more control over the small ruminants as well as over the income generated from them as compared to large ruminants. The small ruminants are less labour intensive and take less time to raise compared to cattle. The meat and milk gains of small ruminants far exceed cattle because of the shorter reproductive cycles.

As the uptake of the *Galla* goats and *Red Maasai* sheep crossbreeds increases, farmers are coming up with innovative ways of marketing their livestock. An annual goat auction is emerging, linked to the Christmas festive season, when livestock is in high demand. Other benefits include income through sale of milk and live animals, and using the manure for crop production. The average price of the improved breeds of small ruminants in local markets is at least US$ 120 per head, which is about three times the price of the local breeds. At the group level, the communities are able to work together and collectively access better services for their farming enterprises, jobs are created through the breed associations, and market access is fostered for the sheep and goats.

Linkages to policy and strategies

Within agriculture, the livestock sector has a huge potential for mitigation of climate change and reducing carbon emissions (GoK, 2015b). Kenya's Intended Nationally Determined Contributions (INDCs) includes both mitigation and adaptation components, and aims to achieve a low carbon, climate-resilient development pathway. At the same time, the country is continuing to implement the National Climate Change Action Plan (GoK, 2012) for the period 2013-2017 and this includes promotion and implementation of Climate-Smart Agriculture (CSA). The methane greenhouse gas (GHG) emissions from enteric fermentation in domestic livestock in Kenya is 14,540 Gg CO_2e per year, and methane emission from manure management is 541 Gg CO_2e per year (GoK, 2015b). Improved small ruminants have great promise in reducing the emissions through improving animal and herd efficiency. Improved *Galla* goat and *Red Maasai* sheep breeding and animal health interventions allow rearing of fewer animals that are more highly productive, hence reducing GHG emission intensity. Improved manure management ensures recovery and recycling of nutrients and energy – potentially playing a useful role in reducing GHG emissions.

Emerging lessons and conclusions

Working with CBOs guarantees greater success in the adoption of improved small ruminant interventions due to the organisational structure that facilitates farmer investments in improved breeds, sharing of information, and scaling-up of interventions to many villages. The intervention has also brought new opportunities for farmers to participate in new markets such as the goat auction.

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Agricultural diversification as an adaptation strategy

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Abstract

The role of agricultural biodiversity for sustaining ecosystem services crucial for food and agriculture becomes particularly relevant in the face of climate change, and has been widely recognised as a central part of climate-smart agriculture (CSA) since the concept was first launched in 2010. The utilisation of agricultural biodiversity in risk reduction and climate adaptation strategies has continued to attract attention, particularly as a component of micro-level strategies oriented towards diversification of production on farm, and land management measures aiming to improve resilience at landscape scale. Despite ample evidence of the value of agricultural biodiversity (including genetic resources) in climate change adaptation, the scalability of biodiversity-based measures is limited as they are often context specific and may have a lower relative value when compared to other options. Public policies can also play an important role in facilitating or hindering the adoption and spread of measures based on agricultural biodiversity.

Importance of agricultural biodiversity for agricultural production

Agricultural biodiversity includes all components of biological diversity of relevance to food and agriculture, encompassing animals, plants and micro-organisms that are necessary to sustain the structure, processes and key functions of agricultural ecosystems. Unlike biodiversity in the wild, agricultural biodiversity is largely the result of the evolution of diverse management practices of farmers, pastoralists, forest managers and other users of natural resources. However, there are also components that are not actively managed and used for production but that remain important as sources of genetic material and for their contribution to ecosystem services such as pollination, control of greenhouse gas emissions and soil dynamics.

A number of studies for both (non-agricultural) prairies ecosystems and for agricultural systems (Lin, 2011) demonstrate that more diverse ecosystems, with more species or more genetic diversity within species, often have higher overall agronomic productivity than simpler systems. Some of the overall yield increase associated with greater diversity is the result of the different functions performed by different species and the complementary niches that they occupy in the system (Yu *et al*, 2015).

The concepts of functions and niches are illustrated in crop pest and disease management from effective use of both inter- and intra-specific diversity providing enhanced resistance to outbreaks of pests and diseases as an important mechanism for increased yield and yield stability. Several mechanisms contribute to this effect, ranging from simple distance between susceptible host plants and physical barriers to transmission, to induced resistance from inoculum sources and competition among pathogen races that reduce disease severity. Studies have also shown that manipulating diversity to manage soil structure and fertility through the rotation and combination of cover crops and nitrogen-fixing crops increases the yield of the primary crop. Both tree-crop intercrops and planted tree fallows (in rotations) bring important but context-specific benefits in crop yields and in stabilising crop production (Sileshi *et al*, 2012). The combination of different species and breeds based on their niches and needs has been demonstrated to increase and stabilise production in livestock-based systems as well. Pastoralists often strive for a mix of productive and resilient individuals, a variety of lineages or animals with different feeding patterns in their herds in order to be prepared for all eventualities (Krätli, 2015).

Agricultural biodiversity in climate change adaptation strategies

Biodiversity can therefore contribute to the resilience of ecosystems, that is, their ability to respond to and recover from disturbance. In agricultural production systems this resilience may be manifested by relatively stable productivity levels over time and relatively more rapid recovery times following shocks. The careful management of agricultural biodiversity can therefore contribute to risk reduction and avoid heavy losses or total production failure.

Climate change considerably increases the risks involved in agricultural production and takes agricultural ecosystems' adaptation capacities to their limit. Large-scale variations in temperature and rain patterns limit land areas suitable for the cultivation of particular crops, requiring the introduction of other crops. Planting millet instead of maize is often presented as an example of crop substitution as a result of climate change (Schlenker & Lobell, 2010). Extreme climatic events take place in many parts of the world, more frequently and more dramatically, causing catastrophic effects in soil and water resources, and reducing arable land. Studies indicate a general trend towards the loss of cropping areas in sub-Saharan Africa, the Caribbean, India and northern Australia (Lobell *et al*, 2008). Climate change affects ecosystem dynamics in ways that are difficult to predict. Some of the possible consequences include: increased asynchrony between crop flowering and the presence of pollinators; the spread of favourable conditions for invasive alien species, pests and parasites; and changes in the presence and abundance of disease vectors.

The utilisation of agricultural biodiversity in risk reduction and climate adaptation strategies has been widely recognised, as illustrated by the multiple examples in the following section of this article. It has been a central part of CSA since the concept was first launched in 2010 (FAO, 2010) and has continued to attract attention since then, particularly as a component of micro-level strategies oriented towards diversification of production at the on-farm level and land management measures aiming to improve resilience at landscape scale.

On-farm actions

In recent years, a number of studies have documented how farmers and farming communities in different countries are adopting measures that rely on the use of agricultural biodiversity in response to climatic changes and their associated effects. These measures have been integrated in guides and sourcebooks supporting the adoption of CSA (FAO, 2013), and can be classified in three categories: cultivation of a larger number of species and farm diversification overall; introduction or increased cultivation of better adapted crops and varieties, and livestock animals and breeds; and integration of trees and shrubs into production systems.

Through the cultivation of more crops, farmers spread the risk of crop failure and increase yield stability overall. Different crops are affected differently by climate events, and this in turn gives some minimum assured returns for livelihood security. Crop diversification may take place spatially (*ie* more species cultivated at the same time) and temporally *(ie* crop rotation). Alternating cereal crops with legumes and broadleaf crops has been a common practice for maintaining soil nutrients, managing diseases and adapting crop production to climatic variations that has been widely successful (Yu *et al,* 2015). The cultivation of home gardens is another common strategy of crop diversification, particularly for domestic consumption in poor farming communities. Cover crops have been introduced to improve soil moisture and enhance seedling survival in areas which have recently started to suffer temporary drought. The introduction of poultry, small farm animals and other livestock has also been observed as a diversification strategy in response to climate change. In some regions of Africa, subject to long droughts, farmers tend to reduce their investment in crops, or even stop planting and focus instead on livestock management. Crop diversification and crop-livestock integration are often combined with adjustments in agricultural practices and adoption of low-input methods for soil fertility improvement, water conservation and weed management.

Another common climate change adaptation measure observed in farmers' fields is to grow crops and crop varieties that better cope with the new climatic conditions. Studies show that in several African countries, farmers are increasing cultivation of species that perform well in dry and hot seasons, such as finger millet, sorghum and fonio (*Digitaria* spp) for cereals, and cowpea for legumes (Schlenker & Lobell, 2010). A study documenting adaptation practices in Eastern Uttar Pradesh, in the foothills of the Nepal Himalayas, revealed that farmers have started to cultivate crops and varieties whose maturity cycles are not expected to be disturbed by possible flooding, in addition to anticipating or postponing the planting time. The substitution of traditional varieties with improved, early maturing ones has also been observed as part of adaptation strategies in places affected by drastic increases or decreases of temperature and rainfall (Dinar *et al*, 2008). The opposite is also observed: farmers stick to the cultivation of traditional varieties because of their capacity to respond and adapt to new climate patterns (Vigouroux, 2011) (Figure 1).

Figure 1. The Kyanika Women's Group in Kenya plays a role in conserving local farmer landraces of crops, such as sorghum, which grows in harsh environments where other crops do not grow well. (Photo: Y Wachira (Bioversity International))

As with crops, different animal species and breeds differ greatly in the extent to which they can tolerate climatic extremes. A number of farm animal species (and breeds within species) have revealed differences in heat tolerance. An example is the expansion of the distribution range of one-humped camels further south in Africa, replacing cattle, because of their better drought resistance (Faye, 2016).

Trees and shrubs on farms add structural complexity to production systems and can act as buffers against extreme effects. Planting trees has been observed in a number of countries as a way to protect crops from lower precipitation and reduced soil water availability (Sileshi *et al*, 2012). Agroforestry systems also protect crops from extreme storm events (*eg* hurricanes and tropical storms) in which high rainfall intensity and winds can cause landslides, flooding, and premature seed and fruit drop from crop plants (Lin, 2011). In addition, trees diversify the production within the farm, by providing fruits, nuts, essences, fibres and other products.

Landscape level actions

A number of studies show that climate change has encouraged farmers to make greater use of the natural resources and the spatial diversity of their landscapes, often acquiring new land and moving their farms to more promising areas. Dual farming systems are becoming common in areas where seasonal fluctuations have been exacerbated by climate change. For example, in the Limpopo basin in Mozambique, farmers use fertile lowlands during droughts and higher dryland fields if floodplain lowlands are flooded (Thomas *et al*, 2007). Forests and bushland within the landscape become an important source of food and other products when farm production fails and during lean periods between crop harvesting.

The use of agricultural biodiversity has also been documented in landscape-scale actions oriented to the restoration of natural resources which have been negatively affected by human exploitation and dramatic climatic events. Examples include: maintaining landscape diversity by preserving a mosaic of agricultural land and natural habitat; conserving and restoring riparian areas; establishing agroforestry and silvo-pastoral systems; and conserving and restoring wetlands.

Genetic diversity for climate change adaptation

Crop breeding programmes around the world have been breeding improved materials in response to climate-related stresses for a long time. In recent years, breeders have identified new breeding priorities responding to environmental constraints that are directly linked to climate change, such as increased drought, more extreme temperatures, more widespread flooding, higher levels of salinity and greater shifts in patterns of pest and disease occurrence. Climate change has fostered the use of new technologies, such as molecular breeding, crop modelling methods and localised participatory breeding approaches, to make genetic improvement more targeted and efficient.

These efforts have produced new varieties better suited to particular climatic patterns. However, crop breeding still faces important limitations. In the first place, public and private investments in crop research and innovation concentrate on a relatively small number of staple crops of international importance, neglecting a wide range of plants which have the potential to make agricultural production more resilient to climate change because of their adaptation to harsh and/or varied climatic conditions. Particularly in the developing world, very little private funding is directed to cereal crops such as sorghum, barley and millet; legumes such as beans, chick pea, pigeon pea, lentil, bambara groundnut and vetches; and roots and tubers such as potato, sweet potato, yams, and cassava.

It has been argued that both public and private crop development communities need to better target stability and resilience of crops to respond to climate variation, described by some authors as the ‘robustness’ of crops (Smit & Skinner, 2002). It is still common for breeders to see an anomalous climatic season (*eg* due to drought) as an inconvenience in field testing, and discard the results, rather than taking this as an opportunity to assess and retain the robustness features of varieties that do well under such conditions. Making crops more adaptive and responsive to variability and change may involve broadening their genetic base, and relaxing the uniformity and stability criteria that are usually applied to improved varieties.

In animal breeding, it is pastoralists that have developed a large diversity of drought-adapted breeds, and also breeds that can cope with increasing rainfall amounts. An example of the latter is the *Deccani* sheep in India, which is the only breed that can cope with extended and intensified precipitation periods in the Western Ghats. While scientific animal breeding has until recently been oriented almost entirely at increasing production, interest in adaptive traits is now growing.

In tree breeding, the issue of climate change adaption is particularly acute because of the longevity of tree species. Climate might change significantly within the actual lifespan of individual trees with commensurate problems of tree diseases (for example, alien invasive fungal diseases) that have received much attention recently in the global media (Alfaro *et al*, 2014).

Clearly, breeders rely on the availability and accessibility of the necessary genetic diversity. Current *in situ* and *ex situ* programmes for the conservation of genetic resources of domesticated species and their wild relatives require considerable improvements, including investments in knowledge generation and data management. The international community has made considerable progress to facilitate the exchange and accessibility of genetic resources for food and agriculture for the purposes of research and breeding. The *International Treaty on Plant Genetic Resources for Food and Agriculture* and its *Multilateral System of Access and Benefit-Sharing* is the most salient result of this progress. However, although both the *Treaty* and the recently adopted *Nagoya Protocol on Access and Benefit-sharing* support farmers and pastoralists to assert rights over crop varieties and animal breeds which they have developed and maintained over long periods of time, very few countries have put in place mechanisms to effectively recognise and protect these rights and ensure that the benefits derived from the use of traditional varieties and breeds are shared with those who have originated or maintained them.

The role of policies in promoting or hindering the conservation and use of agricultural biodiversity for climate change adaptation

Public policies can play an important role in facilitating adaptation to climate change, with significant implications for the adoption/adaptation options considered at the farm, landscape and national levels, and for the weight given to agricultural biodiversity under each option.

Intergovernmental processes and decisions within the *United Nations Framework Convention on Climate Change (UNFCCC)* have encouraged and facilitated national efforts to develop the necessary institutional setting and plans for climate change adaptation. An example of these are the *National Adaptation Programmes of Action (NAPAs)*, which were meant to be instruments for Least Developed Countries (LDCs) to access funds for implementing climate change adaptation activities. To date, 50 LDCs have developed NAPAs. A recent review of their content reveals that 11 nations included a relatively wide range of activities relying on the utilisation of agricultural biodiversity, while 10 included very few activities (Bedmar Villanueva *et al*, 2014). In the majority of the NAPAs, agricultural biodiversity was not incorporated in a comprehensive or systematic manner.

In the last few years, academia has increased its attention to the role of agricultural biodiversity in sustainable intensification. Similarly, intergovernmental policy fora such as the Commission on Genetic Resources for Food and Agriculture of the United Nations Organization for Food and Agriculture (FAO) have included biodiversity as a central element in their discussions around agriculture intensification. However, this increased international interest has barely been reflected in public policy measures at the national level. Agricultural public policies tend to favour streamlined and simplified production systems oriented to satisfy a reduced number of market chains, and often with aspirations to supply goods in international commodity markets. Traditional farming systems, and the agricultural diversity that they generate and maintain, are affected by these agricultural policies. Subsidy programmes and credit schemes focusing on particular crops and varieties, and animal farms and breeds, are a common example of public policies that create disincentives for the diversification of agricultural production. An illustrative case can be found in Malawi, where for the past decade, the Government has run an agricultural subsidy programme oriented towards the production of improved varieties of maize, including hybrid varieties. As a result, the climate adaptation programme in-country based on crop diversification had only very modest success. This was due in part to the loans and insurance programmes that farmers had with seed companies providing almost exclusively hybrid maize varieties (Chisinga *et al*, 2011).

So far, only a very few countries have developed agrobiodiversity policies, which, among other things, underscore the contributions of that diversity for climate change adaptation. A welcome exception is Nepal, whose *Agrobiodiversity Policy* links conservation, characterisation and sustainable use of biological diversity with climate change adaptation, acknowledging that it will be necessary to strengthen ties between farming communities, the national agricultural research administration, and both community and national genebanks.

Conclusions

There is ample evidence of the value of agricultural biodiversity in climate change adaptation in specific settings, but the importance of context limits generalisation: what allows one particular crop, farm animal, tree species or agricultural system to cope with particular climatic conditions may not work for other species or in other systems and climates. This means that the adoption of CSA practices based on biodiversity can be knowledge intensive, both at the research stage and during adoption, and must consider gender-specific perspectives on diversity. Culture plays an important role and may render socially invalid an option that from an agronomic perspective appears at first sight very promising. The scalability of practices based on agricultural biodiversity is also very much influenced by their relative value when compared to other viable options for climate change adaptation. It is important to take into consideration that significant trade-offs are often involved in balancing the maintenance of agricultural biodiversity within a production system with available management practices.

National policies need to integrate agricultural diversification (in terms of species, varieties, breeds and also types of production) in agricultural development programmes, and eliminate the barriers and disincentives that currently prevent a wide range of actors from using agricultural biodiversity more widely and strategically for climate change adaptation.

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News from the Field

The Climate-Smart Village approach: putting science into practice in South Asia

Agriculture in South Asia is predominantly weather-based where the majority of agricultural land is rainfed. Scientists warn that agricultural production systems in the region can be significantly affected by the changing climate, threatening food security in years to come. However, scientists are very optimistic about minimising the impact of climate change on agriculture and food security by putting science into practice. Climate-smart agriculture (CSA) is proposed as a solution to transform and reorient agricultural production systems to stabilise farm productivity and income under the changing climate. What practical steps can millions of smallholder farmers in South Asia take to adapt their agricultural production systems to the changing climate?

The Climate-Smart Village (CSV) approach was developed to address the need for adaptation in agriculture and allied sectors by scaling-out a range of CSA technologies, practices and services into existing production systems among agriculture-dependent farming communities. This approach equips farmers to use climate-smart scientific interventions and innovations, use climate information for cropping decisions, diversify livelihoods, link to markets and make agriculture profitable under current as well as future climate. This approach helps farmers adapt to climate change by implementing portfolios of climate-smart options ranging from rehabilitating agroecosystems, to integrating climate information and good agricultural practices into the existing production systems.

Evidence of success of the CSV approach

The CSV approach has two components: firstly it builds evidence for CSA in a participatory manner, and secondly it supports the development of policies and institutions around this evidence. Efforts to create the evidence base for CSVs through integrated evaluation of CSA interventions in pilot areas are easily scalable horizontally and vertically by Government agencies as well as other development partners. However, there is a need to make a deliberate attempt to understand the decision-making process of policy-makers. Policy-makers in any country deal with policy and developmental issues typically around administrative units such as states, districts and villages and not ecological units such as landscapes. Therefore, CSV pilots engage local, sub-national and national Government agencies, CGIAR Centres (the International Maize and Wheat Improvement Centre (CIMMYT), International Rice Research Institute (IRRI), International Water Management Institute (IWMI), International Food Policy Research Institute (IFPRI), Bioversity International, World Fish Centre, International Crop Research Institute for the Semi-Arid Tropics (ICRISAT)), and other stakeholders in the process of setting up CSVs in India, Nepal and Bangladesh. This enables these agencies to easily relate to the efforts of the CSVs in terms of geographical location, numbers and their priority regions.

The pilots have generated a strong evidence base through its collaborative and participatory research. Interventions relate to *seed/breed, nutrients, water, energy*, *weather* and *knowledge management*, and are tailored to local conditions, often designed with farmers and local government/non-government staff using participatory techniques. Capacity building and detailed portfolio assessment is an integral part of the process. Table 1 presents key indicators of the CSV approach used to evaluate the impact of CSVs in different agro-ecological zones of South Asia.

Data and interviews with farmers in the CSVs indicate considerable potential for CSA interventions in improving crop

Table 1. Output indicators of the CSV approach.

Output	Indicator
A. Economic	• Change in productivity of agriculture and allied sectors • Change in net return per hectare and per livestock unit • Employment generation • Improvement in input use efficiency (water, nutrients and energy) • Coefficient of variation (CV) in yield and income
B. Environmental	• Total area under climate-smart interventions • Improvement of environmental services • Change in emissions intensity
C. Social	• Strengthened capacity of women, youth and marginalised groups • Strengthened cooperation and networks in CSVs
D. Institutional	• Level of local institutions' involvement • Coordination among different departments
E. Human well-being	• Climate-resilient food systems and change in food security • Sustainable livelihoods

yield, farm income, input use efficiency and emissions, along with synergies and trade-offs among them. These are based on several participatory research activities conducted in farmers' fields over the last few years and farmer surveys in the CSVs. In addition to the scientific evidence, the CSV approach is helping to build a strong partnership among the key stakeholders and farmers in promoting adaptation to climate change in agriculture and allied sectors at the local level. National Agricultural Research Systems (NARS), Government agencies, NGOs and development organisations, and the private sector collaborate in participatory evaluation of a range of climate-smart practices, technologies and services with the local farmers and their organisations.

Scaling-out CSA through the CSV approach

National, sub-national and local governments and private sector companies are gradually providing significant amounts of investment for testing, evaluating and scaling of CSVs across different agro-ecological zones. The focus has been on scaling-out a range of CSA technologies, practices and services to make agriculture profitable, to rehabilitate and restore the environment, and to influence policy-makers at different levels. Various portfolios of CSA options have been tested and evaluated under different approaches in CSVs across the region.

A community-based integrated technology transfer approach in CSVs in Nepal and Bangladesh has helped farmers to test, evaluate and adopt various CSA technologies on their farms. In Nepal, recognising the importance of tackling climate change and its impact on agriculture, the Government has started to implement the CSV approach as part of national efforts to adapt to changing climate. Similarly, in the Madhya Pradesh, Haryana, Maharashtra, Telangana and Andhra Pradesh states of India, multiple approaches of CSVs have been implemented (Figure 1) with support from the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS) and seven participating CGIAR Centres (CIMMYT, IRRI, IWMI, IFPRI, Bioversity International, WorldFish Centre and ICRISAT)). Watershed management and climate/crop modelling approaches of CSVs have focused on rehabilitating agroecosystems and deploying a pool of CSA technologies and crop advisories helping to increase crop yields and incomes of farmers, in Telangana and Madhya Pradesh.

Figure 1. Climate-smart village of Uncha Samana block in Haryana, India, where various key climate-smart interventions such as zero tillage, Direct Seeded Rice (DSR), raised bed planting, residue management, crop diversification, and nutrient management have been introduced. (Photo: Prashanth Vishwanathan (CCAFS))

In addition to Government-led efforts, the private sector has also shown interest in scaling-up CSA. *ITC Limited*, one of India's branded food companies, has been undertaking a number of initiatives at building rural capacity in partnership with local communities to develop water and forest resources, open up new non-farm livelihoods, empower women and expand primary education and skills. Considering the importance of managing climatic risks in rural livelihoods, *ITC Limited* is collaborating with CCAFS to help agriculture-dependent communities to implement and scale-up the CSV approach in its outreach areas in India.

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Climate services and insurance: scaling climate-smart agriculture

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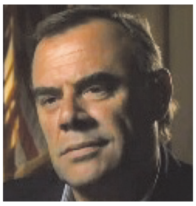

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Abstract

One of the main challenges of climate-smart agriculture (CSA) is finding ways to promote the adoption at scale (*Editor's note: 'scaling', 'at scale' or 'to scale' are used throughout this article to mean 'scaling-out'*) of CSA practices and technologies. Climate services and insurance can constitute a tool to scale CSA by providing an enabling environment that can support the adoption of CSA practices while protecting against the impacts of climate extremes. By using a definition of climate services which includes the production, translation, transfer, and use of climate knowledge and information in climate-informed decision-making and climate-smart policy and planning, this paper aims to discuss how climate services and insurance can bring CSA to scale. Three case studies are presented. It is recognised that understanding the knowledge networks through which information flows, and affects the use of climate information, is critical for promoting CSA at scale.

Introduction

Climate-smart agriculture (CSA) is defined as agriculture that (i) sustainably increases agricultural productivity and incomes, (ii) adapts and builds resilience to climate change, and (iii) reduces and/or removes greenhouse gas (GHG) emissions where possible (FAO, 2013). Framing the second pillar of CSA in terms of 'resilience' reflects the evolution of thinking about climate change adaptation – from what agriculture needs to look like in a future climate scenario, to greater focus on what can be done now to start the journey towards adapting agriculture to climate challenges. CSA extends beyond on-farm practices to include landscape-level interventions (*eg* management of farm-forest boundaries), services (particularly information and finance), institutions (mainly market governance and incentives for adoption) and the food system (mostly consumption patterns and wider climate-informed safety nets).

Efforts to promote the implementation of CSA at scale include the development of climate information and advisory services that support farmer decision-making, weather-related insurance that protects farmers and increases investment in CSA, food security early-warning and safety net systems that protect livelihoods from extreme events, and climate-informed planning by governments. These interventions, which are implemented beyond the farm, provide an enabling environment for CSA by supporting the adoption of climate-smart practices and the transition towards more climate-resilient livelihoods, while protecting against the impacts of climatic extremes.

Climate change adaptation and climate-resilient development goals have stimulated demand for more types and time-scales of climate information. While the foundations of climate services have been under development since the 1980s, the concept was formalised through the *World Climate Conference-3 (WCC-3)*, held in Geneva in 2009, which called for an *"international framework for climate services that links science-based climate predictions and information with the management of climate-related risks and opportunities in support of adaptation to climate variability and change"* (GFCS, 2017). This led to the establishment of the *Global Framework for Climate Services (GFCS)* (WMO, 2014). The term 'climate services' is used to describe activities and processes that can be quite diverse (Vaughan & Dessai, 2014), but can be understood in terms of four pillars: *"(i) production; (ii) translation; (iii) transfer; and (iv) use of climate knowledge and information in climate-informed decision-making and climate-smart policy and planning"* (Climate Services Partnership, 2017).

In index-based insurance, payouts are based not on farmers' actual losses, but on an objectively measured index such as rainfall or satellite vegetation data, that is correlated with losses. Index-based insurance has overcome obstacles, such as moral hazard, adverse selection and high transaction costs, all of which made traditional loss-based crop insurance unfeasible for smallholder farmers. This has led to a surge of interest, over the past decade, in using insurance to contribute to climate change adaptation and climate-resilient development goals. Agricultural insurance complements the use of climate information for farm decision-making, and is emerging as a major user of climate services.

This paper discusses how climate services, and their use for insurance and related safety net interventions beyond the farm, can contribute to bringing CSA to scale. The following section presents the evidence of how climate services and climate-related insurance provide an enabling environment for implementing CSA at scale. The third section brings this discussion into reality by presenting three case studies where climate services and their use have contributed to adoption of CSA practices. The fourth and final section complements the analysis by discussing how, not only the production, but also the translation, transfer and use of climate knowledge are key in order to implement CSA practices and technologies at scale.

Providing an enabling environment for scaling Climate-Smart Agriculture

There is growing recognition that adapting to climate change requires developing resilience to the risks associated with climate variability. Climate change is expected to increase risk from extreme events in much of the developing world (IPCC, 2012). Extreme events erode livelihoods through loss of productive assets, while the uncertainty associated with climate variability is a disincentive to investing in agricultural innovation (Maccini & Yang, 2009). Within farming communities, the impacts are borne disproportionately by the relatively poor (Zimmerman & Carter, 2003). The combined *ex-post* impact of climate shocks on farmers' assets, and *ex-ante* impact of climate risk on farmer decision-making and investment by rural finance markets and supply chains, contribute to poverty traps that lock many farmers in climate-vulnerable livelihoods (Barrett & Santos, 2014), thereby working against the transformation needed to adapt to climate change.

The evidence suggests that climate services, and the use of climate information for farm decision-making, weather-related insurance, agricultural planning and food security management, have considerable potential to enable farmers in environments prone to climate risk to transition towards more climate-smart agricultural systems while protecting their livelihoods from climatic extremes. The evidence also suggests that the way that these interventions are designed and implemented matters.

There appears to be considerable demand for, and use of, climate information by smallholder farmers (Hansen *et al*, 2011). Access to climate information influences farmers' decisions, even when resource constraints limit their options (Mudombi & Nhamo, 2014). Evidence that climate services improve farmer livelihoods is more limited, and comes largely from participatory pilot projects (Rao *et al*, 2015) and model-based valuation (Roudier *et al*, 2014). The design of climate services can influence the benefits available to farmers. Widespread gaps between farmer needs and available climate data, and weaknesses in the translation and communication of climate information (reviewed in Hansen *et al*, 2011), constrain its usefulness for agricultural decision-making. Pilot-scale participatory research has improved the understanding of farmers' needs, and produced innovative processes that improve farmers' understanding and use of climate information (Rao *et al*, 2015). Yet only a few pilot projects have attempted to address the widely recognised mismatch between available information and the needs of farmers and other agricultural decision-makers (Hansen *et al*, 2011).

Programme evaluation (Madajewicz *et al*, 2013) and pilot-scale experimental studies (Cole *et al*, 2013) show that well-designed index-based insurance can improve livelihoods by enhancing adoption of agricultural innovations. Payouts triggered by major climate shocks reduced loss of productive assets and hastened recovery (Bertram-Huemmer & Kraehnert, 2015). Low uptake rates in many initiatives and randomised trials have led to concern that low demand may limit the potential for index-based insurance to benefit smallholder farmers at scale (Cole *et al*, 2013). On the other hand, evidence that farmer demand is influenced by design-related factors, including the degree of basis risk (the fact that farmers may receive a payout even when their crops survive, or they may experience losses when a payout is not triggered) (Elabed & Carter, 2015) and farmers' understanding and trust in the products (Hill & Viceisza, 2012), suggests that improved design and implementation could enhance uptake. Recent rapid scaling of several initiatives suggests that uptake may be determined largely by evolving capacity to overcome these challenges and provide more effective services (Greatrex *et al*, 2015).

Climate-Smart Agriculture: case studies beyond the farm

This section briefly presents three case studies that illustrate how climate services, and the use of climate information for insurance, can become a means to promote the use of CSA practices at scale.

Colombia: from farmers to private sector and government using climate services to inform decision-making processes

In Colombia, the government, private sector and researchers are working together in order to provide farmers with agro-climatic information useful to support their decision-making on what varieties to plant, when to plant seeds, what pests and diseases might appear and how to reduce their impact in the crop, and how to manage water and input resources to make more efficient use of them. In other words, the project is providing information on what CSA practices to implement, given an agro-climatic forecast reaching approximately 18,000 farmers.

The process is promoting the *generation* of climate predictions and understanding how to use them in crop models to produce agro-climatic forecasts. The *translation and transfer* of the climate information is being enabled through Local Technical Agro-Climatic Committees (LTACs), and structured training to technicians. In LTACs, producer associations and the International Centre for Tropical Agriculture (CIAT) are implementing an integrative methodology linking scientific and local knowledge in order to help farmers and technicians to understand climate information and *use* it to decide which CSA options to implement.

Up to now, the National Rice Producer Association of Colombia (FEDEARROZ) is including recommendations associated with agro-climatic forecasts within its support package to farmers, called the *Massive Technology Adoption Programme (AMTEC)*, in order to promote among its producers more efficient use of water in dry seasons, appropriate use of fertilisers and agro-chemicals which reduce damage to the environment, as well as variety selection and pest and disease control preparation. In addition, this approach, integrated with big data and climate-site specific management (Delerce *et al*, 2016), has helped rice producers to avoid economic losses, which were estimated at US$ 3.6 million in 2015, preventing producers from planting seeds when climate conditions were expected to be adverse for their crop. Bean and cereal producers, through the National Cereal Producer Association of Colombia (FENALCE), are also using agro-climatic forecasts, especially for variety selection and pest and disease management, according to anticipated future climate conditions and more efficient use of agro-chemicals, thus reducing farmers' expenditure. Given the importance and usefulness of this initiative, the government of Colombia has included the LTACs in the national strategy to reduce agro-climatic risks, with the goal of establishing LTACs in at least 15 regions of the country.

Ethiopia, Senegal, Malawi, Zambia: R4 Rural Resilience Programme

The *R4 Rural Resilience Initiative (R4)* is a strategic partnership between the United Nations World Food Programme and Oxfam America that aims to improve the income, food security and resilience of vulnerable rural households which face increasing risks due to climate change. The initiative currently operates in Ethiopia, Senegal, Malawi and Zambia, and as of 2016 it reached about 40,000 farmers.

By combining community participation in contract design with scientific support for insurance index design, strong institutional partnerships, and using national safety net programmes to allow qualified farmers to purchase insurance through labour, *R4* successfully targets poor smallholder farmers who were previously considered to be uninsurable. Its work on *risk transfer* through insurance is combined with community *risk reduction* projects, *risk reserves* through facilitating small-scale savings to buffer against idiosyncratic risks, and *prudent risk taking* through improving access to microcredit.

Like other agricultural insurance initiatives, the goals of *R4* align with the productivity and resilience pillars of CSA, presenting innovative features with interesting implications for CSA. First, it seeks to build the resilience of smallholder farmers that are particularly poor and vulnerable to the impacts of a variable and changing climate, bringing innovations such as insurance-for-work in order to overcome barriers to their participation. Second, *R4* seeks to connect insurance to improved access to credit and inputs to foster adoption of more productive practices. Third, using insurance-for-work to support community projects, such as conservation farming, raises the prospect of insurance to support reduction or capture of GHGs.

Evaluation of *R4* in Ethiopia showed that the insurance and related interventions increased farmers' access to credit, fostered investment in production inputs, and built their access base; and that the benefits were greater for women farmers, than for men (Madajewicz *et al*, 2013).

Uruguay: Development and Adaptation to Climate Change in the Agricultural Sector (DACC)

The *DACC* project, established in 2012 with a World Bank loan to the Ministry of Agriculture of Uruguay, aims to assist the farming community to implement sustainable strategies to manage the natural resource base for increased agricultural productivity while improving adaptation to climate variability and change. A key component was the establishment of a *National Agricultural Information System* (*SNIA*, from its Spanish acronym) that integrates existing and newly produced information, products, and tools to improve climate risk management and to assist decision-making and the elaboration of policy.

The *SNIA* pursues two main goals. The first is to facilitate access to relevant information and products, and to assist public and private agricultural stakeholders to access, screen, prioritise, and understand relevant information and products. This goal follows the concept of a 'one-stop service', where users can go to one place (*eg* the *SNIA* web site) for a large portion of their information needs. The second goal is to integrate data and knowledge (*eg* climate, vegetation, land uses, prices, plans, markets, *etc*) that are now available in separate publications, bulletins and websites, and make it available from one location. Because decision-makers, including policy-makers, approach problems holistically (Meinke *et al*, 2009), clearly communicated, integrated and multidimensional information is usually more effective for assisting decision-making, planning and elaboration of policy, than separate publications.

As a result of initial workshops with relevant stakeholders from the Ministry of Agriculture, several activities and products were defined for populating the *SNIA* website, including: early warning systems based on improved agro-climatic monitoring and climate forecasts; monitoring and control of effluents from agricultural systems (dairy, crops, feedlots); characterisation of climate-related risks as input for index-based insurance policies; and sustainable land use plans for crop production. The *SNIA* early warning system takes into consideration climate anomalies, vegetation status, soil water content, and a drought severity index, and overlays these with real-time stocking rates to monitor and identify regions that are most vulnerable to drought. For example, in May 2015, the Ministry of Agriculture declared an official emergency in some provinces of Uruguay based on those layers of information, triggering the implementation of special credit lines to assist farmers to buy feed and to solve problems of access to drinking water for their cattle.

This is a good example of the effectiveness of considering *'translated'* climate information (*ie* soil water balances, vegetation status, drought indices), and integrating it with other information (*eg* stocking rates) to inform decisions such as the declaration of emergencies. This type of *translated and integrated* information is also critical for informing decisions at the farm level, such as, selling or buying livestock, and ensuring adequate levels of feed.

Conclusions and lessons learned

The cases presented in the previous section constitute a good set of examples of how climate services and insurance can promote the adoption of Climate-Smart Agriculture practices and technologies.

The Colombian case study exemplifies how the positive experience of the Local Technical Agro-climatic Committees, which engaged in the four pillars of climate services (*production, translation, transfer and use*), convinced the Government of Colombia of the value of promoting such an initiative countrywide. The case constitutes an example of how climate services can contribute to the adoption of CSA, once that information is put into the hands of relevant stakeholders.

The *R4 initiative* in four countries in Africa is an excellent example of how insurance can enable an environment in which farmers can engage in CSA practices. In particular, this type of initiative can foster participation of farmers in activities that can enhance resilience, it can improve access to inputs to increase the adoption of more productive practices with consequences on incomes and food security challenges, and it can support community projects aimed at reducing or capturing GHG emissions.

Finally, the case of Uruguay exemplifies how the establishment of a *National Agricultural Information System* that includes a strong component on climate information can promote the implementation of policies that aim at working towards CSA practices. The latter includes insurance policies and accessible loans to invest in solutions to cope with water limitations.

This set of examples also demonstrates the importance of focusing not only on the *production* of climate information and knowledge, but also investing in understanding *the translation, transfer and use* of this information. Given that there is a common imbalance between strong and robust research in generating the knowledge, and much smaller efforts (less consistent, less robust, more based on anecdotal approaches) in the other three pillars, good and robust research on the knowledge 'networks' through which information flows, and affects the 'use of knowledge', should be a priority in the research agenda. One example in this direction is the work done by the International Research Institute for Climate and Society (IRI), where index-based insurance has been promoting the involvement of users to define adequate insurance policy. Understanding these knowledge networks is critical for promoting CSA at scale.

Acknowledgements

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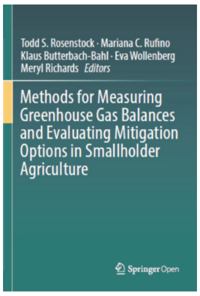

Methods for measuring greenhouse gas balances and evaluating mitigation options in smallholder agriculture

Rosenstock TS, Rufino MC, Butterbach-Bahl K, Wollenberg E, and Richards M (Eds), 2016

Springer International Publishing, 203 + xv pages

eBook ISBN 978-3-319-29794-1

Hardcover ISBN 978-3-319-29792-7, Euros 51.99

Available on http://www.springer.com/gp/book/9783319297927

In this book, the authors present a synthesis of work coordinated by CGIAR's Research Programme on Climate Change, Agriculture and Food Security (CCAFS), under the *'SAMPLES'* program, stemming from a workshop held in October 2012. Setting out to address a dearth of empirical data on GHG emissions and removals from smallholder farms – in particular those in tropical developing countries – it provides a comprehensive range of concepts, methods and tools for measuring GHG emissions and assessing mitigation options for land-use and land-cover (LULC) change.

Comprising some 70 percent of the mitigation potential in these countries, smallholder farms are integral to low emissions development strategies (LEDs) proposed at the policy level. Yet, to date, approaches have suffered from well-documented issues including poor data resolution, high cost or difficulties in producing meaningful, consistent results applicable at multiple scales. As a result, many initiatives and countries still rely predominantly on IPCC Tier 1 data (using default values produced under somewhat different conditions), hampering efforts to properly understand the complexity and diversity of heterogeneous landscapes.

The author team have aimed to develop a resource for multiple audiences, not limited to researchers and practitioners involved in collecting field measurements, for use in monitoring, reporting and verifying (MRV) implemented initiatives, for agricultural commodity companies, carbon standards, as well as those developing Nationally Appropriate Mitigation Actions (NAMAs), national and subnational mitigation plans.

The book comprises ten chapters, organised into three broad categories. It begins with an introduction to the *SAMPLES* approach, and informs the reader how to target appropriate mitigation options in a smallholder landscape, employing techniques such as GIS, remote sensing and use of secondary sources. This is followed by individual chapters on data acquisition for each major GHG source: land use change (LUC), soils and soil fluxes, livestock, biomass and agricultural productivity. The last two chapters deal with option identification: scaling analyses to whole farms and larger landscapes, whilst developing a holistic perspective of the inherent trade-offs between GHGs, livelihoods development and social outcomes. The strengths and weaknesses of various trade-off analysis techniques are discussed, concluding with suggestions for a tiered approach based on data availability.

Detailed case studies are presented in most chapters, illustrating measurement concepts with real life examples developed by leading experts in their respective fields. This format helps break down the otherwise complex subject matter into manageable chunks.

In short, this publication is a detailed and timely resource that will be welcomed by a range of professionals with varying resources and technical capacity. It presents both top-down and bottom-up approaches, and explains how to combine these to scale-up. Interestingly, methods are presented to assess the acceptability of climate mitigation activities, while ample space is dedicated to open source options and low-cost methodological alternatives, suitable for many with limited resources. Importantly, the authors repeatedly acknowledge the need to include local perspectives and communities in decision-making and design – a vital consideration when working in these contexts.

Anyone with a keen interest in the nexus of climate change, agriculture and food security in a smallholder context will find this book extremely useful.

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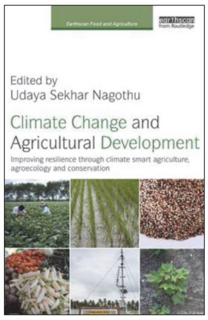

Climate change and agricultural development: improving resilience through climate-smart agriculture, agroecology and conservation

Udaya Sekhar Nagothu (ed), 2016

Routledge, 322 pages

Hardback £85, eBook £24.49

Available on https://www.routledge.com/Climate-Change-and-Agricultural-Development-Improving-Resiliencethrough/Nagothu/p/book/9781138922273

The book presents some of the most progressive and up-to-date thinking on climate-smart agriculture (CSA). The authors set the scene by highlighting how CSA is not entirely a new concept, drawing parallels with many of the associated practices and technologies that are already familiar to farmers. They argue that CSA is however a different approach, combining a suite of sustainable practices, technologies, and institutional frameworks, with the aim of maximising productivity, adaptation and mitigation potential. The book outlines the main parameters through which climate change is affecting agriculture – trends in rainfall and temperature, extreme events such as multi-year droughts, flooding, late frosts, severe storms and heat waves, and changes in the incidences of pests and diseases. They also allude to socio-economic factors such as demographic shifts, changes in consumer demand, and commodity prices as drivers of changes in the context within which food production is taking place. Importantly, the authors note that understanding the impacts of climate change includes identifying who and what is at risk, the assessment of capacity to adapt, and the equity and justice of the distribution of impacts.

Another important point of departure for this book is the realisation that much of the growth in productivity and mitigation potential will come from developing countries. The authors describe an 'adaptation-deficit' where many societies are not even adapted to existing climatic conditions and variability, suggesting that this should be the starting point before even worrying about future climate change. They rightly note that, it is far less expensive to increase yields in low productivity systems where yields are one quarter or less of potential, compared to well-developed systems where only marginal improvements are possible. As such smallholder systems in developing countries need to be the focus of scarce development resources.

Three categories of adaptation to climate variability and change are presented in the book. Although adaptation is typically viewed as either incremental or transformational, the authors include resilience-building as a third category. This categorisation suggests that, although adaptation and resilience are commonly used interchangeably, not all adaptation measures build resilience. The authors rightly highlight that the frontline of adaptation to climate change will be through improved agronomic practices. These agronomic measures are related to integrated soil management, crop varieties, crop mixtures and rotations, among others. The principle of managing current climate variability as the best indicator of the ability to manage future variability is perhaps something that most adaptation programmes should be founded on. Many of the technologies to do that already exist. No-regret interventions that address current climate risk, while building resilience, regardless of how future climate trends turn out is equally a key principle that should underpin adaptation programme design.

The CSA perspective presented in this book acknowledges agriculture's contribution to global GHG emissions as well as its vulnerability to climate. The unique position of the sector to solve the problem on both fronts by reducing GHG emissions and also increasing resilience to climate shocks is brought to the fore. A number of the chapters showcase CSA practices, technologies and perspectives that illustrate this dual potential, illustrating that increased productivity, improved resilience and emissions reduction are connected, and can be achieved jointly. Although there are trade-offs between some multiple objectives, it is clear that there are also many examples of complementarities that present opportunities for pursuing win-win solutions.

The authors characterise CSA as more efficient use of key resources such as water. They demonstrate different approaches to improved water management (water-smart agriculture) that can reduce some of the impacts of climate change, and in some cases, generate significant mitigation benefits. Improved water management, particularly water-smart irrigation, is at the centre of development, food security, and poverty reduction for water scarce regions such as South East Asia. Climate change will worsen these shortages and further complicate crop production and other forms of agriculture, hence the need to help farmers improve water management and productivity. Managing rainfall more efficiently in rain-fed systems in a way that improves yields, without disproportionately increasing emissions, is also presented as one of the key objectives. These measures will also improve resilience of rain-fed production systems.

The book grapples with the complex issues of gender, which clearly continue to bewilder the development community, including those focusing on CSA. Understanding the nature and underlying causes of the gender gap remains one of the most challenging and contentious fields of development. It is clear that the socio-cultural dynamics that underpin gender disparities are unique to specific contexts, and as such, solutions to overcome these will have to be informed by such specificities. Just as there is no single characterisation of the gender gap, no one solution will work everywhere.

Manyewu Mutamba

Closing the gender gap in agriculture under climate change

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Abstract

Women face barriers that significantly constrain their production and entangle them in a low productivity trap. These barriers encompass societal norms, the gender division of labour (GDOL), resource constraints (access to and use of land), no or low use of inputs (*eg* drought-adapted seeds), and limited access to climate services and agro-advisories. Under a changing climate, these barriers will further constrain women's ability to adapt, and the gender gap in agriculture will continue to widen. Gender-responsive climate-smart agricultural (CSA) practices and technologies provide an opportunity to close the gender gap as well as bring women into the forefront in the fight against climate change. Priority activities include identification of the preferences and priorities of women, men and youth to develop practices that are appropriate to each group; labour-saving and productivity-enhancing technologies; access to climate information services; participation of women in agricultural value chains and non-farm activities; and engaging women and men in challenging social and cultural norms.

Background: the gender gap in agriculture under a changing climate

A complex array of societal norms and beliefs interact with access to resources and decision-making to influence how men and women respond to the impacts of climate change. As a result, women and men farmers in developing countries have different vulnerabilities and capacities to deal with the impact of climate change on agriculture (Huyer *et al*, 2015; Kristjanson *et al*, 2016). This affects their willingness and capacity to make use of (CSA) technologies and practices.

Women make up about 20 percent of the agricultural labour force in Latin America and up to 60 percent in Southern Asia and Sub-Saharan Africa (ILO, 2016), with agriculture the primary economic activity for 79 percent of women in least developed countries (Doss, 2011). Nevertheless, there is a substantial gender imbalance in agricultural productivity varying from country to country. For example, in Ethiopia, Malawi, Niger, Nigeria, Tanzania and Uganda production levels of women farmers are 13-25 percent lower per hectare than those of men (World Bank, IFAD, FAO, 2015). Across the developing world, women farmers tend to have significantly less access to important productive, financial and information resources for agriculture, including land. However, closing the gender gap by supporting women's access to resources (*eg*, land, credit, fertilisers, extension services and other productive inputs) can increase yields by 20-30 percent and decrease the global hungry population by 150 million (FAO, 2011).

Women living in rural areas are highly sensitive to climate threats and will be among the most affected by climate change. They are more dependent on natural resource-based activities than men for their livelihoods and family wellbeing, and they have less capacity to adapt with fewer resources (Huyer *et al*, 2015; Jost *et al*, 2016). Effects of environmental stress in farming systems (such as those caused by climate change) include the intensification of women's workloads and decreases in household assets, and are exacerbated by male migration to urban centres for employment (Jost *et al*, 2015). As a result, the concern is that climate change will increase global food insecurity and further exacerbate gender inequalities.

Closing the gender gap in a changing climate

Climate-smart agriculture (CSA) options have the potential to provide a range of benefits for women if they are able to take advantage of them. Studies show that when women have access to information, training and services, they are just as likely as men to adopt new practices (World Bank, FAO, IFAD, 2015). For example, women rice farmers in Vietnam were trained in production technologies and practices, including lower inputs of fertiliser and pesticides. As a result of the training, their production increased to the point that they had extra rice bran to raise pigs. Their knowledge, related to rice varietal choice, crop management and post-harvest management, also increased. As a result of the new practices and knowledge gained, women's participation in household decision-making increased on 'how much money to spend on food', expenditure on children's education, and allocation of remittances. Eighty-four percent felt that they were more highly respected in their family and community (Truong *et al*, 2015). IFAD (2014) highlights several examples of how increased access to seed, credit, and weather information has increased women's social status and their participation in decisions on input use.

However, ensuring that the potential benefits of CSA also extend to women farmers involves recognising gender differences in priorities and capacities for agriculture (Figure 1). As a result of the gender division of labour and household responsibilities, women and men will have different preferences for crops and other agricultural activities. Men tend to prefer crop characteristics that will increase market value such as yield, appearance, and market demand, while women prefer varieties that are more nutritious, better tasting, and easier to cook. Similarly, gender differences in adaptation strategies also exist. A World Bank study in Bolivia found that men focus on large-scale community interventions such as irrigation, whereas women prefer practical improvements such as planting new crop varieties or supplementing traditional revenue with diversified production activities (World Bank, FAO, IFAD, 2015).

Figure 1. Recognising gender differences in priorities and capacities for agriculture is important to ensure the potential benefits of CSA. (Photo: C Schubert (CCAFS))

Evidence suggests that farmers are adopting CSA practices that show small incremental changes rather than large transformative ones. This is because farmers, especially women farmers, lack access to and use of productive resources and information. The introduction of CSA practices will therefore need to respond to both the effects of climate change and gender inequalities to ensure that the *"needs, priorities, and realities of men and women are recognised and adequately addressed …so that both men and women can equally benefit"* (World Bank, FAO and IFAD, 2015).

A gender-responsive CSA approach takes into account the socially differentiated roles, responsibilities, priorities and resources of producers at the community and household levels. Characteristics include use of gender analysis (with sex-disaggregated data) for project design and implementation; engagement with both women and men on priorities (which often differ); identification of barriers to adoption and development of strategies to address the barriers; and monitoring of short-, medium- and long-term benefits (Nelson & Huyer, 2016). Sex disaggregated data and gender research can help in identification and selection of CSA practices that best fit and are appropriate for women, while integrating social research (more specifically sex and gender disaggregated research) into development of CSA practices can address social norms and cultural practices that restrict women from adopting CSA. The CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS) *Gender and Inclusion Toolbox* provides an overview of approaches to identify the different priorities, needs and capacities of women, men and youth in designing climate interventions that strengthen the resilience of each group (Jost *et al*, 2014).

Enabling women's adoption of CSA

Promoting labour-saving and productivity-enhancing technologies

The gender division of agricultural labour reinforces the importance of developing labour-saving and productivity-enhancing CSA technologies for women. Women's work in agriculture and within the household is often labour-intensive and time-consuming, reducing time available for other activities such as education or livelihood diversification. Carrying water and fuelwood long distances can have serious long-term health effects, and exposes women and girls to harassment and injury. Some innovations have been developed to reduce agricultural burdens and workloads, *eg* mechanised farm equipment and the use of draught animals. However, these innovations tend to be targeted at men as heads of households, and their greater access to financial services and information means they are more able to take advantage of them. What is needed is affordable labour saving technologies, specifically targeting women, that will reduce their burden of work and free up time; only then will they be in a position to consider CSA technologies and practices (Huyer, 2016). Additionally, the potential for CSA to increase women's workload is a factor in women's decision to adopt it (Murray *et al*, 2016; Jost *et al*, 2016). In Uganda, women are using locally fabricated fodder choppers that are less cumbersome, less noisy, require less energy to operate, and reduce wastage. Additionally, the time required to chop fodder is substantially reduced. In the same community, treadle pumps to draw water from boreholes for domestic and livestock use have reduced both the time required to water animals from five hours to two hours, and the amount of physical effort required (NARO, 2002).

Gender-responsive climate information services

Information and communication technology (ICT), including radio, TV, mobile phones and social media, can increase women's access to CSA and climate information, and reduce perceived risks of using the information. Factors that hinder women's access to climate information include illiteracy, lack of familiarity with information technologies, language barriers, and socio-cultural attitudes and norms. Research also demonstrates that women's access to and use of weather and agro-advisory services is lower than men's in all developing regions (World Bank, FAO and IFAD, 2015). Their differing access to ICT, and different household and agricultural tasks, mean women require both different *kinds* of information as well as different *channels* for accessing information, such as radio, SMS and voice messaging, as well as through community groups, health clinics and schools. Data from East and West Africa and South Asia indicate that women and men interact with different organisations at the local level, reflecting their information priorities. Women tend to interact with local and informal organisations and prefer information on a wider range of topics such as health and nutrition, while men tend to interact with governmental and international NGOs to obtain information on agricultural production (Huyer *et al*, 2015; Cramer *et al*, 2016; World Bank, FAO and IFAD, 2015).

Use of mobile phone technology can reduce the knowledge gap about CSA across genders if access for women is targeted (Mittal, 2016). Another innovative model is *Agri-Kiosks* in India, that work with female farmer collectives to provide affordable access to quality agricultural inputs (World Bank, FAO and IFAD, 2015). In Bangladesh, early warning systems for floods are being developed to reflect the differing requirements of women and men in terms of literacy levels and degree of access to communication technologies (*ie* mobile phones) (IFAD, 2014). Strengthening the capacity of providers of agro-advisory information to deliver equitable CSA services is also necessary. This involves recruiting more women as providers of information, as well as training providers to understand socio-cultural and gender dynamics and design gender-responsive approaches (WB, FAO and IFAD, 2015).

Facilitating the participation of women in agricultural value chains

Facilitating women's participation in agricultural value chains offers greater opportunities for inclusion in CSA and increased income. They can enter into new higher value-added functions (and therefore receive higher prices for their products) and enter into new market channels that lead to new end markets in the value chain – *eg* from domestic to export markets for the same product (Chimedza, 2016). Climate change is increasing the intensity, frequency and variety of those risks, so that the long-term benefits of agricultural value chain projects are at risk. This will especially affect women, since lack of access to financial capital and gender norms often restrict women from participating and investing in agricultural value chains, especially in processing, marketing and leadership. Gender-sensitive financial services can be one option to support women's productivity and quality, and enable them to participate in value chains as suppliers of agricultural inputs and services in the face of climate impacts. Options include identifying gender issues during design of loan schemes, assessing whether services will reinforce or reduce gender inequalities, or providing lower interest rates for women. In Nigeria, the International Fund for Agricultural Development (IFAD)-funded *Enterprise Development Fund for Women and Youth* supports the creation of job opportunities around value chain points in a number of commodities: (i) village-based input supply enterprises; (ii) post-harvest handling enterprises; and (iii) produce marketing enterprises. Training in business plan development, operations and management, as well as in the technical aspects of the selected enterprise is provided. Starter packs of inputs are provided to trainees after satisfactory completion of the course to support the set-up of businesses (IFAD, 2014).

Enabling diversification of livelihoods for women

It has been found that successful adaptation projects are those that increase women's ability to add value to their agricultural activities – for example, through food processing or marketing – and diversify their income-earning opportunities (Njuki *et al*, 2011). Diversification into alternative income-generating activities can provide additional income security to counteract variable agricultural production. These can include food processing/drying technologies, and production of vegetables or horticulture for household use or the tourism sector (IFAD, 2014). Migration to urban areas to work in service industries is a common strategy, especially for young men; supporting quality education in rural areas would increase skilled employment opportunities for migrants. Business support funds for rural entrepreneurship in both agriculture and other sectors may provide alternative income options at home. For example, Kenya's *Uwezo Fund* aims at enabling women, youth and persons with disability to access finance for the start-up of businesses and enterprises, and to generate self-employment at the local level. Since its inception in 2013, the fund has disbursed over five billion Kenya shillings (around US$ 48 million) (GoK, 2016).

Changing the rules of the game: gender-responsive policy and culture

Engendering climate policy

Despite what we know about the gender gap in agriculture and climate change, gender equality is not often integrated in agriculture and climate policies. Gumucio & Rueda (2015) found that while gender can be quite well integrated into agricultural policies in a region, this does not necessarily translate to climate change policy. They note that seven countries in Latin America conducted gender-sensitive consultation processes during drafting of climate policy, which resulted in gender integration in climate change planning. However, research also shows that when policy does incorporate sex-disaggregated data and recognises the contributions of women, the implementation and monitoring of gender results is often neglected (Gumucio & Rueda, 2015; Ampaire *et al*, 2016).

Participatory and consultative approaches to policy development, as well as the identification of gender and social inclusion as a cross-cutting policy theme can provide guidance and incentive for integrating gender. Capacity building of policy-makers on gender-responsive policy development can also influence changes to organisation cultures and patterns of resource allocation (Gumucio & Rueda, 2015).

Engaging women and men in challenging social norms

Traditional gender roles, that are often deeply entrenched, can prevent women from engaging in adaptive strategies in the face of climate change. The implementation of CSA will fail to benefit women, and in fact may entrench existing inequalities, without an understanding of how gender roles and tasks in households and community may be affected by new CSA technologies and practices. Participatory approaches that promote change in the interests of women and marginalised groups are important for understanding gender norms and community power relations in terms of governance, decision-making and control of resources, and for identifying opportunities for social and gender transformation (Jost *et al*, 2016). They involve engaging with the community to understand and challenge beliefs and practices that restrict opportunities or capacity of women or men. An IFAD project in Mauritania used a peer-to-peer exchange approach with farming couples to develop household strategies for better livelihoods. Couples learned new technologies that were traditionally only for women (vegetable gardening) or men (irrigation). Both women and men learned new skills, and household diets were diversified. Women also reported improved status as a result of being involved in new activities (IFAD, 2014). By engaging couples in joint activities, men's perceptions of what women can do in agriculture changed.

Conclusions

Investing in women farmers and closing the gender gap in agriculture under climate change will not be attained without various stakeholders (governments, the private sector, civil society, research organisations) coming together to invest in improving gender equality and the empowerment of women. The existing evidence on the gender gap that documents the imbalance between the contribution women make and the control that they have over income, property and decision-making must inform development of CSA technologies and practices including climate change policies, as must consultation with women to ascertain their preferences and priorities. This will make investing in gender-sensitive CSA practices and technologies a practical and transformative solution to removing gender-based barriers and improving women's access to agricultural resources (labour, inputs, credit) and knowledge (climate services). Increased active involvement of women in agricultural value chains (production, processing and marketing) can also contribute to transformation, not only by increasing women's adaptive capacity and food security, but also strengthening and raising growth that is gained through new skills, confidence and challenging gender norms.

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News from the Field

Targeting salinity intrusion and drought in Vietnam: from assessments to on-the-ground initiatives

Climate change and its impacts on smallholder farmers are big issues in Southeast Asia (SEA) where agriculture is largely dependent on the weather. A large part of the population of SEA still lives in rural areas, where they depend on agriculture for their food and income. One impact of climate change that is receiving attention in SEA is salinity intrusion. Increased global warming has led to rising sea levels and greater salinity intrusion, especially in coastal farming communities.

Assessing salinity intrusion in Vietnam

Vietnam has had to deal with the effects of salinity intrusion and drought. In April and May 2016, the Ministry of Agricultural Research and Development (MARD) requested the CGIAR Centres operating in Vietnam to assist in the assessment of drought and salinity intrusion in the Mekong River Delta (MRD) brought about by the El Niño Southern Oscillation (ENSO) from 2015-2016. During the ENSO, drought and high temperatures, coupled with the low water discharge levels, resulted in MRD salinity levels peaking two months ahead of normal years, intruding further inland, and remaining for longer during the dry season.

The MRD covers 13 provinces in South Vietnam and produces 50 percent of the total amount of food in the country, as well as agricultural products which are exported to international markets. Eleven of the 13 provinces were affected by the ENSO, with 200,000 ha of rice, 13,000 ha of cash crops, 25,500 ha of fruit trees and 14,400 ha of aquaculture affected by increased salinity alone. In addition, more than 208,000 households lacked freshwater for domestic use.

Although communities were warned of the situation, the local authorities and farmers did not anticipate the severity of the drought and salinity intrusion, and were therefore caught off-guard. The unusually high salinity levels which reached further upstream rendered many of the sluices ineffective. Farmers had limited knowledge of the different salt-tolerant varieties or other coping mechanisms that they could use. Extension workers also did not have the necessary preparation (*eg* skills training) and materials (*eg* publications and seeds) to disseminate the appropriate adaptation options.

The assessment recommended climate-smart agriculture (CSA) practices to help attain sustainable agricultural production while improving adaptation and mitigation potential in the MRD. These could help develop short-, medium-, and long-term plans for addressing climate change in Vietnam.

Adapting to salinity intrusion in the MRD

One direct result of the assessment was a workshop on the participatory mapping of the vulnerable areas in the MRD. This was organised by the Department of Crop Production of MARD and CCAFS, and used the outputs of various research projects, information on salinity intrusion and drought in the MRD, to develop down-scaled risk maps for the provinces. Such maps depend not only on the specific resources available in the provinces, but also the condition of the infrastructure available. Representatives from the local government, international and national research organisations and universities contributed their local knowledge on these factors.

The maps (Figure 1) indicate the areas prone to salinity during years of normal and severe salinity intrusion. Linked to the different colours are CSA options (*eg* aquaculture for red areas, adjustment of cropping calendars or use of salt/drought-tolerant varieties in yellow areas), that extension workers can recommend to farmers. Aside from identifying appropriate responses, the maps could help provinces compare cropping calendars, which are important in managing and sharing water resources among the provinces.

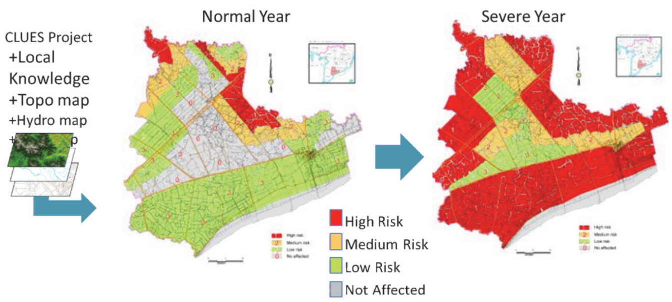

Figure 1. Sample risk map of one of the provinces in the MRD.

Addressing salinity intrusion and other climate impacts in North Central Vietnam

Another initiative to combat salinity intrusion in Vietnam is the project *Enhancing community resilience to climate change by promoting smart aquaculture management practices along the coastal areas of North Central Vietnam (ECO-SAMP)*. This has been implemented by WorldFish, Vietnam Institute for Fisheries Economics and Planning (VIFEP) and Thanh Hoa Agriculture Extension Centre for the past two years.

In the past, farmers grew tiger shrimp due to the higher profits these generated. However, shrimps are very sensitive to changes in the climate and the environment. During months when salinity drops below five parts per thousand (ppt), the shrimp crop is at high risk of failure. In the project, five trial households in Hoang Phong commune, Thanh Hoa province, raised tilapia in mixed aquaculture systems with shrimp, mud crab and seaweed to enhance their resilience and provide more diverse sources of income.

Mono-sex tilapia can thrive in water with salinity levels of up to 15 ppt, so these were introduced to the farms involved in the project. In addition, this species of tilapia is bigger than the local variety grown on some farms, and is therefore more commercially viable for the farmers. Aside from providing farmers with additional sources of income, the fish can feed on the algae and shrimp waste. This helps the farmers save money spent on feeds and the labour for clearing their ponds, and at the same time reduces their carbon footprint from buying commercially produced feeds.

Initially, 25 households in Hoang Phong were implementing the integrated aquaculture system, which helped increase their incomes by 16.9-18.8 percent and helped them save an additional 6.7 million VND on pond clearing. At the end of 2016, the project team scaled-out the system to 103 households in Thanh Hoa province.

All these initiatives are helping scale-out and -up CSA practices in Vietnam, and can be used as learning opportunities for communities and countries experiencing similar conditions in Southeast Asia and the rest of the world.

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Newsflash

Delivering knowledge to the global scientific community

Feeding the world's population through research in agricultural science

The Food and Agriculture Organisation (FAO) has predicted a potential 60 percent increase in the demand for food by 2050 as the population reaches 9 billion.

Burleigh Dodds Science Publishing is a new, independent publisher founded by Rob Burleigh and Francis Dodds, formerly of the award-winning Woodhead Publishing (WP) team. WP has built up one of the world's leading lists of books in the area of food science, widely admired by researchers and the publishing industry for quality and customer focus.

Through our publications we will help researchers to identify key issues and trends, and to find their way more quickly to the research most useful to them, thereby allowing them to plan their own research programmes and to link-up to other research centres to collaborate more effectively. Our goal is to help researchers in agricultural science to address how to feed a growing population in the face of climate change and increasing competition for land, water and other resources.

Here is what the co-founders have to say:

Rob Burleigh – Managing Director

"There can be few more important challenges than feeding the world's growing population. We will be bringing together expertise and experience from across the science community to ensure their work is published in an innovative and ground-breaking way."

Francis Dodds – Editorial Director

"I am really excited to be bringing our unique publishing format to this new business. We will focus our publishing model on exacting customer research and develop our products, in digital and print formats, to deliver to researchers in agricultural science the information they want, when they want it."

Climate-smart publishing in agricultural science

Our mission is something we call 'climate-smart-publishing'. So what is it and how are Burleigh Dodds Science Publishing achieving it?

Let us start with 'climate-smart'. It is widely recognised that agriculture is a significant contributor to global warming and climate change. It has been estimated that agriculture is responsible for 10-12 percent of greenhouse gas emissions.

This figure rises as high as 24 percent if forestry and other land use is included, taking into account such factors as deforestation to clear land for more crops and livestock. Agriculture needs to reduce its environmental impact and adapt to current climate change whilst still feeding a growing population *ie* become more 'climate-smart'. Burleigh Dodds Science Publishing is playing its part in achieving this by bringing together key research on making the production of the world's most important crops and livestock products more sustainable. Our aim is to create a foundation of knowledge on which researchers can build to meet the challenge of climate-smart agriculture.

So, on to 'smart-publishing'. Based on extensive research, our publishing programme specifically targets the challenge of climate-smart agriculture. We are building a database of review chapters, each written by a leading expert, which systematically covers both the major crops and livestock products and, at the same time, each step in the value chain for their production, from breeding through to harvest. Using the latest technology to manage this wealth of material, we have rapidly built up a major publishing programme which we plan to publish in a range of formats to suit our customers, whether books or individual chapters, or in print or electronic formats.

In these ways we are using 'smart-publishing' to help achieve 'climate-smart' agriculture.

Here is a selection of the titles due out in 2017

Achieving sustainable cultivation of cassava - Vol 1: Cultivation techniques

Achieving sustainable cultivation of cassava - Vol 2: Genetics, breeding, pests and diseases

Edited by: Dr Clair Hershey, formerly International Centre for Tropical Agriculture (CIAT), Colombia.

Achieving sustainable cultivation of rice - Vol 1: Breeding for higher yield and quality

Achieving sustainable cultivation of rice - Vol 2: Cultivation, pest and disease management

Edited by: Professor Takuji Sasaki, Tokyo University of Agriculture, Japan.

Achieving sustainable cultivation of oil palm - Vol 1: Introduction, breeding and cultivation techniques

Achieving sustainable cultivation of oil palm - Vol 2: Diseases, pests, quality and sustainability

Edited by: Professor Alain Rival, Centre for International Cooperation in Agricultural Research for Development (CIRAD), France.

Achieving sustainable cultivation of mangoes

Edited by: Professor Víctor Galán Saúco, Instituto Canario de Investigaciones Agrarias (ICIA), Spain and Dr Ping Lu, Charles Darwin University, Australia.

Achieving sustainable cultivation of sugarcane - Vol 1: Cultivation techniques, quality and sustainability

Achieving sustainable cultivation of sugarcane - Vol 2: Breeding, pests and diseases

Edited by: Professor Philippe Rott, University of Florida, USA.

Achieving sustainable cultivation of coffee: Breeding and quality traits

Edited by: Dr Philippe Lashermes, Institut de Recherche pour le Développement (IRD), France.

Achieving sustainable cultivation of bananas - Vol 1: Cultivation techniques

Edited by: Professor Gert Kema, Wageningen University, The Netherlands and Professor André Drenth, University of Queensland, Australia.

Global Tea Science: Current status and future needs

Edited by: Dr VS Sharma, Formerly UPASI Tea Research Institute, India and Dr MT Kumudini Gunasekare, Coordinating Secretariat for Science Technology and Innovation (COSTI), Sri Lanka.

Achieving sustainable cultivation of cocoa - Vol 1: Genetics, breeding, cultivation and quality

Achieving sustainable cultivation of cocoa - Vol 2: Diseases, pests and sustainability

Edited by: Professor Pathmanathan Umaharan, Cocoa Research Centre, The University of the West Indies, Trinidad and Tobago.

Rice insect pests and their management

EA Heinrichs, Francis E Nwilene, Michael J Stout, Buyung AR Hadi and Thais Freitas.

For more information about these titles please visit the website http://bdspublishing.com and as a special promotion for TAA members use voucher **TAA20** at the online bookshop checkout for a **20 percent discount**.

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How can the Data Revolution contribute to climate action in smallholder agriculture?

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Abstract

In this article, we discuss the ongoing Data Revolution in relation to climate action in agriculture. Data are highly relevant for climate action, as climate change makes current local knowledge increasingly irrelevant and requires smarter management of agricultural systems. We discuss five data-related concepts and explore how they are linked with agricultural climate action: lean data, crowdsourcing, big data, ubiquitous computing, and information design. We show practical examples for each of these concepts. There are many opportunities for improving agricultural development projects, providing new services to smallholder farmers, and generating better information for policy- and decision-making. Making the Data Revolution work for smallholder farmers' climate action not only takes further technological development, but also requires careful governance and public investment to avoid a few actors taking over the current innovation space and stifle further development.

Introduction

Climate change is among the most important challenges facing humanity today. Fortunately, climate change emerges at the same time as another major change in human history. This is the Data Revolution, epitomised by the unprecedented amounts of data produced by a wide range of means: satellite sensors, GPS, social media, wearable devices, and so forth. It was the Industrial Revolution that started the massive use of fossil energy that generated the climate problem. Perhaps the Data Revolution can provide the solution?

Data are already key for renewable energy management. Varying levels of sun and wind need to be carefully matched to the fluctuating energy needs of users. So-called 'smart energy grids' feed on data. They constantly measure and forecast energy production and energy use patterns, match supply and demand, and detect energy waste. Also in the agricultural sector, climatic information has become an important focus of innovation in modern systems. In 2013, *Monsanto* took over the *Climate Corporation*, a United States-based climate information service provider, for US$ 1 billion. This made the strategic value of climate data highly evident.

But what about smallholder farming in the (sub-) tropics? Climate change destroys information: local knowledge gradually loses its value as rainfall patterns change and new pests and diseases appear (Quiggin & Horowitz, 2003). The creation of new knowledge, adaptive management, and 'smart' management will require constant data flows. Obviously, the digital divide between rich and poor affects what is possible. Even so, the worldwide, steady expansion of mobile networks is making digital communication more and more accessible to smallholder farmers. Mobile networks have made rural communities leapfrog directly to mobile banking in certain countries. What is needed to make a similar shift in agriculture?

We believe that five emerging concepts related to the data revolution are key in this context. In the following sections, we explore these concepts to understand ongoing efforts and the future potential of data-driven approaches to agricultural climate action in smallholder agriculture. Although we list these concepts here separately, the description of each of the concepts will make clear that they are highly interconnected.

Key concept 1: Lean data

The idea of *lean data* emerged to address the need to monitor the social and environmental impacts of investments. Often, efforts in these areas are evaluated when they are well underway. This limits the degree of learning during their implementation and the scope of adjustments that can be made. Lean data involves using digital means to collect a minimalistic set of indicators at a frequent rate that allow monitoring of what is going on. For example, *constituent voice* measurements use very simple means to retrieve information about the perception of key stakeholders in change processes. Using simple Likert scales, participants indicate how they feel about the intervention in which they are involved. This allows project managers to keep their finger on the pulse. If they observe sudden changes or trends in the data, they can further investigate the causes through more qualitative inquiry.

Another interesting lean data idea has been piloted by the International Centre for Tropical Agriculture (CIAT). The *5Q* concept serves 'real-time' project monitoring using mobile telephone surveys, collecting the feedback of beneficiaries (Figure 1). Farmers respond via mobile phone to ultra-short questionnaires that are administered through automated voice response. By making questions conditional on the answers to previous questions, rich information can be obtained even though each farmer only answers five questions at a time (hence the name *5Q*). The information can be used for timely corrective action during the project cycle. The pilot found some limitations in the ability to synchronise the survey with ongoing field activities, but showed the potential of the *5Q* approach (Jarvis *et al*, 2015).

Figure 1. A local extension agent conducts a *5Q* survey using a tablet. (Photo: Manon Koningstein, CIAT)

The lean data approach has been applied more specifically to agriculture in the *Rural Household Multiple Indicator Survey (RHoMIS)*, developed by a collaborative group from the CGIAR (Hammond *et al*, 2016). This survey format stems from the realisation that a small number of variables can predict household food security status (Frelat *et al*, 2016), and that similar sparse indicators are needed for other aspects of farm performance. Climate-smart agriculture (or sustainable agricultural intensification) is about managing the trade-offs (positive and negative) across a large number of indicators, trying to avoid progress on one indicator causing a negative impact on another. The multiple aspects that need to be managed include productivity, poverty, greenhouse gas emissions, food security, gender and social inclusion. Systems approaches are widely advocated to deal with the multidimensionality of climate change, but there is a need for easy-to-use, quantitative tools to underpin these approaches.

The *RHoMIS* selects standard indicators for each of these aspects that are validated and require a relatively small number of questions. By including only questions that contribute to calculating these indicators, it avoids the 'design by committee' syndrome, which often leads to long questionnaires that satisfy the curiosity of the experts but that are neither complete nor parsimonious. The use of standard indicators and digital data collection tools (Open Data Kit with Android devices) also makes it easy to process the data automatically. This makes the results of the data analysis directly available, enabling the use of the resulting insights immediately to target project interventions. The strength of *RHoMIS* is not that it provides in-depth insights into any of these aspects, but that it allows the broad study of relationships between the different aspects. More in-depth, focused studies could follow-up on particular aspects identified from an exploratory analysis of *RHoMIS* data. The *RHoMIS* is already widely used for target-setting, monitoring and evaluation purposes (Hammond *et al*, 2017). It shows how the lean data approach can not only support adaptive management, but can be combined with a systems approach, which is another strong need for climate action.

Key concept 2: Crowdsourcing

Crowdsourcing is another important concept in the ongoing Data Revolution. Many information-related tasks are still best done by people. Digital means, however, make it easy to distribute tasks to large groups of people, and retrieve and combine the results. This makes it possible to scale the realisation of information-based tasks to levels that were not possible before.

An example of one such task is the transcription of weather data. Many old records with handwritten meteorological records exist; ships would typically keep detailed records of weather conditions. These data are now of much value in calibrating climate models. However, text recognition software has trouble recognising handwriting from several centuries ago. The *Old Weather* project therefore employed online volunteers to transcribe these records (www.oldweather.org). People are motivated to contribute as volunteers for various reasons: the scientific value of the tasks or the personal connection to the persons who wrote these records. The project website makes the task part of a game-like challenge, in which records of achievement are being kept and people receive badges or roles depending on their contribution. Until now, 20,000 people have participated in transcribing millions of records. These data are added to the *International Comprehensive Ocean-Atmosphere Data Set (ICOADS)* climate database (Freeman *et al*, 2016).

The crowdsourcing idea has also been applied to experimentation for climate adaptation in the agricultural sciences. Bioversity International (CGIAR) developed the *triadic comparisons of technologies (tricot)* methodology to make it possible for large numbers of farmers to 'massively test' different technologies (van Etten, 2011; van Etten *et al*, 2017). In *tricot*, each farmer receives a combination of three technologies (for example, crop varieties or types of inputs); they then test and compare the technologies using a very simple on-farm trial format. By giving farmers different, partially overlapping combinations of technologies, larger sets of technologies can be compared: for example, sets of 10-20 crop varieties. Crowdsourced field-testing not only expands the number of trials but also makes clever use of the diverse growing conditions of each field (in terms of weather, soil, planting date, other management choices) to analyse environmental adaptation in a single year. Crowdsourcing provides a bottom-up, data-intensive approach to climate adaptation, which should complement more top-down approaches, based on causal modelling. The strength of the crowdsourcing *tricot* approach lies in its external validity. Crop models are calibrated with data produced on agricultural research stations, which may not represent real conditions on farmers' fields. In contrast, the *tricot* approach samples a wide range of farm conditions that actually occur locally.

Key concept 3: Big data

The term *big data* denotes the massive quantity of data that are produced by humans interacting with digital media, by sensors, by business transactions, crowdsourcing, gene sequencing, *etc*. There are different definitions of big data around and there is overlap with the other key concepts in this paper, but the term big data emphasises the data management challenges that this data deluge has caused, as well as the emerging possibilities. For example, opportunities arise from data that are being generated as a side-product of other processes. Examples include digital transactions (online purchases, mobile money transfer, credit card use, *etc*), the clicking behaviour of website visitors, the terms used by search machine users, messages shared through social media, loyalty card use, and so on. Big data also results from the digitisation of data that were previously only available in analogue format (texts, images, audiovisual materials) or by adding a common structure to data that consists of separate small datasets. Big data generates many opportunities for innovative data analysis, for example by combining data from different sources or by repurposing data to detect real-time trends in time and space.

Big data is different from scientific data. Big data tends to rely on less control over sampling or observation. But the wide coverage or real-time nature of big data may override concerns about representativeness or the lack of experimental control. For example, social media users may not be representative of the world population, but they constitute such a large group that the data they produce may be relevant even if not fully representative. Science was traditionally based on deriving conclusions from scarce data through model-driven inference. Now, new methods are needed to deal with big data. At the same time, the limitations and risks of using big data need to be taken into account and better studied. Due to its limitations in terms of representativeness as well as ownership and privacy issues, big data will not completely substitute 'small data' studies but rather complement these (Kitchin, 2016).

For climate action in agriculture, it is clear that big data approaches have promise. For example, Simko & Pechenick (2010) present a method to aggregate crop trial data from different crop breeding trials, in spite of differences in experimental conditions, rating scales or proxies used. Lobell *et al* (2011) have shown that existing crop trial data can be repurposed to study the effects of climate on crop yield. Different efforts are underway to create consistent databases with crop trial data, standardising data formats. Data standardisation requires the development of 'ontologies', which are documented standards that describe the underlying elements and variables that are contained in the datasets and how these different elements/variables are interlinked (Shrestha *et al*, 2012). Big data approaches are still incipient for applications in smallholder agriculture and well-coordinated efforts are needed to achieve their full potential.

One important product that shows the power of big data for agriculture is the *Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)* dataset (Funk *et al*, 2014). This dataset is based on the interpolation of precipitation data produced by weather stations combined with satellite radar data and goes back several decades. The resulting dataset is quasi-global and gives daily precipitation estimates on a 5 x 5 km resolution grid. An important achievement is to source data from national meteorological institutes and others sources, which requires an important investment in social capital, as the availability of public meteorological data under unrestrictive licenses is on the decrease (Ramirez, 2012).

Key concept 4: Ubiquitous computing

The idea of *ubiquitous computing* is the opposite of the usual practice of concentrating computing mainly in a single device (PC or laptop), and shaping our tasks around this technology. Instead, it proposes to embed computing directly into use objects to integrate the digital devices into the routines of users. The idea of ubiquitous computing is closely related to (but not synonymous with) a number of other concepts, such as the *Internet of Things* (*eg* thermostats and light sensors talking with the lights and curtains in your house) and wearable devices (fitness watches, computing integrated into clothing and so on).

The idea of ubiquitous computing is interesting in smallholder farming because currently farmers often find it difficult to combine computing tasks with their daily practice. Important obstacles are illiteracy and the difficulty of finding a specific time and space for computing tasks. If data acquisition, processing, and feedback are fully integrated into the tools and tasks of farmers and designed according to their abilities and needs, it will be more likely that computing will positively affect their farming practice.

In modern farming, ubiquitous computing is already highly developed. Precision farming technologies make tractors constantly send and receive data to adjust planting density, fertilisation rates and so on within fields. Precision farming is an important part of climate action. Controlling input dosage, for example, can reduce wastage and avoid greenhouse gas emissions from fertilisers.

For smallholder agriculture, ubiquitous computing also holds promise, but is still in its infancy. One example is the development of the *Trans-African Hydro-Meteorological Observatory (TAHMO)* weather station network, which addresses the dearth of weather data in Africa. This initiative has designed a weather station that is extremely low in maintenance by avoiding any sensors with moving parts (Figure 2). It is connected to the mobile network to send the data it collects and is powered by a solar panel. These features help to overcome some of the main limitations of weather station networks in poor rural areas.

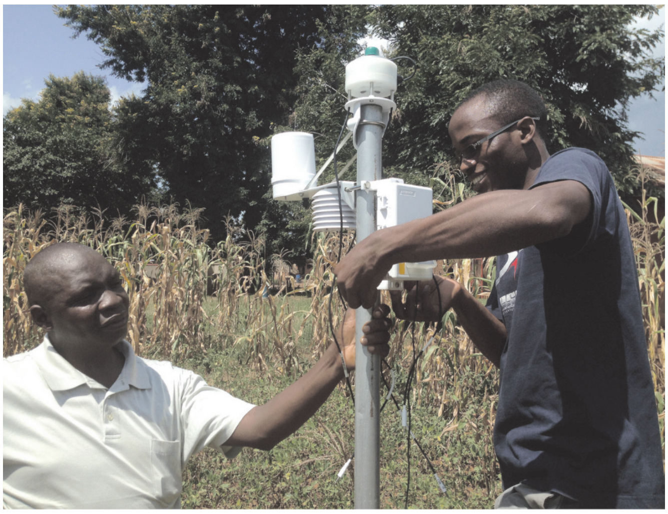

Figure 2. Installation of a meteorological station in Uganda by *TAHMO* engineer George Sserwadda. (Photo: *TAHMO*)

Another ubiquitous computing initiative, *Talking Plants*, focuses on practices around crop seeds, exploring the use of sensors to measure humidity of seeds in storage, and video as a medium to record farmers' information about their seeds, including their personal story, which often has much significance (Heitlinger *et al,* 2014).

It is evident from these two examples that careful design is needed for successful ubiquitous computing solutions. The design process needs to centre on the eventual users, taking into account their specific needs and interests, which may differ among users in terms of gender, age and other social factors. We believe that such design efforts would be very important in helping to bridge the current digital divide.

Key concept 5: Information design

Eventually, climate action depends on human decision-making, so it is crucial that data are converted into understandable information through *information design*. This concept refers to making data available in formats that allow users to derive insights to inform decisions. Over the last decade, complex, interactive visualisations have become available for personal computers, stimulating creativity to generate new visualisation formats. At the same time, scientists have made much progress in understanding how human visual perception works (Ware, 2013). Human visual perception is a pattern-seeking system that is intricately linked with human cognition. Interactive visualisation is being increasingly recognised as having a place in scientific knowledge generation. It should afford the discovery of new information by exploring the data and drilling down to get more detail (Ware, 2013).

For example, Steed *et al* (2013) argue that knowledge discovery from climate simulation data calls for increased visualisation capacity. Simulation data generates many models and scenarios, each producing output in the form of multiple variables. Data reduction as a preparation to then create simple visualisations can remove many of the features, precluding the generation of new insights. Steed *et al* (2013) created an analysis tool *(EDEN)* that includes interactive, multi-dimensional visualisation techniques that are more appropriate for the big data era.

We are not aware of parallel efforts in agricultural climate science that are at an advanced stage, however, the issues are very similar. We believe that more investment is needed in information design in agricultural climate studies.

Final remarks

It is clear that the Data Revolution is already underway to support climate action in smallholder agriculture. Many solutions are within reach from a technological perspective, but still require substantial effort and creativity to be adapted to smallholder agriculture through user-centred design. This involves building systems that respond to local problems with intensive feedback from future users; making the institutional arrangements, or generating business models, to make their use sustainable; and influencing the enabling environment so that these approaches gain long-term policy support and are embedded in solid regulations.

We think that data-intensive approaches are attractive for development investment. They can create practical solutions in agricultural climate action with concrete, visible benefits for farmers. Also, they generate business opportunities, create space for community initiatives, and provide entry points for more responsive policy. In other words, data-driven climate action provides opportunities for a wide range of actors, which could guarantee broad institutional support through an appeal to different institutional styles. From a climate action perspective, this broad appeal is a crucial success factor (Verweij *et al,* 2006).

In terms of policy and institutions, data governance is key, in order to balance privacy and data property rights with wider innovation possibilities provided by access to data. Innovation opportunities would quickly narrow if a few monopolistic players occupy the innovation space provided by the Data Revolution. Proactive policy, as well as public support and investment, will therefore be crucial in establishing an open space for business and community organisations in a way that will give rise to the interdependent, decentralised data management systems that are needed for agricultural climate action.

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News from the Field

Adaptation for Smallholder Agriculture Programme (ASAP)

ASAP is the largest global programme focused on climate-smart agriculture (CSA) and adaptation to climate change by smallholder farmers, and it currently supports projects in 36 countries, see https://www.ifad.org/topic/asap/overview . The Programme is managed by the International Fund for Agricultural Development (IFAD) and has a budget of US$ 366 million. The United Kingdom's Department for International Development (DFID) is the largest contributor to *ASAP*, which is also supported by 10 other donors.

The overall goal of *ASAP* is to increase the resilience of poor smallholder farmers to climate change. It aims to achieve this by introducing, testing and scaling-up multi-benefit adaptation approaches, geared to the needs of farmers. The modality of *ASAP's* operation is to provide additional grant funding into the larger loan-based agriculture and rural development projects that are part of IFAD's regular portfolio developed in *IFAD 9* (2012-2014). *ASAP* grants are intended to make these projects 'climate-smart' so that the projects in their entirety, and their funding streams, contribute to the *ASAP* goal. *ASAP* is seen as a significant step to mainstreaming climate change in IFAD's entire portfolio, as witnessed in the emerging *IFAD 10* (2015-2018) portfolio.

Priority activities are agreed with host governments in the countries where *ASAP* is supporting projects. These include:

- Agricultural diversification strategies;
- Avoiding losses in production caused by climate-related pests and diseases;
- Rehabilitating and protecting soils from water stress and erosion;
- Protecting productive lands and rural infrastructure from extreme climate events;
- Improving management of green and blue water resources;
- Enhancing and diversifying access to clean energy sources;

- Providing better climate information to farmers to be prepared for shocks and stresses;
- Making financial services available for climate management risk and transfer;
- Strengthening the skills base of local institutions;
- Protecting processing and storage infrastructure from extreme climate events;
- Increasing storage opportunities to buffer against climate and economic variability;
- Promoting clean production technologies to reduce human impact on ecosystems;
- Promoting market access to infrastructure.

Project management teams (PMTs) are based in host government ministries or departments. PMTs typically work through service providers, comprising government, Non-Government Organisations (NGOs) and private sector agencies who implement activities. Jointly with host governments, IFAD conducts regular supervision and mid-term reviews of *ASAP*-supported projects, and DFID currently supports a consultant to participate in a selection of reviews as an observer.

Some of the technologies that are being piloted and have scale-up potential are described below.

Climate resilient warehouses in Rwanda

Figure 1. Features of demonstration drying hangars and warehouses built in the Eastern Province according to the climate-resilient guidelines developed by *Climate-Resilient Post-harvest Agri-business Support Project* (*PASP*) and *ASAP*. (Photographs were taken during assessments made in July 2016 by *GEAR Ltd*)

ASAP supports the *Climate-Resilient Post-harvest and Agri-business Support Project (PASP)*, which is mainly funded by an IFAD loan. With increasing amounts of maize and other crops for commercialisation, post-harvest drying and storage are the main constraints to increasing sales and farmer incomes. *ASAP* grant funding supports, among other things, climate-resilient infrastructure such as warehouses and drying facilities (Figure 1). In Rwanda, there is an increasingly short window of opportunity for harvesting between season A (October-January) and season B (March-June) and maize often has to be harvested during rainy periods when cobs are particularly prone to damage. In recent years farmers have reported a delayed onset of season A and increasing rainfall events during the dry period prior to season B, which exacerbates this problem. Storage and drying infrastructure supported by *PASP* incorporates solar panels and water harvesting facilities, and the design specifications for climate-resilient warehouses have been incorporated in the Rwanda Building Code as a national standard. In addition to the four demonstration warehouses of the Support Project, six additional warehouses, funded by the Rwanda Ministry of Agriculture (plus user contributions), have also followed this design.

Biogas systems development in Mali

Energy for domestic use is a problem in Mali. Increasing demand for firewood is contributing to deforestation and erosion, as well as adding to the workload of rural women. Livestock, and cattle in particular, are an essential part of mixed farming systems in southern Mali, providing a source of manure for potential biogas development. *ASAP* support to the *Projet d'accroissement de la Productivité agricole au Mali (PAPAM)*, includes development of biogas systems. Concrete fixed dome biodigesters and flexible plastic tunnel models are currently being piloted, with a target of 600 households in six '*cercles*' (= districts) of southern and western Mali. Biogas is used for cooking, and installations feed two burners. The Project has also installed rooftop solar panels to provide electricity for lighting. Beneficiaries contribute, essentially through the supply of labour and materials to the costs of these installations.

Figure 2. Maize fertilised (centre/right) by residue from biogas tank. (Photo: David Radcliffe)

PAPAM's development of biogas is welcomed by both men and women, with multiple benefits including decreased women's workload (average 58 percent time saved by current beneficiaries) and greater efficiency in cooking. *PAPAM/ASAP* has also trained masons and plumbers in construction and maintenance, thereby contributing to local job creation. Biogas technology reduces greenhouse gas emissions by reducing fuelwood consumption and helping to preserve woodland. Residue from biogas tanks can be mixed with compost to give a nitrogen-rich fertiliser which, in at least one of the sites visited, results in improved maize performance (Figure 2). Building on project experience, *PAPAM* is working with SNV (Netherlands Development Organisation) and with AVSF (*Agronomes et Vétérinaires Sans Frontières*) to elaborate and take forward a national biogas strategy.

Cassava value chain in Mozambique

ASAP funding supports the *Pro-poor Value Chain Development Project in the Maputo and Limpopo Corridors (PROSUL)*. The project's rationale is that improving farmer incomes is the best way to boost resilience and adapt to climate change. Also, that a focus on value chains is most likely to achieve this aim. Three value chains are targeted: horticulture, cassava, and red meat. In the cassava value chain, the introduction of varieties that are more drought-tolerant and resistant to cassava mosaic virus, coupled with capacity-building support to farmer organisations through farmer field schools, led to a trebling of yields (from 6 t ha^{-1} to more than 18 t ha^{-1}) by small-scale producers, even in a relatively poor growing season impacted by the 2015/2016 El Niño effect. Specialist farmers have been supported to run multiplication plots to meet increasing demand for improved cassava stems. The project has also supported service hubs and innovation platforms, linking producers with small- and medium-scale cassava processors, to create market opportunities along the value chain.

Cassava processing plants provide good examples of how private enterprise at different scales supports smallholder producers. For example, a local entrepreneur operates a processing plant in an adapted house in a village. The plant has a capacity of 1 ton cassava/day, which produces around 300 kg of cassava flour, and employs a few local staff. At a larger scale *DADTCO*, a Dutch-Mozambican company, operates three mobile processing plants in Mozambique (Figure 3). These plants are currently located in Morrumbene (Inhambane Province) and between them they process around 50-60 tons of cassava per day, and have accessed cassava from 4,500 local producers since 2013. The plants have 20 permanent employees and engage up to 25 more on a temporary basis, depending on demand.

A majority of cassava producers in southern Mozambique are women. Women constitute the majority of trainees supported by *PROSUL* in the cassava value chain, and are well represented in farmers' organisation committees.

Figure 3. *DADTCO* mobile cassava processing facility, Morrumbene (Photo: David Radcliffe)

Conclusions

ASAP's first phase has a commitment period of 2012-2017. *ASAP*-supported projects approved during this period have a lifetime that runs into the early 2020s, and collectively are anticipated to improve the resilience of an estimated 8 million beneficiaries. IFAD's Environment and Climate Division has developed a *Knowledge Management and Communication Strategy* to collate lessons and provide the basis for scaling-up of best practice. A novel output of this strategy is the *Recipes for Changes* (https://www.ifad.org/topic/r4c/overview). This is basically a collection of local recipes cooked by a beneficiary community that includes an ingredient that is (i) under threat from climate change and (ii) an adaptation solution for small farmers supported by IFAD. So far 11 recipes are on line with 8 videos from Bolivia, Cambodia, Lesotho, Mexico, Morocco, Mozambique, Nicaragua, Rwanda, Senegal, Tonga and Vietnam.

David Radcliffe (Consultant, currently contracted by DAI to investigate lesson learning and knowledge management in *ASAP*)

Steve Twomlow (Regional Environment and Climate Change Specialist, East and Southern Africa, IFAD)

Ilaria Firmian (Environment and Climate Knowledge Officer, IFAD)

International Agricultural Research News

Climate change in mountain areas

The search for ways to reduce agriculture's environmental footprint has expanded exponentially over recent years, as has research aimed at helping agriculture adapt to the current and anticipated effects of climate change. The CGIAR is a major global actor in this field, particularly through its research programme *Climate Change, Agriculture and Food Security (CCAFS)*, the work of which is featured elsewhere in this edition of *Agriculture for Development*. The CGIAR, however, is not alone in this endeavour and almost all international and regional agricultural research institutions have programmes that address issues relating to climate change, including the two Centres whose work is featured here.

Both, the International Centre of Insect Physiology and Ecology (icipe), based in Nairobi, Kenya, and the International Centre for Integrated Mountain Development (ICIMOD), based in Kathmandu, Nepal, have programmes that address the issue of climate change in mountainous areas. Globally, mountain ecosystems provide an invaluable source of water, but are especially vulnerable to the effects of climate change that can result in increased droughts, flooding and erosion. Glaciers are in retreat throughout much of the world, leading to expectations of far greater problems in the future as meltwater diminishes. These impacts serve to greatly exacerbate the already serious situation of mountain ecosystems resulting from deforestation and over-exploitation.

Climate change in the East African Highlands

From 2010 to 2015, icipe led a research programme entitled *Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa (CHIESA)*. Funded by the Government of Finland, the programme aimed to generate knowledge and build the capacity of research communities, extension officers and decision-makers with respect to climate change. It focused on agriculture, hydrology, ecology and geo-informatics and involved four universities in Africa and Europe working in partnership with 22 other partner institutions.

CHIESA's activities focused on three mountain ecosystems in Eastern Africa: Mount Kilimanjaro in Tanzania, the Taita Hills in Kenya, and the Jimma Highlands in Ethiopia. The project consortium took weather measurements, monitored changes in land use and land cover, and studied biophysical and socio-economic factors affecting crop yields and food security. Together with local communities, the project developed and tested numerous climate change adaptation options and disseminated appropriate tools and strategies at the farm level.

Based on its research, the programme produced twelve Policy Briefs covering a wide range of subjects from general topics, such as the effects of climate change on biodiversity, and perceptions of the impact of climate change on ecosystem services, to more specialised topics, such as the impact of climate change on lepidopteran stem borers in maize. The full range of Policy Briefs can be found at http://www.icipe.org/publications/policy-briefs.

Policy Brief number 12, for example, *Traditional weather forecasting: practices, challenges and opportunities*, presents recommendations arising from participatory research that compared forecasts put out by the Tanzanian Meteorological Agency (TMA) with those derived from traditional weather forecasting methods that included:

- The time of fruiting, flowering, and shedding of leaves of various indigenous trees to predict the onset of the rainy seasons.
- Snow and clouds on Kibo and Mawenzi peaks of Mount Kilimanjaro in January are considered an indicator of abundant rainfall and a good agricultural year to come.
- The behaviour of specific insects, for example the movement of safari ants, is used to forecast forthcoming rain.
- The appearance of a rainbow during the rainy season is believed to indicate that rainfall is about to temporarily, or permanently, stop.
- The behaviour of certain birds, for example the singing of the Malachite Sunbird or Red-winged Starling after a prolonged drought, is considered a useful indicator of the onset of a good rainy season.
- Goats and dogs making a noise at night, the continuous croaking of frogs, or the sighting of lemurs are all believed to predict imminent rainfall.

The researchers found that many of these traditional forecasting methods had an underlying scientific basis to them. However, indigenous weather knowledge is largely maintained and passed on orally and, as much has not yet been documented, is in danger of being lost.

A combination of participatory research approaches and household surveys were used to explore local perceptions of the relative applicability and reliability of both traditional knowledge-based weather forecasts and conventional weather forecasts put out by TMA.

Only 26 percent of participants in the study considered weather forecasts from TMA to be reliable and useful. This was attributed to a general shortage of weather stations and forecasting equipment, inadequate surface and upper air observations, and the use of technical language to disseminate the information that neither farmers, nor agricultural extension workers, could fully understand. On the other hand, 86 percent of participants perceived a positive correlation between forecasts derived by traditional methods and those put out by the TMA.

Since neither the traditional knowledge-based, nor conventional forecasts, are error-free, the study recommended integrating the best attributes of both systems.

While the *CHIESA* project terminated in 2015, a two-year follow-on project is now underway, *Adaptation for Ecosystem Resilience in Africa (AFERIA)*. Also funded by the Government of Finland, *AFERIA* aims to disseminate to policy-makers, scientists, extension workers and local communities, the research findings and recommendations of *CHIESA*, including adaptation technologies, such as drip irrigation, roof rainwater harvesting, conservation agriculture, farm forestry and integrated pest management.

Climate change in the Himalayas

The Himalayas store the world's second largest quantity of ice after the polar regions. Supplementing the monsoon rains, meltwater from the high Himalayas is crucial for some 1.3 billion people living downstream in the Indo-Gangetic Plain - 'the grain basket of South Asia'. With global temperatures rising, the long-term future of both the monsoons, and the glaciers themselves, is put in jeopardy. As the warming trend in the Himalayas is higher than the global average, this exacerbates concerns. ICIMOD thus has a major focus on science to inform adaptation strategies and policies.

Central to ICIMOD's efforts is the *Himalayan Climate Change Adaptation Programme (HICAP)*, funded by the Governments of Norway and Sweden since 2011. *HICAP* is a pioneering collaborative programme among three organisations – ICIMOD, *GRID-Arendal* (see http://www.grida.no) and *CICERO* (see www.cicero.uio.no) – and involves an additional 25 regional and global partners. It aims to enhance the resilience of mountain communities, particularly women, through generating and applying knowledge about the nature and impacts of climate change on natural resources, ecosystem services, and the communities that depend on them.

A major output of *HICAP* has been the publication of *The Himalayan Climate and Water Atlas*. The first of its kind, the interactive atlas presents a comprehensive, regional overview of the changing climate and its impact on water resources in the Indus, Brahmaputra, Ganges, Salween and Mekong basins (see http://www.icimod.org/wateratlas/index.html).

The atlas shows that the region's climate, which has been changing rapidly, will continue to do so in the future, with severe consequences for populations locally and downstream. Some of the main points in the atlas include:

- Temperatures across the mountainous Hindu Kush Himalayan region will increase by about 1-2°C (in some places by up to 4-5°C) by 2050.
- Precipitation will change, with the monsoon expected to become longer and more erratic.
- Extreme rainfall events are becoming less frequent, but more violent and are likely to increase in intensity.
- Glaciers will continue to suffer substantial ice loss, with the main loss in the Indus basin.
- Communities living immediately downstream from glaciers are most vulnerable to glacial changes.
- Despite the overall greater river flow projected, higher variability in river flows, and more water in pre-monsoon months, are expected. This will lead to higher incidence of unexpected floods and droughts, greatly impacting the livelihood security and agriculture of river-dependent people.

Changes in temperature and precipitation will have serious and far-reaching consequences for climate-dependent sectors, such as agriculture, water resources and health.

The atlas includes recommendations to encourage policy-makers to develop flexible and cooperative strategies between countries to deal with increased variability, and to meet the challenges posed by either too much, or too little, water.

Another component of the programme involved carrying out poverty and vulnerability assessments with some 8,000 households in almost 350 settlements in four countries. Respondents in the flood plains of the Brahmaputra estimated they lost an average of US$ 155 per household from environmental shocks in 2011. The largest damage was in Dhemaji District in Assam, India, where households reported losing on average US$ 340, predominantly because of floods and droughts.

A community-based flood early warning system and a flexible flood management planning initiative were piloted in two tributaries of the Brahmaputra River in Assam, India. The early warning system sends warning signals to 42 downstream communities along the Singora and Jiadhal rivers. Villagers estimate that the warning signals sent by one of the systems saved livestock and property worth US$ 3,300 in 2013.

Meanwhile, farmers at higher altitudes are exploring new opportunities. With increasing temperatures, crops that could previously be grown only at lower altitudes are moving upwards.

Although *HICAP* is due to end in 2017, ICIMOD will continue to build on its achievements in the on-going search for a greater understanding of the complex change processes in the region, as well the provision of sound advice for policy and action at all levels.

Geoff Hawtin

Opinions Page

(The views expressed here by individual members do not necessarily reflect those of the editors or the Tropical Agriculture Association)

Climate change and climate-smart agriculture in the current political climate

It seems we live in an age of post-modernist politics. I've recently spent time in Australia (the world leader in climate change denial, according to a 2015 paper in *Global Environmental Change*) and I have family in the US and the UK. In all these places, politicians regularly spout known falsehoods, on climate and many other topics, with the express purpose of misleading, bamboozling and deceiving, but none is ever held to account.

Speaking just from a climate change perspective, I found the outcome of the votes on Brexit and the US presidential election profoundly discouraging: addressing climate change will need massive transformations of society in the future, and these can come about only through collective action on a hitherto unimagined scale. Votes like these make this collective action that much more difficult to achieve. Whatever one may say about the EU, the collective cross-border action on environmental issues has been highly effective (a simple example: compare Britain's beaches now with how many of them were 30 years ago). The EU as a bloc does seem to bring about more effective environmental policy-making than most single states seem to be able to manage. As for the US, we are already seeing the roll-back of hard-won progress in renewable energy policy, for example. The US stance on climate change, from the top down, is undeniably important as an opinion leader, and the risks of undoing or stalling the Paris Agreement are real (*see the Editorial of Ag4Dev27 for more on the Paris climate talks – Eds*).

Up to now, I've always thought that climate change denialism would go the way of asbestos and tobacco denialism: the combination of ever-mounting robust scientific evidence and patient, well-informed advocacy would eventually outweigh the massive special interests lined up against acknowledging the obvious truth. Now I'm not so sure. The research-for-development programme that I work for is designed around a set of 'impact pathways' or hypotheses about how we see science informing policy-making, investment and decision-making in the pursuit of the UN's Sustainable Development Goals (SDGs) of poverty eradication, sustainable agricultural production, and food security for all. With post-modernist politics operating, and a public discourse arena in which the veracity of what people say hardly matters, there is no guarantee that improved science will have any effect on policy-making whatsoever. As we heard last year, some say that people in Britain *"have had enough of experts"*: and this in an increasingly complex and interconnected world. It's difficult to make well-being comparisons across the ages, but there seems little doubt that the sum total of human misery is less than it has ever been: literacy rates are at an all-time high, infant mortality rates and poverty rates are well down, the food-secure outnumber the food-insecure by a factor of many, and much of this is down to the achievements of science and technology. This is nothing to get smug about, though: 21,000 children die each day, many from perfectly preventable causes, and many more go to bed hungry each night.

But in attempting to contribute towards solutions, we all need seriously to examine our most basic assumptions. In a post-truth world, if the notion of the Rational Decision-Maker is a myth, then we need vastly improved understanding of what it is that moves large numbers of people to accept non- or pseudo-science as 'par for the course' in choosing the people who represent us and act on our behalf. We cannot underestimate the dominance of beliefs, ideas and interests in shaping our world, and so scientists need to give much greater attention to these as objects of research and as levers for action. The days of scientists pronouncing *ex cathedra* may be behind us: in the future we will need to attach even more importance to process, and engage in meaningful ways with different stakeholders in society where people may have radically different worldviews to our own.

Without much more understanding of worldviews and beliefs and how they can be appropriately addressed, as scientists working on climate change adaptation and mitigation, we have little chance of modifying the discourses that help form policy. These are researchable issues that different groups around the world are addressing. Some work is being undertaken by these groups in collaboration with the agricultural research for development community, but much more will need to be done. We have considerable work to do, if the adoption of climate-smart agriculture interventions at scale, and the transformations in food production and consumption behaviour needed, are to occur; without these, it is hard to see how the agricultural, environmental and food security SDGs will ever be attained.

Philip Thornton

Philip is the flagship leader for policies and institutions with the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS), based at the International Livestock Research Institute (ILRI), Nairobi, Kenya. This is a modified version of https://ccafs.cgiar.org/blog/climate-change-age-post-modernist-politics

TAA Forum

2016 AGM

Report of the 2016 TAA Annual General Meeting

Held at the University of Reading on Wednesday 9 November 2016 at 5pm.

Apologies

1. Apologies were received from John Ferguson, Amir Kassam, Ian Martin and Brian Sims.
2. **Approval of Minutes** of AGM held on Wednesday 17 November 2015 as presented in *Agriculture for Development* 27: Spring 2016.

   Proposer: Tony Young Seconder: Antony Ellman
3. **Matters Arising** - None
4. **Report from Trustees**

   The Trustees' 2015/2016 Report was presented by the Chairman, Keith Virgo (see below).
5. **Adoption of Audited Accounts** for the 2015/2016 Financial Year (see below)

   Proposer: John Wibberley Seconder: John Gowing

   Reappointment of Examiners for the Association

   Montpellier Professional of Dashwood Square, Newton Stewart, Wigtownshire were reappointed for the next financial year.

   Proposer: Keith Virgo Seconder: Ian Lane
6. **ExCo Elections** were held for:

   Alex Tasker as President's ExCo Member promoting early careers; and
   John Ferguson as Convenor of the Scotland Regional Branch.

   Renewal of Officers

   Keith Virgo: Chair
   Paul Harding: Vice Chair /Coordinating Editor *Ag4Dev*
   Elizabeth Warham: General Secretary
   Jim Ellis-Jones: Treasurer
   Linda Blunt: Membership Secretary
   Antony Ellman: Chair of TAAF
   Brian Sims: President's ExCo Member/Technical Editor *Ag4Dev*
   Amir Kassam: Convenor of Land Husbandry Group.

   Proposer: Mick Nightingale Seconder: John Gowing
7. **Friends and colleagues who have passed away were remembered**

   Brian Robinson, 1927-2015
   Benny Warren, 1932-2015
   David Friend, 1940-2015
   Dick Jenkins, 1935-2015
   Patrick Haynes, 1931-2015
   George Taylor-Hunt, 1933-2016
   David Romney, 1929-2015
   John Coulter, 1925-2016
   Paul Davies, 1949-2016
8. **AOB**

   Suggestions from TAA members included:
   More TAA badges for women members.
   Include a visit programme to the meteorology institute or water institute on the same day as the Ralph Melville Memorial Lecture at Reading University to make a whole day event.
   Access for the regions, through video links, to TAA events, especially the Ralph Melville and Hugh Bunting Memorial Lectures.
9. **The Hugh Bunting Memorial Lecture** was presented by Prof Tim Wheeler (see below).

Elizabeth Warham
General Secretary

Trustees' Annual Report for the year ended 30 June 2016

Objectives, Mission, Governance, Trustees and Membership

The Tropical Agricultural Association (TAA) is a unique professional association of individuals, businesses and corporate bodies involved in agricultural development.

Mission. The Association's mission is "*To advance education, research and practice in agriculture for rural livelihoods and sustainable development*".

Governance. The charity is administered in accordance with its constitution adopted on 1 December 1988.

Appointment of Trustees. Trustees are elected or appointed by the Annual General Meeting. Although there is no formal induction programme or training, most Trustees have served the charity for considerable time. It is the duty of the Trustees as a body to manage the affairs of the charity. The Trustees keep under review the major risks to which it may be exposed. The Trustees are supported by TAA's Executive Committee (ExCo), meeting quarterly at venues across the country (Newcastle, Peterborough and London).

Membership. The Association presently has over 600 members, including 24 institutional ones. During the year 67 new members were welcomed, including many students and four new institutions - the European Conservation Agriculture Federation, ECHO East Africa, Panjabrao Deshmukh

Agricultural University in India, and Vanilla Blue, UK-Nigeria.

Activities and Achievements

TAA's achievments during the year, 1 July 2015 – 30 June 2016, have included:

1. Networking and information exchange

UK Regional Branches. These continue to provide a varied and interesting programme for members, including: in the South West a number of meetings and seminars, a tour of farming in Wiltshire and a conference on *Soils* at the Royal Agriculture University (RAU) in Cirencester; in East Anglia events in association with Cambridge-based institutions, including the annual May seminar on *Agri-Tech*; in London and the South East bimonthly 'Curry Club Talks' and strengthened links with the All Party Parliamentary Group on Agriculture & Food for Development (APPG-A&FD); in Northern England a seminar on *Land Degradation* involving students from Newcastle University; and the newly-formed Scottish Branch an inaugural seminar with a focus on *Malawi*.

International Branches. Coordinators continue to act as points of contact in the Caribbean, India, South East Asia, the Pacific and most recently Zambia. Coordinators in Zambia and SE Asia arranged placements for students from RAU and Reading University, providing valuable practical field experience, as well as strengthening TAA's links with the Universities.

Specialist working groups. The Agribusiness group continues with its monthly meetings and the Land Husbandry group has been active at National and International Conservation Agriculture/Farming events.

2. Communication

TAA's Journal - ***Agriculture for Development***. This provides a key service for members raising the Association's credibility and impact. The Journal's already high standard has continued to improve with one open and two themed editions on *Urban Agriculture* and *Agroforestry* being published during the year.

TAA's Website (www.taa.org.uk). Improvements continue to be made with members able to add information to a *Directory of CVs* and *Career Summaries*. *Email Alerts* on latest news, publications, job vacancies and events, reach members almost daily. A *Vacancies Team* posts a stream of new job opportunities of special interest to students and young professionals. A *Student Job Seekers page* and a *Facebook Group* have been introduced and a *Twitter* account has been established to further promote and share the work of TAA.

3. Professional development

TAA's Award Fund (TAAF): This year TAAF made awards to 13 MSc students to enable them to conduct dissertation studies in developing countries. The TAAF committee provided a valuable mentoring service for awardees. Awards were funded by generous donations from individual TAA members in addition to TAA's annual contribution.

Honours. TAA awards were made to George Rothschild as Development Agriculturist of the Year, in recognition of his life-time's work in agricultural research for development; to George Taylor-Hunt and Bill Reed (posthumously), both TAA Awards of Merit in recognition of their work over many years for TAA as members of ExCo and as Convenors of the South West Branch.

4. Evidence and advice for policy

TAA continues to support the APPG-A&FD, originally established with support from TAA institutional members. The convenor for L&SE maintains links with the APPG on a series of panel sessions.

TAA is an 'organisational member' of the Royal Society of Biology and a TAA member serves on the advisory panel of the Society's UK Plant Sciences Federation.

Looking to next year

The Trustees, with the support of ExCo, aim to continue the range of activities, although some changes will occur in the venues and dates of key events.

- The successful South West Branch annual conference at the RAU will continue to be held in mid-October with the next event having the theme of *Pulses*, 2016 being the International Year of Pulses.
- The Hugh Bunting Memorial lecture, previously held in June each year at Reading University, will be held in early November with TAA's Annual General Meeting beforehand. This is intended to facilitate increased participation by postgraduate students.
- An Annual Reunion will be held in London in early January 2017 to include presentations from TAAF awardees and the award of TAA Honours.
- The Ralph Melville Memorial lecture will be linked with either Regional branches or institutional members, the next, in 2017, being in Cambridge.

In addition, the Trustees, in conjuction with ExCo and members, will be assessing past achievements and considering future strategy to ensure that TAA continues to fulfil its mission and objectives. Unfortunately an increase in membership subscriptions was required, becoming effective from July 2016.

Acknowledegments: The Trustees express their thanks for the support provided by ExCo, the TAAF commtee, Convenors of the UK Regional Branches and Specialist Groups and the organisers of our International Branches. We also thank the many TAA members who have contributed ideas, supported our *Ag4Dev* Journal and participated in the Association's activities.

Executive Committee members

President: Andrew Bennett

Chairman: Keith Virgo

Vice Chairman: Paul Harding

General Secretary: Elizabeth Warham

Treasurer: Jim Ellis-Jones

Membership Secretary: Linda Blunt

Coordinating Editor: Paul Harding

Technical Editors: Brian Sims and Elizabeth Warham

Keith Virgo
Chairman

Treasurer's 2016 Annual Report and TAA 2016 Accounts

TAA's 2016 annual accounts (1 July 2015 to 30 June 2016, see below), finalised by our external accountants, Montpelier Professional Limited, were presented and approved at the AGM on the 9 November 2016. These are submitted each year to the Charities' Commission together with the Trustees report and can be viewed on www.taa.org.uk under the page on Finance and Accounts. Key points include:

Income

Total income was £32,189, slightly more than that of 2015, and included:

Subscription income received of £19,580, a small increase on last year.

Donations received for the Award Fund amounting to £8,700. All are greatly appreciated, thank you to the donors.

A tax rebate of £2,812 received from the Inland Revenue for 'Gift Aided' subscriptions and donations. Although there has been an increase in members providing 'Gift Aid' forms, we continue to lose potential income from members who do not.

Other income included £1,007 from events, £33 interest and £57 miscellaneous items.

Expenditure

Total expenditure in 2016 was £32,649 of which 93% was charitable and 7% was for governance expenditure. In both cases this was slightly more than in 2015 and comprises:

Agriculture for Development Journal costs of £13,509, for three publications produced during the year, slightly higher than last year.

TAAF approved eleven awards amounting to £12,000, considerably more than the amount awarded in 2015.

No further funds were invested in support of CARE International's Lendwithcare programme. TAA's contribution (£4,100) has funded 284 micro-loans totalling £14,228. Agricultural loans have been made by micro-finance institutions across 11 countries: Benin, Cambodia, Ecuador, Malawi, Pakistan, Philippines, Rwanda, Togo, Vietnam, Zambia and Zimbabwe. Some 1,232 individuals and 4,575 family members have been supported, and 310 jobs created.

www.lendwithcare.org/groups/profile/tropical_agriculture_association).

Other charitable expenditure included £3,051 for events, £771 for ongoing maintenance of the website, £500 for the All Party Parliamentary Group on Agriculture and Food for Development, and £520 for membership of the Biology Society.

Governance costs amounted to £2,298, slightly more than that in 2014.

Funds available

A small deficit of income over expenditure of £460 was incurred. This compares with a surplus of £757 in 2015. The total funds available at the end of June were £58,768 of which £24,901 is restricted for TAAF and £70 for the UK Forum.

Looking forwards

A deficit of around £10,000 is expected in 2016, although this does not take into account any possible donations. A major reason for the budgeted deficit is due to TAAF awards being made from earlier year TAAF donations. The main uncertainties are membership subscriptions and TAAF donations.

TAA Accounts July 2015 to June 2016

	2016 (2015/16)	2015 (2014/15)	Change
Receipts			
Subscriptions	£19,580	£18,267	£1,313
Award Fund donations	£8,700	£8,148	£552
Other donations	£0	£100	-£100
Functions	£1,007	£976	£31
Inland Revenue	£2,812	£2,841	-£29
Bank Interest	£33	£34	-£1
Miscellaneous	£57	£297	-£240
Total receipts	**£32,189**	**£30,663**	**£1,526**
Expenditure			
Charitable			
Journal	£13,509	£12,774	£735
Shows and functions	£3,051	£1,767	£1,284
Regional Subventions	£0	£298	-£298
Biology Society	£520	£250	£270
LendwithCARE	£0	£2,100	-£2,100
Award fund and expenses	£12,000	£9,215	£2,785
UK Forum for All Parliamentary Group	£500	£500	£0
Internet/web costs	£771	£1,035	-£264
sub total	***£30,351***	***£27,939***	**£2,412**
Governance			
Insurance	£455	£441	£14
Accounting services	£360	£408	-£48
Executive Committee	£1,125	£689	£436
Admin	£358	£429	-£71
sub total	***£2,298***	***£1,967***	**£331**
Total expenditure	*£32,649*	*£29,906*	
Excess of receipts over payments	*-£460*	*£757*	
Bank balance			
Opening balance	£58,790	£58,771	
Movement in the year	-£460	£757	
	£58,330	£59,528	-£1,198
Closing balance	59068	59528	
Liabilities	-300	-300	
Total funds	**58768**	**59228**	**-460**

Jim Ellis-Jones
Treasurer

11th Hugh Bunting Memorial Lecture, held at Reading University on 9 November 2016

Climate change and agriculture: risks and opportunities to food and farming systems in the tropics

Tim Wheeler

Professor Tim Wheeler is the Director of Science and Innovation at the Natural Environment Research Council.

(Summary of presentation prepared by Andrew Bennett)

Introduction

Professor Wheeler started by outlining the contributions made by Hugh Bunting to understanding the impact of climate on agriculture, and the international reputation that Reading University has for its work on climate change and agriculture.

He indicated that in his lecture he would cover the challenges, the evidence, the impacts and possible opportunities, and ways forward to cope with climate change and achieve food security in developing countries.

The Challenge

The global population is set to rise from 7.5bn to 8.3bn by 2030. While current global food production is estimated as 3.6bn tonnes (equivalent to 2,700 calories per person per day), some 850m people are undernourished, 1bn experience micro-nutrient deficiencies and 1.4bn are over-weight. But with rising population, greater spending power, diversifying diets and urban growth, it is estimated that food production will need to grow by 50 percent. However, it is also predicted that the world will be between 0.3-0.7°C warmer by 2030.

The UK produces about 50 percent of its food, with the remainder imported from over 170 countries. The average distance travelled by imported foods continues to increase in many countries, including those in Africa and south Asia.

The Evidence

The production of cereals in sub-Saharan Africa is closely correlated with rainfall, and natural variation in weather, such as El Niño/La Niña, has a major impact on rainfall across the tropics. There is still insufficient evidence to conclude that climate change has influenced the frequency or intensity of the El Niño events or average rainfall.

However there is consistent and compelling evidence of a rise of about 1°C in global temperatures, starting in the early 1900s and increasing most rapidly since the 1960s.

The *Intergovernmental Panel on Climate Change (IPCC) Assessment Report* in 2014 concluded that *"Human influence on the climate system is clear"* and *"warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia"*. It went on to conclude that *"climate change will impact on all four dimensions of food security"*.

FAO has stated that *"food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life"*.

There are four dimensions to food security:

- **Food availability:** the availability of sufficient quantities of food of appropriate quality. Supplied through domestic production or imports.
- **Food access:** access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet.
- **Food utilisation:** utilisation of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met.
- **Stability of the food system:** To be food secure, a population, household or individual must have access to adequate food at all times.

While there has been a significant increase in the numbers of publications on climate change and food security since 2005, the current evidence base for climate change impacts on global food security is heavily skewed towards food availability, with serious gaps on the broader aspects of food security.

There are an increasing number of ingenious experiments to assess the impact of higher carbon dioxide concentration. These indicate that higher CO_2 levels and warmer temperatures:

- Enhanced growth for C3 crops;
- Lengthened the potential growing season;
- Increased crop water use efficiency.

However higher temperatures also would:

- Shorten growing season for current varieties;
- Present new threats from pests and diseases;
- Result in frequent exposure to extreme weather conditions.

Research has shown that crop productivity is highly vulnerable to variations in climate. In rice, a single hot day above 32°C at flowering can reduce the numbers of grains set per head, with a total loss of yield if temperatures exceed 40°C.

Elevated CO_2 levels can also affect seed and grain quality, leading to significant reductions in zinc, iron and protein, but possible higher phytate contents in C3 crops such as wheat, rice, field peas and soya beans. The picture is less clear with C4 crops such as maize and sorghum, but phytates can impact adversely on the nutritional value of foods by rendering important minerals less available.

Given current agricultural practices, the *World Bank Development Review 2010* predicted that, while productivity could rise in the temperate and cool regions, there could be 20-50 percent reduction in yields across the tropics and developing countries of the world. This will exacerbate food insecurity in the areas currently vulnerable to hunger and under-nutrition. These projections are summarised in Figure 1.

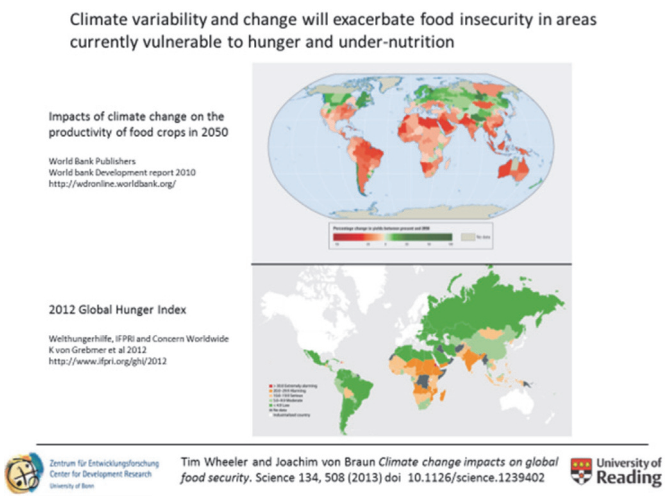

Figure 1. Impacts of climate change on the productivity of food crops in 2015; and the 2012 Global Hunger Index.

The Global Hunger Index is designed to comprehensively measure and track hunger globally, by country and by region. Calculated each year by the International Food Policy Research Institute (IFPRI), it provides insights into the drivers of hunger. Figure 1 contains a summary of the 2012 Global Hunger Index.

A meta-analysis of 52 publications on climate change impacts across Africa and Asia has summarised the likely percentage reductions in yields as:

- Across Africa: wheat -17 percent; maize -5 percent; sorghum -15 percent and millet -10 percent;
- Across south Asia: maize -16 percent and sorghum -11 percent;
- There are no detectable changes in rice production.

A World Food Programme Report estimates that climate change will:

- increase the numbers of people at risk of hunger by 5-20 percent by the year 2050;
- about 65 percent of this global total is projected to occur in Africa;
- in sub-Saharan Africa, 10 million more children could be malnourished.

Predictive models are increasing in their sophistication and accuracy.

Emissions come not only from crop production but elsewhere within the farming and food processing sector. The IPCC attributes agriculture, forestry and land use with 24 percent of global greenhouse gas emissions – some 12 gigatonnes of CO_2 equivalent in 2010. Of this total, 38 percent is from N_20 derived from soil management; 32 percent is from methane produced from enteric fermentation; 12 percent is from biomass burning; 11 percent is from rice production; and 7 percent is from manure management.

Opportunities and Responses

FAO advocates the need for climate-smart agricultural systems, which are designed to improve food security and rural livelihoods, and support climate change adaptation and mitigation efforts. The UK's Royal Society calls for *"sustainable intensification – where yields are increased without adverse environmental impact and without the cultivation of more land"*.

There is clearly a need to develop more climate-resilient crop varieties. Paddy loss due to inundation in Bangladesh and India amounts to an estimated loss of about 4m tons of rice per year, enough to feed 30m people. The International Rice Research Institute (IRRI) has developed and released six flood-tolerant 'scuba' rice varieties, which are able to withstand 17 days of complete submergence. They are now being grown by over 5m farmers.

Biplob Sarker, a rice farmer from Bangladesh, said: "I gave up hope of getting any yield from my land as paddy seedlings remained submerged for 17 days. But to my surprise, the seedlings grew green again after the flood. I still can't believe I have got 18 maunds (672kg) of paddy from there".

The International Maize and Wheat Improvement Centre (CIMMYT), working with the Africa Agricultural Technology Foundation and other partners, has developed new African drought-tolerant maize varieties, which are becoming available to farmers. The long-term goal is to make drought-tolerant maize available royalty-free to small-scale farmers through African seed companies. These new varieties could increase production by 2m tons, which would be enough to feed 14-21m people.

Livestock insurance could also help the downward slide of vulnerable populations, allowing humanitarian resources to be focussed on the needy. The International Livestock Research Institute (ILRI) is working with partners to develop remote sensing technologies that can be used to assess the state of grazing resources, with payments to farmers when and where forage scarcity is predicted to cause livestock deaths.

Improving access to data through initiatives such as the *Global Open Data for Agriculture and Nutrition (GODAN)*, and other multilateral programmes, aim to help poor countries cope with the impacts of climate change.

The Climate and Knowledge Development Network aims to help decision-makers in developing countries to design and deliver climate-compatible development. It has created several fora in which interdisciplinary and transnational groups develop ideas on issues such as 'humans v mosquitoes'; 'disaster preparedness'; 'coastal resilience'; and supply chains.

Conclusions

Professor Wheeler ended his lecture with the following conclusions:

- Changes in CO_2, and in the means and variability of climate, present new risks to food and farming systems across the tropics;
- Under climate change, farms will be prone to environmental stresses not observed in today's climate, with increases in volatility of production due to extreme weather;
- The evidence base on climate change, food security and agricultural trade is still patchy, with a strong focus on food crop production;
- Broad-scale impacts on production are well-understood, with many threats expected to impact developing country agriculture;
- Adaptation and investment will be needed in order to maintain global food supplies to meet future demands for food; and
- Better technology and knowledge to address climate change risks to crops will be vital for food and farming systems in the tropics.

Question and Answers

In the lively questions, comments and answers session, the following points were made:

- There were several traditional strategies aimed at coping with drought, such as the growing of gourds for storing water for livestock.
- In many parts of the world where yield levels remained well below potential, much more could be done to improve yields and cope with uncertain weather, through better and more timely agronomy.
- There was not much information on the impacts of climate change on tree and horticultural crops – though it was known that unfavourable weather at flowering could have a major impact on yields of such crops as oil palm.
- The adoption of 'conservation agriculture practices' which use less energy, do not disturb soil unnecessarily, increase soil organic matter and water retention – and possibly reduce N_20 emissions – should be more widely used and supported.

References

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News from the Regions

TAA SW Conference on Pulses, held at the Royal Agricultural University, Cirencester, on 13 October 2016

Some cropping issues and options in this International Year of Pulses

John Wibberley

Professor John Wibberley is visiting Professor (Comparative Agriculture and Rural Extension) at the School of Agriculture, Policy and Development, University of Reading and at the Royal Agricultural University, Cirencester, where he was until 1989 Head of Agriculture. Since 1989, he manages his own consultancy REALM. He has worked in the Tropics for over 40 years.

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Abstract

Tropical cropping systems have been dominated traditionally by mixed cropping in various ways, except where export crop monocultures were substituted. Farmers' reasons for adopting mixed cropping are considered along with the scope and benefits of integration of permanent and short-term crops. Despite compelling rotational and dietary reasons for inclusion of pulses, factors militating against the actual adoption of ample pulse crops are reviewed. The often poor yield reliability of pulse crops is examined briefly in relation to off-setting system advantages of their cultivation. Factors influencing farmers towards adoption of pulse crops, including the role of extension strategies, are briefly considered in both tropical and temperate contexts. Extension strategies involving farmers at their core are

advocated by Wibberley (1988), Kristjanson *et al* (2005), Kyamuwendo & Wibberley (2011) and by Bunch (2012). The integrated realism of farmers is crucial to the evaluation and adoption of adequately resilient cropping systems.

Introduction

Effective legume nodulation (indicated by pinkish coloured leghaemoglobin in nodules in cross-section) and its impact on soil organic nitrogen within crop rotations is increasingly significant. That a good stand of alfalfa (lucerne, *Medicago sativa* L) could fix up to 300 kg/ha/year of N impressed this author in the 1960s! Later experience in West Africa with interplanted cowpeas (*Vigna unguiculata*), coupled with their regular inclusion in his own breakfast diet as *kosai* (cowpea flour paste 'buns' deep-fried in groundnut oil) in Plateau State, Nigeria, transferred some interest to pulse crops. Later work with farmers' groups in both England and in Africa and elsewhere included some farm-based work with pulses, including field beans (*Vicia faba*). It seems appropriate to consider some of this farm-based work here in the context of farming systems development, and with recognition of the continuing importance of mixed cropping.

As far as pulses (legume crops with large dry edible seeds) are concerned, the FAO set 2016 as *The International Year of Pulses* with the stated aim: *"to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production aimed towards food security and nutrition"*. Three thousand years ago, the Bible records (2 Samuel 17:28) that King David was given *"beans and lentils and parched pulse"* to eat in Gilead (modern-day Jordan). Some 2,600 years ago, the Bible also records a remarkable ten-day comparison between a luxurious meat-containing diet and *"pulse"* (Daniel 1:11-20) – proving a pulse-based diet superior to a luxurious meat-containing one in the case of the Prophet Daniel and his three friends. Today, the UK Government's NHS (National Health Service), along with many other agencies and nutritionists, promote regular inclusion of pulses in normal diets. As well as their noted protein and fibre values, they have low glycemic impact – converting slowly into blood glucose – they contain antioxidant polyphenols thought to protect body cells from free-radical attack, and lower the risk of disease, and they have phytoestrogens, thought to lower risk of certain types of cancer and osteoporosis.

'Pulse' (Latin *puls*) means potage or thick soup made from the relatively large edible seeds of some plants in the Legume family (among its 600 genera and over 13,000 species). The term 'pulse' often refers only to the dried seeds of certain large-seeded legumes, notably peas, edible beans (such as 'kidney' beans, *Phaseolus* spp), lentils and chickpeas. Pulses are very high in protein (typically 20-24 percent), fibre, minerals (notably iron, phosphorus and zinc), vitamins of the B-group especially, but they are low in fats (typically 1-2 percent). Thus soyabean (*Glycine max*) is not classified as a pulse (with around 18 percent fat and some 35 percent protein). Pulses are consumed as whole seeds, split seeds, flours processed in various ways (sometimes with added cereals such as rice), or fractionated to add to processed foods. Both leaves and shoots of pulse crops are vital dietary ingredients in many parts of Africa and other tropical areas; this is especially strategically so with cowpeas in dry areas.

Cropping Choices

The integrated realism of farmers is crucial to the evaluation and adoption of adequately resilient cropping systems, particularly those incorporating pulse crops since these cannot be continuously grown owing to the many specific and cumulative pests, diseases and parasitic weeds to which they are susceptible. They suit an integrated farming systems approach. Integrated farming systems offer scope for reducing environmental impacts while enriching soil fertility and profitability. The preponderance of various forms of mixed cropping (some 80 percent+ of all crops) was confirmed by the author's survey work among typical farmers in the Middle Belt of Nigeria in the mid-1970s. Farmers' reasons for doing so investigated there and subsequently elsewhere too, are summarised below (Table 1). However, mixed cropping does complicate the interpretation of individual crop performance data, may limit the choice of treatments, and the mechanisation of such crops. These drawbacks can be mitigated by the frequently adopted practice of alternating double rows of the constituent crop species, by alley cropping and by various agroforestry systems.

Table 1. Farmers' reasons for practising mixed cropping.

Technical Reasons
• Better use of space and environment to increase biomass supported per hectare;
• Reduce risk of specific pests and diseases spreading so easily;
• Maintaining leaf cover and root systems protects soil from erosion;
• Crop cover suppresses weed establishment;
• Legumes within mixtures fix nitrogen, other crops complement by useful shading;
• Over time, soil organic matter accumulates beneficially to maintain soil fertility.
Economic Reasons
• Greater aggregated yields are obtained – but there is a constant quest for best mixes;
• More dependable overall returns are achieved year by year;
• Better labour returns per hour are gained, though more hours per hectare needed;
• Extends supply period for more perishable foods and prolongs diverse diet choices;
• Provides for inclusion of minor dietary elements such as herbs to flavour cooking;
• A return is obtained while longer-term crops are being established.

Sorghum-cowpea association is probably the commonest crop association in West Africa, typically with two rows of each species alternating with each other (Chantereau & Nicou, 1994; Mortimore *et al*, 1997). Staggered sowing of the cowpeas some two weeks after the sorghum proves optimal with up to 25,000 cowpea plants per hectare for prostrate varieties, but up to 50,000 per hectare with the improved more erect cultivars. In areas with above four months of rainy season, cowpeas can be sown a month ahead of sorghum harvest without detriment to the cereal's yield. A sweet potato/maize/groundnut/sorghum rotation practised at Gindiri, Nigeria had cowpeas interplanted in maize, since that was deemed more likely to benefit directly than the more frugal sorghum crops also included.

Cowpeas

Cowpea is important in Central America and the Far East, but is considered the most economically important indigenous African legume crop. Bunch (2016) notes that *"in Mozambique, much of the population lives on little more than cassava, a crop very resistant to poor soils but also nutritionally deficient. As a result, childhood stunting in many areas of Mozambique is nearing 50%"*. In 2015, in Inhambane Province, it rained only three times during the cropping season, and one of these was right at planting time. Virtually no crops produced much of anything, but two crops grew quite well: 60-day cowpeas, a very drought-resistant crop, and ratooned pigeon pea. For this particularly droughty area, Bunch is testing a highly innovative system: intercropping maize, cowpeas and pigeon peas (*Cajanas cajan*) all in the same field, at the same time. The cowpea will be harvested before either of the other two crops will need the space it has occupied. The pigeon pea and maize will then continue to grow together, improving the soil year after year. Bunch (2016) states: *"Most years all three crops will be providing an edible grain, with two of them being very high in protein. In years of extreme drought, both the cowpeas and pigeon peas will produce quite well, and if the maize suffers so much it will obviously produce nothing, a second crop of 60-day cowpeas could provide an additional source of human food"*. In time, as the soil organic content increases, even the maize should be able to resist most droughts.

If the farmers also add *'mother of cacao'* trees (*Gliricidia sepium*) to the system, the maize will probably produce fairly well every year. Such a system, even on just one hectare, will soon be producing a surplus of food, and the pigeon pea will serve as a very profitable cash crop (and perennial for up to 5 years), since Indian traders pay extremely good prices for it to satisfy the growing demand of a burgeoning middle class in India.

Bunch (2016) also reports that *"In Zambia, Sebastian Scott, a young agronomist who has set up his own experimental farm, discovered that pigeon peas (Cajanus cajan) can be ratooned (ie cut off at ground level or just above it after harvest)"*. This discovery is extremely important in drought-prone areas, because the following year the plant has the above-ground stature of a small bush that can grow up intercropped with maize and other crops, but it has the root structure of a two- to four-year-old plant, which gives it *much* more drought-resistance. Bunch (2016) concludes that *"as a result of this system and very minimal applications of animal manure, Sebastian's maize production has shot up from 1 t/ha to over 4 t/ha in seven years, with no expense of chemical fertiliser"*.

Research highlights of the bean/cowpea collaborative research support programme (1981-2002) in Nigeria are presented by Langyintuo *et al* (2003). Huge losses in storage due to insect pests – such as *Bruchid* beetles – can be prevented by hermetically sealing properly dried cowpea beans in triple-layered polythene bags. This is now practised through women's groups in Northern Nigeria and Niger, developed and disseminated by Purdue University, USA. The Purdue team recognise cowpea as the most economically and nutritionally important indigenous African grain legume, grown by millions of resource-poor farmers. It is a key cash crop in areas too dry to grow cotton or other export crops (Rowland, 1993). Most of the more than 3 million tonnes of cowpea grain produced annually in West and Central Africa is grown on small farms (Kergna *et al*, 2003). Globally, it is cultivated annually on about 14 million hectares, with more than 4.5 million tonnes produced – making the yield average only one third of a tonne per hectare!

Cowpea is the principal source of protein for rural and urban populations, young leaves are used as a vegetable in West and Southern Africa. The green pods and fresh grain are also consumed everywhere in Africa, and also in Asia and Latin America. Storage is often identified as the key challenge for small-scale cowpea growers, so many farmers sell cowpea grain at low harvest-time prices, rather than risk losses by *Bruchid* beetles during storage. Better on-farm storage and processing is urgent. International support for cowpea improvement includes the Brazilian Agricultural Research Institute (EMBRAPA)'s support for appropriate rhizobia inoculation of cowpeas for smallholder farmers in Ghana. Work coordinated at the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria by Umar (2012) is developing Bt cultivars of cowpea (genetically modified using *Bacillus thuringiensis* carrier) against the pernicious pest *Maruca* pod-borer.

According to Boukar *et al* (2013), average grain yield of cowpea in West Africa is approximately 492 kg/ha, which is much lower than its potential yield. They attribute this low productivity to a host of diseases, insect pests, parasitic weeds, drought, poor soils and low plant population density in farmers' fields. An *ex situ* collection of over 15,000 accessions of cowpea and wild *Vigna* germplasm from different parts of the world have been assembled in the IITA gene bank in Nigeria. However, proper and cultivar-specific agronomy is also vital. For instance, Jakusko *et al* (2013) in experiments in Yola, Nigeria found that for the erect varieties tested, seed yield per plot increased with decreased row spacing. They therefore suggest a spacing of 45cm x 25cm, which produced 1,228-1,241 kg/ha.

Conclusions

Pulse crops present a challenge for farmers in choosing suitable species, rotations and crop mixtures, and in providing the good soil structural conditions and availability of pollinators for them to succeed. These combined requirements set suitably high standards for proper husbandry of land and crops when pulses are included. Scope for improved diets and livelihoods, especially in marginal areas, is offered by judicious production of pulses, of which cowpea is a notable case. Mixed cropping systems offer the best insurance approach in such areas, as well as providing real scope for improved productivity through appropriate on-farm comparisons to optimise systems.

Although there is clearly ongoing need and scope for new cultivars to emerge, their adoption can prove expensive, even unaffordable and inaccessible, to small-scale farmers who constitute the vast majority (some 84 percent) of African farmers. Farmer groups refining and sharing best practices offer immediate hope, while preoccupation with introducing new cultivars can distract and even discourage agronomic work using proven ones. Farmers approach the matter of crop mixtures as a means of balancing the practical considerations for reliability and resilience rather than the 'over the horizon' potential striven for by researchers with new varieties. Both need each other, but field-proven results and realities must always lead the way forward. Better on-farm storage and processing into locally packaged compound foodstuffs adds value relatively easily.

The International Year of Pulses 2016 has focused welcome attention on these relatively neglected cropping and human dietary components. Both soil fertility and human health stand to benefit from the ongoing efforts stimulated.

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The International Year of Pulses: future global challenges and crop opportunities (Summary)

Karen Rial-Lovera

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The United Nations declared 2016 *The International Year of Pulses (IYP)* in order to raise awareness about the importance of pulses crops for sustainable agriculture and food security. The benefits of pulses extend from fixing atmospheric nitrogen (N) into the soil, improving soil fertility, promotion of subsequent crop yields, improvement of diets in developing and developed countries, and climate change adaptation and mitigation. With a global production reaching 77 million tonnes in 2014, and an increase of 1 percent per annum (FAOSTAT, 2016), global pulse production is, however, facing the challenge of more sustainable intensification in order to feed a growing and demanding population by 2050.

The increasing income per capita in several developing countries such as India – the world's largest producer of pulses – is creating shifts in diets toward animal-based proteins, reducing the country's consumption and production of pulses. A similar case is observed in China, where pulses production has been declining in the last 50 years (FAOSTAT, 2016). Nevertheless, given that pulses are a much cheaper staple source of protein, especially for low-income consumers around the world, their inclusion in diets can contribute to dietary diversification by improving the nutritional balance of food intake (Heine, 2016).

Pulses (peas in particular) can also serve as a low-cost foodstuff alternative to the animal feed industry. However, current pulse usage is largely determined by regional production patterns, availability, and price competitiveness, especially with soybean. Nevertheless, this trend is changing. The geographic distance between the production regions and the main domestic end-users tends to have a greater influence on cost, and hence use, than simple preference based on nutritional value (Heine, 2016).

Indeed, the importance of pulses for the feed industry and human consumption is growing. Yet the expansion of the pulses growing area has not matched that of the main oil crop – soybean. High Government subsidies to soybean and cereals make these crops more attractive for farmers to grow, although pulses are now becoming cash crops in many developing countries. India, for instance, should be praised for being the first country to provide subsidies to pulses growers.

Pulses, in spite of having an unexploited genetic pool of diversity for adaptation and yield growth, have not been the subject of extensive research and development (R&D) programmes for seed enhancement, herbicide tolerance and pest resistance in comparison to soybean. Consequently, pulses have registered only limited productivity gains. Extensive efforts are required therefore, to reduce the yield gap and food insecurity, promoting initiatives to disseminate high yielding varieties to farmers, especially to the majority who are small-scale producers. Introducing positive shifts in the supply of pulses also requires addressing the many barriers to innovation – especially the under-investment in agricultural R&D by both the public and private sectors.

Climate change is a serious threat not only to pulses, but to food security in many parts of the world. In regions expected to be severely impacted by changes in climate, such as Africa and Central America, pulses are important components of traditional diets. Adopting heat-tolerant varieties can then significantly reduce potential future loss in productive area (Beebe *et al*, 2010). By including pulses in crop rotations, smallholders could improve yields and increase their incomes, while containing the threat to food security posed by climate change (Heine, 2016). Promoting better know-how at the farm level, and investing in productivity and consumer advocacy, will generate valuable additions to farmers' livelihoods and improve the marketability of pulses at the local, regional and international levels.

In conclusion, pulses can play a vital role in supporting the productivity and incomes of smallholders, the sustainability of agricultural practices, as well as addressing hunger and malnutrition, all of which are objectives of the *2030 UN Agenda for Sustainable Development* (UN, 2015). However, significant efforts are still required to promote consumption and also to increase pulses productivity at global scale.

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Obituaries

Professor Paul Davies BSc, MSc, PhD, CBiol, FRSB (1949-2016)

Paul died on 27 October 2016 while undergoing treatment for cancer. He had just retired as Deputy Vice-Chancellor of the Royal Agricultural University, Cirencester. He was an active member of the SW Branch of the TAA and hosted several TAA meetings at the RAU, including an annual World Food Day Symposium organised by John Wibberley.

He will be remembered by colleagues for his sincerity, warmth, eloquence and huge knowledge of agriculture at home and abroad. He inspired and guided the careers of several generations of under- and post-graduate students. His Memorial Service in November 2016 was attended by colleagues, current and former students, farmers and the local community.

Paul was born into a farming family in 1949, in Llangollen, North Wales. He graduated in agricultural botany in 1971 from the University College of North Wales. He married, Janice, and moved to Exeter to study for an MSc in plant pathology, and then to the University of East Anglia for a PhD on *The infection of carrot in cool storage by* Mycocentrospora acerina.

He was Lecturer in Crop Science at Writtle College between 1976 to 1978, and in Crop Protection at Harper Adams from 1979 and 1986, before moving to the Royal Agricultural College at Cirencester as Director of Studies. He played a central role in the development of RAC and its translation into the Royal Agricultural University in 2015. During his time at RAC/RAU he was Director of the International Centre, Dean of Studies, Vice Principal and Deputy Vice-Chancellor. He also was a co-founder of the African Fellowship Trust, which has supported nearly 100 African scholars to undergo specific courses of study at RAC.

Paul published extensively in a wide range of areas from pathology, food safety, food security, wheat production and legumes. He was involved in many educational development programmes in the USA, Malaysia, China, Vietnam, the Philippines, Brazil, Argentina and Honduras.

We all had hoped that in his well-deserved retirement he would have more time to enjoy his family and his garden and to continue to share his huge knowledge and enthusiasm.

He made a difference to the lives of many and we will all miss him.

A personal appreciation by John Wibberley follows this obituary.

Our condolences and sympathy go to Janice, Suzy, Nick and their families.

Andrew Bennett

Professor W Paul Davies – an appreciation

Professor Paul Davies, the kindest of men, wherever one met him both recent and then
When at first Nineteen-Eighty in Crops-Teaching clan we gathered in Cirencester with a plan
To tour round the Cotswolds inspecting good farms, savouring progress and scenery charms,
Engaging in banter and talking of plants, research underpinning our teaching's advance.
For several years onwards this informal group met round the UK in July as a troop
Thus keeping us knowing of crop innovations and sharing the progress at each other's stations.

It was not for six years 'til Paul left Harper Adams to join RAC for next thirty years' spasms
Director of Studies, then Vice-Principal post, and seeing the place University boast.
Ever courteous, diligent, welcoming, friendly, Paul never forgot crops research student-friendly.
Pursuing his science at Bangor first honed, via Exeter where Plant Pathology toned,
Then East Anglian carrots for his PhD, a suitable contrast of background to be
Equipped as a boy from his family farm, surrounded by hills of superb North Wales charm
To serve at The Royal of Cirencester through thirty years' seasons with all that occurred.
A hard-working hand on the tiller to steady, to promote RAU Paul was sure, ever ready.
His travels to China, Malaysia too, sufficed to build networks and research to do,
While African Fellows were glad of his care, and Principal's four he saw into their Chair!

We grieve early loss of this man dedicated; in Chapel St George now commemorated,
His legacy kind but his hard work now done, into God's care we trust him and for His well-done!

E John Wibberley

Tim Machen (1939-2016)

Tim was a real countryman and a longstanding member of the Tropical Agriculture Association (TAA) in the South-West. His passion and overseas work centred on livestock in development and range ecology, following his earlier work as a Dairying Adviser in Cornwall. Tim gained his MSc in Tropical Agricultural Development at the University of Reading. At home beside the mighty River Zambezi, Tim was as unflappable in a dug-out canoe with crocodiles as he was growing orchids and the many other plants he loved! As a Sustainable Development Consultant, he served in many contrasting countries, including Zambia, Tanzania, Sri Lanka, Bangladesh and Oman, with more recent short stints in Ethiopia, Jordan, Moldova, Yemen, Saudi Arabia, Iraq, Malaysia, Turkmenistan, Kyrgyzstan, Russia and Malawi. Tim's concern for the land and its proper husbandry led him to be a Trustee for many years of *Land Heritage*, which sought to provide tenancies for starter-farmers wishing to farm organically. Its farms lay principally in the West Country and it was eventually absorbed into the *Soil Association*.

Along with his wife Frances, Tim was a regular attender of TAA meetings. He maintained his interest in sustainable land-use strategies, including the future of family farming. Following the dramatic flooding in the Somerset Levels in 2014, Tim keenly advocated for long-term research and increased tree-planting within the upper catchment farmlands, alongside proper maintenance of the major carrier waterways. At his own home at Helland Farm, he grew cricket bat willow trees (*Salix alba caerulea* or white willow). Now neglected in Somerset, these vigorous native trees were planted by Tim from the 1990s in high water-table land alongside rhynes (drainage ditches). They have a straight trunk, branch-free to almost 4 metres, maturing at about 15-20 years, and are valued at around £200 each. It was typical of Tim that he should pioneer and promote something he felt others could emulate with public benefit in the district. Tim also led informative rambles around his village of North Curry for the Taunton Deane Ramblers group, which were much appreciated.

Tim Machen was a true Christian gentleman with a deep-thinking, inquiring mind. He strove for a fairer, kinder world. Always courteous and kind himself, he was good company and we shall much miss him.

John Wibberley

Sanjeev Vasudev (1957-2017)

Sanjeev was for the 'face of TAA in India' for many years. He was Coordinator for our India Branch and acted as a hospitable host to members visiting Delhi, and collaborated in conferences and other events attended by members. Sadly, on 11 February, he died suddenly while on a field trip to Himachal Pradesh, where he was hoping to initiate an eco-tourism venture.

Sanjeev was an agriculturalist at heart. He had an extremely varied career as a consultant in rural and social development projects across India, Bangladesh, Bhutan and Nepal, working with a wide range of international development agencies. In 2003, he established *STADD*, as a development consulting firm based in New Delhi, focused on working in South Asia on issues concerning poverty, natural resource management, agriculture, forestry, markets, institutional development and rural development. Sanjeev's interests covered many themes, including poverty, climate change, agriculture, forestry, handicrafts, livelihoods, micro-credit, self-help groups and institutional development. He also had specific experience in the potential of bamboo.

He set up and led a parallel NGO *SocietySTADD* to work on issues concerning rural livelihoods, natural resource management, and rural technologies through self-funded projects and those supported by the World Bank and UNDP-GEF Small Grants Programme. The *Society* focused on the subject of conservation agriculture (CA), which brought him into frequent contact with TAA members (such as Amir Kassam and others). Sanjeev became Founder Adviser of the *Professional Alliance for Conservation Agriculture (PACA)*. In 2014, he established *STADD:ICE* (Innovation and Capacity Enhancement) as an initiative to strengthen capacities of professionals involved with international cooperation.

Among his varied interests, in 2008 Sanjeev became a Trustee of the *Swami Sivananda Memorial Institute (SSMI)*. This long-established trust aims to empower women and children to realise their potential with dignity, through knowledge, skills, income and social confidence. *SSMI* is also addressing the needs of child nutrition, education, and health. In 2012, Sanjeev was appointed Professor of Agricultural Ecology and Agribusiness at the Birla Institute of Management Technology (BIMTECH), Noida, teaching post-graduate students in Sustainable Development as part of their Diploma in Business Development programme.

I first met Sanjeev in 2002 during an IFAD mission in Uttarakhand: he was on the team looking at the potential for bamboo. We met frequently thereafter in Delhi, and discussed the possibility of creating a TAA India Branch, which we launched in early 2004, with Sanjeev as 'Coordinator'. It was always a pleasure when visiting Delhi to be invited to the *Long Bar* at the Gymkhana Club to enjoy a few pegs, supper and Sanjeev's cheerful and thought-provoking company! On occasions I was privileged to meet his family as well, who were also great hosts. Indeed, he leaves a close-knit family: his wife Kiran, who has a senior position in the Tax Department, and his two daughters, Alysha and Anthara. I was always impressed how Sanjeev supported his two girls and encouraged them to make their own decisions about their future. With this enlightened upbringing, I am sure that they will go far.

Keith Virgo

TAAF News

Five more TAAF awardees who completed their MSc dissertations in 2015/16 have submitted their reports. Summaries of these reports are included in this issue of the journal, and the remainder will appear in a later issue.

Calls for applications for MSc awards in the 2016/17 academic year have been circulated to twenty UK universities. We have sufficient funds for up to 15 awards this year. A good batch of applications was expected by the deadline of 31 March 2017.

Two TAAF awardees from 2014/15, James Alden and Paul Baranowski (who completed their Masters degrees in Environmental Technology at Imperial College - see reports in *Ag4Dev26*), were selected as *Young Development Agriculturalists of the Year 2016*. They were awarded this honour at the TAA Annual Reunion on 11 January 2017. Eight past and present TAAF awardees attended the Reunion, which provided an excellent opportunity for networking and exchanging experiences between young and old members of the TAA.

Donations for TAAF totalling almost £6,000 have been received from TAA members and institutions in the financial year 2016/17 to date (with Gift Aid this will rise to over £7,000). Together with the TAA annual subvention of £3,000, TAAF has sufficient funds for two years' operation.

However the long-term future of the Award Fund is as ever uncertain. Further donations by TAA members or institutions, or legacies following the guidelines included in *Ag4Dev23* (see article *Remember TAAF in your will*, pages 59-60), will be greatly appreciated and will be put to very good use.

Antony Ellman and Alastair Stewart

Bethany White, MSc Anthropology, Environment and Development, University College, London.

Facing uncertainty in agriculture: the use of local ecological knowledge and adoption of new agricultural technology in adapting to climate change for smallholder farmers, Northern Ghana.

This research explores the environmental problems experienced by farmers in the Northern Ghanaian *Kpachelo* community, and examines how community members respond to the challenges they face (Figure 1). An assessment is made of local perceptions of climate change, and of the extent to which local ecological knowledge (LEK) and the programmes of a non-governmental organisation called *Research and Information Network Services (RAINS)* inform farmers' adaptation practices.

Results indicate that farmers are very aware of climatic changes: they observe that rainfall has reduced in quantity, shortened in length and increased in unpredictability in comparison to previous years. Most farmers explain these changes through their own human activities such as bush burning, deforestation and "immoral activities" which they believe anger Allah or traditional gods. Farmers therefore blame themselves for local climatic changes taking place, suggesting that weather is understood as something which can be manipulated by human behaviour.

Local ecological knowledge, such as use of indigenous seeds, composting and short duration crops, existed prior to and has been re-energised through *RAINS* programmes. These are the most important form of climate change adaptation. The survival of LEK over time implies its relevance for contemporary semi-arid contexts. Non-farming activities, such as *shea* production, provide important additional support to household income. Farmers are limited in how they adapt to climate change, as insufficient capital, lack of access and poor markets limit their ability to use modern farming techniques and sell surplus produce.

Prior to undertaking the research I spent time developing provisional research tools based on a review of literature and NGO documents. Once in the field, time was saved by adapting research tools to key research areas. Maintaining a research diary provided an important resource in which to clarify thoughts, manage time and refer back to. However ultimately the most essential lesson learnt when collecting independent research is the need to act assertively and to trust one's instincts.

The research provides additional evidence to an evolving body of climate change literature. Such documents are crucial in shaping future climate change policy. Locally, *Kpachelo* community now has a written record of the current climatic situation, which could be useful in applying for funding, lobbying and for future individuals' reference. I intend to pursue future climate change research opportunities, in which my first-hand research experience and understanding of climate change adaptation within a West African context will no doubt prove useful.

Figure 1. Focus group: under 40 male farmers group.

Catherine Clarke, MSc Anthropology, Environment and Development, University College, London.

An investigation of the food sovereignty impacts of a large-scale land acquisition for industrial oil palm in southwest Cameroon.

The government of Cameroon welcomes foreign direct investment as part of its *Vision 2035*. As such, several large-scale land deals for industrial oil palm are currently being negotiated. The case of *Herakles Farms/SGSOC*, awarded a 3-year provisional lease for 19,843 ha in 2013, has proved particularly controversial. Now under new management, the company is seeking to renew its contract for up to 99 years.

My study aimed to identify the potential impacts of the proposed land-use changes on local food sovereignty. An exploration of local livelihood strategies and social support networks (Figure 2), coupled with data collection on company encroachment into farms, livelihood contributions of farms captured, and compensation options, informed the study's findings.

The findings suggest that food strategies in the region are precarious, dependent on sharing to cope with recurrent food shortages and reciprocal support strategies to improve food sovereignty. Some 12.7 percent of the study population will suffer directly from farm grabs: the availability of land to provide for the future needs of these forest-farming communities has been drastically curtailed.

In their efforts to strengthen food security and sovereignty in the face of large-scale land acquisition, communities attempt to secure unoccupied land. This results in increased forest degradation and local competition for resources. Compensation options do not offer same-value remuneration, working instead to increase corporate land control. Potential employment opportunities are unlikely to benefit the local population.

The TAAF award enabled me to spend eleven weeks in the field. This meant I had time to employ a wide range of data collection methods. Market analysis, farm visits, crop surveys and encroachment monitoring all provided important evidence on the question of food security and its implications for understanding local food sovereignty. My study has contributed an in-depth understanding of the impacts of the project on local communities, which will be valuable for future campaign and advocacy work.

Figure 2. With Ayong village Traditional Council

Jack Marley, MSc International Marine Environmental Consultancy, Newcastle University.

Spatio-temporal mapping and analysis of shark population dynamics from the local ecological knowledge of former shark fishermen in the Maldives.

Monitoring of population dynamics is essential to managing the conservation of sharks, but current regimes are deficient in baseline records of abundance and size, while marine biomes in particular are chronically under-represented in assessments of biodiversity. The local ecological knowledge (LEK) of marine resource users contains spatial information of environmental change over human lifetimes, and could bridge gaps in the scientific record prior to the onset of monitoring. However, conventional methods of applying LEK in biodiversity monitoring are inadequate for integrating socio-cultural data into the geographic mapping necessary to visualise such changes.

The present study developed a baseline for the population dynamics of Indian Ocean shark species from the LEK of former shark fishers in the Maldives. By pioneering a novel application of human ecology mapping, this knowledge was visually reproduced to illustrate temporal changes throughout the marine environment.

Semi-structured interviews (n = 32) (Figure 3) were conducted to estimate changes in the distribution, abundance and total length of nine native species throughout the region preceding, during and following the implementation of the 2010 shark fishing moratorium. Variance between LEK estimates of species median size were validated with regional fishery-dependent and independent sources to determine its reliability as a local source of ecological data. Median total length of silvertip sharks (*Carcharhinus albimarginatus*) was fitted to a generalised linear model to infer changes with time, and results were described over the spatial extent of the Maldives with kernel density mapping.

Figure 3. Interviewing shark fisherman.

LEK estimates of size were within 1 foot of variance with official data for a majority of species (66 percent), and revealed significant changes in median total length of *C. albimarginatus* over time, with marked increases post-ban. Spatial mapping of LEK baseline data for pre-ban populations of *C. albimarginatus* presented discernible changes in size in the first application of this method in marine biodiversity monitoring.

The outcomes of this research include a replicable model for integrating communal knowledge systems into marine biodiversity monitoring worldwide and within the Maldives. This study also provides an opportunity for guided future research.

The author wishes to extend his thanks for the hospitality and goodwill of the people of the Republic of the Maldives, the generous financial and logistical support of *Banyan Tree* and the Tropical Agriculture Award Fund, and the invaluable counsel of Dr Steve Newman and Professor Selina Stead.

Iona Hamilton Stubber, MSc International Marine Environmental Consultancy, Newcastle University.

Contribution of marine protected areas to food security in Small Island Developing States, Island of Rodrigues, Mauritius.

Food security is a significant international concern with world population expected to grow to 9 billion by 2050. In Small Island Developing States (SIDS), Marine Protected Areas (MPAs) have been created in an effort to conserve marine resources depleted due to overexploitation and climate change. Although ecological planning of MPAs often takes account of priorities such as endangered species, sensitive habitats or nursery areas, recent studies stress the importance of considering socio-economic factors in both development and ongoing management.

Alternative livelihood projects are becoming an increasingly common vehicle for reducing fishing pressure and improving socio-economic conditions of coastal communities. Replacement jobs are provided for displaced fishers, resulting in increased resilience to natural or economic shocks.

The island of Rodrigues provides an interesting case study of local perceptions of coastal management and alternative livelihood projects in an SIDS. The semi-autonomous island is located 650 km from Mauritius in the Western Indian Ocean. It is surrounded by a 230km^2 shallow lagoon with a fringing reef. Local people are still dependent on a fishing-farming livelihood. In an effort to conserve coastal resources, four northern no-take marine reserves were established in 2007. Two years later, a much larger multi-use South East Marine Protected Area (SEMPA) was gazetted, currently the biggest MPA within Mauritian territory. Alternative livelihood projects for displaced fishers have been established in Rodrigues. There has also been some interest in aquaculture. Despite the number of reserves, catch has continued to decline due to high levels of non-compliance.

The aim of this research was to understand perceptions of marine resources and alternative livelihoods in Rodrigues on a multi-governance level, in order to inform decision-makers on the future management of coastal resources. Data on marine resources and perceptions on alternative livelihoods were obtained through semi-structured household and key informant interviews conducted between May and July 2016.

Analysis of the data revealed a significant relationship between perceived effectiveness of marine management and location of marine reserves and MPAs. In Riviere Banane, 73 percent of respondents stated marine management was effective at conserving and managing marine resources, while in Morouk, 59 percent of respondents perceived marine management to be ineffective. This was related to perceived lack of inclusiveness in marine management decisions in Morouk.

Key strengths were perceived with regard to financial assets (available funding). Weaknesses were identified with regard to physical, human, and social capital (where projects lacked management expertise and ongoing support). The study indicates the importance of local participation in coastal management for achieving positive perceptions and compliance. If marine reserves and MPAs are to enhance food security on SIDS, participation must be supported by effective enforcement for implementing marine management and achieving conservation goals. Governance, policy and management of MPAs must be tailored to the socio-economic, political and cultural characteristics of each coastal community.

This research, with TAA funding, provided a once in a lifetime opportunity to begin a career in aquaculture development. Although my research was not as specific to aquaculture as originally planned, exploring alternative livelihood projects was extremely beneficial: it gave a broader picture of strengths and weaknesses of alternative income opportunities for displaced fishers in Rodrigues. The data collected can be used to build on current and future projects in Rodrigues and other similar SIDS, for developing sustainable long-term solutions with the support of the local community. The knowledge and skills I obtained while conducting my research will be invaluable for my future involvement in aquaculture development projects in SIDS. For now, I am gaining aquaculture hatchery experience in Scotland. I look forward to applying the knowledge and skills I gained in Rodrigues, to future community-based aquaculture development projects and opportunities.

Marcel Mallow, MSc Biodiversity, Conservation and Management, Oxford University.

Smallholders' perceptions on biodiversity-friendly farming methods in the Peruvian Amazon: can Ucayali's oil palm smallholders be allies for sustainability?

Do oil palm smallholders care about environmental sustainability and biodiversity impacts, or are most of them still purely subsistence farmers below an apparent 'income threshold'? This was one of the central questions that my two-month fieldwork experience in the Peruvian Amazon in Pucallpa evolved around. It was an incredibly formative experience, both personally and professionally. I am very thankful for the support and funding provided by the TAAF, which made it possible for me to integrate a fieldwork component in the MSc dissertation of my Biodiversity, Conservation and Management degree at the University of Oxford. It gave me a unique opportunity to look into the complex realities and diversified livelihood strategies of oil palm smallholders in the Ucayali region of Peru, and to see how biodiversity is perceived, as well as the role it plays in decision-making at farm level.

In a region where the oil palm crop has been accused of causing vast deforestation and biodiversity loss, smallholder perceptions on more biodiversity-friendly farming practices were explored through an extensive oil palm smallholder field survey. To achieve a heterogeneous and representative sample, more than 2,000 km were travelled via motorbike to the, often marginalised, oil palm communities. The final sample, excluding the pilot, comprised 52 smallholder surveys conducted at farm level.

One interesting insight that emerged from the statistical analysis was a positive correlation between the farmers' total landholding (ha) and their oil palm area's biodiversity performance, possibly hinting back to an existing income threshold as mentioned above. We rated this 'biodiversity score' via observation of the following farming practices, which are shown to have an impact on biodiversity richness (these areas were previously identified via a literature review and key informant interviews with officials from regional institutions):

- Complexity-enhancing measures;
- Low-intensity management;
- Soil conservation and improved fertilisation.

The surveys revealed that smallholders in Ucayali are strongly willing to move towards more environmental sustainability and thus biodiversity-friendliness, especially through improved soil conservation measures and targeted fertilisation as these result in higher yields, thus making them win-win actions. Complexity-enhancing measures and low-intensity management however were judged more hesitantly: substantial efforts would be needed to communicate the long-term benefits of biodiversity-friendly farming and to support a transition from intensive production systems.

Regional support for these endeavours is still largely missing. For example, urgently-needed demonstration plots, like the ones the World Agroforestry Centre (ICRAF) has been testing in Brazil where oil palm is farmed in a mixed-crop system, have not yet been established. This is so, even though the local agency for agricultural innovation (INIA) is pushing for alternative ways to handle the organic matter crisis in oil palm landscapes. Abandoned demonstration plots of the Universidad Nacional de Ucayali should be reactivated to help communicate sustainable innovation to the farm level.

Meanwhile, smallholders and their committees in the region are engaging with biodiversity. They show a genuine interest in improving their practices and in switching to more diverse production systems integrating, for example, fast-growing non-competing timber species like *Bolaina* and *Capirona*, as well as planting groundcover species which thrive in shady conditions and are good both for soil conservation and for providing alternative income (*eg Kudzu* seeds).

The attention this project dedicated to marginalised oil palm farming communities has been well-received both by regional institutions and by smallholders, who perceived the interviews as a way of mutual learning. The insights of the surveys and key informant interviews resulted in recommendations directing attention towards (i) soil conservation measures, and (ii) establishment of landscape complexity.

Concerning the first point our study has shown that farmers are relatively poorly-informed about their soil: those farmers who carry out soil analysis perform significantly better, not only in yield but also in terms of biodiversity score. Improving oil palm farmers' knowledge of their soils by incentivising them to carry out soil analysis would be both environmentally and economically sustainable. Installing a facility at the local university could fill this gap by providing soil analysis at reduced cost, or for free, while at the same time strengthening the regional scientific landscape and agricultural expertise.

What is needed in terms of landscape complexity is to communicate the benefits of diversification at farm level, especially in terms of ecosystem services and climate change adaptation. Smallholder support schemes also need to move away from the oil palm crop as a strict monoculture, requiring intensive inputs which many smallholders cannot afford. This could be achieved through demonstration plots which show a biodiversity-friendly multi-crop production model (Figure 4) that *Ucayalino* smallholders can identify with.

Figure 4. Biodiversity-friendly oil palm plantation.

Finally, a prerequisite of any approach to making smallholder oil palm farming in the region more sustainable is to grasp the still poorly understood complexity of smallholder realities and the factors that influence decision-making at farm level. In view of the ambitious goal of making all palm oil produced in the region comply with Roundtable on Sustainable Palm Oil (RSPO) standards by 2020, whether suitable for smallholders or not, the regional government should step-up efforts to collect reliable data on Ucayali's smallholders in order to be able to give them the incentives and support they need for a more sustainable production. My dissertation, parts of which are to be published, aimed to contribute to this process with data and insights on exactly this crucial group.

Institutional Members' Page

Climate Smart Agriculture Booster

The *CSA Booster* at Reading University: sustainable agriculture for a changing world

Reading is one of five universities that have joined forces to create the *Climate-Smart Agriculture (CSA) Booster*, a consortium of European partners financed by Climate-KIC. The concept, developed by the UN's Food and Agriculture Organisation (FAO), aims to help achieve food security and agricultural development goals in developing countries by focusing on the adaption to climate change and the lowering of greenhouse gas emission intensity per output.

Matthieu Arnoult, Partner Lead (*CSA Booster*) says: *"CSA integrates economic, social, and environmental dimensions of sustainable development, and relies on three pillars: the sustainable increase of productivity; the adaptation and resilience to climate change; and finally the reduction or elimination of greenhouse gases emissions."*

"The concept is becoming popular in developing countries, as these are among the hardest hit by the effects of climate change. But conversely, CSA is not getting much attention in developed countries. This is partly due to the lack of recognition and public awareness, which isn't helped by minimal communications within the industry itself, and is possibly due to the fact that climate change effects are not, as of yet, being felt particularly harshly, so there's little incentive."

Matthieu continued: *"However, there is a good business case to be made for CSA, as climate-conscious approaches are more efficient, with higher output-to-input ratios to be expected, and we are working with our partners, Wageningen University (Netherlands), INRA agricultural research institute (France), IBIMET institute of biometeorology (Italy), and the South Pole Group (Switzerland), to promote CSA in Europe and beyond by bringing together a network of partners to identify, assess, demonstrate and implement CSA solutions at scale."*

"We aim to be an independent broker between solution providers and users, by building an open innovation platform where all stakeholders can meet and share knowledge. In addition, The CSA Booster will also develop a set of integrated services such as solution, technology and impact assessment, policy and subsidy analysis and support, matchmaking and brokering, education and training."

Matthieu added: *"By 2020, we aim to enact annually a mitigation target of 10 Mt $C0_2e$, coupled to a €30M reduction in damages and losses in value chains, and the facilitation of €20M of CSA-related investment. To this end, we are keen to get in touch with anyone in the farming sector with some experience to share, or with an interest in increasing the sustainability of the industry."*

CSA calls upon a range of approaches (technical, policy, financial, training, and so on), and is not a single specific agricultural technology or practice that can be universally applied. It is an approach that requires site-specific assessments to identify suitable agricultural production technologies and practices which need to be tailored to a sector, to a region, to a farm even, given its own mix of crops and/or livestock, its soil and weather conditions, and the experience of the farmer.

Some solutions have a mitigating effect (carbon sequestration through pasture or grazing management, animal breeding of lower GHG emitting breeds, *etc*) while others are geared towards adaptation (breeds or varieties more resistant to heat or pathogens, and vaccines).

For more information, visit: http://csabooster.climate-kic.org/ or contact Matthieu Arnoult at: m.h.p.arnoult@reading.ac.uk.

CSA Booster and Climate-KIC are financed by EIT, the European Institute of Innovation and Technology https://eit.europa.eu/

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Reminiscences and Reflections

Zambian interlude, 1972-1974

Hugh Brammer

Hugh Brammer spent 22 years soil surveying in the Gold Coast/Ghana, East Pakistan and Zambia, followed by 13 years as FAO Agricultural Development Adviser in Bangladesh.

As indicated at the end of my previous reminiscences (Brammer, 2015), FAO saved me in the nick of time from accepting a World Bank job in Mexico by offering me a posting to Indonesia. But then, as had happened once before, that posting was delayed and I was invited to take a 12 months' posting to Zambia, where I went in January 1972. That was an assignment in which I occupied the government post of Senior Soil Scientist and FAO topped up my salary. It was a way in which I preferred to work: in a responsible role, not merely as an adviser. My supposed task was to defrost a team of Norwegians on offer from their government to strengthen a rudimentary soils team in the year, and my assignment was extended for another 12 months.

My soils work in Zambia was very different from that in the Gold Coast/Ghana and in East Pakistan: a new challenge, in fact. Whereas in those territories I had been part of a large organisation working on reconnaissance soil surveys and increasingly in a managerial capacity, in Zambia I was very much on my own. The priorities were surveys for soil conservation in settled areas and for assessment of possible new settlement in 'bush' areas. My formal counterpart was a young Zambian soil scientist, Nicholas Mumba, working on the central agricultural research station at Mt Makulu, outside the capital Lusaka. His other duties often prevented him from joining me, so I frequently went out accompanied only by a driver/assistant in a Land Rover equipped with a power auger mounted on the back (Figure 1), and with a strengthened front bumper which enabled us to force our way though bush with trees up to 4 inches in diameter (and which made enough noise to frighten off lions and elephants that occupied the bush: one of my predecessors, Dick Webster, working alone, had spent a day in a soil profile pit surrounded by a herd of elephants rumbling their interest in his occupation). It was hands-on work for me as a soil surveyor! Later, a young British Planning Officer, Barry Clayton, was transferred to assist me; and, eventually, the Norwegian soils team arrived and was introduced to tropical soils and their management.

Figure 1. Inspecting power auger sample with driver/assistant and Land Planning Officer.

Again, this was an interesting and exciting experience, often in remote savannah environments ('MMBA' to some: Miles and Miles of Bloody Africa!), following in the footsteps of an illustrious ecologist predecessor, Colin Trapnell. I recall two incidents in particular. One was the moment when – deep in the bush, probably 30-40 miles away from the nearest other person except for my driver – I came to a novel conclusion about the genesis and classification of soils extensively developed on the Barotse sands in western Zambia and wondered where this side of the moon one could, in 1973, turn up 20- (perhaps 30-) thousand square miles of *terra* previously *incognita*.

The other incident was my encounter with a young British ecologist who was visually upset by my answer to her question about the effect on the environment of cutting down savannah trees for agricultural expansion: desertification was her firm conviction; a rising water-table with reduced evapotranspiration was mine. As it happened, later on that field trip, I was approached by an older British ecologist who had been sent out to examine why riverine forest in that area of eastern Zambia was reported to be dying and had found it dying in the wrong place: from waterlogging at the lower end of the valleys, not from drought at the upper end.

In my 24 months in Zambia, I visited all but one of its 52 Districts (together with – in the course of duty! – the Victoria Falls and the country's major game parks). Before my departure in January 1974, I produced a new soil map of the country with both a technical and a popular report on the country's soils (Brammer, 1973a, b). Although I did not know it then, that was the end of my soil survey career, after 22 years working constantly on the frontiers of pedological knowledge. The unexpected change that came next will be described in a subsequent article.

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Brammer H, 1973a. *Soils of Zambia, 1971-1973*. Soil Survey Report No 11, with 1:2.5 million soil map of Zambia. Ministry of Rural Development, Zambia.

Brammer H, 1973b. *Soils of Zambia*. (A popular account of soil survey and the soils of Zambia), Rural Information Services, Ministry of Rural Development), Zambia.

Brammer H, 2015. Soil surveying in East Pakistan, 1961-1971. *Agriculture for Development* **26** (Winter 2015), 62-63.

Upcoming events

2nd Annual Kew Science Symposium: The State of the World's Plants II

Date and Time: 09.00, 25-26 May 2017

Details: Kew, a TAA Institutional member, invites you to the second 2-day annual symposium, coincident with the launch of the *2017 State of the World's Plants*. There will be six themed sessions and a panel Q & A at the end of each session. Invited speakers have been asked to address a series of globally significant questions based on their own plant science research and policy work. These questions are as follows:

1) Madagascar: megadiverse and misunderstood – how can we hope to reverse threats to biodiversity? 2) The immediate risk of extinction/climate change won't matter if everything has already died out… 3) Wildfires: a necessary evil? 4) Invasive plants: born to invade? 5) From field to healed: how do we detect the medicinal plants of the future? 6) Valuing nature: which plant species are most valuable?

More Details: http://www.kew.org/state-worlds-plants-symposium-programme

Venue: Jodrell Laboratory, Royal Botanic Gardens, Kew Road, Richmond, Surrey TW9 3DS U.K.

Registration: https://tickets.kew.org/WebStore/shop/ViewItems.aspx?CG=science&C=sotwp

Symposium on Climate Change and Drought Resilience in Africa

Date: 16-18 October 2017

Details: The focus will be on "building resilience to climate change and droughts in Africa", showcasing experiences from research, field projects and best practice to foster climate change adaptation among countries in the region. New techniques and technologies for climate smart agriculture have already shown some great potential and impact in Africa.

Venue: Nairobi, Kenya

Further details: http://africa-eu-sti-portal.net/en/1068.php Jaume II St, in the Campus de Cappont of the University of Lleida, Spain.

TAA Seminar: Transfer of crop research knowledge to small farmers, with emphasis on Sub-Saharan Africa

Date and Time: 13.30, 16 May 2017

Details: The annual TAA East Anglia seminar will be held in collaboration with NIAB International (Cambridge), the University of Cambridge Global Food Security (GFS) initiative and CambPlants Hub. Two main papers are envisaged: (i) Tinashe Chiurugwi of NIAB International will present a paper on 'Supporting smallholders in improving wheat cultivation', drawing on outcomes of NIAB's KALRO ago-transfer project in Kenya. (ii) Peter Emmrich of the John Innes Centre, Norwich, will describe his current research on grass pea, aimed at developing it as a drought-tolerant crop for Ethiopia.
http://www.taa.org.uk/assets2/seminar_2017_flyer%20%20ver2.pdf
Keith Virgo: eastanglia convenor@taa.org.uk
Tea/coffee and biscuits; and there will be an opportunity to visit the research glasshouses on the NIAB Innovation Farm.

Venue: Cambridge: Sophi Taylor Centre, NIAB Innovation Farm, Villa Road, Histon, Cambridge CB24 9NZ). Parking plentiful; Guided Bus service from railway station/city centre (car shuttle service will meet at 'Histon & Impington' stop).

Location details:
https://www.innovationfarm.co.uk/sites/innovationfarm.co.uk/files/imce_uploads/NIAB-Park-Farm-Map.pdf

Registration: We request donations of at least £5.00 per person to cover the costs of the venue and refreshments. https://www.eventbrite.co.uk/login/?referrer=/preview%3Feid%3D28041906096

European Climate Change Adaption Conference: Our climate ready future

Dates: 5-9 June 2017

Details: The aim is to inspire and enable people to work together to discover and deliver positive climate adaptation solutions that can strengthen society, revitalise local economies and enhance the environment. A gathering for the people who will deliver action on the ground – from business, industry, NGOs, local government and communities – to share knowledge, ideas and experience with researchers and policymakers. Set in the cultural city of Glasgow, at the heart of a city-region that is putting climate adaptation and climate justice at the core of decision-making, ECCA 2017 offers a unique opportunity to visit many innovative local adaptation projects and share experience of how climate adaptation can work in practice. Sectoral themes: urban energy & infrastructure; agriculture & forestry; water security & flooding; biodiversity, ecosystem services & nature-based solutions; health & wellbeing. http://ecca2017.eu/conference/

Registration: https://confpartners.eventsair.com/ecca-2017/reginterest/Site/Register

Venue: SECC, Glasgow, UK.

LANDac Conference 2017

Dates: 29-30 June 2017

Details: LANDac's Annual International Conference 2017 will look back over the decade since the land grab 'hype' began, analysing the processes of transformations that have taken place in those locations where investments have been made and revisiting our understanding of the implications of these investment flows for food security, rural livelihoods and local development. The event will also look forward in assessing new challenges in the field, such as land governance in the context of climate change and increasing urbanisation, and land in relation to the SDGs, using existing knowledge to set the land agenda to 2030 and ensure no one is left behind.

Contact Organisers: email landac.geo@uu.nl

website: http://www.landgovernance.org/annual-conference-2017-call-for-abstracts-released/

Venue: Muntgebouw, Utrecht, the Netherlands

1st World Conference on Soil & Water Conservation under Global Change

Dates: 12-16 June 2017

Details: Discussion session 1 (13th): Analysis and recommendations to change present limitations for the study and research of soil and water degradation processes and in the application of prevention and remediation practices. Discussion session 2 (15th): Analysis and setting the challenges and required achievements in the next decade, to prevent and counteract the previewed effects of global changes on soil and water degradation processes and effects on food and water supply for the increasing world population and the environmental degradation and natural disasters.

Full details (including registration):
http://www.consowalleida2017.com/

Venue: Centre de Cultures i Cooperació Transfonterera (Centre of Cultures and Transboundary Cooperation), 67 Jaume II St, in the Campus de Cappont of the University of Lleida, Spain.

21st IFMA Congress 'Future Farming Systems'

Dates: 2-7 July 2017
Pre-Congress Tour: 25 June-1 July 2017
Post-Congress Tour: 8 July-14 July 2017

Details: IFMA (International Farm Management Association) hold a week-long International Congress every other year which is organised, wherever possible, by the member organisation that covers Farm Management of the host country and a partner educational establishment. The IFMA Congress allows ideas, experiences, best practice and knowledge covering farm management and agricultural education/training to be exchanged through presentations, visits and demonstrations.

More details (including registration):
http://www.ifma21.org/congress/

Contact: Richard@iagrm.com

Venue: Edinburgh, Scotland UK.

5th International Conference on Agriculture & Food

Date: 20 June 2017

Details: A wide range of topics including horticultural and agricultural production, post-harvest technology, food production and agriculture and food policy.

Further details:
https://www.sciencebg.net/en/conferences/agriculture-and-food/

Venue: Holiday Village, Elenite, Bulgaria.

AquaConSoil 2017: 14th International Conference on Sustainable Use and Management of Soil, Sediment & Water Resources

Dates: 26-30 June 2017

Details: Topics to be covered at this 5-day conference will range from (i) assessment and monitoring of soil, water and sediment quality; (ii) risk assessment; (iii) advances in remediation technologies; (iv) strategies and policies for pollution management and remediation; (v) reuse and upgrading of land, water and sediment in the circular economy and (vi) sustainable use & spatial planning of the subsurface

The AquaConSoil program will offer Thematic Lecture Sessions, Poster Sessions, Special Sessions, Exhibition, Technical Tours, Courses, and a Matchmaking event. It will provide great opportunities for scientists, companies and policy makers to extend and enforce their network, start new cooperation activities and be informed of and inspired by the latest developments in the field of sustainable use and management of soil, sediment and (ground) water resources.

Further details: http://www.aquaconsoil.org/

Venue: Lyon Convention Centre, 50 Quai Charles de Gaulle, 69463 Lyon cedex 06, Lyon, France.

European Conference on Precision Agriculture

Dates: 16-20 July 2017

Details: Continuing the successful format of previous conferences, building in strong industry sessions and participation. The theme of 'Innovating through Research' will enable all involved in Precision Agriculture to participate. A Study trip on Thursday 20th July will be in conjunction with the James Hutton Institute (JHI – a TAA Institutional Member) and its core site near Dundee.

Further details (including registration) : https://ecpa.delegate-everything.co.uk/?utm_campaign=546191_1610%20Plant%20Newsletter%20Oct%202016&utm_medium=email&utm_source=dotmailer&dm_i=2VFU,BPFZ,48EACT,1576Z,1

Venue: John McIntyre Conference Centre, within the Pollock Halls Centre, Edinburgh EH16 5AY, UK

21st World Congress of Soil Science (WCSS)

Dates: 12-17 August 2018

Details: The theme will be "Soils to feed and fuel the world". The WCSS is the main event of the International Union of Soil Science. It takes place every four years and is open to all members of the IUSS and other participants.

Further information: http://www.21wcss.org/

Contact: fcamargo@ufrgs.br
Flavio Camargo Vice-President Congress

Venue: Rio Centro Exhibition and Convention Centre, Rio de Janeiro, Brazil.
http://www.riocentro.com.br/

9th International Conference on Sustainable Water Resources Management

Dates: 18-20 July 2017

Details: organised by Wessex Institute, UK. It will cover a wide range of topics, including:
Water management and planning, Water rights and accessibility, Water markets economics and policies, Climate change, Sediment soil erosion, Irrigation, Water resources in arid regions, Ground water, Urban water management, Hydraulic engineering, Water quality and pollutant control, Water quality and health, River basin management, Flood risk management, Hydroinformatics, GIS and remote sensing, Trans-boundary water management, Water, food and energy, Socio-economic aspects, Water resources strategies, Innovative technologies, Water and the community, Integrated water analysis, Wetlands as water sources.

Further Details (including registration): https://www.wessex.ac.uk/index.php?option=com_chronoforms5&view=form&Itemid=5530&chronoform=Abstract&conf=water-resources-management-2017

Venue: The Orea Hotel Pyramida, Belohorska 24, 16901, Prague 6, Czech Republic.

7th World Congress on Conservation Agriculture

Dates: 1-4 August 2017

Details: The World Congress is to be led by the American Confederation of Farmers Organizations for a Sustainable Agriculture (CAAPAS), which began as an association of farmers who promoted the No Till System and is currently working to promote sustainable production systems.
CAAPAS will be hosting the Congress along with the XXV Aapresid s congress, which attracted 5,000 attendants and more 5,000 online delegates from all over the world to the last congress. The 7th WCCA provides the opportunity to learn from No-Till farmers associations and network with an international gathering of agricultural experts. Argentina, Brazil, Paraguay and Uruguay wish to demonstrate modern agriculture, based on the principles of Conservation Agriculture (CA), our known No-Till System, and with farmers, the crucial actors in this revolution. Agricultural production systems are not sustainable unless they are profitable, and CA holds the key to building and maintaining healthy soils and profitable farming systems. Food security, climate change, smallholder and family agriculture, gender equality, biotech, machinery innovations, bio-energy, water, soils, crops, agribusiness, legislation and more are going to be part of the 7th WCCA proposal.

Further Details: http://congresoaapresid.org.ar/

Venue: Rosario-Santa Fe, Argentina.

African Green Revolution Forum 2017

Dates: 4-8 September 2017

Details: Initiated in 2010, the African Green Revolution Forum brings together African Heads of State, Ministers, farmers, private agribusiness firms, donors, financial institutions, NGOs, civil society, scientists, and other stakeholders to discuss and develop concrete investment plans for achieving the green revolution in Africa.

Since its inception, the AGRF has become a platform that has grown in scope and focus to become the event of choice for thought leaders to influence, invest and drive a green revolution in Africa. It is an action-oriented, thematically-organised, participatory community of practice where concrete plans are developed and implementation on progress is monitored and evaluated toward scaling up investments and innovation for sustainable agricultural growth and food security in Africa. The Forum adds value for smallholder farming by promoting investments and policy support for driving agricultural productivity and income growth for African farmers in an environmentally sustainable way.

Agriculture offers solutions to some of the problems posed by climate change and growing urban populations and at the same time offers opportunities to farming communities to improve their standard of living and resilience.

This year the organisers invite participants to come ready to build on the progress already achieved – quickly, efficiently, and at the speed and scale required to secure Africa's rise through an agricultural transformation.

Further details: http://africa-eu-sti-portal.net/en/1067.php

Venue: Abidjan, Côte d'Ivoire.

Hugh Bunting Memorial Lecture, Reading

Date and Time: 18.00, 8 November 2017
Please note this is not confirmed at the time of publication. Check TAA website.

Details: We are hoping that the lecture will be presented by Dr Margaret Najjingo Mangheni, Reader in Agricultural Extension at Makerere University, Uganda. The theme of the lecture is elected to be "Innovation Systems and ICT for Smallholder Farmers". More information will be added nearer the date. The lecture will be followed by a wine reception.
We are also hoping to arrange a visit to the University's Cocoa and Crop Environment Labs in the afternoon

Venue: Reading University, Agriculture Building, Earley Gate, Reading, UK.

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How to become a member of the TAA

If you are reading someone else's copy of *Agriculture for Development* and would like to join, or would like to encourage or sponsor someone to join, then please visit our website at http://www.taa.org.uk/

Step One - Application: Applications can be made on-line at:
http://www.taa.org.uk/membership
Alternatively an application form can be downloaded, completed and sent to:
TAA Membership Secretary, 15 Westbourne Grove, Great Baddow, Chelmsford CM2 9RT.

Step Two - Membership Type: Decide on the type of membership you require – see the details and subscription rates below:

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Institutional Member (printed copies of *Agriculture for Development* and online access for staff)	£120	Student Membership (online copies of *Agriculture for Development)*	£15

Step Three - Payment: Payment details are on the website with 'Bank Standing Order' being the preferred method since this ensures annual payment is made and is one less thing to remember!

Payment can also be made by bank transfer, on-line using PayPal, or by cheque.
Bank details are available from: treasurer@taa.org.uk

Step Four - Access to website and Journals: When application and payment has been received then the Membership Secretary will contact you with your membership number and log-in details for you to fully access the website and journals.
The latest journal will be sent to full members.

For membership enquiries contact: membership_secretary@taa.org.uk

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