Pre-proposal for the Integrative CRP on Climate Change, Agriculture and Food Security (CCAFS)

Contents

PART 1

Summary narrative

Overview

Climate change will have far-reaching consequences for agriculture and natural resources – demanding a response that integrates food security, adaptation and mitigation, and puts greatest investment towards poor agriculture-dependent people whose livelihoods are most at risk. The overall purpose of CCAFS is to marshal the science and expertise of CGIAR and partners to catalyse positive change towards climate-smart agriculture, food systems and landscapes. CCAFS Phase II builds directly on the experience of CCAFS Phase I (including Extension Phase). CCAFS will be comprised of four Flagships: F1 on Climate-Smart Practices and Portfolios; F2 on Climate Information Services and Climate-Informed Safety Nets; F3 on Low Emissions Development; and F4 on Food System Governance under Climate Change.

2030 outlook for climate change, agriculture and food security: CCAFS' meta-analysis of future impacts of climate change finds that 70% of studies project declines in crop yields by the 2030s, with yield losses of 10-50% in half the studies (Challinor et al. 2014). The meta-analysis finds that incremental adaptation options (e.g. varieties and nutrient regimes) can reduce but not eliminate losses. Climate extremes, which may exceed critical thresholds for agricultural production, will increasingly require effective mechanisms to mitigate risk (IPCC 2012). Thus, even by 2030, we face a future in which both incremental and transformative adaptation options must come into play. While analyses of livestock systems and fisheries are less developed, we would expect similar patterns of impact and response. Transformative changes might include shifts away from certain crop-livestock systems, moving out of agriculture, or changes in diets. Turning to emissions, CCAFS analyses suggest that a reasonable target for mitigation in developing country agriculture is 1-1.2 Gt CO_2e per year by 2030 (Scholes et al. 2014; Wollenberg et al. 2015). Like adaptation, incremental actions, such as sustainable intensification to achieve emissions efficiencies, will be crucial yet insufficient to achieve these targets. Society will need to also look to changes throughout the food system, particularly around waste and dietary patterns, and to address the use of biomass for fuel.

The 2030 adaptation and mitigation challenges in agriculture are framed by rapid change in smallholder farming and food systems. Rapid urbanization is likely to reduce the importance of smallholder agricultural incomes in achieving food security, and lead to concentration in farmland (Collier & Dercon 2014). At the same time, rural development is likely to be geographically uneven (World Bank 2008), centred on development corridors along transport routes (forthcoming ISPC study). Nonetheless, with population growth, the number of smallholder households globally is projected to grow from about 560 million today to some 750 million by 2030, largely in Africa and Asia (Campbell & Thornton 2014). Farming in 2030 is likely to be characterized by a higher degree of inequality in farm incomes, sizes, technologies and market linkages. Trends in feminization of agriculture may well continue (Bruinsma 2003). For CCAFS, the implication of this 2030 future is to use the research process to distinguish more carefully among farming systems and households, some of which may follow non-agricultural adaptation pathways. The greatest opportunities for emissions reductions in developing countries may be in relatively larger-scale, higher-input farming systems. Thus CCAFS will provide the most policy-relevant outputs by including a range of options for adaptation and mitigation that go beyond the strict confines of smallholder agriculture sectors. Relevant options may lie in the realms of food security safety nets (F2), food system functions including governance, diets and nutrition (F4), closing gender gaps in assets and decision-making (all Flagships), supply chain governance (F3) and financial innovation in support of transformative adaptation (F1).

SRF alignment: The CGIAR SRF frames the context and structure of CCAFS. CCAFS focuses on 3 SLOs, 10 IDOs and 14 sub-IDOs (Annex 4, Fig. 4.1), and will provide a platform for cross-CGIAR research on climate change. CCAFS is also aligned with the SRF geographically (c. 45% of investments focus on Africa, 30% on Asia and 25% on poverty hotspots in Latin America, with additional work in hotspots for agricultural mitigation).

Key developments in CCAFS: The proposals for Phase II differ from that of the Extension Phase by responding to the ISPC commentary as follows: (1) updated theory of change, particularly development of

hypotheses on change mechanisms and assumptions on CRP behaviours promoting impact (Vermeulen & Campbell 2015); (2) more explicit focus on food systems (particularly F4), and links to nutrition; and (3) greater integration with other CRPs, both thematically (e.g. co-investment) and geographically (country and site integration). Retained from the Extension Phase is the strong focus on outcomes and partnerships. The regional hubs, with Regional Program Leaders, remain the central mechanism for connecting research and policy engagement across all Flagships (focus regions being West Africa, East Africa, South Asia, South East Asia and Latin America; with a small Pacific hub). The Flagships remain essentially the same, having received a major update on the basis of learning during the Extension Phase. Dropped from Phase I is the knowledge-to-action research theme, now mainstreamed, while gender and social inclusion (GSI) has been elevated through new appointments and a new strategy.

Added value of the 4 Flagships as a program: The external environment for climate change and food security now cuts across adaptation and mitigation, and across the whole food system. For example, the UNFCCC call for INDCs to the post-2015 agreement asks for contributions to both mitigation and adaptation, within a multi-sector plan that addresses production and consumption. Thus the pathway to impact for CCAFS depends critically on its capacity to integrate the adaptation-led Flagships F1 and F2 with low emissions strategies (F3) and institutional approaches to food systems (F4). Several Flagship hypotheses are inter-dependent. For example, CCAFS F2 Hypothesis 1 is that access to effective advisory services, insurance and safety net programs are essential to CSA implementation at farm level, to be evaluated under F1. The integration also provides opportunities for novel scientific approaches. For example, modeling approaches can assess low emissions development options (F3) in the context of policy priorities for food security (F4).

Mechanisms for cohesion across Flagships: The 5 regional hubs (WA, EA, SEA, SA and LAM) will provide the key mechanism for cohesion across the Flagships, integrating the research areas at the site ("climate-smart villages") and policy levels, and providing the platform for interaction with partners in the impact pathway, including governments, private sector, farmers' organizations and NGOs. The Global Engagement Research Leader provides an equivalent function at the global level, synthesizing and connecting CRP research with major global agencies and policy processes, while the GSI Research Leader will facilitate comparative approaches to gender across the portfolio.

Working with other CRPs: While CCAFS has programmatic content, it will also integrate climate change work across CRPs through: (1) co-investment in Learning Platforms and Twinned Flagships (35% of CCAFS budget; Annex 5, Tables 5.1 & 5.4); (2) building linkages to other CRPs through CCAFS' regional impact pathways; (3) active collaboration in the CGIAR country collaboration; and (4) establishing a climate change gender network that cuts across CRPs. Boundary issues with other CRPs need to be resolved (see Annex 5).

CCAFS will host the following six Learning Platforms for AFS-CRPs and I-CRPs: LP#1 *Ex-ante evaluation and decision support for climate-smart options* (see CoA 4.1); LP#2 *Foresight, models and metrics for climate-sensitive breeding*, to address emerging climate challenges (1.7); LP#3 *Participatory evaluation of CSA practices and portfolios in CSVs* in Africa, Asia, and LAM – linked to CSA up-scaling, using technologies and practices derived from AFS-CRPs and I-CRPs (1.1/1.2/1.3); LP#4 (with PIM) *Weather-related agricultural insurance products and programs*, to link to insurance activities in many AFS-CRPs (2.3); LP#5 *Smallholder agricultural emissions* to enhance understanding of emissions, mitigation options and incentives (3.1/3.2/3.3); LP#6 *Policy engagement on CSA*, covering national to global levels building on the skills and experience from multiple Centres and partners (4.2/4.3).

Three Twinned Flagships will cover: TF#1 *Managing water resource variability, risks and competing uses for increased resilience* (with WLE – see F1); TF#2 *Supply chain governance to avoid deforestation* (with FTA – see 3.4); and TF#3 *Food and nutrition security futures under climate change* (with PIM and A4NH – see 4.4).

CCAFS already established integrated regional impact pathways, involving numerous Centres. Through additional planning more formalised connections with other CRPs can be established. CCAFS will contribute

to CGIAR Country Collaboration (Annex 5.2) in all countries through its LP#1, involving downscaling of climate models and scenario development. It will play a greater role, through its Regional Program Leaders, in WA (Burkina Faso, Ghana, Mali, Niger, Nigeria), EA (Ethiopia, Kenya, Rwanda, Tanzania, Uganda), SA (Bangladesh, India, Nepal), SEA (Vietnam), and LAM (Nicaragua). CCAFS will contribute to the 2015 inter-Centre planning for integration in Bangladesh (through WorldFish scientists), Ethiopia (ILRI), Nicaragua (CIAT, Bioversity, and ICRAF), Tanzania (ILRI, IITA) and Vietnam (IRRI, CIAT, ICRAF), including by mobilizing its national and local partners. In all the countries mentioned above (excluding Rwanda and Nigeria), CCAFS already has integrated cross-Centre activities and impact pathways. These will be incorporated (and modified where appropriate) into the broader integration plans. This includes CSVs (LP#3) where multiple Centres are operating in 13 of the above countries, and climate change science-policy platforms (part of LP#6) in 12 of the above countries. Cross-CRP work is most advanced in Burkina Faso, Vietnam, Nicaragua and India (e.g. in Burkina a common impact pathway and scenario process has been implemented with FTA and WLE; in Vietnam CSVs have been established with explicit cross-CRP contributions (see Annex 5, Fig. 5.2); in Nicaragua diversification through implementation of agroforestry systems is taking place with FTA; and in India flood and drought management is being implemented with WLE). Funding for the above has been Programd in the pre-proposal. CCAFS/IRRI are already hosting a cross-CRP meeting in Vietnam in 2015 on behalf of MARD to prepare for COP21 and improve cross-CRP collaboration.

Because CCAFS works with all Centres, its climate change gender network will link to Centre gender expertise, and through to all CRPs. CCAFS (and other I-CRPs) can play a powerful role in fostering gender research (as demonstrated by CCAFS in the Paris April 2015 meeting on gender and climate change; Huyer et al. 2015).

Working with youth: Long-term adaptation and low emissions development must engage the next generation. CCAFS will support the relevant work of other CRPs and include youth in its social inclusion strategy. CCAFS work with youth to date has emphasized opportunities in entrepreneurship and value chains, for example strengthening the capacity of West African youth in agribusiness, farm enterprises and economic transformation. The role of youth groups in scaling up CSA and climate services will be explored, including training programs for young farmers and professionals. Work with the Ministry of Education in the Philippines is a model for empowering young people to transmit CSA information to their parents and communities as "infomediaries".

Scientific framework to produce international public goods (IPGs): CCAFS will use the CSA concept to structure its approach to climate-responsive options. The origin of the concept is that many proposed actions in agriculture deliver on both adaptation and mitigation, signalling a move away from the clear distinction within the UNFCCC negotiations. A wide range of public, private and civil society entities, including funds and development banks, are now committed to achievement of CSA, which is defined in terms of outcomes for each of food security, adaptation and mitigation (FAO 2013). CSA is closely aligned with sustainable intensification at the farm level (Campbell et al. 2014) and also includes agro-ecological approaches (Sugden 2015). But the concept extends beyond on-farm practices to include landscape-level interventions (e.g. management of the farm-forest boundary), services (particularly information and finance), institutions (particularly market governance, incentives for adoption) and the food system (particularly consumption patterns and wider climate-informed food system safety nets). CSA may also be understood as a process that comprises parallel elements of institution-building (Lipper et al. 2014), as per CCAFS' theory of change.

However, as CCAFS has identified (Neufeldt et al. 2013), the scientific basis for CSA needs considerable work. Fundamentals include establishment of credible metrics for the three goals of CSA, empirical research to understand how selected interventions deliver on these metrics, improved understanding of trade-offs, and thus definition of which agricultural development pathways can lead towards a "safe operating space". These fundamentals need to be explored within a wider research design that addresses the enabling environment needed for CSA to deliver on green economy and SDG agendas (Steenwerth et al.

2014). CCAFS proposes to address the fundamental questions via participatory research at climate-smart villages (CSVs), sites ranging from village to district scale at which portfolios of CSA interventions are tested in a globally comparable manner with farmers and development agencies, including private sector. This research will be linked to higher-level analyses (e.g. models of scaling processes and trade-offs) to generate IPGs relevant to societal questions on alternatives for agricultural development. Ground-breaking innovative science will include advanced methods to produce high-resolution historical meteorological data, multi-dimensional scenarios science applied to food systems at multiple scales, and co-investment with AFS on breakthrough technologies (e.g. biological nitrogen inhibition). A key feature of emerging adaptation science (and linked mitigation science) is that it is both basic – improving understanding of biophysical and socio-economic processes – and applied, being problem-focused and demand-driven (Moss et al. 2013).

Impact pathways to outcome targets: Through a bottom up process with Centre and non-CGIAR partners, CCAFS established targets for projects, Regions and Flagships, in the context of impact pathways and the associated theories of change. These have been modified to fit the Phase II time horizon (Annex 6, Table 6.1).

Theory of change (ToC): ISPC commentary has noted that in the Extension Phase CCAFS presented a set of coherent impact pathways linked to compelling IDOs, but was insufficiently clear on the ToC. The new ToC incorporates explicit hypotheses on how change happens to bring about successful CSA at scale. These 11 hypotheses are spelt out in the Flagship sections of this pre-proposal, and summarized in the ToC diagram (Annex 7 Fig. 7.1). We posit that the selected 14 sub-IDOs will be achieved through large-scale, equitable adoption of climate-smart practices, services and institutions. Our ToC for how this large-scale adoption might occur builds on the theory presented by Lipper et al (2014) for CSA, which proposes four areas for action: (1) building evidence; (2) increasing local institutional effectiveness; (3) coordinating climate and agricultural policies; and (4) stable financing. Thus we hypothesize that the following mechanisms for change will bring CSA to scale, delivering on the 14 sub-IDOs: (1) building an evidence base, set of decision tools and information services that inform priority-setting and agricultural practice, including among farmers (Flagship 1 Hypothesis 1, F4 H4); (2) strengthening institutions and services, particularly at local level, that enable the full range of adaptation and mitigation responses and deliberately close the gender gap (F2 H1, F2 H3, F4 H4); (3) enactment of coordinated policies and plans, coupled with new territorial and supply chain governance, that deliver climate-smart, low-emissions agricultural development (F4 H1, F3 H1, F3 H2); and (4) tailored large-scale investment in CSA by both public and private sectors, linked to clear incentives for farmers (F1 H2, F2 H2, F4 H3). Each hypothesis has assumptions presented in the Flagship sections. Project-level impact pathways within each Flagship will specify assumptions at a more detailed level. Further, CCAFS has used internal learning to develop 10 principles about how CRP behaviours can enhance the likelihood and quality of outcomes (Vermeulen & Campbell 2015). While unintended outcomes have tended to be serendipitous and positive under Phase I (e.g. additional partners adding scale to outcomes, or unexpected results on gender differences leading to better tailoring of ICT services), regular evaluation and update of the ToC is crucial. Mechanisms for internal learning are given in the "Leadership, management and governance" section.

Evidence of demand

At the global and regional levels, demand comes from the UNFCCC and IPCC processes and from development partners (public, private, civil society) that are implementing CSA programs. At the national level, there is additional demand associated with national climate policy processes, including NAPAs, NAPs, NAMAs and INDCs. Recent evidence of demand for CCAFS research and engagement include:

- **Peer-reviewed science** e.g. CCAFS and CGIAR publications comprising 15% of citations in IPCC AR5 Working Group II chapter on agriculture and food systems (3-fold greater than in the past) and 6% of citations in IPCC AR5 Working Group III chapter on land use.

- **Policy positions** e.g. multiple citations of CCAFS work in parties' 2015 submissions on agriculture to UNFCCC SBSTA (e.g. by EU and Sudan on behalf of the Africa Group of Negotiators).
- **Tools** e.g. ICRAF-CCAFS gender toolbox in use by 61 partners in 19 countries.
- **Metrics** e.g. FTA-CCAFS emissions factors for peatlands submitted by Indonesian government as baselines in formal UNFCCC accounting processes (Hergoualc'h & Verchot 2014).
- **Databases** e.g. CCAFS Climate Portal receiving 18,278 total hits in 2014, of which 54.3% were "new"; 41.87 terabytes were shared and 235,236 files downloaded (CCAFS 2014).
- **Communications products** e.g. over 18,000 downloads of a CCAFS summary of the implications of IPCC AR5 science findings for smallholders.
- **Inputs to national policy** – CCAFS science is informing policy in 20 countries on a demand-driven basis e.g. helping to determine the agriculture component of Colombia's INDC.
- **Inputs to implementation** e.g. CCAFS science used to develop finance model for index-based insurance by Agricultural Insurance Company of India.
- **Public sector CSA leadership** e.g. CCAFS with FAO co-leading the Knowledge Action Group of the GACSA, co-launching a CSA portal with World Bank, and co-delivering a Learning Alliance with IFAD
- Private sector CSA leadership e.g. WBCSD inviting CCAFS to be its science partner in the CSA stream of the Low Carbon Technology Partnership Initiative.
- **Capacity development** e.g. Contributions of CCAFS data, materials and expertise to postgraduate training programs such as MSc CCAFS at NUI Galway. CCAFS will deliver on at least five areas of the CGIAR CapDev framework.

Comparative advantage

The comparative advantage of CCAFS is currently under external review by the IEA.

Comparative advantage of CGIAR on climate and agriculture: CCAFS was established as a partnership between CGIAR and Future Earth to combine the comparative advantage of CGIAR on agricultural research and national-level research and policy partnerships with that of advanced research institutions on modelling of climate and global socio-economic systems. The CGIAR provides additional comparative advantage through: global reach among developing countries that gives CGIAR unique ability to identify global hotspots for investment in agricultural adaptation and mitigation, to conduct comparative research, and to develop standardised metrics, tools and analyses (e.g. regional comparisons and global models); a systems approach that similarly enables analysis and prioritisation across farming systems and landscapes, integrating expertise across all Centres and CRPs (e.g. MOT tool); research linkages from farm to global level to inform policy and practice at all levels (e.g. science-policy platforms); complementary role alongside development agencies as a knowledge partner in global processes (co-leadership of GACSA Knowledge Group); strong partnerships linked with global visibility that enable leveraging of research funding and influence in coordinated manner at global and regional levels (e.g. under the Global Framework for Climate Services); and established legitimacy to facilitate global multi-stakeholder processes leading to influential outputs (e.g. Commission on Sustainable Agriculture and Climate Change).

Comparative advantage of proposed CRP: Current priorities in global agriculture and climate address agriculture and food security as a whole, not broken down into agricultural sub-sectors. Therefore a CRP that integrates across Centre specialisms can strongly enhance both research and impact. The CRP is in the unique position to test and improve climate-smart, low emissions technologies and policies for the major crop and livestock systems of smallholder farmers in developing countries in multiple locations over time. An integrated climate CRP also allows CGIAR to speak with one voice on evidence-based policy, databases and metrics. CCAFS has demonstrated its ability to raise the profile of the CGIAR in climate change processes and to leverage external skills and funding. A climate CRP will increase the effectiveness of impact pathways, e.g. joint submissions to UNFCCC, and enhance the delivery of integrated products, e.g. standardized CSA metrics and tools that cut across sub-sectors and align with formal policy mechanisms.

Iterative definition of research areas: CCAFS will continue the internal learning processes that have been successful in Phase I to regularly refine the research agenda in light of comparative advantage. CCAFS has used the Extension Phase and formal review processes to iteratively develop a more nuanced focus on areas of comparative advantage. For example, at a Flagship level, Flagship 2 has moved from the broad scope of climate risk management towards specific types of interventions for which the CRP has the clearest niche relative to other providers (e.g. climate information services and insurance products). At a finer scale, deliberative processes with partners have defined specific areas of comparative advantage, for example definition of precise research outputs that CCAFS can provide that complement the functions of the Global Research Alliance on GHG Emissions (GRA). CCAFS has also used deliberative processes with development partners to avoid mission creep from research to development, for example defining clear research niches to support the development work of USAID Feed the Future program.

Phasing target countries and Regions: CCAFS plans to continue taking a dynamic approach to comparative advantage by phasing geographies as progress is made on outcomes. Several countries will be phased out in years 3-6 to allow entry of others with emerging demand. Geographic priority-setting is based on a mix of modelling approaches, formalized scoring systems with stakeholders, and regional consultations led by CCAFS regional programs to elicit qualitative priorities (e.g. CAADP priority countries for CSA investment) and emerging opportunities (e.g. demand from Nigerian government to support the new National Agricultural Resilience Framework).

Strategic fit and relevance of partnerships

The ISPC noted that CCAFS has built a comprehensive and relevant range of strategic partnerships for key functions (research, capacity building, knowledge management, action on practices, policy and institutional change, and management and governance), but that regular review will be essential to improving influence on policy processes. CCAFS regularly reflects on partnerships through internal learning. For example, at the global level, CCAFS has reviewed its role in two key areas of partnership for policy influence, within UNFCCC and GACSA. In 2014, CCAFS also realigned the portfolio to replace legacy projects; this entailed a reformulation of partnerships to deliver impact pathways. CCAFS partners have been consulted and have directly contributed to this pre-proposal.

Partners: Under Phase II, CCAFS Strategic Partners (Tier 1 – see management section) will include 14 CGIAR Centres, CARE, CSIRO, CTA, FAO, GIZ, GRA, IFAD, IIRR, IRI (Columbia University), NEPAD, NUI-Galway, PAFO, University of Leeds, University of Oxford, University of Vermont, Wageningen University, WBCSD, WISAT and World Bank. Future Earth, representing the global environment change community, continues as a Strategic Partner. Key partners for research and development in the regions include NEPAD, CORAF, ASARECA, ACPC, CATIE, UCI, ICAR and APAARI. In expectation that the national level remains the key route to impact, CCAFS will invest most in working directly with national governments and NARES, facilitating science-policy platforms in target countries. Other key partners will be agencies implementing food security and CSA programs (e.g. Alliance for CSA in Africa including CARE and World Vision, national meteorological services, radio stations, farmers' organisations). GACSA is a key partnership to link research into emerging large investments. Other global partners for achieving outcomes at scale are the World Bank, IFAD and WBCSD, while key partners for joint research and dissemination at global level include FAO, GRA, CTA, CIRAD, IRI and IIASA. CCAFS is working with NUI-Galway to develop research capacity through a Masters degree program and PhD and postdoctoral researcher training on CCAFS aligned topics.

CCAFS will also work with GFAR during GCARD3 to engage with a wealth of development partners to ratify and refine the research strategy. As in Phase I, CCAFS will set a budget target of 25-30% to non-CGIAR partners.

Regional initiatives: CCAFS will continue close alignment with key regional initiatives on improving climate change responses in agriculture. During Phase I CCAFS has worked in Africa with CAADP-NEPAD both to provide direct inputs to countries' CSA plans (NAFSIPs) and to provide scientific backstopping to the

Alliance for CSA in Africa. CCAFS also plans to continue its close partnership with the Africa Group of Negotiators, building on several years of scientific inputs that have helped African countries to improve the quality of their contributions to various fora and processes within the UNFCCC. CCAFS has established relationships with regional bodies in the target regions (e.g. ECOWAS, COMESA, ASEAN, CAC) and farmers' organizations (e.g. CECOCAFEN, FEDEARROZ, FENALCE, PAFO, WFO) and will work further with these agencies to scale up action.

Private sector: During Phase I, private sector partnerships have been pivotal to several large-scale outcomes (e.g. work with National Insurance Company of India, National Insurance Company of Nigeria, IKSL, Root Capital, Rainforest Alliance, Green Mountain). CCAFS anticipates greater research emphasis during Phase II on investment and implementation, as recently formulated CSA plans are rolled out. Therefore the partnership strategy for Phase II increases engagement with the private sector. At the global level, the strategy will focus on multi-company initiatives, to maximize impact across the agri-food sector (e.g. WBCSD and Farming First). At regional and national levels, the focus will be on partnerships with individual companies with a track record of improving outcomes for smallholder farmers.

Commitment by Strategic Partners: Non-CGIAR Strategic Partners have agreed on a set of topics for co-investment (Annex 5, Tables 5.1, 5.4 & 5.5). Future Earth has agreed to represent non-CGIAR partners on the CCAFS ISC through one of its steering committee members. CCAFS will continue close links to Future Earth and will contribute to its new strategy (Future Earth 2014) through the Knowledge Action Network on Food-Energy-Water that CCAFS has been asked to help develop.

Links to global targets and processes: CCAFS will deliver on SDG goals 1, 2, 11 and 13, and the CSA framework speaks directly to emerging metrics under the SDGs (Annex 8). Within the public and private sector, there is increasing focus on CSA and targets are being developed in GACSA, Alliance for CSA in Africa and WBCSD, representing major commitments by CCAFS partners. CCAFS is involved in helping frame these targets and will co-develop activities to contribute to them.

Leadership, management and governance

The CCAFS governance model from Phase I, which has been favourably reviewed, will be maintained with minor modifications (detailed roles and responsibilities are on the CCAFS website). The Lead Centre is CIAT.

Governance: The Independent Steering Committee (ISC) will have the exact responsibilities given in the CGIAR Guidance for Pre-Proposals. It will have: 7 independent members (with gender, geographical and disciplinary diversity, and mixed experience from academia, development agencies and the private sector) and 4 *ex officio* members, namely the Lead Centre DG, the CRP Director, a Future Earth representative (representing non-CGIAR partners), and a DG representing CGIAR Tier 1 partners. It will meet twice per year (once physical and once virtually), as well as conduct business by emails when required.

Leadership and management: Initial feedback from the External Evaluation is positive and thus no change of leadership is envisaged. The core team will be: CRP Director, 4 Flagship Leaders (FLs), 5 Regional Program Leaders (RPLs), and 2 cross-cutting leaders (all named in Annex 9; CVs in Annex 10). All core team members will be performance-assessed by their line managers in their organisations, with inputs by the Director. All were selected competitively in previous phases of CCAFS.

The CRP Director will be responsible for intellectual leadership and representation; sign off on deliverables; facilitating fund raising; ensuring that all CRP strategies (e.g. gender, M&E, learning, knowledge management, theory of change, partnership and capacity development) are prepared, updated and implemented; and have decision-making authority with respect to day-to-day operations. The CRP Director will report administratively to the DG of CIAT and programmatically to the ISC Chair. The Coordinating Unit will consist of the Director and administrative, data management and communications support.

The FLs will be primarily responsible for: Flagship programmatic coherence; facilitating and participating in the delivery of international public goods (IPGs); technical backstopping for projects in their Flagship

portfolio; facilitating development outcomes through their global partners; and ensuring integration with the other I-CRPs. Phase I demonstrated the crucial role of the RPLs, who will be primarily responsible for: the updating of national to regional theories of change and the delivery of development outcomes, through coordination, strategic partnerships, capacity development; technical backstopping of projects; and integration of work with AFS-CRPs. Flagships and Regions will work in a matrix. A Phase I evaluation (Ash 2013) has shown that the matrix management was effective in the delivery of both IPGs and outcomes. The two cross-cutting leaders are responsible for delivery of outcomes and IPGs across the program. The GSI Research Leader will ensure that gender and social inclusion are mainstreamed, and facilitate the delivery of gender-related IPGs. The Global Engagement Research Leader will facilitate delivery of IDOs and IPGs related to global policy processes and private sector peak bodies (e.g. WBSCD).

The Program Management Committee (PMC) will have the following responsibilities: ensuring coherence across Centres, CRPs, Flagships, Regions and partners; preparing and implementing a fund-raising strategy that links to all partners; preparing, updating and implementing all CRP strategies; preparing the annual plan of work and budget; preparing annual reports; preparing inputs to the ISC. The PMC, drawn from the above-mentioned core team, comprises Bruce Campbell (CRP Director, CIAT), Andy Jarvis (F1 Leader, CIAT), Lini Wollenberg (F3 Leader, U Vermont), James Kinyangi (East Africa RPL, ILRI), Pramod Aggarwal (South Asia RPL, CIMMYT), Sophia Huyer (GSI Leader, WISAT) and Sonja Vermeulen (Global Engagement Research Leader, U Copenhagen). They will meet 11 times per year (9 virtually and 2 physically).

Strategic Partners' roles in governance: 14 Centres have expressed an interest to be Tier 1 (Strategic) Partners (all except CIP). It is not feasible for CCAFS to reduce this number as climate change is indeed of relevance to all CGIAR Centres. For this reason, all Centres will have representation on the ISC through an elected CGIAR DG. Similarly, CCAFS has a number of non-CGIAR Strategic Partners – partners that: leverage significant resources for work on a CCAFS-partner jointly defined agenda (e.g. IRI); lead projects within CCAFS (e.g. CARE, IIRR); lead Flagships within CCAFS (e.g. Vermont); have a global or regional mandate for development (e.g. IFAD, GIZ, CTA); peak bodies for various stakeholder groups (e.g. WBSCD, PAFO). These partners will be represented on the ISC through Future Earth (for Strategic Partner roles - Annex 5, Table 5.5).

Each Strategic Partner will have a named Contact Point, with responsibilities tailored to the partner roles. The CGIAR Contact Point responsibilities include: building strategic and operational links between CCAFS and their Centre (including other Centre CRP activities); building effective cross-Centre collaboration; work plan and budget development, and reporting for their Centre contribution to CCAFS; contributing to CCAFS strategic development. Contact Points report to their line managers with input by the Director.

Given the large number of Centres/non-CGIAR Strategic Partners, a Partnership Advisory Committee (PAC) will be established comprising Centre Contact Points and non-CGIAR Strategic Partners. PAC will meet once per year: to assess CCAFS' mission to deliver on "Clear partnerships and collaborative arrangements built on trust, ownership and joint commitment to vision and impacts" (Campbell et al. 2006); to discuss CCAFS strategies and possible changes; to review progress and lessons; and to discuss specific partnership issues needing resolution. PAC will feed directly into the ISC through *ex officio* representatives. To reduce transaction costs, PAC will convene on the sidelines of global conferences.

Monitoring and evaluation: One of the ten assumptions in the ToC is that internal learning is crucial (Vermeulen & Campbell 2015). CCAFS has linked strategies for M&E and internal learning, that incorporate results-based management (RBM), and encompass: rigorous annual reflection (including reflections on ToCs), risk analysis, narrative reporting on development outcomes, regular reviews of both internal systems and development outcomes, longer-term learning cycles (e.g. utilizing baselines/ep-IAs) and ISC oversight. The CCAFS RBM system now incorporates the sub-IDOs to evaluate progress against impact pathways. Indicators are additive from projects to Regions to Flagships and link to the targets in the Performance Indicator Matrix. A web-based Planning & Reporting (P&R) system supports RBM. Each project will establish

its own baseline and M&E for specific indicators, using standardised procedures across the CRP. Where there are economies of scale across several projects, and for specific indicators, CRP-wide baselines and M&E will be established. CCAFS has good experience, having undertaken household, village and organisation baseline surveys in Phase I (Förch et al. 2014; Perez et al. 2015).

Management budget

Planning process: During 2014, in preparation for the Extension Phase and Phase II, a new portfolio of activities was developed linked to regional priorities and impact pathways, and to global challenges. This was accomplished through competitive selection of R4D concept notes followed by integrated planning at regional level (involving in all 140 scientists and practitioners, 45% non-CGIAR partners) where concept note ideas were modified and/or combined to establish a portfolio of inter-linked projects, many involving multiple Centres. Research and engagement gaps were identified and filled; and global engagement strategies and the delivery of key IPGs were planned. The core team ran a modified Delphi process to guide the overall distribution of budget among Flagships. This planning remains relevant to Phase II, but with greater emphasis now placed on cross-CRP linkages.

Overall budget (Table 1): The starting assumption on the CCAFS Phase II budget is the budget expected for the Extension Phase (as in December 2014 prior to the 18% cut). From that Extension Phase 2015 budget, we expect a 10% cut on W1 and W2 due to projects that are ending, showing poor performance and through reduced management costs. Because of the above re-planning of the CCAFS portfolio (when non-strategic projects were cut), the bilateral funds at the start of 2017 will be relatively low, but will grow through time. As Centres commit to CCAFS in Phase II, W3 is assumed to be 20% higher than it was in 2015, while W3 + bilateral are expected to equal W1 + W2. By the second three year period of Phase II, W3 + bilateral are expected to be double W1 + W2. CCAFS management posits that a strong strategic focus is better than a large portfolio of dispersed activities driven by bilateral funding. Bottom-up planning has identified the projects and activities that can be accomplished with this budget in 2017.

Table 1. Budget assumptions for CCAFS Phase II, in relation to the 2015 budget (USD 000s)

Funding Source	2015 (post 18% cut)	Average annual budget 2017-2019	Average annual budget 2020-2022	Total II Phase 2017-2022	%
W1+2	40,454	36,409	36,409	218,452	40%
W3	9,744	11,692	11,692	70,154	13%
Bilateral	12,274	24,716	61,125	257,524	47%
Total	**62,471**	**72,817**	**109,226**	**546,130**	**100%**

Management costs constitute 2.9% of the overall budget, covering the activities and staff positions of the Coordinating Unit, including communications, data management, administrative support, governance meetings, and annual costs incurred by CIAT as Lead Centre.

Partnerships for research and development outcomes are a crucial component of the ToC. CCAFS will allocate 25-30% of its budget to partners. This amount is expected to leverage own-resources from within partners at 2-3 times that level. The **capacity development** budget is expected to take up 35% of the overall budget, some allocated through the partnership budget but other coming from CGIAR staff costs and operational expenses. **Gender** research will comprise 17% of the overall budget, a slight rise from what was allocated in Phase I (the amount allocated to gender across all budget categories).

Budgets to Flagships (Table 2): The largest budget in the first 3-year period goes to F1 so that national to global policy processes and outcomes (F4) are grounded in the realities of farms and livelihoods (the focus of F1). F1 integrates productivity, adaptation and mitigation, whereas F2 is focusing more tightly on the risk management aspects of adaptation and F3 providing technical and institutional backstopping on mitigation. F4 gets slightly higher budgets than F2 and F3; the CCAFS and F4 vision is to facilitate policy and

institutional change in national to global policy processes, and thereby drive appropriate and scaled-up CSA investment. In the second 3-year period, the budget to F2 and F3 will rise relative to other Flagships as we assume that the global community and developing countries will devote more attention to intensified climate extremes (F2) that will also drive more funding to cutting emissions (F3).

Table 2. Flagship budget assumptions for CCAFS Phase II, in relation to the 2015 budget (USD 000s)

Flagship	2015 (post 18% cut)	Average annual budget 2017-2019	Average annual budget 2020-2022	Total II Phase 2017-2022	%
Flagship 1. Climate- Smart Practices	22,982	26,788	33,860	181,943	33%
Flagship 2. Climate Information Services	10,941	12,753	22,937	107,071	20%
Flagship 3. Low-Emissions Development	12,778	14,894	26,214	123,324	23%
Flagship 4. Food System Governance under Climate Change	15,771	18,383	26,214	133,792	24%
Total	**62,471**	**72,817**	**109,226**	**546,130**	**100%**

Co-investment: Of its total budget in 2017, CCAFS will allocate c. USD 26 million to co-investment with other CRPs (see Annex 5, Tables 5.1 & 5.4). Amounts to be allocated by other CRPs are still to be determined during the planning process for the full proposal.

Outcome targets: The outcome targets in the Performance Indicator Matrix (also Annex 6, Table 6.1) are based on collaborative planning with projects and analysis of scientific evidence. Outcome delivery in Phase I also served as a guide to what is feasible. For example, after three seasons of work, climate advisories were distributed to 4 million farmers in Senegal. After a few seasons of work in India, new weather-based insurance products are likely to reach 1 million farmers by the end of 2015. An ep-IA on Laser Land Levelling indicates that 0.5 million hectares have already been covered by this technology (Gill 2014). In all five CCAFS targeted Regions, multi-stakeholder scenario building with associated quantitative modelling (IMPACT and GLOBIOM) was the entry point for national engagement in about 15 countries, providing further evidence of what can be achieved (Vervoort et al. 2014; Palazzo et al. 2014). Projects and regional programs have identified concrete opportunities in the public and private sector for the delivery of research-informed outcomes (e.g. as a key partner to the NEPAD project to deliver on CSA for 6 million farmers; as a partner with WBSCD to establish and implement CSA targets for the global private sector). Engagement strategies are in place or are being put in place to increase the likelihood of success. The CCAFS core team and partners are highly attuned to identifying opportunities for engagement with stakeholders that can deliver outcomes, one of the assumptions underlying the CCAFS ToC (Vermeulen & Campbell 2015).

Value for money: Calculations on value for money (see Annex 6, Table 6.2) indicate that over the 6-year period CCAFS will budget USD 8-18 per farmer household for different Flagships, with differences amongst Flagships related to relative effort needed, and the degree to which external stakeholders are able to facilitate particular outcomes. For example, the research cost of getting innovative mitigation finance to farmers (F3) is likely to be double that of adaptation, agriculture and food security finance (F1, F2), given that adaptation and food security are the priority for most countries and agencies. CCAFS believes that it will reach high targets for money invested in CSA that has been informed by CCAFS science, with research costs of USD 1 informing nearly 20 times as much CSA investments. Building the capacity of key research user agencies is estimated to cost about USD 100,000-200,000 per agency. To ensure research-based outcomes in key development agencies requires about USD 1 million over a 6-year period.

Consolidated performance indicator and budget matrix

Name of CRP	CLIMATE CHANGE, AGRICULTURE AND FOOD SECURITY (CCAFS)	
Overall contribution to 2022 Targets in 2016 - 2030 SRF:	*Number of farm households that have adopted improved varieties, breeds or trees, and/or improved management practices (millions), (with benefits to women – millions).*	*12.5 (7)*
	Number of people, of which 50% are women, assisted to exit poverty (millions).	*3.75*
	Additional people, of which 50% are women, meeting minimum dietary energy requirements (millions) (tentative target).	*3.75*
	Percent reduction in women of reproductive age who are consuming less than the adequate number of food groups (tentative target).	*0.015*
	Reduction of agriculturally-related greenhouse gas emissions compared with 2015 (% and Gt CO2e yr-1).	*0.2 (8%)*
	ha of forest saved from deforestation (million).	*2*

	Totals at CRP level:	546,130	15,745	92,491

	Expected Performance Outcomes (numbers cumulate to the totals in 2022)							Budget Elements (US$)		
Flagship projects (each outcome below is aligned to a specific sub-IDO -underlined)	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Means of verifiying performance against outcomes**	**2017 - 2022 Total** (Note A)	**Total dedicated to administration/ Management**	**Total dedicated to ensure gender-responsiveness**
Flagship 1: *Climate Smart Practices and Portfolios*								181,943	5,245	29,041
Outcome 1.1: Reduced production risks (Number of farm households with reduced production losses related to CC, with increased benefits for women (millions)).			3			8	Baseline survey of current practices, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey and ep-IA.	36,480	1,052	4,888
Outcome 1.2: Improved access to financial and other services (Number of farm households with improved access to capital, new business models and novel finance, with increased benefits for women (millions)).			0.8			3.5	Baseline survey of current financial flows, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey and ep-IA.	8,315	240	565
Outcome 1.3: Increased access to productive assets, including natural resources (Number of sub-national organisations and institutions that are adapting their plans and directing investment towards climate-smart food systems to increase equitable access to productive assets).	5	10	25	30	40	53	Baseline survey of organisational practices, strategies showing link to ToC , outcome statements from projects and external check thereof, resurvey of organisations.	29,529	851	2,835
Outcome 1.4: Improved forecasting of impacts of climate change and targeted technology development (Number of site specific targeted CSA technologies/ portfolios tested, with all options examined for their gender implications).	15	20	30	40	50	60	Outcome statements from projects and external check thereof.	41,046	1,183	5,295
Outcome 1.5: Enhanced capacity to deal with climatic risks, extremes (Number of farm households with strengthened adaptive capacity and food security, with increased benefits for women (millions)).			3			8	Baseline survey of adaptive capacity, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey and ep-IA.	38,372	1,106	5,027
Outcome 1.6: Gender-equitable control of productive assets and resources (Number of households where women have increased control over productive assets and resources (million)).			1.5			4	Baseline survey of women's control, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey and ep-IA.	26,382	761	10,236
Outcome 1.7: Increased capacity of beneficiaries to adopt research outputs (Number of key next user agencies of research outputs that demonstrate progress on at least two of five core capabilities to adopt research outputs).	1	2	4	6	9	12	Baseline of current capacity, key informants in next user groups, evidence in correspondence, strategies showing link to ToC.	1,819	52	195

	Expected Performance Outcomes (numbers cumulate to the totals in 2022)							Budget Elements (US$)		
Flagship projects (each outcome below is aligned to a specific sub-IDO - underlined)	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Means of verifiying performance against outcomes**	**2017 - 2022 Total (Note A)**	**Total dedicated to administration/ Management**	**Total dedicated to ensure gender-responsiveness**
Flagship 2: ***Climate Information Services and Climate-Informed Safety Nets***								107,071	3,087	20,879
Outcome 2.1: Improved access to financial and other services (Number of farm households with improved access to weather-related insurance, with increased benefits for women (millions)).			4			8	Baseline survey of current insurance products and reach, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey and ep-IA.	24,626	710	3,694
Outcome 2.2: Improved forecasting of impacts of climate change and targeted technology development (Number of national/state governments or regional bodies using climate-based seasonal agricultural prediction and early warning to improve planning, food security intervention).	4	8	12	15	18	20	Baseline survey of organisational practices, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey of organisations.	18,202	525	-
Outcome 2.3: Enhanced capacity to deal with climatic risks, extremes (Number of farm households with strengthened adaptive capacity and food security, with increased benefits for women (millions)).			6.5			15	Baseline survey of adaptive capacity, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey and ep-IA.	43,899	1,266	6,585
Outcome 2.4: Enabled environment for climate resilience (Amount of new investments by national, regional and global agencies, that is informed by CCAFS science and engagement ($ million invested)).	13	26	39	52	65	80	Baseline database of investments in climate information services (with GACSA and WMO), strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey of organisations.	6,424	185	642
Outcome 2.5: Participation in decision-making (Number of households where women's participation in decision making has improved – in decisions over own labor, over own income and in groups or collective organization (million)).			3.25			7.6	Baseline survey of women's participation in decision-making, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey and ep-IA.	12,848	370	9,636
Outcome 2.6: Increased capacity of beneficiaries to adopt research outputs (Number of key next user agencies of research outputs that demonstrate progress on at least two of five core capabilities to adopt research outputs).	1	2	4	6	9	12	Baseline of current capacity, key informants in next user groups, evidence in correspondence, strategies showing link to ToC.	1,071	31	321
Flagship 3: ***Low Emissions Development (LED)***								123,324	3,555	24,295
Outcome 3.1: Improved access to financial and other services (Number of farm households with improved access to capital, new business models and novel finance, with increased benefits for women (millions)) .			1			2	Baseline survey of current financial flows, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey and ep-IA.	14,799	427	2,960
Outcome 3.2: More efficient use of inputs (Number of farm households with more efficient use of inputs, with increased benefits for women (millions)).			3.25			8.8	Baseline survey of current practices, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey and ep-IA.	14,799	427	2,960
Outcome 3.3: Land, water and forest degradation (including deforestation) minimized and reversed (Number of hectares where deforestation has been avoided (millions)).			1			2	Use of 1-3 global forest monitoring systems to track deforestation, strategies showing link to ToC, outcome statements from projects and external check thereof, ep-IA.	18,499	533	1,850
Outcome 3.4: Reduced net greenhouse gas emissions from agriculture, forests and other forms of land use (Gt CO2e/yr).			0.1			0.2	Use of GHG calculators to track GHG emissions in relation to practices, baseline survey of practices, strategies showing link to ToC, outcome statements from projects and external check thereof, ep-IA.	49,330	1,422	7,399
Outcome 3.5: Increased above and below ground biomass for carbon sequestration (Gt CO2e yr-1).			0.3			0.89	Use of carbon models to track changes in relation to practices, baseline survey of practices, strategies showing link to ToC, outcome statements from projects and external check thereof, ep-IA.	12,332	356	2,590
Outcome 3.6: Participation in decision-making (Number of households where women's participation in decision making has improved – in decisions over own labor, over own income and in groups or collective organization (million)).			2.25			4.4	Baseline survey of women's participation in decision-making, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey and ep-IA.	12,332	356	6,166
Outcome 3.7: Increased capacity of beneficiaries to adopt research outputs (Number of key next user agencies of research outputs that demonstrate progress on at least two of five core capabilities to adopt research outputs).	1	2	4	6	9	12	Baseline of current capacity, key informants in next user groups, evidence in correspondence, strategies showing link to ToC.	1,233	36	370

	Expected Performance Outcomes (numbers cumulate to the totals in 2022)							Budget Elements (US$)		
Flagship projects (each outcome below is aligned to a specific sub-IDO - underlined)	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Means of verifiying performance against outcomes**	**2017 - 2022 Total (Note A)**	**Total dedicated to administration/ Management**	**Total dedicated to ensure gender-responsiveness**
Flagship 4: ***Food System Governance Under Climate Change***								133,792	3,857	18,276
Outcome 4.1: Optimized consumption of diverse nutrient-rich foods (Number of organisations and institutions in selected countries/states adapting plans and directing investment towards climate- and nutrition-smart food systems to optimise consumption of diverse nutrient-rich foods).	0	2	5	10	18	35	Baseline survey of organisational practices, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey of organisations.	45,489	1,311	9,098
Outcome 4.2: Improved forecasting of impacts of climate change and targeted technology development (Number of countries/states where CCAFS projections and priority setting used to target and implement technology interventions in food systems / value chains (priority setting)).	4	8	12	16	20	25	Baseline survey of current country situation, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey of countries.	28,096	810	-
Outcome 4.3: Enabled environment for climate resilience (Number of global/regional organisations that have increased their equitable institutional investments in climate smart food systems).	2	4	7	10	12	14	Baseline survey of organisational investment practices, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey of organisations.	22,745	656	1,820
Outcome 4.4: Enabled environment for climate resilience (Amount of new investments by national, regional and global agencies, that is informed by CCAFS science and engagement ($ million invested)).	20	60	100	200	350	400	Baseline database of investments in CSA (with GACSA), strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey of organisations.			
Outcome 4.5: Gender-equitable control of productive assets and resources (Number of national/state organisations and institutions that are adapting their plans and directing investments towards climate-smart food systems to increase women's access to, and control over, productive assets and resources).	1	2	4	8	13	25	Baseline survey of organisational practices, strategies showing link to ToC, outcome statements from projects and external check thereof, resurvey of organisations.	34,786	1,003	6,957
Outcome 4.6: Increased capacity of beneficiaries to adopt research outputs (Number of key next user agencies of research outputs that demonstrate progress on at least two of five core capabilities to adopt research outputs).	1	2	4	7	10	14	Baseline of current capacity, key informants in next user groups, evidence in correspondence, strategies showing link to ToC.	2,676	77	401

Gender summary

Gender as a crucial focal area in climate change research

In least developed countries 79% of economically active women report agriculture as their primary economic activity, while rural women play an increasing role in smallholder agriculture as a result of out-migration of males (FAO 2011; Carvajal-Escobar et al. 2008). Research presented at a CCAFS-facilitated meeting in Paris in 2015 reviewed the implications of climate change and found that 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). Women appear to be less able to adapt because of financial or resource constraints as well as less access to information and extension services (Twyman & Koningstein 2015; Jost et al. 2015; Twyman et al. 2014; Tall et al. 2014). In rural Bangladesh, women are less likely to buy micro-insurance if risk is low-probability, while men are likely to buy more units of insurance (Clarke and Kumar 2015). Women's participation in REDD+ decision-making processes in Vietnam is low (Thuy et al. 2015); a similar situation is expected throughout the broader agriculture and climate change community. In Nicaragua, while women are viewed as agents of adaptation, understanding of gender and climate change does not take into account the root causes of gendered vulnerabilities (Gonda 2015). Women are also important agents of change in response to climate-induced change: engaging women in technology design and management decisions improves community outcomes and is a central component of gender justice (Edmunds et al. 2013), while women's resilience strategies and local environmental knowledge are valuable resources for recovery and adaptation (UNDP 2011; WEDO 2007). Despite this, gender is not well integrated into climate change policy (Acosta et al. 2015; Huyer 2014).

Rural women in particular are at high risk of negative impacts from climate change, due to household responsibilities including childcare, fuelwood and water collection as well as increased agricultural work when men out-migrate to urban areas for employment. One of the important effects of environmental stress in farming systems (such as those imposed by climate change) is the intensification of women's workloads, while another is decreases in assets of poor households (Jost et al. 2015; Agwu & Okhimamwe 2009; Goh 2011). Climate variability and weather-related shocks affect women's and men's assets in different ways. Cultural norms can affect control and ownership of assets during drought, e.g., in one case women gained increased control of the household's livestock because men sold their livestock first (Kristjanson et al. 2010). Women and men are also changing cropping practices in response to climate variability, with different impacts on control of the income from crops and on workloads (Jost et al. 2015; Nelson & Stathers 2009). CSA options have the potential to provide benefits for women – when they have access to information on CSA, they are just as likely as men, if not more so, to adopt the practices. In Kenya the most rapid adoption of climate-resilient farming was among women whose husbands were away and not making the day-to-day decisions. However, the possibility of increased labour loads is a significant barrier for women (Twyman et al. 2014; Bernier et al. 2015; Jost et al. 2015; Goering 2015).

These examples illustrate the centrality of gender research in work on agriculture under climate change. Changes in farming systems that are likely to occur in the face of climate change make it more important. Some are topics of research in CCAFS, such as transformative adaptation including accelerating out-migration (F4), increasing frequency of extreme events and the reshaping of widespread climate-informed safety nets (F2) and massive investments in CSA (F1). These processes need to be understood and actions put in place to ensure that gender and social inclusion is achieved.

Gender and Social Inclusion (GSI) Strategy

Social inclusion involves gender, socioeconomic status, ethnicity and age (youth and seniors) and affects dynamics around perspectives, needs and access to resources (FAO & CCAFS 2013). Scientific information and

agricultural assets are set within contexts of power relationships, and thus existing gender norms and power inequalities will influence climate change impacts and adaptations. For example, ethnic, gender, and seniority hierarchies were found to influence the processing of climate information among different groups in Uganda (Roncoli 2006; Rossi & Lambrou 2008; Moser 1993; Boyd 2010). While the focus in the "Gender Summary" is on gender, CCAFS will conduct gender research within a broader framework of power and inclusion.

To ensure that the CRP can deliver to the ToC, a new GSI strategy is being put in place.[1] It is a framework for the integration of gender into research in keeping with commitments in the CGIAR SRF. The goal is to ensure that rural women benefit from the CRP contribution to the three CGIAR SLOs. In support of this goal, the CRP will undertake research that can inform, catalyze and target CSA solutions to women and other vulnerable groups, increase the control of disadvantaged groups over productive assets and resources (including, e.g., climate information, novel climate finance), and increase participation in decision making (e.g. in local and national climate adaptation strategies). The GSI Strategy focuses on women as central to agriculture in developing countries within a broader social context. This focus is appropriate since gender equality is a key leverage point for change given women's important roles in in agricultural production, food security, nutrition and livelihoods. Addressing gender equality will open spaces for addressing other inequalities.

Gender in the CRP will be approached primarily as a cross-cutting theme incorporated via strategic and integrated research. The workplan and objectives for **strategic research** are in the process of development but will fall under five categories: (1) Analysis of data collected to date in the Gender Household Survey, to provide a baseline in relation to the gender and youth sub-IDOs (CCAFS et al. 2013)[2]; (2) Revision and repackaging of the content of the Gender and Inclusion Toolbox for Participatory Climate Change Research (Jost et al. 2014) and other resource guides based on user experience and feedback, including development of an online curriculum, as requested by partners. This work will be complemented by gendered participatory research in all Flagships; 3) Research related to enabling mechanisms to promote women's control of resources and access to decision making in CSA policy and programming; (4) Research related to climate finance and global climate policy processes, investigating the degree to which they can enhance gender equality; (5) Connecting and synthesizing research across Flagships on related topics, and providing supporting/supplementary research. A review is being undertaken on CCAFS gender-related activities to date, to identify gaps and future priorities, in consultation with Flagship and Regional Program Leaders, the gender and CC network, the CGIAR Gender and Agriculture network, and external partners. Strategic Partners will provide additional expertise as needed.

GSI **integrated research** will focus on integrating gender into CCAFS work. Mechanisms include: 1) gender focal points at Centres; 2) gender analysis in design, during the implementation phase and in ep-IAs; reporting on gender indicators, outputs and outcomes; 3) integrating gender research into operational manuals/guides/workplans as well as developing GSI manuals and guides; 4) allocating resources explicitly for gender-specific research and activities to support implementation (e.g. a review of sex-disaggregated methodologies for agriculture and climate change research); 5) integrating gender research in the regional impact pathways.

[1] Through a globally competitive process CCAFS hired a Gender and Social Inclusion Leader as a result of the major programmatic changes made in 2014, and Sophia Huyer (WISAT) took up this position in May 2015. A first task is the updating of the CCAFS gender strategy.

[2] The Survey covers asset ownership, climate change perceptions, awareness and adoption of CSA practices, farming and household decision-making; participation and decision-making in groups, sources of information, etc.

Research will be communicated to other researchers, advocacy groups and policy makers through policy briefs summarizing key findings and recommendations; toolkits; info briefs; and working papers. Forums for dissemination of the CRP work include the CRP GSI website; and contributions to international publications as well as presentations and panels. The CRP collaborates with partners on inputs into global policy processes.

Theory of change (ToC) for delivering gender outcomes

The CRP GSI ToC (Annex 7, Fig. 7.2) integrates gender into the four areas identified by Lipper et al. (2014) for large-scale, equitable adoption of climate-smart practices, services and institutions: 1) Implementing a program of integrative and strategic research to "build evidence" that is informed by gender research; 2) Enhancing the role of women in local institutions; 3) Ensuring that gender and women's empowerment are dealt with in coordinated climate and agricultural policy; 4) Building mechanisms to engender finance.

Achieving the SLOs

The CGIAR SLO targets will not be reached unless gender and social transformation are integral to actions taken to achieve them. Women can be vulnerable to climate change, but they are also powerful agents of change and sources of solutions and responses to change. Their role in the household along with childcare, food security, health and livelihood activities make them important leverage points for positive change. Climate change related trends such as depletion of natural resources, decreasing assets and agricultural productivity will affect women's incomes and livelihoods in particular as a result of lower levels of access to resources and decision making (OECD 2003). Increasing investment in CSA and enacting climate-smart policies and plans that increase access to productive assets for both men and women smallholders will significantly increase productivity and food and nutrition security, improving the diets of millions.

Gender development outcomes

Each Flagship includes indicators for one gender sub-IDO and has gender dimensions on 1-5 of its other sub-IDOs (Annex 11). In all, CCAFS focuses on 2 of the gender sub-IDOs (control and participation), but activities will also assess the effects on workloads of women and youth. In addition, of the 14 other sub-IDOs for CCAFS, 7 have indicators that include a gender dimension (Annex 11).

The 2030 target for CCAFS is to bring benefits to 15 million women (see e.g. Flagship 1 and 2 visions). This will involve in F1: research on gender and social dimensions of promising CSA options to *reduce production risk* (sub-IDOs in italics); identifying gender-sensitive options for scaling out by major development agencies; and identifying trade-offs among food security, adaptation, and mitigation of CSA practices and portfolios for men and women. *Increased access to productive assets, including natural resources* will be another priority area, targeting local climate change adaptation planning. *Enhanced smallholder market access to financial and other services* for women and men will be another targeted sub-IDO (F1, F2, F3) and will be part of scaling up strategies that include gender and diversity objectives. This includes developing methods to identify and meet gender-specific climate service needs and increasing the access of FHH and women in MHH to capital through weather-based insurance (F2). Different mechanisms of getting climate-informed advisories to women will be tested and examined for their outcomes with a focus on *improving capacity of women and young people to participate in decision-making.* Many of these activities will also lead to *enhanced capacity to deal with climatic risks and extremes.* Research on how women farmers can benefit from LED options will be complemented by metrics for M&E and analysis of impacts of LED on livelihoods, gender equity, food security and mitigation), together with a focus on *increasing resource efficiency* and *enhancing women's participation* in decision-making around options (F3). Increased influence for women in LED decision-making will be supported by analysis of opportunities and strategies. *Gender-equitable control of productive assets and resources* will also be a focus at the policy level (F4) as part of the strategy to achieve an *enabled environment for climate resilience.* This work will include gender and social inclusion analyses of current and emerging food systems

policies in relation to climate change. Outputs from all the above activities will include gender-appropriate communications, and capacity development materials and strategies as well as equitable public-private partnerships and business models. National level tools include training and planning materials as well as policy documents integrating gender into nutrition and food security. All such materials will be supplemented by deep engagement with key agents of change. Partners will report annually on gender activities and achievements, as well as on the gender indicators (Annex 11).

Hypotheses for achieving the IDOs: *H1* National policies that are informed by evidence and deep engagement between policy makers and advocacy groups will increase women's empowerment; *H2* CSA options that cater to gender and social inclusion will increase women's control of productive assets at the local level and be up-scalable; *H3* Private sector investment goals in CSA that are aligned with the goals of vulnerable farmers will increase local control of productive assets; *H4* Addressing household conflict resulting from women's increased control of productive resources will lead to increased empowerment; *H5* Decreasing labour and energy expenditures of women and youth through CSA practices and options will lead to increased empowerment of both groups. All these hypotheses will be examined in the course of the research.

Organization and Management

Gender specialists are located in Centres. They generally work across Flagship programs and often across CRPs. The current gender FTE is approximately 21. This number is expected to increase as vacant positions in centres are filled. A Gender and Social Inclusion Research Leader and Program Manager will coordinate GSI work and provide inputs to the Regional Program Leaders and Flagship Leaders on design, implementation and monitoring. Through results-based management, insufficient attention to serious gender research will be penalized by budget adjustments (CCAFS is currently doing a gender audit). CCAFS will also coordinate a system-wide gender and CC network to promote collaborative research and programs; sharing of methods, tools, and approaches; and exchange of experience on project design, proposal writing, and implementation. It will actively participate in the new gender platform. Members of the CCAFS gender network have close links with other CRPs (including individuals from the AFS-CRPs and I-CRPs), and so will be key nodes to ensure connections. CCAFS management and governance bodies are updated regularly on gender research through membership of the GSI Leader on the PMC; major seminars presenting gender research; periodic gender reviews and other activities. Currently 2 of 6 members of the PMC are women (this will shift to 3 out of 7 in Phase II), while 1 of 4 FLs and 1 of 5 RPLs are female.

Partnerships

CCAFS GSI has developed a range of partnerships with research institutions and civil society from ongoing gender research, both integrated and strategic. University and research partners have included the University of Florida (support to the gender survey), University of Pretoria, and NARES (e.g. in Tanzania this involved training of women on the use of a Climate Scenarios and Analogues tool for designing adaptation strategies). Civil society partners include ProLinnova (mitigation innovations by smallholder farmers), Ecohabitats in Colombia, VI Agroforestry (Kenya), SARI (Tanzania), IIRR (Vietnam), CARE (Global and Vietnam), CATIE (Central America) WOCAN and WISAT. Because WISAT, CATIE and CARE are Strategic Partners (Annex 5), their perspectives on GSI progress will be fed into the CCAFS ISC through the PAC.

Enabling environment for women scientists

The CRP supports women's active participation in research, capacity building, policy engagement activities and events at local, national, regional and international levels. It will increase access of women scientists to research and training opportunities, as proposed by F3. It has a policy of recruitment and leadership development of women scientists working in Flagships.

Table of target beneficiaries and target countries at CRP level

Results or outcomes	Target IDOs and sub-IDOs	Total number of poor smallholders	Total number of other beneficiaries	Target countries	Key assumptions
Widespread adoption of CSA practices, to promote food security, resilience and, where feasible, reduced emissions; with positive impacts for women	Reduced production risks; Increased access to productive assets, including natural resources; Gender-equitable control of productive assets and resources; Enhanced capacity to deal with climatic risks, extremes; Improved forecasting of impacts of climate change and targeted technology development; Increased capacity of beneficiaries to adopt research outputs	Globally, 500 million, both women and men (the GACSA target for 2030)	500+ development agencies with better information to drive CSA development	WA (Mali, Niger, Burkina Faso; Ghana; Senegal, Nigeria); EA (Tanzania, Kenya, Uganda, Ethiopia, Rwanda); SA (Nepal, Bangladesh, India); SEA (Vietnam, Cambodia, Laos, Myanmar, Philippines); LAM (Honduras, Guatemala, Colombia, El Salvador, Peru)	By working within the major global players (e.g. World Bank, FAO, IFAD, DFID, GIZ, NEPAD, iNGOs etc) the reach of CCAFS will go far beyond the target sites and countries; CCAFS will have to be highly strategic in partnership development to ensure the most promising impact pathways are selected for attention
Strengthened adaptive capacity and food security, with increased benefits for women, through climate information systems and climate-informed safety nets	Enhanced capacity to deal with climatic risks, extremes; Participation in decision-making; Increased capacity of beneficiaries to adopt research outputs; Improved forecasting of impacts of climate change and targeted technology development	Globally, 500 million, both women and men (the GACSA target for 2030)	500+ development, meteorological, humanitarian and insurance agencies with better information to drive development	(as above)	Bringing the meteorological, agricultural, insurance and humanitarian communities together will have major payoffs for smallholder farmers; science can make progress in weather forecasts and designing better insurance triggers for weather-based insurance
Major increase in new and appropriate investments in CSA, climate information service and climate-informed safety nets for smallholders, and in low emissions development approaches	Improved access to financial and other services; Improved forecasting of impacts of climate change and targeted technology development; Increased capacity of beneficiaries to adopt research outputs	Globally, 500 million, both women and men (the GACSA target for 2030)	1000s of farmer's organisations, youth groups, women's groups, local civil society actors and local input suppliers; 100s of investors with enhanced capacity to direct investments to appropriate CSA	(as above)	CCAFS is able to produce the appropriate knowledge products to drive investments, coupled with good engagement strategies with investment agencies

Reduced net GHGs from agriculture, without compromising food security and gender and social inclusion objectives	Reduced net greenhouse gas emissions from agriculture, forests and other forms of land use; More efficient use of inputs; Land, water and forest degradation (including deforestation) minimized and reversed; Participation in decision-making; Increased capacity of beneficiaries to adopt research outputs	Globally, 500 million, both women and men (the GACSA target for 2030); though recognized that emissions reducing technologies will only be applicable to a portion of these	Society at large through reduced GHGs; 1000s of farmer's organisations, youth groups, women's groups, local civil society actors and local input suppliers through better knowledge about what is possible in low emissions development	WA (Ghana; Nigeria); EA (Tanzania, Kenya, Uganda, Ethiopia, Rwanda); SA (Nepal, Bangladesh, India); SEA (Vietnam, Cambodia, Laos, Myanmar, Philippines, Indonesia); LAM (Honduras, Guatemala, Colombia, El Salvador, Peru, Madrid)	Win-win practices and policies for adaptation/food security on the one hand and mitigation on the other can be fostered; the politics of climate change do not derail research for development activities
Governance of food systems enhanced, with positive impacts for women	Optimized consumption of diverse nutrient-rich foods; Improved forecasting of impacts of climate change and targeted technology development; Gender-equitable control of productive assets and resources; Increased capacity of beneficiaries to adopt research outputs	Globally, 500 million, both women and men (the GACSA target for 2030)	1000s of organizations and institutions dealing with food systems;	WA (Mali, Niger, Burkina Faso; Ghana; Senegal, Nigeria); EA (Tanzania, Kenya, Uganda, Ethiopia, Rwanda); SA (Nepal, Bangladesh, India); SEA (Vietnam, Cambodia, Laos, Myanmar, Philippines); LAM (Honduras, Guatemala, Colombia, El Salvador, Peru)	CCAFS policy engagement strategies and science is state-of-the art so as to build trust and credibility with a wide range of policy actors; CCAFS is able to identify the key actors that can drive large scale change

PART 2

Flagship 1: Climate-Smart Practices and Portfolios

The vision

The F1 vision is that all farmers, including women and marginalized groups, are resilient and food secure despite a variable and changing climate. By 2030, F1 plans to enhance the adaptive capacity and food security of 30 million small-scale farmers, and reduce their GHG emissions, through the adoption of CSA, with benefits to at least 15 million women. Three key 2022 outcomes (see Performance Indicator Matrix for full list) are: (a) 8 million farm households, with *reduced production risk* and strengthened *capacity to deal with climatic risks* as a result of CSA adoption and programmatic investment at scale; (b) 3.5 million farm households with improved *access to financial services*, through new business models and novel finance (incl. climate finance), with increased benefits for women (see Annex 11 for methods); and (c) 4 million farm households with *increased control by women over productive assets and resources*.

The challenge

Agriculture and climate function hand in hand, and dysfunction hand in hand. Today, 32-39% of global yield variability is explained by climate, translating into annual production fluctuations of ~2 to ~22 million tons, for major crops such as maize, rice, wheat and soybean (Ray et al. 2015), whilst at the same time agriculture contributes 19-29% of global greenhouse gas emissions (Vermeulen et al. 2012). By 2050, FAO state that we need to deliver 60% more food for a growing global population with shifting consumption patterns (Alexandratos & Bruinsma 2012). And all this in a harsher climate - the IPCC report, through a global meta-analysis published by CCAFS Phase I researchers (Porter et al. 2014), reported that decreases of ~5 % in crop productivity are expected for every 1^{o}C warming above historical levels. Yield gains from adaptation through crop management and varietal substitution can play an important role, but are likely limited to moderate or low (< +3 ºC) levels of warming (Porter et al. 2014), suggesting that in some cases more profound systemic and/or transformational changes may be required in places at higher levels of warming. These global drivers and trends represent a truly grand challenge that requires concerted action.

GACSA, with 22 countries and a total of 96 members signed on, has the goal of reaching 500 million farmers with climate-smart agriculture practices, technologies and programs by 2030. This constitutes a challenge in scale of the likes rarely before seen in development. Farmers will require diverse interventions and support to match their unique but changing growing conditions, socio-economic context, and markets. Meeting the GACSA objective will require demonstrating the maturity of CSA interventions in diverse contexts, encouraging adoption and investment by the myriad of actors required to take the concept to scale, particularly among women and the private sector. While the challenge is grand, the political and financial will is finally keeping pace. CSA options are in high demand by a host of development actors. Developing countries are looking to CSA to provide them with viable options for national contributions (INDCs) for a climate agreement and SDGs in which all parties—developed and developing— will be asked to participate.

Despite the significant global action and investment now being oriented towards CSA, there is scant evidence on the synergies and trade-offs of different practices, technologies and portfolios towards the achievement of the distinct pillars of CSA. This Flagship focusses on supporting GACSA, its members and other players in the CSA space with research-informed knowledge to bring CSA to scale effectively.

Scientific rationale and theory of change

Numerous studies have shown that climate change can be a significant threat to food availability and stability by reducing agricultural productivity and increasing interannual variations in yields (Wheeler & von Braun 2013). Adaptation will be required if food production is

to be increased in both quantity and stability in order to meet food security needs during the 21st century. A climate-smart agriculture (CSA) approach is proposed as a solution to transform and reorient agricultural systems to support food security under the new realities of climate change. The F1 ToC assumes that CSA differs from "business-as-usual" approaches by emphasizing the capacity to implement flexible, context-specific solutions, supported by innovative policy and financing actions (Lipper et al. 2014). The ToC is aligned to the CRP ToC as illustrated in Annex 7, Fig 7.3.

F1 will contribute to two CGIAR SLOs: (a) Reduced poverty, (b) Improved food and nutrition security for health (Annex 4, Fig. 4.1). It will contribute to six IDOs (bold) and seven sub-IDOs (italics):

- **Increased resilience of the poor to CC and other shocks**; via *reduced production risk* to farm households as a result of adoption of CSA practices and portfolios.
- **Enhanced smallholder market access**; via smallholder farmers' *improved access to capital* through new business models and novel finance (including climate finance) with increased benefits for women.
- **Improved productivity**; via improved equitable *access to productive assets*, through local adaptation plans and directed investment from sub-national public-private institutions/actors.
- **Adaptation and mitigation achieved;** via *improved forecasting of impacts of climate change and targeted technology development* through analysis of trade-offs amongst CSA objectives, priority setting, and action research with farm households; and via farm households with *enhanced capacity to deal with climatic risks and extremes*, through adoption of risk-reducing CSA practices/actions.
- **Enabling environment improved**; via *increased capacities of next users to adopt research outputs* through mainstreamed efforts in capacity development.
- **Equity & inclusion achieved**; via farm households with *increased control by women over productive assets and resources* through all actions being implemented with a gender lens.

In developing the F1 ToC with partners, some key knowledge gaps were identified to achieve the targets proposed, and the CoAs have been constructed around the knowledge gaps. Research in Phase I and the Extension phase demonstrated that agricultural research has not taken a CSA lens to evaluate the benefits of a particular agricultural technology or practice (also see Branca et al. 2011), with fewer than 1% of studies examining all three CSA pillars (Rosenstock et al. preliminary findings). Notably, in the context of developing economies where adaptation is a priority, little is known about the mitigation effects of different adaptation strategies and vice versa. Even less knowledge is available on targeted, gender-responsive impacts on women's labor, gendered barriers to control of productive resources, and lack of access to information services (Twyman et al. 2014; Jost et al. 2015) and cross-commodity CSA portfolios (combinations of technologies, practices, and social/institutional innovations) at local levels. Greater evidence is needed to guide investments in CSA options and provide actionable information that addresses capacity gaps and facilitates scaled adoption of CSA portfolios to enhance food security in a changing climate and contribute to long-term mitigation targets. Evidence is needed on which practices and technologies generate CSA-related outcomes, where these practices should be targeted, the costs involved and their expected co-benefits or dis-benefits (including gender and labor aspects). Further, we need better understanding of instruments for achieving impact at scale, including enabling multi-level policy environments (sub-local to national), private sector involvement and novel financing and incentive systems for CSA (including both climate- and development- finance). CCAFS will assess the evidence of what works where for farmers and their

supporting organisations and institutions (public, private and non-governmental actors). Crucial components of the ToC include working with partners to deliver on outcomes, and building the capacity of key actors in the impact pathways (see sections below).

Specifically, two research hypotheses address the ToC for this Flagship:

Hypothesis F1 H1: Context-specific knowledge on the impacts of portfolios of practices, technologies and information systems on CSA-related outcomes as well as on their cost-effectiveness advantages compared to current practice, leads to adoption of CSA at the local level.

Hypothesis F1 H2: Improved understanding of the socio-economic, technical, financial and political enabling environments required to incentivize investment in and adoption of CSA practices and portfolios will lead to adoption of CSA at scale.

Partners for outcomes and research

As per the F1 ToC, achievement of the impact targets will largely be achieved through ensuring that CCAFS science is incorporated into the programming of large CSA investment programs and projects, hence downstream impact partners will be those with the greatest ambition and scope for CSA-related programming. F1 will collaborate with the major multi-lateral and bilateral agencies facilitating CSA investment and implementation (starting with GACSA, African CSA Alliance, FAO, World Bank, IFAD, DFID, USAID, GIZ, CTA) to develop the tools needed to prioritize, plan and bring CSA practices to scale. Regional bodies involved in CSA implementation are also involved, (e.g. Africa Union, NEPAD, ECOWAS, COMESA, APAN, CAC, ECLAC and IICA). A host of partners at national level (incl. government, private sector and civil society) will complement these efforts and ground the research to national realities. Impact partners are generally involved as collaborators, but do not receive funds and where appropriate represent significant leveraged funding for the Flagship.

The climate-smart village (CSV) approach – essentially a multi-stakeholder learning platform at key sites – will be used to trial options with partners. Each CSV is established with its own ToC, or linked into a national ToC to ensure that case study work builds into plans for scaling up. Many of the local partners from Phase I in the well-established CSVs will continue in Phase II. These partners were selected through robust analysis of institutional capacities, mandates and commitments to long-term place-based action research. Partnerships are well established, and continuity is a key criterion to ensure that the participatory platforms in CSVs deliver. Local NARES are a key partner in most CSVs. These partners receive long-term partner agreements with funding to cover their implementation costs. Local private sector actors will continue to be involved in CSVs in Phase II.

Other private sector partners are crucial for the F1 ToC, being heavily involved in the CoA related to innovative finance and CSA incentive instruments, including certification organisations (e.g. Rainforest Alliance) and impact investors (e.g. Root Capital). Other major agri-food companies are also involved through the WBCSD.

Non-CGIAR research partners have been identified to complement CGIAR expertise on key topics:

- *Agricultural research*: e.g. NARES from Vietnam, India, Nepal, Niger, Kenya, Colombia, Honduras.
- *Climate and agricultural modelling, GxE approaches*: Future Earth partners including University of Leeds, AgMIP, University of Florida.
- *Household modelling and data analytics*: Partners with strong track record on household approaches such as Wageningen University and CSIRO, and Penn State, HEIG-VD, Virginia Tech on analytics

- *Social and interdisciplinary sciences*: CATIE, International Institute of Rural Reconstruction (IIRR), Institut d'Economie Rural (IER), National University of Ireland Galway (incl. Masters and PhD postgraduate training)

Some of these partnerships involve sub-agreements for particular research input to the program, whilst others are collaborative and built on the premise of joint planning, and co-investment towards joint goals and targets on knowledge generation (e.g. AgMip).

Research questions

This Flagship has 7 CoAs. Three of them cover the testing of technologies and portfolios in Africa (1.1), Asia (1.2) and Latin America (1.3). But these multi-stakeholder learning platforms are situated within opportunities for scaling up, thus other CoAs focus on scaling through tools for making investment choices (1.4), sub-national adaptation planning processes (1.5) and finance and incentives (1.6). The longer-term agenda is catered for under 1.7 – using the information and tools to set in motion climate-sensitive breeding strategies.

CoA 1.1, 1.2 and 1.3 Participatory evaluation of CSA practices and portfolios CSVs in Africa, Asia, and LAM (Learning Platform)

CSVs are both a test-bed for generating greater evidence of CSA effectiveness (including innovations from AFS-CRPs and I-CRPs), and participatory action sites for grounding research on appropriate enabling conditions (policy, innovative finance and value chain innovations). CSVs are clusters of villages or landscapes. A key approach is to evaluate portfolios of options in addition to individual CSA options, and have robust action research to understand the effectiveness of options. Close integration with AFS-CRPs is envisioned to identify technologies and practices. The CoAs will draw on the successes of Phase I in 9 sites in Africa, 7 sites in Asia and 3 sites in LAM. The CSV concept is now being taken up by other agencies and CCAFS will contribute with information and advice in these other sites. The rationale is that significant investment is becoming available for scaling CSA, and a pipeline of tested CSA options, that can be adapted to different site-specific conditions, needs to be developed to maximise value for money of CSA-related finance. CSVs will generate evidence of CSA effectiveness at local scales (hypothesis 1) and inform appropriate incentives and scale-out strategies to generate greater CSA investment and outcomes (hypothesis 2).

Key research questions are: What are the relative synergies and trade-offs of different CSA portfolios in terms of productivity, adaptation and mitigation outcomes and their context-dependencies? What are the gender-, social-, health- and nutrition- dimensions of promising CSA options? How does a development agency target and adapt CSA practices (specific or combinations) for increased synergies and improved adoption? What are the appropriate local-level enabling environment conditions required to increase CSA investment and enhance adoption of practices and portfolios, and how might policy, finance and institutional innovations be designed to out-scale effectively? How do we know if CSA is effective and for whom?

This CoA will use a range of qualitative and quantitative methods across a broad set of CSVs in different biophysical, economic and social contexts to fill gaps in evidence on CSA best bets. Research outputs include:

- On-farm tested, and evaluated and up-scalable gender sensitive and specific CSA options (e.g. climate-adapted germplasm, agroforestry, aquaculture, water harvesting, soil and water management options, livestock nutrition), including transformative options, and models of integrated crop-livestock-tree systems for increasing resilience.
- Improved understanding of farmer's and stakeholders perceptions along the value chain of CSA options, and assessments of the conditions for success and failure of interventions.
- Simulation of CSA options under different climate and socio-economic scenarios for informed decision making (together with F4)

- Empirical and big-data analysis of climate-specific management options, generating climate sensitive extension schemes and site-specific advisory systems (including precision agriculture) for farmers.
- Policy evidence about novel "farmer citizen science approach" effectiveness for adapting CSA options to the local context, outscaling and engaging extension services and private sector suppliers.

CoA 1.4 Evidence, investment planning and application domains for CSA technologies and practices

This CoA will develop a range of tools, databases and knowledge products to help CSA investments make the best choices for delivering scaled impact. Significant CSA investment is in the pipeline, and donors, multi-lateral agencies and government agencies are asking what the best-bet CSA options are for different types of farmers under a given context. The primary outcome of this CoA will be more effective CSA programming, which will ultimately increase CSA adoption by farmers and return on CSA investments by donors. Decision support tools are therefore needed to evaluate cost effectiveness of a range of CSA options, and support decision makers through the process of identifying priorities at a range of scales, from local- to national- levels. Methodologies for application domain analyses are also needed. This CoA contributes to hypothesis 2 by linking local-scale research on CSA portfolios and their impacts with larger-scale databases and decision support tools.

Key research questions are: What is the value proposition of different CSA practices, technologies and portfolios in terms of the three pillars of CSA, and what are the relative cost-benefits across a range of contexts, timescales and development scenarios? What decision support tools will improve the value for money of CSA programming now and into the future and how can they best be applied to support that goal?

A suite of tools for different purposes and contexts will be developed and applied to support donors, governments and investors make better choices for CSA-related programming. This will increase the relevance and likely impact towards the achievement of CSA-related outcomes at scale. Research outputs include:

- Further development of a compendium of CSA practices and technologies, with information on the associated costs, benefits and adoption constraints.
- Understanding farming systems diversity and prioritization and decision support tools for guiding CSA investments, including spatial models to understand application domains of promising CSA options.

CoA 1.5 Equitable sub-national adaptation planning and implementation

Wide-scale adoption of CSA practices, technologies and portfolios will require an enabling environment which includes local, institutional, national and regional level plans and policies. This CoA will explore appropriate plans and policies at sub-national levels (national policy is covered under F4) that can provide incentives for CSA scale-out. This may include both public-sector policies and programs, as well as strategies from private sector or civil society. The rationale is that local level enablers for adaptation are needed for farmers to access credit, extension, technologies amongst other resources that will increase adoption rates of CSA practices and portfolios. Yet there is limited knowledge on how sub-national policies and programs can deliver incentives for farmers to adopt tried and tested CSA practices and portfolios (hypothesis 2).

Key research questions are: What are the most appropriate sub-national policies and how might local CSA programs be best designed to promote CSA adoption? What is the role of local institutions in providing supporting services to farmers that increases CSA adoption levels, and promotes gender-equitable outcomes?

This CoA is particularly focused on Asia (but not exclusively) where significant local adaptation planning takes place (e.g LAPAs in Nepal), with the objective of research contributing to improvement of these adaptation plans. Equitable and effective adaptation plans are a key scale out strategy to provide incentives for CSA adoption and reach programmatic targets and support CSA investment. Research outputs include:

- Research on institutional arrangements for CSA promotion in and around CSVs.
- Evaluation of LAPAs in South Asia and their efficacy in promoting adaptation and gender-equitable CSA adoption.
- Evaluation of scaling out strategies and their efficacy across a range of contexts and regions.

CoA 1.6 Incentives and innovative finance for scaling CSA up and out

This CoA will explore innovative value-chain based incentive mechanisms for CSA adoption, and emerging innovative finance instruments that will support CSA scaling out. The rationale is that technical knowledge and availability of CSA practices and portfolios are not sufficient to achieve the ambitious goals of mass CSA adoption of global and regional initiatives aligned to GACSA. Financial and other incentives need to be understood and leveraged to boost adoption levels and deliver scale out strategies that have the capacity to reach millions of farmers, including those marginalized. CSA has opened new opportunities for novel financial instruments to promote agricultural technology adoption, including from climate finance. This opens up questions about how new finance streams, and value-chain innovations might be best harnessed to deliver benefits to smallholder farmers and deliver on the outcomes of CSA (hypothesis 2).

Key research questions are: What motivates the private sector to take up and promote CSA? What is the potential of impact investment to incentivize equitable adoption of CSA practices and portfolios at local levels through a value chain approach? Is certification of climate-smartness a viable and marketable business model that delivers equitable benefits to farmers, and in so doing, promote adoption of CSA practices and portfolios? What other existing and innovative finance instruments exist that will provide incentives to farmers to access, adopt and promote CSA practices and portfolio, and what are their efficacy in reaching and positively impacting on those most marginalized (including women and youth)?

This CoA is crucial to the impact pathway in that it frames many of the strategies for scaling out CSA in support of ambitious national, regional and global goals. Insights generated from this research will inform CSA investment and increase the value for money of CSA investment by using appropriate gender-sensitive incentive mechanisms for adoption. Research outputs include:

- Establishment of public-private-partnerships with value chain actors to develop evidence based certification schemes that facilitate entry points for CSA investment through commodity chains
- Research on CSA certification feasibility in West Africa and Central America in coffee and cocoa value chains, and in SE Asia in the rice sector
- Research on the reach and efficacy of impact investment and other novel financial instruments, including those originating from climate finance

CoA 1.7 Foresight, models and metrics for climate sensitive breeding (Learning Platform)

This CoA will interface with AFS-CRP breeding programs, providing support on integrating climate in breeding strategies so that the next generations of crops, livestock and fish contain the abiotic, biotic and nutritional quality traits required to make agriculture climate-smart. Significant global investment is targeted on technology improvement within the CGIAR and across national programs and private sector actors. Breeding, delivery and adoption cycles are often long and new technologies must be targeted for the needs over the coming decades and not only the immediate problems of today. New crop, fish and livestock technologies must be designed in a way that sensitivity to climate variability and change is reduced at local-scales (hypothesis 1). As the climate signal leads to the appearance of novel environments breeding practice will need to adapt to changing climates at rates often above what current programs achieve (Araujo et al. 2015; Burke et al. 2009).

Key research questions are: How can genotypic responses to climate be better understood and predicted through use of current and future crop, livestock and fish modelling tools and climate databases? What are the predictable aspects of climate that need to be taken into account when breeding for future climates? How can research and breeding efforts accelerate rapid adaptation of cropping systems in climate-affected regions?

Greater inclusion of climate variables in the definition of breeding strategies will ensure that the pipeline of emerging technologies from agricultural research are progressively more adapted to climate constraints, providing farmers with improved options to confront climate challenges. Research outputs include:

- Modelling of impacts on specific crop, fish and livestock technologies and quantification of uncertainties
- Next generation GxExM analyses and empirical / big data approaches to understand abiotic constraints affecting different crops and cultivars across climate gradients.
- Improved linkage of genetic, environmental, physiological and agronomic information as a means to mainstream climate information into breeding programs.
- Genotypes identified that have climate-adaptive capacity using historical nursery data, which may have been overlooked for lack of yield potential or other factors (together with AFS-CRPs).

Capacity development

A key component of the ToC of this Flagship is to make development more climate-smart. In essence, this is achieved through the capacity strengthening of development actors to actively manage towards CSA outcomes. F1, as related to the CapDev framework, will focus on partner capacity building in the area of intervention strategy design, gender-sensitive approaches, and institutional strengthening. These CapDev areas can be delivered on given F1's focus on evidencing the impact of specific CSA strategies, attention to gender and youth sensitive considerations and barriers to CSA adoption, and creating an enabling institutional environment for increased investment and scaling up of CSA. This covers local organizations working directly with farmers, through bilateral and multilateral investors and donors who support CSA.

Geography and beneficiaries

Work under this Flagship will focus in all 5 CCAFS priority Regions: WA, EA, SA, SEA and LAM, as well as involve some global activities (e.g. climate sensitive breeding strategies). Significant activity is expected in Senegal, Kenya, Colombia, India, and Vietnam where momentum

and significant demand exists for research under this Flagship. These countries will reduce in activity in years 3-6 to bring other priority countries into the fold. Geographic priorities have been set through a mix of modelling studies from Phase I highlighting the crops and geographies most at risk from climate change (e.g. maize-beans systems in East Africa (Thornton et al. 2009; Adhikari et al. 2015), and where partners (government, regional agencies, donors, non-governmental) have prioritized actions (e.g. Africa Union and ECOWAS priority CSA countries like Mali etc.). Flagship direct beneficiaries will be 1) smallholder farmers, at least 50% of which are women, within the CSV sites adopting CSA portfolios, 2) government (sub-national, national and regional) agencies benefitting from decision support tools and improved climate-related planning approaches, and 3) the CSA investment community who will achieve greater value for money in their programming. Indirectly, the improved plans, strategies and CSA programming will deliver benefits to a much larger population of smallholder farmers outside of CSVs, with the target of reaching 8 million farm households by 2022.

Significance of expected contribution to gender IDOs

The CCAFS gender survey provides sex-disaggregated (and intra-household) information about awareness and adoption of CSA practices. In general women tend to be less aware of CSA practices but when they are aware they are just as likely (if not more so) than men to adopt the practices (Twyman et al. 2014; Bernier et al. 2015). F1 will contribute to the gender and youth IDOs by identifying trade-offs of food security, adaptation, and mitigation of CSA practices and portfolios and whether they differ for men and women, young and old. For example, do certain CSA practices or packages affect women's labor more than men? Who controls the benefits received from implementing CSA practices/portfolios? Addressing questions related to CSA and gender will help identify those practices and portfolios that have positive impacts on the control of productive assets and resources within communities and contribute to achieving the gender and youth IDOs.

Lessons learnt and unintended consequences

The work in early years of Phase I was scattered and non-strategic having been inherited from the pre-CRP period. Through a major planning phase in 2014, non-strategic activities were trimmed and a new portfolio of projects was established for extension phase, many of which are proposed to continue. In Phase II, this Flagship will ensure greater co-location of evaluations, concentrated in CSVs, and ensure common analytical frameworks for evaluating benefits on productivity, adaptation and mitigation (in conjunction with Flagship 3) to get to grips with cost-effectiveness of CSA. Research will be embedded in local participatory platforms for understanding the social, gender and biophysical constraints and enablers for adoption. Much greater integration with AFS-CRPs will also ensure that CSA technologies and practices emerging from the CGIAR are systematically assessed for CSA outcomes, and that breeding strategies strengthen the pipeline of CSA technologies that the CGIAR and breeding partners will deliver over the coming decades. Climate-smart agriculture is inherently context specific so efforts must be made to guard against the indiscriminant transfer of CSA technologies between unique biophysical, socio-economic, and political settings. Similarly, small-scale farmers are not uniform in their composition. They can range from subsistence to semi-commercial operations. CSA options must cater to this socio-economic diversity as well, risking mal-adaption when these conditions are not met. Effort must also be made to ensure the profit-signals driving private sector investment in CSA are not at odds with F1's efforts to reach truly vulnerable farmers, especially women.

Integration with other CRPs

All CGIAR Centres are to be involved due to the broad, integrative mandate of this Flagship. Their involvement may encompass direct programmatic research involvement (Centres with the largest budget share in F1 are Bioversity, CIAT, CIMMYT, ICRAF and IWMI), or

through co-investment in the Learning Platforms, or both. Primary docking stations of F1 with other CRPs are (Annex 5, Tables 5.1 & 5.4 for investment levels):

- Learning Platform LP#2: Foresight, models and metrics for climate sensitive breeding. The success of interaction between the climate and breeding communities was demonstrated in Phase I with CIMMYT where climate-informed information led to seed companies changing breeding strategies. LP#2 will be for all relevant AFS-CRPs. Leeds University, as a Strategic Partner, will play a key role in LP#2, through their connection to the climate science community.
- Learning Platform LP#3: Participatory evaluation of CSA practices and portfolios in CSVs. Some of the CSVs are already testbeds for up to 5 Centres. In Phase II CoA 1.1, 1.2 and 1.3 will constitute LP#3 with AFS-CRPs and I-CRPs. WISAT, CARE, CATIE and GIZ will be Strategic Partners in LP#3.
- Twinned Flagship TF#1 (co-investment with WLE): Managing water resource variability, risks and competing uses for increased resilience. This research area cuts across several CCAFS Flagships.

In addition, CCAFS will contribute to the co-investment platform with FTA and RTB on tree-crop commodities.

Comparative advantage of the CGIAR and host Centre

CCAFS has been a lead agency in the development of the CSA approach. It garners legitimacy from the CGIAR being in numerous developing countries, and from its work in fields, with households, local agencies and national governments. F1 will continue to be led by CIAT in Phase II. CIAT is well positioned given strong geographic representation in all of CCAFS target Regions, direct involvement in 5 AFS-CRPs as a strategic contributing Centre, and a broad multi-crop and livestock focused mandate which is advantageous given the breadth of this Flagship. Nevertheless, a primary success factor for this Flagship lies in sourcing integrative research between multiple Centres in contribution to the research hypotheses, and CIAT has a strong track record in nurturing such partnerships. University of Leeds will provide scientific leadership under CoA 1.7.

Relevant previous projects

- Developing, adapting and targeting portfolios of CSA practices for sustainable intensification of smallholder and vulnerable farming systems in South Asia (CIMMYT-ICRISAT-IRRI). This project focuses on CSV-based testing of CSA options with significant outcomes already being reported.
- Partnerships for scaling climate-smart agriculture (P4S-CSA) (ICRAF-CIAT): supporting national and regional bodies to plan and prioritize CSA investments across Africa, including a CSA compendium and cost-effectiveness prioritization tools.
- Mainstreaming CSA practices in mixed tree/food crop systems among poor smallholder farmers in W Africa & Latin America (CIAT-IITA). Project focused on identifying CSA certification and impact investment opportunities for incentivizing technological adoption.
- CCAFS Gender Household Survey - Methodology for gathering gender-disaggregated data on agricultural activities, decision-making, risk-perception and values from rural households.

Flagship 2: Climate Information Services and Climate-Informed Safety Nets

The vision

The F2 vision is that farmers in risk-prone regions across Asia, Africa and Latin America will be supported by effective climate services, and protected by timely and well-targeted safety nets; enabling transition toward CSA and more prosperous livelihoods. By 2030, F2 plans to enhance the adaptive capacity of 45 million farmers, with benefits to at least 23 million women. Three key 2022 outcomes (see Performance Indicator Matrix for full list) are: (a) 15 million farm households with *enhanced capacity to deal with climatic risks*, with increased benefits for women, through accessing climate-informed advisory services and safety nets; (b) An *enabled environment for climate resilience* through development organizations using CCAFS research to design and target USD 80 million of investment in climate services; and (c) 20 national or subnational governments or regional bodies using climate-based seasonal agricultural prediction and early warning to *improve forecasting of impacts of climate change* for agricultural planning or food security interventions.

The challenge

Climate change makes the SDG goals of ending rural poverty, achieving food security and ensuring the sustainability of agriculture among the world's most daunting challenges. Global action is being mobilized to address this challenge through CSA – a transformation of agriculture that (a) sustainably increases productivity and incomes; (b) builds resilience; and (c) reduces and removes greenhouse gases (FAO 2013). Reducing vulnerability to climate risks in the present is necessary for adapting to climate change in the future, as vulnerable farmers experience climate change largely as shifts in the frequency and severity of extreme events. The IPCC (2012; Pachauri & Meyer 2014) concluded that increasing extreme precipitation is very likely in the mid-latitudes and wet tropics, increasing heat waves and coastal inundation are very likely globally, and evidence suggests increasing drought risk in presently dry regions. Extreme events erode livelihoods through loss of productive assets, impaired health and destroyed infrastructure; while the resulting uncertainty is an impediment to adoption of CSA practices, and to the transformational change required to adapt to climate change (Barnett et al. 2008). In risk-prone environments, efforts to foster the transition toward more climate-smart agricultural livelihoods must therefore be supported by strategies, programs and policies that enable vulnerable populations to overcome the obstacle of climate risk.

A surge of interest globally, and synergies between the CGIAR and several partner communities, have opened the door for major advances in climate information and advisory services, weather-related insurance, and expanded use of early warning for food security management. The *UN Global Framework for Climate Services* (GFCS) formalized global commitment to develop effective climate services in vulnerable countries (Hewitt et al. 2012). CCAFS has already demonstrated major progress in rural climate services, e.g., scaling to 3.9 million farmers in Senegal (Lo & Dieng 2015) and co-leading the first GFCS national (Tanzania, Malawi) implementation project. Index-based insurance, which overcomes barriers to insuring smallholder farmers, has gained momentum over the past decade. Major support is promised by the *G7 Initiative on Climate Risk Insurance*, launched in May 2015 with the aim of extending climate hazard insurance to 400 million vulnerable people in developing countries by 2020. Development organizations and donors increasingly look to these interventions to advance climate adaptation and resilient development goals. GACSA aims to build the resilience of 500 million farmers by 2030.

Scientific rationale and theory of change

Efforts to foster the transition to CSA in high-risk environments must be underpinned by effective climate information services and climate-informed safety nets, as agriculture becomes increasingly information-dependent, traditional knowledge struggles to keep up with the pace of change, and increasing frequency and severity of climatic extremes challenge the capacity of smallholder farmers. By

addressing critical gaps in knowledge, methodology and evidence; and supported by the well-established partnerships in CCAFS Regional Programs, F2 will enable a set of scalable interventions that provide an enabling environment for smallholder farmers to adopt CSA practices, adapt to fluctuating weather and climatic trends, and protect livelihoods from climatic extremes. This will enable 45 million farm households in high-risk environments to transition into livelihood strategies that are more climate-smart, food-secure and prosperous by 2030. The ToC is aligned to the CRP ToC as illustrated in Annex 7, Fig 7.4. Crucial components of the ToC include working with partners to deliver on outcomes, and building the capacity of key actors in the impact pathways (see sections below).

F2 will contribute to one CGIAR SLO: Reduced poverty (Annex 4, Fig. 4.1). It will contribute to four IDOs (bold) and six sub-IDOs (italics):

- **Adaptation and mitigation achieved**; via *enhanced capacity to deal with climatic risks and extremes* as a result of more effective climate services, insurance programs and safety net interventions; via an *enabled environment for climate resilience* through guidance and evidence to donors and development organizations to improve how climate services funds are invested for agriculture and food security; and via *improved forecasting of impacts of climate change and targeted technology development* through research and engagement to support use of climate-based seasonal agricultural prediction and early warning by national and regional bodies, to improve planning and food security interventions.
- **Enhanced smallholder market access**; via *improved access to financial and other services,* including increased benefits to female-headed households and to women in male-headed households, through deep engagement with the insurance industry.
- **Enabling environment improved**; via *increased capacities of next users to adopt research outputs* through the capacity development of key agencies in the impact pathway (e.g. national meteorological services).
- **Equity & inclusion achieved**; via *improved capacity of women and young people to participate in decision-making* — through improved access to climate-based advisories and insurance.

Research will target three hypotheses that relate to the three key 2022 outcomes:

Hypothesis F2 H1: The capacity of rural communities to adopt CSA practices and cope with extreme climatic events is enhanced through effective advisory services, insurance and safety net programs that: use the best available climate information, build on science/evidence, target the vulnerable, and respond to farmer needs.

Hypothesis F2 H2: Climate services that effectively and equitably empower rural communities to adapt to a variable and changing climate can be scaled up through investment that is evidence-based, well designed, well targeted, and coordinated with other investments.

Hypothesis F2 H3: By using enhanced, climate-based seasonal agricultural prediction and early warning to improve planning, safety nets, and food security interventions; governments and humanitarian organizations can more effectively protect farmers' productive assets and future livelihood potential from climate shocks.

The ToC depends on the following assumptions: 1. Improving access to relevant climate-related information can remove obstacles to implementing advisory, insurance and safety net services that effectively empower and protect rural communities. 2. Strategic gaps in knowledge, methods, tools, guidance and evidence currently constrain the effectiveness and scale of weather-related insurance and safety nets targeting smallholder farmers. 3. Growing interest and increasing investment in climate services will continue, creating opportunity to expand reach to rural communities in the developing world. CCAFS research and engagement will influence targeting, design and

coordination of investments; and spur further investment through evidence. 4. Effective partnerships with relevant major climate service, agricultural insurance, and food security information and response organizations and initiatives will be maintained and expanded.

Partners for outcomes and research

F2 partners with major global and regional actors in climate science, climate services, index-based insurance and food security information systems where: (a) untapped synergies offer opportunity to advance the agenda, or (b) partners are positioned to bring research into development at scale. The current set of partners reflects engagement and learning through Phase I; and the process of developing a new outcome-focused, regionally-coordinated project portfolio in the Extension Phase.

Research partners generally either provide expertise that complements CGIAR core strengths, or bring capacity in a particular area that enables rapid progress. As host, IRI supports F2 with relevant climate science; and facilitates connections with the broader climate research, climate services, and index insurance communities. U Reading contributes expertise in use of meteorological data, and participatory communication approaches. WSU supports development and application of crop forecasting tools, leveraging work across crop modeling groups under AgMIP. U Florida brings gender expertise to rural climate services research. Larger projects in the new F2 portfolio partner with regional research institutions: CATIE in Latin America and AGRHYMET in WA. Most projects partner with relevant NARES or national universities.

Most F2 partners play a role in impact pathways, e.g. as service providers, policy drivers, change agents, or funders. Global partners include climate services (e.g., WMO, GFCS, GFDRR, USAID, DfID), and food security early warning and response (e.g., WFP, FAO, FEWSNET, ACF). CoA 2.1 targets meteorological services and climate institutions (e.g., AGRHYMET, ICPAC, RIMES). CoA 2.2 involves communications partners: agricultural extension and NGOs that work with rural communities (World Vision, CARE), and media and ICT (FRI, MANOBI, ESOKO, URAC, AGRONET). CoA 2.3 engages insurance parastatals of India and Nigeria, the private insurance and reinsurance (SwissRe) sectors, and experienced technical partners (GIZ, Pula Advisors). Activities generally engage agriculture and other relevant ministries and agencies, as sustainability depends on government buy-in.

F2 private sector partnership is strongest in weather-related insurance (CoA 2.3), where links have been established with SwissRe, Aon Benfield, ACRE, and insurance industries and their associations in Nigeria and India. The set of private sector partners in communication technologies and media (MANOBI Société Anonyme, ESOKO (Ghana), URAC (Senegal)) will expand as opportunities to scale up climate services and insurance mature. F2 partners with consulting companies (e.g., GEOSAS to engage subnational government in Ethiopia; Pula Advisors for insurance in Nigeria) that are strong in particular niches outside of CGIAR core strengths.

Research questions

F2 will have 5 CoAs. CoA 2.1 deals with producing information about climate variability and its agricultural impacts, tailored to decision-maker needs. CoA 2.2 ensures that farming communities get information in an actionable form and equitable manner. CoA 2.3 supports weather-related insurance for smallholder farming communities. CoA 2.4 deals with early warning systems and their use to manage food security in the face of shocks. CoA 2.5 provides guidance and evidence to improve investment in climate services for agriculture.

CoA 2.1 Climate information and seasonal agricultural prediction for risk management

This CoA is about the production of relevant information about climate variability, including predictions of seasonal climate impacts on agricultural production and biological threats, to enable better management of risk associated with climate variability. It will enhance NMS

to respond effectively to the information needs of agricultural decision-making. Many promising opportunities to manage risk and adapt to a variable and changing climate are information-dependent, but are constrained by the availability of relevant information. In the African context, a multi-stakeholder gap analysis concluded that inadequate provision of climate information and weak effective demand by development practitioners have been reinforcing, therefore both must be addressed in parallel (IRI 2006).

Key research questions are: What is the potential for merging remote sensing and reanalysis data with ground observations, to fill gaps in historical meteorological data with sufficient accuracy and resolution? To what degree can advances in climate science, data availability and system modeling improve the lead-time, accuracy and spatial resolution of forecasts of the impacts of seasonal climate on agricultural production and biological threats? What are the most efficient strategies to produce locally relevant climate information tailored to the needs of decision-makers; and to what degree can these strategies enable resource-constrained meteorological services to expand agriculturally relevant services?

Advancing this research area requires strong collaboration between agricultural and climate expertise. Research will include targeted work on methodology and tool development; and place-based efforts to address gaps and build capacity to meet information needs for rural climate services (CoA 2.2), index-based insurance (CoA 2.3) and early warning systems (CoA 2.4). Expected research outputs include:

- validated methods for seasonal and sub-seasonal prediction of agriculturally-relevant information;
- validated tools to forecast seasonal climate impacts on crops, rangelands and biological threats;
- efficient methods to tailor historic and forecast climate information to farmers' needs;
- methods and tools to extend the lead time and accuracy of climate hazard and food security early warning systems.

CoA 2.2 Equitable rural climate information and advisory services

This cluster will address the design, communication and institutional challenges in providing effective, equitable climate services that benefit smallholder farmers at scale; including integrating climate information into agricultural advisory services. Research targets key challenges that have been validated by a range of stakeholders in the initial CCAFS focus Regions in Africa and South Asia (Tall et al. 2013): salience, access, legitimacy, equity and integration. With enabling institutional support and policies, climate information (historical, monitored, predicted) and advisories offer great potential to inform farmer decision-making, enable farmers to better manage risk, take advantage of favorable climate conditions, and adapt to change.

CCAFS is positioned to leverage growing interest among development organizations that see climate services as a way to support climate change adaptation and climate-resilient development goals. While mounting evidence of the potential benefits has made the case for climate services (e.g., Hellmuth et al. 2007; Tall et al. 2014), a substantial body of research also shows that the availability of information is often not sufficient for smallholder farmers to benefit. Benefits are often constrained by gaps between known farmers' needs; and the types, scale, formats, and timing of the information that are routinely available (Hansen et al. 2011). A comissioned evaluation highlighted the research challenge of developing services at scale while tailoring them to farmers' diverse needs (Feinstein 2015).

Key research questions are: What kind of information is most valuable in a given context, and how can the information and its uncertainties be best communicated? What factors enable or constrain the ability of smallholder farmers – particularly marginalized groups including women – to access and benefit from climate-related information and advisories; and what is the scope for overcoming

the constraints and enhancing capacity to respond? What are the best communication channels and institutional arrangements for co-production of climate services at scale, that are sufficiently tailored to the differing needs of vulnerable user groups? To what degree can advances in ICT be exploited to manage the tradeoff between providing services at scale, and tailoring services to context- and gender-specific user needs?

Research questions will be answered in the context of efforts to develop climate services at pilot to national scales including: the new F2 project portfolio, an expanding set of bilateral projects, and partner-led initiatives such as the GFCS. Participatory approaches will be integral. Evaluation of how farmers access, use and benefit from information will strengthen the evidence base. Expected research outputs include:

- scalable communication channels based on ICT and radio;
- methods and curriculum to equip intermediary organizations to deliver services to rural communities;
- methods to identify and meet particular climate service needs of women and youth;
- evidence and insights from climate services piloted at Climate-Smart Villages;
- institutional arrangements that foster sustainable co-production of services with relevant agencies and targeted rural communities.

CoA 2.3 Weather-related agricultural insurance products and programs (Learning Platform)

This cluster will strengthen knowledge and evidence about how to design, target and implement insurance programs that enable vulnerable rural communities, including women and disadvantaged groups, to manage climate risk and adapt to climate change. It addresses: index and insurance design, gender-specific needs, bundling, communication and capacity challenges at scale, public-private partnerships and sustainable business models. As a Learning Platform for AFS-CRPs, it will provide a platform for knowledge sharing and coordination and foster connections with relevant initiatives, in collaboration with PIM. Well-designed and appropriately targeted index-based insurance is overcoming obstacles to insuring smallholder farmers. Initial CCAFS-led work in India and Nigeria has shown huge potential to support the livelihoods of millions of vulnerable households by protecting productive assets, and enabling access to credit and improved technologies. Recent evidence refutes earlier doubts about the feasibility of providing insurance for relatively poor farmers at scale, and highlights the importance of insurance specific risk-related development needs (Greatrex et al. 2015).

Key research questions are: What is the potential for advances in agricultural systems modeling, remote sensing, data assimilation and other relevant technologies to design scalable insurance products that capture the most important risks and increase farmers' satisfaction? How can insurance be best designed, bundled with other synergistic risk management options, and targeted to address particular climate-related agricultural risks? What public-private partnership arrangements and business models best enable insurance for smallholder farmers in a given context, in a manner that is scalable and sustainable?

Similar to CoA 2.2, research questions will be answered in the context of existing insurance programs, and pilots that are developed with a view to implementation at scale. Research will be coordinated with major external programs and networks such as WRMF, GIIF and the new G7 insurance initiative. Work on developing improved insurance indexes will link closely with CoA 2.1. Expected research outputs include:

- tools and indexes that better cover important risks and raise satisfaction of farmers and insurers, including atlases of risks and triggers for weather index insurance in target countries;
- science-based schemes for targeting and scaling insurance as an effective risk management option;
- sustainable public-private partnerships and business models;
- communications and capacity-building approaches, including South-South learning.

CoA 2.4 Early warning and decision systems for food security planning and response to climate shocks

This cluster will improve climate-related early warning systems; and provide evidence and guidance to improve strategies for national safety net programs and humanitarian organizations to respond to climatic extremes in ways that better protect farmer livelihoods. Whenever the impact of a climate shock exceeds the capacity of rural communities to cope, climate-informed, timely, well-targeted intervention protects food security and the productive assets needed to recover after the crisis. The resulting security will foster investment in CSA.

Key research questions are: How can knowledge management systems and institutional communication networks be optimized to take advantage of increased lead-time for climatic extremes in order to link early warning to early action? How can probabilistic seasonal forecasts be integrated with models for prediction of yield, price, and household food security in a way that adds scientific rigor to targeting and other key decisions related to food security interventions?

Research questions will be answered in partnership with food security decision-makers in governments and humanitarian organizations. Improvements to early warning systems will build on work under COA 2.1 and involve climate science expertise. Three projects in the new F2 portfolio work with decision-makers to improve early warning systems, and the responses that they inform. Expected research outputs include:

- tools and methods to improve prediction of impacts of climate and weather extremes on food security;
- methods and evidence for integrating climate and early warning information into food security planning and response processes;
- evidence to improve the nature, timing or targeting of food security safety net interventions;
- mechanisms to coordinate action between local agricultural development efforts, and food security management at a national or regional level in the face of climate shocks.

CoA 2.5 Guidance and evidence for climate service investment

This cluster will engage major stakeholders, policy processes and donors that support climate services for agriculture and food security, and advance ex-ante analysis of the development impacts of investment options within the chain of climate services. Investment in climate services continues to grow rapidly. Shaping how major programs and donors invest in climate services provides opportunity to expand the impact of F2 research. CCAFS has developed relationships with the GFCS and relevant investors (USAID, WB, DfID, IFAD). Despite mounting evidence that has supported the case for climate services, a gap remains in the quantitative evidence of the returns on investment that development donors increasingly require. A F2-comissioned evaluation (Feinstein 2015) highlighted this as a priority for future research.

Key research questions are: (a) What are the costs and benefits of alternative options for investing in climate services for agriculture and food security? (b) What methods can best overcome current gaps in the knowledge and evidence needed to inform national and regional

investments in climate services? (c) How can donors and technical support institutions best coordinate efforts to build capacity for climate services, considering potential synergies and overlaps?

The research will initially be addressed through a CCAFS position hosted by ACPC, and supported by experts from IFPRI and elsewhere, to develop and adapt methods (e.g., WMO 2015) for ex-ante cost-benefit analysis of new climate services investments, and apply them in Africa. Economic analyses and engagement with major climate services partners and funders will be tied to and informed by research and capacity development activities under CoA 2.1, 2.2 and 2.4. Expected research outputs include:

- synthesis of knowledge about impacts of climate services on agriculture and food security management;
- improved methods for ex-ante evaluation of climate services investments;
- analyses of alternative climate services investments at national to regional scales.

Capacity development

Mutually reinforcing capacity constraints in the production and use of climate information have constrained the development of effective climate services in target regions, and must be addressed in parallel (IRI 2006). Likewise, investing in the capacity of insurers, local intermediaries (e.g., agro-dealers, agricultural extension) and farming communities has proven essential to scaling up insurance for smallholder farmers. Because resource constraints and mandates often limit the capacity of meteorological services to support agriculture, F2 will work with NMS to *assess capacity needs and inform intervention strategy*, ensuring that any development funds invested in NMS are well targeted and coordinated. F2 will incorporate successful approaches to communicating climate information with farmers, into innovative learning materials to mainstream them within agricultural extension and intermediary organizations. Experience with the *design and delivery of innovative learning materials and approaches* will also be extended to insurance, to enable local dealers and intermediary organizations to help rural communities make appropriate decisions about agricultural insurance options. An example of *institutional strengthening* is collaborative work ("ENACTS") with IRI to equip African NMS to reconstruct historic weather data, and make high-resolution products tailored to user needs available through web-based "maprooms". *Organizational development* includes developing national governance frameworks for climate services, in partnership with WMO under the GFCS.

Geography and beneficiaries

F2 will conduct actives in all CCAFS Regions: WA (Ghana, Mali, Senegal, Burkina Faso, Nigeria), EA (Ethiopia, Kenya, Uganda, Tanzania, Malawi, Rwanda), SA (India, Bangladesh, Nepal), SEA (Vietnam, Laos, Cambodia, Philippines), and LAM (Colombia, Guatemala, Honduras). Within countries and regions, F2 prioritizes rainfed systems subject to major climate-related risks, considering feasibility in term of, e.g., seasonal predictability. Some activities (e.g., informing climate services investment options) will be global or regional. Opportunities outside of current regions will be assessed based on strategic priorities.

Beneficiaries will include: (a) smallholder farming households, with emphasis on women and youth; (b) NMS and Regional Climate Centres; (c) government agencies and NGOs implementing climate services and insurance, (d) food security information providers, (e) government and humanitarian organizations involved in food security interventions or safety net programs; and (f) climate service investors.

Significance of expected contribution to gender IDOs

The first phase of CCAFS provided insights into the differing needs of women and men for climate-related information, and how those needs can be addressed. In the next phase, research under CoA 2.2 and 2.3 will strengthen understanding of how climate services and

agricultural insurance can meet the differing needs of women and youth; incorporate those insights into efforts to scale up climate services and agricultural insurance; and test the degree to which these services can be gender transformative by improving control of resources and participation in decision-making. At least 40% of farmers that benefit from F2 interventions will be women. Within beneficiary farm households, at least 50% of the beneficiaries will be female.

Lessons learnt and unintended consequences

Strategic research and partner engagement during the first phase led to successful examples of piloting and scaling, particularly in the areas of climate services and insurance. The scope of F2 narrowed as the focus shifted from scoping and testing to partnership and scaling, demands for evidence increased, and CCAFS shifted from a logframe to a theory of change approach. Most farm-level adaptation practices address both progressive change and climate risk, which led to confusion and coordination challenges between the Phase I climate risk management and progressive adaptation Themes. Field- and farm-level risk management practices (e.g., crop diversification, water harvesting) were therefore either incorporated into F1: Climate-Smart Practices and Portfolios, or dropped.

F2-related interventions may carry risk of unintended consequences. For example, communicating inherently probabilistic seasonal forecast information in deterministic terms can lead to inappropriate decisions. Inequitable access might enable the politically or economically privileged to use information to the detriments of disadvantaged groups. Some suggest that insurance can inhibit the shift from poorly adapted to better-adapted production systems. Where such risks are already recognized, research will anticipate them and seek solutions. For example, F2 is developing training to help intermediaries and farmers interpret forecasts in probabilistic terms, incorporating lessons from IRI's extensive experience. Monitoring and evaluation will be sensitive to other unintended negative consequences.

Integration with other CRPs

F2 will host a Learning Platform (LP#4) on weather-related agricultural insurance products and programs (see CoA 2.3). A 2014 CCAFS workshop revealed that several CRPs across many Centres work on insurance (Garvin & Hansen 2014). Greater integration across Centres will allow knowledge sharing needed to advance the research agenda, command the attention of major external initiatives and funders, and position the CGIAR to deliver greater development outcomes. For AFS-CRPs interested in insurance, F2 will provide a platform for: sharing knowledge, tools, methods and good practice; coordinating research and sharing results across CRPs; and connecting the CGIAR to major global agricultural insurance networks, initiatives and funders (see Annex 5, Tables 5.1 & 5.4 for investment levels). F2 will collaborate with PIM on implementing this Learning Platform, and work with interested CRPs to develop appropriate mechanisms. F2 anticipates the involvement of most CGIAR Centres, through direct research involvement (Centres with greatest budget share are ICRAF, CIMMYT and ICRISAT), through participation in the Insurance Learning Platform, or both.

Comparative advantage of the CGIAR and host Centre

For the climate services community, the CGIAR brings understanding of climate-sensitive farmer decisions, and a wealth of experience communicating with farmers. In addition to its experience with insurance in at least 18 countries, the CGIAR's understanding of important risks, and agro-meteorological and crop modeling expertise, complement the strengths of other organizations working on index insurance. Its understanding of how weather impact crops and biological threats provides opportunity to improve and evaluate food security early warning methods. As a research organization, the CGIAR is trusted to provide objective, evidence-based guidance for food security planning and intervention in the face of climate extremes.

To address the need for rigorous climate science and connections with the broader climate community, the International Research Institute for Climate and Society hosts F2. IRI was established at Columbia University in 1996 as the world's first international institute focused on applying climate science to societal challenges. IRI works with CGIAR scientists and key partners to design and deliver innovative solutions for climate-related development challenges. The partnership builds upon IRI's climate, social and sectorial science expertise; and experience in engaging partners, building the capacity of climate information providers, and addressing climate-related challenges throughout the developing world.

Relevant previous projects

- Improving Index Insurance in Maharashtra. CCAFS-SA is working with industry and government to improve index insurance products that increase satisfaction of farmers and economic viability. Products adopted by Maharashtra are expected to benefit 500,000 farmers in 2015.
- Scaling Up Climate Services in Senegal. Forecasts and advisories, piloted at the Kaffrine CSV site since 2011, now reach over 4 million farmers, and are mainstreamed into the Ministry of Agriculture's planning. CCAFS-WA, ICRISAT, AGRHYMET, ANACIM, URAC, FONGS, ISRA.
- Capacitating African Smallholders with Climate Advisories and Insurance Development (CASCAID) (2015-2018). Climate services, early warning and insurance for smallholder agriculture in W Africa. ICRISAT, ICRAF, AGRHYMET, U Reading, WSU, IRI, U Ghana, IUCN, NMS.
- Tailored Agro-Climate Services and food security information for better decision making in Latin America (AGROCLIMAS) (2015-2018). Supports agroclimatic advisory services to reduce impacts of climate extreme events on food security. IRI, CATIE, ACF, NMS, MoAg.

Flagship 3: Low Emissions Development (LED)

The vision

The F3 vision is that LED will reduce agricultural greenhouse gas (GHG) emissions while ensuring food security. By 2030, F3 plans to reduce agricultural emissions intensities in developing countries by 15% relative to 2015 levels. Research will provide guidance for LED technical packages, enabling conditions, incentives and trade-offs. Key 2022 outcomes (see Performance Indicator Matrix for full list) are: (a) *Reduced net greenhouse gas emissions from agriculture* by 200 $MtCO_2e/yr$; (b) 2 million ha of *deforestation avoided* due to improved governance of agriculture-forest landscapes; (c) 2 million farm households with *improved access to financial services* as a result of sustainable business models for reduced emissions and climate finance opportunities, with increased benefits for women.

The challenge

CSA addresses one of the greatest challenges of the 21st century – the massive reduction of GHG emissions needed to avoid catastrophic climate change (SDG 13). To limit global warming by 2°C above pre-industrial levels by 2100, IPCC scenarios indicate that agriculture must reduce emissions (Van Vuuren et al. 2011). However, 3/4 of agricultural emissions originate from the developing world. To "double agricultural productivity and incomes of small-scale food producers by 2030" (SDG 2.3) and minimize further emissions, LED options are thus needed for smallholder farmers that enable food security and value chain development, with mitigation as a co-benefit. By enabling LED, F3 will also contribute to challenges related to natural resource use efficiency (land, energy, nutrients, water) and reducing waste (post-harvest loss).

Scientific rationale and theory of change

Globally, agriculture, forest and other land use (AFOLU) contribute nearly a quarter of annual greenhouse gas emissions, 10-12 $GtCO_2e/yr$ (Smith et al. 2014). Smallholder farming in developing countries contributes ~1/3 of agricultural emissions (1.7 $GtCO_2e/yr$) or ~ 3.4% of total global emissions—twice the emissions from global aviation and 4 times the agricultural emissions of the EU or US (Vermeulen and Wollenberg 2015). Yet to stay within the 2° warming limit, agriculture must reduce GHG emissions by ~1 $GtCO_2e$/year by 2030 globally (van Vuuren et al. 2011; Kleinwechter et al. 2014; Wollenberg et al. 2015). Developing countries can contribute to this target with reductions of ~0.76 $GtCO_2e/yr$ including 0.3 $GtCO_2e/yr$ from smallholder farms (IPCC data from Smith et al. 2008; Smith et al. 2013) (Annex 12.1). While mitigation's significance in agriculture is well understood, the need for better information on benefits to smallholder farmers, GHG emissions, and conditions enabling LED for diverse farmers and country institutions have constrained progress. Given the significant mitigation potential in agriculture, F3 asks: How can developing countries achieve food security while reducing agricultural GHG emissions intensities? F3 will test the feasibility of LED among smallholder farmers and major supply chains, focusing on high-impact practices: reducing methane from paddy rice and livestock, nitrous oxide from cereal crops, increasing carbon sequestration in agricultural landscapes, and increasing supply chain efficiencies (Smith et al. 2014; Dickie et al. 2014; Scholes et al. 2014).

The impact pathway for F3 is in Annex 12, Fig. 3, and the Flagship's theory of change is explained by the hypotheses, assumptions and strategy below. Crucial components of the ToC include working with partners to deliver on outcomes, and building the capacity of key actors in the impact pathway (see sections below). The ToC is aligned to the CRP ToC as illustrated in Annex 7, Fig. 7.5. F3 will contribute to two CGIAR SLOs: (a) Reduced poverty; (b) Improved natural resource systems and ecosystem services (Annex 4 Fig. 4.1). It will contribute to six IDOs (bold) and seven sub-IDOs (italics):

- **Adaptation and mitigation achieved;** via *reduced net GHG emissions from AFOLU,* by shifting to more efficient practices and via *increased above- and below-ground biomass* for carbon sequestration through avoided deforestation, soil restoration and agroforestry; both based on improved technical options and incentives, public and private investment in LED practices and community-based innovation.
- **Natural capital enhanced and protected, especially from climate change;** via *minimizing and reversing land, water and forest degradation* through actions in agricultural supply chain governance and local management of soils.
- **Increased incomes and employment;** via *more efficient use of inputs* through the transition to LED.
- **Enhanced smallholder market access**; via *improved access to financial and other services,* as part of the package that incentivizes LED.
- **Enabling environment improved**; via *increased capacities of next users to adopt research outputs* through working with key stakeholders to better understand possible synergies between development and emissions reductions, through training and exchange on GHG estimation and through developing capacity to implement actions that advance LED.
- **Equity & inclusion achieved**; via *improved capacity of women and young people to participate in decision-making* about LED technology.

To achieve outcomes at significant scales we hypothesize that:

Hypothesis F3 H1: Development interventions in crops, livestock and trees—including those for climate change adaptation—can drive incentives and technical support for near-term shifts to LED practices.

Hypothesis F3 H2: LED incentives, policies and sustainability standards in food supply chains and government jurisdictions will enable institutionalized change for the longer-term to reduce emissions from food systems.

The ToC depends on the following assumptions: 1. Countries will engage in LED to meet mitigation targets, access climate finance, and/or better compete in global markets. 2. To implement LED, countries will require information on GHG emissions, viable business models, enabling conditions and tools to set priorities and assess feasibility of new practices and their potential impact on food security. 3. Women and men farmers will change their behavior when the benefits of new practices are higher, barriers can be overcome, or a majority of farmers in their networks have shifted practices. F3's strategy thus will be to: focus on first-mover countries (see Geography and Beneficiaries) while building demand globally by demonstrating LED's feasibility and benefits; integrate information across (i) agricultural development initiatives (emphasizing CC adaptation and sustainable intensification interventions) and (ii) LED policies such as INDCs, NAMAs, LED Strategies, and Green Municipalities; build on well-established partnerships in CCAFS' regional programs to co-develop technical and institutional options in CCAFS' regional climate-smart villages and other existing innovation hubs/sites of CRPs and partners; and engage with development banks, donors, private sector suppliers and investors in LED and agricultural development to support finance of LED.

Enabling conditions include expected global agricultural investment of USD 83 billion/yr to meet 2050 food needs (FAO 2009) and climate finance from the Green Climate Fund and other donors. In the private sector, consumers of cattle, oil palm and other major commodities are demanding lower carbon footprints and reduced deforestation. F3 results will inform F1 and F4 for CSA implementation and policy. F4 analysis of food systems policies will enable better understanding of the context for LED.

Partners for outcomes and research

Central to the theory of change is a partnership of a) large-scale implementers (national ministries, local governments, private sector), with b) civil society organizations addressing farmers' interests, including producer, women's and youth organizations, and c) technical and social science researchers developing and evaluating LED options through controlled field-based trials, case studies of promising policies and programs and modeling of scenarios (NARES, ARIs, GRA, the CGIAR). As recommended by the CCAFS evaluation, F3 will partner with organizations delivering development. For example, In Kenya, we will partner with MoALF and county governments to pilot a dairy NAMA. We will explicitly seek partners such as PROLINNOVA with demonstrated success in channeling resources to farmers' organisations, community groups and local government for farmer-level impacts.

Partners that bridge science and policy are critical to impacts. For example, F3 will work with the GRA to jointly advance quantification methods, contribute to global data platforms and share results with national policy makers; with FAO to jointly support science-policy workshops; and with both to produce guidance documents. With the CCAC, F3 will develop regional strategies for scaling up practices. With the World Bank and other donors, F3 will identify metrics, readiness indicators and technical opportunities. GACSA will provide a forum for stakeholder input to research and sharing findings. Research partners provide complementary expertise and links to decision-makers. For example, national partners such as IAE in Vietnam and INTA in Costa Rica monitor GHG emissions and inform policy development. Collaboration with regional/national partners such as CATIE or Universidad Nacional de Colombia-sede Medellín ensure technical packages for local circumstances. IIASA is a leader of global land use scenario analysis for the IPCC. France's initiative (involving INRA and CIRAD) for increasing global soil carbon provides leadership for wider ambition.

In the private sector, F3 will partner with 1) agricultural input suppliers, 2) beef, dairy and palm oil companies, 3) producers' organizations and 4) standards groups to reduce the environmental impacts of supply chains (some facilitated by Wageningen). Yara International will help collate and analyze data to develop improved N_2O models and use findings to identify optimal regional fertilizer application strategies. Danone will support best management practices to improve production and reduce emissions of dairy supply chains in Kenya. The producers' organizations CORFOGA, FEDEGAN and FEDEARROZ will support implementation of NAMAs in the livestock and rice sectors in Costa Rica and Colombia, and GIZ will be a partner in NAMA activities. The WBSCD and the Consumer Goods Forum are interested in how to best monitor emission reductions.

Research questions

F3 has 5 CoAs. CoAs 3.1 and 3.2 inform GHG emissions and LED priorities among smallholders, while 3.3 examines incentives and institutional arrangements to scale up. CoA 3.4 focuses on reducing the impact of commodity supply chains on deforestation. CoA 3.5 tackles mitigation options in the broader food system (food loss and waste, diet shifts). Centre contributions to CoAs are summarized in Annex 12.2

CoA 3.1 Quantifying GHG emissions from smallholder systems

A transition to LED requires robust information on GHG emissions and practical methods for monitoring. Insufficient data on emissions for smallholder systems, particularly on N_2O and enteric CH_4 has led to emission factors with high uncertainty (Scholes et al. 2014; IPCC 2006). F3 will work across CRPs to support better data, innovative estimation methods, a shared database, and collaborate with partners to support a Learning Platform among NARES and global scientists to improve baselines and mitigation planning.

Key research questions are: What is the potential net reduction of emissions and emission intensities from smallholder farms in promising sectors (farm and country level, with links to FTA on national accounting)? What are the most cost-effective methods of quantifying GHG emissions of smallholder food systems? What are the emissions of proposed low emissions technical packages? What MRV procedures are appropriate to national needs to best achieve accountability for agricultural systems?

Standardized methods will be used across CRPs, with controlled, experimental trials on farmers' fields and novel approaches to activity data, making use of ICT, crowd-sourced data and large data sets. Existing data from analog sites, e.g., Australian semi-arid systems that resemble some agro-ecosystems in Africa and South America, will be consolidated. Results will improve biogeochemical process and statistical models to reduce the costs of emissions estimates and feed into CoA 3.2 and 3.3 for impact. Countries will have more reliable mitigation information to plan policy and access climate finance. Key outputs will be:

- Tier 2 and 3 emissions estimates for key source categories and mitigation practices, (e.g. reducing ruminant emissions through improved feeding), with methods linked to IPCC guidance.
- Improved GHG estimation models for smallholder conditions in the tropics (e.g. N_2O emissions model for agriculture soils), including linkages with crop-soil models to better estimate productivity. Training in use of models in CCAFS Regions.
- Verified low-cost methods for monitoring, including use of such as dairy cow feed baskets. "Big data" spatial data sets and emissions factor platforms with the IPCC and the GRA, integrating results with existing data platforms and building on available data, feeding into F4 and AgMIP.
- Improved accounting for soil C uncertainty and analysis of tradeoffs among competing objectives (e.g., cost, scale and accuracy) to inform GHG measurement and LED policy, with WLE.
- Strengthened capacity of young scientists, 50% of which will be women, using the CLIFF Network

CoA 3.2 Identifying priorities and options for low-emissions development

F3 will provide decision-makers with ex-ante analysis and tools to identify low-emissions options, test practices for their feasibility using farmer field-trials and evaluate trade-offs. Testing will include emerging options such as BNI in crops with an inter CRP-JIRCAS consortium, cows bred for reduced methane in collaboration with the GRA, and bioenergy compatible with food production. Current analyses and tools lack adequate developing country data and don't link production to GHG emissions (Richards et al. 2015). Empirical evidence for their feasibility and impacts on emissions, food production, livelihood resilience, and equity is also lacking. Among AFS-CRPs, F3 will synthesize findings across technical options and AEZs. CoA 3.2 will build on 3.1 results.

Key research questions are: What are countries' best-bet, scalable technical and policy options for LED and the costs of implementing them? What are plausible country targets for reducing agricultural emissions? What are technical options' suitability and potential impacts in agro-ecological zones and target countries? What are the barriers, enabling conditions and incentives to support behaviour change among women and men farmers, farm advisers, and supply chain actors? How to improve the inclusiveness and influence re gender?

The research design will involve participatory evaluation of technologies using trials with smallholders in regions with high expected potential for mitigation and planning tools at national levels using 3.1 results. Evidence will provide the foundation for larger-scale action in 3.3. Key outputs will be:

- Promising LED technical options and their trade-offs, including emerging options such as BNI and reduced methane cows, based on multi-year field-trials.
- Analysis of LED sub sectors and decision making to increase women's benefits and influence.
- A global information platform with synthesis of LED agricultural management practices and conditions, including what works and does not work.
- Identification of global hot spots for emissions and mitigation opportunities
- User-friendly tool and training for mitigation planners to compare mitigation options and priorities; most current tools focus on emissions rather than mitigation options and lack smallholder data.
- Ex ante LED policy analysis based on scenarios using global data sets, RCPs and shared SSPs (in coordination with FTA, PIM)

CoA 3.3 Policy, incentives and finance for scaling up low emissions practices.

Building on options identified in CoA 3.2, F3 will develop and test approaches for integrating mitigation into national agricultural development programs, sustainability initiatives and private sector investment to support large-scale implementation of low-emissions agriculture. Global experience in implementing LED is limited to a few pilot projects (Woelke et al. 2012; Ha 2014) and little information exists on the incentives, finance and business models, enabling conditions and accountability needed to implement LED (Branca et al. 2011). New models are needed for land-based mitigation that go beyond REDD+ and the use of conditional payments. Similar to 3.2, F3 will integrate information about policy and institutional options across CRPs.

Key research questions are: What information can inform policy, incentives and finance to lead to successful farm-level changes in practices at large scales? What is the economic feasibility of LED and sustainable business models and mechanisms for financing transitions to LED? What public-private institutional arrangements and interactions, including farmer-centred innovation, provide large numbers of youth, and women and men farmers, with access to technical information and inputs? What enabling conditions are needed to enable women to benefit from LED? What are generalizable metrics for measuring progress on low-emissions agriculture and assessing trade-offs? What are the impacts of different policies on mitigation targets?

This CoA will use comparative analysis to identify and test promising models using participatory action research and pilot programs in target countries working in collaboration with national partners, agricultural input providers and producer organizations. Key outputs will be:

- Evidence-based economic and finance models appropriate to different farmer contexts
- Information platform on business opportunities for green investment in low emissions agriculture.
- Policy analysis of pilot tests of CC adaptation and sustainable intensification initiatives, NAMAs, LEDS, private sector sustainability initiatives for up-scaling to multiple sites in countries
- Metrics and systems for national and subnational monitoring and evaluation of impacts of LED on livelihoods, gender equity, food security and mitigation
- Technical and policy guidance and standards broadly disseminated through communications and public outreach campaigns and partnerships, including a section on enabling conditions for women farmers

- Model country action plans and international training courses for scaling up LED and dynamically reassess the feasibility of mitigation goals.

CoA 3.4 Supply chain governance to avoid deforestation (Twinned Flagships with FTA TF#2)

F3 will improve the private and public governance of beef, palm oil, soy and other major commodities that lead to forest or peat land conversion to incentivize forest conservation and assess compliance in practical ways. Agriculture's largest contribution to mitigation is through reducing deforestation as agricultural commodities account for ~73% of deforestation globally (Hosonuma et al. 2012). As policy interventions to support avoided deforestation by agriculture emerge, evidence for their impacts and improvements is poor. In this CCAFS-FTA collaboration, CCAFS will emphasize private sector and market governance in supply chains related to agriculture, while FTA will focus on supply chains related to high-value trees and forest products. Activities will be undertaken in Indonesia, the Brazilian Amazon and the Congo Basin in Africa. Findings will be shared with the International LEDS Initiative AFOLU working group and UN-REDD. Opportunities for governance of smallholder commodity production in the Congo and the potential for reducing aquaculture's impact on mangroves (together with Fish CRP) will be explored.

Key research questions are: How can private-public governance influence commodity sustainability practices to reduce deforestation and GHG emissions while promoting the sustainability of local livelihoods and ecosystems? What are the most important institutional architectures, incentives and other factors driving positive impacts and scale of implementation? What are the impacts of public and private regulations, and hybrid governance arrangements on avoided deforestation, reduced emissions, and local livelihoods? How do promising hybrid governance arrangements provide opportunities and mechanisms for up- and out-scaling? How to achieve local governance where national governance is weak, e.g. in Congo?

The research design will include case studies in deforestation hot spots with major sustainability initiatives for agricultural commodities: oil palm, cattle, and soy. The CoA will partner with existing sustainability initiatives. Key outputs will be:

- Impact assessment of regulations and sustainability initiatives on hectares avoided deforestation, GHG emissions, and associated social impacts and trade-offs
- Good practice guidelines and options for public, private and hybrid governance arrangements for improving sustainable commodity supply chains
- Engagement in multi-stakeholder platforms (such as the Roundtable for Sustainable Palm Oil), taskforces and other commodity sustainability initiatives
- Viable methods to determine compliance within supply chains

CoA 3.5 Opportunities for mitigation through efficient and resilient food production systems

To help ensure sustainable consumption (SDG 12), F3 will synthesize best-bet options and incentives for reducing post-harvest losses and food waste in agricultural supply chains and shifting diets, recognizing that supply chains need to be optimized for specific contexts and increasing efficiency in supply chains may involve trade-offs. This CoA will catalyse new areas of research across CRPs. Demand for emissions-intensive food is increasing (e.g. animal products, trade). Shifting nutritional strategies and reducing food waste and loss have the potential to mitigate over 3 $GtCO_2e$ per year globally (Smith et al. 2013; Dickie et al. 2014), however no evidence exists for interventions necessary to achieve them.

Key research questions are: Is reducing emissions compatible with diets that have a higher nutritional value and that increase human resilience? How much mitigation can be achieved by reducing food waste and post-harvest loss in focal countries' supply chains, and what are the opportunities for achieving this? How can a growing demand for animal protein be satisfied with lower emissions to achieve food security in socially acceptable ways? How can public and private policies and incentives shift dietary preferences to reduce emissions while equitably enhancing nutrition?

The research will focus on working with producers, processors, distributors and consumers to conduct exploratory analyses to quantify food system efficiencies in CCAFS Regions. F3 will engage youth organizations as potential advocates for sustainable consumption. Key outputs will be:

- Country-level reviews of food loss, waste, and dietary trends with policy scenarios and private sector investments for implementing mitigation
- Analyses of market and production inefficiencies that result in increased consumption of higher-emission food
- GHG footprints of diet trajectories according to IPCC and FAO scenarios
- Analysis of potential economic measures and business strategies to drive low-emissions consumption, including marketing strategies

Capacity development

To develop locally appropriate LED, farmers, farm advisers, and policy makers need to know about technical options and their benefits and risks, as well as have the skills to test them. F3 will assess, build and monitor capacity in 4 areas to advance progress in F3's impact pathway: 1) *learning about LED options* by farm advisers and mitigation planners through the use of tools such as IRRI's Crop Manager and CIMMYT's Nutrient Expert, ® and the Mitigation Options Tool developed by the University of Aberdeen; 2) *institutional strengthening* of ministries of agriculture and environment to develop LED policy by co-producing data, tools and scenarios about mitigation opportunities and impacts; 3) *develop future LED research leaders* using fellowships for post-graduate students from developing countries with priority given to women, to learn GHG estimation and measurement techniques at CGIAR Centres and participate in CCAFS' Climate, Food and Farming Network, including the regional network CLIFF-LAMNET; 4) continue bringing policy makers and scientists together in expert workshops with FAO to *assess needs and develop interventions*. Post-doctoral positions for gender specialists in selected sectors will support more *gender-sensitive* research.

Geography and beneficiaries

F3 will focus initially on first-mover countries pioneering LED where rapid implementation is likely and the CGIAR has a comparative advantage (Vietnam, Bangladesh, Mexico, Colombia, Costa Rica, Kenya). Agriculture in most of these countries generates ~30-60% of national emissions, so interest in reducing net agricultural GHG emissions is high. With successful cases from these countries and working with global partners and platforms and advanced research institutes in China, Brazil, India, and Indonesia, F3 also will aim to build generalizable evidence to support mitigation at larger scales. The research on agriculture and deforestation will focus on forest-agriculture landscapes in the Amazon, Indonesia and the Congo Basin.

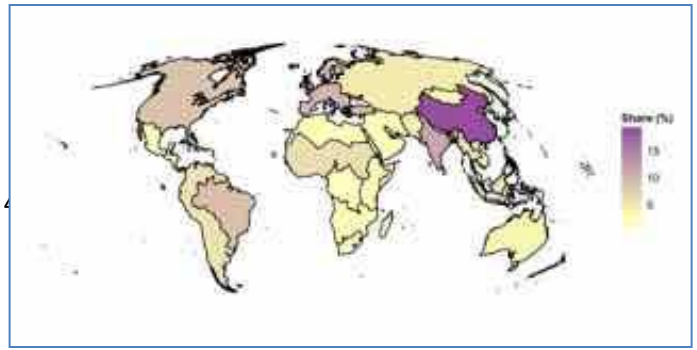

Figure 1: Share of mitigation potential in agriculture in 2020 (source: Kleinwechter 2014)

F3 beneficiaries will be 1) women and men smallholder farmers seeking increased finance and technical options, 2)

national and local governments seeking to meet mitigation goals, 3) consumers seeking food products with reduced GHG footprints. Primary users of the research will be 1) national agricultural decision-makers, 2) investors in agricultural development, including development banks, private finance, and producers' associations, and 3) advocates for sustainable and low-emissions food systems, including NGOs such as EDF. F3 will prioritize women and young scientists from developing countries for training.

Significance of expected contribution to gender IDOs

Building on F3's prior grassroots gender work and recommendations of the external evaluation, F3 will identify how women and girls (via their unions and organizations, such as NIAPP) can influence the vision, development and evaluation of policy and projects for reducing emissions, taking on board women's technical, social, and cultural needs. F3 will identify women-led supply chain roles, such as dairy farming in Kenya, to ensure that climate-related finance and resources flow to women. Within supply chains, we will create spaces for women and men to exchange views and information to support changes in gender relations, as in Phase I where Honduran women worked with men to select agroforestry species. However, achieving outcomes in both GHG mitigation and gender involves trade-offs. Men often dominate activities associated with priority mitigation options, such as beef cattle intensification in Brazil, and few opportunities exist for women to shift to these activities in the near-term. A F3 goal is to identify how to reduce these trade-offs by identifying enabling conditions to benefit women. F3 will focus on encouraging and improving women's roles in decision-making, and training women scientists. A current review will analyse technical agronomic practices that reduce GHG emissions re potential impact on gender equity and social justice among smallholder farmers and livestock keepers in selected CCAFS Regions, to develop a gender-responsive design framework for mitigation projects.

Lessons learnt and unintended consequences

During the last five years, F3 established GHG quantification guidance, research and engagement partners, data and information platforms. Estimating GHG emissions is technically demanding work that requires capacity strengthening and long-term investment with partners. Wider engagement with scientific researchers and global partners such as the GRA is needed to consolidate emissions data. In Phase II we will focus on fewer interventions and production systems to allow more in depth testing of options and incentives with farmers. Country-level priority and target setting is in progress and will further inform Phase II. Potential unintended consequences include: constraining agricultural development if finance is contingent on mitigation outcomes; incorrectly estimating mitigation potentials; and missing opportunities for mitigation based on priority-setting now with limited information. As part of the technology development process, F3 will analyze trade-offs and monitor the impacts of interventions, reducing the risk of unintended consequences.

Integration with other CRPs

F3 will establish Learning Platform (LP#5) across all CRPs and with partners, for example through GACSA, on *smallholder agricultural emissions* (see Annex 5, Tables 5.1 & 5.4 for investment levels) to standardize methods and metrics for LED, integrate emission factors and LED opportunities across agri-food systems and regions, analyse mitigation hotspots and targets to inform Centre and partner research; enable policy learning about incentives and finance across countries; and integrate supply chain opportunities for mitigation. LP#5 will include the SAMPLES program (see CoA 3.1 and 3.2). With PIM, F3 will develop scenarios for ex ante analysis and national planning for LEDS at landscape scales and sustainable food consumption. With WLE and France's *4‰* Initiative, F3 will explore policies and incentives for avoiding loss of and sequestering soil carbon. F3 and Livestock (Environment Flagship) will co-invest in reduced emissions from feed and forage options, and breeding and health interventions. The Livestock CRP will generate technologies while F3 will quantify emissions,

identify priorities and incentives for LED. The Livestock CRP will coordinate findings with CCAFS on the soil carbon impacts of reduced degradation in pastures and mixed livestock-crop systems and improved forages. CCAFS and FTA will have a twinned Flagship TF#2 on supply chain governance to avoid deforestation (CoA 3.4), complementing work on sustainable intensification in the AFS-CRPs for more sustainable landscape management, e.g. with Fish CRP on the potential of improved governance to avoid deforestation of mangroves.

Comparative advantage of the CGIAR and host Centre

With the capacity to test technologies and policies in multiple locations globally over time, the CGIAR is well positioned to generate scientific evidence and learning among countries and international organizations about LED options. The CGIAR has grown to become a significant player in mitigation in developing countries, aided by the cross-Centre approach adopted in Phase I. This comparative advantage arises from CG Centres' location in multiple developing countries and work on multiple sub-sectors. UVM has led CCAFS' mitigation program since 2010. UVM now has strong partnerships with the 15 CGIAR Centres. The Gund Institute is an international leader in ecosystem services and modeling, attracting world-class scientists and collaborating with partners in 20 countries globally.

Relevant previous projects

- Standard assessment of agricultural mitigation potential and livelihoods (SAMPLES) supports tropical countries to measure GHG from agriculture and identify mitigation options compatible with food security. ICRAF, ILRI, CIFOR, IRRI, CIMMYT, ICRISAT, CIAT, Aarhus University, KIT. 2012-ongoing.
- NAMA development in Colombia. Economic analyses of mitigation and adaptation options for agroforestry and silvopastoral systems to inform mitigation policy and finance in Colombia, with CIAT 2012-2014.
- Assessing incentives for scaling up AWD will ensure mitigation technologies increase gender equity, inform extension strategies, and enable the public sector to provide incentives for implementing AWD. IRRI with partners in Bangladesh, Cambodia, Laos and Vietnam**.** Livestock modeling in partnership with ILRI and FAO to update 1) IPCC AR5 report with GHG emissions, and 2) Improve understanding of the diversity of livestock management systems and GHG emissions in CCAFS Regions.

Flagship 4: Food System Governance under Climate Change

The vision

The F4 vision is that national, regional and global policies and institutions enable equitable food systems that are resilient to a variable and changing climate. By 2030, equitable institutional investments in climate-smart food systems will have increased in 20 national/subnational jurisdictions compared with 2017, thus supporting millions more men, women and children in meeting their minimum dietary energy requirements through a diverse and locally acceptable diet despite challenges posed by climate change. Three key 2022 outcomes (see Performance Indicator Matrix for full list) are: (a) *Enabled environment for climate resilience* through USD 400 million of new investments, informed by CCAFS science, by national, regional and global agencies; (b) *Improved forecasting of impacts of climate change* and associated priority setting informed by CCAFS science in at least 25 countries; (c) 25 targeted national/state institutions adapting their plans and directing investments towards climate-smart food systems to *increase women's access to, and control over, productive assets and resources*.

The challenge

While climate change is a major challenge of the 21st Century (Stern 2006), it intersects with other grand challenges facing humanity: malnutrition, population growth, inequity, rapidly urbanisation, migration and unsustainable resource management including water, land, energy and biodiversity (Rockström et al. 2009). F4 takes as its entry point the enabling environments needed to address climate change but links with the grand challenges through partnership and research to foster institutional change. Climate change challenges are such that incremental adaptation may not be sufficient and transformational adaptation will be needed (Kates et al. 2012). Both will require major behavioural shifts. Farmers will need to adopt practices and technologies that help them increase their resilience. This will require a supporting environment revolving around appropriate governance in public and private sectors. This focus on institutions is crucial to achieve climate-smart food systems at scale. F4 will provide research outputs that speak to the grand challenge of providing healthy diets for a developing-world population that is still growing rapidly, through a food systems oriented approach.

At the global level, there is progress in UNFCCC with a dedicated work stream, partly a result of CCAFS work in Phase I. At country level there is a flurry of activity in relation to climate policies, adaptation strategies and national commitments. Climate finance is coming on stream through mechanisms such as the GCF, and these need to be directed to address country priorities in adaptation. At the same time, interest in food systems and the roles that all actors (including private sector) can play, is spiralling (Beddington et al. 2012). As countries increase their investment in CSA and enact climate-smart policies, this will increase control of productive assets and resources by both men and women so that food and nutrition security (FNS) can be increased.

Scientific rationale and theory of change

Climate change will have far-reaching consequences that will disproportionately affect poor, food insecure and marginalized groups that depend on agricultural livelihoods and have low adaptive capacity (Nelson et al. 2009). Responses are possible to the triple challenges of food security, adaptation to and mitigation of climate change, but they require an enabling environment to catalyse positive change towards climate-smart food systems (Lipper et al. 2014). The theory of change of F4 is to enhance governance mechanisms across scales that can support resilient and equitable food systems in the face of a changing climate. Research results coupled with well-established partnerships in CCAFS's Regional Programs will be used to engage more effectively with stakeholders to be supportive to increasing resilience of the most vulnerable, and to improving FNS. There are challenges in how best to facilitate adoption and scaling through an

enabling institutional environment. These include priority setting and targeting of interventions under future uncertainty and innovative ways of engaging partners (ISPC 2013; Kristjanson et al. 2014). F4 will target the enactment of policies and other governance mechanisms that are informed using knowledge, tools and approaches derived from the science of CCAFS and partners and that take into account climate-smart practices, and social inclusion. International climate finance and investment in climate-smart food systems could help to overcome constraints to scaling, provided that countries' priorities are taken into account and investments are channelled appropriately. While national policies are key, civil society, private sector and other actors need to be engaged. The ToC is aligned to the CRP ToC as illustrated in Annex 7, Fig. 7.6. As shown in Annex 4 Fig. 4.1, F4 will contribute to one CGIAR SLO: Improved food and nutrition security for health. It will contribute to four IDOs (bold) and five sub-IDOs (italics):

- **Adaptation and mitigation achieved;** via *improved forecasting of impacts of climate change and targeted technology development* through ex-ante analysis, downscaling climate forecasts and decision support tools; via *enabled environment for climate resilience*, through national agencies using CCAFS science to enhance food system governance and scale up climate-smart investments.
- **Improved diets for poor and vulnerable people;** via *optimized consumption of diverse nutrient-rich foods* through equitable climate-smart institutions enacted at national to global scales to increase access to diverse and locally acceptable diets.
- **Enabling environment improved**; via *increased capacities of next users to adopt research outputs* through mainstreamed efforts in capacity development with key institutional actors.
- **Equity & inclusion achieved**; via *increased control by women over productive assets and resources* through institutional actions that empower women and marginalized groups.

To achieve outcomes at significant scales we hypothesize that:

Hypothesis F4 H1: Institutions in selected countries are adapting plans and directing investment towards climate- and nutrition-smart food systems for enhanced FNS. This work will contribute to improved diets for poor and vulnerable people through enabled environments where governance systems are enacted to optimize consumption of diverse nutrient-rich food. National policies and global investments are informed by improved national planning and implementation environments, and governance for climate-smart food systems.

Hypothesis F4 H2: Countries are using CCAFS projections and priority setting to target CSA interventions in food systems and value chains. This work will improve forecasting of impacts of climate change and targeted technology development through analysing trade-offs and priority setting for policy implementation and investment planning. Actionable policy solutions will put in place institutional environments within which adaptation and mitigation may be achieved, leading to country readiness for CSA. National processes are complemented at macro-level and by strengthening capacities for impact analyses.

Hypothesis F4 H3: Global, national and regional institutions will increase their institutional investments in climate-smart food systems on the basis of CCAFS science and engagement. This work contributes to an enabled institutional environment for climate resilience at national to global scales. Institutional research on differential implementation of governance mechanisms in target countries and engagement with national to global decision makers will enable more supportive processes and institutions for scaling CSA.

Hypothesis F4 H4: National institutions are adapting their plans and investing in climate-smart food systems to increase women's access to, and control over, productive assets and resources. This work supports women in increasing their equitable control of their productive

assets and resources. Women are improving their households' FNS, while equitable policy enactment and governance will enable farmers to adopt CSA.

The ToC depends on the following assumptions: 1. Decision makers recognise the need for both, scientific evidence and soft skills, to use the later effectively. 2. Innovative tools and mechanisms can support national decision making processes effectively, when scaled up through meaningful engagement with farmers, community organisations, policy makers and ministry staff. 3. Investment decisions can be informed by research on governance and not only by technological solutions. 4. Adaptation will attract climate finance, with mechanisms in place that allow CCAFS to inform donor decisions and strengthen country capacity to successfully compete.

Partners for outcomes and research

Achieving the F4 vision requires engagement with partners along the impact pathway, primarily through CCAFS Regional Programs. Centre partners in F4 include: ILRI, CIAT, Bioversity, IFPRI, IITA, IRRI, ICRISAT, WorldFish, ICRAF, and CIP. In Phase II, all AFS will become partners for CoA 4.1. Key partners for impact include regional organisations such as NEPAD, ECOWAS, COMESA, AGN, IGAD, ASEAN, CAC, ECLAC and FLAR, and international NGOs and networks such as CARE, CTA, GACSA, WEF and WBSCD. International and bilateral partners include FAO, IFAD and GIZ, and increasingly in future, international investment and climate finance institutions such as GCF, where CCAFS science may influence investment priorities in target countries. Other key partners include national ministries involved in policy planning and implementation, and climate change units in several countries in East and West Africa and LAM. Such partners are next-users of CCAFS's outputs. F4 works with a range of national agencies (in Kenya, for example, these include the Kenya Red Cross, National Drought Management Authority, and Meteorological Department). In future, communications for development partners such as Mediae will be increasingly important, offering opportunities for scaling to reach millions of rural households, men, women and children.

Links with the private sector are crucial for reducing barriers in the enabling environment to foster uptake of CSA at scale. The CCAFS scenarios work in Phase I has helped foster partnerships with the private sector. Examples include commercial farmers' organizations (e.g. Ethiopia), agribusinesses (e.g. in Sri Lanka), traders (e.g. in Cambodia), and commercial investment banks (e.g. in India). Increasing opportunities exist to guide private sector investment. Initiatives such as SUSFANS, TRANSMANGO and CIMSANS that involve F4 partners at ECI, Wageningen, and CSIRO already have food industry partners such as Unilever, Nestle and Mars.

F4 with the CCAFS Regional Programs has gone through several processes in selecting research partners. Regional research priorities workshops have been held that build on the science-policy platforms that CCAFS has developed in several regions. These have included network analysis to analyse gaps and overlaps in specific regions to identify partner synergies, where appropriate. Most of the current F4 portfolio was identified via competitive processes. In future, a combination of these processes for prioritising and selecting partners will be undertaken, linked to CCAFS, Flagship and regional impact pathways. F4 works with several key partners for research. ECI adds value through their work on food systems and their expertise scenarios for policy guidance. IIASA are world leaders in integrated assessment modelling, complementing CGIAR expertise with additional capacity in land-use and environmental modelling. CSIRO adds value in systems modelling at multiple scales. Governance work is undertaken with Future Earth's Earth System Governance project as well as other partners (Universities of Pretoria, Osnabrück, Indiana) that bring different skills and perspectives to CGIAR expertise. Links with universities (Reading, Cape Town, Leeds, UCI) and with IRI bring cutting-edge climate science to bear. IDS, IIED, ODI, IISD and Stockholm Resilience Centre bring strong skills in R4D and policy analysis.

Research questions

To realize its vision, F4 will work in four CoAs, which will bring CCAFS science to decision making at different scales. Climate science, environmental research and agricultural modelling (4.1) will be linked to food systems research and socio-economic scenarios (4.4) to integrate climate concerns into policies related to food systems, FNS, and development. Research focusing on national adaptation planning, including stakeholder engagement and social inclusion (4.2), will be supported by macro-level comparative analyses of governance systems, institutions for scaling CSA, climate finance and the role of non-traditional actors (4.3); and vice versa.

CoA 4.1 Ex-ante evaluation and decision support for climate-smart options (Learning Platform)

This CoA will address ex-ante evaluation of CSA options at multiple scales, in relation to synergies and trade-offs that occur between the three pillars of CSA (FAO 2013). It will target practices and beneficiaries in relation to what works where and under what conditions, and deal with the application of decision support tools and ICTs for targeting policy development and investment choices for climate-smart food systems. Advances have been made in global databases that can be used for priority setting (Sebastian 2014) and tools to evaluate impacts of policies and practices on development outcomes (Dumollard et al. 2013). As climate science advances, there is a need to ensure that global climate databases are up-to-date, to maintain the relevance of ex-ante studies. Major issues remain, including the need to robustly link scales of analysis, taking into account gender and social inclusion, the challenges that exist in collecting and archiving large amounts of information, and improving the scope of climate change impacts work with regard to changes in climate variability (ISPC 2013). Recent advances in remote sensing, mobile telephony, citizen science, crowdsourcing, and Big Data analysis offer considerable scope for overcoming some of the challenges (Fritz et al. 2015).

This CoA will address the following research questions: How is scientific information about climate change and its likely impacts on agriculture, food security and livelihoods best packaged for different stakeholders for integration into decision making? How should the climate resilience of large populations be tracked and measured, so that policies and programs are supporting appropriate activities and targeting the right people, particularly women? How can changes in climate variability be robustly incorporated into impact studies and decision support tools? What are appropriate methods to carry out ex-ante evaluations at multiple scales?

Work will be carried out in response to demands within and outside CCAFS, mainly through AFS-CRPs. It will act as entry point to ex-ante evaluation in CCAFS, and provides a platform for other CRPs to provide prioritization and ex-ante evaluation backstopping with respect to climate science. Research outputs will include:

- A range of data maintained on CCAFS and partner websites, including up-to-date downscaled climate information that builds on current CCAFS data portals (e.g. ccafs-climate.org).
- Decision support tools developed and curated by CCAFS and partners for helping to set priorities, target policy development and investment in CSA and climate-smart food systems.
- Training materials developed and archived in the public domain, to strengthen the capacity of partners in applying decision tools in targeting, policy and investment decision-making.

CoA 4.2 Improved national climate change planning and implementation environments

Research under this CoA will address the improvement of adaptation and food system policies at the national (and state) level, through engagement with decision makers via stakeholder platforms, science-policy dialogues and other mechanisms. F4 will assess methods for

policy analysis and policy change and co-development of knowledge depending on context. Researchers will engage with stakeholders to ensure that the best information available about climate change, its impacts on food systems, and adaptation are used in the design and implementation of policies that can lead to climate-resilient, equitable food systems at scale. At another level, researchers will assess those methods of engagement and synthesise findings to inform information uptake in other settings. The rationale of this CoA is to help bridge the gap between science and policy and mainstream climate change information into, and link climate-smart food systems with, national food security planning and implementation processes. This work can help to understand and provide national enabling environments that will allow smallholders to adopt climate-smart practices. Depending on national context, the focus will be on adaptation and commodity plans that incorporate suitable climate-smart technologies and practices, national implementation of global treaties on the use of genetic resources for CSA, and gender action plans that evaluate potentials of policies and practices in overcoming gender disparities (Holvoet & Inberg 2013; Nelson & Stathers 2009). Work in the CoA complements national mitigation policy work in F3.

Several research questions will be addressed: What are strengths and weaknesses of emerging food systems policies in relation to climate change and effects on different beneficiaries? What are effective ways to produce site-specific insights from and for policy instruments, and how may subnational contexts be incorporated into national policy design to ensure local voices are empowered to contribute to national decision making? Which tools are effective in bridging the climate change science-policy divide, with respect to novel decision making tools, cross-scale methodologies, engagement and capacity enhancement? What are differential implementation strategies of global treaties in national contexts; what drives policy change?

Research outputs will include:

- Comparative analyses of current and emerging climate policies and "good practice" guidelines on engagement with national climate planners.
- Monitoring and evaluation of climate policy processes.
- Capacity strengthening for formulating local and national priorities in regional and global fora.

CoA 4.3 Governance and institutions for climate-smart food systems

This CoA takes a broad view of institutions and governance beyond the national policy focus of CoA 4.2, to include any structures, mechanisms, formal or informal rules that govern social interactions and individual behaviour in 'institutions'; and formal and informal processes and mechanisms contributing to frameworks, rules and actions that produce, maintain and regulate a particular system in 'governance'. Research addresses governance and institutions from national to global scales including stakeholders beyond the policy process, and cross-scale linkages for enhanced climate governance and investment in climate-smart food systems. The CoA includes work in all CCAFS Flagships and Regions requiring engagement and CGIAR representation in regional to global climate processes, and will link with others including A4NH, PIM, and ILRI. The rationale is to better understand the institutional environment and governance systems in which climate-smart food systems can be taken to scale, going beyond regional and global policy processes to consider other institutions and actors that shape discourse and power relations, and institutional change (Bizikova et al. 2014; Purdon 2014). This is needed so planning and investments can be targeted towards specific stakeholders, information flows fostered between national, regional and global actors, and local voices considered in regional and global fora.

Research questions under this CoA include: How do donor priorities and discourses on climate change and CSA exert influence "downwards" on national and local institutions, and how can influence be exerted "upwards"? What are multi-level governance processes that support transformation, compared with those that promote incremental change, and when might transformation in food systems as a result of climate change need to be considered? What are indicators and metrics of "good enough" governance for climate-smart food systems at multiple scales? What governance mechanisms make food systems more resilient to climate change, and to what extent are their characteristics context-specific? What are the roles of civil society, private sector, and non-traditional actors in shaping discourse and how can they assist in strengthening governance arrangements in the face of climate change? How can ICTs support accountability in multi-scale governance systems?

Research outputs will include:

- Syntheses of case studies of selected regional and global bodies and comparative analyses of governance mechanisms for conferring differential levels of resilience in food systems.
- Novel analytical tools, indicators and metrics for evaluating governance effectiveness.
- Evidence for institutions effectively supporting scaling and learning under uncertainty in R4D.
- Innovative ICT-based tools and gaming to support accountability mechanisms in institutions at multiple scales and to engage youth in decision-making, respectively.

CoA 4.4 Food and nutrition security futures under climate change (Twinned Flagships with A4NH and PIM)

This CoA focuses on the scenario-guided formulation and implementation of policies and action plans relevant to FNS and poverty under climate change. It takes a food systems approach, based on state-of-the art, multi-level modelling that covers a range of food systems elements and has potential to focus on nutrition, poverty and diversity in household choices. This approach is combined with collaborative scenario-guided policy processes that have guided national plans in several countries. The food systems focus will be used to engage with strategic processes that would otherwise not have a climate focus. These include the enactment of mainstream national policies focusing on socio-economic development, poverty and livelihoods, food security, health, and nutrition. The focus on food systems (Ingram et al. 2010) allows for collaboration with private sector (e.g. farmers' organizations, traders, food industry, and consumers) and civil society (e.g. media and special interest groups). Co-investment with CCAFS Regions, PIM and A4NH will extend cutting-edge FNS scenario research through a greater focus on climate impacts, and social inclusion.

This CoA will address these research questions: How can multi-dimensional scenarios for climate impacts (including extreme weather events) on food systems be simulated? How can policies, private sector strategies and other institutions affecting FNS become more climate-smart through the use of scenarios? How can scenario processes assist in integrating bottom-up perspectives into multi-level governance, to make them more inclusive? How can scenario-guided strategy development as a process of social learning integrate strategic planning capacity in institutions?

Research outputs will include:

- Food systems scenarios and documentation downscaled to country level in selected regions.
- Policy documents informed by inclusive, multi-level scenario processes in several countries.
- Scenario-based strategic planning capacity strengthened with national to global partners.

- Reports on scenario-guided investments by private sector partners in each focus region.
- Innovative approaches to downscaling scenarios as multi-level engagement and accountability mechanisms in devolved governance systems.

Capacity development

F4 will continue to enhance the capacity of partners to design institutional change and R4D processes on the basis of adaptive management principles for outcome-focused implementation and M&E. This is done through a ToC that relies on iterative engagement tools. The Climate Change and Social Learning Initiative will continue to promote learning-based approaches and develop an evidence base of conditions under which these can add value in R4D. Engagement in CCAFS Regions is tied to capacity development, e.g. strengthening negotiating capacity of AGN in UNFCCC, and F4 projects combine engagement and co-learning through science-policy dialogues or multi-stakeholder platforms. Jointly with F1, F4 and partners will continue to expand CCAFS web portals, priority-setting tools and data, along with documentation on how to use them. This will be complemented by in-country capacity development for integrated assessment of adaptation and mitigation. Scenarios are great vehicles for decision makers to engage with uncertainty, multi-disciplinary perspectives and diverse societal voices. Scenario-guided policy processes will be combined with training of sub-/national planners to employ scenarios and with ICT to empower communities to monitor resilience and accountability.

Geography and beneficiaries

Work in F4 will focus on all CCAFS Regions: WA (Ghana, Senegal, Burkina Faso, Mali, Niger), EA (Kenya, Uganda, Tanzania, Ethiopia), SA (India, Nepal, Bangladesh), SEA (Cambodia, Vietnam, Laos, Philippines, Myanmar), LAM (Nicaragua, Guatemala, Honduras, Colombia, El Salvador, Peru). Activities in other countries will be selected on the basis of CGIAR site integration plans and synergies with other CRPs, particularly A4NH, PIM, and Livestock, capitalising on emerging opportunities to inform policy and investment. F4 will expand activities led by WorldFish in the Pacific.

F4's stakeholders will include policy makers relevant to food systems in ministries and planning agencies, investors and donors, R4D partners, NGOs, civil society, and private sector. Issues around communities and social inclusion are not often included in climate change planning at national to global levels, and this is a gap that will be addressed along with partners and other CRPs (e.g. PIM). F4 will develop a focus on the inclusion of youth via scenarios and gaming. F4 aims to empower local voices in multi-scale governance, thus providing the entry point to local level impact. With a focus on women, youth and vulnerable groups, empowerment in decision making will be key in strengthening their role in climate-smart food systems and their FNS.

Significance of expected contribution to gender IDOs

F4 will contribute to the sub-IDO Gender equitable control of productive assets and resources. Women smallholders have less access to productive resources and to decision making at local, national and global levels (FAO 2011; World Bank 2012; Holvoet & Inberg 2013). Climate-smart institutions that increase their ability to control and make decisions around the use of resources can contribute to improving child health, FNS and increased expenditure on education, contributing to poverty reduction (Meinzen-Dick 2011). In the past, a lack of sex disaggregated research has resulted in underestimation of women's contributions to livelihoods, health and nutrition, leading to gender-blind national policy making (Huyer 2014). Policies and Programs thus need to be based on gender and equity assessments so that existing inequalities are not exacerbated (EIGE 2012). F4 will build on the results of research that informs, catalyses and targets CSA

for women and other vulnerable groups (Kristjanson 2012; Jost et al. 2015). It will explore research that strengthens the roles and opportunities of women in multi-level governance processes for climate-smart food systems.

Lessons learnt and unintended consequences

F4 has shifted from three related sub-themes in Phase I to one integrated Flagship, mainstreaming research on knowledge into action in all Flagships and Regions of CCAFS. The proposed CoAs reflect several shifts: from understanding impacts of climate change on agriculture to evaluating trade-offs and synergies in bundles of practices at different scales; to a greater food systems focus, recognising that climate change and other grand challenges will have impacts on many if not all spheres of human activity; and to greater consideration of transformational change. Emphasis is being placed on governance and institutions: moving from a focus on policy development to guide their implementation, and from policy to include other governance mechanisms of food systems. All activities will have an outcome orientation to R4D, successfully piloted by F4 during CCAFS' extension phase, which underscored the importance of new partnerships and skills in research teams.

The uncertainties associated with climate change effects could have unintended consequences, through under-estimating the effects of climate change on downside risk at local and national levels and the differential impacts at temporal and spatial scales. Critically assessing existing governance arrangements may result in power shifts. One way to help address these issues is to use a problem-orientated, combined top-down and bottom-up approach (Vermeulen et al. 2013) that relies on engagement. We will use adaptive management and learning to maintain flexibility so that if negative consequences begin to appear, activities can be altered.

Integration with other CRPs

CGIAR Centre involvement with F4 will encompass direct programmatic research involvement (Centres with the largest budget share in F4 are Bioversity, CIAT, ICRISAT, IFPRI, IITA, ILRI, IRRI and WorldFish) as well as co-investment involvement. F4 will have three major points of co-investment with other CRPs (see Annex 5, Tables 5.1 & 5.4 for levels of investment):

- Learning Platform (LP#1): Ex-ante evaluation and decision support for climate-smart options (see CoA 4.1), helping with prioritisation related to climate change in other Flagships of CCAFS and in AFS-CRPs (e.g. Livestock). CSIRO (modelling) and WISAT (gender) will be Strategic Partners in LP#1.
- Learning Platform (LP#6): Policy engagement on CSA, covering national to global levels and building on the skills and experience from multiple Centres and partners. While this is a learning platform, relevant research on policies in CSA will be conducted in CoA 4.2/4.3, linked to PIM. Activities include representing CGIAR in regional to global climate processes (e.g. related to UNFCCC, IPCC, GACSA, and Future Earth), and in private sector initiatives (e.g. WEF and WBSCD). CCAFS will play a role in climate-related processes of regional economic and development agencies (e.g. NEPAD, ASEAN, ECLAC ECOWAS, SPC). Appropriate CGIAR Centres will deal with specific regional organisations (e.g. ICRAF-CIAT with NEPAD; ICRISAT with ECOWAS; ILRI with COMESA; CIAT-BIOVERSITY with CAC; IRRI with ASEAN). Global Landscapes Forum led by CIFOR will be a key global event linking CCAFS, FTA and WLE, amongst others.
- Twinned Flagship with A4NH, PIM (TF#3): Food and nutrition security futures under climate change (CoA 4.4).

Comparative advantage of CGIAR and host Centre

CGIAR has become a global player in ex-ante analysis using integrated modelling at different scales, bringing a strong R4D perspective. Its networks span a wide range of multidisciplinary perspectives in many developing countries. CCAFS has successfully undertaken multi- and

cross-Centre policy research during Phase I. These strengths can be built on in Phase II. The proposed hosting organisation for F4 is ILRI, continuing the relationship that has existed since 2010. The comparative advantage of ILRI to host F4 includes the following:

- A long history and considerable expertise in livestock systems R4D, particularly related to the mixed crop-livestock systems that predominate in the developing world, which will continue to be of paramount importance for the future food security of hundreds of millions of poor people.
- Expertise in food systems research, with strong linkages to non-CGIAR organisations working in this arena, and strong expertise in nutrition and zoonoses research.
- Demonstrated achievements in the fields of vulnerability science, governance research, and the development of metrics and indicators.

At the same time, F4 has built a team that is both multi-disciplinary and cuts across institutes.

Relevant previous projects

- Mapping hotspots of climate change and food insecurity in the global tropics: vulnerability mapping using downscaled climate data. ILRI, CIAT, CCAFS. CCAFS Report no. 5, 2011
- Innovative data products and tools for ex-ante evaluation: a large archive of CMIP5 climate data and tools, downscaled in novel ways, widely used to set priorities and evaluate national and local impacts of climate change. CCAFS F1, CIAT, ILRI, IFPRI, CIP, IIASA, Universities of Leeds, Oxford, Cape Town.
- Impacts of climate change on the agricultural and aquatic systems and natural resources within CGIAR's mandate, impacts of climate change on commodities and natural resources researched by, and with contributions from 15 CGIAR Centres. CCAFS Working Paper no. 23, 2012
- Scenario-guided policy formulation: Climate and socio-economic scenarios developed for policy planning in Honduras, Cambodia, Bangladesh, Uganda, Tanzania, Ghana, Burkina Faso and Colombia. University of Oxford, FAO ESA EPIC program, UNEP WCMC, OXFAM, WRI, UCI. (Vervoort et al. 2014)
- Linking science, policy and practice: Innovative science-policy-practice research investigating social inclusion, social learning and communications for development. Prolinnova, Mediae, Shamba Shape-Up, IDRC-CARIAA, IIED.

PART 3. Annexes

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Annex 2. Acronyms

A4NH – CGIAR Research Program on Agriculture for Nutrition and Health

ACCFP – African Climate Change Fellowship Program

ACF – Action Against Hunger (Action Contre la Faim)

ACPC – African Climate Policy Centre

ACRE – Agriculture and Climate Risk Enterprise

AEDD – Agency for Environmental and Sustainable Development

AEZ – agro-ecosystem zones

AFOLU – Agriculture, Forestry and Other Land Use

AFS-CRPs – agri-food systems CGIAR research programs

AgMIP – Agricultural Model Inter-comparison and Improvement project

AGN – African Group of Negotiators

AGRA – Alliance for a Green Revolution in Africa

AGRONET - National Agricultural Information and Communication Network

ANACIM – Agence Nationale de l'Aviation Civile du Sénégal

APAARI – Asia-Pacific Association of Agricultural Research Institutions

APAN – Asia Pacific Adaptation Network

ARI – Agricultural research institute

ASARECA – Association for Strengthening Agricultural Research in Eastern and Central Africa

ASEAN – Association of Southeast Asian Nations

AWD – alternate wetting and drying

BARC – Bangladesh Agricultural Re-search Council

BMGF - Bill & Melinda Gates Foundation

BMZ – Federal Ministry for Economic Cooperation and Development, Germany

BNI – biological nitrification inhibition

C – Celsius

CAADP – Comprehensive Africa Agriculture Development Program

CAC – Central America Agricultural Council

CARE – Cooperative for Assistance and Relief Everywhere

CARIAA – Collaborative Adaptation Research Initiative in Africa and Asia

CASCAID - Capacitating African Smallholders with Climate Advisories and Insurance Development

CATIE – Centro Agronómico Tropical de Investigación y Enseñanza

CBD – Convention on Biological Diversity

CC – climate change

CCAC – Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants

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

CDKN – Climate and Development Knowledge Network

CECOCAFEN – Coffee Cooperatives Central Association in the Northern Regions

CGIAR – CGIAR' was originally the acronym for the 'Consultative Group on International Agricultural Research'. In 2008, CGIAR redefined itself as a global partnership. To reflect this transformation and yet retain its roots, 'CGIAR' was retained as a name. CGIAR is now a global research partnership for a food-secure future

CGIS – Centre for Environmental and Geographic Information Service

CGRFA – Commission on Genetic Resources for Food and Agriculture

CH_4 – methane

CIAT – International Centre for Tropical Agriculture

CIDA – Canadian International Development Agency

CIFOR – Centre for International Forestry Research

CIM – Centre for International Migration and DevelopmenCIMMYT – The International Maize and Wheat Improvement Centre

CIMSANS – Centre for Integrated Modeling of Sustainable Agriculture & Nutrition Security

CIP – International Potato Centre

CIRAD – Centre de Coopération Internationale en Recherche Agronomique pour le Développement

CLIFF – Climate, Food and Farming Network (research network of F3)

CMIP5 – Coupled Model Inter-comparison Project Phase 5

CNEDD – Conseil National de l'Environnement pour un Développement Durable (Niger)

CO_2e/yr – carbon dioxide equivalent per year

CoA – cluster of activities

COMESA – Common Market for Eastern and Southern Africa

CONEDD – Le Conseil National l'Environnement et du Développement Durable

COP – Conference of Parties

CORAF -–Conseil Ouest et Centre Africain pour la Recherche et le Developpement Agricoles

CORFOGA – Corporación Ganadera (Livestock Corporation), Colombia

CRP – CGIAR Research Program

CSA – climate-smart agriculture

CSIR – Council for Scientific and Industrial Research

CSIRO – Commonwealth Scientific and Industrial Research Organization

CSV – climate-smart village

CTA – Technical Centre for Agricultural and Rural Cooperation

CTCN – Climate Technology Centre and Network

DfID – Department for International Development, United Kingdom

DG – director general

DNDC – DeNitrification-DeComposition (computer simulation model)

DRC – Democratic Republic of Congo

EA – East Africa

ECI – Environmental Change Institute at the University of Oxford

ECLAC - Economic Commission for Latin America and the Caribbean

ECOWAS – Economic Community of West African States

EDF – Environmental Defense Fund

EIGE – European Institute for Gender Equality

ep-IA – ex-post impact assessment

EPIC - Economics and Policy Innovations for Climate-Smart Agriculture Program

ESA – Agricultural Development Economics Division of the Food and Agriculture Organization of the United Nations

ESSP – Earth System Science Partnership

EU – European Union

F1 – Flagship 1 (of CCAFS)

F2 – Flagship 2 (of CCAFS)

F3 – Flagship 3 (of CCAFS)

F4 - Flagship 4 (of CCAFS)

FAO – Food and Agriculture Organization of the United Nations

FAOSTAT – The Food and Agriculture Organization Corporate Statistical Database

FEDEARROZ – Federación Nacional de Arroceros (National Federation of Rice Growers), Colombia

FEDEGAN – Federación Colombiana de Ganaderos (Colombian Cattle Ranchers' Federation)

FENALCE – Federación Nacional de Cultivadores de Cereales y Leguminosas

FEWSNET – Famine Early Warning Systems Network

FHH – female-headed households

Fish AFS – CGIAR Research Program on Fish Agri-Food Systems

FONGS – Federation of Non-Governmental Organizations in Senegal

FLAR – Latin American Reserve Fund

FMNR - Farmer Managed Natural Regeneration

FNS – Food and nutrition security

FONGS - Federation of NGOs of Senegal

FRI - Farm Radio International

FTA – CGIAR Research Program on Forests, Trees and Agroforestry

FTE – full time equivalent

GACSA – Global Alliance for Climate-Smart Agriculture

GAEZ - Global Agroecological Zones

GCAM - Global Change Assessment Model

GCAP - Global Conservation Agriculture Program

GCDT - Global Crop Diversity Trust

GCF – Global Climate Fund

GFAR - Global Forum on Agricultural Research

GFCS - Global Framework for Climate Services

GFDDR - Global Facility for Disaster Reduction and Recovery

GHG – Greenhouse gas

GIIF - Global Index Insurance Facility

GIZ - German Corporation for International Cooperation

GLAM - General Large-Area Model for annual crops

GLF – Global Landscape Forum

GLOBIOM – IIASA's Global Biosphere Management Model

GRA – Global Research Alliance on Agricultural Greenhouse Gases

GSI – Gender and social inclusion

Gt – gigatonne

H – hypothesis

ha – hectare

HEIG-VD - La Haute Ecole d'Ingénierie et de Gestion du Canton de Vaud (HEIG-VD

IADB - Inter-American Development Bank

IAE – Institute for Agricultural Environment, Vietnam

IASWC - Indian Association Of Soil & Water Conservationists

ICAR - International Committee for Animal Recording

ICIMOD - International Centre for Integrated Mountain Development

ICPAC - Intergovernmental Authority on Development (IGAD) Climate Prediction and Applications Centre

ICRAF – World Agroforestry Centre

ICRISAT – International Crops Research Institute for the Semi-Arid Tropics

I-CRP – Integrative CGIAR Research Program

ICT – Information and communication technology

IDO – Intermediate Development Outcome

IDRC – International Development Research Centre

IDS – Institute of Development Studies

IEA – Independent Evaluation Arrangement

IEC – Information, Education & Communication

IER - Institut d'Economie Rural

IFAD – International Fund for Agricultural Development

IFAD-ASAP – (IFAD) Adaptation for Smallholder Agriculture Program

IFC - International Finance Corporation

IFPRI – International Food Policy Research Institute

IGAD – Inter-Governmental Authority for Development

IIASA – International Institute for Applied Systems Analysis

IICA - Inter-American Institute for Cooperation on Agriculture

IIED – International Institute for Environment and Development

IIRR - International Institute of Rural Reconstruction

IISD - International Institute for Sustainable Development

IITA – International Institute of Tropical Agriculture

IKSL - IFFCO Kisan Sanchar Limited

ILRI – International Livestock Research Institute

IMAGE – Integrated Model to Assess the Global Environment

IMPACT - International Model for Policy Analysis of Agricultural Commodities and Trade

INDC – Intended nationally determined contribution

INRA – French National Institute for Agricultural Research

INTA – Instituto de Innovación y Transferencia de Tecnología Agropecuaria (Institute for Innovation and Transfer of Agricultural Technology), Costa Rica

IPCC – Intergovernmental Panel on Climate Change

IPG – international public good

IRI – International Research Institute for Climate and Society

IRRI – International Rice Research Institute

ISC – Independent Steering Committee

ISI – International Scientific Indexing

ISPC – Independent Science and Partnership Council

ISRA - Institut Sénégalais de Recherches Agricoles

ITPGRFA - International Treaty on Plant Genetic Resources for Food and Agriculture

IUCN - International Union for Conservation of Nature

IWMI - The International Water Management Institute

JIRCAS - Japan International Research Centre For Agricultural Sciences

KIT - Karlsruhe Institute of Technology

LAM - Latin America a

LAMNET - Latin America Greenhouse Gas Mitigation Network

LAPA - Local Adaptation Plans of Action

LED – Low emissions development

LEDS - Low Emissions Development Strategy

LP#1 – Learning Platform: *Ex-ante evaluation and decision support for climate-smart options*

LP#2 – Learning Platform: *Foresight, models and metrics for climate-sensitive breeding*

LP#3 – Learning Platform: *Participatory evaluation of CSA practices and portfolios in CSVs*

LP#4 – Learning Platform: Weather-related agricultural insurance products

LP#5 – Learning Platform: *Smallholder agricultural emissions* and programs

LP#6 – Learning Platform: *Policy engagement on CSA*

MAGNET - Model description of Agricultural economy

MARD - Ministry of Agriculture and Rural Development (Vietnam)

M&E – Monitoring and evaluation

MESSAGE - Model for Energy Supply Strategy Alternatives and their General Environmental Impacts

MHH – male-headed household

MICCA – Mitigation of Climate Change in Agriculture Program

MoALF – Ministry of Agriculture, Livestock and Fisheries, Kenya

MOT – Mitigation Options Tool

MRV – monitoring, reporting and verification

Mt – metric tonnes

N_2O –nitrous oxide

NAFSIP – National agriculture and food security implementation plan

NAMA – Nationally Appropriate Mitigation Action

NARC – Nepal Agricultural Research Council

NARES – National Agricultural Research and Extension Systems

NEPAD – New Partnership for Africa's Development

NERC – National Environmental Research Council

NGO – non-governmental organization

NIAPP - National Institute of Agricultural Planning and Projection

NMS - National Meteorological Services

NUI - National University of Ireland

ODI – Overseas Development Institute

OECD - The Organisation for Economic Co-operation and Development

OWS - Organization for Women in Science for the Developing World

PAC - Partnership Advisory Committee

PACCA - Policy Action and Climate Change Action

PAFO - Pan African Farmers' Organisation

PAHO - Pan American Health Organization

PIM – CGIAR Research Program on Policies, Institutions, and Markets

P&R – planning and reporting

PMC – program management committee

QUT – Queensland University of Technology

R4D – research for development

RBM – results-based management

RCP – representative concentration pathway

REDD+ – Reducing Emissions from Deforestation and Forest Degradation Plus

RIMES – Regional Integrated Multi-Hazard Early Warning System for Africa and Asia

RPL – regional program leader

RTB – CGIAR Research Program on Roots, Tubers and Bananas

SA - South Asia

SAMPLES – Standard Assessment of Agricultural Mitigation Potential and Livelihoods Program

SAN – Sustainable Agriculture Network

SARI – Selian Agricultural Research Institute

SBSTA – Subsidiary Body for Scientific and Technological Advice

SDG – Sustainable Development Goal

SEA – South East Asia

SLO - System-Level Outcomes

SPC - Secretariat of the Pacific Community

SP-CPSA - Sécretariat Permament de la Coordination des Politiques Sectorielles Agricoles

SRF – Strategic results framework

SSP – Shared socio-economic pathway

SUSFANS – Sustainable Food And Nutrition Security

TF#1 – Twinned Flagship: *Managing water resource variability, risks and competing uses for increased resilience*

TF#2 – Twinned Flagship: *Supply chain governance to avoid deforestation*

TF#3 – Twinned Flagship: *Food and nutrition security futures under climate change*

ToC – Theory of change

TRANSMANGO – Assessment of the impact of drivers of change on Europe's food and nutrition security

TSBF - Tropical Soil Biology and Fertility Institute

UCI – University for International Cooperation

UNECA - United Nations Economic Commission for Africa

UNEP – United Nations Environment Program

UNFCCC – United Nations Framework Convention on Climate Change

UN-REDD - United Nations collaborative initiative on Reducing Emissions from Deforestation and Forest Degradation

URAC - Union des Radios Associatives et Communautaires du Sénégal

US – United States of America

USAID – United States Agency for International Development

USD – United States dollar

UVM – University of Vermont

W1 – Window 1 funds (funds that are directed to the CGIAR for further allocation to CRPs)

W2 – Window 2 funds (funds that are directed to a specific CRPs)

W3 – Window 3 funds (funds that are directed to a specific CGIAR Centre)

WA - West Africa

WB – World Bank

WBCSD – World Business Council for Sustainable Development

WCMC - World Conservation Monitoring Centre

WEDO - Women's Environment and Development Organization

WEF – World Economic Forum

WFO - World Farmers' Organisation

WFP - World Food Program

WHO - World Health Organization

WISAT - Women in Global Science and Technology

WLE – CGIAR Research Program on Water, Land and Ecosystems

WMO – World Meteorological Organisation

WOCAN - Women Organizing for Change in Agriculture and Natural Resource Management

WRI – World Resources Institute

WRMF - Weather Risk Management Facility

WSU – Washington State University

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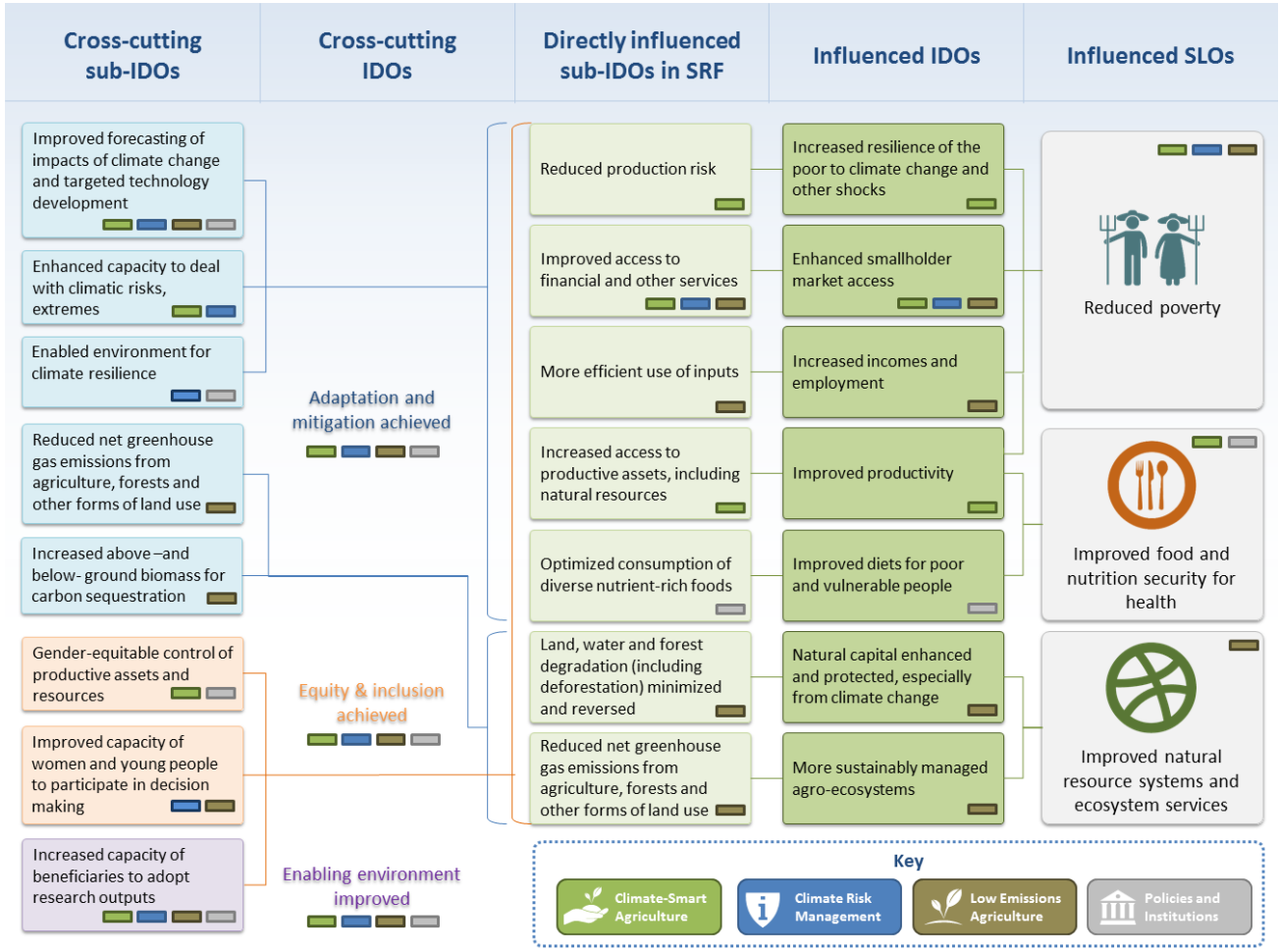
Annex 4. Alignment of CCAFS within the CGIAR Strategic Results Framework

Figure 4.1. Alignment of CCAFS within the CGIAR Strategic Results Framework



NOTES:

(a) CCAFS has not selected a capacity development sub-IDO, but the sub-IDO under "Enabling environment improved", namely "Increased capacity of beneficiaries to adopt research outputs" is a crucial capacity development variable for the Theory of

Change, with beneficiaries being partners and other agents of change in the impact pathways. One of the three outcomes of CSA is climate change adaptation and thus building adaptive capacity for climate change is crucial. Therefore the bulk of CCAFS is directed to building capacity.

(b) "Reduced net GHG emissions from agriculture, forests and other forms of land use" is a sub-IDO both within the cross-cutting climate change IDO and the main body of indicators – it is regarded as one sub-IDO, not two; but it does then contribute to two IDOs (a cross-cutting IDO and one in the main body of indicators).

Annex 5. CRP boundaries, cross-CRP linkages and co-investments CRPs and Strategic Partners

Climate change is a cross-cutting issue in the CGIAR SRF, with a cross-cutting IDO focussed on adaptation and mitigation, as well as many other IDOs having sub-IDOs referencing climate change or closely connected to climate change. Thus CCAFS has a role in delivering programmatic research, as well as providing a platform for integration across the CRP portfolio.

To facilitate integration of climate change work across the CRP portfolio, (i) CCAFS has proposed six Learning Platforms, most of which involve all CRPs as well as non-CGIAR partners (section 5.1), and (ii) CCAFS will contribute significantly to CGIAR Country Collaboration Plans (section 5.2).

Boundaries between CCAFS and other CRPs need to be clear. In this regard, CCAFS has clarified the boundary on technology development (section 5.3) and has proposed three Twinned Flagships (across CRPs) to deal with specific major areas of work that cut across 1-2 other CRPs (section 5.4). At a further level of detail, some CCAFS projects may have links to specific CRPs, but this detail has not been included in this Annex. As an example of CCAFS-other CRP discussions that have taken place, the proposed FTA-CCAFS collaborative arrangement is included below (section 5.5).

Strategic Partners will contribute to these various collaborative arrangements as well as to other components of CCAFS. The details of some of these arrangements have been discussed and preliminary roles and investment levels agreed (section 5.6).

5.1 Learning Platforms

The following Learning Platforms (Fig. 5.1) are proposed:

LP#1. Ex-ante evaluation and decision support for climate-smart options. This Learning Platform will interact with all CRPs including in countries and regions that are not target locations for CCAFS, so as to provide the climate science downscaling needed for making choices about development options throughout the CGIAR portfolio.

LP#2. Foresight, models and metrics for climate-sensitive breeding. CCAFS complements the AFS-CRPs by providing input into the breeding work of AFS-CRP from climate change foresight, models and metrics. Productive relationships between the climate and breeding communities were established at CIMMYT (MAIZE) and CIAT (GRiSP) in Phase I and these need to be extended throughout the AFS-CRPs, where there is demand.

LP#3. Participatory evaluation of CSA practices and portfolios in CSVs in Africa, Asia, and LAM). This CSV complements the AFS-CRPs by providing a multi-stakeholder platform for testing emerging technologies from AFS-CRPs that fit within climate-smart portfolios (see section 5.3). CSVs are run by different Centres or partners and link to the appropriate CRPs (see Fig. 5.2).

LP#4. Weather-related agricultural insurance products and programs. This will be developed in collaboration with PIM and includes insurance bundled with technologies developed by AFS-CRPs.

LP#5. Smallholder agricultural emissions. This Learning Platform will link to many CRPs, but especially those dealing with issues/sectors where the mitigation potential is great (e.g. Livestock Environment Flagship of Livestock AFS; soils in WLE; Rice AFS, MAIZE, WHEAT, FTA).

LP#6. Policy engagement on CSA. This Learning Platform will involve all CRPs, helping bridge connections to the climate policy processes (both adaptation and mitigation), and showcasing CGIAR and partner work in these processes.

The proposed amounts CCAFS will co-invest in the Learning Platforms are shown in Table 1. During the lead up to the full proposal preparation, CCAFS will work with the other CRPs to clarify their co-investment levels.

Figure 5.2. Overview of the Flagships and CoAs of CCAFS, showing Learning Platforms that cut across many CRPs (shaded), and Twinned Flagships, connected to 1-2 other CRPs (patterned)

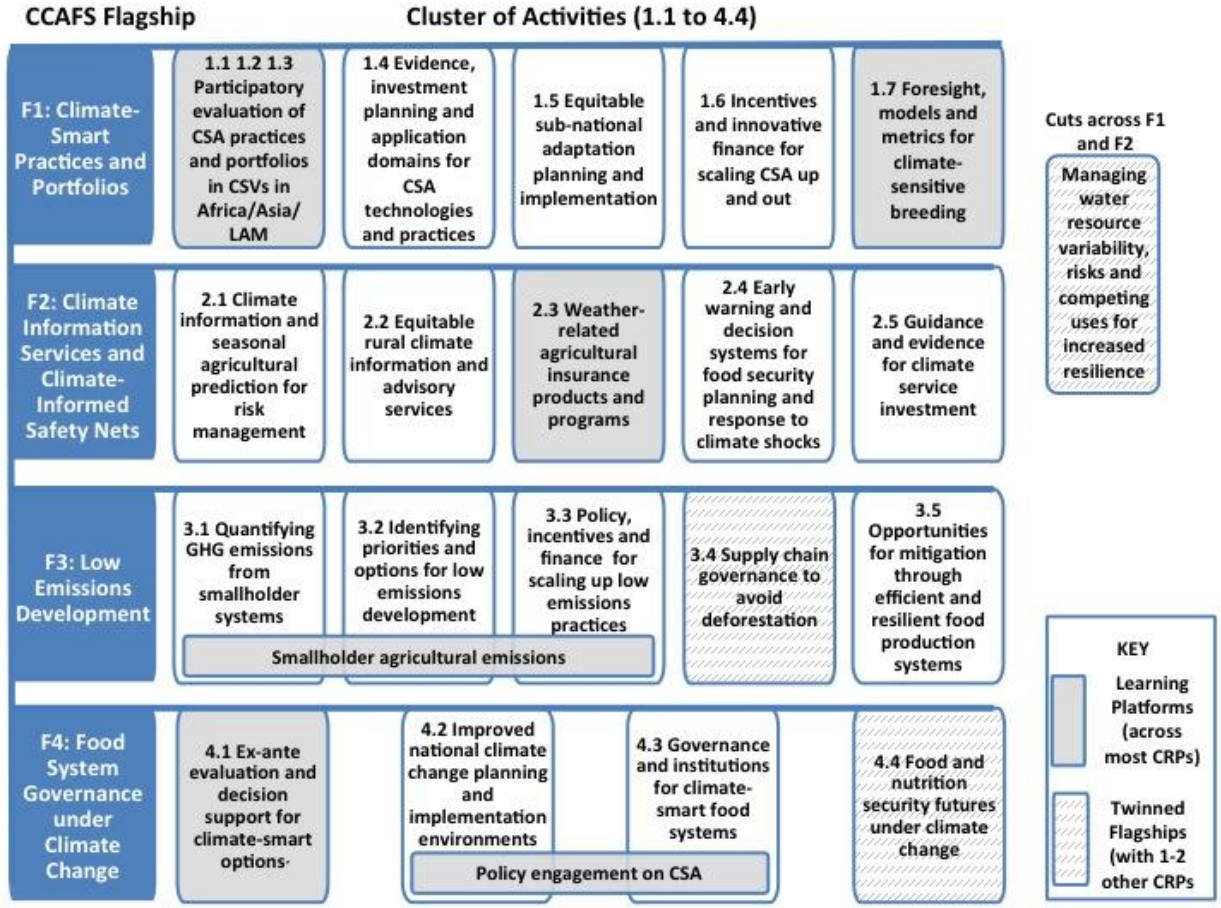


Table 5.1. Co-investments in Learning Platforms (c. USD 000s per year) (√ = confirmed interest – investment amounts to be confirmed)

Topic	LP#1. Ex-ante evaluation and decision support for climate-smart options	LP#2. Foresight, models and metrics for climate-sensitive breeding	LP#3. Participatory evaluation of CSA practices and portfolios in CSVs in Africa/Asia/ LAM	LP#4. Weather-related agricultural insurance products and programs	LP#5. Smallholder agricultural emissions	LP#6. Policy engagement on CSA
CCAFS	500	450	8,000	3,900	4,000	700
Rice	√	√	√	√	√	√
Maize	√	√	√	√	√	√
Wheat	√	√	√	√	√	√
RTB	√	√	√			√
DCLAS	√	√	√	√	√	√
Fish	√		√		√	√
Livestock	√		√	√	√	√
FTA	√		√		√	√
WLE	(see Twinned Flagship)		(see Twinned Flagship)	√	√	√
PIM	√		√		√	√
Strategic Partners (levels of investment shown are for funds allocated internally by the Partner for the Partner's own use)	CSIRO (TBC)	Leeds (390)	CARE (100)	IRI (200)	Vermont (588)	CARE (50)
	WISAT		IIRR (300)		Wageningen (TBC)	Future Earth (TBC)
	Oxford (200)		Wageningen (TBC)			WISAT (75)
			GIZ (TBC + 150 technical expert)			CTA (300)
			CATIE (175)			

5.2 CGIAR Country Collaboration

Further details on country collaboration are given in Table 5.2. As an example of what has been achieved through cross-CRP site work, Fig. 5.2 shows the network of CSVs in South East Asia and their CRP connections.

Table 5.2. Main countries where CCAFS will contribute to CGIAR Country Collaboration

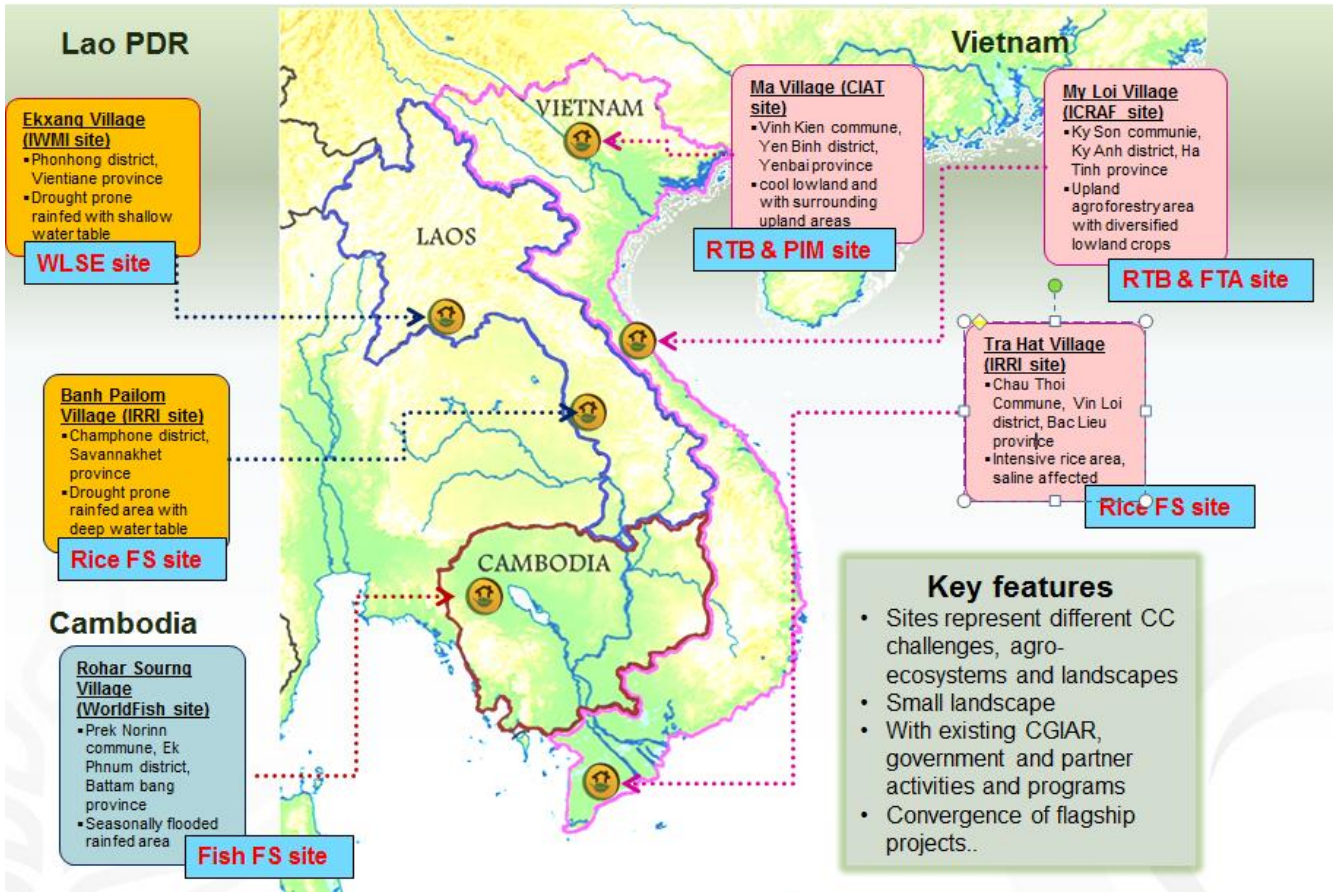
Region	Country	Staff in-country	Number of CSVs[1]	National science – policy platforms	Other contributions
WA	Burkina Faso	ILRI & IWMI scientists working on two WA F1 projects	2 (ICRAF, ILRI, IWMIand ICRISAT)	Yes (led by CONEDD & SP-CPSA)	CCAFS, FTA and WLE (DCLAS now joined) jointly developing scenarios and impact pathways with application to the National Program for the Rural Sector, and directed to the national revision of this policy
	Ghana	IWMI PI for the project in WA	2 (ICRAF, ILRI and ICRISAT)	Yes (CSIR)	A National CSA action plan to operationalize the National Climate Change Policy has been developed and validated. Three district level platforms been put in place.
	Mal	CCAFS Regional Program Leader (ICRISAT) and PIs of ICRISAT and ICRAF	2 (IWMI, ILRI and ICRISAT)	Yes (AEDD)	CSA prioritization achieved for the agro-ecological zones of the country (platform). CASCAID project underway through ICRAF in partnership with Mali meteo, AIMS and U. Reading. Three district level platforms put in place
	Niger		1 (ICRISAT, ICRAF and ILRI)	Yes (CNEDD)	CSV serving as a model for scaling up within the World Bank funded project on CSA in Niger
	Nigeria				Work initiated on climate services and insurance with Ministry
EA	Ethiopia	CCAFS-ILRI Economist on Climate Services (ILRI/ACPC)	1 (ILRI)	Yes (ICRAF P4CSA with NEPAD/ Oxfam	
	Kenya	CCAFS Regional	2 (ILRI, CIMMYT,	Yes (ICRAF	CSVs joint implementation on

[1] Each CSV encompasses a number of villages in a defined area

Region	Country	Staff in-country	Number of CSVs[1]	National science – policy platforms	Other contributions
		Program Leader (ILRI)	ICRISAT, CIAT, IITA)	P4CSA with NEPAD/ World Vision	business models for scaling up CSA and local adaptation planning
	Rwanda	National Climate Services Coordinator			Joint learning for implementation of a national climate services program for farmers in 30 districts
	Tanzania	GFCS National Coordinator	1 (CIP, CIAT)	Yes (IITA/ PACCA)	CSVs joint implementation on business models for scaling up CSA and local adaptation planning
	Uganda	IITA PACCA Project Leader	2 (IITA, CIAT)	Yes (IITA/ PACCA)	
SA	Bangladesh	Worldfish	1 (WorldFish)	Through Planning Commission,	Future scenarios; partnerships with CEGIS, BARC, and others; work on national crop monitoring system; supporting National Adaptation Plan Revision through partners in Bangladesh
	India	CCAFS Regional Program Leader (CIMMYT) and several CG centre scientists working on CCAFS	c. 5 (scaling out to 1500++ villages) (CIMMYT, IRRI, ICRISAT)	Through work on solar energy, insurance, and investments in CSA	Crop yield monitoring system; investment prioritization toolkit; partnerships with ICAR-NICRA, Indian met dept, insurance and ICT industry; crowdsourcing (Bioversity), insurance (CIMMYT, IFPRI, IWMI, industry; Govt.), management of floods and droughts (IWMI), mitigation (CIMMYT, IRRI)
	Nepal		8 (scaling up/ out partnership with Min of Agric, NARC, IFC, iNGOs,	Through NARC, Min of Agri, Planning Commissio	Operational national crop yield monitoring system (with Min of Agri, WFP),), ICT for risk management (Dept of Hydro-meteorology, NGOs); insurance (Min of Agri, NARC)

Region	Country	Staff in-country	Number of CSVs[1]	National science – policy platforms	Other contributions
			CDKN, Li-Bird, CIMMYT, IFPRI, Bioversity, ICIMOD, agri industry)	n	
SEA	Vietnam	CCAFS Regional Program Leader (IRRI), and several CG Centre scientists working on CCAFS	3 (CIAT, ICRAF and IRRI led, plus IFPRI, Bioversity, CIP and WorldFish) (see Fig. 2)	Yes (MARD)	Strongly integrated and supportive of Vietnam's national program; Local institutions engaged actively; CSA prioritization currently being done together with MARD; Four Flagship projects tackle integrated CSA approaches and upscaling issues. Three Flagship projects on low emission development are designed to support the Vietnam Green Growth Strategy.
LAM	Nicaragua	CIAT country office	1 embracing several CRPs and Centres (CIAT, ICRAF, ILRI, Bioversity, CIMMYT; CRPs: CCAFS, PIM, FTA, MAIZE, Humidtropics, WLE)	No	Linking farmers to markets program; diversification through implementation of agroforestry systems in Nicaragua; initiative to strengthen capacity and understanding of family agriculture dynamics and diversity; crowdsourcing

Figure 5.3. Example of Climate-Smart Villages in South East Asia, facilitated by different Centres and involving different CRPs.



5.3 CCAFS and technology development

CCAFS complements the technologies/practices developed by AFS-CRP (e.g. drought resistant maize, micro-dosing, agroforestry technologies) and by some I-CRPs (e.g. solar irrigation) by providing a Learning Platform (LP#3) where these technologies/practices can be tested for their climate smartness as part of a portfolio of climate-smart approaches, that could include, e.g., weather-based advisories, insurance, local adaptation planning, GHG accounting. In some cases, the local CSV facilitators will introduce the AFS technologies into the CSV processes, while in other cases Centres/CRPs may be active in the CSVs themselves, sometimes through co-investment. CSVs are sites (villages, groups of villages, districts, communes, landscapes) where action research is conducted with farmers, service providers, private

sector etc. A particular Centre/CRP may use a CSV to test its own technology whereas the interest for CCAFS is: on the overall outcomes for food security, adaptation and mitigation (including the synergies and trade-offs amongst these objectives of CSA); and on CSVs as multi-stakeholder learning platforms for scaling up and out. CSVs are designed as learning platforms for multiple CRPs. One of the criteria for the site selection was whether other Centres/CRPs were active in the site (See Fig. 2 for the South East Asia example).

While agricultural technology development is not the focus of CCAFS, CCAFS will develop tools and approaches in many of the other Learning Platforms that have relevance to technology development.

5.4 Collaboration between CCAFS and specific CRPs: Twinned Flagships

In research areas where there is potential for large overlap with other CRPs, CCAFS has developed Twinned Flagships, as shown in Table 5.4. Each CRP contributing will co-invest in the joint area of work.

Table 5.4. Co-investments in Twinned Flagships (amounts shown are USD per year)

Topic	**TF#1. Managing water resource variability, risks and competing uses for increased resilience**	**TF#2. Supply chain governance to avoid deforestation**	**TF#3. Food and nutrition security futures under climate change**
CCAFS	2,200	2,500	3,500
Other CRPs	WLE (TBC)	FTA: 2,500	PIM (TBC)
			A4NH (TBC)
Strategic Partners (levels of investment shown are the funds allocated internally by the Partner for the Partner's own use)		Vermont (146)	Oxford (400)
			Wageningen (TBC)
			CSIRO (TBC)

5.5 CCAFS-FTA collaborative framework[1]

Climate change research in CCAFS and FTA addresses both mitigation of and adaptation to climate change. CCAFS focuses on the 40% of tropical land based emissions that come directly from agriculture. FTA focuses on emissions from deforestation, forest degradation, and land-clearing fires that account for 60%. Together, FTA & CCAFS provide a coherent approach to climate change across the CGIAR.

[1] CCAFS has worked on tables showing collaboration with many other CRPs. This section serves as a well-developed example, also building on Phase I collaboration

However, the two programs have developed **distinct characteristics** in Phase II by which they differ and complement each other (Fig. 5.5, Table 5.5). While the emphasis in CCAFS on CSA, enhanced food security and improved nutrition has been increased, the emphasis in FTA is on providing an integrated proposal for joint bio-production and environmental services provision through forest, tree and agroforestry resource management at the landscape scale. In particular, FTA's Flagship 7 focuses on mitigation of and adaptation to climate change using these tree resources in landscapes, mainly through policies and measures that link climate mitigation and adaptation to development (e.g. rural income generation), and is expanding its work in Flagship 5 on governance arrangements for sustainable supply that avoids deforestation. CCAFS addresses mitigation through low emissions agricultural development in its F3, and FTA addresses adaptation of peoples and forests to climate change in its CoA 7.2.

FTA has added a new activity (CoA 7.3) on **bioenergy** to support adaptation and mitigation goals as well as rural income goals, by integrating bioenergy production in forest and tree production cycles. The rationale behind is that renewable bioenergy reduces fossil fuel emissions and provides income to the rural poor. FTA has further developed its focus on performance assessment (providing hard data of how climate aspirations translate into achievements) that is expected to provide services to the whole CGIAR (CoA7.4).

Both programs work on **low-emission development strategies** (LEDs): CCAFS as a broad strategy to encompass its mitigation work in F3; FTA as a specific area of work related to the role of tree resources in LEDS (CoA 7.1). Through its FP5 work on sustainable global value chains and investments, FTA aims to contribute to LEDS by supporting public-private governance arrangements that ensure sustainable commodity supply, thus avoiding deforestation and reducing GHG emissions, while also increasing social inclusion, and leveraging the role of finance for stimulating greater adoption of environmental, social and governance frameworks. Both programs will coordinate their LEDS work.

CCAFS and FTA will have a **Twinned Flagship on "sustainable supply to avoid deforestation"** linking CCAFS CoA 3.4 (supply chain governance to avoid deforestation) and FTA CoA 5.1 (governance arrangements for sustainable supply). The outputs to be achieved collaboratively are: 1) Impact assessment of regulations and sustainability initiatives on hectares of avoided deforestation, GHG emissions, and associated social effects; 2) options on instruments and guidelines for improving sustainable commodity supply from public, private and hybrid governance arrangements; and 3) metrics for M&E of public and private governance for sustainability of commodity supply (the latter with FTA CoA 7.4). CCAFS F3 will emphasize private sector and market governance in supply chains related to the agricultural sector, while FTA F5 will accentuate supply chains related to high-value trees and forest products. Both will support public and private actors at sub-national, national and global levels. Work on sustainable commodity chain governance will be co-located in select sites in Indonesia, the Brazilian Amazon and the Congo Basin.

Regarding **adaptation**, FTA is focusing on ecosystem-based adaptation (CoA 7.2), and CCAFS on climate smart agricultural practices (F1) and climate information systems and climate-informed safety nets (F2). Both programs promote the use of climate information systems in National Adaptation Plans (NAPs) in complementary ways, with CCAFS focusing on seasonal forecasts for agricultural decision-making and food system safety nets, and FTA focusing on decadal scale variability for risk management, and national NAP policy architecture and implementation. Both programs also analyze synergies between mitigation and adaptation and climate finance but from different angles (in CCAFS F1 and F3 always in relation to the triple objectives of productivity, adaptation, and mitigation related to CSA, whereas in FTA-FP7 this is focused on adaptation using forest and tree systems). CCAFS contributes to a co-investment platform shared by FTA and RTB on

tree-crop commodities (FTA CoA 3.3) that integrates climate mitigation and adaptation with sustainable intensification of cocoa, coffee, rubber and oilpalm.

CCAFS and FTA will closely **coordinate** their work at the national and international levels (e.g. to provide coherent national policy advice and CGIAR output on climate mitigation and adaptation to the UNFCCC). They have been cooperating over the past years on joint issues such as reference levels, emission hot spots, and climate mitigation aspirations in the land sector, and there will be future cooperation to produce joint outputs. CCAFS has a Learning Platform on "Policy engagement on CSA" that includes engagement with UNFCCC processes and is specifically collaborating with FTA on Global Landscape Forum at the UNFCCC. CCAFS and FTA will also engage private sector platforms aimed at supporting sustainable supply by harnessing the potential of standards to support adoption of sustainability practices, as well as private commitments to build deforestation-free supply chains.

Co-location of work happens in several regions covered by both CCAFS and FTA (EA, WA, SA, SEA, and LAM); FTA additionally works in Southern Africa. CCAFS emphasizes interventions mostly at the national level, where it sees a major impact pathway in the national planning processes and food system policies, and FTA is more strongly now focusing on the national level, too, and there will be heightened efforts to coordinate FTA-CCAFS work at the national level. E.g, previous joint work in Burkina Faso on common impact pathways and multi-stakeholder scenario development indicates our commitment to work together.

CCAFS and FTA together represent a winning team for the CGIAR because they **complement** each other in unique ways, building on the comparative strengths in each of the teams. Regarding mitigation, CCAFS brings its strong agricultural and food security perspective into the equation addressing the 40% of tropical emissions from agriculture, and FTA brings in a strong global coverage of mitigation (emission reduction) policies addressing the 60% of tropical emissions from deforestation, forest degradation (38%) and land-clearing fires (22%). CCAFS and FTA particularly cooperate in the Twinned Flagship on "Supply chain governance to avoid deforestation", with CCAFS focusing on the agricultural dimensions and FTA on the forest dimensions, but with co-investment on common issues and common sites. Regarding adaptation, both programs have clear complementarity in addressing the issue in the context of LEDs, adaptation finance, the use of bioenergy to raise rural energy and income security. Both CCAFS and FTA stand for a strong performance assessment approach in both mitigation and adaptation, which is now being expanded to include private sector commitments and LEDs.

The mechanisms to **coordinate** the collaboration between FTA and CCAFS consist in one joint annual planning meeting, jointly funded projects and workgroups, jointly defined impact pathways at the national level to be developed, and one major joint dissemination and outreach event per year, e.g. collaboration on the annual Global Landscape Forum. The period 2017 and beyond will see increased collaboration between FTA and CCAFS via jointly funded projects regarding mitigation and low carbon economy of global value chains (oil palm, beef, soya bean) and GHG accounting at landscape scale.

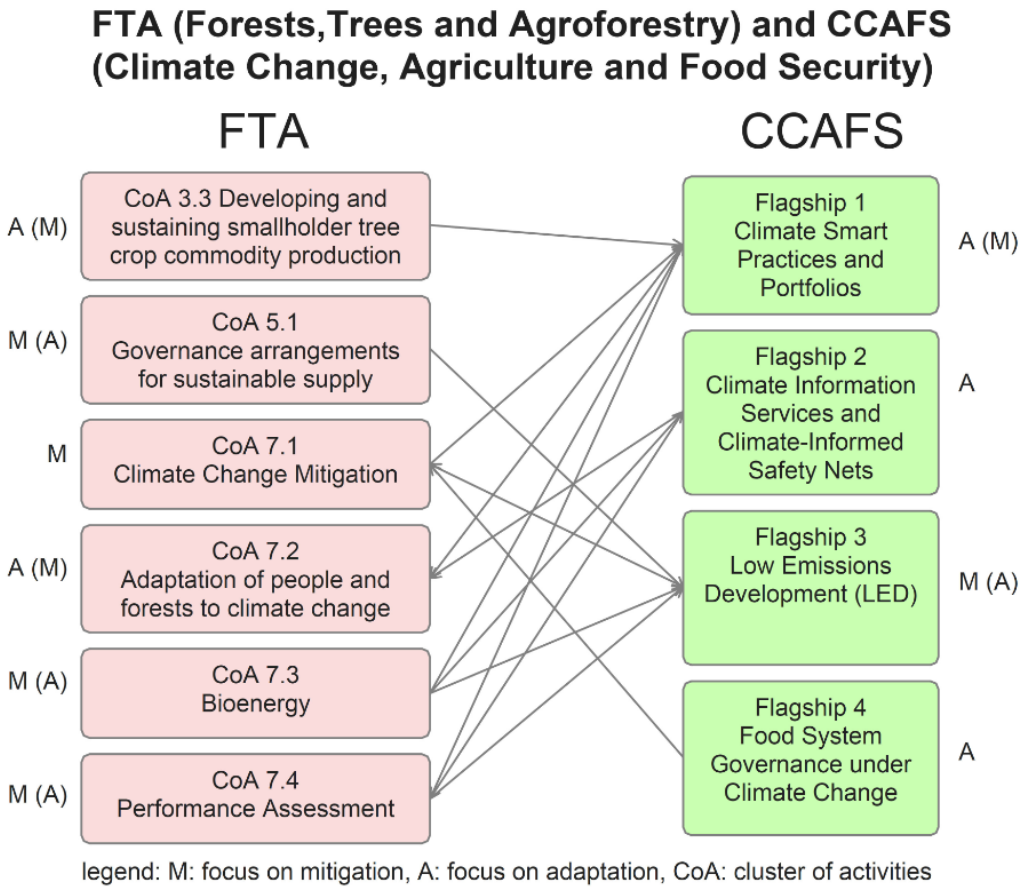


Figure 5.5. Correspondence between CCAFS and FTA activities

Table 5.5: "Multi-dimensional complementarity" of CCAFS and Flagship 4 in FTA

Issue	FTA	CCAFS
	Complementarities	
Objectives	FP 7 addresses the interrelated issues of a) **climate change mitigation** through forests, trees and agroforestry, b) the **adaptation** of forests and people to climate change, c) **bioenergy,** and d) **performance assessment.** FP5 looks at the governance arrangements involving public and private actors that contribute to more **sustainable commodity supply**, while ensuring more **inclusive business models**, and **responsible finance** for select global value chains.	CCAFS tackles **food security, adaptation to climate change and mitigation of climate change**. CCAFS seeks to catalyse positive change towards climate-smart agriculture (CSA), food systems and landscapes.
"Centres of gravity"	*Emphasis* on **policy research** for climate ***mitigation*** and **low emissions development** strategies **with forests, trees and agroforestry** (FT&A) in the landscape	*Emphasis* on research for ***adaptation*** **technology adoption** in agriculture (CSA practices) and food systems governance to reduce risk in agriculture and increase food security
Regional coverage	East Africa, West Africa, Central Africa, South Asia, South East Asia, Latin America, Southern Africa, Central America	East Africa, West Africa, South Asia, South East Asia, Latin America
Policy level coverage	• Sub-national mitigation and adaptation activities and programs, National Adaptation Plans (NAPs) • National REDD+, NAMA, INDC policies • International REDD+, NAMA, INDC policies • Low emission development strategies (LEDs)	• National Adaptation Plans • Global policies to include agriculture in climate mitigation agreement and food systems governance • Low emission development (LED)
Builds on	Policy research as core strength of CIFOR and practice research in ICRAF	• Joint strength of agricultural research in 15 CG Centres
Exclusively covered themes	REDD+, INDCs, NAMAs related to FT&A	CSA to raise food security Value chain and product diversification approach

5.6 Co-investment with Strategic Partners

CCAFS has several Strategic Partners, as outlined in the Summary pre-proposal. These contribute to various Learning Platforms (Table 5.1) and Twinned Flagships (Table 5.4), but also to other aspects of CCAFS. The agreed roles and overall investment levels (where already determined) are summarised in Table 5.6 for all Strategic Patners. CCAFS and partners have agreed to joint fundraising to raise these initially agreed investment levels.

Table 5.6. Proposed topics for collaboration between non-CGIAR Strategic Partners and CCAFS. The funds shown are for the partners own use, or may involve transfers of funds amongst partners where appropriate

	Potential Topics (2017-2022)	**Strategic Partner**	**CCAFS**
		USD 000s per year	
CARE	• Climate and agricultural finance that matters for poor women and men and youth to enable climate-resilient pathways out of poverty (helping CCAFS mainstream gender and social inclusion) • Impactful practice in strengthening gender equality and social inclusion in 'climate-smart' communities, agriculture and rural enterprises (helping CCAFS mainstream gender and social inclusion) • Facilitating 'climate-smart agriculture' that bring benefits to poor and marginalized communities (CoA 1.1/1.2) • Scaling-out climate information services and participatory scenario planning through community-driven adaptation and risk management initiatives (CoA 2.2) • Bringing a gender equality and social inclusion lens to UNFCCC negotiations and other global processes through joint papers and events (LP#6)	150	345
CATIE	• Providing a scientific-development platform for CCAFS in LAM with emphasis in Central America (Nicaragua and Trifinio). • Hosting CCAFS LAM CSV scientific coordinator in Central America. • Increasing smallholders, producer organizations, value chains and territorial platforms' capacities to cope with and adapt to the impacts of climate variability and change.	175	1.000

	• Implementation of CSA through an inclusive and territorial approach. • Scaling-up and scaling-out good practices and lessons learned.		
CSIRO	• Downscaling climate change impacts, including incorporating variability (LP#1) • Cross-scale modelling of livelihoods in relation to climate smartness across scales (TF#3) • Transformational processes, adaptation pathways and guidelines (CoA 4.3) • Farm-scale mitigation (CoA 3.2) • Farm scale adaptation (CoA 1.2) • Innovation systems (working with Coordinating Unit)	TBC	400
CTA	• Joint communication and dissemination on key strategic products, both global and regional • Joint global or regional events to promote products and engage in policy processes	300	700
FAO	• Co-facilitation of the GACSA Knowledge Action Group • Joint global outreach and collaboration on policy engagement around CSA, linked to LP#6 • Shared capacity development initiatives, events and products • Contributions to the construction and dissemination of an online database of CSA practices • Joint work on gender and social inclusion, e.g. Gender and Inclusion Toolkit and CCAFS contribution to IFAD-WB-FAO gender agriculture sourcebook and uptake of CCAFS methods • Work on specific projects as mutually agreed • Policy-science workshops (Flagship 3)	TBC	300
Future Earth	• Representing partners on the CCAFS Independent Steering Committee • Hosting the Knowledge Action Network on Food-Energy-Water, to which CCAFS will contribute • Joint products and events in relation to global processes	TBC	120
Global Research Alliance on	• Data sharing on GHG emissions from smallholder farming (Flagship 3) • Technical guidelines for field measurement and contributions	TBC	TBC

Agricultural Greenhouse Gases	to LP#5 • Joint documentation on experience in reducing emissions from livestock; and policy briefs • Joint meetings to coordinate research agendas		
GIZ	• CCAFS core team and GIZ climate change theme team will have a joint planning meeting in October to finalise collaborative arrangements • Building links between research and development initiatives involving adaptation and mitigation, involving F1 F2 and F4 work with GIZ agriculture division; and F3 work with GIZ environment and climate division • Best practice principles for innovation platforms • Work on specific projects as mutually agreed	TBC + 150 in Technical Expert	TBC + 300
IFAD	• Learning Alliance between CCAFS and IFAD to deliver innovative global public goods scientific knowledge products relevant to development programming, contribute to policy dialogue at global and national levels and develop capacity among national research institutions • Joint global outreach including events and policy reports • CGIAR contributions to IFAD-ASAP analyses and country program designs • Collaboration under the umbrella of the GACSA Investment Action Group • Joint work on gender and social inclusion, e.g. CCAFS contribution to IFAD-WB-FAO gender agriculture sourcebook and uptake of CCAFS methods in IFAD programs	755 (IFAD + EC)	886
IIRR	• Enhancing CCAFS skills in participatory action research (CoA 1.2 and LP#3) • Improving capacity development on key CSA technologies (CoA 1.2) • Implementing CSV in SEA (CoA 1.2)	300	244
IRI (Columbia University)	• Hosting the Flagship 2 leader • Knowledge and methods to tailor historic and seasonal climate information to agricultural needs (CoA 2.1) • Embedding climate information into decision systems (CoA 2.4)	900	750

	• Brokering partnership with global climate services community (CoA 2.2/2.5) • Guidance on index insurance implementation good practice and partnership opportunities (CoA 2.3, LP#4) • Good practice guidance on interpreting and using climate change scenarios for impact studies		
NEPAD	• Scaling up CSA via the Alliance for CSA in Africa • (Joint site-level learning on CSA under LP#3 • Continental standards and benchmark for assessing CSA practice and adoption • Foresight, models and metrics for climate-sensitive breeding • Smallholder agricultural emissions to enhance understanding of emissions, mitigation options • Policy engagement on CSA in Africa linked to LP#6 • Livestock, fish, and drylands	TBC	682
Pan-African Farmers Organization (representing African regional farmers organisations)	• Policy engagement and capacity development for UNFCCC and the Alliance for CSA in Africa, linked to LP#6 • Scaling climate smart solutions up and out in Africa • Increase the capacity of smallholder farmers to cope and adapt to climate variability and change • Index-based insurance linked to LP#4 • Low emissions practices • Integration of climate change into agricultural policies • Joint global outreach	TBC	300
NUI Galway	• Training and capacity building oriented international Masters degree (MSc CCAFS program) • PhD and postdoctoral researcher training on CCAFS aligned topics	186	250
Univ of Leeds	• Co-leadership of LP#2 (F1 CoA 1.7)	350	250
Univ of Oxford	• Hosting a scenarios team on climate change foresight (LP#1) • Food systems perspectives for climate change and nutrition (TF#3)	600	400
Univ of Vermont	• Hosting the Flagship 3 leader • Food security and mitigation of greenhouse gas emissions in	790	3216

	coffee, soybean, rice, maize and other agricultural systems • Reducing the impacts of agriculture on land use conversion • Participatory planning for CSA in coffee landscapes		
Wageningen University	• Coffee and Cacao systems (CoA 1.6) • Managing nitrogen to reduce emissions (CoA 3.2) • Enhancing incentives to reduce emissions in dairy value chains (CoA 3.3) • Food systems perspectives for climate change and nutrition (MAGNET model and H2020 SUSFANS) (TF#3)	XXX	2.600
WISAT	• Hosting the Gender and Social Inclusion Leader • Bringing CCAFS perspectives into national assessments on gender and science & technology – cross-national indicator framework on women's representation in sectors relevant to S&T for development, complemented by policy analysis.	75	900
World Bank	• Hosting two CCAFS staff members so that research to practice links are made, and clear pathways between needed research products and operational divisions are fostered • Joint global outreach, including high-level events • Co-delivery of CSA country profiles • Collaboration on CSA metrics • Joint work on gender and social inclusion, e.g. CCAFS contribution to IFAD-WB-FAO gender agriculture sourcebook	TBC	300
World Business Council on Sustainable Development	• With support from the French COP Presidency, WBCSD leading the Low Carbon Technology Partnership Initiative (LCTPi) on Climate-Smart Agriculture, with ambitious targets for private sector delivery of food security, adaptation and mitigation outcomes by 2030. • CCAFS leading one of four priority action areas on the CSA LCTPi (CSA metrics) on behalf of WBCSD members. CCAFS providing the wider WBCSD CSA program with strategic advice on private sector priorities, guidance on regional dialogues in key CSA geographies, and field trips that demonstrate CSA activities and results. • CCAFS contributions WBCSD-led LCTPi initiative on reducing deforestation associated with agriculture, linked to TF#2.	367	130

Annex 6. CCAFS targets and value for money

Table 6.1. Targets, based on project and regional inputs.

Note: 1. "Other" column refers to impacts in non-target regions and countries through partners.
2. In some cases F1 and F2 target the same farmers and hence total CCAFS target < F1 + F2.

Sub-IDOs	Indicator	2030	2022 target for each sub-IDO										
		CCAFS	CCAFS	Flagship totals				Regional contribution to Flagships (T = total)					
				F1	F2	F3	F4	WA	EA	SA	SEA	LAM	Other
SLO Reduced poverty	Number of farm households that have adopted improved varieties, breeds or trees, and/or improved management practices (millions), (with benefits to women – millions)	30 (15)	12.5 (7)										
	Number of people, of which 50% are women, assisted to exit poverty (millions)		3.75										
	Number of national/subnational[1] jurisdictions where equitable institutional investments in climate smart food systems have increased	20											
IDO Increase resilience of the poor to climate change and other shocks													
Reduced production risk	Number of farm households with reduced production losses related to CC, with increased benefits for women (millions)		8.0	8.0				1.0	1.0	3.0	1.5	1.2	0.3
IDO Enhanced smallholder market access													
Improved access to financial and other services	Number of farm households with improved access to capital, with increased benefits for women (millions) (F2: weather-related insurance; F1 & F3: new business models, novel finance)		11.1	3.5	8.0	2		F1 0.5 F2 2.0 F3 0 T 2.0	F1 0.5 F2 1.0 F3 0.4 T 1.5	F1 1.0 F2 3.0 F3 0.3 T 3.3	F1 1.0 F2 1.0 F3 0.6 T 2.3	F1 0.3 F2 0.4 F3 0.5 T 1.0	F1 0.2 F2 0.6 F3 0.2 T 1.0
IDO Increased incomes and employment													
More efficient use of inputs	Number of farm households with more efficient use of inputs, with increased benefits for women (millions) (F3 covers F1 & F2 farmers as well, through collaborative work)		8.8			8.8		0	1.3	2.0	2.0	1.5	2.0
SLO Improved food and	Additional people, of which 50% are women, meeting minimum dietary energy requirements		3.75										

[1] Wherever "State" or "subnational" is mentioned this refers to States in the case of India

Sub-IDOs	Indicator	2030	2022 target for each sub-IDO										
		CCAFS	CCAFS	Flagship totals				Regional contribution to Flagships (T = total)					
				F1	F2	F3	F4	WA	EA	SA	SEA	LAM	Other
nutrition security for health	(millions)												
	Percent reduction in women of reproductive age who are consuming less than the adequate number of food groups		1.5%										
IDO Improved productivity													
Increased access to productive assets, including natural resources	Number of sub-national organisations and institutions that are adapting their plans and directing investment towards climate-smart food systems to increase equitable access to productive assets		53	53				10	10	10	11	10	2
IDO Improved diets for poor and vulnerable people													
Optimized consumption of diverse nutrient-rich foods	Number of organisations and institutions in selected countries/states adapting plans and directing investment towards climate- and nutrition-smart food systems to optimise consumption of diverse nutrient-rich foods[1]		35				35	3	5	8	8	5	6
SLO Improved natural resource systems and ecosystem services	Reduction of agriculturally-related greenhouse gas emissions compared with 2015 (% and Gt CO_2e yr^{-1})	15%	0.2 (8%)										
	ha of forest saved from deforestation (million)		2										
IDO Natural capital enhanced and protected, especially from climate change													

[1] WA Orgs: 3 (e.g. Ministry of Food and Agriculture Ghana; PAFA Program in Senegal); Countries: 3 (Ghana, Senegal, Burkina Faso); EA Orgs: 5 (e.g. Ministries of agriculture in 3 countries (MoALF, MAAIF & MoAFC), FAO, NGOs (e.g World Vision)); Countries: 4 (Kenya, Uganda, Tanzania, Rwanda); SA Orgs: 8 (e.g. Ministries of agriculture, iNGOs such as Practical Action; CDKN); Countries: 5 (Nepal, Bangladesh, Bhutan and 2 states in India); SEA Orgs: 8 (e.g. Key Ministries, CARE and Local NGOs); Countries: 4 (Cambodia, Vietnam, Laos, Philippines); LAM Orgs: 5; (ACF, CRS, FAO, SESAN, UTSAN); Countries: 2 (Guatemala, Honduras)

Sub-IDOs	Indicator	2030	2022 target for each sub-IDO										
		CCAFS	CCAFS	Flagship totals				Regional contribution to Flagships (T = total)					
				F1	F2	F3	F4	WA	EA	SA	SEA	LAM	Other
Land, water and forest degradation (including deforestation) minimized and reversed	Number of hectares where deforestation has been avoided (millions)		2			2		0			0.3	1.7	
CROSS CUTTING													
IDO Adaptation and mitigation achieved													
Improved forecasting of impacts of climate change and targeted technology development	Number of site-specific targeted CSA technologies/ portfolios tested, with all options examined for their gender implications [1]		60	60				11	11	15	11	10	2
	Number of national/state governments or regional bodies using climate-based seasonal agricultural prediction and early warning to improve planning, food security intervention[2]		20		20			3	5	3	3	4	2
	Number of countries/states where CCAFS projections and priority setting used to target and implement technology interventions in food systems / value chains (priority setting)[3]		25				25	3	5	5	4	4	4

[1] F1 WA: e.g. Farmer managed natural tree regeneration, conservation agriculture; stone bunds and vegetation barriers, zaï & half-moons techniques, improved varieties, micro-dosing; etc.; EA: e.g. crop and livestock index based insurance, climate service packages, manure management, crop diversification, seed systems, integrated soil fertility management, agro-forestry, resilient small ruminant breeds, soil and water management, multiple stress tolerant crop varieties etc.; SA: e.g. RCTs, water management, solar energy, improved seeds, nutrient sensors etc; SEA: e.g. crop diverisfication options, CC smart crops, water mgt, climate information on-farm use, farm waste mgt etc.; LAM e.g. Conservation agriculture, agroforestry systems, crop rotation, contour trenches, stone bunds, water reservoirs, tolerant varieties to heat and water stress; composting; live fences / windbreaks; seed banks; intercropping; participatory early warning systems; farm mapping for planning and land-optimization; staggered; sowings.

[2] WA: AGRHYMET, CILSS, Mali or Burkina Faso; EA: IGAD, FEWSNet, WFP-EA, Ethiopia, Rwanda, Kenya or Tanzania or Uganda (at least 2); SA: WFP-Nepal, Bangladesh or Nepal or Sri Lanka; SEA: RIMES, Vietnam or Cambodia or Laos; LAM: Guatemala, Colombia, CAC; WVI regionally in Africa.

[3] WA: Mali, Niger, Burkina Faso; EA: Tanzania, Kenya, Uganda, Ethiopia; SA: Nepal, Bangladesh, states of Punjab, Haryana, Bihar, MP, Maharashtra in India; SEA: Vietnam, Cambodia, Laos/ Myanmar, Philippines LAM: e.g. Honduras, Guatemala, Colombia, El Salvador

Sub-IDOs	Indicator	2030	2022 target for each sub-IDO										
		CCAFS	CCAFS	Flagship totals				Regional contribution to Flagships (T = total)					
				F1	F2	F3	F4	WA	EA	SA	SEA	LAM	Other
Enhanced capacity to deal with climatic risks, extremes	Number of farm households with strengthened adaptive capacity and food security, with increased benefits for women (millions)		17.9	8	15			F1 1.0 F2 3.0 T 3.0	F1 1.0 F2 2.2 T 2.2	F1 3.0 F2 5.0 T 6.0	F1 1.5 F2 3.0 T 4.5	F1 1.1 F2 1.5 T 2.5	F1 0.2 F2 0.5 T 0.7
Enabled environment for climate resilience	Number of global/regional organisations that have increased their equitable institutional investments in climate smart food systems[1]		14				14	2	3	1	1	2	5
	Amount of new investments by national, regional and global agencies, that is informed by CCAFS science and engagement (USD million invested) (F4 encompasses national/state investments in CSVs)		425		80		400	F2 10 F4 15 T 20	F2 10 F4 35 T 40	F2 20 F4 80 T 85	F2 15 F4 60 T 70	F2 15 F4 35 T 35	F2 10 F4 175 T 175
Reduced net GHG emissions from agriculture, forests and other forms of land use	Reduction of agriculturally-related greenhouse gas emissions compared with 2015 (Gt CO_2e yr^{-1})		0.2			0.2		0	0.01	0.05	0.02	0.12	
Increased above- and below-ground biomass for carbon sequestration	Additional carbon sequestered in biomass and soil compared with 2015 (Gt CO_2e yr^{-1})		0.89			0.89		0	0.01	0.01	0.02	0.11	
IDO Equity & inclusion achieved													
Gender-equitable control of productive assets and resources	Number of households where women have increased control over productive assets and resources (million)		4	4				0.5	0.5	1.5	0.7	0.6	0.2
	Number of national/state organisations and institutions that are adapting their plans and directing investments towards climate-smart food systems to increase women's access to, and control over, productive assets and resources		25				25	2	3	5	5	4	6

[1] IFAD, FAO, GCF, ECOWAS, ADB, AfDB, FONTAGRO, ECLAC

Sub-IDOs	Indicator	2030	2022 target for each sub-IDO										
		CCAFS	CCAFS	Flagship totals				Regional contribution to Flagships (T = total)					
				F1	F2	F3	F4	WA	EA	SA	SEA	LAM	Other
Participation in decision-making	Number of households where women's participation in decision making has improved – in decisions over own labor, over own income and in groups or collective organization (million)		10.0		7.6	4.4		F2 1.5 T 1.5	F2 1.1 F3 0.6 T 1.1	F2 2.5 F3 1.0 T 2.5	F2 1.5 F3 1.0 T 2.1	F2 0.8 F3 0.8 T 1.6	F2 0.2 F3 1.0 T 1.2
IDO Enabling environment improved													
Increased capacity of beneficiaries to adopt research outputs	Number of key next user agencies of research outputs that demonstrate progress on at least two of five core capabilities to adopt research outputs		55	12	12	12	14	10	10	10	10	10	5

Table 6.2. Costs of research (USD) per outcome, with outcomes arranged to allow comparison of similar indicators (see the Performance Indicator Matrix for full outcome descriptions) (1.1-1.7 are from F1, 2.1-2.6 from F2, 3.1-3.7 from F3, and 4.1-4.6 from F4)

Note**:** The value for money calculations are based on distributing the budgets amongst sub-IDOs (i.e. amongst the outcomes/indicators) (see Performance Indicator Matrix) and making the assumption that outcomes/indicators are mutually exclusive. This is not strictly correct as some outcomes are pre-cursors to others.

Value of money indicator for each outcome (sub-IDO in brackets)	F1 (USD)	F2 (USD)	F3 (USD)	F4 (USD)
Per farm household				
1.1: with reduced production losses (Reduced production risks)	4.56			
1.2/2.1/3.1: with improved access to F1/F3: capital, new business models and novel finance; F2: weather-related insurance (Improved access to financial and other services)	2.38	3.08	7.40	
1.5/2.3: with strengthened adaptive capacity and food security (Enhanced capacity to deal with climatic risks, extremes)	4.80	2.93		
1.6: where women have increased control over productive assets and resources (Gender-equitable control of productive assets and resources)	6.60			
2.5/3.6: where women's participation in decision making has improved (Participation in decision-making)		1.69	2.80	
3.2: with more efficient use of inputs (More efficient use of inputs)			1.68	
Total per farm household (can be summed as generally the same households being targeted within Flagships)	18.33	7.70	11.80	
1.4: Per site specific targeted CSA technologies/portfolios tested (Improved forecasting of impacts of climate change and targeted technology development)	684,106			
1.7/2.6/3.7/4.6: Per research user agency that demonstrate progress on at least two of five core capabilities to adopt research outputs (Increased capacity of beneficiaries to adopt research outputs)	151,619	89,226	102,770	191,131
Per organisation (F1: sub-national; F2: national/state government or regional body; F3 Per organisation and institution)				
1.3: adapting their plans and directing investment towards climate-smart food systems to increase equitable access to productive assets (Increased access to productive assets, including natural resources)	557,158			
2.2: using climate-based seasonal agricultural prediction and early warning to improve planning, food security intervention (Improved forecasting of impacts of climate change and targeted technology development)		910,101		
4.1: adapting plans and directing investment towards climate- and nutrition-smart food systems (Optimized consumption of diverse nutrient-rich foods)				1,299,694
4.5: adapting plans and directing investments towards climate-smart food systems to increase women's access and control (Gender-equitable control of productive assets and resources)				1,391,440
4.2: Per country where CCAFS projections and priority setting used to target and implement technology interventions in food systems / value				1,123,853

chains(Improved forecasting of impacts of climate change and targeted technology development)				
2.4 Per million dollar of new investments by national, regional and global agencies informed by CCAFS science (Enabled environment for climate resilience)[1]		80,303		56,863
Per MT CO2				
3.3: where deforestation has been avoided (Land, water and forest degradation)			8,000	
3.4: for net greenhouse gas emissions from agriculture, forests and other forms of land use (Net greenhouse gas emissions)			41,108	
3.5: for increased above and below ground biomass for carbon sequestration (Increased above and below ground biomass)			13,857	

[1] There are two indicators for this sub-IDO for F4. Only this one is used in this table as they track the same sub-IDO

Annex 7. Theory of change

Figure 7.1. Theory of change diagram for the CRP, with envisaged change mechanisms, hypotheses and some key partners.

For assumptions on CRP behaviours, see Vermeulen and Campbell 2015.

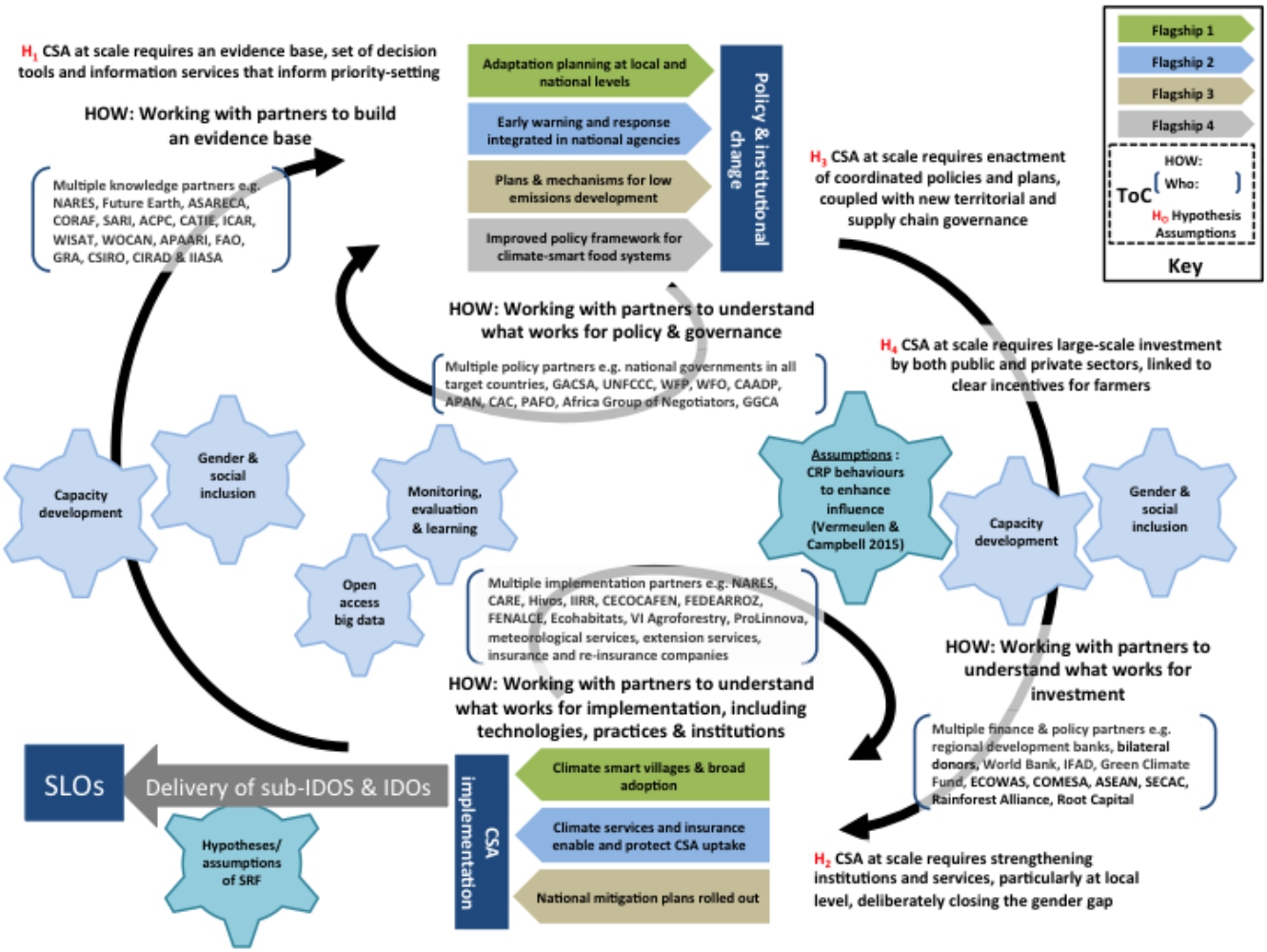


Figure 7.2. Gender dimensions of the CCAFS ToC, with four main areas of activity and some of the main hypotheses.

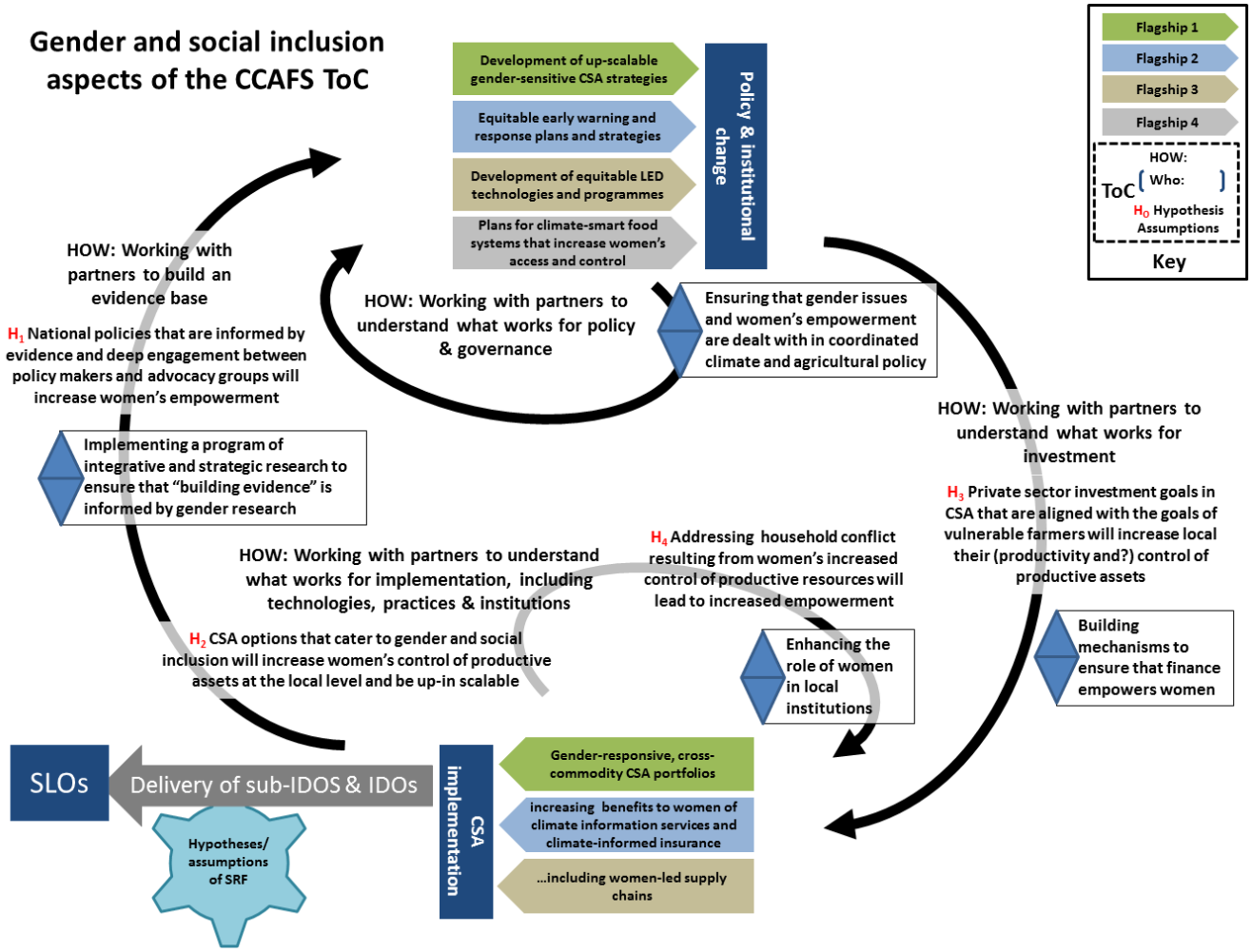


Figure 7.3. Flagship 1 ToC, with abbreviated hypotheses and CoAs (see text for assumptions). The three main sub-IDOs are shown as "By 2022" targets – additional sub-IDOs are in the Performance Indicator Matrix.

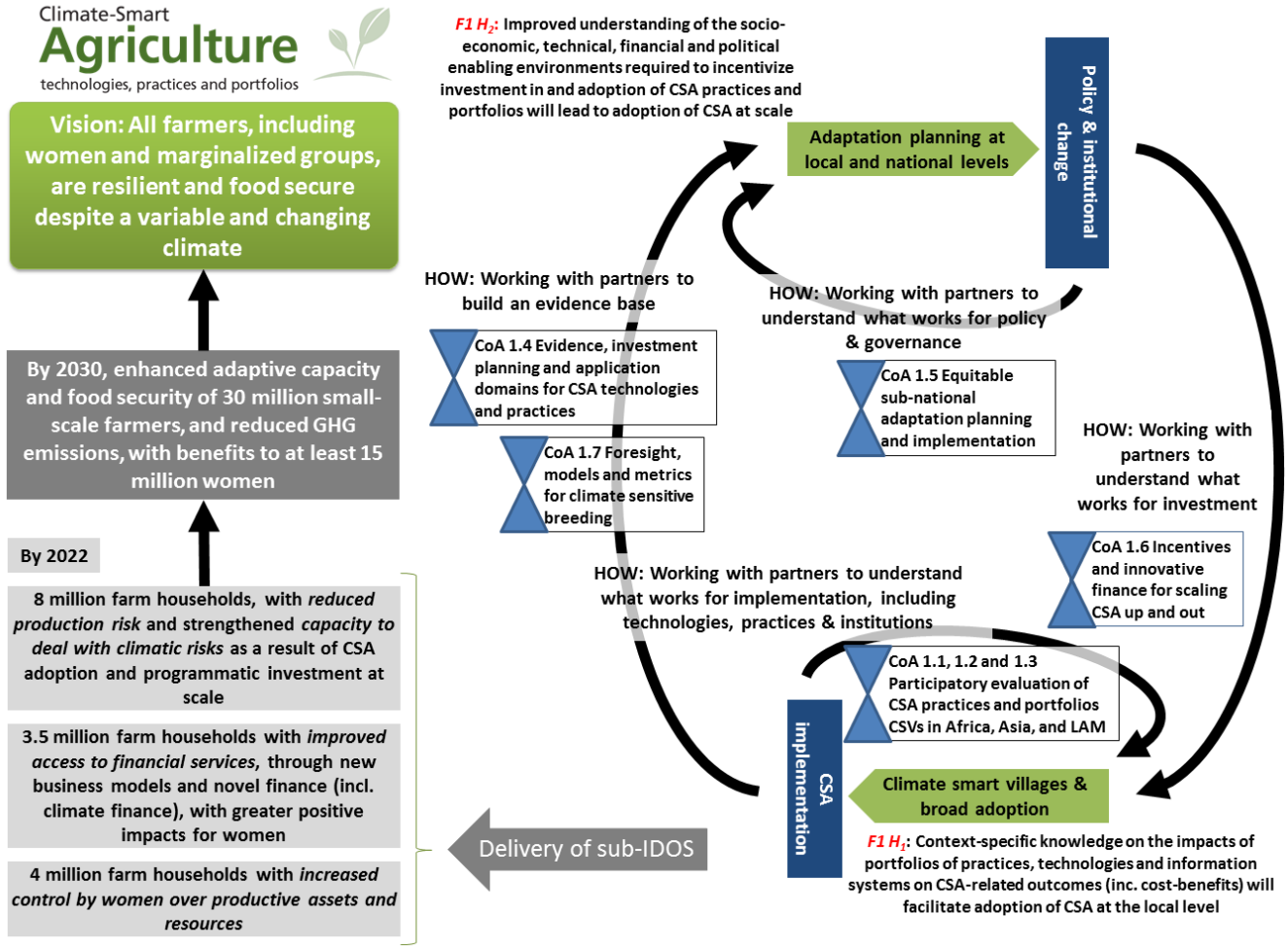


Figure 7.4. Flagship 2 ToC, with abbreviated hypotheses and CoAs (see text for assumptions). The three main sub-IDOs are shown as "By 2022" targets – additional sub-IDOs are in the Performance Indicator Matrix.

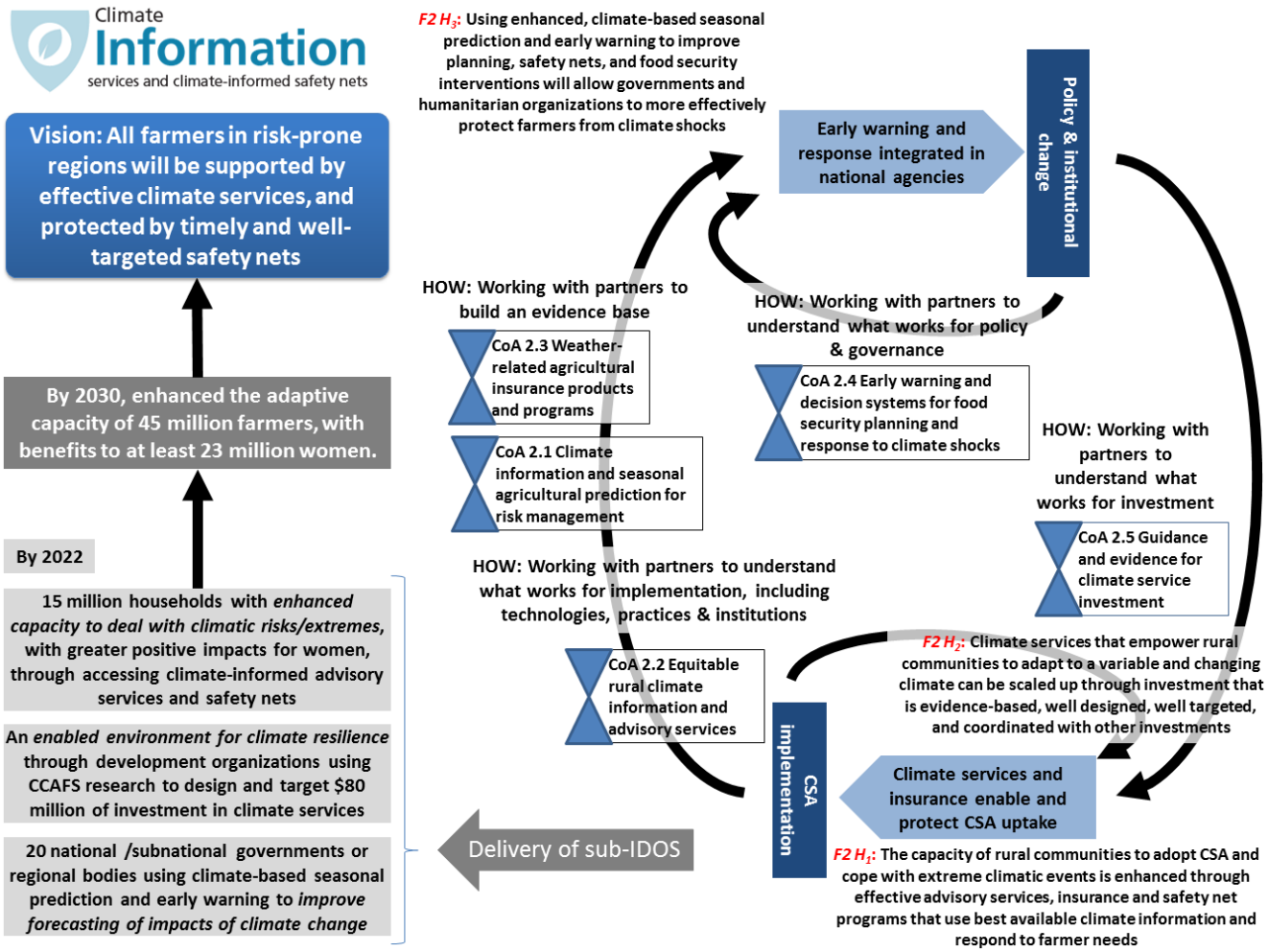


Figure 7.5. Flagship 3 ToC, with abbreviated hypotheses and CoAs (see text for assumptions). The three main sub-IDOs are shown as "By 2022" targets – additional sub-IDOs are in the Performance Indicator Matrix.

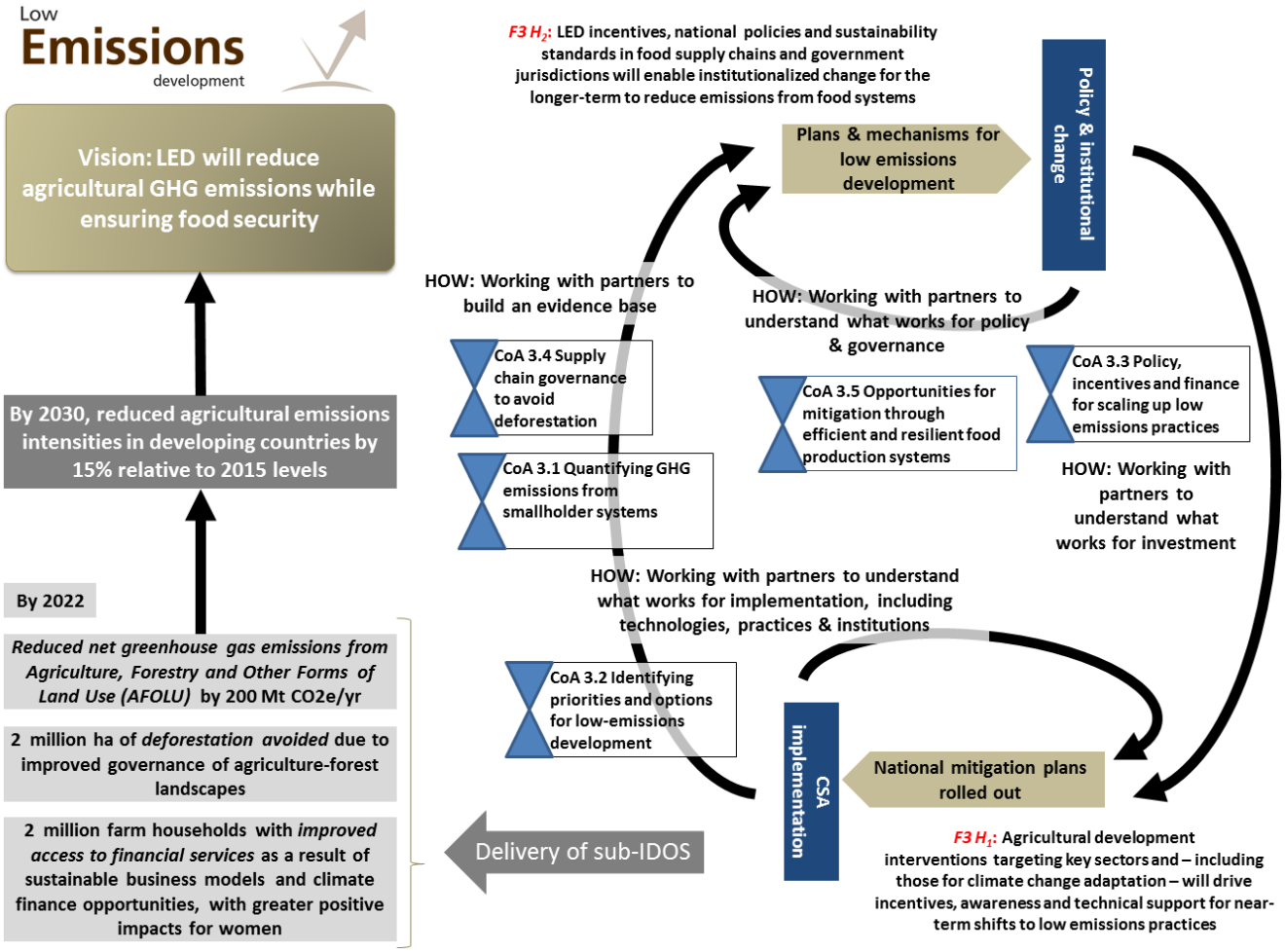
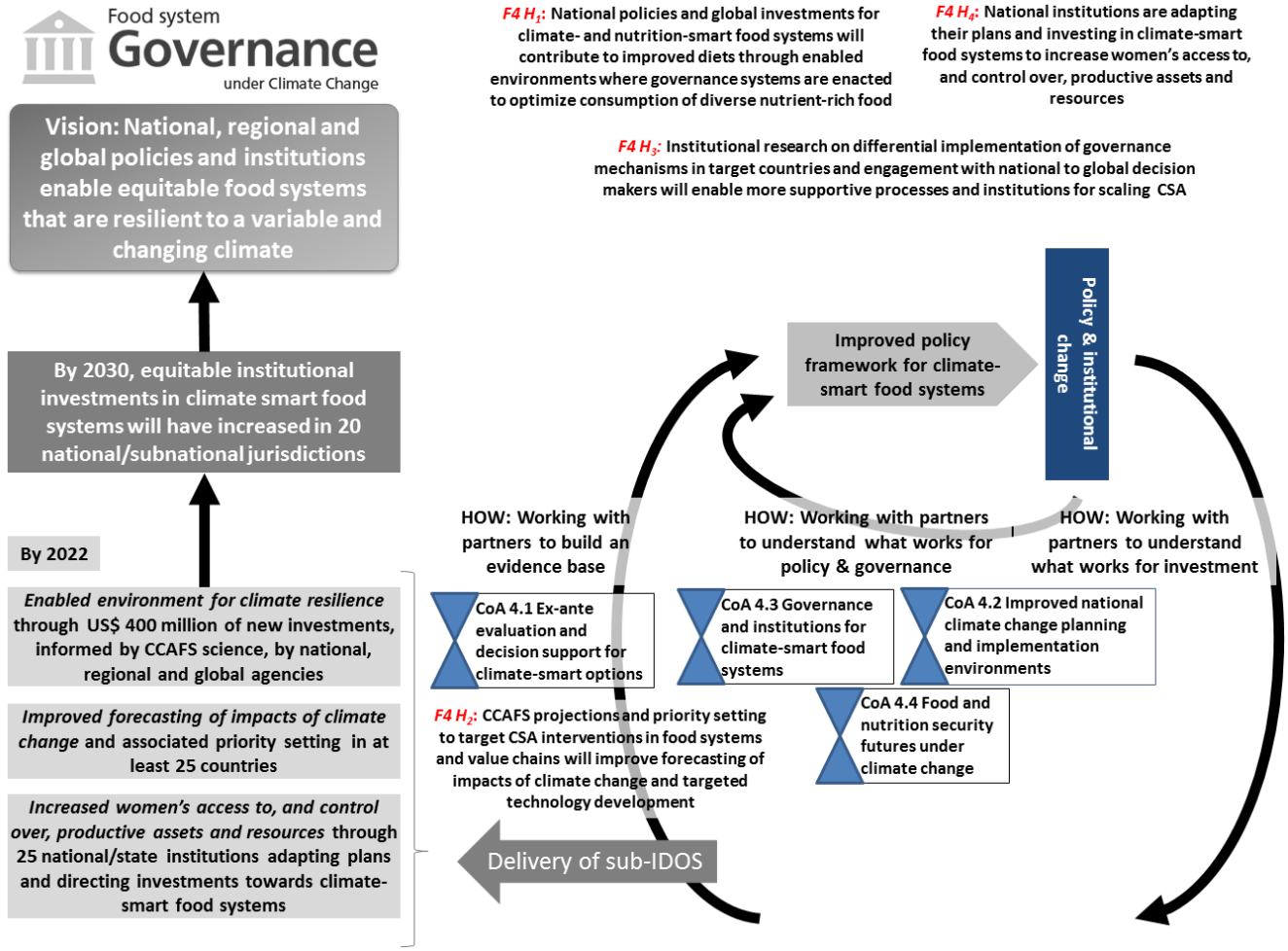


Figure 7.6. Flagship 4 ToC, with abbreviated hypotheses and CoAs (see text for assumptions). The three main sub-IDOs are shown as "By 2022" targets – additional sub-IDOs are in the Performance Indicator Matrix.



Annex 8. Alignment of climate-smart agriculture with the proposed SDG indicators

Table 8.1: Alignment of CSA with the proposed SDG indicators

CSA dimension	SDG proposed indicators	Relevent CCAFS sub-IDOs
Productivity	Crop yield gap Livestock yield gap	(AFS-CRPs will measure this)
Adaptation/ resilience	Losses from natural disasters, by climate and non-climate-related events Farmers with nationally appropriate crop insurance (%) – to be developed	Reduced production risk; Enhanced capacity to deal with climate risks, extremes Improved access to financial and other services
Mitigation/ emissions	Net GHG emissions in the Agriculture, Forest and other Land Use (AFOLU) sector Nitrogen use efficiency in food systems	Reduced GHG emissions from agriculture, forests and other land use Increased above- and below-ground biomass for carbon sequestration More efficient uses of inputs
Other environmental dimensions	Annual change in forest area and land under cultivation	Land, water and forest degradation minimised and reversed

Annex 9. Core team

The core team of CCAFS will be the CRP Director, 4 Flagship and 5 Region leaders, a Gender and Social Inclusion Research Leader and a Global Engagement Research (GSI) Leader. See CVs in Annex 10.

The CRP Director will be Bruce Campbell.

Flagship Leaders will be: F1 – Andy Jarvis (CIAT); F2 – Jim Hansen (IRI); F3 – Lini Wollenberg (U Vermont); F4 – Phil Thornton (ILRI).

Regional Program Leaders (RPL) will be: West Africa – Robert Zougmoré (ICRISAT); East Africa – James Kinyangi (ILRI); South Asia – Pramod Aggarwal (CIMMYT); South East Asia: Leo Sebastian (IRRI) and Latin America – Ana Maria Loboguerrero (CIAT)

The GSI Leader will be Sophia Huyer (WISAT) while the Global Engagement Research Leader will be Sonja Vermeulen (U Copenhagen)

The Program Management Committee will be as follows:

- Bruce Campbell (CRP Director, CIAT)
- Andy Jarvis (F1 Leader, CIAT)
- Lini Wollenberg (F3 Leader, U Vermont)
- James Kinyangi (East Africa RPL, ILRI)
- Pramod Aggarwal (South Asia RPL, CIMMYT)
- Sophia Huyer (GSI Leader, WISAT)
- Sonja Vermeulen (Global Engagement Research Leader, U Copenhagen)

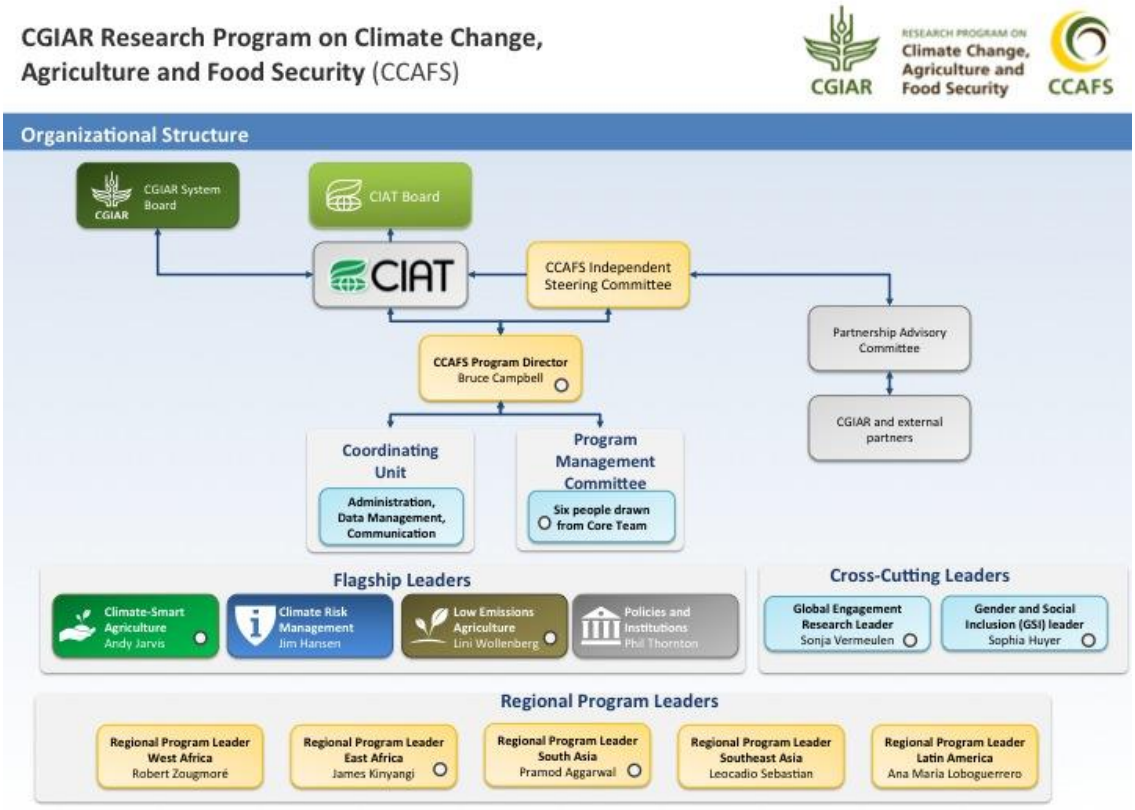


Figure 9.1. CCAFS organizational structure

Annex 10. Technical competence (CVs)

Program Management Committee

Dr. Bruce Campbell (Director)

CGIAR Research Program, Climate Change, Agriculture and Food Security, CCAFS Coordinating Unit
Rolighedsvej 21, DK-1958 Frederiksberg, Denmark; Tel: +45 35331046; Email: b.campbell@cgiar.org

Dr. Bruce Campbell has degrees in Ecology from Cape Town (B.Sc. Hons.), Minnesota (M.Sc.) and Utrecht (Ph.D.), but has increasingly moved into inter-disciplinary work, championing new approaches to doing applied research on natural resource management. For two decades he focused on social-ecological systems in southern Africa, covering a spectrum of production systems (forestry, livestock, dryland and irrigated cropping), from small-scale (e.g. soil fertility management) to large-scale (e.g. deforestation analyses), and from biophysical and social science angles. In this time he served as the inaugural Director of the Institute of Environmental Studies, University of Zimbabwe. For ten years Dr. Campbell was the Director of the Forests and Livelihoods Program at the Centre for International Forestry Research (CIFOR) in Indonesia involving a team of 50 scientists based in eleven locations in Asia, Latin America and Africa. The team included anthropologists, political scientists, sociologists, economists, ecologists, botanists, foresters and geographers. He also had a spell in Northern Australia, where much of the work involved Aboriginal natural resource management. He was the inaugural Director of the School for Environmental Studies at Charles Darwin University in Darwin. In 2009, he became the Director of the newly-established CGIAR Challenge Program on climate change, based at the University of Copenhagen, and in 2011 the Director of its successor, the CGIAR Research Program on Climate Change, Agriculture and Food Security. Bruce is a staff member of the International Centre for Tropical Agriculture (CIAT), and operates from the University of Copenhagen. He serves on several editorial boards, and is a scientific committee member of PECS, the ICSU Program on Ecosystem Change and Society. He has published over 140 peer- reviewed articles and more than a dozen books.

Recent publications include:

- Wise RM, Fazey I, Stafford Smith MD, Park SE, Eakin HC, Archer Van Garderen ERM, Campbell B. 2014. Reconceptualising adaptation to climate change as part of pathways of change and response. Global Environmental Change 28:325-336.
- Campbell, B.M., Thornton, P., Zougmoré, R., van Asten, P. and Lipper, L. 2014. Sustainable intensification: What is its role in climate smart agriculture? Current Opinion in Environmental Sustainability, 8: 39-43
- Lipper L, Thornton P, Campbell BM, Baedeker T, Braimoh A, Bwalya M, Caron P, Cattaneo A, Garrity D, Henry K, Hottle R, Jackson L, Jarvis A, Kossam F, Mann W, McCarthy N, Meybeck A, Neufeldt H, Remington T, Sen PT, Sessa R, Shula R, Tibu A, Torquebiau EF. 2014. Climate-smart agriculture for food security. Nature Climate Change 4:1068–1072
- Vermeulen, S.J., Campbell, B.M and Ingram, J.S.I. 2012. Climate Change and Food Systems. Annu. Rev. Environ. Resour. 37:195–222
- Sayer, J. & Campbell, B. 2004. The science of sustainable development: local livelihoods and the global environment. Cambridge University Press, Cambridge.

Dr. Andy Jarvis (F1 Leader)

Research Area Director, Decision and Policy Analysis, International Centre for Tropical Agriculture (CIAT), Recta Cali-Palmira km17, Cali, Colombia. Tel. +57 2 4450000. Email: a.jarvis@cgiar.org

Dr. Andy Jarvis is the Director of the Decision and Policy Analysis Research Area in the International Centre for Tropical Agriculture (CIAT) and has been over the past 5 years, a Flagship Leader on the CGIAR Research Program for Climate Change, Agriculture and Food Security (CCAFS), based in Cali, Colombia. Dr. Jarvis holds a PhD and a First Class Bachelor of Science from the Department of Geography at King's College London. Dr. Jarvis has 10 years' experience of cutting edge scientific research in developing countries to support the goals of alleviating poverty and protecting essential ecosystem services of importance to humanity. Dr. Jarvis has also worked as a consultant to the Food and Agriculture Organisation (FAO) on developing climate change strategies to conserve agricultural biodiversity, and been a consultant on a variety of projects for the European Union, Global Environment Facility amongst others. In 2003 Dr. Jarvis won the Crop Science Society of America (CSSA) C-8 Genetic Resources award for best research paper stemming from his work on conservation prioritization research for wild peanuts in Latin America, and in 2009 received the prestigious Ebbe Nielsen award for innovative research in bioinformatics and biosystematics.

Dr. Jarvis leads a research agenda on climate-smart agriculture and adaptation to progressive climate change across the CGIAR, supervising staff and students (undergrad, masters and PhD level), proposal development and fund raising. His research which includes spatial analysis and environmental modelling has focused on building adaptive capacity and food systems that are more resilient to progressive climate change through the provision of technologies, practices and policies. This has included:

- Analyse and designing processes and decision-support tools for farming systems adaptation of in the face of future uncertainties of climate in space and time.
- Supporting the development of breeding strategies for addressing abiotic and biotic stresses under future climate change,
- Integrate adaptation strategies for agricultural and food systems inserted into policy and institutional frameworks.

Over the past ten years Dr. Jarvis has published over 70 articles, book chapters or books, with over 30 of these in peer-reviewed articles published in international journals. These include:

- Colin K. Khoury, Anne D. Bjorkman, Hannes Dempewolf, Julian Ramirez-Villegas, Luigi Guarino, Andy Jarvis, Loren H. Rieseberg and Paul C. Struik. 2014. Increasing homogeneity in global food supplies and the implications for food security. *PNAS*, 2014 DOI: 10.1073/pnas.1313490111
- Lipper, L. Philip Thornton, Bruce M. Campbell, Tobias Baedeker, Ademola Braimoh, Martin Bwalya, Patrick Caron, Andrea Cattaneo, Dennis Garrity, Kevin Henry, Ryan Hottle, Louise Jackson, Andrew Jarvis, Fred Kossam, Wendy Mann, Nancy McCarthy, Alexandre Meybeck, Henry Neufeld, Tom Remington, Pham Thi Sen, Reuben Sessa, Reynolds Shula, Austin Tibu and Emmanuel F. Torquebiau. 2014. Climate-smart agriculture for food security. Nature Climate change 4: 1068–1072. doi:10.1038/nclimate2437.
- Vermeulen S J, Challinor A, Thornton P K, Campbell B M, Eriyagama N, Vervoort, J M, Kinyangi J, Jarvis A, Läderach P, Ramírez-Villegas J, Nicklin K J, Hawkins E, Smith D R. 2013. Addressing uncertainty in adaptation planning for agriculture. Proceedings of the national academy of sciences of the United States of America 110 (21): 8357-8362.
- Jarvis, A., Ramirez-Villegas, J., Herrera Campo, B.V., and Navarro-Racines, C.E. 2012. Is Cassava the Answer to African Climate Change Adaptation? *Tropical Plant Biology* 5 (1): 9-29, doi:10.1007/s12042-012-9096-7.
- Series of Climate-Smart Agriculture Country profiles supported by the World Bank (Colombia, Argentina, Costa Rica, Mexico, Grenada, Peru, El Salvador) Available online

Dr. Eva "Lini" Wollenberg (F3 Leader)

Gund Institute for Ecological Economics, University of Vermont, 617 Main Street, Burlington VT 05405 USA Tel +1.802.656.9891, Lini.wollenberg@uvm.edu, http://www.ccafs.cgiar.org

Lini Wollenberg is the low-emissions agriculture Flagship Leader for the CGIAR Research Program on Climate Change, Agriculture and Food Security and Research Associate Professor at the Gund Institute for Ecological Economics and Rubenstein School of Environment and Natural Resources, University of Vermont. Dr. Wollenberg holds a PhD and MS in Wildland Resource Science from the University of California, Berkeley and has worked for more than 30 years on research and policy related to climate change mitigation, local governance, environment and rural livelihoods, community-based forest management, participatory action research and adaptive collaborative management. She was previously the director of the Centre for Sustainable Agriculture at the University of Vermont (2007-2009), a principal scientist in the governance program at the Centre for International Forestry Research (CIFOR) (1994-2007) and a program officer for the Ford Foundation (1991-1994).

As part of her CCAFS responsibilities, Dr. Wollenberg has facilitated cross-centre program planning, research and outcome delivery, including a program on the quantification of net greenhouse gas emissions in agriculture across five centres.

Dr. Wollenberg has authored over 60 publications, including books and peer-reviewed articles in international journals, and has assisted in more than 100 publications of research partners:

Recent publications include:

- Agrawal A, Wollenberg E, Persha L. 2014. Governing Agriculture-Forest Landscapes to Achieve Climate Change Mitigation. Lead article of special section. *Global Environmental Change.* 29: 270-280.
- Ogle SM, Olander L, Wollenberg E, Rosenstock T, Tubiello FN, Paustian K, Buendia L, Nihart A, Smith P. 2014. Reducing greenhouse gas emissions and adapting agricultural management for climate change in developing countries: providing the basis for action. *Global Change Biology*. 20:1–6. doi: 10.1111/gcb.12361
- Neufeldt H, Jahn M, Campbell C, Beddington JR, DeClerck F, De Pinto A, Hellin J, Herrero M, Jarvis A, LeZaks D, Holger M, Rosenstock T, Scholes M, Scholes R, Vermeulen S, Wollenberg E, Zougmoré R. 2013. Beyond climate-smart agriculture – toward safe operating spaces for global food systems. *Agriculture and Food Security*. 2:12.
- Newton P, Agrawal A, Wollenberg E. 2013. Enhancing the sustainability of commodity supply chains in tropical forest and agricultural landscapes. *Global Environmental Change.* 23:1761-1772.
- Olander L, Wollenberg L., Tubiello FN, Herold M. 2013. Advancing agricultural greenhouse gas quantification. *Environmental Research Letters.* 8(1):011002. http://iopscience.iop.org/1748-9326/8/1/011002

Dr. James Kinyangi (East Africa Regional Program Leader)

Principal Scientist and Regional Program Leader – CCAFS East Africa, International Livestock Research Institute (ILRI), PO Box 30709, Nairobi 00100, Kenya. Email: J.Kinyangi@cgiar.org

Dr. Kinyangi has over 15 years of research leadership and program experience in climate change adaptation and mitigation, implementing partnerships for science and policy support, knowledge management and capacity strengthening for linking climate change, agriculture and food security, crop-livestock integration, soil-

crop modeling, soils and land management, and water, and poverty analysis in Africa. He has previously worked with FAO, AGRA, ILRI, TSBF-CIAT in various capacities. Dr. Kinyangi received a PhD in soil, crop sciences from Cornell University in 2007 and a MS degree in crop and soil sciences from Michigan State University in 2000. He is a fellow at the Sigma Delta Honor Society of Agriculture.

Dr. Kinyangi oversees the work of both CGIAR and non-CGIAR partners and coordinates actions that lead to coherent implementation of the CCAFS East Africa regional strategy, linking climate change, agriculture and food security. He is in charge of developing core activities with partners to contribute to research outputs and outcomes that are critical to achieving policy changes and addressing regional priorities around climate change adaptation and mitigation. He has written research articles on global change, ecosystem science, soils and land management in the tropics. Key contributions include the development of spatial x-ray pattern analyses for soils and pioneering work on the first nanometer scale image of soil.

Recent publications include:

- Vermeulen SJ, Challinor AJ, Thornton PK, Campbell BM, Eriyagama N, Vervoort JM, Kinyangi J, Jarvis A, Läderach P, Villegas JR, Nicklin KJ, Hawkins E, Smith DR. 2013. Addressing uncertainty in adaptation planning for agriculture. *Proceedings of the National Academy of Sciences.* 110 (21): 8357–8362. DOI: http://dx.doi.org/10.1073/pnas.1219441110
- Campbell B, Kinyangi J, Nersisyan A, Leigh RA, Dibb-Leigh JA, Zougmoré RB, Seré C, Aggarwal P, Hoefner F. 2013. Perspectives: legislating change. *Nature.* 501: S12-S14. DOI: http://dx.doi.org/10.1038/501S12a
- Liang B, Wang CH, Solomon D, Kinyangi J, Luizao F, Wirick S, Skjemstad J, Lehmann J. 2013. Oxidation is key for black carbon surface functionality and nutrient retention in Amazon anthrosols. *British Journal of Environment and Climate change.* 3(1): 9-23. (supporting online information)
- Vermeulen, S, Zougmoré R, Wollenberg, E, Thornton P, Nelson G, Kristjanson P, Kinyangi, J, Jarvis, A, Hansen, J, Challinor, A, Campbell, B, Aggarwal, P. 2011. Climate change, agriculture and food security: a global partnership to link research and action for low-income agricultural producers and consumers. *Current Opinion in Environmental Sustainability.* DOI.ORG/10.1016/J.COSUST.2011.12.004
- Kinyangi J, Solomon D, Liang B, Wirick S, Lerotic M, Lehmann J. 2006. Nanoscale biogeocomplexity of the organomineral assemblage in soil: application of STXM microscopy and C 1s-NEXAFS spectroscopy. *Soil Science Society of America Journal.* 70: 1708–171

Prof. Pramod Aggarwal (South Asia Regional Program Leader)

Regional program leader for South Asia, CGIAR Research Program on Climate Change, Agriculture and Food Security, New Delhi. Email: p.k.aggarwal@cgiar.org

Prof. Pramod Aggarwal is Regional Program Leader of the CGIAR Research Program on Climate Change, Agriculture and Food Security since 2010. Before this, he was ICAR National Professor at the Indian Agricultural Research Institute, New Delhi and the Coordinator of the ICAR Network on Climate Change and Agriculture. He was the Coordinating Lead Author for the chapter 'Food, Fiber, and Forest Products' of the Fourth Assessment Report (2007) of the Inter-Governmental Panel on Climate Change and a Review Editor for AR5. He is a member of the Editorial Boards of several journals and is a Fellow of the National Academy of Sciences, India and National Academy of Agricultural Sciences, India.

Prof Aggarwal holds a Ph.D. from University of Indore and also from Wageningen University, Netherlands. He was awarded *Ernestoilly Trieste Science Prize* by the Academy of Sciences for the Developing World for his work on climate change and agriculture. His research contributions include developing the concept of climate-smart

villages (CSVs), crop growth models for the tropical environments, impact assessment of climatic variability and climate change on crops, characterizing risks of yield loss for developing weather derivatives, adaptation strategies, inventories of greenhouse gases emissions, mitigation options, yield gap analysis, genotype by environment by management interactions, and crop yield monitoring systems. CSVs are now being replicated in more than 1500 villages in South Asia. His work on insurance has led to improved products with higher satisfaction of stakeholders and is being used by millions of farmers in India.

Recent publications include:

- S. Asseng, F. Ewert, P. Martre, R.P. Rötter, D.B. Lobell, D. Cammarano, B.A. Kimball, M.J. Ottman, G.W. Wall, J.W. White, M.P. Reynolds, P.D. Alderman, P.V.V. Prasad, P.K. Aggarwal, et al.. 2015. Rising temperatures reduce global wheat production. Nature Climate change. 5: 143-147.
- Campbell, B., Kinyangi, J., Nersisyan, A., Leigh, RA, Dibb-Leigh, J.A., Zougmoré, RB, Seré, S. Aggarwal, P.K. & Hoefner, P. 2013. Perspectives: Legislating change: What should governments do to enhance sustainable agriculture and mitigate droughts?; Nature 501, S12–S14 (26 September 2013)
- Aggarwal P, Zougmoré R and Kinyangi J. 2013. Climate-Smart Villages: A community approach to sustainable agricultural development. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: www.ccafs.cgiar.org
- Naresh Kumar, S., P. K. Aggarwal, Rani Saxena, Swaroopa Rani, Surabhi Jain and Nitin Chauhan. 2013. An assessment of regional vulnerability of rice to climate change in India. Climatic Change. 118:683–699.
- Varshney RK, Bansal KC, Aggarwal PK, Datta SK, Craufurd PQ. 2011. Agricultural biotechnology for crop improvement in a variable climate: hope or hype? Trends Plant Sci.;16(7):363-71.

Dr. Sophia Huyer (Gender and Social Inclusion Research Leader)

Gender and Social Inclusion Leader, CGIAR Research Program on Climate Change, Agriculture and Food Security, Brighton, Canada. Email: s.huyer@cgiar.org

Before taking on her current position with CCAFS, Sophia Huyer was Executive Director of Women in Global Science and Technology – WISAT. She has been a leader in research and policy analysis on global gender equality issues relating to science, technology and sustainable development for over 20 years, including agriculture, climate change, energy and natural resources management. She provided strategy and capacity development support to the Organization for Women in Science for the Developing World (OWSD) as their Senior Advisor from 2009-2013 and was affiliated with the Gender Advisory Board of the UN Commission on Science and Technology for Development (GAB-CSTD) to 2014. She has been a consultant to FAO, UN Women and UNDP on gender equality relating to agriculture, climate change, disaster and risk reduction, energy and infrastructure. Most recently she was advisor to the FAO initiative on Reducing Women's Work Burden and co-author of the resulting publication: Running Out of Time: The Reduction of Women's Work Burden in Agricultural Production and author of the UNDP / Government of Macedonia report "Gender and Climate Change in Macedonia: Applying a Gender Lens to the Third National Communication on Climate Change".

Sophia held a Fulbright Fellowship at the Kennedy School of Government at Harvard University in 2000 and was a member of the Advisory Council of the Alliance for Affordable Internet (A4AI) for 2013-2014. She received her Ph.D. in Environmental Studies from York University in Toronto.

Recent publications include:

- Huyer, S. "Women and Science", in UNESCO Science Report 2015, Paris: UNESCO (forthcoming).

- Co-author, “Role of Innovative Technologies for Gender Equitable Climate Smart Agriculture” and “Innovative Activity Profile: Harnessing Information and Communication Technology for Gender-Responsive Climate-Smart Agriculture”, Gender and Agriculture Sourcebook, FAO and World Bank (forthcoming).
- Grassi, F., J. Landberg, and S. Huyer. (2015). Running Out of Time: The Reduction of Women’s Work Burden in Agricultural Production, Rome: FAO.
- Huyer, S. with contributions from M. Risteska (2014). Gender and Climate Change in Macedonia: Applying a Gender Lens to the Third National Communication on Climate Change. Prepared for UNDP Skopje and the Government of Macedonia. 2014.
- Main contributor, UNCTAD (2011). Applying a Gender Lens to Science, Technology and Innovation. Geneva.

Dr. Sonja J. Vermeulen (Global Engagement Research Leader)

Sonja Vermeulen is Head of Research for the CGIAR Research Program on Climate Change Agriculture and Food Security (CCAFS). In this role, Dr Vermeulen synthesizes research across the CCAFS themes on adaptation, climate risk management, low emissions development and policy analysis, and leads CCAFS initiatives to connect to policy processes at the global level. Prior to her position at CCAFS, Dr Vermeulen served as Director of the Program on Business and Sustainable Development at the International Institute for Environment and Development (IIED) and earlier in her career she worked in research and management positions in Zimbabwe. Trained as an ecologist, Dr Vermeulen’s work has spanned the natural and social sciences, across the fields of forestry, agriculture and natural resource management. Her career has bridged academic and applied research, with a strong focus on linking science with policy processes and private sector strategies. Dr Vermeulen is based at the CCAFS Coordinating Unit in the University of Copenhagen, Denmark, and is a citizen of South Africa and the UK.

PhD in Ecology/Conservation Biology, Imperial College London (1999)

MSc in Tropical Resource Ecology, University of Zimbabwe (1994)

MA and BA (Hons) in Natural Sciences, University of Cambridge (1990)

Recent publications include:

- Steenwerth, K.L., Hodson, A.K., Bloom, A.J., Carter, M.R., Cattaneo, A., Chartres, C.J., Hatfield, J.L., Henry, K., Hopmans, J.W. Horwath, W.R., Jenkins, B.M., Kebreab, E., Leemans, R., Lipper, L., Lubell, M.N., Msangi, S., Prabhu, R., Reynolds, M.P., Sandoval Solis, S., Sischo, W.M., Springborn, M., Tittonell, P., Vermeulen, S.J., Wheeler, S.M., Wollenberg, E.K., Jarvis, L.S. and Jackson, L.E. 2014. Climate-smart agriculture global research agenda: scientific basis for action. Agriculture & Food Security 3:11.
- Vermeulen, S.J., Challinor, A.J., Thornton, P.K., Campbell, B.M., Eriyagama, N., Vervoort, J., Kinyangi, J., Jarvis, A., Läderach, P., Ramirez-Villegas, J., Nicklin, K., Hawkins, E., and Smith, D.R. 2013. Addressing uncertainty in adaptation planning for agriculture. Proceedings of the National Academy of Sciences 110: 8357–8362.
- Vermeulen, S.J., Campbell, B.M. and Ingram, J.S.I. 2012. Climate change and food systems. Annual Review of Environment and Resources 37: 195-222.
- Vermeulen, S.J., Aggarwal, P.K., Ainslie, A., Angelone, C., Campbell, B.M. Challinor, A.J., Hansen, J.W., Ingram, J.S.I., Jarvis, A., Kristjanson, P., Lau, C., Nelson, G.C., Thornton, P.K. and Wollenberg, E. 2012. Options for support to agriculture and food security under climate change. Environmental Science and Policy 15: 136-144.

Other members of the Core Team

Dr Jim Hansen (F2 Leader)

CCAFS Flagship Leader; and Senior Research Scientist, International Research Institute for Climate and Society (IRI), Columbia University, New York. Email: jhansen@iri.columbia.edu

Dr. Hansen leads CCAFS Flagship 2: *Climate Information Services and Climate-Informed Safety Nets*. He has worked on managing climate-related risk for agriculture and food security since 1996 – first at the University of Florida where he was part of the Southeast Climate Consortium, then since 1999 at the IRI. His research has dealt with a range of issues involving the use and value of climate-related information for managing the risks that confront agriculture and food security. His research contributions have included integrating climate information with agricultural modeling; the economics of risk and advance information in agriculture; developing effective climate information services for farmers; farm economic risk and sustainability analysis; spatial scaling in agroecosystem modeling; stochastic weather modeling; and modeling multiple cropping systems. Other professional contributions include: serving as Co-Editor-in-Chief of Agricultural Systems (2002-2010); contributing to the multi-stakeholder Gap Analysis for the Implementation of the Global Climate Observing System Program in Africa; and serving on the International Review Team for Australia's Managing Climate Variability R&D Program, and the Steering Group for the international Climate Prediction and Agriculture (CLIMAG) Program of ESSP. He holds a Ph.D. in Agricultural and Biological Engineering from the University of Florida, and an M.S. in Agronomy and Soil Science and B.S. in General Tropical Agriculture from the University of Hawaii.

As CCAFS Theme 2 and Flagship 2 Leader, Dr. Hansen has overseen development of a consolidated portfolio of research across the CGIAR; fostered partnerships with the climate science and climate services communities; co-lead development of major externally-funded climate services initiatives in Rwanda, Tanzania and Malawi; and overseen design and development of crop production forecasting software.

He has published more than 50 refereed journal publications and more than 320 other publications (books, book chapters, proceedings, published research reports), including:

- Greatrex, H., Hansen, J.W., Garvin, S., Diro, R., Blakeley, S., Le Guen, M., Rao, K.N., Osgood, D.E., 2015. Scaling up index insurance for smallholder farmers: Recent evidence and insights. CCAFS Report No. 14. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.
- Hansen, J.W., Mason, S., Sun, L., Tall, A., 2011. Review of seasonal climate forecasting for agriculture in sub-Saharan Africa. *Experimental Agriculture* 47:205-240.
- Barrett, C.B., Barnett, B.J. Carter, M.R., Chantarat, S., Hansen, J.W., Mude, A.G., Osgood, D.E., Skees, J.R., Turvey, C.G., Ward, M.N., 2007. Poverty Traps and Climate Risk: Limitations and Opportunities of Index-Based Risk Financing. IRI Tech. Rep. No. 07-03. International Research Institute for Climate and Society, Palisades, New York, USA.
- Hansen, J.W., Challinor, A., Ines, A.V.M, Wheeler, T., Moron, V., 2006. Translating climate forecasts into agricultural terms: advances and challenges. *Climate Research* 33:27-41.
- Hansen, J.W., Hellmuth, M., Thomson, M., Williams, J. (Editors, alphabetical order), 2006. A Gap Analysis for the Implementation of the Global Climate Observing System Program in Africa. IRI Technical Report No. 06-01. International Research Institute for Climate and Society, Palisades, New York. 49 pp.

Dr. Philip K Thornton (F4 Leader)

Principal Scientist and Flagship Leader, International Livestock Research Institute (ILRI), PO Box 30709, Nairobi 00100, Kenya. p.thornton@cgiar.org

Dr. Thornton has led the Flagship on "Policies and institutions for climate-smart food systems" of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) since 2014, and previously the research theme on "Integration for Decision Making". He is an Honorary Research Fellow in the School of Geosciences at the University of Edinburgh, and a CSIRO McMaster Research Fellow for 2015-2016. He studied agriculture at the University of Reading and received a PhD in Farm Management and Agricultural Economics from Lincoln College, New Zealand in 1983. He has over thirty years' experience as a researcher and research leader in agricultural R4D organisations. Over the last ten years he has undertaken consultancies for the World Bank, FAO, the Science Council of CGIAR, IDRC, and three UK Government Foresight Projects. He has contributed to several global assessments including the IPCC's Fourth and Fifth Assessments.

He leads a research agenda on policies and institutions for climate-smart agriculture, overseeing a research portfolio of projects across multiple CGIAR centres and external partners. His research activities include integrated modelling at different scales, evaluating climate change impacts and adaptation options in smallholder farming systems, researching social learning and scenarios as tools for fostering institutional change, and contributing to the development of tools and databases for ex ante impact assessment.

He has published over 120 refereed journal papers and more than 320 other publications (books, book chapters, proceedings, published research reports).

Recent publications include:

- Perez C, Jones E, Kristjanson P, Cramer L, Thornton P K, Förch W, Barahona C (2015). How resilient are farming households, communities, men and women to a changing climate in Africa? Global Environmental Change (in press).
- Vervoort J, Thornton PK, Kristjanson P, Förch W, Ericksen P, Kok K, Ingram JSI, Herrero M, Palazzo A, Helfgott A, Wilkinson A, Havlik P, Mason-D'Croz D, Jost C (2014). Challenges to scenario-guided adaptive action on food security under climate change. Global Environmental Change 28, 383-394.
- Kristjanson PM, Harvey B, Van Epp M, Thornton PK (2014). Social learning and sustainable development. Nature Climate Change 4, 5-7.
- Vermeulen S J, Aggarwal P K, Ainslie A, Angelone C, Campbell B M, Challinor A J, Hansen J W, Ingram J S I, Jarvis A, Kristjanson P, Lau C, Nelson G C, Thornton P K, Wollenberg E (2012). Options for support to agriculture and food security under climate change. Environmental Science & Policy 15, 136-144.
- Thornton PK, Jones P G, Ericksen P J, Challinor A J (2011). Agriculture and food systems in sub-Saharan Africa in a four-plus degree world. Philosophical Transactions of the Royal Society Series A 369, 117-136.

Dr. Robert Zougmoré (West Africa Regional Program Leader)

Principal scientist, ICRISAT West & Central Africa, Bamako Email: r.zougmore@cgiar.org

Robert Zougmoré is an agronomist and soil scientist with a PhD (2003) in Production Ecology & Resource Conservation (University of Wageningen). He currently leads the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS) for the West Africa Region. With 25 years of research experience, his major research covered soil and water management, runoff and soil erosion, land rehabilitation and integrated soil fertility management at plot and watershed levels. His current work focuses on the development of climate-smart agriculture technologies, practices, institutions and policies for better climate risk management in West Africa. As leader of the CCAFS Regional Program, he has been instrumental in planning participatory

action research in climate-smart villages as well as identifying partnerships, opportunities for and impediments to action, measures and communication channels needed to sustain and broaden successful outcomes, knowledge and capacity gaps, and potential policy responses to promote climate-smart agriculture. Linking strongly with CCAFS Flagships, he has been able to engage country partners in various CCAFS-led initiatives such as the prioritization of CSA options, the testing and development of climates-smart agriculture technologies, practices, tools, approaches and their mainstreaming into national agricultural plans and policies. He initiated the national science-policy dialogue platforms in the CCAFS pilot countries to stimulate knowledge exchange among key national stakeholders and also linked with the sub-regional actors such as ECOWAS to inform the setup of the regional CSA alliance in West Africa.

Before joining CCAFS, he was a senior staff member within the Environment Program of the Sahara & Sahel Observatory (Tunisia) where he was actively involved in the development and implementation of initiatives pertaining to Desertification, land Degradation and Drought (DLDD) and climate change adaptation in Africa aiming to contribute to defining informed environmental policies. He also coordinated a joint-funded IDRC/DFID project entitled "Experimenting a capacity development approach and a toolkit for monitoring and evaluation within climate change adaptation initiatives", in collaboration with UNECA, AGRHYMET, and IUCN.

Dr. Zougmoré has published widely with more than 50 papers and book chapters on soil erosion, integrated soil, water and nutrient management options and their economic benefits, and climate-smart agriculture. Recent publications include:

- Robert Zougmoré, Alain Sy Traoré and Yamar Mbodj (Eds.), 2015. Overview of the Scientific, Political and Financial Landscape of Climate-Smart Agriculture in West Africa. Working Paper No. 118. CGIAR Research Program on Climate Change, Agriculture and Food Security. Available online at: www.ccafs.cgiar.org
- Zougmoré R., Jalloh A., Tioro A., 2014. Climate-smart soil water and nutrient management options in semiarid West Africa: a review of evidence and analysis of stone bunds and zaï techniques. *Agriculture & Food Security; 3:16.*
- Campbell, B.M., Thornton, P., Zougmoré, R., van Asten, P. and Lipper, L. 2014. Sustainable intensification: What is its role in climate smart agriculture? *Current Opinion in Environmental Sustainability 8: 39-43;http://dx.doi.org/10.1016/j.cosust.2014.07.002*
- Vom Brocke K., Trouche J., Weltzien E., Kondombo-Barro C.P., Sidibé A., Zougmoré R., Gozé E., 2014. Helping farmers adapt to climate and cropping system change through increased access to sorghum genetic resources adapted to prevalent sorghum cropping systems in Burkina Faso. *Expl Agric.: 50(2): 284-305. doi:10.1017/S0014479713000616*
- Bruce Campbell, James Kinyangi, Robert Zougmoré, Pramod Aggarwal, et al., 2013. Agriculture and Drought. Perspectives: Legislating change, *Nature outlook 501, S12–S14 (26 September 2013).*

Dr. Leocadio S. Sebastian (South East Asia Regional Program Leader)

Regional Program Leader for Southeast Asia, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), International Rice Research Institute (IRRI)-CCAFS Office, Agricultural Genetics Institute, Km 2 Pham Van Dong Ave, Tu Liem District, Hanoi, Vietnam, l.sebastian@irri.org

As regional program leader for CCAFS Southeast Asia, Dr. Leocadio S. Sebastian's primary responsibilities are to ensure coherence among CCAFS research for development activities from field to regional levels and play a key role in achieving outcomes and impacts at the national and regional levels. He leads the integration of the CCAFS agenda into the regional agenda and national programs in the CCAFS focus countries Cambodia, Indonesia, Laos, Myanmar, Philippines, and Vietnam. His specific responsibilities include:

- Develop and implement an engagement, partnership and communications plan for the Region;
- Liaise between CCAFS projects and the multitude of relevant stakeholders from farm to regional levels to ensure linkage and coordination with activities related to climate change in agriculture;
- Foster outcome and impact of CCAFS research for development activities;
- Contribute actively to the management operation of CCAFS in close and cross-cutting collaboration with the CCAFS' Flagship and other regional program leaders.

Prior to joining CCAFS, Dr. Sebastian was Regional Director for Asia Pacific Region at Bioversity International (September 2008-August 2013) and Executive Director (2000-2008) of the Philippine Rice Research Institute (PhilRice), where he strengthened and mobilized the national rice research and development network, enabling the Philippines to increase rice productivity and improve PhilRice's stature as a premier knowledge-generating institution in Southeast Asia. His expertise in research and development management is internationally recognized due to his involvement in various international research networks, consortia, and review panels organized by the World Bank, the Food and Agriculture Organization of the United Nations (FAO), Global Crop Diversity Trust (GCDT), Rockefeller Foundation, the CGIAR, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and the International Rice Research Institute (IRRI). Leo has receeived the following prestigious awards in the Philippines: Ten Outstanding Young Men (TOYM) in 2001, Outstanding Young Scientist in Plant Breeding, Pantas (Sage) Award for Research Management and the Japan International Cooperation Agency (JICA) Presidential Award.Leo earned his doctorate degree in plant breeding and genetics from Cornell University in Ithaca, New York, through a Rockefeller Foundation Fellowship Award, and his BS and MS degrees from the University of the Philippines Los Baños.

Recent publications include:

- Ramirez M, Ortiz R, Taba S, Sebastian LS, Williams D, Ebert A, Vezina A. 2012. Demonstrating interdependence on plant genetic resources for food and agriculture. In: Halewood M, Lopez NI, Louafi S, (Eds.). 2012. *Crop Genetic Resources as a Global Commons: Challenges in International Law and Governance.* Earthscan.
- Sebastian LS, Chandrabalan D, Borromeo KH, Zhang Z, Mathur PN. 2011. Agrobiodiversity Conservation and Use in Asia, Pacific and Oceania region. FFTC Extension Bulletin.
- Mamaril CP, Castillo M, Sebastian LS. 2009. Facts and Myths about Organic Fertilizers. PhilRice. Science City of Munoz, Nueva Ecija, Philippines.
- Sebastian LS, Payumo JG. 2008. NARES capacity in relation to international treaties and conventions on intellectual property rights, agricultural biotechnology, and plant genetic resources management. *Asian Journal of Agricultural Development.* 3:91-114.
- Singleton G, Joshi RC, Sebastian LS, (Eds.). 2008. Philippine Rats. PhilRice. Science City of Munoz, Nueva Ecija, Philippines.

Dr. Ana María Loboguerrero Rodríguez (Latin America Regional Program Leader)

Regional Leader, Latin America, CGIAR Research Program for Climate Change, Agriculture and Food Security (CCAFS), International Centre for Tropical Agriculture (CIAT), Recta Cali-Palmira km17, Cali, Colombia. Tel. +57 2 4450000. Email: a.m.loboguerrero@cgiar.org

Dr. Ana María Loboguerrero Rodríguez is the leader of the Latin American program of the CGIAR Research Program for Climate Change, Agriculture and Food Security (CCAFS), based in Cali, Colombia. She holds a Master and a PhD on Economics from University of California, Los Angeles, USA (UCLA). Dr. Loboguerrero has 7 years' experience of working on climate change challenges. Previously, she worked in the research and the monetary and reserves departments of the Central Bank of Colombia, the research department of the Inter-

American Development Bank and the Sustainable Environmental Development Deputy Directorate of the National Planning Department of Colombia as coordinator of climate change. The deputy directorate is committed to study and develop schemes and to include environmental policies and disaster risk management into Colombia's National Planning Department's development planning strategies. The directorate also predicts and gauges climate change and climate variability impacts on Colombia's economic sectors and ecosystems. While at the deputy directorate, Dr. Loboguerrero led the formulation of the Colombian Climate Change Policy, the National Adaptation Plan, the National Development Plan and the research agenda on climate change as well as coordinated technical support for the Colombian Low Carbon Growth Strategy.

Dr. Loboguerrero has also worked as an external expert panel member of the evaluation of the Food and Agriculture Organization's (FAO) work in climate change mitigation and adaptation. She was a lecturer of economics at UCLA and several universities in Colombia. She taught Economics of Climate Change at the University of Los Andes and supervised several undergraduate, masters and PhD dissertations. In 2011, Dr. Loboguerrero participated in the NEXUS Fulbright Program with a project related to the Economics of Climate Change for Colombia, including a three-month research visit to the International Research Institute for Climate and Society (IRI) at Columbia University. Dr. Loboguerrero was part of the Brown International Advanced Research Institute on Climate Change and its Impacts, participated in The Economics of Climate Change Program for Sustainability Leadership of the University of Cambridge, in the International Seminar on the Economics of Climate Change and Social Impacts: Methodologies and Techniques for Analysis from ECLAC and the European Union, in the Seminar on Environmental Economy in Latin America from the Inter-American Development Bank and in the Seminar on Mainstreaming Climate Change Adaptation into Public Policy Formulation, from the IberoAmerican Network of Climate Change Offices.

Since 2013 Dr. Loboguerrero has led research in Latin American for CCAFS. In this position she has contributed to strengthening the agricultural sector in the region so that it is not totally dependent on climate variability, instead managing climate to its advantage, or at least to avoid the bulk of negative consequences. Dr. Loboguerrero has used her experience working in the public sector to become a key partner of policy makers and planners in the region so that they use climate information and tools to design and implement plans and strategies and find ways to make climate information useful and applicable for end-users.

Dr. Loboguerrero's research agenda has focused on the construction and comparison between various types of economic models to assess the consequences of adaptation and mitigation on the economic development of the countries. This research agenda has informed policies and interventions that combine and consider trade-offs between adaptation and mitigation, leading towards a low emissions agricultural development in Colombia. Among other studies, Dr. Loboguerrero was author of a chapter of the book (soon to be published) by the World Bank: Low-Carbon Development for Colombia. In this chapter she presents the results of a Computable General Equilibrium Model built by her to assess several representative types of low-carbon measures in the energy, transport, and AFOLU sectors and to determine the expected direction and magnitude of the macroe-conomic effects of specific climate mitigation measures. Other papers available on line in Energy Economics include: "Agriculture, Forestry, and Other Land-Use Emissions in Latin America" and "Achieving CO2 Reductions in Colombia: Effects of Carbon Taxes and Abatement Targets".

Flagship 1

Dr. Andy Jarvis – see under Program Management Committee

Prof. Andrew Juan Challinor

CCAFS CoA 1.7 Joint Leader, Institute for Climate and Atmospheric Science (ICAS), School of Earth and Environment, University of Leeds. Email: a.j.challinor@leeds.ac.uk

Professor Challinor has over fifteen years of research experience and holds a BSc and PhD from the University of Leeds. After obtaining his PhD, he spent some years at the University of Reading, conducting postdoctoral research on the impacts of climate variability and change on food crops. He returned to Leeds in 2007 to take up a Lectureship and initiate and lead the Climate Impacts group. Professor Challinor led the NERC consortium End-to-end quantification of uncertainty for impacts prediction (EQUIP) and currently co-leads Flagship work on modeling work for crop breeding under the Climate-Smart Agricultural Practices Flagship of the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS).

Professor Challinor was co-creator and lead developer of the crop simulation model GLAM, which has over 300 registered users across the globe. Two major projects ongoing include the UK-TSB funded "Breeding strategies for a variable climate" and the AMMA2050's DFID-NERC Future Climates For Africa project (UK lead on modelling for crop breeding).

Professor Challinor's work focusses principally on using climate modelling and process studies to understand food production and food security; treatments of uncertainty and managing risk; and climate-resilient pathways and adaptation. He is the co-creator and lead developer of the crop simulation model GLAM, which has over 300 registered users across the globe. Professor Challinor's career goal is to contribute significantly to the knowledge and policy base for sustainably strengthening the food security and health of populations vulnerable to climate variability and change. He achieves this by working with experts in a range of disciplines, from epidemiologists and ecologists to social scientists and economists.

He was also Lead Author on the 'Food Production Systems and Food Security' chapter of the Fifth Assessment report of the IPCC and has published over 70 publications, over fifty of which have been published to date in internationally refereed journals, and seven of which have been published as book chapters.

Recent publications include:

- Challinor, A. J., Parkes, B. and Ramirez-Villegas, J. (2015), Crop yield response to climate change varies with cropping intensity. Global Change Biology, doi: 10.1111/gcb.12808
- Falloon, P., D. Bebber, J. Bryant, M. Bushell, A. J. Challinor, S. Dessai, S. Gurr and A.-K. Koehler (2015). Using climate information to support crop breeding decisions and adaptation in agriculture. *World Agriculture* 5 (1) 25-42.
- Ramirez-Villegas J; Watson J; Challinor AJ (2015) Identifying traits for genotypic adaptation using crop models., Journal of Experimental Botany, 66, pp.3451-3462. doi: 10.1093/jxb/erv014
- Challinor AJ; Watson J; Lobell DB; Howden SM; Smith DR; Chhetri N (2014) A meta-analysis of crop yield under climate change and adaptation, Nature Climate Change 4 (4) pages 287 – 291
- Iizumi T, Luo JJ, Challinor AJ, Sakurai G, Yokozawa M, Sakuma H, Brown ME, Yamagata T. (2014) Impacts of El Niño Southern Oscillation on the global yields of major crops, Nat Commun 5

Dr. Julian Ramirez-Villegas

Research Fellow, CGIAR Research Program on Climate Change, Agriculture and Food Security, and University of Leeds, Leeds, UK. Email: J.Ramirez-Villegas@leeds.ac.uk; j.r.villegas@cgiar.org

Dr. Julian Ramirez-Villegas is a Research Fellow for F1 of the CGIAR Research Program on Climate Change, Agriculture and Food Security since 2013. Julian works jointly in the Climate Impacts Group led by Prof. Andy Challinor at the University of Leeds, and the International Centre for Tropical Agriculture (CIAT). His current role involves close collaboration with F1 projects to produce the science that underpins CSA. Before this, Julian was doing a PhD on climate change impacts and adaptation at University of Leeds, while also fulfilling some

duties as a research assistant at CIAT; and prior to that he worked as a research assistant at CIAT for a few years.

During his career, he has contributed to a broad range of research projects and has published a number of papers related to crop-climate modeling, climate change impacts, adaptation, and genetic resources conservation. Julian's trajectory at CIAT and the University of Leeds has made him earn two best peer reviewed publication prizes (in 2013 at University of Leeds, and 2015 at CIAT), an innovation grant for young scientists (2014, CIAT), and an outstanding young scientist award (2010, CIAT).

Dr. Ramirez-Villegas holds a Ph.D. from the University of Leeds in the United Kingdom. His research contributes largely to the understanding of adaptation strategies for tropical agriculture at multiple temporal scales, the study of uncertainties and robustness in projections of impacts and adaptation, and the study of breeding needs under changing climates. His work on modeling breeding strategies under climate change has been of paramount importance in the development of future adapted bean varieties at CIAT.

Recent publications include:

- Ramirez-Villegas, J., Watson, J., and Challinor, A. J. 2015. Identifying traits for genotypic adaptation using crop models. Journal of Experimental Botany, 66(12): 3451-3462.
- Challinor, A.J., Parkes, B., and Ramirez-Villegas, J. 2015. Crop yield response to climate change varies with cropping intensity. Global Change Biology, 21(4): 1679-1688.
- Ramirez-Villegas, J. and Thornton, P. K. 2015. Climate change impacts on African crop production. Working Paper No. 119. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.
- Ramirez-Villegas, J. and Khoury, C. K. 2013. Reconciling approaches to climate change adaptation for Colombian agriculture. Climatic Change, 119(3-4): 575-583
- Ramirez-Villegas, J., Jarvis, A., and Laderach, P. 2013. Empirical approaches for assessing impacts of climate change on agriculture: the EcoCrop model and a case study with grain sorghum. Agricultural and Forest Meteorology, 121: 26-45.

Dr. Mangi Lal Jat

Senior Cropping Systems Agronomist & CIMMYT-CCAFS South Asia Coordinator, Global Conservation Agriculture Program (GCAP), International Maize and Wheat Improvement Centre (CIMMYT), New Delhi, India.
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Dr Jat has PhD in Agronomy from the Indian Agricultural Research Institute (IARI), New Delhi. Started his professional carrier in agricultural research in 1998 as Scientist (Agronomy) at Project Directorate of Cropping Systems Research, Indian Council of Agricultural Research (ICAR), Meerut and served ICAR for 12 years as systems agronomist before joining CIMMYT and contributed immensely in developing, adapting and deploying modern agronomic management practices in major cropping systems. Joined CIMMYT's Global Conservation Agriculture Program in 2009 and contributed to the development & deployment of Conservation Agriculture and Precision Agriculture based management technologies, climate smart agriculture practices (CSAPs) and capacity development to several thousand stakeholders across South Asia for linking science with society.

He is currently responsible for coordinating CIMMYT-CCAFS South Asia program on developing, adapting and catalyzing scaling-up and -out climate smart agriculture (CSA) and Climate Smart Villages (CSVs) for addressing issues of resource degradation, abiotic stresses and climate change across South Asia.

An Associate Fellow of the National Academy Agricultural Sciences (NAAS), Fellow of Indian Society of Agronomy (ISA), Dr Jat has received several awards including IPNI-FAI award for Best Research on Management and balanced use of inputs in achieving maximum yield, PS Deshmukh Young Agronomist Award of ISA, Young

Soil Conservationist Award of IASWC, Dhiru Morarji Memorial Award, and several other recognitions including award of honour from Govt of Punjab, India, IPNI-USA, Colorado State University, USA etc. He also served on a FAO mission to develop CA program for the Govt of Bhutan. He also served as editor of several national journals and international conferences proceedings. His research findings are published in over 250 peer-reviewed journal articles, book chapters, bulletins, reviews, symposia proceedings & abstracts. Recognizing his contributions, several international organizations invited him to share his experiences as keynote speaker, lead speaker, chair and co-chair of the events. He is also member of Research Advisory Committee (RAC) of the ICAR Institutes. He is currently guiding 14 PhD and MS students of various Universities.

Recent publications include:

- Aryal, JP; Sapkota, TB; **Jat, ML** and Bishnoi, D. 2015. On-farm economic and environmental impact of zero-tillage wheat: a case of north-west India. *Experimental Agriculture, 51:* 1-16., *Cambridge University Press 2014*. doi:10.1017/S001447971400012X
- Powlson, DS; Stirling, CM; Jat, ML, Gerard, BG., Palm, CA; Sanchez, PA and Cassman, KG. 2014. Limited potential of no-till agriculture for climate change mitigation. *Nature Climate Change*, 4: 678-683. DOI:10.1038/NCLIMATE2292
- **Jat, ML**; Bijay-Singh and Gerard, Bruno. 2014. Nutrient Management and Use Efficiency in Wheat Systems of South Asia*. Advances in Agronomy*, 125: 171-259 (http://dx.doi.org/10.1016/B978-0-12-800137-0.00005-4).
- Sapkota, TB; Majumdar, K; **Jat, ML**; Kumar, A; Bishnoi, DK; McDonald, AJ and Pampolino, M. 2014. Precision nutrient management in conservation agriculture based wheat production of Northwest India: Profitability, nutrient use efficiency and environmental footprint. *Field Crops Research* 155:233-244.
- Wright, H; Vermeulen, S; Laganda, G; Olupot, M; Ampaire, E and **Jat, ML.** 2014. Farmers, food and climate change: ensuring community-based adaptation is mainstreamed into agricultural Programs. *Climate and Development*, 6:4, 318-328, DOI: 10.1080/17565529.2014.965654

Julian F. Gonsalves

Senior Advisor, IIRR (Asia), Tagaytay City, Philippines; Email: juliangonsalves@yahoo.com

Julian Gonsalves is an experienced facilitator, manager, action researcher and advocate with a three decade focus on smallholder agriculture, international agriculture and rural development. He is a proponent of participatory approaches. He has worked in more than 35 countries since his career in 1980. He has a Phd in extension education and international agriculture from Cornell University, Ithaca, New York, which he pursued under a grant from the Rockefeller Foundation. He has a Masters Degree from Michigan State University where he specialised in knowledge utilization strategies. He has a BS degree in Agronomy from the University of Agricultural Sciences in Bangalore, India.

His special area of interest/competence include: program formulation/design, management, review and evaluation, external assessment, training design and evaluation on sustainable resource use and management, rural and agricultural research, climate-resilient livelihoods farmer-led extension; community-based natural resources management/community forestry; participatory development approaches; and integrated conservation development activities; strengthening institutional capacity and human resources development; designing development support communications (IEC) strategies; networking, advocacy and collaborative mechanisms for effective partnerships; documenting best practices through participatory workshops and approaches for scaling up impact of pilot program for research efforts. Julian Gonsalves has also pioneered the writeshop process (an intensive, participatory writing process that aims to produce a written output by a

multidisciplinary team in a defined period of time under one roof) and has since then helped conceptualized or managed over 30 writeshops in over a dozen countries. Most of the early work of Julian has focused on regenerative agriculture approaches.

He served on the CIDA/IDRC Scientific Advisory Committee (CIFSRF) for Food Security. He has provided support to the CGIAR CCAFS work in the Southeast Asia Region and provides assistance as needed.Through IIRR and ICRAF he is involved as advisor to the CCAFS South East Asia project on Scaljng up of Climate Smart Agriculture with two sites ,one in the Philippines and Vietnam where community level adaptive research activities are being implemented. Through IIRR he is also involved in supporting the capacity building needs for partners in Cambodia, Laos and Vietnam and has designed communication support material on Climate Smart Agriculture.

Recent publications include:

- Gonsalves, J. 2014. *A new relevance and better prospects for wider uptake of social learning within the CGIAR.* CCAFS Working Paper 37. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen, Denmark.
- Gonsalves, J. and P. Mohan. 2011. *Strengthening Resilience in Post-Disaster Situations: Stories, Experience, and Lessons from South Asia.* Academic Foundation and International Development Research Centre (IDRC), New Delhi, India.
- Campilan, D., J. Roa and J. Gonsalves. 2009. *Beyond the farmer and the farm: users' perspectives and agricultural livelihoods*. In: Farmer First Revisited (I. Scoones and J. Thompson eds). ITDG Publishing, Oxford, UK. 97-101.
- Gonsalves, J., T. Becker, A. Braun, D. Campilan, H. de Chavez, E. Fajber, M. Kapiriri, J. Rivaca-Caminade and R. Vernooy (eds). 2005. *Participatory Research and Development for Sustainable Agriculture and Natural Resource Management: A Sourcebook*. CIP-UPWARD, Los Baños, Philippines and IDRC, Ottawa, Canada. 3 volumes. 666pp.
- Estrella, M., J. Blauert, D. Campilan, J. Gaventa, J. Gonsalves, I. Guijt, D. Johnson and R. Ricafort (eds). 1999. *Learning from Change: Issues and Experiences in Participatory Monitoring and Evaluation.* Intermediate Technology Publications, London, UK. 274pp.

Dr Jacob van Etten

Theme leader, Climate adaptation, Bioversity International, Turrialba. Email: J.vanEtten@cgiar.org

Dr Jacob van Etten works as a senior scientist at Bioversity International since 2012. Before that he was professor, academic director and dean in biology and environmental studies at IE University in Madrid, Spain. He has also worked in the Food and Agriculture Organization of the United Nations (FAO) and the International Rice Research Institute (IRRI). Dr Van Etten holds a PhD in Social Sciences and Production Ecology and Resource Conservation from Wageningen University, the Netherlands. His work focuses on agriculture from a interdisciplinary geographical perspective. He has been in charge of Bioversity's contribution to CCAFS and has been leading in a Program of work on local climate vulnerability studies, the use of climate information, and "climate-smart" participatory technology evaluation. His recent work focuses creation of location-aware information services for climate adaptation using citizen science / crowdsourcing approaches.

Recent publications include:

- Ulrichs, M., Cannon, T., van Etten, J., et al. (2015). Assessing climate change vulnerability and its effects on food security: Testing a new toolkit in Tanzania. CCAFS Working Paper.

- Brush, S. B., Bellon, M. R., Hijmans, R. J., Orozco, R. Q., Perales, H. R., & van Etten, J. (2015). Assessing maize genetic erosion. PNAS, 112(1), E1.
- Harvey, C. A., et al. (2014). Climate‐Smart Landscapes: Opportunities and Challenges for Integrating Adaptation and Mitigation in Tropical Agriculture. Conservation Letters, 7(2), 77-90.
- van Etten, J. 2011. Crowdsourcing crop improvement in Sub-Saharan Africa: a proposal for a scalable and inclusive approach to food security. IDS Bulletin 42(4) 102-110.
- Fuller, D.Q., J. van Etten, Y.I. Sato, C. Castillo, L. Qin, A.R. Weisskopf, E.J. Kingwell-Banham, J. Song, and S.M. Ahn. 2010. The contribution of rice agriculture and livestock pastoralism to prehistoric methane levels: an archaeological assessment. The Holocene, 21: 743-759.
- van Etten, J., and R.J. Hijmans. 2010. A geospatial modelling approach integrating archaeobotany and genetics to trace the origin and dispersal of domesticated plants. PLoS ONE 5(8): e12060.

Scientific software

- van Etten, J., L. Calderer and B. Madriz. ClimMob. Crowdsourcing Climate-Smart Agriculture ClimMob.net (R package, online platform, and Android application)
- Hijmans, R.J., J. van Etten et al. raster: Geographic data analysis and modeling.
- http://cran.r-project.org/web/packages/raster/index.html (typically downloaded 200-600 times per day).
- van Etten, J., gdistance: Distances and movements on geographical grids.
- http://cran.r-project.org/web/packages/gdistance/index.html (typically downloaded 20-60 times per day).

Mark Lundy

Senior Researcher and Theme Leader, Linking Farmers to Markets, International Centre for Tropical Agriculture, CIAT, Cali, Colombia. Email: m.lundy@cgiar.org

Mark Lundy is a Senior Scientist at the International Centre for Tropical Agriculture, CIAT, in Cali, Colombia. His work focuses on the role of markets in reducing rural poverty and includes topics such as learning networks to increase NGO and farmer capacities for enterprise development, exploring how private companies can better partner with smallholder farmers, the role of public and donor agencies in supporting better market linkages and how to establish and sustain effective trading relationships between buyers and smallholder farmers that add business value while reducing rural poverty. Emerging areas of work include sustainable food systems and climate adapted value chains. Mark is lead author of a series of guides on participatory rural enterprise development, the LINK method on inclusive business models and an active participant in multi-stakeholder forums focused on sustainability and smallholder inclusion in Latin America and Africa. He holds a B.A. in International Relations, an M.A. in Latin American Studies and a M.Sc. in Community and Regional Planning.

Mr. Lundy's recent work has focused on climate change has focused on how to move from the identification of climate risks to effective mechanisms for scaling CSA practices through value chain institutions. He currently leads the Climate Change, Agriculture and Food Security project on Climate Smart Value Chains with activities in Ghana, Peru and Nicaragua. This project tests the capacity of two large-scale value chain interventions – voluntary certification and impact investing – to incorporate site and crop-specific CSA practices and take them to scale with small cocoa and coffee farmers, producer organizations, governments and private sector firms.

Recent publications include:

- Lundy, M., Amrein, A., Hurtado, JJH., Bexc., G., Zamierowski, N., Rodriguez, F., Mosquera, EE. 2014. LINK Methodology: A Participatory Guide on Business Models that Link Smallholders to Markets, Second edition. International Centre for Tropical Agriculture, CIAT, Cali, Colombia
- Lundy, M., Bexc, G., Rodriguez Camayo, F., Oberthur, T. 2012. *Business models for quality coffee*. In T. Oberthur, P. Läderach, H.A. J. Pohlan and J. Cock (eds.) Specialty Coffee: Managing Quality. International Plant Nutrition Institute, Southeast Asia Program, Penang, Malaysia.
- Díaz Nieto J, Fisher M, Cook S, Läderach P, Lundy M. 2012. Weather Indices for Designing Micro-Insurance Products for Small-Holder Farmers in the Tropics. *PLoS ONE* 7(6): e38281. doi:10.1371/journal.pone.0038281
- Lundy, M., Gottret, M.V., Best, R. 2012. *Linking Research and Development Actors through Learning Alliances.* In World Bank (eds.) Agricultural Innovation Systems: A Sourcebook. World Bank, Washington, DC, USA
- Faminow, M.D.; Carter,S.E.; Lundy, M. 2009. Social entrepreneurship and learning: The case of the Central American learning alliance. *Journal of Developmental Entrepreneurship*: 14 (4): pages 433-450.

Dr. Todd S. Rosenstock

Environmental Scientist, World Agroforestry Centre, Nairobi, Kenya: t.rosenstock@cgiar.org

Dr. Todd Rosenstock is Environmental Scientist at the World Agroforestry Centre (ICRAF) since 2013. Before this, he was an ICRAF Research Fellow focused on Climate Change Mitigation and Land Health. He sits on the Steering Committee for the Alliance for Climate-Smart Agriculture in Africa and participates in the Integrated Planning and Monitoring Sub-group of the Global Alliance for Climate-Smart Agriculture's Knowledge Action Group. He co-leads CCAFS' Flagship Project Partnerships for Scaling Climate-Smart Agriculture (P4S) and the CGIAR-wide Standard Assessment of Mitigation Potential and Livelihoods in Smallholder Systems (SAMPLES) Programs. He is a member of the Editorial Board of the journal Global Change Biology.

Dr. Rosenstock holds a Ph.D. (Agroecology) and M.S. (International Agricultural Development) from the University of California, Davis. His research contributions include evaluating the scientific basis for climate-smart agriculture, targeting climate-smart agricultural responses under multiple uncertainties, methods for measurement and monitoring greenhouse gas emissions and removals in smallholder farming systems, developing mitigation strategies in complex systems, and inventories of greenhouse gases emissions. His work on climate-smart agriculture is helping set the global research and development agendas on the topic.

Recent publications include:

- Kimaro, AA, M Mpanda, J Rioux, S Shaba, E Aynekulu, K Karttunen, H Neufeldt and TS Rosenstock. 2015. Is conservation agriculture 'climate-smart' for maize farmers in the highlands of Tanzania? *Nutrient Cycling in Agroecosystems.* doi: 10.1007/s10705-015-9711-8
- Rosenstock, TS, M Mpanda, J Rioux, E Betemariam, A Kimaro, H Neufeldt, K Shepherd, and E Luedeling. Targeting conservation agriculture in the context of livelihoods and landscapes. 2014. *Agriculture, Ecosystems, & the Environment,* 187:47-51. doi: 10.1016/j.agee.2013.11.011
- Rosenstock, TS, K Tully, C Arias-Navarro, H Neufeldt, K Butterball-Bach, and L Verchot. 2014. Agroforestry with $_{N2}$-fixing trees: sustainable development's friend or foe? *Current Opinion in Environmental Sustainability,* 6: 15-21. doi: http://dx.doi.org/10.1016/j.cosust.2013.09.001
- Ogle, SM, L Olander, L Wollenberg, TS Rosenstock, F Tubiello, K Paustian, L Buendia, A Nihart, and P Smith. 2013. Reducing greenhouse gas emissions and adapting agricultural management for climate

change in developing countries: providing the basis for action. *Global Change Biology*, 10:1-6. doi: 10.1111/gcb.12361

- Rosenstock TS et al. (eds) *forthecoming.* Guidelines to quantify greenhouse gas emissions and removals and identify climate change mitigation options in smallholder farming systems at whole-farms and landscape levels. Springer. 10 chapter volume.

Flagship 2

Dr. James Hansen – see "Other members of core team"

Mr. Pierre C. Sibiry Traoré

Senior Scientist in Remote Sensing, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Bamako, Mali. Email: p.s.traore@cgiar.org.

Mr. Traoré specializes in climate change science, remote sensing, cropping systems modeling, systems and spatial analysis applied to agro-ecological intensification in smallholder settings. He has over twenty years of scientific experience, focused on physical geography and Geographic Information Systems (GIS). At ICRISAT, he was nominated for both Advisory Board Member for the African Climate Change Fellowship Program, as well as manager for the CGIAR's ESRI Virtual Campus Account, providing unlimited ArcGIS training and certification to CGIAR and affiliated staff. He has secured and managed over USD12M in research grants from BMZ, the World Bank (in partnership with IFPRI), the International START Secretariat, BMGF, CCAFS, IDRC, DFID to conduct research on (1) agro-biodiversity management and sustainable land management for adaptation to climate change and variability, (2) the use of very high resolution imagery to support agro-ecological intensification sustainable in smallholder settings, (3) Spurring a Transformation for Agriculture through Remote Sensing (STARS), (4) "Capacitating science-policy exchange platforms to mainstream climate change into national agricultural and food security policy plans," (5) Capacitating African Smallholders with Climate Advisories and Insurance Development (CASCAID), and (6) the Agricultural Model Inter-comparison and Improvement Project (AgMIP), inter alia. His work has contributed to ICRISAT's strategic vision – having coined the "Hypothesis of Hope" concept for climate strategy, developed research thrust on knowledge engineering, geospatial white paper – as well as for other partners, such as IER, McKnight Foundation, ACCFP, BMGF: next-gen agricultural models.

Recent publications include:

- Traore, S.S., Forkuo E.K., Traore, P.C.S., Landmann T., 2015. Assessing the inter-relationship between vegetation productivity, rainfall, population and land cover over the Bani River Basin in Mali (West Africa). IOSR Journal of Engineering, 5 (6), 10-18.
- Akinseye, F.M., Agele, S.O., Traore, P.C.S., Adam, M., Whitbread, A.M., 2015. Evaluation of the onset and length of growing season to define planting date— a case study for Mali (West Africa). Theor. Appl. Climatol. DOI: 10.1107/S00704-015-1460-8.
- de By, R. A., Zurita-Milla, R., Stratoulias, D., Bijker, W., Tolpekin, V., Traore, P.S., Schulthess, U., Dempewolf, J., Becker-Reshef, I., and Blaes, X., 2015. STARS - Monitoring smallholder farming in sub-Saharan Africa and South Asia from an UAV perspective. 9th EARSeL SIG Imaging Spectroscopy Workshop. Special Session on RPAS based hyperspectral remote sensing of vegetation. Luxemburg, 14-16 April 2015.

- Traore, S.S., Landmann, T., Forkuo, E.K., Traore, P.C.S., 2014. Assessing Long-Term Trends in Vegetation Productivity Change Over the Bani River Basin in Mali (West Africa). J. Geography and Earth Sciences 2(2):21-34.
- Singh, P., Nedumaran, S., Traore, P.C.S., Boote, K.J., Rattunde, H.F.W., Vara Prasad, P.V., Singh, N.P., Srinivas, K., Bantilan, M.C.S., 2014. Quantifying potential benefits of drought and heat tolerance in rainfed season sorghum for adapting to climate change. Ag. For. Meteorology 185:37-48.

Dr. Giriraj Amarnath

Researcher, Remote Sensing and Geographic Information Systems (GIS), International Water Management Institute (IWMI), Colombo, Sri Lanka. Email: a.giriraj@cgiar.org

Dr. Giriraj Amarnath is a remote sensing researcher specialized in the application of Remote Sensing and Geographic Information Systems in the study of risk assessment across a wide range of natural hazards and monitoring land and water resources in Asia and Africa. He has over 13 years' experience in research including 3 years in academic at University of Bayreuth, Germany. He has conducted research on the: (1) mapping flood inundation extent in south Asia and south-east Asia, (2) global flood hotspots assessment for climate risk studies, (3) piloting operational flood mapping and modeling in Eastern Sudan, (4) snow cover mapping and monitoring in the Hindu-Kush Himalayas, (5) vegetation cover change and biodiversity assessment in Western Ghats (India), Sagarmatha National Park (Nepal), (6) species niche modeling for endangered plants species in Western Ghats (India), (7) environmental impact assessment using RS/GIS and (8) relationship between upstream-downstream linkages in Indo-Gangetic plain and the possible causes of climate change impacts in this region.

In recent years he has become interested in studying the relationship between land cover/use changes, hydrology, impact of flooding on food security and livelihood. He is applying his expertise in geospatial technology in a recent project that assesses south Asia exposure and vulnerability towards climate hazards. Giriraj's academic and professional work have given him substantial experience including time living and working in India, Nepal, Germany, South Asia, Southeast Asia and Eastern Africa.

Recent publications include:

- Uddin, K., Gurung, D. R., Giriraj, A., & Shrestha, B. (2013). Application of Remote Sensing and GIS for Flood Hazard Management : A Case Study from Sindh Province , Pakistan. American Journal of Geographic Information System, 2(September 1988), 1–5. doi:10.5923/j.ajgis.20130201.01
- Tang, B.-H.; Shrestha, B.; Li, Z.-L.; Liu, G.; Ouyang, H.; Gurung, D. R.; Amarnath, Giriraj; Aung, K. S. (2013). Determination of snow cover from MODIS data for the Tibetan Plateau Region. International Journal of Applied Earth Observation and Geoinformation, 21:356-365.
- Amarnath, Giriraj. (2013). An algorithm for rapid flood inundation mapping from optical data using a reflectance differencing technique. Journal of Flood Risk Management, 12p. DOI: 10.1111/jfr3.12045
- Amarnath, G., Bajracharya, B., & Shrestha, B. (2012). Geoinformatics for Landscape Ecology and Biodiversity Research. Asian Journal of Geoinformatics, 12(1).
- Gurung D.R., Kulkarni A.V., Giriraj A., Aung K.S., Shrestha B. & Srinivasan J. 2011. Changes in seasonal snow cover in Hindu Kush-Himalayan region. Cryosphere Discussion, 5, 755–777.

Dr. Jonathan Hellin

Poverty and Value Chain Specialist, International Maize and Wheat Improvement Centre (CIMMYT), Distrito Federal, Mexico. Email: j.hellin@cgiar.org.

Dr. Jonathan Hellin has twenty-five years' agricultural research and rural development experience (farmers' access to markets, land management, and climate change adaptation and mitigation) including twelve years' field work in Latin America, East Africa, South Asia and the Caribbean. He has authored and co-authored two books and over 80 articles (including 50 in peer-reviewed journals), and lectured at universities in the United Kingdom, United States and Central America. His current research interests include index insurance and farmer' uptake of climate smart agricultural technologies, and agricultural development in the Western Highlands of Guatemala focusing on farmers' use of maize landraces and also soil conservation.

Dr. Hellin's program at CIMMYT contributes to the improved livelihoods and poverty reduction in maize and wheat-based farming systems through better targeting, assessments of methods and impacts, improvement of policies and capacity building. Responsibilities include carrying out research on (1) maize input and output chains in South Asia, East Africa and Mexico; (2) improved post-harvest maize storage in East Africa; (3) maize diversity and market access in Mexico and Guatemala; (4) smallholder farmers' adaptation to climate change. He has also developed and used training materials on sustainable livelihoods and innovation systems in China and Latin America. His current research focuses on the application of index insurance to enhance farmer uptake of climate smart agricultural technologies.

Recent publications include:

- Hellin, J., Krishna, V.V., Erenstein, O. and Boeber, C. In press. India's Poultry Revolution: Implications for its Sustenance and the Global Poultry Trade. International Food and Agribusiness Management Review Volume 18 Special Issue A.
- Beuchelt, T.D., Camacho Villa, C.T., Göhring, L., Hernández Rodríguez., V.M., Hellin, J., Sonder, K. and Erenstein, O. 2015. Social and income trade-offs of conservation agriculture practices on crop residue use in Mexico's central highlands. Agricultural Systems 134: 61– 75
- Hellin, J., Bellon, M.R. and Hearne, S. 2014. Maize Landraces and Adaptation to Climate Change in Mexico. Journal of Crop Improvement, 28:4, 484-501, DOI: 10.1080/15427528.2014.921800
- Hellin, J., Keleman, A., López, D., Donnet, L. and Flores, D. 2013. La importancia de los nichos de mercado: un estudio de caso del maíz azul y del maíz para pozole en México. La revista Fitotecnia Mexicana 36(6): 315-328
- Neufeldt, H., Jahn, M., Campbell, B., Beddington, J.R., DeClerck, F., De Pinto, A., Gulledge, J., Hellin, J., Herrero, M., Jarvis, J., LeZaks, D., Meinke, H., Rosenstock, T., Scholes, M., Scholes, R., Vermeulen, S., Wollenberg, E. and Zougmoré, R. 2013. Beyond climate-smart agriculture: toward safe operating spaces for global food systems. Agriculture & Food Security 2:12. doi:10.1186/2048-7010-2-12

Dr. Kindie Tesfaye Fantaye

Associate Scientist, International Maize and Wheat Improvement Centre (CIMMYT), Addis Ababa, Ethiopia. Email: k.tesfayefantaye@cgiar.org.

Dr. Fantaye has developed profound professional experience in research, teaching and academic management. His research and teaching focus is on crop modelling, soil-plant-water-atmosphere relations, plant physiology, agro-ecosystems, agricultural water management, climate change adaptation and farming systems modelling, and farming systems and environmental interactions. His expertise is in agro-meteorology, agronomy, farming systems, systems analysis and crop modelling, plant physiology and natural risk management. He has more than 10 years of experience in project development, implementation, management and working with several teams and managing interest of diverse groups.

Recent publications include:

- Tesfaye, K.; Gbegbelegbe, S.; Cairns, E.J.; Shiferaw, B.; Prasanna, B.M.; Sonder, K.; Boote, K.; Makumbi, D.; Robertson, R. 2015. Maize systems under climate change in sub-Saharan Africa: Potential impacts on production and food security. International Journal of Climate Change Strategies and Management 7 (3): 247-271.
- Tesfaye, K.; Jaleta, M., Jena, P.; Mutenje, M. 2015. Identifying potential recommendation domains for conservation agriculture in Ethiopia, Kenya, and Malawi. Environmental Management 55: 330–346.
- Merga, F.L., Worthmann, C.S., Tesfaye, K. 2015. Dry soil planting of maize for variable onset of rainfall in Ethiopia. Agronomy Journal 107 (4): 1618-1625.
- Hadgu G.; Tesfaye, K.; Mamo, G. 2014. Analysis of climate change in Northern Ethiopia: Implications for agricultural production. Theoretical and Applied Climatology: DOI 10.1007/s00704-014-1261-5
- Merga, F.; Tesfaye K.; Wortmann, C.S. 2014. Dry soil planting of sorghum for Vertisols of Ethiopia. Agronomy Journal 106 (2): 469-474.

Dr. Peter Läderach

Central America and Caribbean coordinator of the Decision Analysis and Policy (DAPA) Program, International Centre for Tropical Agriculture (CIAT), Managua, Nicaragua. Email: p.laderach@cgiar.org.

Dr. Läderach has experience with development and implementation of spatial analyses and supply chain tools and methodologies for coffee and cocoa supply chains. He has performed analyses on the impact of climate change on the agricultural sector in Central America and the Caribbean. The CIAT CIM joint funded position aims to bridge the gap between research and development. Peter Läderach holds an Msc in Geography and a PhD in Tropical Agriculture. Since 2005 he has lead a team at the International Centre for Tropical Agriculture (CIAT) that has developed and implemented spatial analyses and supply chain tools for coffee and cocoa that allow the spatial identification and prediction of product attributes; the control and management of product quality; the information flow along the supply chain; and the quantification of the impact of climate change. Dr. Läderach and his team are currently implementing several projects in Latin America and Africa that deploy these methodologies for a variety of crops.

Recent publications include:

- Laderach, P. Jarvis, Ramirez, J. and Fischer. 2008. Predictions of Land Use Changes under Progressive Climate Change in Coffee Growing Regions of the AdapCC Project: Veracruz. 1-65. 2008. CIAT. Final Report Veracruz, Mexico.
- Schepp, K.; Laderach, P. 2008. Adaptación para los pequeños productores de café al cambio climático. Presentación de los resultados intermediarios y experiencias del proyecto piloto AdapCC – una cooperación pública-privada entre Cafédirect y la GTZ. International Workshop SIAASE: Adaptation to Climate Change: The role of ecosystems services, 3-5 November 2008. CATIE, Turrialba, Costa Rica. 2p.
- Laderach, P.; Jarvis, A.; Ramírez, J. 2008. The impact of climate change in coffee-growing regions. Documento presentado en: Taller de Adaptación al Cambio Climático en las Comunidades Cafetaleras de la Sierra Madre de Chiapas, 17-18 de Noviembre del 2008, Tuxtla Gutiérrez, Chiapas. 4p.
- Läderach, P., T. Oberthür, S. Cook, S. Fujisaka, M. Estrada Iza, J.A. Pohland, and R. Rosales Lechuga. 2007. Systematic agronomic farm management for improved coffee quality. Precision Agriculture submitted.
- Estrada, M., P. Läderach, T. Oberthür, and P.H.A. Jürgen. 2006. Análisis de las interacciones y del impacto de condiciones ambientales, agronómicas, y el manejo innovador sobre la calidad de taza del café (Coffea arabica L.). X Congreso Internacional de Manejo Integrado de Plagas y Agroecología, Tapachula, Chiapas, México, ISBN 9709712225, Resúmenes, 6-7.

Dr. Miguel Robles

Research Fellow, Markets, Trade and Institutions Division International Food Policy Research Institute (IFPRI), Washington, D.C. Email: m.robles@cgiar.org.

Dr. Robles is a Research Fellow at the International Food Policy Research Institute (IFPRI) in the Markets, Trade and Institutions Divisions. At IFPRI he has conducted research on several topics including, most recently, a new approach to provide weather index-based insurance in Africa, Asia and Latin America; the behavior of international agricultural commodity markets; price transmission estimations from international markets to domestic food markets in Latin America and Asia; analysis of futures markets and the role of speculation; analysis on the welfare impact of changing food prices in Latin America and Asia; rural employment strategies in developing countries; and general equilibrium modeling of rural-urban linkages. Dr. Robles' work on weather insurance has been recognized internationally and was awarded at the Marketplace on Innovative Financial Solutions for Development. Prior to joining IFPRI he worked as a Research Associate at the Group for the Analysis of Development and participated in several research projects with UNDP, IADB, FAO, World Bank, and PAHO. He holds a PhD in Economics from the University of California Los Angeles UCLA where he specialized in Macroeconomics and Asset Pricing.

Recent publications include:

- Benson T., N. Minot, J. Pender, M. Robles, & J. von Braun. 2013. Information to guide policy responses to higher global food prices: The data and analyses required. Food Policy. 38: 47-58.
- Iannotti L, Robles M, Pachón H, Chiarella C. (2012). "Food prices and poverty negatively affect micronutrient intakes in Guatemala" in Journal of Nutrition. 2012 Aug;142(8):1568-76.
- Iannotti, Lora and Miguel Robles (2011). "Negative impact on calorie intakes associated with 2006-08 food prices crisis in Latin America" Food and Nutrition Bulletin, Food and Nutrition Bulletin, vol. 32, no.2 June 2011.
- Robles, Miguel & Meagan Keefe (2011). "The effects of changing food prices on welfare and poverty in Guatemala". Development in Practice, Volume 21, Numbers 4&5.
- Hernández, M., Robles M. and M. Torero (2011). "Beyond the numbers. How urban households in Central America responded to the recent global crises". IFPRI Issue Brief 67.

Dr. Elisabeth Simelton

Climate Change Scientist, World Agroforestry Centre (ICRAF), Hanoi, Vietnam. Email: E.Simelton@cgiar.org.

Dr. Simelton's role at ICRAF consists of assisting the country coordinator in fieldwork activities, data analyses, report writing, scientific publications, data synthesis, proposal development and workshops. Previously, Dr. Simelton interviewed ethnic minority farmers about their interest in soil conservation methods. This motivated her to return to work on an aquaculture project in Hoa Binh province. Revisiting the community after project implementation and meeting farmers who had been able to change their lives for the better was the greatest highlight of her work, continuing to motivate her as she contributes to the creation of trade-off models for new policies – such as payments for environmental services – that will make a difference to the lives of poor farmers throughout the country. As a geographer she sees how the landscape is connected and she how important it is to approach environmental management holistically. Agroforestry and ICRAF offers her the chance to work with this approach to find the most effective solutions for problems such as rural poverty and deforestation.

Recent publications include:

- Simelton, E., B.V. Dam. 2014. Farmers in NE Viet Nam rank values of ecosystems from seven land uses. Ecosystem Services 9, 133-138.
- Lasco, R.D., R.J.P. Delfino, D.C. Catacutan, E. Simelton, D.M. Wilson. 2014. Climate risk adaptation by smallholder farmers: the roles of trees and agroforestry. Current Opinion in Environmental Sustainability 6, 83-88.
- Zhang, T., E. Simelton, Y. Huang, Y. Shi. 2013. A Bayesian assessment of the current irrigation water supplies capacity under projected droughts for the 2030s in China. Agricultural and forest meteorology 178, 56-65.
- Simelton, E., C.H. Quinn, N. Batisani, A.J. Dougill, J.C. Dyer, E.D.G. Fraser. 2013. Is rainfall really changing? Farmers' perceptions, meteorological data, and policy implications. Climate and Development 5 (2), 123-138
- Simelton, E. R. Bunch. 2012. Restoring The Soil: A Guide For Using Green Manure/Cover Crops To Improve Food Security For Smallholder Farmers. Land Degradation & Development. Canadian Foodgrains Bank, Winnipeg, Canada. ISBN: 978-0-9688546-4-8. 2012.

Flagship 3

Dr. Eva "Lini" Wollenberg – see under Program Management Committee

Prof. Dr. Klaus Butterbach-Bahl

Principal Scientist, Livestock Systems and the Environment, International Livestock Research Institute (ILRI), Old Naivasha Rd., Uthiru, Nairobi 30709-00100, Kenya, Tel. +254-708158982 email: k.butterbach-bahl@cgiar.org

Dr. Klaus Butterbach-Bahl works as principal scientist in the Livestock Systems and Environment group of the International Livestock Research Institute (ILRI). He has a joined appointment with the Institute of Meteorology and Climate Research, Atmospheric Environmental Research (IMK-IFU), Karlsruhe Institute of Technology, where he is head of the Bio-Geo-Chemical Cycles Department. He earned a diploma in Geography and Biology, a PhD with research on methane emissions from paddy rice, and an habilitation in soil ecology. He has gained more than two decades of work experience researching biosphere-atmosphere exchange processes of climate-relevant trace gases as affected by environmental changes and anthropogenic management. He has been the principal investigator on a significant number of national and international research projects and has published approximately 200 research papers in peer-reviewed journals.

At ILRI Dr. Butterbach-Bahl works on the establishment of environmental footprints of agricultural production systems, using both modelling and field experiments. Key foci are quantifying greenhouse gas emissions associated with livestock production and developing and testing feasible mitigation strategies in the context of smallholder livestock production systems. Given his background, Dr. Butterbach-Bahl also focuses on inventorying agricultural greenhouse gas emissions, including emissions from upland croplands and rice paddies and national- and regional-scale emissions that use GIS-coupled biogeochemical and empirical modelling approaches.

Recent publications include:

- Medinets S, Skiba U, Rennenberg H, Butterbach-Bahl K. 2015. A review on soil NO transformation: Associated processes and possible physiological significance in organisms. *Soil Biol. Biochem.* 80, 92-117.
- De Vries W, Du E, Butterbach-Bahl K. 2014. Short and long-term impacts of nitrogen deposition on carbon sequestration by forest ecosystems. *Curr. Opin. Environm. Sustain.* 9-10:90-104.

- Wolf B, Zheng X, Brüggemann N, Chen W, Dannenmann M, Han X, Sutton MA, Wu H, Yao Z, Butterbach-
- Yao Z, Du Y, Tao Y, Zheng X, Liu C, Lin S, Butterbach-Bahl K. 2014. Water-saving ground cover rice production system reduces net greenhouse gas fluxes in an annual rice-based cropping system. *Biogeosciences.* 11:1-16.
- Zhou M, Butterbach-Bahl K. 2014. Assessment of nitrate leaching loss on a yield-scaled basis from maize and wheat cropping systems. *Plant Soil.* 374:997-999.

Dr. Alessandro (Alex) De Pinto

Senior Research Fellow, Environment and Production Technology Division, International Food Policy Research Institute. 2033 K Street, NW, Washington, DC 20006 USA, Tel.: +1.202.862.5636, A.DePinto@cgiar.org

Dr. Alex De Pinto is an environmental and natural resource economist with 20 years of experience working in economically depressed areas. His research focuses on land-use management and economic spatial analysis and uses a series of modeling techniques that make it possible to simulate location specific effects of policy changes and their consequent environmental effects. Dr. De Pinto is currently leading research projects on climate-smart agriculture and the nexus land use change and GHG emissions in Latin America, South and Southeast Asia.

Recent publications include:

- Li M, De Pinto A, Ulimwengo J, You L, Robertson R. 2015. Modeling Land-use Allocation with Mixed-level Data: An Econometric Analysis for the Democratic Republic of the Congo. *Environment and Resource Economics.* 60:433–469.
- Neufeldt H, Jahn M, Campbell BM, Beddington JR, DeClerck F, De Pinto A, Gulledge J, Hellin J, Herrero M, Jarvis A, LeZaks D, Meinke H, Rosenstock T, Scholes M, Scholes R, Vermeulen S, Wollenberg E, Zougmoré R 2013. Beyond climate-smart agriculture: toward safe operating spaces for global food systems. *Agriculture & Food Security.* 2:12.
- De Pinto A, Robertson R. 2013. Adoption of Climate Change Mitigation Practices by Risk-averse Farmers in the Ashanti Region, Ghana. *Ecological Economics.* Vol 86.
- Bryan E, De Pinto A, Ringler C, Asuming-Brempong S, Bendaoud M, Artur, Givá N, Anh DT, Mai NN, Asenso-Okyere K, Sarpong DB, El-Harizi K, van Rheenen T, Ferguson J. 2012. Institutions for agricultural mitigation: potential and challenges in four countries. CAPRi Working Paper 107.
- De Pinto A, Demirag U, Haruna A, Koo J, Asamoah M. 2012. Climate Change, Agriculture, and Food-crop Production in Ghana. IFPRI Policy Note No. 3. Washington, DC, USA: International Food Policy Research Institute (IFPRI).

Dr. Henry Neufeldt

Head of the Climate Change Unit at the World Agroforestry Centre (ICRAF). PO Box 30677, Nairobi, Kenya. Tel. +254.20.722.4238. Email: h.neufeldt@cgiar.org

Dr. Henry Neufeldt is head of the Climate Change Unit at the World Agroforestry Centre (ICRAF) in Nairobi, Kenya, a position he has held since 2009. He holds degrees in environmental sciences and soil science from Bayreuth University (Germany). After his PhD on indicators of sustainable soil management in the Cerrado region of Brazil, he first worked as a consultant on questions related to soil and water salinization in the Chaco region of Paraguay and then at the Institute for Energy and Environment in Leipzig, Germany on modeling policy interventions on greenhouse gas emissions and farm economics at regional scales. He also worked as a research coordinator at the Tyndall Centre for Climate Change Research at the University of East Anglia in

Norwich, where he directed the European Commission's flagship project called Adaptation and Mitigation Strategies: Supporting European Climate Policy (ADAM).

Dr. Neufeldt now focuses on climate impacts, adaptation, mitigation, food security, land cover change and sustainable development in the context of agroforestry systems and climate policies. He has published extensively on questions related to the policies, economics and scalability of climate-smart agriculture; climate finance in the context of smallholder development; greenhouse gas fluxes and mitigation; bioenergy; quantitative benefits of improved natural resource management to adapt to climate shocks; and monitoring and evaluation of complex agro-ecosystems. He is the ICRAF focal point for the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and advisor on agriculture, forestry, and other land use (AFOLU) climate bonds to the Climate Bond Initiative.

Over the past ten years, Dr. Neufeldt has published more than 90 articles, book chapters or books, with over 40 of these in peer-reviewed articles published in international journals.

Recent publications include:

- Neufeldt H, Kissinger G, Alcamo J. 2015. No-till agriculture and climate change mitigation. *Nature Climate Change* 5 488-489.
- Neufeldt H, Pacheco P, Ojha HR, Ayeri Ogalleh S, Donovan J, Fuchs L, Kleinschmit D, Kristjanson P, Kowero G, Oeba VO, Powell B. 2015. Public Sector, Private Sector and Socio-Cultural Response Options. In: B Vira, C Wildburger, S Mansourian (eds.), *Forests, Trees and Landscapes for Food Security and Nutrition. A Global Assessment Report.* IUFRO World Series Volume 33. Vienna. p.129-153.
- Lipper L, Thornton P, Campbell BM, Baedeker T, Braimoh A, Bwalya M, Caron P, Cattaneo A, Garrity D, Henry K, Hottle R, Jackson L, Jarvis A, Kossam F, Mann W, McCarthy N, Meybeck A, Neufeldt H, Remington T, Thi Sen P, Sessa R, Shula R, Tibu A, Torquebiau EF, 2014. Climate-smart agriculture for food security. *Nature Climate Change.* 4, 1068-1072.
- Neufeldt H, Adhya TK, Coulibaly JY, Kissinger G, Pan G. 2013. Bridging the gap I: Policies for reducing emissions from agriculture. In: UNEP 2013 (ed), *The Emissions Gap Report 2013.* United Nations Environment Program, Nairobi.
- Neufeldt H, Jahn M, Campbell BM, Beddington JR, DeClerck F, De Pinto A, Gulledge J, Hellin J, Herrero M, Jarvis A, LeZaks D, Meinke H, Rosenstock T, Scholes M, Scholes R, Vermeulen S, Wollenberg E, Zougmoré R. 2013. Beyond climate-smart agriculture – toward safe operating spaces for global food systems. *Agriculture and Food Security* 2:12.

Dr. Pablo Pacheco

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Dr. Pablo Pacheco is a principal scientist for the Forests and Governance Portfolio in the Centre for International Forestry Research (CIFOR). Over the past 5 years, he has been the coordinator of CIFOR research on trade and investment, and the Flagship leader on the CGIAR Research Program for Forests, Trees and Agroforestry (FTA) based in Bogor, Indonesia. Dr. Pacheco holds a B.A. in Rural Sociology, a Msc in Agricultural Economics, and a PhD in Geography from Clark University, MA, USA. Dr. Pacheco has over 20 years of experience on scientific research to support the goals of natural resources management, alleviating poverty and promoting rural development, with particular attention on tropical developing countries. His main research areas include the implications of trade and investment for forests and people, landscapes and agrarian change, forests and landscape governance, and institutions for natural resources management. Before

working with CIFOR, he worked at the Inter-American Institute for Cooperation on Agriculture (IICA) and conducted consultancy work for FAO and the World Bank. He also supported NGOs in Bolivia and Brazil to conduct research on agricultural development and natural resources development, land and forest governance, and agricultural and forest policy.

Dr. Pacheco leads a research agenda on global governance, trade and investment for CIFOR and contributes to FTA and CCAFS with research on governance arrangements involving public and private sectors for supporting sustainable commodities supply, including timber, oil palm and beef, under broader territorial perspectives. He also supervises staff and masters and PhD students, develops proposals and does fundraising. His main areas of research include: impacts of trade and investment on forests and people, forest policies for sustainable timber supply, public and private institutional arrangements for sustainable commodity supply, dynamics and implications of biofuel development, emerging policy perspectives and initiatives for the transition to a green economy.

Over the past ten years Dr. Pacheco has published over 100 articles, book chapters, books and institutional papers, with over 30 of these in peer-reviewed articles published in international journals.

Recent publications include:

- Pacheco, P. and R. Poccard-Chapuis. 2015. Cattle ranching development in the Brazilian Amazon: Looking at long-term trends to explore the transition towards sustainable beef cattle production. In J. Emel and N. Harvey (eds). The political ecologies of meat, London and New York, Routledge, Earthscan. pp. 42-66.
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Dr. Idupulapati Rao

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Dr. Idupulapati Rao is a plant nutritionist and physiologist with the tropical forages and bean programs in the agrobiodiversity research area of the International Centre for Tropical Agriculture (CIAT), based in Cali, Colombia. Dr. Rao holds a PhD from the Department of Botany from Sri Venkateswara University in India. Dr. Rao worked for about 10 years at the University of Illinois and the University of California (Berkeley) before joining CIAT in 1989. Dr. Rao has been working at CIAT for the past 25 years and has contributed to the development of abiotic stress (soils and climate)-adapted tropical forages and common bean germplasm options for sustainable intensification of crop-livestock systems in the tropics. Dr. Rao won the outstanding principal staff award from CIAT in 2000 and outstanding research publication awards in 1999, 2003 and 2009. He was also part of the CIAT team that won the excellence in science award from the CGIAR for outstanding partnership in 2001.

Dr. Rao leads the LivestockPlus project of CCAFS at CIAT. He is supervising research support staff and contributing to capacity building through undergraduate, graduate and postdoctoral students. He also participates actively in proposal development for resource mobilization. His collaborative research work with a range of partners aims at improving crop and forage adaptation to major edaphic (low soil fertility, aluminum toxicity) and climatic (drought, waterlogging, heat) stresses and integrating multiple stress-adapted crop and forage cultivars for sustainable intensification of crop-livestock systems.

His work contributes to the following research areas: (i) defining adaptive attributes of tropical forages (grasses and legumes) and common bean to edaphic and climatic constraints; (ii) developing phenotyping protocols to identify multiple abiotic stress resistant *Brachiaria* hybrids and common bean genotypes; (iii) improving nitrogen use efficiency of crop-livestock systems through biological nitrification inhibition; and (iv) developing low emission strategies for cattle sector through sustainable intensification of tropical forage based systems.

Over the past ten years, Dr. Rao has published over 75 journal articles, 30 book chapters and 30 articles in conference proceedings.

Recent publications include:

- Rao IM, Peters M, Castro A, Schultze-Kraft R, White D, et al. 2015. LivestockPlus – The sustainable intensification of forage-based systems to improve livelihoods and ecosystem services in the tropics. *Tropical Grasslands–Forrajes Tropicales*. 3:59-82.
- Rao IM. 2014. Advances in improving adaptation of common bean and Brachiaria forage grasses to abiotic stresses in the tropics. In: M. Pessarakli (ed). *Handbook of Plant and Crop Physiology, Third Edition.* pp. 847-889. USA: CRC Press, Taylor and Francis Group.
- Subbarao GV, Rao IM, Nakahara K, Sahrawat KL, Hash CT, Ando Y, Kawashima T. 2013. Potential for biological nitrification inhibition (BNI) to reduce nitrification and N2O emissions from pasture-crop-livestock systems. *Animal.* 7s2:322-332.
- Peters M, Rao I,Fisher M, Subbarao G, Martens S, Herrero M, van der Hoek R, Schultze-Kraft R, Miles J, Castro A, Graefe S, Tiemann T, Ayarza M, Hyman G. 2013. Tropical forage-based systems to mitigate greenhouse gas emissions. In: C. H. Hershey and P. Neate (Eds.) *Eco-Efficiency: From Vision to Reality*. Cali, Colombia:CIAT. 171-190.
- McClean P, Burridge J, Beebe S, Rao I, Porch T. 2011. Crop improvement in the era of climate change: An integrated multi-disciplinary approach for common bean (Phaseolus vulgaris L.). *Functional Plant Biology.* 38:927-933.

Dr. Mariana C. Rufino

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Dr. Mariana Rufino is a senior scientist in the forest and environment portfolio of the Centre for International Forestry Research (CIFOR) and focal point for the CGIAR Research Program for Climate Change, Agriculture and Food Security (CCAFS). Dr. Rufino holds a PhD in Production Ecology and Resource Conservation and a MSc in Plant Sciences from Wageningen University. She has technical expertise in the areas of farming systems, food security, and the environmental impacts of agriculture and land use change. Dr. Rufino has implemented research projects in several low-income countries, mainly in Sub-Saharan Africa, South Asia and Southeast Asia. This includes identifying gaps in knowledge, designing research programs, interacting with donors, securing funding, and providing strategic leadership.

Dr. Rufino has worked on the ground in several countries in Africa, collaborating with government officers, national research organisations and universities. She has experience developing models to evaluate the impact of management on land productivity at field, farm, landscape and global levels. At CIFOR, she guides a team that assesses technical opportunities to reduce deforestation and the impact of agriculture on the environment by implementing climate-smart agriculture.

Over the past ten years Dr. Rufino has published over 50 articles and book chapters, with over 40 of these in peer-reviewed articles published in international journals.

Recent publications include:

- Douxchamps S, Van Wijk MT, Silvestri S, Moussa AS, Quiros C, Ndour NYB, Buah S, Somé L, Herrero M, Kristjanson P, Ouedraogo M, Thornton PK, Van Asten P, Zougmoré R, Rufino MC. 2015 Linking agricultural adaptation strategies and food security: evidence from West Africa. *Regional Environmental Change. In press.*
- Havlík P, Valin H, Herrero M, Obersteiner M, Schmid E, Rufino MC, Mosnier A, Böttcher H, Frank S, Fritz S, Fusse S, Kraxner F, Notenbaert AM, Thornton P. 2014 Climate change mitigation through livestock system transitions. *Proceedings of the National Academy of Sciences.* 111:3709-3714.
- Rufino MC, Atzberger C, Baldi G, Butterbach-Bahl K, Rosenstock TS, Stern D. 2014. Targeting landscapes to identify mitigation options in smallholder agriculture In Rosenstock et al. (eds) *Guidelines for Assessing Low-Emissions Options for Smallholder Agriculture*. http://samples.ccafs.cgiar.org/measurement-methods-overview/
- Rufino MC, Brandt P, Herrero M, Butterbach-Bahl K. 2014 Reducing uncertainty in Nitrogen budgets for African livestock Systems. *Environmental Research Letters.* 9:105008.
- Bouwman AF, Klein Goldewijk K, Van der Hoek KW, Beusen AHW, Van Vuuren DP, Willems J, Rufino MC, Stehfest E. 2013 Exploring global changes in nitrogen and phosphorus cycles in agriculture induced by livestock production for the period 1900-2050. *Proceedings of the National Academy of Sciences.* 110:20882–20887.

Dr. Clare Stirling

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Dr. Clare Stirling is the project leader for Climate Change Research in the International Maize and Wheat Improvement Centre (CIMMYT) and, for the past 3 years, CIMMYT contact point for the CGIAR Research Program for Climate Change, Agriculture and Food Security (CCAFS). Dr. Stirling holds a PhD and Hons Bachelor of Science from the Department of Agriculture at Sutton Bonington, University of Nottingham, United Kingdom (UK). She has over 20 years of experience working in the area of agricultural crop and native species responses to climate change, both as a researcher and research manager. She has held positions as a senior research manager in natural resource management and climate change for the UK Agriculture and Horticulture Development Board, where she sat on a number of high-level committees including the UK agriculture industry's Greenhouse Gas Action Plan. Previously, Dr. Stirling worked for several years in Photosynthesis Productivity at Essex University and whilst a lecturer there ran a MSc course called Crops in a Changing Environment. She also held research positions in crop physiology at ICRISAT in Patancheru, India; in ecophysiology with the climate change group at the UK's Natural Environment Research Council's Centre of Ecology and Hydrology, and was principle investigator on several long-term research projects funded by the UK

Department for International Development (DFID) Plant Sciences Research Program on smallholder intercropping systems in Asia whilst at the University of Bangor.

Dr. Stirling has published over 50 articles, book chapters or books, including over 30 in peer-reviewed articles published in international journals.

Recent publications include:

- Powlson DS, Stirling CM, Jat ML, Gerard BG, Palm CA, Sanchez PA, Cassman KG. 2015. Reply to 'No-till agriculture and climate change mitigation'. *Nature Climate Change.* 5(6):489.
- Bellarby J, Stirling C, Vetter SH, Kassie M, Kanampiu F, Sonder K, Smith P, Hillier J. 2014. Identifying secure and low carbon food production practices: A case study in Kenya and Ethiopia. *Agriculture, Ecosystems and the Environment.* 197:137-146.
- Powlson DS, Stirling CM, Jat ML, Gerard BG, Palm CA, Sanchez PA, Cassman KG. 2014. No-till agriculture and climate change mitigation. *Nature Climate Change.* 4(8):678-683.
- Stirling C, Hellin J, Cairns J, Silverblatt-Buser E, Tefera T, Ngugi H, Gbegbelegbe S, Tesfaye K, Chung U, Sonder K, Cox R, Verhulst N, Govaerts B, Alderman P, Reynolds M. 2014. Shaping sustainable intensive production systems: improved crops and cropping systems in the developing world. In: *Climate change impact and adaptation in agricultural systems.* Jurg Fuhrer and PJ Gregory (eds). CABI Climate Change Series.

Dr. Reiner Wassmann

Senior Scientist and Climate Change Specialist; International Rice Research Institute (IRRI); Los Baños, Philippines; Tel. +63-2-580-5600 ext. 2737; E-mail: RWassmann@cgiar.org

Dr. Reiner Wassmann is the Coordinator of Climate Change Research at the International Rice Research Institute (IRRI). He is also affiliated with the Karlsruhe Institute of Technology (Germany), where he holds a permanent position as Senior Scientist with several delegations to work at IRRI. He holds a PhD in Biology from Goettingen University (Germany). Dr. Wassmann has been working on climate change research since 1987 and has focused on rice production systems since 1991. He has been involved in CCAFS since its inception through research activities and serving as the CCAFS focal point for IRRI. While his initial research addressed GHG emissions and mitigation, his current portfolio covers a wide range of aspects related to rice systems, including both mitigation and adaptation. Geographically his current research is concentrated on Southeast Asia.

Dr. Wassman was a lead author of the revised IPCC Guidelines, National Greenhouse Gas Inventories Guidelines: Agriculture, Forestry, and Other Land Use, published in 2007.

Recent publications include:

- Sander BO, Wassmann R. 2014. Common Practices for Manual Greenhouse Gas Sampling in Rice Production: A Literature Study on Sampling Modalities of the Closed Chamber Method. *Greenhouse Gas Measurement and Management.* 4:1-13.
- Zhang T, Zhu J, Wassmann R. 2010. Responses of rice yields to recent climate change in China: An empirical assessment based on long-term observations at different spatial scales (1981–2005). *Agricultural and Forest Meteorology.* 150:1128–1137.
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- Wassmann R, Jagadish SVK, Sumfleth K, Pathak H, Howell G, Ismail A, Serraj R, Redoña E, Singh RK, Heuer S. 2009. Regional vulnerability of climate change impacts on Asian rice production and scope for adaptation. *Advances in Agronomy.* 102:91-133.
- Gadde B, Menke C, Wassmann R. 2009. Rice straw as a renewable energy source in India, Thailand, and the Philippines: Overall potential and limitations for energy contribution and greenhouse gas mitigation. *Biomass and Bioenergy.* 33:1532–1546.

Flagship 4

Dr. Philip K Thornton – See "Other members of core team"

Dr. Mark Rosegrant

Mark W. Rosegrant is the Director of the Environment and Production Technology Division at the International Food Policy Research Institute (IFPRI) in Washington, DC. With a Ph.D. in Public Policy from the University of Michigan, he has extensive experience in research and policy analysis in agriculture and economic development, with an emphasis on climate change, water resources and other natural resource and agricultural policy issues as they impact food security, rural livelihoods, and environmental sustainability. He currently directs research on climate change, water resources, sustainable land management, genetic resources and biotechnology, and agriculture and energy. Rosegrant developed IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), and led the further development of IMPACT to include water supply and demand and climate change through linked crop models. IMPACT has been used widely for projections and scenarios for global and regional food demand, supply, trade and prices under climate change. He is the author or editor of 12 books and over 100 refereed papers in agricultural economics, water resources, and food policy analysis. Dr. Rosegrant has won numerous awards, such as Outstanding Journal Article (2008), Quality of Communications Award (2004), and Distinguished Policy Contribution Award(2002) awarded by the Agricultural and Applied Economics Association (formerly American Agricultural Economics Association); and Best Article Award (2005) from the International Water Resources Association. Dr. Rosegrant is a Fellow of the American Association for the Advancement of Science; and a Fellow of the Agricultural and Applied Economics Association.

Recent publications include:

- Rosegrant, M.W. and S. Msangi. 2015. Consensus and Contention in the Food-Versus-Fuel Debate. Annual Review of Environmental Resources 39:271–94.
- Rosegrant, M.W., R.E. Evenson, S. Msangi and T.B. Sulser. 2014. Agricultural Productivity and Child Mortality: The Impact of the Green Revolution. World Food Policy 1(1)1-24.
- Rosegrant, Mark W.; Ringler, Claudia; Zhu, Tingju; Tokgoz, Simla; Bhandary, Prapti. Water and food in the bioeconomy. 2013. Challenges and opportunities for development. Agricultural Economics 44 (2013) supplement 139–150.
- Robertson, R., G. Nelson, T. Thomas and M.W. Rosegrant. 2013. Incorporating process based crop simulation models into global economic analyses. American Journal of Agricultural Economics 95(2)228-235.
- Rosegrant, M.W., S. Tokgoz, P. Bhandary. 2013. The New Normal? A tighter global agricultural supply and demand relation and its implications for food security. American Journal of Agricultural Economics 95(2)303-309.

Dr. Polly Ericksen

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Dr. Polly Ericksen leads the research Program on Livestock Systems and Environment (LSE) at the International Livestock Research Institute (ILRI) in Kenya. Dr. Ericksen holds a PhD in Soil Science and an MSc in Economics from the University of Wisconsin-Madison, and a BS in History from Swarthmore College. Dr. Ericksen has over 18 years of experience working on agricultural development, natural resource management and global environmental change in developing countries. This includes experience working for an NGO, a research fellowship at Columbia University's International Research Institute for Climate and Society (IRI), and five years at the University of Oxford working with the Global Environmental Change and Food Systems (GECAFS) initiative of the Earth Systems Science Partnership. Since 2013 Dr. Ericksen has been the ILRI contact point for CCAFS, coordinating ILRI's research contributions to the CCAFS portfolio.

The LSE Program at ILRI is home to 20 scientists and more than 30 research technicians and administrative staff, with an annual budget over USD 10 million. LSE's research is organized into four themes:

- Adaptation and resilience
- Understanding and managing the Environmental Footprint of Livestock
- Ecosystem Services and Natural Resource Management
- Systems Analysis for Sustainable Intensification

Recent publications include:

- Robinson LW, Ericksen PJ, Chesterman S, Worden J. 2015. Sustainable intensification in drylands: what resilience and vulnerability can tell us. Agricultural Systems. 135:133-140.
- Ericksen P, de Leeuw J, Thornton P, Said M, Notenbaert A, Herrero M. 2013. Climate change in sub-Saharan Africa: what consequences for pastoralists? In I. Scoones, A. Catley and J. Linds (eds), Pastoralism and development in Africa: Dynamic Change at the Margins. London: Earthscan/Routledge.
- Thornton PK, Jones PG, Ericksen PJ, Challinor AJ. 2011. Agriculture and food systems in sub-Saharan Africa in a four-plus degree world. Philosophical Transactions of the Royal Society A. 369:117-136.
- Ingram JSI, Ericksen PJ, Liverman DM, eds. 2010. Food Security and Global Environmental Change. London: Earthscan.
- Ericksen PJ. 2008. What is the vulnerability of a food system to global environmental change? Ecology and Society. 13(2):14. [online] URL: http://www.ecologyandsociety.org/vol13/iss2/art14/

Dr. Mario Herrero

Mario Herrero is Chief Research Scientist of CSIRO's Agriculture Flagship and CSIRO's Office of the Chief Executive Science Leader in the area of Food Systems and Global Change. He has more than 20 years experience working on strategic agricultural R4D projects in Africa, Latin America, Asia and Europe. Before coming to Australia in February 2013, he spent 13 years in Kenya at the International Livestock Research Institute, where he led the Sustainable Livestock Futures and Climate Change Programs at the International Livestock Research Institute. A known team player and a long term CCAFS collaborator, with an extensive network of partners and donors, he works in the areas of agriculture, food security and global change, targeting agricultural investments in the developing world, sustainable development pathways for smallholder systems, ex-ante impact assessment, climate change (impacts, adaptation and mitigation), development of scenarios of livelihoods and nutrition futures, multi-scale integrated assessment, and others. He has experience

working at different scales, from the animal and farm level to the country, regional and global levels. He has coordinated several global and regional integrated assessments initiatives such as the African Livestock Futures Report for the Office of the UN Special Representative on Food Security, and the CGIAR global assessment of food production systems, ecosystems services and human well-being to 2030. He has also contributed tonumerous international assessments such as the IPCC 4th and 5th Assessment Reports, 2010 World Development Report, the 2007/2008 Human Development Report and the 2007 Comprehensive Assessment of Water Management in Agriculture. He regularly participates in international committees such as IPCC's Working Group 3 (Mitigation) and the IPCC Task Force on Greenhouse Gas Emissions, and has served in several donor and science advisory committees on agriculture, livestock and the environment. He has published more than 300 fully refereed papers, book chapters and reports in his areas of expertise. He is currently on the editorial boards of Agricultural Systems (Elsevier), Global Food Security (Elsevier), Agriculture and Food Security (BioMed Central) and Tropical Grasslands, and has been a guest editor for the Proceedings of the National Academy of Sciences journal (PNAS). He has also supervised over 60 academic theses on different aspects of tropical agricultural production systems, and has recently become an Honorary Professor of Agriculture and Food Innovation at the University of Queensland, Australia. Dr Herrero obtained his PhD from the University of Edinburgh in Scotland.

Recent publications include:

- Thornton, PK and Herrero, M. 2015. Adapting to climate change in the mixed crop-livestock farming systems in sub-Saharan Africa. Nature Climate Change (in press)
- Herrero, M., Thornton, P.K., Bernués, A., Baltenweck, I., Vervoort, J., van de Steeg, J., Makokha, S., van Wijk, M.T., Karanja, S., Rufino, M.C., Staal, S.J. 2014. Exploring future changes in smallholder farming systems by linking socio-economic scenarios with regional and household models. *Global Environmental Change* 24, 165-182.
- Herrero, M., Havlík, P., Valin, H., Notenbaert, A., Rufino, M.C., Thornton, P.K., Blümmel, M., Weiss, F., Grace, D., Obersteiner, M. 2013. Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. PNAS 110 (52), 20888-20893. (+ dataset developed, updated and maintained)
- Herrero, M., Thornton, P.K. 2013. Livestock and global change: Emerging issues for sustainable food systems. PNAS 110 (52), 20878-20881.
- Thornton P K and Herrero, M 2010. The potential for reduced methane and carbon dioxide emissions from livestock and pasture management in the tropics. *PNAS* 107, 19667-19672.

Dr. Michael Halewood

Michael Halewood is the Leader of the 'Genetic Resources Policies, Institutions and Monitoring' group at Bioversity International. He has more than 20 years' experience working in the field of genetic resources policy research with a focus on agricultural systems and innovation. His research currently addresses how policies and institutions effect the availability and use of crop diversity to adapt to climate change; options for national level implementation of international agreements on access and benefit sharing and climate change in ways that support the use of biological diversity for climate change adaptation; the impacts of current trends in public investment in and regulation of seed systems on the use of biological diversity and options for policy reform; and how social networks influence the diffusion and uptake of climate smart technology. Since joining Bioversity International in 2001, Michael has managed a number of large policy development and implementation projects in countries across Africa, Asia and South America. These projects work to achieve policy outcomes through i) establishing and establishing partnerships through multistakeholder policy actor

teams linked to national policy development processes, ii) active participation in international policy-making fora including CBD, ITPGRFA, CGRFA. Michael is a co-editor of the 'Issues in Agrobiodiversity' book series published by Routledge (with 8 titles to date). From 2004-2011, he coordinated representation of the CGIAR at the Conferences of the Parties to the Convention on Biological Diversity, and Nagoya Protocol, the Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture and the FAO Commission on Genetic Resources for Food and Agriculture. He has been an invited expert on a number of international panels and initiatives including, most recently, the Expert Review Committee of the International Access to Seed Initiative, the Informal Advisory Committee on Capacity-building for the Implementation of the Nagoya Protocol, and the Open-ended, Ad Hoc Technical Advisory Committee on the Multilateral System of Access and Benefit-sharing.

Recent publications include:

- Galuzzi, G., Halewood, M., Lopez., I., Vernooy, R. 2015. Twenty five years of international exchanges of plant genetic resources facilitated by the CGIAR genebanks: a case study on international interdependence. Submitted to Open ended As Hoc Working Group to Enhance the Functioning of the Multilateral System, June 2015
- Bedmar Villanueva, A., Halewood, M., López Noriega, I. 2015. Agricultural Biodiversity in climate change adaptation planning: an analysis of the National Adaptation Programs of Action. CCAFS Working Paper no. 95.
- Halewood, M. (2014) International Efforts to Pool and Conserve Crop Genetic Resources in Times of Radical Legal Change. In: Cimoli, M., Dosi, G., Maskus, K.E., Okediji, R.L. Reichman, J.L. and Stiglitz J.E. (eds) Intellectual Property Rights: Legal and Economic Challenges for Development. Oxford University Press, Oxford.
- Halewood, M. 2013. What kind of goods are plant genetic resources for food and agriculture? Towards the identification and development of a new global commons. International Journal of the Commons. Volume 7(2) pp. 278-312.
- Halewood, M.; Andrieux, E.; Crisson, L.; Gapusi, J.R.; Wasswa Mulumba, J.; Koffi, E.K.; Yangzome Dorji, T.; Bhatta, M.R.; Balma, D. 2013. Implementing 'Mutually Supportive' Access and Benefit Sharing Mechanisms Under the Plant Treaty, Convention on Biological Diversity, and Nagoya Protocol. Law, Environment and Development Journal 9/1

Dr. Leslie Lipper

Leslie Lipper is a Senior Environmental Economist in the Agriculture and Development Economics Division at FAO, where she also leads the Economics and Policy Innovations for Climate smart agriculture (EPIC) Program. Leslie has been at FAO for 15 years, leading applied research and policy analysis programs related to natural resource management and poverty reduction. She is a contributing author to the food security and food production systems chapter of the IPCC fifth assessment report, and the lead author of a perspectives piece on "Climate Smart Agriculture for Food Security" published in Nature Climate Change, as well as two recent FAO reports related to climate change and food security: Climate Smart Agriculture: policies, practices and financing for food security, adaptation and mitigation (2010) and Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies (2009).

Ph.D. Agricultural and Resource Economics, May 1999, University of California, Berkeley

M.S. International Agricultural Development, May 1984, University of California, Davis

B.A. International Relations, May 1980, University of California, Davis

Recent publications include:

- Arslan, A., N. McCarthy, L. Lipper, S. Asfaw, A. Cattaneo, and M. Kokwe. 2015. Climate Smart Agriculture? Assessing the Adaptation Implications in Zambia. *Journal of Agriculture Economics*. Available online March 5, 2015.
- Arslan, A., N. McCarthy, L.Lipper, S. Asfaw, and A. Cattaneo. 2014. Adoption and Intensity of Adoption of Conservation Farming Practices in Zambia. *Agriculture, Ecosystems & Environment*, 187: 72-86.
- Lipper, L., P. Thornton, B.M. Campbell, T. Baedeker, A. Braimoh, M. Bwalya, P. Caron, A. Cattaneo, D. Garrity, K. Henry, R. Hottle, L. Jackson, A. Jarvis, F. Kossam, W. Mann, N. McCarthy, A. Meybeck, H. Neufeldt, T. Remington, Pham Thi Sen, R. Sessa, R. Shula, A. Tibu, and E.F. Torquebiau. 2014. Climate-Smart Agriculture for Food Security. *Nature Climate Change*, 4: 1068-1972.
- Porter, J.R., L. Xie, A., A. Challinor K. Cochrane, M. Howden, M. Mohsin Iqbal, D. Lobell, M.I. Travasso, N. Chhetri, K. Garrett, J. Ingram, L.Lipper, N. McCarthy, J. McGrath, D. Smith, P. Thornton, J. Watson, and L. Ziska. 2014. "Food Security and Production Systems". *In*: IPCC Working Group II Fifth Assessment Report, Chapter 7.
- Thornton, Philip and Lipper, Leslie, How Does Climate Change Alter Agricultural Strategies to Support Food Security? (April 11, 2014). IFPRI Discussion Paper 01340. Available at SSRN: http://ssrn.com/abstract=2423763 or http://dx.doi.org/10.2139/ssrn.2423763

Dr. Petr Havlik

Dr. Petr Havlík is senior research scholar at the International Institute for Applied Systems Analysis (IIASA) in Austria. He holds a PhD in Business and Economics from the University of Montpellier 1 (France), and the Mendel University of Agriculture and Forestry in Brno (Czech Republic). At IIASA, Petr works in the Ecosystems Services and Management Program. He is the major developer of the global agricultural and forest sector economic model GLOBIOM, and currently leads a group of about 20 economists and natural scientists which continue the development and implementation of the model. GLOBIOM is extensively used for designing solutions to satisfy the future needs of humanity in terms of food, fibre and fuel, climate change mitigation, and ecosystems services in general, within the limited resources of land and water under climate change. Building on the strong IIASA tradition in scenario development and analysis, Petr is one of the main contributors to the land component of the new IPCC scenarios, and participates in global agriculture related foresight activities within European Commission funded research projects such as ANIMALCHANGE, FOODSECURE, TRANSMANGO, SUSFANS, and with international agencies such as OECD. He also contributes to regional foresight activities in collaboration with CCAFS. Petr held over three years a joint position between IIASA and the International Livestock Research Institute (ILRI) where he contributed to development of a new livestock production systems database setting the new standard in the livestock sector assessment. Besides the above mentioned specific contracts and collaborations, Petr is Co-Principle investigator in several other large-scale international research projects, and service contracts with the European Commission, FAO, CSIRO, country agencies and the World Bank.

Recent publications include:

- Havlík, P., D. Leclère, H. Valin, M. Herrero, E. Schmid, J-F Soussana, C. Müller and M. Obersteiner. (2015). Global climate change, food supply and livestock production systems: A bioeconomic analysis, In: Climate change and food systems: global assessments and implications for food security and trade, Aziz Elbehri (editor). Food Agriculture Organization of the United Nations (FAO), Rome, 2015.
- Havlík, P., Valin, H., Herrero, M., Obersteiner, M., Schmid, E., Rufino, M.C., Mosnier, A., Thornton, P.K., Böttcher, H., Conant, R.T. Frank, S., Fritz, S., Fuss, S., Kraxner, F., Notenbaert, A. (2014). Climate change

mitigation through livestock system transitions. Proceedings of the National Academy of Sciences U.S.A. 111: 3709-3714.
- Cohn, A.S., Mosnier, A., Havlík, P.,Valin, H., Herrero, M., Schmid, E., O'Hare, M. and Obersteiner, M. (2014). Cattle ranching intensification in Brazil can reduce global greenhouse gas emissions by sparing land from deforestation. Proceedings of the National Academy of Sciences U.S.A. 111: 7236-7241.
- Nelson, G.C., Valin, H., Sands, R.D., Havlík, P., Ahammad, H., Deryng, D., Elliott, J., Fujimori, S., et al. (2014). Climate change effects on agriculture: Economic responses to biophysical shocks. Proceedings of the National Academy of Sciences U.S.A. 111(9): 3274-3279.
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Dr. Lars Otto Naess

Lars Otto Naess is a social scientist with the Institute of Development Studies (IDS). He has 20 years' professional experience on climate change, development and agriculture working in Tanzania, Kenya, Ethiopia, Malawi, Indonesia, Namibia, Zimbabwe, Brazil, Pakistan, India, and Nepal. Current research interests include social and institutional dimensions of adaptation to climate change, the political economy of policy processes on climate change and agriculture at national and sub-national levels, the role of local knowledge for adaptation to climate change, and adaptation planning in the context of international development. Previous affiliations include Centre for International Climate and Environmental Research-Oslo (CICERO), the UN Food and Agriculture Organization, and the Tyndall Centre for Climate Change Research, University of East Anglia. He holds a PhD in Environmental Sciences from the Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, UK.

Recent publications include:

- Naess, L.O., Newell, P., Newsham, A., Phillips, J., Pueyo, A., Quan, J. and T. Tanner. Climate policy meets national development contexts: Insights from Kenya and Mozambique. Global Environmental Change, In Review.
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- Naess, L.O., Polack, E. and B. Chinsinga, 2011. Bridging research and policy processes for climate change adaptation. IDS Bulletin 42(3): 97-103.

Dr. Joost Vervoort

Joost Vervoort is a senior researcher at the Environmental Change Institute, University of Oxford. He holds a PhD in Production Ecology and Resources Conversation from Wageningen University, on strategies for participatory knowledge development in social-ecological systems, and an MSc in Natural Resources Management from Utrecht University. Since 2011, he leads a global project on scenario-based policy guidance

for CCAFS in six global regions (South Asia, Southeast Asia, East Africa, West Africa, the Andes and Central America). This project has led to successful national and regional policy outcomes in each of these regions as well as partnerships with major global partners (FAO, UNEP WCMC, OXFAM GB, WRI). Vervoort leads a work package on scenario development in FP7 TRANSMANGO (2014-2017) on European food systems, and co-leads a work package in H2020 SUSFANS (2015-2019) which focuses on a modelling toolbox for policy on European food and nutrition security. Vervoort has a keen interest in combining scenarios and games for the exploration of strategies and policies – he is developing a scenario game for the Future Earth project 'Seeds of a Good Anthropocene'. He has taught scenario methods at Oxford University (including training for high-level private sector executives as the Saïd Business School), Wageningen University, the University of Amsterdam, at Microsoft, and a range of design schools.

Recent publications include:

- Vervoort, J. M., P. K. Thornton, P. Kristjanson, W. Förch, P. J. Ericksen, K. Kok, J. S. I. Ingram, M. Herrero, A. Palazzo, A. E. S. Helfgott, A. Wilkinson, P. Havlík, D. Mason-D'Croz, and C. Jost. 2014. Challenges to scenario-guided adaptive action on food security under climate change. *Global Environmental Change*.
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Dr. Ruth Meinzen-Dick

Ruth Meinzen-Dick is a Senior Research Fellow at International Food Policy Research Institute (IFPRI), and Coordinator of the CGIAR System-wide Program on Collective Action and Property Rights (CAPRi). Her MSc and PhD degrees in Development Sociology at Cornell have prepared her for understanding a wide range of social institutions and their interaction with the biophysical context, on the one hand, and with state policies on the other. She has more than 25 years' experience in the CGIAR, conducting and directing research on water policy, local organizations, property rights, and poverty impacts. She has led the IFPRI Gender Task Force and currently co-leads IFPRI's theme on Strengthening Institutions and Governance, and serves on the Management Committee of the CGIAR Research Program on Policies, Institutions and Markets. Her responsibilities at IFPRI include developing research methodologies, supervising and carrying out research, writing and editing books, reports, and articles, fundraising, developing networks of researchers and practitioners, and project management. Substantive areas of research include policies for water and natural resource management, gender analysis, local organizations, property rights and collective action, comparative analysis of irrigation system performance, relations between farmers and government agencies; impact of agricultural research on poverty; sustainable livelihoods, and adoption of climate-smart agriculture. In the CAPRi program she has worked across the CGIAR and other organizations to build a community of practice of over 800 people working on the interface between social institutions and natural resource management. She

has extensive field research experience in India, Zimbabwe, Uganda, Kenya, Nepal, Pakistan, and Sri Lanka, and has been involved in research in many other countries in Africa, Southeast Asia, and Latin America. She is a past president of the International Association for the Study of the Commons, past Steering Committee member and Chair of the Nominations Committee of the Global Water Partnership, and currently serves on the Council of the International Land Coalition. Dr. Meinzen-Dick is a founding coeditor of Water Alternatives and serves on the editorial boards of International Journal of the Commons, Global Food Security, and Agriculture and Human Values. Among over 140 peer-reviewed books, book chapters and journal articles that she has authored or coauthored.

Recent publications include:

- Meinzen-Dick, R. (2014). Property rights and sustainable irrigation: A developing country perspective. Agricultural Water Management 145:23–31
- Meinzen-Dick, R., C. Kovarik and A. Quisumbing. (2014). Gender and sustainability. Annual Review of Environment and Resources 39:29–55.
- Mwangi, E., R. Meinzen-Dick, and Y. Sun. (2011). Gender and sustainable forest management in East Africa and Latin America. Ecology and Society 16(1): 17. [Online]
- Palanisami, K., R. Meinzen-Dick, and M. Giordano. (2010). Climate change and water supplies: Options for sustaining the tank irrigation potential in India. Economic and Political Weekly 45(26 & 27): 183-190.
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Dr. Blane Harvey

Blane Harvey is a Research Associate with the UK's Overseas Development Institute (ODI) and an Adjunct Research Professor at Carleton University's (Canada) Department of Geography and Environmental Studies. Until recently, Blane led work on program-based learning, strategic outreach and engagement with the IDRC's Collaborative Adaptation Research in Africa and Asia (CARIAA) Program.

Blane studies how climate change knowledge is produced, validated and communicated, and how social learning and knowledge sharing can support action on climate change in the global South. He is also interested in how community-based media can use action research to influence policy and affect social change.

Blane has been an active contributor to the UN climate change negotiations process since 2003 with a focus on strengthening action to support adaptation in developing countries and is a contributing author on indigenous knowledge and climate change in Africa for the Intergovernmental Panel on Climate Change's 5th Assessment Report (WG II).

Recent publications include

- Ensor, J. and B. Harvey (2015). Social learning and climate change adaptation: Evidence for international development practice. WIREs Climate Change.
- De Souza, K, E. Kituyi, B. Harvey, M. Leone, K.S. Murali & J. Ford (2015). Vulnerability to climate change in three hot spots in Africa and Asia: Key issues for policy-relevant adaptation and resilience-building research. Regional Environmental Change 15(5), 747-753.
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Annex 11. Gender Summary Annexes

CCAFS SLOs, IDOs and sub-IDOs that include a gender dimension, by Flagship

SLO; IDO; Sub-IDO	Indicator	F 1	F 2	F 3	F 4
SLO Reduced poverty: IDO Increase resilience of the poor to CC and other shocks S-IDO Reduced production risk	Number of farm households with reduced production losses related to CC, with increased benefits for women	X			
SLO Reduced poverty: IDO Enhanced smallholder market access S-IDO Improved access to financial and other services	Number of farm households with improved access to capital, with increased benefits for women	X	X	X	
SLO Reduced poverty: IDO Increased incomes and employment S-IDO More efficient use of inputs	Number of farm households with more efficient use of inputs, with increased benefits for women			X	
SLO Reduced poverty/SLO Improved food and nutrition security for health: IDO Improved productivity S-IDO Increased access to productive assets, including natural resources	Number of sub-national organisations and institutions that are adapting their plans and directing investment towards climate-smart food systems to increase equitable access to productive asset	X			
Climate Change Cross-cutting: IDO Adaptation and mitigation achieved S-IDO Improved forecasting of impacts of CC and targeted technology development	Number of site specific targeted CSA technologies/ portfolios tested, with all options examined for their gender implications	X			
Climate Change Cross-cutting: IDO Adaptation and mitigation achieved S-IDO Enhanced capacity to deal with climatic risks, extremes	Number of farm households with strengthened adaptive capacity and food security, with increased benefits for women	X	X		
Climate Change Cross-cutting: IDO Adaptation and mitigation achieved S-IDO Enabled environment for climate resilience	Number of global/regional organisations that have increased their equitable institutional investments in climate smart food systems				X
Gender Cross-cutting: IDO Equity & inclusion achieved S-IDO Gender-equitable control of productive assets and resources	Number of households where women have increased control over productive assets and resources	X			
	Number of national /state organisations and institutions that are adapting their plans and directing investments towards climate-smart food systems to increase women's access to, and control over, productive assets and resources				X
Gender Cross-cutting: IDO Equity & inclusion achieved S-IDO Participation in decision-making	Number of households where women's participation in decision making has improved – in decisions over own labour, over own income and in groups or collective organization		X	X	

"With increased benefits for women"

CCAFS has given a number of the sub-IDOs a gender dimension, through the use of "with increased benefits for women" or "equitable" in the indicators. In using the former, this implies tracking gender outcomes in

households and documenting the degree to which outcomes positively impact women and men; with the target being that women benefit as much or more than men. Indicators where "equitable" will be tracked would involve examining the gender dimensions of outcomes to check that plans and investments are gender-sensitive and advancing women's control and participation.

Annex 12. Flagship 3 Annexes

1. Technical data on emissions and targets for mitigation

Global mitigation target for agriculture

Integrated assessment models indicate that climate change mitigation in agriculture and food systems of about 1 Gt CO_2e/yr by 2030 is needed to stay within the 2° limit (van Vuuren et al. 2011, Kleinwechter et al. 2014, Wollenberg et al. 2015). The average of the assessment models is 1.16 Gt CO_2e/yr; we rounded to 1 Gt CO_2e/yr to create a simple policy target.

Table 12.1. GHG emissions and mitigation modeled by integrated assessment models for the agriculture sector in 2030 to avoid exceeding 2°C

	2030			2020		
	Reference scenario	2°C world scenario	Mitigation modeled	Reference scenario	2°C world scenario	Mitigation modeled
Integrated assessment models	Emissions, $GtCO_2e$	Emissions, $GtCO_2e$	$GtCO_2e$	Emissions, $GtCO_2e$	Emissions, $GtCO_2e$	$GtCO_2e$
GCAM	8.97	7.78	1.19	7.06	6.47	0.59
IMAGE	7.80	6.42	1.36	7.77	7.08	0.69
MESSAGE	8.58	7.66	0.92	Not available		
Average			1.16			0.64

Mitigation potential in developing countries in 2030

Based on IPCC data (Smith et al. 2008, Smith et al. 2013), CCAFS estimates a mitigation potential of 0.76 $GtCO_2$e/yr from developing (non-Annex 1) countries, 76% of the global target.

Table 12.2. Mitigation potentials for Annex 1 and non-Annex 1 countries

	Economic mitigation potential in 2030 (Smith et al. 2008, 2013)	Mitigation potential in 2030 to meet 1 GtCO2e/yr global target (75% of economic potential)
Annex 1 countries	1.01	0.76
Non-Annex 1 countries	0.35	0.26
Total	1.36	1.02

Smith et al. (2008) calculated regional mitigation potentials for the following mitigation options: cropland management, grazingland management, livestock management, manure management, rice management, restoration of degraded lands. We allocated these potentials to the countries within each region proportional to 2012 emissions and land use. For non-CO2 mitigation potentials (livestock management, rice management, manure management, and fractions of crop and grazingland management), we allocated mitigation potentials

according to a country's contribution to 2012 regional emissions within the corresponding emissions subsector. For soil C mitigation potentials (restoration of degraded lands, and the N_2O fractions of cropland management and grazingland management), we allocated mitigation potentials according to the regional percentage of the corresponding land use within the country in 2012. We used 2012 data in order to base our calculations on actual emissions rather than projections. Emissions and land use data were taken from FAOSTAT, with the exception of degraded land. Degraded land within each country was determined using data from FAO/IIASA's Global Agroecological Zones (GAEZ) portal. Degraded land was calculated as as the overlay of areas under crops from the 'dominant land cover' dataset of GAEZ with areas categorized as having 'severe' or 'very severe' fertility constraints from the 'nutrient availability' dataset of GAEZ.

CCAFS Flagship 3 mitigation targets for 2030 and 2022

F3's vision is that in 2030, low emissions development (LED) has achieved mitigation co-benefits without compromising development targets to reduce GHG emissions by 15% compared to 2015 levels. Among key 2022 outcomes are:

(a) Reduced net greenhouse gas emissions from agriculture, forests and other forms of land use by 200 Mt CO_2e/yr

> 100 Mt CO_2e/yr of this target will be from agriculture, calculated using the country mitigation potentials from Sith et al. (2008) for CCAFS focus countries.
>
> 100 Mt CO_2e/yr of this target will be from avoided deforestation. This figure was calculated using figures for annual forest loss in Brazil and Indonesia, provided by collaborators at Wageningen University and Research Centre (Sarah Carter and Martin Herold). Based on F3's anticipated activities, we anticipate contributing to 15% of potential avoided deforestation in these countries.
>
> The total (200 Mt CO2e/yr) is 8% of 2012 emissions in CCAFS Regions (using the latest available FAOSTAT agricultural emissions data).

(b) 2 million ha of deforestation avoided due to improved governance of agriculture-forest landscapes

> This figure was calculated using figures for annual forest loss in Brazil and Indonesia, provided by collaborators at Wageningen University and Research Centre (Sarah Carter and Martin Herold). They estimated annual agriculturally-driven deforestation at 5.0 and 1.8 million ha/yr in Brazil and Indonesia, respectively. Based on F3's anticipated activities, we anticipate contributing to 15% of potential avoided deforestation in these countries, which will total approximately 1.7 and 0.3 million hectares in Brazil and Indonesia, respectively, between 2015 and 2022.

The significance of agricultural emissions

Globally, nearly a quarter of annual greenhouse gas emissions currently come from agriculture, forestry and other land use, ~10-12 $GtCO_2e$/yr (Smith et al. 2014). However, Integrated assessment models indicate that under a 2°C scenario, agricultural emissions will contribute an increasing fraction of global emissions, as their mitigation is more challenging than emissions from the energy sector.

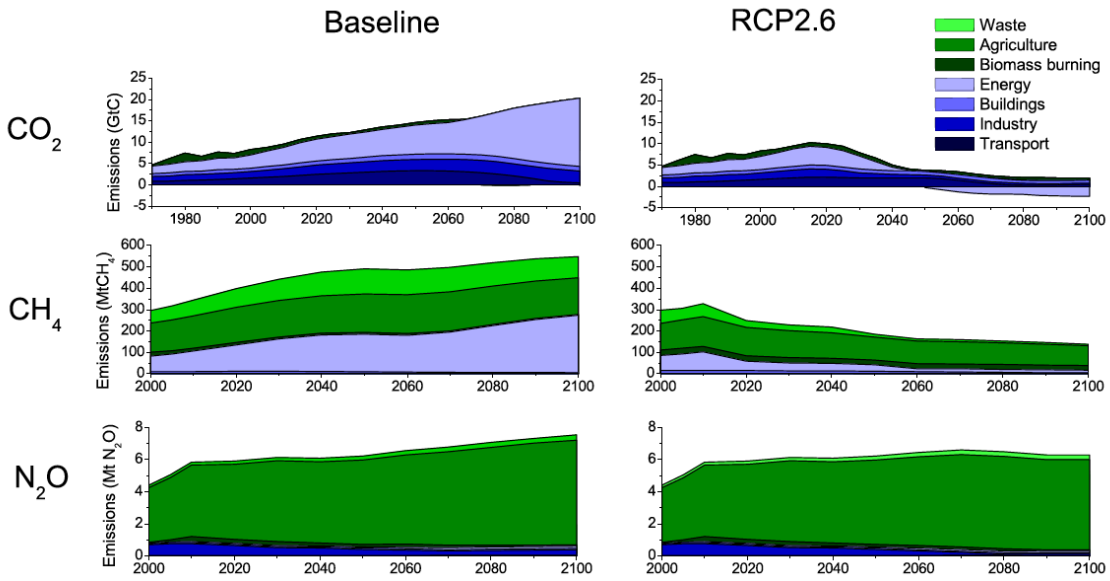

Figure 12.1. Trends in anthropogenic emissions of major greenhouse gases, baseline (left) vs. mitigation scenario RCP2.6 (right) (transport includes also international transport; industry includes both energy-related emissions and process emissions; deforestation emissions are included under the heading biomass burning) (van Vuuren et al. 2011)

2. Centre participation in CoAs

	CoA 3.1 **GHG quantification**	**CoA 3.2** **Priority setting & developing technical options**	**CoA 3.3** **Scaling up options and implementation**	**CoA 3.4** **Governance for avoided deforestation**	**CoA 3.5** **Supply chain efficiencies**
CIFOR	GHG measurement and MRV across landscapes, global mitigation hot spots		Analysis of forest-agriculture interface in GHG emission reduction strategies (NAMAs, INDCs, LEDS, Green Economy) in EA and SEA via FP4	Green municipalities in Amazon and Indonesia to avoid deforestation by cattle and oil palm	
CIAT	Measurement and modeling of livestock, MRV for NAMAs, CLIFF PhD student network	Pasture intensification and livestock, BNI in Costa Rica and Colombia, paddy rice in Colombia, soil carbon links to WLE	Pasture intensification and livestock, BNI in LAM, paddy rice in Colombia		Consumer demand, defining the foods of the future, turning waste into added value
IFPRI		LED scenarios in Colombia			Modeling of future diet shifts

IITA				Links to intensification in Congo Basin	
ILRI	Measurement and modeling of livestock and improving DNDC (EA, SEA)	Dairy (EA)	Policy implementation (EA)		Postharvest loss, diet shifts (TBD)
CIMMYT	Measurement and modeling for wheat and maize, improving N modeling globally	Conservation agriculture and nutrient management in SA and Mexico	CSVs in South Asia		Postharvest loss
IRRI	MRV for paddy rice; quantification of GHG reduction from AWD (GRA collaboration)	Paddy rice in SEA and SA; technological options: (i) AWD (outscaling in VN and BD through CCAC), (ii) mobile phone apps (link to FP2) ; (iii) alternatives to straw burning;	Paddy rice in SEA from field to national scale (NAMA in Vietnam); link to Climate-smart Villages (FP1)	MRV for paddy rice; quantification of GHG reduction from AWD (GRA collaboration)	Paddy rice in SEA and SA; technological options: (i) AWD (outscaling in VN and BD through CCAC), (ii) mobile phone apps (link to FP2) ; (iii) alternatives to straw burning;
ICRAF	MRV for NAMAs in EA and LAM, activity data	Dairy and agroforestry in EA; , and expl; rangeland management and FMNR in the Sahel and southern Africa	Dairy and agroforestry in EA; rangeland management in the Sahel and southern Africa	Link to FTA: subnational level governance in Indonesia, Vietnam, DRC and Peru	Bioenergy value chain; dietary shifts

3. Flagship 3 Contribution to Strategic Results Framework