3-Year System Business Plan Companion Document:

Action 1 - The 2-degree[1] initiative for agriculture and food system solutions

CGIAR Special Initiative on Climate Change

Prepared by: CCAFS in consultation with Centers/Science Leaders

Document Status: A draft strategy for input by the System Council, with a view to presenting a final version to the SMB in December 2018 for approval.

Request of SMB: For review and consideration of whether the draft is ready to seek input from the System Council in November 2018.

Note: This draft is a light edit of **Draft 0** based on inputs from CGIAR Research Leaders and DGs. Most importantly, the Impact Areas have been brought up to date in this Draft, but detailed text for each Impact Area needs to be sharpened. Many detailed comments from Research Leaders still need to be incorporated. Text in [ ] indicates text that still needs to be developed.

Vision

The challenges related to climate change are immense and urgent. To illustrate urgency, in many rainfed agricultural systems, there are at most 12 harvests left to achieve the SDGs, including zero hunger, gender equality, and urgent climate action on a huge scale. Agricultural research for development needs to step up massively, to contribute to the productive, sustainable and equitable agriculture and food systems that are desperately needed around the world.

Through this Special Initiative, CGIAR will rise to the climate change challenge – through rigorous climate-informed priority setting, making use of its "back catalogue" (the 50 years

[1] The title speaks to the Paris Agreement and the important target of limiting the increase of global average temperature at no more than two degrees C above pre-industrial level. However, even if a two-degree world can be achieved, many developing countries will experience temperatures higher than two degrees, with significant adaptation challenges for farmers.

plus of CGIAR work) to tailor information for policy processes, fully embracing digital agriculture as a means of rapidly scaling solutions to millions of smallholders, and new innovative partnerships with the private sector, financial institutions and actors in the broader food system.

Why focus on climate change?

By 2030, agricultural research for development will have to reach the 600-700 million smallholder farmers who will be of critical importance in feeding a global population of around 8.6 billion people. Current crop yield growth rates per year are already seriously lagging behind what is likely to be required to ensure food security for the global population (Aggarwal et al., 2018). Despite some successes, in many developing regions there is only limited evidence of farmers making the changes needed to enhance food security of significant proportions of the population. At the same time, evidence is accruing that the effects of climate change on food systems are probably being under-estimated; these include the impacts of increasing variability and extreme events on food systems, and the effects on nutritional content of a wide range of commodities, for example.

Because of lags in the climate system, we are already locked in to a temperature rise of 1.5-2.0 °C, whatever happens to GHG emissions in the future. Humankind needs to ensure that this temperature rise is only temporary, by redoubling mitigation efforts as soon as possible and scaling up countries' commitments under the Paris Agreement.

While smallholder farmers in the tropics and subtropics will continue to be critical for achieving the food security of hundreds of millions of people, many of them will be exposed to some of the worst impacts of climate change: sea-level rise and coastal inundation and salinization in the big river deltas of Asia and the small island states of the Pacific; considerable shortening of growing seasons in southern Africa and parts of eastern Africa; high temperatures combined with increased weather variability in large parts of West and South Asia and West and North Africa. In some of these places, planetary boundaries with respect to the nitrogen and phosphorus cycles, land-use change and freshwater use are already in danger of being exceeded, and these will be compounded by climate change effects. For highly vulnerable and dis-empowered groups such as women, the poor and the youth, there will be few livelihood alternatives, given likely continued dependence on agriculture as one of the main drivers of economic development.

At the same time, agriculture in developing countries contributes to about ¾ of the sector's emissions globally and is expected to grow. Livestock, paddy rice and nitrogen fertilizer are the major sources of emissions. Agriculture is also a major driver of deforestation in the tropics. Opportunities for reducing emissions in ways that are compatible with development are available for most agricultural systems, especially if accounted for using emissions per unit food (emission intensity). Improved fodder, more productive breeds and manure management can reduce the emissions intensity of cattle. Managing irrigation to periodically dry paddy rice fields can reduce methane. Efficient use of nitrogen can reduce nitrous oxide emissions. At the same time, agriculture can also remove emissions from the atmosphere, by sequestering carbon in the soil or perennials, providing negative emissions, which are now recognized as critical for meeting the 2 °C target.

CGIAR institutional case for a special initiative

CGIAR has an extensive track record on research and engagement dealing with climate change – both for adaptation and mitigation. This was accelerated in 2009 by the creation of a climate change Challenge Program and significant work on Reduced Emissions from Deforestation and Forest Degradation (REDD); further prioritised by a CGIAR Research Program (CRP) on climate change initiated in 2011, and then climate change mainstreamed in all CRPs in Phase II starting 2017. In addition, CGIAR has a massive "back catalogue" that can be curated and re-interpreted in terms of climate trends and options, using big data analytics.

There have also been significant CGIAR-facilitated successes related to the uptake of climate-smart agriculture (CSA)[2], deforestation-free development, support to policy formulation, and input into major investments in CSA and reducing deforestation. This Special Initiative is designed to greatly expand that influence and impact, through (i) improving coordination and integration across CGIAR Centers, programs and system entities; (ii) enhancing engagement at international, national, and subnational/local levels) in on-going policy processes; (iii) fully integrating some common transformational approaches; (iv) enhancing communication targeted at decision makers; (v) consistent use of some common tools to foster synergies; (vi) using CGIAR big data and information, curated at CGIAR level, for climate change-related analysis and advice; and (vii) expanding the depth of work, by focussing on six Impact Areas. Because the Impact Areas will be geographically focussed, this Special Initiative will also contribute to greater coordinated action of the CGIAR in specific countries. The Impact Areas and Special Initiative are not new areas of work, but rather fit within the current structures of the CGIAR.

The Special Initiative is intended to demonstrate and better communicate how the CGIAR is rising to the challenge of climate change, to justify and maintain current levels of investment in research focussed on climate change, and to secure new funds for a deepened focus on Impact Areas.

Why is CGIAR uniquely placed to take on this Special Initiative?

CGIAR is the only institution with a clear mandate for scientific research focussed on the food system with offices in 50+ developing countries. It has the mandate of providing international public goods for eradicating poverty and hunger, and enhancing the environment. It is privileged to work from farmers' fields to national policy processes. In countries it has extensive partnerships with public, private and civil society agencies. It also operates at regional and global levels, in processes relevant to climate change. It has diverse capacity strengths – technical, social and economic, covering agriculture, environment, nutrition, livelihoods, markets and trade. It also covers all the important sectors relevant to climate change: crops, livestock, fisheries, agroforestry, forestry, water and soils.

CGIAR's decades of research ("back catalogue") can be capitalised on in the context of climate change for adaptation, dealing with climate variability and extremes, reducing greenhouse

[2] "Climate-smart agriculture" is merely used as shorthand for agriculture and food systems that deal with climate impacts and attempt to reduce greenhouse gas emissions or sequester carbon (where feasible), while also meeting many other challenging goals in the food system. See Campbell, 2018.

gas emissions and enhancing carbon capture. CGIAR's experience has led to many globally-significant databases, models and tools that are relevant to climate change (Box 1). It already has delivered many important outcomes for climate change policy and actions (Box 2).

Climate action is extremely urgent, and requires cooperative actions across countries. CGIAR with its nation to region to global presence is uniquely placed to foster such collaborative action based on sound science.

Box 1. Significant databases, models and tools produced by the CGIAR

- AgTrials (>35,000 trials with weather data) (Hyman et al., 2017)
- CCAFS-Climate (portal for downscaled climate model outputs with over 190,000 downloads per annum)
- GLOBIUM's agricultural emissions model (used for IPCC scenarios)
- SAMPLES (Emissions data for global accounting)
- SHAMBA tool is standard used for smallholder carbon credit
- 10 years of REDD+ research with data from 4.000 households in 6 tropical countries and global database of REDD+ projects
- Poverty and Environment Network (PEN), a database from 10.000 rural households in tropical forested countries
- GCAN framework developed for USAID programming in the climate, gender and nutrition space
- IMPACT modelling suite used across CGIAR to explore solutions to the global climate challenge
- Use of ecosystem-based adaptation-cum-mitigation tools for water management, such as green infrastructure, MAR, and others
- Global assessment of the economics of land degradation

Box 2. Examples of important outcomes from CGIAR research for climate action and policy

- [drought tolerant maize]
- [alternate wetting and drying]
- Thailand secured initial NAMA funding to support reducing emissions in paddy rice among 100,000 rice farmers and 420 agricultural mitigation service providers in 6 provinces of Thailand potentially contributing to GHG reduction of about 1 million tons of CO_2eq and transforming the rice sector towards low-carbon production.
- The KUSUM Scheme for solar irrigation in India will replace 1.75 million diesel pumps and 1 million electric pumps thereby avoiding 4.55 million MT CO_2 which is 8.68 percent of national CO_2 emissions.
- FTA's REDD+ research contributed to international expert consultations that led to a UNFCCC decision 2011 for a stepwise approach on setting, measuring and reporting reference levels for forests under climate change (UNFCC Decision 12/CP17).
- FTA's REDD+ research was involved the Indonesian National REDD+ Strategy development; it supplied information that informed the Government of Indonesia's decisions on their forest moratorium and forest reference emission levels (peatland

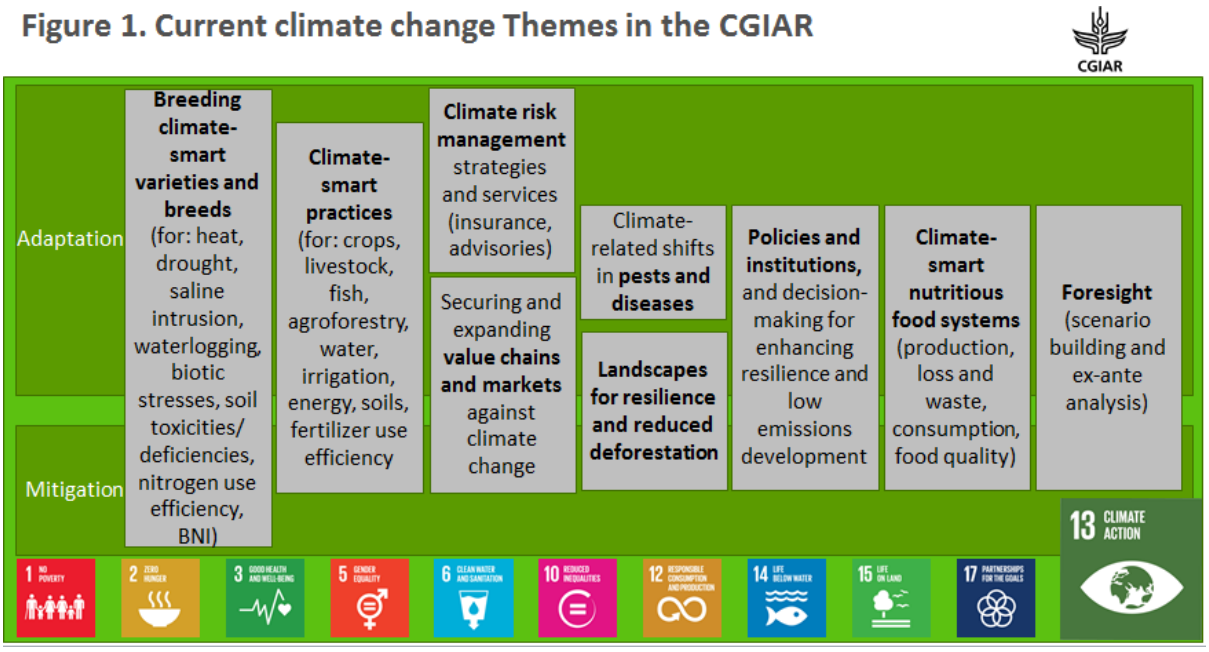
emission factors); gave support to the successful establishment of Indonesia National Carbon Accounting System (INCAS)

- The 2013 IPCC Supplement on Wetlands significantly improved countries' ability to report on GHG emissions in wetlands. For example, Indonesia used the emission factors from this report for Tier 2 reporting of its national GHG inventory.
- The Philippine Government proposed a carbon tax based on combined Climate-Energy-Economy-wide Analyses; such CGIAR analyses are increasingly used by governments to inform national green growth strategies.
- Advising WHO and FAO on safety options for the use of untreated wastewater in agriculture, an area of an estimated 30 million hectare.
- Development of flood risk insurance products for resource-poor farmers in India
- Key player in informing negotiators, especially of demand for adaptation and mitigation in NDCs leading to the Koronivia decision on agriculture in COP23

Current CGIAR portfolio

CGIAR already covers many areas relevent to climate change as illustrated in Figure 1. The Themes include climate-smart breeding, developing climate-smart practices, climate risk management, securing value chains against climate change and making them carbon neutral, dealing with climate impacts on pests and diseases, building resilient landscapes and reducing deforestation, policies and institutions for promoting climate-smart actions, and climate-smart nutritious food systems. The work also involves foresight to identify priorities and vision futures with stakeholders. Gender considerations are mainstreamed in all activities, and youth-related initiatives have now begun. Annex 1 lists the CRP Flagships with significant climate change work.

Figure 1. Current climate change Themes in the CGIAR



The current work needs to be deepened around these Themes, and greater synergies amongst different parts of the CGIAR need to be fostered, both within Themes and across Themes. This will be partially achieved through deepening the research in Impact Areas.

Objectives of the Special Initiative

Having to adapt the food system to at least 2 degrees of global warming is inevitable, whilst at the same time the food system must find new ways to reduce emissions. Climate change is often described as a tragedy of the commons, and solutions can only be formed through collective action. With CGIAR working in and across numerous countries, and in global processes, it is uniquely placed to play a defining role in setting the planet on a more sustainable path to achieving food security in a hothouse earth context.

The overall goal of this Special Initiative is to support and add value to country efforts to deliver on agriculture- and food system-related[3] goals of the Paris Agreement and to achieve the targets of SDG 13 on Climate Action. While the objectives are climate-focussed, agriculture and food systems are connected to almost all SDGs, thus this initiative also has important links to many other SDGs, in particular poverty reduction, preventing hunger and sustainable consumption and production (see Figure 1 for main SDGs). Through this Special Initiative, the CGIAR will:

1. Develop new agricultural technologies and practices which stand up to 2 degrees of global warming and its associated impacts on climate variability, maintain (or enhance) productivity, contribute to resilient farming communities and do not increase GHG emissions.
2. Work with development agencies, national governments and the private sector to systematically mainstream 2-degree adapted practices, technologies and information systems into policy frameworks, agricultural finance, farming systems and more broadly into food systems, and in so doing, reach [20] million hectares with climate-smart agriculture, and reach [1] billion urban and rural consumers with climate-smart food by [20XX].
3. Chart a pathway for agriculture to meet Paris agreement targets, so that by 2030, we have reduced agricultural emissions by 1 $GtCO_2e\ yr^{-1}$, reduced emissions from food loss and waste by 20%, achieved zero deforestation and restored [350] million ha of degraded and deforested lands.

Taking a transformative approach

Climate change adaptation and mitigation in agriculture and food systems will be challenging to realize. The magnitude and complexity of these challenges is enormous and most likely requires transformational adaptation, in contrast to incremental adaptation. This Special Initiative will include a focus on 6 Impact Areas that are geographically targeted and time bound. The theory of change for each Impact Area will include the following five cross-cutting elements that are hypothesised as crucial to bring about transformation (Figure 2).

1. Developing and promoting **climate-resilient and low-emission practices and technologies.** New technologies and practices will be needed for the challenges ahead. For example, because of unpredictable and variable weather, we will need technologies that deal with multiple stresses, e.g. drought, floods, heat. In addition, it is estimated we only have technologies to deal with 20-40% of the emissions reductions required. Furthermore,

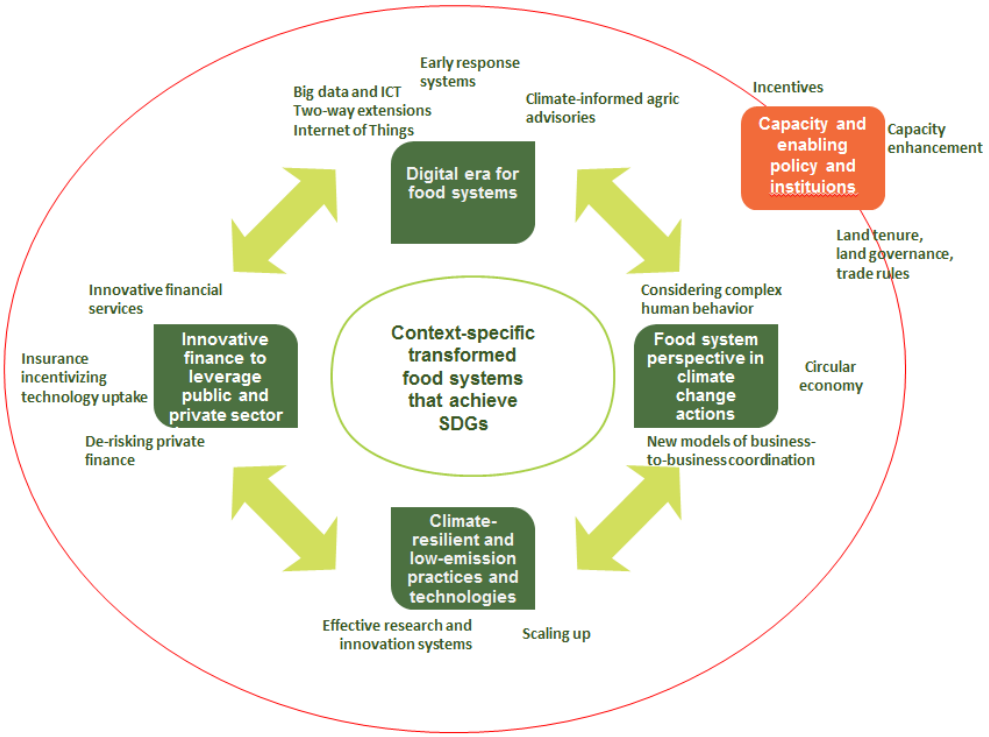
[3] Agriculture is used in the broad-sense of covering crops, livestock, fisheries and forests

adoption of such technologies in food systems is at very low levels. A great effort is needed on scaling up. The research and innovation system will need to be highly effective, with researchers working seamlessly with other stakeholders.

2. Ushering in the **digital era in food systems**: Agriculture and allied sectors have lagged behind in the use of information and communications technologies. This needs to change, ushering in the digital era in food systems to generate efficiency gains for farmers, to foster two-way agricultural advisory systems that are climate-informed, estimate emissions in more efficient ways based on big data and better models, and facilitating adaptive safety nets, such as index-based insurance that can be made more efficient through use of digital platforms.

Many opportunities with respect to big data, blockchain technologies, precision agriculture, farmer profiling and e-extension have the potential to transform food systems for a climate-impacted world. Using big data, ICTs and artificial intelligence can help farmers to best manage their crops, livestock, fisheries and forests under a changing climate. The CGIAR Special Initiative will take advantage of the digital era to develop more efficient early warning systems for managing extreme events and pests and diseases, for developing agricultural insurance products that can satisfy farmers' needs and for developing adaptive safety nets that can be able to protect the most vulnerable rural population.

Figure 1: Five key elements to achieve transformed food systems under climate change



3. Mobilizing **innovative finance to leverage public and private sector investments.** Innovative models to financing will be needed to drive food systems transformation, as current levels of financing are totally inadequate to the task ahead. New skills in R&D will be needed to link with banking, credit, investment and insurance communities; and to design schemes that incentivise investment, including systems that de-risk agriculture to drive private sector investment. This is particularly important given climate impacts on weather systems that are increasing risks.

The CGIAR Special Initiative will address the climate change challenge through innovative partnerships and joint initiatives with the agri-tech world, digital service providers, value chain actors, certification stakeholders, climate financiers, landscape investors and other actors interested in mainstreaming the climate variable into their businesses.

4. Strengthening the **food system perspective in climate change actions.** Climate solutions cannot only be focussed on production. It will be crucial to deal with food loss and waste, the consumption shifts that will be needed from a climate and health perspective, building resilience in supply chains and making supply chains more carbon neutral. Many of these areas are relatively new to the CGIAR, stressing the need for new partnerships. Food system changes will take a combination of incentives for individual behaviour change and wider institutional shifts.

All Themes and Impact Areas will take a food system perspective. Some key areas for innovation that will be addressed include: new products that substitute for unhealthy and unsustainable options; mechanisms to reduce food loss and waste, focussing on post-harvest loss, but also, through partnerships, on food waste along the supply chain; and changes in consumers' choice incentives.

5. **Capacity and enabling policies and institutions.** This element is key to all the other elements. Initiatives are needed to create a conducive enabling environment which encourages innovation, investment and action. The right policies and incentives need to be in place, with policy involving not only agricultural policy, but policy related to such issues as digital infrastructure, ease of doing business, land tenure etc. This will need to be complemented by efforts to enhance capacity at various levels for effective implementation.

Through this Special Initiative, the current policy work will be greatly expanded, and in particular an action research approach will be embraced by all Themes and Impact Areas, also through new partnerships with policy stakeholders. CGIAR will deliver on appropriate tools and information to support specific decision makers and specific policy processes. Decades of research of the CGIAR will be reinterpreted and brought up to date to address climate change. This cross-cutting work will contribute to the scaling of climate-resilient and low-emission practices and technologies, the expansion of digital agriculture etc. The activities will respond to specific needs in relation to managing uncertainty through foresight, generating quantitative information about the synergies and trade-offs between adaptation and mitigation strategies, integrated modelling (farms-landscapes-supply chains), providing evidence in the preparation of investments cases for promoting an adaptation and mitigation agenda, developing innovative ways to address MRV, and policies and strategies to mainstream gender and youth in climate actions.

Climate Change Impact Areas

The current work of the CGIAR will be brought to bear on "Impact Areas" for climate change adaptation and mitigation. In the first three years of the business plan, the focus will be on 6 Impact Areas, with additional Impact Areas to be considered in future three-year periods, and with some Impact Areas being phased out if unproductive or having achieved targets.

For each Impact Area, target outcomes and a theory of change will be prepared. Focus geographies will be selected based on foresight and hotspot analysis.

Impact Area #1: Tackling multiple climate-induced stresses on food systems in three global food-baskets

CGIAR's foundations lie in solving a global food security threat in the 1960's and 1970's which required global concerted efforts and resulted in the green revolution. Hothouse earth raises a similar global problem which affects every country and inevitably requires collective action. Scientists assign a 5% probability on the earth's climate staying within the two degree warming limit set out in the Paris Agreement, hence adapting food systems to stand up to 2° C of warming, and the new variability and extremes that this already implies, is no longer a target, but an absolute necessity. Two degrees is highly significant to agriculture. In the absence of adaptation, on average, global crop productivity is expected to decrease by 5-10% per degree of warming (Challinor et al., 2014). Whilst a range of options exist to abate this impact, the gap between what is needed and what is feasible today is huge, and research has already shown the rate of climate change outstrips our ability to adapt through breeding (Challinor et al. 2016).

The challenge of adapting to two degrees is unprecedented. Not only does this require new tolerances to heat, but also traits that address secondary impacts of two degrees which include new pest and disease pressures, drought, waterlogging, and even reduced nutritious quality as a result of increased carbon dioxide. Hence, holistic breeding strategies are needed, that target multi-trait characteristics, and take a long-term view to guiding important food crops, livestock and fisheries through the multiple threats of the 21st Century. In addition, a systems approach will be needed, to diversify farming systems as an adaptation strategy, but also from a nutrition perspective.

As part of this Impact Area, one major food basket in each region (Latin America, Africa and Asia) will be selected through ex-ante assessment of climate impacts and broader socio-economic assessment. Priority setting and stakeholder consultation in each food basket will identify the multi-trait requirements for key staple crops, livestock and fisheries and the diversification strategies that are needed. The technical work will be complemented by institutional and policy work on, for example, seed systems, public-private partnerships that are needed for achieving scale.

This work will build on the breeding and systems work of the relevant agri-food CRPs in each food basket, and the work of PIM on foresight. A4NH will participate in terms of the diversification and nutritional component.

Impact Area #2. Preparing for saline intrusion, sea-level rise and flooding in coastal Asia

Almost 40 per cent of the world's population lives within 100 km from a coast. These populations, especially in the tropics, face immense risks from sea level rise (currently rising at 3.4 mm per year) and associated coastal flooding and salinity intrusion. High intensity rains induced by climate change aggravate such risks. Besides direct loss of assets and lives, these populations face additional risks of direct land loss, contamination of groundwater, coastal erosion and changes in already complex land-sea interactions such as siltation. All this is likely to affect the regions' food and economic security significantly, given areas at risk provide much of the current food security, especially in Asia. Asia has high coastal populations in China, India, Bangladesh, Indonesia and Vietnam and being affected by the El Niño Southern Oscillation (ENSO), is very vulnerable to climate change. These regions, especially their deltas,

constructed polders and small islands, could also witness massive outmigration if the frequency of climatic risks increase significantly.

While the impact of climate change on coastal mega-cities and strategies to build their resilience have received considerable attention, coastal agriculture and fisheries value-chains have remained largely neglected. The latter could witness large-scale impacts of climate change even in short-term in the form of salinization of soil and water resources and therefore get adversely affected by reduced agriculture production, change in or loss of fresh water fish habitats, loss of fishing opportunities and adversely impacted value-chains. CGIAR centers, together with national partners, will be involved in promoting the use of weather forecasts; developing other adaptation strategies such as water and salinity management at a landscape level; conservation of fragile ecosystems, identifying opportunities for reducing migration, and; seeking institutions, markets and policies that will minimize impacts and incentivize new practices. In addition, there will be attempts to identify new agriculture opportunities created because of the changing climate including sea level rise. Scaling up alternate wetting and drying in paddy rice in deltas will be a means of addressing water variability and salinization, while also reducing emissions.

This Impact Area will will draw heavily on Rice and WLE and build on the systems work of relevant AFS-CRPs, notably Wheat, Fish and FTA, and enabling policy work from PIM.

Impact Area #3: Climate Change, fragility and resilient livelihoods in the Middle East and North Africa

Climate change threatens the viability of agriculture, ecosystems, and rural livelihoods in the Middle East and North Africa (MENA). Agriculture is a critical source of employment and incomes, and environmental degradation coupled with declining and more variable productivity may pose a massive challenge in a region already beset by instability. There is evidence that environmental factors are already starting to influence migration flows. While the longer-term impacts of climate change on human population distributions are difficult to predict, there are serious potential risks for rural communities dependent largely on natural resources and the agricultural sector for incomes and livelihoods. Considerable investment will be needed to strengthen resilience and maintain rural livelihoods, thereby giving people the option of remaining where they are and minimizing involuntary displacements in the future. Broad uptake of a wide range of agricultural technologies could lead to substantial gains in enhanced water-use efficiency, the collection, conservation and utilization of biodiversity, building resilient and integrated crop-livestock farming systems, and including more diverse protein sources in diets, for example.

Several CRPs and regional research and private-sector partners would contribute expertise and South-South learning on these topics. But ultimately, climate change adaptation pathways in MENA will need to deliver viable rural livelihoods and high-value jobs for young people. This will require increased focus on agricultural value chain transformations and fostering vibrant, diversified rural economies, along with the policy and institutional interventions that can promote such changes.

This impact area will work primarily with Grain Legumes and Dryland Cereals, and Livestock. It will also involve value chain work from PIM, and water and landscape based approaches from WLE.

Impact Area #4. Resilient and adaptive water systems for agriculture in 2-degree dryland Africa

Key impacts of climate change are mediated by water – not least drought. Risks of drought are increasing as the hydrological cycle intensifies because of climate change. Vulnerability to water scarcity and drought is highest where water infrastructure used to store water, regulate flows and irrigate crops is poorly developed. Vulnerability is also high where landscapes are degraded because less water is then stored in upland soils, wetlands and aquifers, reducing availability of surface and groundwater during drought. Arid and semi-arid regions of Africa are particularly vulnerable because they are often poorly served by water infrastructure and impacted by land and water degradation. Water scarcity and drought thus pose a serious threats to food security in arid and semi-arid regions of Africa. More broadly, research has shown that water scarcity disrupts economies because of impacts across sectors, including as a result of higher competition for water resources, putting development gains in jeopardy. Resilient and adaptive water systems will hence be imperative for agricultural development and poverty reduction in drought-prone areas of Africa under climate change.

Opportunities for building resilient and adaptive water systems extend well beyond business-as-usual irrigation development. Research-led innovation is key to change at two levels. If developed together, they offer the opportunity to manage threats to water security in Africa while supporting farmers to leapfrog to new, climate-smart irrigation technologies that will allow them to reduce vulnerabilities to climate change while contributing to the transition to low-carbon energy development.

At national and basin scales, research is needed to support climate-resilient water resource planning and management that achieves system-wide gains in water productivity and water-use efficiency. Governments, basin and aquifer management agencies, the private sector and sector groups need data and tools that enable them to assess water-related risks under changing climates and make decisions on infrastructure investment, water allocation, ecosystem management and sector policies.

At farm level, recent developments in solar-powered pumps have potential to transform irrigation development in drought-prone regions of Africa. The opportunity is not to only reduce climate change vulnerability, but also to make low-cost, small-scale irrigation in electricity-constrained Africa a reality. Several pilots, even large-scale, have been attempted in various African and South Asian countries, which have provided mixed results on environmental benefits, costs and market opportunities. Key research needs now are to link technological advances to development of business models that will underpin climate resilience, incentivize water productivity at farm level and support expansion of renewable energy. Research on governance is also key, to understand the policy and regulatory mix and institutional arrangements needed to safeguard social equity, support women's economic empowerment and enable coherence across the water-energy-food nexus.

Climate hotspots (at national or sub-regional scale) will be selected for work based on their suitability for solar irrigation solutions. While the work is focused on SSA, there is a rich experience of solar-powered pumps in agricultural systems in China, India and in northern Africa, thus South-South learning will be fostered. This Impact Area will be led by WLE, but with strong participation by other Agri-Food CRPs, depending on the geographies targeted, and by PIM on governance and policy issues.

Impact Area #5. Propelling a circular bio-economy for climate-smart development for five key value chains

This Impact Area aims at fostering, in the global south, the development of climate-smart low-emissions value chains (food, feed, bioenergy, biomaterials). Agricultural expansion and demand for forests products (timber, charcoal, raw materials) continues driving deforestation, forest degradation, and GHG emissions. Addressing these trends is fundamental to mitigate climate change and to keep our global resource use within planetary boundaries (e.g. Raworth 2018). It can be achieved by shifting to a circular, bio-product intensive economy.

This Impact Area aims at maximizing development and mitigation potentials of the bioeconomy in three ways:

1. Phase-in bio-based renewable materials that reduce countries' dependence on fossil carbon resources, reducing emissions,
2. Maximize farm-to-fork exploitation of all co-products, by-products and waste for materials, feed and energy; reducing post-harvest losses, emissions and the land footprint of production,
3. Strengthen bioeconomy value chains/webs, which will contribute to other key sustainable development objectives (e.g. increasing smallholders' resilience, providing for decent jobs, sustainable growth, and promoting sustainable production and consumption).

A circular (bio-)economy relies on the cycling and recycling of bio-based natural products and residues, optimizes material fluxes, storage and processing, reduces food loss and waste. It calls for enlarging the notion of value chains to value *webs*, where multi-cropping systems give rise to several products. A holistic approach to all material fluxes enables to optimize input/output flows in crop and livestock production, forestry and fisheries, and diversify farm and forest revenues, thus reducing risks. These developments require supportive regulations, public procurement, incentives and consumer engagement.

This Impact Area explores three main areas of work:

(i) Developing, testing and scaling-up a variety of climate-smart bio-resources (for materials, feed and energy) derived from tree crops and agricultural waste (re-engineered wood products; modern biofuels, livestock, crop by-products and co-products), for low-energy, low GHG production cycles.

(ii) Conceiving innovative farm-to-fork value webs, developing enabling policy environment and economic incentives (valuing reduced impact, marketing and triggering sustainable consumption) nationally and internationally, and their inclusion in NDCs.

(iii) Assessing their impacts on climate, land, and people (ecological footprints, life-cycle analyses, emissions, environmental and socio-economic benefits), local and global implications, also addressing equity and fair trade (cf. Jarvis and Campbell 2018).

This Impact Area would require a broad multi-center, multi CRP approach. For instance, FTA could address the bioenergy and wood-based materials systems, as well as impacts on forests. PIM together with WLE and FTA could work on resource governance and policies. CCAFS, with various crop-based Agri-Food CRPs could contribute with specific production systems. Life cycle

analysis would mobilize the competencies of nearly all Centers and CRPs. To maintain focus, foresight analysis will select five value chains where significant climate change gains can be fostered.

Impact Area #6: Prediction, prevention and management of climate-driven pests and diseases: a One Health approach in three climate hotspots

Climate-driven biotic stresses, climate driven pests and climate sensitive diseases are major threats to food and nutrition security, health and ecosystem services. Documented changes in distribution of pests and diseases has resulted in lost animal and plant productivity, virgin soil disease outbreaks, and, in some cases, reduced risk of infection. Predicting, detecting and managing climate-sensitive pests and diseases can help prevent chronic shocks (e.g. by reducing aflatoxin associated with stunting and immune suppression), as well as acute shocks (e.g. rapid response to El-Nino driven outbreaks of vector-borne disease).

Climate driven pests and diseases are intrinsically a One Health problem. Changes in environment lead to changes in survival of vectors, parasites, and microbes. Initial work by the CGIAR Agri-Food CRPs and others has helped identify those pests and diseases of most importance. These include:

- Vector borne emerging zoonotic diseases such as Rift Valley fever which affect human health, livestock productivity and trade.
- Endemic zoonotic diseases which are climate and weather sensitive due to their epidemiology. For example, many foodborne diseases are both zoonotic and climate sensitive.
- Mycotoxin contamination pre and post harvest results in food losses, missed market opportunities and risks to human health.
- Invasive alien species
- Endemic plant pests
- Climate sensitive livestock disease

There are several promising options for better addressing climate diseases, centred around prediction, prevention and management. A CCAFS working paper identified five key areas:

1. Improve capacity to forecast near-term disease and predict long term. For example, mycotoxin forecasts are widely used, but not yet implemented in Africa.
2. Improve disease surveillance and response. IT and remote mapping offer new, cheaper technologies. However, systems require incentives to implement
3. Invest in adaptation responses that deliver co-benefits, for example, vaccination for priority livestock diseases.
4. Increase resilience by supporting diversification and promoting resistant species and breeds.
5. Improve extension and animal and plant health delivery through capacity building, IT and innovative delivery.

The CGIAR has long-standing partnerships around climate and disease. For example, a Biorisk Management Facility has been established to engage not only researchers, but also the civil society, including farming communities, non-government organizations, and public and private structures, to sustainably address challenges posed by biotic stresses and climate change on agricultural production. CGIAR scientists have worked for several decades on

epidemiology of climate sensitive livestock and agriculture-associated human diseases and more broadly on mitigation and adaptation of agricultural systems. The CGIAR is one of the lead global centres for mycotoxin research.

The Impact Area would:

- Establish a One Health platform for agriculture-associated and climate sensitive human, animal and plant disease in low and middle income countries
- Identify three climate change hotspots where CGIAR collaboration would be stepped up, for use as learning laboratories

This Impact Area would address the lack of early warning and rapid response systems that can allow timely actions and prevent further spread of pests and diseases into new areas. Horizon scanning, modelling and forecasting tools will be designed and deployed to guide decisions and enhance preparedness amidst stakeholders and farming communities. Knowledge generated by this Impact Area will also be instrumental for ongoing breeding efforts, by providing detailed information on future targets for resistance breeding under different climate change scenario.

CGIAR organising for climate change-related R&D

The capacity of the whole CGIAR must be brought to bear on the climate challenge, with much greater concerted action and coordination. We are proposing to significantly expand the influence and impact of CGIAR's work, while also not creating new bureaucratic structures and governance bodies in the System to achieve this. Themes in the current CGIAR portfolio, cross-cutting Themes and Impact Areas will be allocated to appropriate CRPs, Platforms or Centres for leadership, synthesis and coordination. For example, each of the targeted bread-baskets in Impact Area #1 would be led by an appropriate Agri-Food CRP, but tasked to ensure that other applicable CRPs are brought in.

Extra resources ("stretch targets") acquired for the Impact Areas would be allocated to appropriate CRPs with targets and activities revised through the POWB, if they were additional to the Phase II proposal. In Year 1, the foresight and hotspot analyses would be conducted in order to select bread-baskets, coastal hotspots etc. On the basis of this a more detailed budget plan will be presented.

To sharpen the focus on climate change in the CGIAR, all CGIAR principal investigators would have at their disposal some basic tools, e.g. tools for ex ante analysis when determining priorities, climate risk assessment tools, consistent methods for GHG emissions estimates, mitigation option tool for targeting mitigation options, maladaptation assessment procedure. Guidelines for improving theories of change to tackle climate change adaptation and mitigation will be drawn up. An internal procedure for assessing climate-related actions in the POWB and annual reporting will be implemented.

Annex 1: CRPs and their Flagships involved in climate change-related research

Focus area: A = Adaptation; M = Mitigation

Climate change integrating CRP

CGIAR Research Program on Climate Change, Agriculture and Food Security

- CCAFS generates evidence and supports adoption of climate-smart agricultural policies, practices, and services that alleviate poverty, increase gender equity, and support sustainable landscapes. CCAFS also plays an integrating role across all the CRPs

CCAFS FP1 (A): Priorities and policies for CSA
CCAFS FP2 (A/m): Climate smart technologies and practices
CCAFS FP3 (M): Low Emissions Development
CCAFS FP4 (A): Climate services and safety nets

Other integrating CRPs

CGIAR Research Program on Agriculture for Nutrition and Health

- A4NH is built on the notion that agriculture can do much more than reduce hunger and poverty – it has an enormous potential to significantly improve the nutrition and health of people around the world. The links between nutrition and climate change is a focus area.

No particular Flagship, but collaboration with CCAFS on climate change and nutrition

---

CGIAR Research Program on Policies, Institutions, and Markets

- PIM is action-oriented research to provide support for policies that help poor farmers, both men and women, improve their lives; produce nutritious and affordable foods; and protect the soil, water, and biodiversity in rural landscapes.

PIM FP1 (A): Technological Innovation and Sustainable Intensification
PIM FP3 (A/M): Inclusive and Efficient Value Chains
PIM FP4 (A): Social Protection for Agriculture and Resilience
PIM FP5 (A/m): Governance of Natural Resources

CGIAR Research Program on Water, Land and Ecosystems

- WLE works on transforming agricultural food systems, making them the key to healthy, functioning ecosystems, human well-being and resilient livelihoods. Agriculture doesn't have to be the cause of degradation, it can be the cure.

WLE FP1 (M): Restoring Degraded Landscapes (RDL)

WLE FP2 (A): Land and Water Solutions for Sustainable Intensification (LWS)
WLE FP4 (A/m): Managing Resource Variability, Risks and Competing Uses for Increased Resilience

---

Agri-food CRPs

CGIAR RESEARCH PROGRAM ON Forests, Trees and Agroforestry

CGIAR Research Program on Forests, Trees and Agroforestry

- FTA aims to enhance the role of forests, trees and agroforestry in sustainable development and food security and to address climate change.

FTA FP1 (A): Tree genetic resources to bridge production gaps and promote resilience
FTA FP2 (A/m): Enhancing how trees and forests contribute to smallholder livelihoods
FTA FP3 (a/M): Sustainable global value chains and investments for supporting forest conservation and equitable development
FTA FP4 (A): Landscape dynamics, productivity and resilience
FTA FP5 (A/M): Climate change mitigation and adaptation opportunities in forests, trees and agroforestry

---

CGIAR RESEARCH PROGRAM ON Fish

CGIAR Research Program on Fish

- FISH aims to enhance sustainability, productivity and access to fish by those most in need to reduce poverty, enhance food and nutrition security and improve natural resource systems.

FISH FP1 (A/m): Sustainable aquaculture
FISH FP2 (A): Sustaining small-scale fisheries

CGIAR RESEARCH PROGRAM ON Grain Legumes and Dryland Cereals

CGIAR Research Program on Grain Legumes and Dryland Cereals

- GLDC aims to increase the productivity, profitability, resilience and marketability of critical and nutritious grain legumes and cereals within the semi-arid and sub-humid dryland agroecologies of sub-Saharan Africa and South Asia. These agroecologies are where poverty, malnutrition, climate change and soil degradation are among the most acute globally.

GLDC FP1 (A): Priority setting and impact acceleration
GLDC FP3 (A): Integrated farm and household management
GLDC FP4 (A): Variety and hybrid development
GLDC FP5 (A): Pre-breeding and trait discovery

CGIAR RESEARCH PROGRAM ON Livestock

CGIAR Research Program on Livestock

- LIVESTOCK focuses on seizing opportunities presented by rapid increases in demand for animal-source food in developing countries, including a focus on low emissions development.

LIVESTOCK FP1 (A/m): Livestock genetics
LIVESTOCK FP2 (a/M): Livestock health
LIVESTOCK FP3 (a/M): Livestock feed and forage

LIVESTOCK FP4 (A): Livestock and the environment

CGIAR Research Program on Maize

- MAIZE is an international collaboration between more than 300 partners that seeks to mobilize global resources in maize research and development to achieve a greater strategic impact on maize-based farming systems in Africa, South Asia and Latin America.

MAIZE FP1 (A): Enhancing MAIZE's R4D strategy for impact
MAIZE FP2 (A): Novel diversity and tools for increasing genetic gains
MAIZE FP3 (A): Stress tolerant and nutritious maize
MAIZE FP4 (A/m): Sustainable intensification of maize-based systems for improved smallholder livelihoods

---

CGIAR Research Program on Rice

- RICE is a forward-looking, holistic, global partnership that focuses on the win-win proposition of the social, economic, and environmental sustainability aspects of rice.

RICE FP3 (A/M): Sustainable farming systems
RICE FP4 (A/m): Global rice array

CGIAR Research Program on Roots, Tubers and Bananas

- RTB is working globally to harness the untapped potential of those crops in order to improve food security, nutrition, income, climate change resilience and gender equity of smallholders.

RTB FP1 (A): Discovery research for enhanced utilization of RTB genetic resources
RTB FP2 (A): Adapted productive varieties and quality seed of RTB crops
RTB FP3 (A): Resilient RTB crops
RTB FP5 (A): Improved Livelihoods at Scale

CGIAR Research Program on Wheat

- WHEAT is an unprecedented global alliance for productive, climate-resilient and profitable wheat agri-food systems in lower and middle-income countries.

WHEAT FP1 (A): Enhancing WHEAT's R4D strategy for impact
WHEAT FP2 (A): Novel diversity and tools for improving genetic gains and breeding efficiency
WHEAT FP3 (A): Better varieties reach farmers faster
WHEAT FP4 (A/m): Sustainable intensification of wheat-based farming systems