



Sectoral Guide Consultation Version 1

Agriculture and food security



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Executive summary

Purpose of GCF's Agriculture and Food Security Sectoral Guide

This guide seeks to provide an overview of country needs and evidence-based programming experiences in the agriculture and food security (agriculture) sector. It aims to guide proposal development in the sector for the GCF in line with its investment criteria during its first replenishment period 2020-2023.

The importance of the Agriculture Sector in climate adaptation and mitigation efforts

The world is facing an unprecedented and interlinked global shocks and challenges that threaten the gains made in global food security and poverty reduction in recent years. In 2020, social and economic shocks related to COVID-19, climate change, conflict, and increasing natural hazards affected food production, disrupted supply chains, and exerted stress on access to safe, affordable, and nutritious foods. At the same time, humanity is also challenged with an unprecedented loss of biodiversity and ecosystem services where current food production systems constitute one of the major drivers behind this loss. Since most agriculture is rainfed in developing countries, climate change directly impacts agriculture by increasing temperatures, rainfall variability; and increasing the frequency and intensity of extreme weather-events. Dependence on rainfed agriculture in developing countries, poses additional threats to rural livelihoods in these countries.

Most of the conventional and modern seeds, animals, and farming practices providing the world's food are rendered less productive as the climate changes, having been developed for past climates and usually not suited for climatic specific contexts. Hence, farming and food systems need to be transformed across the globe to build resilience to these climate impacts and meet the increasing demand for food by growing populations and cities including by reducing food loss and waste. This need is most acute in developing countries, affecting at least 2.4 billion people on 19 million km² of agricultural land. Reconfiguring the world's agriculture and enhancing food and nutritional security will be challenging, but it offers opportunities for enhancing climate resilience, reducing agricultural CO₂ and non-CO₂ emissions (10-12% of global total, IPCC), and providing a suite of co-benefits, including: reducing the degradation of ecosystems and land and water resources; reducing biodiversity loss creating millions of new jobs by improving value chains in agriculture and market mechanisms; improving nutrition; reducing waste; and providing new opportunities for marginalized groups including women, youth and those living in poverty and indigenous peoples to manage resources and access services, assets, knowledge and skills.

Paradigm-shifting pathways

A transformation towards resilient and low-emission agriculture and food systems can be achieved through three paradigm-shifting investment pathways: 1) Promoting resilient agroecology; 2) Facilitating climate informed advisory and risk management services; and 3) Reconfiguring food systems. The three pathways are interlinked and need to be supported by enabling context to ensure their success.

The first paradigm shifting pathway on *Promoting Resilient Agroecology* supports adaptation and climate-resilient interventions to reduce the shock of a changing climate on agricultural productivity, while promoting low emission synergies, where possible and appropriate. The interventions in resilient agroecology directly respond to key regional climate hazards and the specific risks they pose to agricultural production, while building more resilient communities through improved farming systems and practices. Support for climate adaptation and

productivity gain can be targeted toward unique farmer groups and production value chain actors, and include improved climate-resilient varieties, innovative adaptation practices and technologies, diversification, improving land and water management, and appropriate financial mechanisms. Production technologies and practices should be financially viable and climate-resilient, but may also focus on low-emissions agriculture, ensuring that interventions are not maladaptive or contribute increasing risk.

The second paradigm shifting pathway on Facilitating Climate Informed Advisory and Risk Management Services emphasizes that climate information is key to mainstreaming climate considerations in agricultural management. Farmers often lack access to critical information about daily weather, what future climate risks they face, what they should do about these risks, and what risk management services are available to them. These services envisaged under this pathway can help farmers build resilience to climate change, proactively respond to climate hazards, lower transactional costs, increase production standards, and strengthen the development of national and local agricultural economies. When coupled with risk management interventions, such as insurance, and social protection programs, these can build resilience for agriculture and improve livelihoods of both the most vulnerable and food insecure farmers, as well as more well-off market-oriented farmers. Farming communities will be able to plan their farming systems better and plan ahead factoring in best response mechanisms.

The third paradigm shifting pathway on Reconfiguring Food Systems covers the process spanning from the farm-gate to the consumer and supports the transformation towards food systems that use resilient and low emission practices and technologies to feed the rapidly growing population. Activities would include avoidance of conversion of high carbon stocks (such as forests, peatlands) due to agriculture; shifts to energy-efficient fertilizer production; use of technologies, agricultural practices, energy sources and infrastructure on farms that reduce emissions and improve resilience to climate threats; reshaping supply chains, food retail, marketing, and procurement; reducing food loss and waste; shifting consumption towards healthier and more environmentally friendly, low-emission diets; and building supply chain resilience through reliable storage facilities. Climate-resilient food systems enable consistency and adaptive capacity in availing, transporting, processing, storing and distributing agricultural inputs and products. They foster national food security and support domestic and international agri-food business, and ensure that food systems are sustainable, deforestation-free, and inclusive of all actors of the value chain.

Barriers and enablers to achieving these paradigm-shifting pathways in the Agriculture and Food Security Sector

The key challenge faced in the agriculture and food security sector is the need to increase both the quantity and quality of food production, while reducing the sector's environmental footprint and achieving these objectives in the context of a changing climate and loss of biological diversity. The three paradigm shifting pathways provide a way to address this challenge across adaptation and mitigation areas. However, the financing required for this transformation is high. The Paris Agreement target of US\$ 100 billion annually, if split between mitigation and adaptation, is insufficient to meet future adaptation needs across all sectors. The cost of adaptation in agriculture alone will be more than annual target of Paris Agreement.

Climate resilient and low emission agriculture requires a holistic approach to address the adaptation and mitigation needs. There are a number of barriers across these pathways that limit their implementation. Some of the key general barriers include:

- Lack of integrated agricultural development planning and capacities that consider maladaptation risks and investment needs across the agriculture sector, climate information services and supply chains as well as inadequate attention in national

- climate change strategies and action plans;
- Limited investment in innovative farming practices, agricultural technologies and business models to incentivize farmers to adapt to a changing climate while maintaining high quality agricultural production and limiting the overuse or degradation of agroecology and ecosystem services;
- Lack of access to affordable finance for farmers and local agri-businesses to invest in low-emission agricultural practices, regenerative businesses and sustainable food systems:
- Inadequate public and private finance to invest in commercially viable climate-resilient projects and programs at scale;
- Lack of knowledge and access to information on resilient and low-emission agricultural practices and related benefits; cultural and behavioral barriers in changing food production systems and diets.
- Lack of awareness of low-emissions agricultural practices, use of modern ICT tools and techniques for advancing in technologies for climate resilient agriculture value chain and food systems.
- Cultural and behavioral barriers in changing food production systems and diets.

Notwithstanding the generic barriers, there the sector faces a number of pathway-specific barriers which need to be addressed to achieve low emission and climate resilient agriculture.

At the same time, experience has highlighted pertinent actions across these pathways that help to create enabling environment by addressing the key challenges in agriculture and food security sector:

- Alignment of appropriate incentive systems and policies at national and sub-national levels through institutional and regulatory reforms to foster change.
- Empowerment of communities and local leadership; and building on traditional knowledge, resources and agroecology.
- Inclusion of women, youth and marginalized communities, including indigenous people, to enhance their ownership of improved practices and increase productivity as well as profits and to attract the entire workforce towards adoption of climate resilient agriculture.
- Engagement of the private sector at all levels and scales as both actors and innovators on investments and financing of regenerative businesses across agriculture and food systems value chain.
- Evidence-based monitoring, evaluation and learning backed by science and data; knowledge management, and innovative approaches that links the three paradigm-shifting pathways.
- Capacity development of all stakeholder groups and by targeting their specific needs to deliver sustainable outcomes.

Role of the Green Climate Fund (GCF) in financing paradigm shifting pathways

As the world's largest climate fund mandated to promote a paradigm shift towards low-emission and climate-resilient pathways in developing countries, the GCF is well placed to support developing countries raise and realize their climate ambition in the agriculture and food security sector. Through its country-driven approach, the GCF helps countries design, finance and implement innovative climate initiatives that can be replicated, scaled up and sustained after project completion to achieve transformational change. The GCF offers a range of financing instruments (including grants, loans, guarantees, and equity) and works with diverse groups of partners in order to share risk and catalyze larger financial flows towards transformative climate investments. More details on the GCF's programming can be found in its [Programming](#)

[Manual.](#)

Based on its mandate and comparative advantages, the GCF offers its four-pronged approach to support developing countries drive implementation across these paradigm-shifting pathways. (Figure ES.1 below):

- **Transformational planning and programming:** Strengthen the capacity of developing countries to undertake integrated agricultural development planning that mitigates risks of mal-adaptation and maximizes joint adaptation-mitigation synergies and co-benefits; put in place enabling community-responsive policy frameworks; undertake policy changes such as subsidy reforms in an inclusive manner; and identify and design transformational climate investments in the agriculture and food security sector to realize their Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs). It is also important to understand the needs for extension services and their linkages to climate information, insurance and social protection programs, and co-design delivery systems to meet users' needs; as well as to catalyze opportunities for climate action in food systems. Such actions prepare the country for GCF investment and build its capacity for seeking other funding sources.
- **Catalyzing climate innovation:** Invest in innovative, high-potential business models, technologies, practices, and financing instruments with potential for scaling up; leverage emerging digital technologies and strengthen national capacities to empower farmers and agribusinesses to provide climate information services in new ways; and support countries develop innovative financing instruments, such as weather index insurances. About three quarters of GCF agriculture projects are currently funded with grants for climate innovation, primarily landscape-level projects in land and water management, resilient practices, irrigation, capacity building, climate information, livelihoods diversification, and market access.
- **Mobilization of finance at scale:** This includes a range of instruments including blended finance and innovative structuring to de-risk and catalyze public and private finance at scale. For example, leveraging guarantees and concessional finance to scale up successful, high-potential, climate-compatible investments by public and private partners; creating funds to support input suppliers, MSMEs and cooperatives; and incentivizing agroecology conservation and ecosystem services (watershed management, hydrological services, nutrient cycling) through payments for ecosystem services (PES). It also includes supporting public-private partnerships to stimulate resilient supply chains and mobilizing larger institutional sources of capital through aggregation and securitization via capital markets.
- **Coalitions and knowledge to scale up success:** Disseminate and enable uptake of best practices, technologies, and standards for transformational climate investment to replicate and scale up action. Leverage partnership and coalitions to expand successful practices. This process enables the GCF climate investment portfolio to function as a global thought leader, targeting investment to high-impact actions that are most closely suited to different agro-ecological and socio-economic contexts.

By making investments through these drivers across the three investment pathways, GCF can support developing countries catalyze a paradigm shift in agriculture and food security that will build the resilience of millions of small and vulnerable farm households, contributing to adapting to climate challenges, reducing emissions and to the sustainable development agenda.

Proposals to the GCF are assessed based on six GCF Board approved investment criteria (impact potential, paradigm shift, sustainable development, need of recipients, country ownership and

efficiency and effectiveness¹). This guide also provides some examples of how these criteria could pertain to the agriculture and food security paradigm-shifting pathways.

Figure ES.1: Drivers of change across paradigm shifting pathways

		Four drivers of paradigm-shift				
		Transformational Planning & Programming	Catalyzing Climate Innovation	Mobilization of Finance at Scale	Coalitions & Knowledge to scale up success	
Paradigm - Shifting Pathways	Promoting Resilient Agroecology	<ul style="list-style-type: none"> Integrated agricultural development planning that mitigates the risks of maladaptation & maximizes joint adaptation-mitigation synergies & co-benefits Enabling community-responsive policies, frameworks & practices Investment pipeline development 	<ul style="list-style-type: none"> Promoting new business & financing models for reaching scale that incentivize low-emissions resilient inputs, practices & technologies Integration of novel climate-responsive technologies, services & programs Promote landscape level NRM for hazard prevention 	<ul style="list-style-type: none"> Guarantees & concessional finance for input suppliers, SMEs & cooperatives Financial services for SMEs Incentivizing via PES Bundling services & interventions together 	<ul style="list-style-type: none"> Knowledge platforms for sharing what technologies, management practices & business models are most suited for different agro-ecological & socio-economic contexts Promoting successful business models for scaling resilient agriculture 	
	Facilitating Climate Informed Advisory & Risk Management Services	<ul style="list-style-type: none"> Understanding needs & identifying gaps for information, advisory, & extension systems Co-designing delivery systems to meet users' needs 	<ul style="list-style-type: none"> Developing & testing new business models & financing instruments for agricultural insurance & social safety net program Leveraging emerging digital technologies supports reaching scale Supporting incubation & acceleration of startups & SMEs 	<ul style="list-style-type: none"> Engaging private sector ICT service providers, maximizing synergies with PPPs, supporting start-up service providers Blended finance mechanisms with proven risk management business models 	<ul style="list-style-type: none"> Blended finance to engage private finance Technical investment assistance ESG impact measurement Mobilization of national & global funds through capital markets 	<ul style="list-style-type: none"> Monitoring, evaluation, & learning to inform scaling based on contextual relevancy & priority issues Promoting Public awareness & capacity building for scale
	Reconfiguring Food Systems	<ul style="list-style-type: none"> Identifying key leverage points for catalyzing high-impact adaptation & mitigation in sustainably productive food systems Behavior economics evaluation of demand for nutritious low-emissions food Strengthening policy coherence & cross-institutional coordination 	<ul style="list-style-type: none"> Enabling NRM, market, trade, & transport infrastructure Quality & sustainability certification & regulation Providing challenge grants for SMEs 	<ul style="list-style-type: none"> Supporting PPPs to stimulate resilient supply chains Capitalization of climate & food security funds Providing low-emissions resilient companies with guarantees, concessional debt & equity investments 	<ul style="list-style-type: none"> Engaging regional/global platforms to promote learning Replicating successful information & advisory system business models 	<ul style="list-style-type: none"> Supporting private sector actors mainstreaming climate risk in business model, internal policies & investments Engaging Food system platforms & industry alliances/groups

Introduction

Agriculture is central to food security¹, livelihoods, and economic development, across the world but more importantly in developing countries. Agriculture is largely characterized by rural production systems and support livelihoods for 86% of the world's rural population. It is also a key sector for climate change adaptation and mitigation. Many of the world's 500 million small-scale producers live in poverty, and face challenges such as disruptions from climate change, increasing demand for food from growing populations, and degrading agroecological landscapes and resources. Since these small-scale producers produce much of the planet's food, they need to be put at the forefront of reconfiguring our food systems². While many actions within the agriculture sector are interlinked, the impacts are affected by actions in many other GCF identified sectors, such as forest and land use, water, energy, ecosystem, and health. Agriculture and food security support employment across many sectors and can exacerbate or mitigate risks and hazards. The COVID-19 pandemic may add between 83 and 132 million people to the total number of already undernourished people in the world², reinforcing the importance of agriculture and its linkages to nutrition, migration, stability, and even national security.

This sectoral guidance shares the programming direction, evidence-based knowledge, best practices, and lessons learned to guide proposal development for the Green Climate Fund (GCF) under its first replenishment period 2020-2023. These investments aim to transform agriculture and food systems while meeting country priorities. This sectoral guidance also provides strategic insights into where GCF's funded activities can have the greatest impact across result areas related to agriculture and informs countries and accredited entities in developing funding proposals that meet the [GCF's investment criteria](#).

This guidance mainly supports the GCF result areas of most vulnerable people and communities; health, food and water security; and forest and land use. It also links to ecosystem and ecosystem services, resilient infrastructures, and energy access and generation. At the same time, GCF is preparing sectoral guides across its other results areas³ and recognizes the importance of a complementary approach. The table below shows the cross-sectoral issues addressed within this guidance and identifies cross-sectoral issues found in other sector guides.

¹ Food security in this document is defined broadly as “a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”. This includes food security for rural communities producing food, as well as food security for those communities that depend on the food produced by farmers (https://doi.org/10.1007/978-94-007-0753-5_1073).

² Food systems are here defined as: “ the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products. Food systems comprise all food products that originate from crop and livestock production, forestry, fisheries and aquaculture, as well as the broader economic, societal and natural environments in which these diverse production systems are embedded” FAO, IFAD, UNICEF, WFP and WHO. 2020. The State of Food Security and Nutrition in the World 2020.

³ GCF seeks to have an impact within eight mitigation and adaptation results areas: Low-emission energy access and power generation; Low-emission transport; Buildings, Cities, industries and appliances; Sustainable land use and forest management; Enhanced livelihoods of the most vulnerable people, communities and regions; Increased health and well-being, and food and water security; Resilient infrastructure and built environment to climate change threats; Resilient ecosystems.

SECTOR GUIDE NAME	CROSS-SECTORAL ISSUES ADDRESSED
Agriculture and Food Security (this document)	Agroforestry; soils, grassland and water management for food production; livestock and manure management; aquaculture; climate information for farmers; insurance; and staple and cash crop food systems; nutrition and food security; food waste.
Forest and Land Use	Forest protection at the agricultural frontier; watershed protection for agricultural production
Ecosystem and Ecosystem Services	Fisheries and fishery supply chain management; peatland; land restoration for ecosystem services; watershed management; soil fertility and regenerative agriculture, provision of pollination and pest control services for resilient agriculture, maintenance of water balance for crop and livestock production.
Energy	Biomass fuel from agriculture
Water	Wastewater management; water management for flood control
Health	Agricultural pollutants and human health; nutrition; diets

This sectoral guide has five sections. Section 1 provides an overview of the agriculture and food security sector within the global context of climate change. Section 2 highlights key paradigm shifting pathways for climate resilience and low-emission agriculture and food security, as well as the GCF drivers to realize the pathways. Section 3 sets out financing instruments to scale up public and private investment in the agriculture and food security sector, including GCF financing structures. Section 4 demonstrates successful country cases in leveraging the four paradigm-shifting drivers. Section 5 provides guidance for developing proposals aligned with the GCF investment criteria.

1. Global Context

1.1 The scientific basis: Why is agriculture and food security relevant to climate action?

Meta-analyses of studies of climate change impacts on crops indicate a 70% of declines in crop yields by the 2030s, with yield losses of 10-50% in half the studies⁴). Yield changes can be expected from many factors, including shifting rainfall patterns, amount and intensity coupled with increased temperatures causing climate hazards and natural disasters such as flood and drought. For the major cereals (wheat, rice and maize) in tropical and temperate regions, climate change without adaptation will negatively affect production for local temperature increases of 2 °C or more above late-20th-century levels, although individual locations may benefit from such variations. After 2050, the risk of more severe impacts on losses in crop yield will increase substantially, and the variability of crop yields across years in many regions will also increase Porter et al. (2014⁵ documented several studies that show a large negative sensitivity of crop yields to extreme daytime temperatures around 30 °C. High-emission scenarios up to the end of the current century will regularly exceed such temperatures during the crop growing season, particularly in lower latitudes. Although rainfall projections into the future are more uncertain than temperature projections, growing seasons in many parts of the tropics are projected to shorten⁶, with dramatic consequences if global warming is not contained. Changes in climate and CO₂ concentration are projected to increase the distribution and competitiveness of and invasive weeds of agronomic importance³In addition, studies have highlighted the negative effects of elevated CO₂ on the protein and micronutrient density of many foods⁷

Climate change will affect livestock systems through changes in herbage growth brought about by changes in atmospheric CO₂ concentrations and shifts in rainfall and temperature regimes, affecting the composition of pastures and the quality of fodder. While increases in CO₂ concentrations and rainfall may increase net primary productivity of rangeland, increased temperatures limit such positive effects and changes in many rangelands are likely to be negative⁸. Thus, widespread negative impacts of climate change on forage quality are projected⁹. As temperatures increase,

⁴ Challinor, A.J., Watson, J., Lobell, D.B., Howden, S.M., Smith, D.R. and Chhetri, N., 2014. A meta-analysis of crop yield under climate change and adaptation. *Nature Climate Change* 4(4), 287-291.

⁵ Porter JR, Xie L, Challinor A, Cochrane K, Howden M, Iqbal MM, Lobell D, Travasso MI, 2014. Food Security and Food Production Systems. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. <http://www.ipcc-wg2.gov>

⁶ Ericksen PJ, Thornton PK, Notenbaert A, Cramer L, Jones PG, Herrero M, 2011. Mapping hotspots of climate change and food insecurity in the global tropics. CCAFS Report no. 5. CGIAR Research Program on Climate Change, Agriculture and Food Security (CAAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org

⁷ Myers, S.S., Smith, M.R., Guth, S., Golden, C.D., Vaitla, B., Mueller, N.D., Dangour, A.D. and Huybers, P., 2017. Climate change and global food systems: Potential impacts on food security and undernutrition. *Annual review of public health* 38, 259-277.

⁸ Boone RB, Conant RT, Sircely J, Thornton PK, Herrero M, 2018. Climate change impacts on global rangeland ecosystem services. *Global Change Biology* 24(3), 1382-1393.

⁹ Porter JR, Xie L, Challinor A, Cochrane K, Howden M, Iqbal MM, Lobell D, Travasso MI, 2014. Food Security and Food Production Systems. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of*

increasingly negative effects on feed intake, reproduction and performance across all domesticated livestock species can be expected, notwithstanding substantially increased water demand by animals in some areas. Changes in climate coupled with increasingly frequent extreme weather events will affect host-pathogen systems, and outbreaks of some tropical vector-borne diseases that are highly sensitive to climatic conditions and their incidence may become more frequent.

Likewise, Climate change will affect aquatic systems. Increasing temperatures will lead to increased production of fishery resources in some areas, but decreased production in others. Increases in marine acidification will negatively affect important invertebrate species, including those responsible for building coral reefs that provide essential habitat for many fish species. The poorest fishers and others dependent on fisheries and subsistence aquaculture will be the most vulnerable to these changes¹⁰

Impact of climate change on food security

Given that at least 70% of agriculture globally is rain fed, the links between changes in climate and climate variability (particularly rainfall, temperature and extreme events) agriculture and food and nutrition security are clear. This applies not only to direct production and productivity changes but also to the entire value chain. All dimensions of food security and the food system may be affected by climate change, including food access, utilization and stability. Although there is limited quantitative understanding of how non-production elements of food security may be affected, the extent of adaptation possibilities, costs and benefits in these domains¹¹, several studies indicate that real prices for food are likely to have future increases under climate change than compared with no climate change scenario. The resultant impacts on global nutrition indicators vary across scenarios and studies^{-12, 13}, For instance, nutrition outcomes in some regions such as sub-Saharan Africa are not projected to improve without substantial investment and adaptation action. The after-effects of both short-term price shocks and climate-related disasters such as drought and flood on food insecurity may be greater than those associated with climate change, particularly in the first half of the current century (Porter et al., 2014; Nelson et al., 2014).

The relationship between climate change and food production depends to a great extent on the preparedness and adaptation actions and their timely executions. Adaptation outcomes focusing on ensuring resilient food systems under a changing climate could have the most direct benefits on livelihoods, which have multiple benefits for food security, including enhancing food production,

Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

<http://www.ipcc-wg2.gov>

¹⁰ Ibid

¹¹ Ibid

¹² Porter JR, Xie L, Challinor A, Cochrane K, Howden M, Iqbal MM, Lobell D, Travasso MI, 2014. Food Security and Food Production Systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. <http://www.ipcc-wg2.gov>

¹³ Nelson, G. C., H. Valin, R. D. Sands, P. Havlík, H. Ahammad, D. Deryng, J. Elliott, S. Fujimori, T. Hasegawa, E. Heyhoe, P. Kyle, M. von Lampe, H. Lotze-Campen, D. Mason-D’Croz, H. van Meijl, D. van der Mensbrugge, C. Müller, A. Popp, R. Robertson, S. Robinson, E. Schmid, C. Schmitz, A. Tabeau, and D. Willenbockel. 2014. Climate change effects on agriculture: Economic responses to biophysical shocks. Proceedings of the National Academy of Sciences 111(9): 3274-3279. <https://dx.doi.org/10.1073%2Fpnas.1222465110>

access to markets and resources, and reduced disaster risk. In cropping, livestock and fisheries systems alike, there are many possible adaptation options. In some cropping systems in developing countries, farmers are already adapting to observed climate changes, for example by altering cultivation, sowing times, crop cultivars and species to help ensure food production and thus contributing to enhanced food security. Some livestock farmers are switching to more resilient breeds of cattle, or to more resilient species altogether, such as camels and small livestock. In aquaculture systems, different management approaches can help to increase system resilience, helping fishing and aquaculture communities respond to the challenges brought about by climate change.

Climate risks in agriculture

The framework of climate-related risk from IPCC¹⁴ focuses on assessing the risk of specific consequences or impacts that may harm a system. The vulnerability of the system is one of three components of the risk, with exposure and hazard being the other two components. Despite the uncertainties concerning development and greenhouse gas emission pathways into the future, there is a considerable and growing amount of information on the spatial variation of climate change impacts on farming systems around the world, and on populations who may be most at risk.

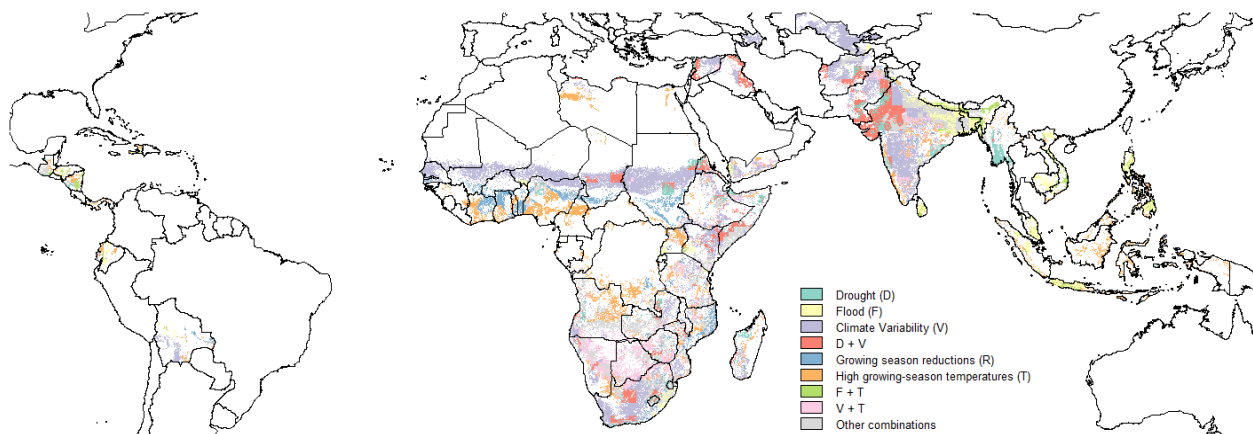
Based on a broad-brush climate risk assessment for agriculture which builds on previous study¹⁵, has highlighted regional differences in the climate change hazards that regions face, their adverse effects on agriculture and rural livelihoods; and the types of adaptation action needed in different agroecological situations to strengthen the capacity of agrarian communities to address climate hazards in the future.

Figure 1 shows areas in Latin America, Africa, and Asia facing substantial impacts from different climate hazards to agriculture combined with chronic food insecurity. It can be discerned from the spatial analysis that 73 countries have high exposure and acute vulnerability to droughts, floods, climate variability, reduction in crop growing season, high temperatures, and their combination. It shows the places where small-scale agricultural producers are already facing high climatic risk, and those where these risks may increase by mid-century. Because the risks vary in time and space, different interventions may be needed to help producers, particularly in large parts of sub-Saharan Africa and South Asia, become more resilient to the changing climate in order to achieve food security of the population. The climate risks in agriculture and food security sector are prominent and hence need climate informed decision making throughout the agriculture and food systems value chain.

Figure 1: Areas of current and future climate risk for agriculture³

¹⁴ IPCC, 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York: Cambridge University Press. <http://www.ipcc.ch/report/ar5/wg2/>

¹⁵ Ericksen PJ, Thornton PK, Notenbaert A, Cramer L, Jones PG, Herrero M, 2011. Mapping hotspots of climate change and food insecurity in the global tropics. CCAFS Report no. 5. CGIAR Research Program on Climate Change, Agriculture and Food Security (CAAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org



1.2 Global adaptation and mitigation targets: Where is the sector today?

Agriculture sector is highly impacted by climate change but at the same time, also contributes to climate change thus necessitating a holistic consideration of both mitigation and adaptation. The Paris Agreement acknowledges adaptation challenges such as “the fundamental priority of safeguarding food security and ending hunger, and specific vulnerabilities of food production systems to the adverse impacts of climate change”. Farmers and supply chains around the world are adapting to climate change, but there are considerable challenges ahead in producing 30-60% more food by 2050 while still achieving greenhouse gas (GHG) emission reduction targets and securing agroecology and ecosystem services. Agriculture is responsible for 19% of global GHG emissions, 11% through direct emissions, and additional 8% through indirect emissions from converting land for agricultural expansion⁴; with food losses accounting for another 8%. Furthermore, direct agricultural emissions of methane and nitrous oxide contribute 10-12% of global emissions⁵. Non-Annex I countries produce about 75% of these global non-CO₂ emissions in agriculture⁶. Agricultural expansion leads to about 80% of deforestation related emissions. Within agricultural production systems, livestock, is the largest source of emissions and the sub-sector and its emissions are expected to grow with increasing demand for livestock products. Reducing agricultural emissions to zero by 2050 would not be feasible given the current practices and projected food demands.

Climate resilient and low-emission practices in agriculture and food security sector provide viable strategies for large-scale adaptation and mitigation impacts leading to paradigm shifts. Agricultural production is expected to grow by 15% from 2019 to 2028, and direct agricultural emissions to increase by 5%⁷. Virtually all countries (179 of 189 iNDCs submitted) included agriculture in their adaptation priorities and 63% included agriculture GHG mitigation targets⁸. Productivity improvements will outpace emissions increases, suggesting that coupled with the mitigation potential of different agricultural practices (agroforestry, regenerative agriculture, etc.) agricultural development can be compatible with mitigation, but only if additional carbon is not lost from the soil or from high carbon stock ecosystems like forests and peatlands. This will require intensifying use of existing lands and restoring degraded lands rather than clearing additional forest.

Agricultural adaptation policies and measures, mostly focusing on crops and livestock, are included

in 90% (120 of 133) of non-Annex I country NDCs to the Paris Agreement⁹. Creating a paradigm shift – particularly for small-scale agricultural producers – involves incentives and opportunities for shifting from subsistence, climate-impacted livelihoods to more climate-resilient and food secure livelihoods, with greater market integration and climate-resilient value chains. Opportunities exist to foster synergies between mitigation and adaptation that link the two goals. Production technologies and practices should be financially viable and climate-resilient but also low in emissions, putting countries on low-emission development pathways. There are also potential synergies between resilient and low-emissions technologies and practices that provide other environmental and social co-benefits addressing, for example, groundwater depletion, freshwater pollution, land degradation, and loss of biodiversity and indigenous people.

1.3 Global adaptation and mitigation targets: Where does the sector need to be?

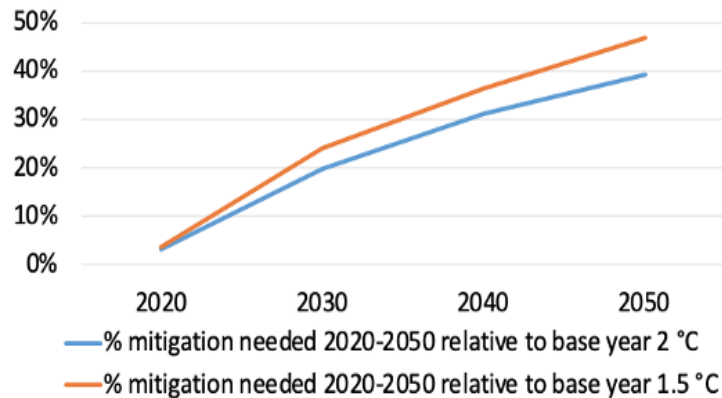
Climate change resilience and low-emission development in agriculture and food security sector are essential to meeting the Paris Agreement and Sustainable Development Goals (SDGs) on Climate Action. To align with a 2 °C mitigation target, the agriculture sector will have to reduce nitrous oxide and methane emissions by about 1.5 billion tonnes of CO₂ equivalents per year by 2030; this would entail reducing 2020 emission rates by about 20%. For the 1.5-degree target, emissions must decline by ~1.9 billion tonnes of CO₂e per year by 2030, or about 24% relative to 2020 levels (Figure 3). This is about 6% (2 °C) or 7% (1.5°C) of the 26 billion tonnes of CO₂e per year of mitigation needed across all sectors in 2030¹⁰. A target for carbon sequestration in agricultural soils, based on low-cost options and simple assumptions about increased efficiency of crop and livestock production and reduced land use change, used in IPCC integrated assessment modeling of land use scenarios¹¹, is ~1.2 billion tonnes of CO₂e by 2030.

Many SDGs are also directly relevant to agriculture and food security targets: changing global agriculture and food systems to end hunger and cater to an additional 2 billion people by 2050 (SDG 2); decreasing GHG emissions and increasing food availability along supply chains while reducing food waste (SDG 12.3); species conservation and ecological services compatible with resilient low-emissions agriculture (SDG 15); poverty reduction (SDG 1); economic growth and jobs for youth (SDG 8); improving women's status in agricultural value chains (SDG 5); and peace, justice and strong institutions (SDG 16).

The scale of meeting adaptation, mitigation and the SDGs simultaneously are enormous. Many regions of the world have only 9 agricultural seasons left to achieve their SDGs by 2030. This calls for an agricultural paradigm shift that would provide multiple benefits, including poverty alleviation, employment, environmental sustainability, and means of addressing under- and over-nutrition, food loss, and food waste, among other issues. The Global Commission on Adaptation suggests the need to reach at least 300 million small-scale agricultural producers by 2030 to achieve these goals.

Targets for 1.5 °C and 2 °C pathways are based on average values of emissions needed in the agriculture, forestry, and other land use (AFOLU) sector for N₂O and CH₄ for Representative Concentration Pathways (RCPs) 1.9 and 2.6 using integrated assessment scenarios for SSP2 (the middle-of-the-road shared socioeconomic pathway). Full accounting for supply chain or land use change impacts are not depicted.

Figure 2: Mitigation needed from 2020 to 2050 to stay below the 2 °C and 1.5 °C policy targets.



1.4 Financing Adaptation and Mitigation: How much will it cost to meet these targets?

Global adaptation costs are increasing as challenges mount and inaction persists. Estimates of global adaptation costs in developing countries may be as high as US\$ 140-300 billion per year by 2030 and US \$500 billion per year by 2050, depending on the study, methods, and tools used¹². Based on these estimates, the Paris Agreement target of US\$ 50 billion annually across all sectors is insufficient to meet future financing needs for adaptation.

With respect to mitigation, US \$5-30 billion is needed annually by 2030 to implement measures costing up to US \$20 per tonnes of CO₂e globally, directed mostly toward improving management of croplands and grazing areas. Accounting for actions such as restoring soils and soil carbon would increase the total cost to US \$30-460 billion in 2030 for mitigation measures costing up to US \$100 per tonnes of CO₂e. However, if mitigation measures are prioritized and disincentive measures are avoided, the financing gap can be minimized to a greater extent. For instance, global agricultural subsidies in 2017 alone amounted to more than US\$ 500 billion and mobilization of a portion of that on climate actions could bring a transformational change in climate mitigation and adaptation. The Global Commission on Adaptation recently estimated that US\$ 1.8 trillion invested in global adaptation from 2020 to 2030 would generate US\$ 7.1 trillion in total net benefits.

2. Paradigm-Shifting Pathways in agriculture and food security sector

2.1 Three Paradigm-Shifting Pathways in the Agriculture and Food Security Sector

Transformation towards climate resilient and low emission agriculture requires a holistic approach to address the adaptation and mitigation needs. Based on experience, three paradigm-shifting pathways - **(1) Promoting resilient agriculture; (2) Facilitating climate informed advisory and risk management services; and (3) Reconfiguring food systems** - have been identified to achieve that goal. The three pathways are interlinked and share many of the same interventions and proposed actions the steps to achieve each of them are important across all three pathways.

Pathway 1: Promoting Resilient Agroecology

The impacts of hazards and shocks from climate change, their consequences for agriculture and rural livelihoods, and their adverse effects on the economies of developing countries are severe and ever increasing. The *Promoting Resilient Agroecology* pathway supports adaptation, while fostering mitigation and ecological health synergies and ensuing co-benefits. Climate-resilient interventions pertinent to agroecological conditions can reduce climate shocks on agricultural productivity. Climate hazards pose significant threat on gains made in poverty reduction and food security for at least 2.4 billion people on 19 million km² of agricultural land in the lower latitudes. Smallholder producers, particularly women and other marginalized groups, are among the most vulnerable to such risks. Priorities for resilient agriculture should directly respond to key regional climate hazards and the specific risks they pose to agricultural production within that context and within the farming landscapes

Reorienting how farmers manage fields, farms, ranches, communal lands and natural habitats is the direct mechanism to achieve resiliency within given context. A range of adaptation interventions can be promoted to unique farmer groups and value chain actors, introducing actions that include: improved and climate-resilient crop varieties and livestock breeds; innovative adaptation practices and technologies; improving natural resource management (land, water, ecosystems, biodiversity) and use of other production inputs.).

Improved seeds, crop varieties, and livestock breeds that address specific climate risks are key to adapting to climate change. Sustainable practices and technologies also include, for example, agroecological approaches¹⁶, water resource management, integrated pest management, integrated soil management, agricultural system diversification, agroforestry. Diversifying crops and livestock and introducing improved or locally developed varieties are key components of improving on-farm productivity and resilience including non-farm activities. Crop, livestock and aquaculture diversification can improve resilience by buffering crop production from the effects of greater climate variability and extreme events, and by reducing pest and disease outbreaks. There exists a vast experience of such accomplishments through crop rotation, intercropping, mixed cropping and other variations based on agroecology.

Soil and water management is critical since agriculture in developing countries is largely rainfed. Rainfall variability induced by climate change are likely to alter crop cycles due to shifts in seasonality

¹⁶ <http://www.fao.org/agroecology/knowledge/practices/en/>

and imbalances in production parameters. Further the extreme weather events such as drought and floods will cause soil erosion and loss of crop yields, livestock and even human lives. There is a need to better manage soil, irrigation, drainage and water flow and storage to reduce vulnerability and increase resilience. Promising actions include technologies such as efficient and climate proofed irrigation systems, use of renewable energy for irrigation, integration of woody species and cover crops for integrated water management at watershed level. Soil management interventions, such as minimum tillage and residue management have proven to improve soil water infiltration and water holding capacity. Improved approaches for water resource management at landscape, watershed level can support resilient and equitable water distribution, access and use

Improved agricultural production systems suited to agroecological conditions would reduce absolute emissions of N₂O and CH₄, minimize the emissions intensity of food, increase reliance on efficient and renewable energy, avoid further conversion of high-carbon landscapes, and increase carbon sequestration in the soil and biomass to offset emissions. While building resilience and increasing productivity will often be the main objective for small-scale agricultural producers, realization of low-emission co-benefits would encourage large scale adoption. Synergistic programming between adaptation and low-emissions goals offer opportunities for integrated solutions that are economically feasible and consistent with sustainable agriculture practices that are accessible, inclusive and culturally appropriate. These include (but are not limited to) improving management practices of paddy rice, nitrogen, manure, grazing land and livestock (fodder management and stall feeding), , Considerations should be given to enhancing soil health and organic carbon sequestration in cropping systems; tailoring improved seed and crops to local contexts; and increasing agroforestry, and regenerative agriculture compatible to agroecology. These climate-resilient and low emissions practices and technologies need to be geographically targeted and scaled with an understanding of local needs, socio-economic contexts, and biophysical factors to tailor interventions accordingly.

Achieving this paradigm shift to a climate-resilient agricultural production will require hundreds of millions of farmers innovating at landscape levels to manage lands and safeguard ecosystem health, produce the world's food in the face of a changing climate, and reduce agricultural GHG emissions. It also requires expanding access to appropriate financial mechanisms that support the uptake and scaling of resilient agricultural technologies and practices.

Pathway 2: Facilitating climate informed advisory and risk management services

Climate information and early warning systems have an important role given the increased frequency and intensity of natural hazards, including storm, flood, drought, pest outbreak, or heat waves. Information and advisory systems combined with enhanced extension services support both Pathways 1 and 3, and further help farmers in building resilience to climate change, reduce emissions, lower transaction costs, increase productivity, improve production standards, and strengthen the development of national and local agricultural economies. Advances in digital agriculture are already leading to swift changes in providing better information and advisory, and early warning, but also shifting the dynamics of different actors across value chains. When coupled with risk management interventions, such as insurance and social protection programs, these can improve livelihoods and build resilience for both the vulnerable food-insecure farmers, and well-off market-oriented farmers.

There is an increasing emphasis on using climate-informed digital advisory services to empower both small farmers and agribusinesses. Investing in digitalization could facilitate more evidence-based decision-making in the agriculture and food security sector. The rapid expansion of mobile

phones offers the potential to use climate related early warning systems to alert producers and businesses to natural hazards of all kinds. It also allows the agricultural extension and advisory service to be based on evidence for specific agro-ecological areas for specific areas and better targeting of the recipients.

While climate change phenomena increase the need for rapid information flows the agricultural extension services have not been able to keep pace with the changing circumstances. It has long been under-funded and focused on male farmers and large farms, resulting in significant gaps in access by women (who compose 43% of developing country farmers¹⁷), youth, smallholders, and other vulnerable groups¹³. Experience has shown that gender and age responsiveness are key to meeting the needs of all farmers such as Women Extension Volunteer Approach in Ghana¹⁴ to cite an example. There are other mechanisms such the youth “infomediary” model¹⁵, and “farmer promoters” through the Participatory Climate Services for Agriculture (PICSA) approach¹⁶. Designing and deploying multi-channel, multi-directional delivery mechanisms can ensure that all target groups have ample opportunities to receive information and services without additional burden. The most effective delivery mechanisms tend to be those that facilitate personal relationships and multi-way communication and low or no cost, including in-person extension, cooperatives, community representatives, knowledge exchange platforms, and social mobile apps. Participatory radio campaigns with integrated call-in services, such as Farmradio.org, have proven particularly effective as has popular culture; Shamba Shape-up, a farm renovation television series. The associated iShamba mobile service, increased income or food production for nearly 429,000 viewer households in 2014¹⁷, and is now watched by over 6 million viewers per week¹⁸.

Digital technology investments can reduce transaction costs, supporting transparency and risk management, and speeding cash flows. The emerging big data analytics offer the opportunity to analyze, understand, and address the underlying risks of market failures. Improving access to innovative technologies, including digital agriculture and service provisions, such as that offered by iShamba, can increase the potential for scaling and replication exponentially. Tech-enabled finance provides an opportunity to develop new financial and market service delivery models. More general e-commerce in agriculture sector can reduce transaction costs and effectively bridge the gap between smallholder farmers and consumers.

Customized information packages, training on financial literacy, and access to finance on incremental basis can help ensure the reach of financial services to women, youth, and the impoverished so they can make prudent investments to adapt to climate variability and change, and ultimately raise their productivity and income. Promoting financial inclusion is crucial to develop and implement innovative approaches to finance that go beyond private collateral as the basis for lending. For example, mobile money in Kenya has given women more control over their finances and supported female-headed households in addressing their poverty¹⁹. Such support fosters robust supply chains and attracts private sector engagement and investment.

Insurance is a classic approach to risk management that transfers and distributes risk while ensuring that households do not have to trade long-term benefits (e.g. school attendance and healthcare) for short-term survival (e.g. food purchases). Weather index insurance programs can be offered by governments or the private sector in small increments. They increase the resilience of vulnerable smallholder farmers by linking insurance payouts to a predefined index such as rainfall level, temperature, or crop yield. Index insurance explicitly targets obstacles to farmers’ income, integrates with other development interventions, gives farmers a voice in the design of products, and invests in

¹⁷ FAO, 2011, <http://www.fao.org/3/i2050e/i2082e00.pdf>

local capacity²⁰. Several hundreds of thousand farmers are now covered by index insurance contracts throughout Africa²¹ with promising growth in adoption levels²², although significant challenges remain to be addressed²³. Equity frameworks designed specifically for insurance are useful tools to support inclusive approaches²⁴. Insurance and the payouts can be tied to mobile platforms and linked to climate-informed advisories that reduce risk and bring the premiums down to manageable levels.

Adaptive approaches can be bundled for synergistic benefits. Social safety nets support food-insecure households during climate and food security crises. The sheer existence of such systems makes vulnerable households more willing to try new innovations to improve on-farm production and resilience. For example, Ethiopia's Productive Safety Net Program¹⁸ targets participatory integrated watershed management and degraded land rehabilitation programs at both the landscape and smallholder farm levels, to restore and build the productive capacity and ecosystem services of the land while also providing essential support for households. The results show a potential for integrated programs working at the scale of both farm and landscape to be transformational.

Pathway 3: Reconfiguring food systems

Ensuring food security starts with producing food, but must also include how food is stored, transported, sold and consumed. Food systems reconfiguration includes reshaping supply chains, procurement, marketing, and retail; reducing food loss and waste; shifting consumers to demand safer, healthier and more environmentally sustainable diets; and building supply chain resilience through resilient storage facilities²⁵ among others. Food systems must be environmentally sustainable, deforestation-free, inclusive of all producers, and supportive of rural employment opportunities.

Climate-resilient food systems enable adaptive capacity in mobilizing, transporting, processing, storing and distributing agricultural products, fostering national food security and supporting domestic and international agricultural businesses. Climate impacts and other shocks like COVID-19 disrupt these essential systems in a variety of ways, directly affecting their economic viability and profitability and ultimately food access and security (e.g. in urban and peri-urban areas even if there is food in the stocks). GCF investments have the potential to not only improve resilience to climate impacts, but also to other shocks, such as COVID-19.

The food value chain including production, storage, transportation, processing, marketing and distribution practices all contribute to GHG emissions. Low-emission goals for food systems include significant dietary shifts, reducing food loss and waste, improving energy efficiency, and finding alternative sources of energy across the value chain, suggesting that multisectoral approaches need to be adopted. Large agri-food actors are increasingly exhibiting their social responsibility, however, there is a need for adoption of more consistent approach climate considerations should be coherently embedded in their operations at all levels.

Catalyzing a paradigm shift in the food system requires suites of interventions including coordinated policies, capacity building, technological innovation, service provision, and engaging stakeholders to forge stronger ties between consumption and production hubs. Enabling environments for inclusive business models help ensure sustainability of outcomes, market development, and market reorientation. Emphasizing supply chain and market integration can help reach farmers at scale by providing opportunities to promote and incentivize climate-resilient and low-emissions interventions. There is an important role for both smaller actors, such as local cooperatives, and

¹⁸ <https://essp.ifpri.info/productive-safety-net-program-psnp/>

industry platforms and farmer organizations like the World Business Council for Sustainable Development, the International Fertilizer Association, World Farmers' Organization, Committee on World Food Security (CFS) along with other global, regional, national and local organizations. These provide opportunities to engage with public and private stakeholders in the value chain.

Greater commitments to sustainability across food systems ranging from supporting sustainably produced and certified products, to enhancing demand for organic and locally produced foods, to reducing food losses from production to consumption are needed to achieve sustainable food systems. One of the most visible industry efforts toward low-emission resilient agriculture are the 750+ zero-deforestation commitments (as of 2017) made by producers, processors, traders, manufactures, and retailers²⁶. While few of these commitments have been met by 2020, they are important milestones and demonstrate the need for systematic approach for tracking as well as incentives to encourage climate resilience. Identifying relevant incentives pertinent to stakeholders across the food system can unlock numerous opportunities to transform livelihoods. Supporting sustainable food systems provides significant potential for Agri-food businesses to gain from expansion in market share, potential price premiums, reducing reputation risk, improved bottom-line profits and ensuring long-term supply chain sustainability.

2.2 Barriers and cross-cutting enablers for the Paradigm-Shifting Pathways

2.2.1 Barriers

- There are a number of policies, institutional, financial and technical barriers that cut across the three paradigm shifting pathways that limit their implementation at scale. There are also several pathway specific barriers that are discussed in section 2.3. Some of the key general barriers include: Lack of integrated agricultural development planning and capacities that consider maladaptation risks and investment needs across the agriculture sector, climate information services and supply chains as well as inadequate attention in national climate change strategies and action plans;
- Limited investment in innovative farming practices, agricultural technologies and business models to incentivize farmers to adapt to a changing climate while maintaining high quality agricultural production and limiting the overuse or degradation of agroecology and ecosystem services;
- Lack of access to affordable finance for farmers and local agri-businesses to invest in low-emission agricultural practices, regenerative businesses and sustainable food systems;
- Inadequate public and private finance to invest in commercially viable climate-resilient projects and programs at scale;
- Lack of knowledge and access to information on resilient and low-emission agricultural practices and related benefits; cultural and behavioral barriers in changing food production systems and diets.
- Lack of awareness of low-emissions agricultural practices, use of modern ICT tools and techniques for advancing in technologies for climate resilient agriculture value chain and food systems.
- Lack of secure land tenure and farm size limiting farmers ability to invest in improved management practices.

2.2.2 Enablers

The barriers need to be addressed to enable the agriculture and food security sector in achieving paradigm shorts. Experience has highlighted pertinent actions across these pathways that help to

create enabling environment by addressing the key challenges in agriculture and food security sector:

National and sub-national policy, institutional, and regulatory environments must provide appropriate incentives to foster change at scale. Together, they create enabling environment to achieve cost-effectiveness and integrate adaptation and mitigation actions. Such enabling mechanisms will need to be country and context specific and will encompass sectors beyond agriculture. The thematic aspects of gender, private sector and governance need to be taken into account to foster transformative changes across food systems.

Empowering communities and local leadership are essential to avoid marginalization of the resource-poor and vulnerable groups while encouraging market-based approaches. Empowerment of producer and consumer organizations, women, youth, marginalized groups, and local leaders would play a vital role in integrating local solutions, enhancing ownership of initiatives, strengthening their negotiating power, and increasing access to resources which are essential for lasting impact.

Inclusion of women and youth, and other marginalized groups, such as indigenous people, will increase productivity and help engage the entire workforce. Building an enabling context means expanding their access to the means of productivity, including land tenure, financing, inputs, extension services, training, markets, paid work, and decision-making authority. Such enabling environment would produce livelihood gains with multiplier effects and contribute to rapid post COVID-19 recovery. Cultural challenges also need to be addressed to ensure effective participation of these groups. In rural areas, promoting innovation such as the Climate-Smart Agriculture Youth Network, can attract a fresh mass of workforce with a deep understanding of local agricultural production systems and interest in national and global change.

Engaging the private sector at all scales, given their role in innovative investments and mobilization of financial resources, is essential for catalyzing change. At farm and local levels, it means expanding the assets and capacities of small-scale, subsistence producers for more resilient livelihoods and enhanced productivity, facilitating their contributions to more sustainable food markets. At broader scales, the private sector can have a leadership role in supporting climate-resilient, sustainable and regenerative business practices throughout the entire agricultural value chains, generating employment in emerging sectors and markets, while also reducing their own risks from climate impacts.

Evidence-based learning, knowledge management, monitoring and evaluation based on science, digital technology, data, research and innovation can revolutionize agricultural production and food systems and link the three paradigm-shifting pathways. Harmonizing existing data and systems, building on geospatial information, and identifying best practices based on evidence adapted to local contexts can provide a strong basis for new insights, enhance replication and reduce duplication. In addition, the support for locally managed information systems that encourage local and regional peer to peer sharing and learning plays a key role.

Capacity building at all scales, from farmers to market intermediaries, financial institutions, agricultural research, higher education, and policymakers, is key to delivering sustainable outcomes. Capacity building efforts need to cater towards understanding climate risk; identifying, designing, and implementing transformational climate investments and enabling frameworks; introducing new resilient and low-emission technologies; leveraging private finance; strengthening local organizations; and building an enabling policy context.

2.3. Role of the GCF in financing the paradigm shifting pathways

As the world's largest climate fund mandated to promote a paradigm shift towards low-emission and climate-resilient pathways in developing countries, the GCF is well placed to support developing countries achieve transformative change in the agriculture and food security sector. Through its country-driven approach, the GCF helps countries design, finance and implement innovative climate initiatives that can be replicated, scaled up and sustained after project completion to achieve transformational change. The GCF offers a range of financing instruments (including grants, loans, guarantees, and equity) and works with diverse groups of partners in order to share risk and catalyze larger financial flows towards transformative climate investments. More details on the GCF's programming can be found in its [Programming Manual](#).

Based on its mandate and comparative advantages, the GCF offers a four-pronged approach to address the barriers highlighted above and drive implementation of the paradigm-shifting pathways at scale (figure 3): **transformational planning and programming** to support preparation and readiness; **catalyzing climate innovation** by identifying and promoting new business models, technologies, and financing mechanisms; **mobilization of finance at scale** to ensure financial sustainability; and **leveraging coalitions and knowledge** to scale up and replicate successful endeavors.

Figure 3: Drivers of change across paradigm shifting pathways

		Four drivers of paradigm-shift				
		Transformational Planning & Programming	Catalyzing Climate Innovation	Mobilization of Finance at Scale	Coalitions & Knowledge to scale up success	
Paradigm - Shifting Pathways	Promoting Resilient Agroecology	<ul style="list-style-type: none"> Integrated agricultural development planning that mitigates the risks of maladaptation & maximizes joint adaptation-mitigation synergies & co-benefits Enabling community-responsive policies, frameworks & practices Investment pipeline development 	<ul style="list-style-type: none"> Promoting new business & financing models for reaching scale that incentivize low-emissions resilient inputs, practices & technologies Integration of novel climate-responsive technologies, services & programs Promote landscape level NRM for hazard prevention 	<ul style="list-style-type: none"> Guarantees & concessional finance for input suppliers, SMEs & cooperatives Financial services for SMEs Incentivizing via PES Bundling services & interventions together 	<ul style="list-style-type: none"> Knowledge platforms for sharing what technologies, management practices & business models are most suited for different agro-ecological & socio-economic contexts Promoting successful business models for scaling resilient agriculture 	
	Facilitating Climate Informed Advisory & Risk Management Services	<ul style="list-style-type: none"> Understanding needs & identifying gaps for information, advisory, & extension systems Co-designing delivery systems to meet users' needs 	<ul style="list-style-type: none"> Developing & testing new business models & financing instruments for agricultural insurance & social safety net program Leveraging emerging digital technologies supports reaching scale Supporting incubation & acceleration of startups & SMEs 	<ul style="list-style-type: none"> Engaging private sector ICT service providers, maximizing synergies with PPPs, supporting start-up service providers Blended finance mechanisms with proven risk management business models 	<ul style="list-style-type: none"> Blended finance to engage private finance Technical investment assistance ESG impact measurement Mobilization of national & global funds through capital markets 	<ul style="list-style-type: none"> Monitoring, evaluation, & learning to inform scaling based on contextual relevancy & priority issues Promoting Public awareness & capacity building for scale
	Reconfiguring Food Systems	<ul style="list-style-type: none"> Identifying key leverage points for catalyzing high-impact adaptation & mitigation in sustainably productive food systems Behavior economics evaluation of demand for nutritious low-emissions food Strengthening policy coherence & cross-institutional coordination 	<ul style="list-style-type: none"> Enabling NRM, market, trade, & transport infrastructure Quality & sustainability certification & regulation Providing challenge grants for SMEs 	<ul style="list-style-type: none"> Supporting PPPs to stimulate resilient supply chains Capitalization of climate & food security funds Providing low-emissions resilient companies with guarantees, concessional debt & equity investments 	<ul style="list-style-type: none"> Supporting private sector actors mainstreaming climate risk in business model, internal policies & investments Engaging Food system platforms & industry alliances/groups 	

- **Transformational planning and programming:** it aims at strengthening capacity of developing countries to undertake integrated agricultural development planning that mitigates risks of mal-adaptation and maximizes joint adaptation-mitigation synergies and co-benefits; fosters community-responsive policy frameworks; and helps design transformational climate investments in the agriculture and food security sector to realize their NDCs and National Adaptation Plans (NAPs). It is also important to understand the need for extension services, insurance and social protection programs, and co-design delivery systems to meet users' needs; and catalyzing opportunities for climate action in food systems. Such actions prepare the country for GCF investment while building its capacity to seek other sources of climate finance.
- **Catalyzing climate innovation:** The approach encourages investment in innovative, high-potential business models, technologies, practices; leveraging digital technologies and strengthening national capacities to empower farmers and agribusinesses to provide climate information services in new ways; and support countries to develop innovative financing instruments, such as weather index insurances. About three quarter of GCF agriculture projects are currently funded with grants for climate innovation, primarily landscape-level projects in land and water management, irrigation, capacity building, climate information, livelihoods diversification, and market access.
- **Mobilization of finance at scale:** This includes a range of financing instruments and innovative structuring to de-risk climate investments and catalyze public and private finance at scale. For example, leveraging guarantees and concessional finance to scale up successful, high-potential, climate-compatible investments by public and private partners; creating funds to support input suppliers, MSMEs and cooperatives; and incentivizing biodiversity conservation and ecosystems services (watershed management, hydrological services, nutrient cycling) through payments for ecosystem services (PES). It also includes supporting public-private partnerships to stimulate resilient supply chains and mobilizing larger institutional sources of capital through aggregation and securitization via capital markets.
- **Coalitions and knowledge to scale up success:** Disseminate and enable uptake of best practices, methodologies, and standards for transformational climate investment to replicate and scale up action. Leverage partnership and coalitions to disseminate successful practices. The approach enables the GCF climate investment portfolio to function as a global thought leader, targeting investment for high-impact actions that are most closely suited to different agro-ecological and socio-economic contexts.

Key actions for each of the paradigm-shifting pathways

This section briefly examines the barriers that need to be addressed for each of the three investment pathways. Within each pathway, it then highlights the interventions and financial instruments that will be needed to achieve transformation. Further the barriers related to the four GCF drivers and mechanisms to address them are also discussed. They form the basis for a robust response to ensure agriculture and food security while addressing adaptation and mitigation actions.

Pathway 1: Promoting Resilient Agroecology

Agriculture is highly prone to climate risks and faces many barriers to reducing those risks and vulnerabilities. Financial resources to drive a paradigm shift at the scale is inadequate. Change is most needed in some of the most difficult areas for agriculture, including highly degraded lands, steep

slopes, arid and semi-arid lands, and areas prone to flooding and salinity. For any given investment, improving climate resilience or reducing GHG emissions strongly depends on the agroecological and socio-economic context necessitating customization of solutions suited to specific place.

Fostering synergies between investments that target both resilient and low-emission production pathways can be challenging given trade-offs between resilience and low-emissions outcomes. Farmers, local decision-makers and even extension agents often lack adequate knowledge and site-specific information to improve practices and enable investments in sustainable and resilient farming. Insecure land tenure inhibits the long-term agricultural investment needed to sequester carbon while building resilience towards new threats imposed by changing climates. Also, farmers do not adopt low-emissions and climate-resilient practices and technologies due to market failures. These limitations lead to disincentivizing farmers and MSMEs for climate-resilient investments. Subsidies and pricing policies (or a lack thereof) present another set of barriers to reducing investment risks by dis-incentivizing MSMEs and preventing producers from reaching new and more resilient markets. The four GCF drivers within the resilient agroecology pathway will help address these issues as discussed below:

- *Transformational planning and programing* targets existing community-responsive technologies, practices, and landscape interventions for local and regional level resources and climate context, maximizing joint adaptation-mitigation synergies. In general, investments should address resilience or have full synergies between low-emissions and climate-resilient outcomes. Investments should also provide low-emission outcomes so long as there is no maladaptation and agricultural risks are not increased.
- *Catalyzing climate innovation* would help promote business models for reaching scale through interventions that incentivize low-emission resilient inputs, practices, and technologies to improve productivity, efficiency, resilience and ecological health. Financial guarantees for expanding input suppliers can play important role in reducing market failures and farmer knowledge gaps that limit adoption of climate-resilient practices at scale. A comprehensive approach includes ensuring access to affordable inputs and markets with premium for crops produced through low-emissions and climate-resilient means. An emphasis on developing and promoting novel and practical risk management technology, approaches, services and programs including (but not limited to): promoting stress-tolerant seed, breed, and germplasm development; disseminating climate-risk reducing water management technologies, soil fertility management practices; natural resource management (NRM) system
- *Mobilization of investments at scale* focuses on facilitating private sector participating in innovative business opportunities in low-emission and climate-resilient agriculture. While grants and loans are important, the other financial instruments such as guarantees and concessional finance (debt or equity) can support input suppliers in expanding their businesses. Microfinance, especially when bundled with other services such as climate information, agricultural advisories, and insurance, presents prospective business opportunity that will meet the twin objectives of enhancing access to finance as well as low-emissions, climate-resilient innovations in agriculture (linking with Investment Pathway 2). Business incubators and accelerators would be important approaches to facilitate development of new business models for scaling up technologies and practices. Landscape approaches may provide opportunities for incentivizing sector-wide investments via Payment for Ecosystem Services (PES) and supporting institutional arrangements. It is noteworthy that these approaches will also have synergies with Pathway 3, Reconfiguring Food Systems.

- *Replication of knowledge to shift finance flows* should develop and leverage existing knowledge platforms to understand the technologies, management practices, and business models that are most suited to different agro-ecological areas and socio-economic contexts. Information on targeting site specific technologies, successful business models, and related capacity are essential parameter for replication and scaling up the successful innovations.

Pathway 2: Facilitating climate informed advisory and risk management services

Climate information and advisory services are key for mainstreaming climate actions in agriculture. In some countries, agricultural advisory systems are underfunded sources while in many others extension systems have been rolled back. They are limited by inadequate policy, institutional, and regulatory environments thus posing challenges to meet the investment needs for adoption of modern technologies such as digital platforms for information sharing and accessing financial resources. Technologies exist for information sharing, but the lack information on private sector, innovative business models, climate risk management standards continue to pose challenges for startup businesses to turn a profit. However, they also present potentials innovations in digital agricultural at all scales, ranging from providing on-farm advice through agroclimatic advisories, to regional production and supply chain management, to broad scale early warning systems and evidence-based knowledge management systems. Climate change risks put an additional layer, to the risks that farmers and MSMEs already face, often discouraging them from making new investments. Therefore, the four GCF drives as described below have been identified to facilitate transformational change at scale.

- *Transformational planning and programming* in Pathway 2 can help address the barriers by understanding needs and providing targeted information, advisory, and extension services. Co-designing delivery systems to meet users' needs produces the most successful results as direct involvement creates ownership. Leveraging digital technologies supports reaching wider audience while also using and strengthening traditional means such as direct extension, radio, television, and print media. Transformational Planning and Programming for investments in this Pathway can also play a vital role developing much needed financial services (e.g., Insurance) and safety nets to minimize risk and increase willingness to embrace the interventions identified in Pathway 1.
- *Catalyzing climate innovation* focuses on building the public infrastructure and human resources for developing and delivering timely, client-oriented, tailor made, practical information and financial services. Key to this effort is developing fundamental information, such as climate data from weather stations, and complementing it with strong technological and computing infrastructure. Qualified human resources and institutions need to develop, package and deliver reliable, practical, and actionable information to farmers. Actions to develop and test business models for agricultural insurance and social safety net programs are needed, while also promoting off-farm livelihood opportunities for farmers to diversify income and build resilience.
- *Mobilization of investments at scale* should focus on engaging ICT service providers from private sector and maximizing synergies with public-private partnerships (PPPs), fostering expansion of start-up service providers. Initiatives on business incubation and acceleration through technical assistance, combined with concessional finance, can increase successful investment. Actions can also enable solutions by private sector and through blended finance in reducing vulnerability and risk management with proven business models, including supporting bundling of index insurance, savings, and loan programs, particularly through leveraging digital and mobile technologies.

- *Replication of knowledge to shift finance flows* should create national, regional, and global climate and risk service platforms promoting learning from successful public and private sector business models for information, advisory, and financial services. Lessons can be shared, transferred and scaled up through these platforms. The knowledge shared can include both successful experiences as well as business models and institutional arrangements with proven mechanisms for scaling up the interventions, services and programs. - Some examples of platforms, frameworks, and companies with such solutions are the Platform for Agricultural Risk Management (PARM), Global Framework for Climate Services (GFCS) and Agriculture and Climate Risk Enterprise (ACRE).

Financing for reducing vulnerability and risks is likely to come from a wide variety of funding sources, including GCF readiness support for planning and programming, blended finance for catalyzing climate innovations, and for expansion and replication of knowledge. Currently, climate funding rarely leverages capital from other players or involves domestic financial service providers that could further mobilize additional capital. There are major untapped opportunities for climate finance programming to leverage other financial sources and to distribute this funding through innovative financing mechanisms that are widely used in other sectors. Examples include incentivizing payments for environmental services and increasing the variety of environmental services. Blended finance approaches offer high potential and include concessional capital, guarantees or risk insurance, private sector technical assistance funds, private finance design-stage grants, and/or results-based financing that comes from the public or philanthropic funds, which can then make investments more attractive for commercial and institutional investors.

Pathway 3: Reconfiguring food systems

There are significant opportunities for reconfiguring food systems through sound planning, engaging private sector and fostering resilience-building and low-emission synergies. However, barriers to making supply chains climate resilient remain. Markets for agricultural commodities are limited by poor infrastructure, high transaction costs and reach of small-scale producers. Poor communication and collaboration along the supply chain create bottlenecks and increase costs, reduced yields, food loss and waste, and stagnation of technology. Innovations in sustainability are also impeded by the policy, institutional, and regulatory environments when subsidies and market protection for farmers in industrialized countries constrain competition and market access for producers and MSMEs from developing countries. The lack of food production regulations and certification system inhibits consumer-driven price points for environmentally friendly supply chains and industry development. Lack of aggregation system in developing countries is another factor making markets weaker with insufficient pull to drive changes at scale. With regard to pathway 3, the four GCF drivers includes the approaches to address the sector in following ways:

- *Transformational planning and programming* for reconfiguring food systems should focus on identifying the key leverage points for catalyzing high-impact adaptation and mitigation by understanding the key risks across the food systems. The entire value chain provides venues for reducing emissions and adapting to resilient practices including processing, aggregation, transport, storage, marketing and distribution. On the demand side, it is also important to use approaches, such as behavior economics and consumer evaluation of demand, to identify how low-emission, resilient and nutritious foods can be promoted, leading to increased investments in sustainable food systems.
- *Catalyzing climate innovation* for Pathway 3 calls for interventions that span from the farm-gate to the consumer, addressing foundational needs of the food system to produce low emission and climate resilient food for a rapidly growing population. Investments in innovative technologies

and practices serving the markets, processing, trade, and transport are important to provide the needed infrastructure for reconfiguring food systems. Regulations such as quality standards and certification sustainability would be attractive measures to crowd in private investment in certain countries existing markets for high quality and certified food. *Mobilization of investment at scale* should focus on strategic investment that foster private finance investments in low emission and resilient food systems. Public-private partnership (PPP) mechanism should be explored to catalyze investment, stimulate entrepreneurship and promote resilience of the agriculture value chain. The initiatives on development corridors and zones should be capitalized to galvanize joint efforts for common goals around climate, ecosystem health, and environmental sustainability. There is an opportunity to leverage the climate and food security funds that have recently been established and their offer of a variety of instruments that could reach wide spectrum of stakeholders for sustainable food systems.

- *Replication of knowledge to shift finance flows* for Pathway 3 aims to support private sector actors in sharing successful business models, internal policies, and foster partnerships across regenerative businesses Food system platforms, industry alliances/groups can provide the mechanisms for sharing lessons, good practices and leveraging additional investments for scaling up the successful ventures. Challenge grants for MSMEs and other relevant actors can be provided to promote this driver for low emission and resilient food system interventions.

3. Financing of paradigm-shifting pathways in agriculture and food security

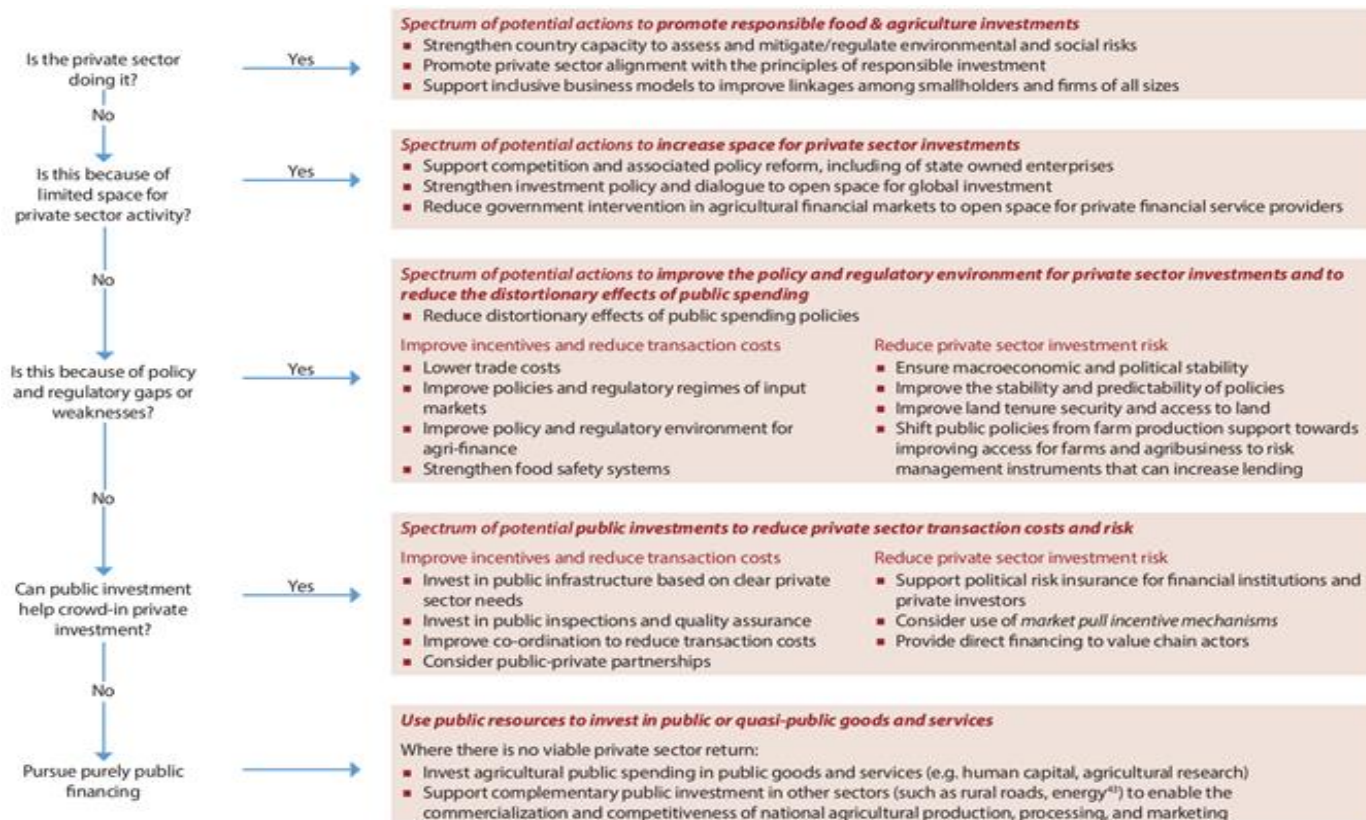
3.1 What financing instruments are involved in agriculture and food security paradigm shifts?

Financing remains a major challenge for addressing the mitigation and adaptation needs in agriculture and food security to shift the paradigm towards low emission and resilient agriculture. There are many different sources of finance and financing instruments, and the returns on many of these investments are significant, both global returns on adaptation and mitigation, as well as direct returns to producers and intermediaries across value chains.

However, the optimum source of finance and instruments for enabling paradigm shifts will vary widely as the climate-resilient solutions are highly context specific. The factors influencing such decisions range from policy and market environments to expected climate change impacts and cultural norms. It is understood that some financing sources and instruments would be more applicable to a specific pathway than others. Applicability also varies across the spectrum of national to regional to local to household level, and to goals of the financing solution.

The Maximizing Finance for Development Framework (MFDF), (Figure 3) developed by the World Bank and partners, provides a practical guide to assessing the best use of domestic funding sources within blended private finance approaches.

Figure 4: Maximizing Finance for Development Framework



Public Domestic Finance

The FAO has assessed tracking of domestic climate finance as part of an effort to improve the integration of agriculture into National Adaptation Plans. The findings suggest that the international community has established various frameworks and tools for tracking the state of domestic climate finance, as well as its role in blended finance schemes. Broadly, the Nationally Determined Contributions to the Paris Agreement outline the climate goals that countries aim to realize, including those they are able to meet with domestic funding, and those which will require external support.

Public domestic finance can also engage stakeholders that could help leverage additional capital. This can be accomplished by (1) creating enabling environments through policy, institutional, and regulatory frameworks such as Environmental, Social, and Governance (ESG) standards, and (2) incentivizing public and private financiers to crowd in additional capital by building on their comparative advantages to meet their organizational goals while yielding to climate resilience. . In combination, these two crucial roles would also pave the way to encourage mechanisms of blended finance for regenerative businesses. For example, policies and regulations can enact mandatory reporting, carbon credit and social responsibility requirements, mainstreaming the climate considerations into national budgets, and climate-related financial disclosures. Increasing the ease of doing business, fostering start-ups and incubators, and offering incentives can catalyze actors to assess agricultural loans and insurance risk, invest in climate-resilient solutions, and reduce supply chain vulnerability.

Domestic finance can help climate finance reach local levels. This is accomplished by first acknowledging that big impacts are delivered through many small results, and establishing programming frameworks that prioritize locally-relevant results. This process should engage all the stakeholders including donors, governments, NGOs, and vulnerable communities in ensuring that sustainable development is a priority and that will deliver the results to combat climate change. Tailored capacity building at national, regional, and local level is needed to ensure adequate human and institutional capacity for implementation and decision making in alignment with the principles of the subsidiary. Finally, flexible, grant-based, programmatic finance channeled through local financial mechanisms, with simplified access and approval processes, will move funds quickly to the local level.

Private and Blended Finance Opportunities

The majority of climate finance will come from private sources. Donors contribution accounted for less than 5% of the estimated funding needed to shift smallholder farmers to low emission and climate-resilient agriculture in 2017. An additional 29% was supplied by financial service providers, leaving a funding gap of 65% majorly affecting MSMEs. Sub-Saharan African agricultural MSMEs alone are experiencing a lending gap of US\$ 100 billion. In order to fill this gap, there is a need to mobilize financial resources in a ratio of 5:4:1 comprising long-term agri-finance, short-term agri-finance, and non-agri finance. Availability of financing from public sector and development partners are insufficient, therefore, to achieve paradigm shift, utmost efforts need to be made to mobilize private sector finance.

Blended finance is the strategic use of public or philanthropic funding to catalyze private sector climate investments. Blended finance is one of the significant tools to increase finance for

important private sector activities and mobilize private capital to help achieve low emission and climate resilient development. In blended finance models, each organization accomplishes its own objectives but at the same time contributes to common goals. Blended approaches are myriad, and often involve concessional capital, guarantees/risk insurance, private sector technical assistance funds, design-stage grants, and/or results-based financing that comes from the public or philanthropic funds, which make the investments more attractive for commercial and institutional investors. Approximately US\$140 billion has been mobilized through blended finance for sustainable development in developing countries, with agriculture representing around 15-20% of the financing deals. Each source of private finance has different risk tolerance, financial return requirements and level of commercial maturity. GCF is already using blended finance, but predominantly in the energy sector, however, the experiences can be replicated in agriculture and food security sector.

To build successful blended finance schemes, it is critical to: employ de-risking instruments and establish partnerships early in the process with domestic and international financial institutions, private investors, corporates, and other development financial institutions (DFIs). These partnerships help explore the instruments and innovative financial mechanisms are most appropriate to leverage additional capital and deploy them directly to MSMEs and farmers for pioneering business models. Additional keys to success in blended financing include: layered capital structures for both public and private sources; leveraging financial instruments that are not yet widely used in the sector, including profit participating debt, structured debt, payment for ecosystem services, payment-for-performance contracts, equity subscriptions, warrants, and convertible debt; avoiding prescriptiveness; considering additional revenue streams, such as project establishment support and carbon finance; conducting pre-investment planning; bringing in international and domestic DFIs, and ensuring that every project truly leverages additional capital. The art of designing situation-responsive blended finance schemes means fostering synergy between multiple sources. Dedicated climate finance funds, such as GCF, play an important role as vehicles for donor funding to finance mitigation and adaptation investments. The Global Environment Facility (GEF), for example, has a dedicated Least Developed Countries Fund (LDCF – GEF), as well as a Special Climate Change Fund (SCCF – GEF). Other major funds include the Pilot Program for Climate Resilience (PPCR), the Adaptation Fund, the Bio-carbon Fund, and the Amazon Fund. Carbon Brief and The Climate Policy Initiative offer tools for tracking the international flows of climate finance. Programming that leverages complementarity between funding sources and uses a variety of coherent financial mechanisms to thoughtfully address each element of the Pathways of Action is well on its way to catalyzing a true paradigm shift. The Figure 4 below highlights examples of innovative blended finance and risk mitigation instruments, and how these may translate to key opportunities for paradigm-shifting use of GCF funding.

Figure 5: Summary table of goals and examples of financial instruments

Main goal of the structure	Financial Instruments Used	Example
Improving the risk/reward profile	Concessional capital is a classic blended finance structure that uses public resources to provide below-market terms within a capital structure of debt or equity products.	Acumen Fund for Climate Resilience: Investing USD 50 million in approximately 18-20 early-stage African agribusinesses receiving equity investments, long-tenor loans at below market rates, as well as technical assistance to climate adaptation interventions, including for data analytics, business development and gender mainstreaming.
	Guarantees, risk insurance, or first loss position products (first loss equity, junior loan) can be used to reduce the risks for commercial investors. Public resources can be used to repay investors in the case of default. In this model, public money is blended with private capital through a risk-sharing mechanism.	Mobilizing Credit for Agriculture (Cambodia): USAID sponsored a 50% loan loss guarantee on a portfolio of agribusiness loans provided by three financial institutions in Cambodia, lowering the potential amount of losses significantly and facilitating additional lending.
Increase likelihood of social impact	Results-based financing, performance-based contracts or development bonds (DIBs) where payments are made if certain impact targets are met. Conditional added payments encourage commercial investors to meet development goals after investing	Sustainable Cocoa and Coffee Production DIB: The sponsor committed to pay the investor a premium if the DIB could not meet four pre-defined criteria related to income, productivity and commercial activities for Peruvian coffee farmers.
<p>Technical Assistance – Blended Finance in developing countries often come with grant support for:</p> <ul style="list-style-type: none"> ▪ Design stage grants for pipeline development and project preparation funds ▪ Technical Assistance Facilities integrating ESG reporting standards and providing training and capacity building to investees ▪ Subsidizing investment costs and creating enabling environment for the investment. 		

3.2 Green Climate Fund Portfolio and Financing Structures

There are significant opportunities for supporting agriculture and food security through strong programmatic planning, engaging private sector investment, and fostering resilience-building and low-emissions synergies with GCF support. There also exists a range of opportunities for public private partnerships, and for governments and international organizations to create the enabling conditions for the private sector to innovate and engage. The appropriate financing models and instruments will be based on the situational context, capacity and sustainability needs.

Dedicated climate finance funds, such as GCF, play an important role as vehicles for donor funding to finance mitigation and adaptation investments. Climate funding needs to secure the economic activities of the farmers and enterprises who make the daily decisions that determine the sector’s climate resilience. GCF provides opportunities for climate finance to reach the local level and support famers, microfinance institutions, MSMEs, and agri-businesses. GCF funding is deployed through mechanisms including grants, loans, guarantees, and equity, structured as appropriate. About three quarters of GCF agriculture projects are currently funded with grants. These are primarily landscape-level projects in resource management, resilient practices, irrigation, capacity building, climate information, livelihoods diversification, and market access.

Agriculture-related projects represent a large share of the GCF portfolio in terms of number of projects, with more moderate funding levels. Some common financial structures include: 1) concessional capital that uses public resources to extend financing at below-market terms; 2) guarantees, risk insurances or first loss position products (such as first loss equity or junior loans) that reduces investment risk; 3) results-based finance that increases social impact potential; and 4) grants for technical assistance or subsidizing public goods that enable climate outcomes. Effective deployment of finance can mitigate key challenges: for example, business-as-usual intermediaries lacking scale, risk-aversion to utilizing innovative financial instruments, limited support to build local capacity, challenges in reaching marginalized groups such as women and youth, inappropriate co-financing targets, and poor oversight of policies for local finance.

Across all three investment pathways, transformational planning and programming will primarily depend on grant support through GCF's Readiness Programme and Project Preparation Facility (PPF). Most direct agriculture projects and landscape-level actions (e.g. Resilient Agriculture, Climate Informed Advisory and Risk Management Services) will rely on grants for catalyzing climate innovation. Yet there are also opportunities to mobilize private finance, particularly blended finance models and public-private partnerships in agriculture and payment for environmental services for landscape level natural resource management. Strategically deployed blended finance, in some cases, can offer incentives that can enable actors to accurately evaluate agricultural loans and insurance risks, invest in climate-resilient solutions, and reduce supply chain vulnerability. There are major untapped opportunities for programming to leverage other financial sources and to distribute this funding through innovative finance mechanisms that are already widely used in other sectors. That will also require expanding the horizons to cover the entire value chain and parameters of food systems to achieve a paradigm shift.

The GCF has provided funding for pioneering business models such as the ACUMEN Resilient Agriculture Fund (Table 1), smallholder agri-insurance in Zimbabwe, climate and water monitoring in Pakistan, value chain loans in Cambodia, agricultural climate information in Zambia, and credit lines for resilient low-emissions agriculture in Niger. Currently, few projects look at policies, long-term incentives, and non-crop subsectors. See the complete list of GCF [approved projects](#) for more information.

Table 1. Examples of GCF agriculture and food security projects with innovative financing approaches

Region and Focus	Sectors	Project Amount	Partners and Rolls	Finance Instrument	Innovative Finance Approach
Acumen Resilient Agriculture Fund					
Africa (Uganda, Nigeria, Ghana, Kenya) Adaptation	Agricultural productivity and income for smallholder farmers	USD 56 million	Acumen (Fund Manager), GCF, Other limited liability partnerships (LLPs)	Equity Debt with extended tenor Grant for Technical Assistance Facility	Equity plus self-liquidating and long tenor debt capital (up to 12 years) for early-stage companies, based on their individual capital requirements. Technical Assistance Facility to support building profitable, scalable, socially responsible, climate adaptive businesses that serve as a base for pyramid markets, support greater gender integration, and provide a financial return
Integrated Climate Risk Management for Food Security and Livelihoods in Zimbabwe					
Africa (Zimbabwe) adaptation	Agricultural productivity and risk management for smallholder farmers	USD 9.8 million	World Food Program (WFP), GCF	Grant for improved access to finance and insurance products	Resilient assets creation supporting agricultural production and risk transfer via weather index insurance provision.
Strengthening Climate Resilience of Agricultural Livelihoods in Zambia					
Africa (Zambia)	Agricultural productivity and resilience for smallholder farmers	USD 137.3 million	UNDP, GCF	Grant for improved access to finance and insurance products	Resilient agriculture, and support for smallholder farmers' access to markets and financial services for sustained investment in climate-resilient practices.
Climate-Friendly Agribusiness Value Chain Sector					
Asia-Pacific (Cambodia) Adaptation and Mitigation	Agricultural production and agribusiness	USD 141.4 million	Asian Development Bank, GCF	Senior long tenor debt (32 year; GCF) Long tenor debt (32 year; ADB) Grants (GCF)	Strengthened capacity of financial institutions to devise and channel climate-friendly agribusiness investments.

4. Country case studies

This section provides examples (from GCF and others) for each of the GCF drivers. Many of the examples below span across pathways and drivers, but efforts have been made to identify most relevant pathways in each example.

4.1 Transformational planning and programming

Zimbabwe's *Integrating Risk Management for Food Security and Livelihoods* project leverages grant funding to focus on the long-term adaptation of vulnerable and food-insecure households. This GCF supported project will employ climate forecasts and weather-based index insurance (Pathway 2), and community-based asset creation to enhance smallholders' (including 66% women) investment capacity (Pathway 1) in climate-resilient development.

Kenya created an enabling environment for Climate-Smart Agriculture (CSA), meeting its NDC, and other national and international commitments. It aligned multiple national policies and strategies including climate action plans, mitigation plans, climate finance plans, and agricultural plans, so that all plans had consistent and supportive actions. It also created a CSA Framework, implemented a broad range of CSA policies, dealt with institutional needs for national adaptation planning, and established inter-ministerial working groups. It is supported by many international organizations. With this enabling environment in place, the Kenya Project (Pathway 1) is increasing agricultural productivity, building smallholder resilience, and providing immediate and effective responses to crises.

4.2 Catalyzing climate innovation

Zambia introduced a project to increase the resilience of farmers who are highly vulnerable to climate-induced variability, including floods and droughts, the *Strengthening Climate Resilience of Agricultural Livelihoods in Agro-Ecological Regions I and II*. The project is entirely grant-funded and employs value-chain approaches to increase access to climate information services, alternative livelihoods, sustainable water management options, and innovative inputs and practices. Through this project, GCF is steering funding from the Ministry of Agriculture towards mainstreaming climate resilience in national agricultural development and extension. This project includes elements of both Pathways 1 and 2.

Kyrgyz Republic's *Carbon Sequestration Through Climate Investment in Forests and Rangelands* aims to reduce both land degradation drivers and the resulting emissions by providing support to national institutions, green growth investments, and participatory and ecosystem-based sustainable management approaches. The project focuses on integrated rangeland and forestry resource planning, and blends GCF funds with those of a regional development bank. In this collaboration, GCF funds training and capacity building, while the regional bank subsequently provides loans to farmers that have been trained on climate resilient practices for livestock and grassland management (Pathway 1).

Tanzania reduced both GHG emissions and cereal crop losses by introducing and rapidly scaling up an inexpensive and innovative technology, the Purdue Improved Crop Storage (PICS) bag to eliminate insect damage to stored grain (Pathway 1). PICS bags reduced Tanzanian post-harvest losses from 14% to less than 1%. Joint demonstrations at county fairs and community events by trusted local officials, NGOs, and civil society organizations were highly effective in reaching large number of individuals. Current efforts focus on economic viability via the private sector, and a Tanzanian company, Pee Pee Tanzania Limited (PPTL), began selling PICS bags in 2015, and sales reached 780,000 units by 2017. Successful scaling has been facilitated by actors in the agricultural input supply chain, local and international NGOs, and USAID financial support. This demonstrates

the case of taking a simple technology to market scale despite low capital and capacity and achieving impacts quickly with coordination between the private sector, philanthropy, and NGOs supported by combination of public and private finance.

4.3 Mobilization of investments at scale

Multi-country in Africa: Engaging the private sector can open up important channels of financial flow. The *Acumen Resilient Agriculture Fund* is leveraging this approach by supporting innovative agri-business start-ups aiming to bolster smallholder farmers' climate resilience by providing aggregators, digital platforms, and innovative financial services to smallholders (Pathway 2 and 3). The long-term vision of the project is moving climate change adaptation activities from grant dependence to long-term capital formation.

Multi-country in Africa: Post-harvest losses can be up to half of what farm families produce. At harvest time when everyone is selling the same crop, prices are lower. A Warehouse Receipt program allows a farmer to deposit surplus crops in a certified storage facility (public or private) and receive a receipt, which they take to a financial institution that advances part of the crop's value to the grower to buy seeds and inputs for the next growing season. Once prices rise after the harvest, the grower can sell the crop, so the warehouse facility repays the loan (with interest while deducting the storage fee) and gives the remaining profit to the grower. Appropriate government enabling conditions are needed for storage facilities, banks and other lenders, and producers to trust in this IFC-supported program that reduces crop loss (Pathway 3), increases farmer profits (Pathway 1), and smoothens agricultural prices.

Cambodia's *Climate-Friendly Agribusiness Value Chains Sector* project aims to reduce greenhouse gas emissions and climate vulnerability across Cambodia's value chains for both staple and cash crops (Pathway 3). The initiative targets four agricultural value chains in four provinces with the goal of increasing productivity, competitiveness, and resilience at each value chain stage. The project blends Asian Development Bank and GCF funding to provide both loans and grant for capacity building.

Latin America's Eco.Business Fund uses capital from public investors and donors to support businesses and to de-risk private institutional investments in support of climate change adaptation and mitigation, sustainable resource use, and biodiversity conservation business practices. It provides financing and technical assistance to businesses and financial institutions committed to environmental practices across four priority sectors (Pathway 3): Agriculture and Agri-Processing, Aquaculture and Fisheries, Forestry, and Tourism. Eco.Business has contributed to nearly 8 million tonnes of CO₂-e storage, over 4 million m³ of water conservation, over 100,000 hectares of conservation farmland, and 360,000 direct jobs. Eco.Business invests its funds via debt financing for: 1) intermediaries committed to green finance, such as local finance institutions delivering funds to producers and businesses; 2) real-sector intermediaries such as aggregators and commodity buyers making credible sustainable sourcing commitments; 3) businesses using sustainable production and consumption methods.

4.4 Coalitions and knowledge to scale up success

Pakistan: The *Transforming the Indus Basin with Climate Resilient Agriculture and Water Management* project is strengthening government capacity to leverage information and innovative technology to adapt to climate change impacts on agriculture and water management. It is also aiming to enhance climate resilience of the most vulnerable farmers through skills, knowledge, and technology improvements (Pathway 2). Specifically, the project is building out a climate information and monitoring system to help determine optimum water allocation and cropping practices. This system (and the capacity to employ it) will inform key national decisions

regarding priorities for further investment and can serve as a model for other countries facing similar climate challenges.

Niger's Inclusive Green Financing for Climate Resilient and Low Emissions Smallholder Agriculture project aims to improve smallholder access to credit to support climate resilient and low-emission agriculture. The project employs incentives to engage commercial banks and microfinance institutions (Pathway 2), as well as provides technical assistance and capacity building to smallholders. A climate resilient and low emissions credit line, funded by GCF, IFAD, and the Nigerien national bank, will support farmers in transitioning their production systems to climate-resilient, low-emissions management (Pathway 1). A scale up of this approach to other West African countries is being explored.

Ghana, Mali, and Senegal: Changing agricultural development plans to recognize climate impacts requires that policymakers in each country understand climate change impacts on agriculture, based on key scientific findings. In each country, the first step in mainstreaming climate change in agriculture was developing a multi-stakeholder national science-policy dialogue. Exposing multiple decision-makers to climate impacts in structured settings helped integrate evidence-based findings into policy-making processes. Creating the science-policy dialogue also provided a structure for two-way communication between scientists and policymakers that contributed to co-developing solutions to support climate resilient agriculture and address climate change vulnerabilities and impacts. This effort supports actions in all three pathways by getting decision-makers to understand risks, opportunities and solutions.

5. Overview of GCF Investment Criteria for Impactful Proposals

5.1 GCF's Six investment criteria

Proposals to the GCF need to align with GCF result areas and are assessed based on six GCF investment criteria²⁷, summarized here along with examples of how these criteria could pertain to the agriculture and food security paradigm-shifting pathways. GCF supported actions can refer to individual projects at a site or to broader programmatic responses. The GCF investment criteria and examples of key questions broadly assessed are:

1. **Impact:** What are the likely and measurable impacts of the GCF-supported actions? How many beneficiaries are there, what gains will be made, and how will mitigation actions result in low-emission sustainable development pathways and adaptation actions to increase climate-resilient sustainable development?
2. **Paradigm shift:** How do the actions support lasting paradigm shifts? How are they simultaneously innovative, transformative, and replicable, with scale-up potential? What potential exists for knowledge, learning, and improving national enabling environments, strategies, frameworks, and policies? How would this be done?
3. **Sustainable development:** How do the actions align with national SDG priorities? What are expected environmental, social, gender, and economic co-benefits?
4. **Recipient needs:** How do the actions address vulnerabilities and barriers, minimize exposures, and support development to respond to climate risks and impacts? Are actions required for alternative financing or capacity needs to support recipients, institutions, or implementing agents?
5. **Country ownership:** Do the actions align with national policies (especially the NDCs and NAP), frameworks, and strategies and are they strongly supported by an engaged variety of stakeholders with a capacity to deliver?
6. **Efficiency and effectiveness:** How do the actions build on best practices? Are they cost-effective and efficient in both their financial and non-financial aspects? Are they economically and financially viable, and do they involve options for additional or long-term investment opportunities?

5.2 Investment criteria examples for the three agriculture and food security paradigm-shifting pathways

The three agriculture and food security paradigm-shifting pathways extend from household farms, to regions, to the agricultural context of an entire country. The pathways work through the range of governance, institutional, and organizational structures, from village leaders and organizations to national ministries and policies. These issues of scale and reach are implicit in project or program design for agriculture and food security, and in responses to investment criteria. Using the investment criteria identified above, Box 1 provides examples of the type of information and assessment, and potential issues and questions to be answered within GCF proposals for each of the three paradigm pathways.

BOX 1: Examples (non-exhaustive) of Investment Criteria for the Three Agriculture and Food Security Paradigm Pathways.

AGRICULTURE & FOOD SECURITY PARADIGM SHIFTING PATHWAYS			
	Promoting Resilient Agroecology	Facilitating Climate Informed Advisory and Risk Management Services	Reconfiguring Food Systems
INVESTMENT CRITERIA EXAMPLES			
Impact	Tonnes of CO _{2e} sequestered and emissions reduced; change in hectares cleared or burned; area & farmers adopting resilient seeds, practices, technologies, land irrigated, new animal, fish or crop breeds adopted. MSMEs & people supporting low emissions resilient production that obtain finance. Improved soil, water, and ecosystem health.	Farmers using digital information weekly; extension advice given online, by phone, to groups; vulnerable farmers reached; area covered by early warning systems; number of beneficiaries for insurance, saving, & loans; new start-up providers numbers; number of food insecure households and accessing safety net/social programs.	Number & value of new value chains created; total value of MSME loans; innovative and flexible incentive for adopting climate-resilient practices in food systems; tonnes produced meeting quality & sustainability certification; employment in new supply chains; improved nutritional outcomes; reduced food loss and waste.
Paradigm shift	What new practices, innovations or varieties are ready for regional expansion with a strong potential for replication?	How will access to new information & technology, (e.g. digital platforms) & services (financial & insurance) change planting, harvesting, storage or transport opportunities &/or mitigate risks?	What are key leverage points & actions for production, supporting business models & supply chains? Shift in what foods people want.
Sustainable development	Quantify how the pathway activities help achieve or contribute to relevant SDGs, noting that there are many cross-cutting linkages to a variety of SDGs.		
Recipient needs	What are BAU trends for key crops & other BAU environmental, social or economic impacts? Are vulnerable groups (women, youth, indigenous peoples) targeted?	Are barriers to information & advisory services (financial, structural, or technical) identified & addressed?	Are users along the value chain involved in identifying needed improvements in NRM, market, trade, & transport infrastructure?
Country ownership	What other national actions are boosting resilient production & lowering emissions? Are any new institutional, governance, or coordinating mechanisms needed?	Is there political support & an enabling environment for country-wide information sharing, especially in rural, agricultural areas? What capacity & incentives are needed to support financial & risk services & safety nets?	Do key stakeholders understand & are they committed to reorienting how food is produced & consumed in the country? Do policy frameworks support this?
Efficiency & effectiveness	What does financial analysis show for BAU versus resilient production with & without GCF support, & over time, as climate impacts worsen?	Can information & advisory services be tailored to specific audiences & financed partly by insurance companies, or public-private partnerships?	Will promoting nutritious, low emissions food create demand? What value would this have for national nutritional & economic security? At what financial cost?

For impact (criterion 1), a strong proposal would include baseline climate information and projections, as well as the current status of production, land clearing and soil degradation, farm and household beneficiaries and their food security, and climate impacts experienced by these farmers. It would also include potential impacts of the project on yield, emission reduction, projected household resilience and food security, stability of the agroecology and any further co-benefits, which might include new jobs created, food produced and/or sold in local or distant markets, additions to value chains, deforestation avoided, nutritional outcomes improved, and reduced food loss and waste.

Paradigm shifts (criterion 2) result from strong collaboration at local, national, and international scales, combined with leveraging actions and clear plans to implement the shift. Genuine partnerships are needed to make transformative projects a reality. Agricultural producers must organize, network, and improve access to information. Small-scale producers often have small and diverse plots of land, and therefore there are high transaction costs to reach them with context-relevant information and services. Strong, empowered local organizations can reduce these high transaction costs. Examples such as Farmers for Climate Action (a movement of farmers, agricultural leaders, and rural Australians working to ensure that farmers are a key part

of the solution to climate change) or WeFarm (a farmer-to-farmer digital network with over a million users across Kenya and Uganda) are successful cases of good local networking leading to concrete benefits. Rizoma in Brazil is a regenerative agriculture production company aimed at making the farming sector contribute to climate solutions. Paradigm shifts are most likely with a strong enabling context, involvement of government, businesses, farmers' organizations, and civil society, and a shared vision of actions needed for agriculture in a thriving rural economy.

Sustainable development (criterion 3) helps to track how proposals help countries meet their SDG targets. Goal 2 (Zero Hunger) is vital to Agriculture and Food Security, but a strong and thriving farm sector and rural economy can support many other SDGs, from Goal 1 (Reducing Poverty) to Goal 17 (Partnerships). There are potential linkages even with goals that may seem less direct – such as Goal 14, Life Below Water. For example, agricultural runoff with agrochemicals, forest clearing for farms, and farming practices leading to erosion and sedimentation can destroy coastal reefs, mangroves, sea grasses, and fisheries. Therefore, a comprehensive understanding of effects of project interventions on sustainable development is crucial.

Recipient needs (criterion 4) demonstrates the vulnerability and challenges farmers and food systems face under climate change. Vulnerability and risk reduction flow through sectors. While often viewed through a rural lens, food security is an increasing concern for urban populations. Climate impacts are already changing the face of recipients. The private sector may be a key recipient, providing jobs, supporting value chains, and growing potential export earnings. Their needs and risks, the barriers they face, and the resources they bring are all part of assessing recipient needs.

Country ownership (criterion 5) is vital, and it goes beyond looking at a proposal's consistency with climate commitments, strategies, and policies, or the capacity of agriculture or irrigation ministries. Having the right set of enabling conditions in place, or clear plans to create these conditions and eliminate barriers, is essential to cross-cutting and multi-sectoral approaches to improving agriculture and food security. It is necessary to ensure that there exists the capacity at all scales to effectively deliver and implement programs, along with strong partnerships that share a vision of what can be achieved. Programming can incentivize capacity building and facilitate enabling regulatory and legal frameworks for better governance and accountability systems.

Efficiency and effectiveness (criterion 6) involve demonstrating that activities are likely to be cost-effective and viable, and they build on best practices. Strong economic analysis and financial rate of return with and without the project, and under different climate or risk scenarios, contributes to the project's design process even before a proposal is submitted. This analysis can include innovative finance mechanisms and cost sharing options, whether from local farmers or the private sector, or other international donors or investors. Effectiveness can also quantify the values of certain practices using a variety of benchmarks, such as carbon stored, ways that biodiverse areas contribute to livelihoods, or practices of indigenous people supporting their food security and livelihoods.

5.3 Programs, initiatives, and coalitions supporting the paradigm shifting investment pathways

Paradigm shifting in agriculture and reconfiguring food systems will necessarily impact a wide variety of actors spanning many sectors. Positive paradigm shifts are most likely to occur when all relevant actors are informed or involved in charting a course for lasting, resilient agricultural systems. Social power dynamics based on access, influence, and wealth shape behaviors, relationships and interests and will need to be addressed. Yet there is huge heterogeneity among

agricultural sector stakeholders in any given area, so actions must be highly tailored to their unique circumstances. All producers are not the same, and their practices are embedded in specific agroecological environments that determine what they produce, consume, or sell. Along value chains there are people, businesses, and institutions involved in processing, transporting, distributing, and selling foods, whether locally or for export markets. There are also hierarchies, from local producer organizations and cooperatives to national production boards and ministries focused on agriculture, nutrition, food security, and land and natural resources. Within the private sector, there are MSMEs to multinational corporations involved in production, processing, transport distribution, and sales. Multiple actors provide information, capacity, and support services to agriculture, from universities and research centers, to extension agents and specialists in food safety and quality control, to the news media. Economic and financial interests are pivotal to reconfigure food systems, as are civil society and NGOs, and regional organizations with interests in paradigm shifts.

A paradigm shift will require collaboration beyond traditional boundaries, at a scale not seen before and will need support by genuine partnerships to make transformation a reality. It will need to forge effective partnerships among different stakeholder groups including political and social thought leaders, civil society, the research community, international development organizations, farmers, market intermediaries and businesses. That will yield promising business opportunities for implementing climate actions for low emission and climate resilient agriculture and food security.

Conclusion

There is a broad agreement that current agriculture and food systems are not on a sustainable trajectory that will enable us to reach the Paris Agreement and the SDGs by 2030, particularly on the face of anthropogenic climate change. This sector guide provides important insights into the three key investments pathways that should be in place to reach a paradigm shift where agricultural production, food security, and food systems can become more inclusive, sustainable, and climate-resilient. Mitigation in agriculture will help ensure GHG efficient agriculture and food systems thus contributing towards emission reduction targets.

This guide helps the stakeholders to understand the strategic directions of GCF in agriculture and food security, the paradigm shifting pathways and the drivers of change. It will serve as an important tool to the partners in developing robust funding proposals to respond to these investment pathways by taking into account the four key drivers. Together, they can catalyze a paradigm shift in agriculture and food security that will support millions of vulnerable farm households and actors across the entire value chain for transformation towards low emission and climate resilience of the sector. It is noteworthy that these pathways are not mutually exclusive and that a paradigm shift will need to consider a holistic approach where actions need to be highly context specific. Vulnerability to climate change is positively correlated with poverty. Therefore, a paradigm shift in agriculture and food security should ensure that climate-resilience, poverty alleviation, and development approaches are all well aligned within countries.

¹ <https://www.greenclimate.fund/projects/criteria>

Challinor, A.J., Watson, J., Lobell, D.B., Howden, S.M., Smith, D.R. and Chhetri, N., 2014. A meta-analysis of crop yield under climate change and adaptation. *Nature Climate Change* 4(4), 287-291.

² FAO, IFAD, UNICEF, WFP and WHO. 2020. The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. Rome, FAO. <https://doi.org/10.4060/ca9692en>

³ Jones PG, Thornton PK, 2015. Representative soil profiles for the Harmonized World Soil Database at different spatial resolutions for agricultural modelling applications. *Agricultural Systems* 139, 93-99. <https://doi.org/10.1016/j.agsy.2015.07.003>

⁴ Ibid.

⁵ Smith P, Bustamante M, Ahammad H et al. (2014) Agriculture, forestry and other land use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (eds O Edenhofer, R Pichs-Madruga, Y Sokona et al.), pp. 811–922. Cambridge University Press, Cambridge

⁶ Smith, P. et al. in IPCC Climate Change 2007: Mitigation (eds Metz, B., Davidson, O. R., Bosch, P. R., Dave, R. & Meyer, L. A.) Ch. 8 (Cambridge Univ. Press, 2007).

⁷ OECD and Food and Agriculture Organization of the United Nations. 2019. Agricultural Outlook 2019-2028. https://doi.org/10.1787/agr_outlook-2019-en

⁸ Ross, K., K. Hite, R. Waite, R. Carter, L. Pegorsch, T. Damassa, and R. Gasper. “NDC Enhancement: Opportunities in Agriculture.” Working Paper. Washington, DC: World Resources Institute. Available online at www.wri.org/publication/enhancing-ndcs-agriculture.

⁹ Strohmaier, R., Rioux, J., Seggel, A., Meybeck, A., Bernoux, M., Salvatore, M., Miranda, J. and Agostini, A. (2016). The agriculture sectors in the Intended Nationally Determined Contributions: Analysis. Environment and Natural Resources Management Working Paper No. 62. Rome: Food and Agriculture Organization of the United Nations. Retrieved from: <http://www.fao.org/3/a-i5687e.pdf>

¹⁰ For 2°C, 1.5 billion t CO₂e/26 billion tons CO₂e. For 1.5°C, 1.9 billion t CO₂e/26 billion t CO₂e. The method for setting the target is explained in Figure 2.

¹¹ Hupperman, D., et al. *IAMC 1.5°C Scenario Explorer and Data hosted by IIASA*. Integrated Assessment Modeling Consortium & International Institute for Applied Systems Analysis, 2019. doi: 10.5281/zenodo.3363345

¹² UNEP 2016. The Adaptation Finance Gap Report 2016. United Nations Environment Programme (UNEP), Nairobi, Kenya.

¹³ FAO, IFAD, UNICEF, WFP and WHO. 2019. The State of Food Security and Nutrition in the World 2019. Safeguarding against economic slowdowns and downturns; Jafry, T and R. Sulaiman V. (2013) Gender Inequality and Agricultural Extension, *The Journal of Agricultural Education and Extension*, 19:5, 433-436, DOI: 10.1080/1389224X.2013.824166; Wong, S. (2016) Can Climate Finance Contribute to Gender Equity in Developing Countries?. *J. Int. Dev.*, 28: 428– 444. doi: [10.1002/jid.3212](https://doi.org/10.1002/jid.3212).

¹⁴ Hird-Younger, M. and B. Simpson. 2013. Women extension volunteers: An extension approach for female farmers- MEAS Case Study.

¹⁵ Manalo IV, J. A., Balmeo, K. P., Berto, J. P., & Saludez, F. M. (2019). The Infomediary Campaign in the Philippines as a Strategy to Alleviate Information Poverty. In Management Association, I. (Ed.), *Crowdsourcing: Concepts, Methodologies, Tools, and Applications* (pp. 789-818). IGI Global. <http://doi:10.4018/978-1-5225-8362-2.ch039>

¹⁶ Gumucio T, Hansen J, Rose A. 2019. Access and use of weather and climate information by women and men farmers: Rwanda Climate Services for Agriculture qualitative evaluation preliminary findings. CCAFS Info Note. Wageningen, Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CAAFS).

¹⁷ Clarkson, G., Garforth, C., Dorward, P., Mose, G., Barahona, C., Areal, F., et al. (2018). Can the TV makeover format of edutainment lead to widespread changes in farmer behaviour and influence innovation systems? *Shamba Shape Up in Kenya*. *Land Use Policy* 76, 338–351. doi: 10.1016/j.landusepol.2018.05.011

¹⁸ Nora, Cara. 2019. Shamba Shape Up: television can be participatory. Blog Post Thrive. <https://wle.cgiar.org/thrive/big-questions/how-can-media-galvanize-more-effective%2%A0responses-social-and-environmental-3>

¹⁹ Suri, T., & Jack, W. 2016. The long-run poverty and gender impacts of mobile money. *Science*, 354(6317), 1288–1292; Ndiaye, O K. 2013. “Is the Success of M-Pesa ‘Empowering’ Kenyan Rural Women?” *Feminist Africa* 18 156 – 161. http://www.math.uct.ac.za/sites/default/files/image_tool/images/429/feminist_africa_journals/archive/18/s_tandpoints_is_the_success_of_m-pesa_empowering_kenyan_rural_women_.pdf

²⁰ Greatrex H, Hansen J, Garvin S, Diro R, Le Guen M, Blakeley S, (2015) Scaling up index insurance for smallholder farmers: Recent evidence and insights. Report No 14. CCAFS, Copenhagen. Available at: https://cgspace.cgiar.org/bitstream/handle/10568/53101/CAAFS_Report14.pdf.

²¹ Greatrex, H., S Alo, R Diro, J Hellin, E Fisher. 2016. Interdisciplinary entanglements in index insurance. International Research Institute for Climate and Society. <https://repository.cimmyt.org/bitstream/handle/10883/18232/58378.pdf?sequence=1>

²² Hansen, J., A. Rose, and J. Hellin. 2017. “Prospects for Scaling up the Contribution of Index Insurance to

Smallholder Adaptation to Climate risk”.

²³ Moore, D. Niazi, Z. Rouse, R. Kramer, B. 2019. Building Resilience through Financial Inclusion: A Review of Existing Evidence and Knowledge. Financial Inclusion Program Innovations for Poverty Action.

²⁴ Fisher, E, Hellin, J, Greatrex, H, Jensen, N. Index insurance and climate risk management: Addressing social equity. *Dev Policy Rev.* 2019; 37: 581– 602. <https://doi.org/10.1111/dpr.12387>

²⁵ Loboguerrero, A. M., Thornton, P., Wadsworth, J., Campbell, B. M., Herrero, M., Mason-D'Croz, D., Dinesh, D., Huyer, S., Jarvis, A., Millan, A., Wollenberg, E., & Zebiak, S. (2020). Perspective article: Actions to reconfigure food systems. *Global food security*, 26, 100432. <https://doi.org/10.1016/j.gfs.2020.100432>

²⁶ Lambin, E.F., Gibbs, H.K., Heilmayr, R. et al. The role of supply-chain initiatives in reducing deforestation. *Nature Clim Change* 8, 109–116 (2018). <https://doi.org/10.1038/s41558-017-0061-1>

²⁷ <https://www.greenclimate.fund/projects/criteria>