DOCUMENT OF THE INTER-AMERICAN DEVELOPMENT BANK GROUP

TECHNICAL GUIDANCE FOR ALIGNING IDB GROUP'S OPERATIONS TO THE PARIS AGREEMENT

AGRI-FOOD SECTOR

March 2023

This document was prepared under the guidance of Juan Pablo Bonilla (CSD/CSD), Aitor Ezcurra (INO/SMC), Pedro Martel (CSD/RND) and Guillermo Foscarini (INO/SMC). Contents were prepared by Ana R. Rios (RND/CHO), with the collaboration of Sofía Viguri (CSD/CCS) and Camila Rodríguez (DSP/ADV). The team appreciates inputs by Marion Le Pommellec, Santiago Bucaram, Ginés Suárez and Juan de Dios Mattos (CSD/RND); and comments by Yuri Soares (LAB/STI); Lina Salazar, Maja Schling, Gonzalo Muñoz and Juan Manuel Murguia (CSD/RND); Nora Lambrecht (DSP/SEG); Andreas Jørgensen (DSP/ADV); VPS/ESG, CSD/HUD, and colleagues from CSD/RND. Elizabeth Chavez and Yolanda Valle (CSD/RND) assisted in the production of this document.

TABLE OF CONTENTS

ABBREVIATIONS

CC	Climate Change
CH_4	Methane
CO_2^e	Carbon Dioxide equivalent
CSA	Climate Smart Agriculture
FAO	Food and Agriculture Organization
GHG	Greenhouse gases
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
LAC	Latin America and the Caribbean
LTS	Long Term Strategy
MDB	Multilateral Development Banks
MSME	Micro, Small and Medium Enterprises
N_2O	Nitrous Oxide
NDC	Nationally Determined Contribution
PA	Paris Agreement
PAIA	Paris Agreement Alignment Implementation Approach
PBL	Policy Based Lending
SC	Specific Criteria
SFM	Sustainable Forest Management
UNFCCC	United Nations Framework Convention on Climate Change

I. Introduction

1.1 This document is a preliminary technical complement to the Paris Agreement Alignment Implementation Approach (PAIA). The PAIA has been developed by the IDB Group (IDB, IDB Invest, and IDB Lab), as a methodological tool to pursue the objective of aligning to the Paris Agreement (PA) new operations and projects that have been reformulated. Both the PAIA and this technical guidance are based on the Joint Framework for the assessment of PA alignment in direct investment operations, developed by Multilateral Development Banks (MDB).[1]

1.2 The PAIA outlines IDB Group's strategy to assess the alignment of operations to the PA with the objective of informing decisions on project activities to be financed and ongoing country dialogue. To do so, it establishes a set of principles to guide the consistent and equitable interpretation of the Joint MDB framework when performing the assessment; and it lays out a series of methodical steps to be followed along the preparation cycle of projects.

1.3 The PAIA builds upon IDB's Environmental and Social Policy Framework (ESPF) and IDB Invest's Environmental and Social Sustainability Policy (ESSP). All operations covered by the ESPF and the ESSP must *comply* with these policies during the preparation, execution, and closing of projects. In contrast, PA alignment assessment is meant to *inform* project design before approval using the information and tools at the disposal of the IDB Group at the time it is made.

1.4 This document contains technical guidance that complements the PAIA for operations related to the agri-food sector.[2] It provides IDB Group personnel with additional criteria to interpret the Joint MDB Framework, with specific considerations that are relevant to operations and tools at the IDB Group.[3]

1.5 The objective of this guidance is to help IDB Group personnel design operations aligned to the mitigation and adaptation goals of the PA; and ensure they present the necessary elements to determine, justify, and disclose all necessary information to assess this alignment at approval.

1.6 This document will be revisited by Management on a yearly basis upon its approval and updated as necessary to reflect the lessons learned by the IDB Group and other institutions as they work towards aligning operations and other financial flows with the goals of the PA. Updates will respond to possible adjustments in the MDB Joint Framework, as well as to the need to incorporate the experience during its implementation, consider technological and knowledge advancements in the region, among others.

1.7 **Scope of this document**. This guidance covers IDB Group's operations regarding future agri-food sector: investment loans, investment grants[4] and guarantees (i.e., operations involving capital expenditures, referred to as "direct investments" in the

---

1 Technical Note BB1 and BB2: Joint Framework of the MDBs for the Assessment of Alignment with the Paris Agreement of Direct Investment Operations. (November 2021 working document).

2 For purposes of this document, the agri-food sector encompasses agricultural production and food consumption. Agriculture (capitalized), as defined in the Agriculture Sector Framework, includes agriculture (crop farming), livestock farming, fishing, and forestry. The adjective "agricultural" describes that which belongs to Agriculture.

3 In case this document presents discrepancies with the Joint MDB Framework, the second prevails except in cases explicitly justified in this guidance.

4 As established in the PAIA, investment grants with an approved amount greater than US$3 million.

MDB frameworks) and policy-based loans and guarantees. It also provides guidance applicable to products with financial intermediaries and corporate finance, which have specific methodological approaches.

1.8 **Relation to other IDB Group documents**. The technical guidance builds on the dialogue agenda between the countries and clients of the IDB Group in Latin America and the Caribbean (LAC), ensuring that the systematic analysis of operations as result of alignment with the PA, actively provides feedback to IDB Group's action in the region supporting the transition to climate-resilient and low greenhouse gas (GHG) agri-food systems. This technical guidance is related to the Agriculture Sector Framework Document (GN-2709-10) and the Climate Change Sector Framework Document (GN-2835-8), as well as the IDB Group Climate Change Action Plan 2021-2025 (GN-2848-9).

II. THE AGRI-FOOD SECTOR AND CLIMATE CHANGE[5]

2.1 The well-being of the population and the future of the planet are determined in great part by the agri-food sector.[6] It is a critical sector for the achievement of multiple sustainable development goals such as zero hunger and poverty eradication, as well as those linked to environmental sustainability and equity (Food and Agriculture Organization–FAO, 2021a), and for the response to CC (International Food Policy Research Institute–IFPRI, 2022). The sector must increase its capacity to feed a growing population, and it must do so in a sustainable and inclusive way, providing the quantity and variety of food needed for a nutritious diet. This challenge is important, but it is further magnified by the impacts of CC. At the same time, this landscape presents the opportunity to promote an agri-food sector that contributes to climate action, increases its productivity in a sustainable manner, and promotes the inclusion of vulnerable groups. All of this through various existing policies, technologies, practices, and innovations with the potential to contribute to the achievement of this goal.

2.2 The intrinsic characteristics of the sector pose challenges for the implementation of climate action. These characteristics include: (i) a high degree of dispersion, since action would be required from about a quarter of the world's population; (ii) the multiplicity of objectives that concern the sector, encompassing –in addition to climatic aspects– considerations around food and nutritional security, biodiversity, generation of foreign exchange and livelihoods, among others; (iii) the need for small farmers to participate, given that 75% of production units worldwide have a maximum of two hectares; and (iv) the need to modify production practices, consumption patterns, as well as the management and conservation of forests and carbon sinks (Ahmed et al., 2020). An important challenge is the active involvement of the private sector, which plays a fundamental role due to its preponderance in sector's investment. Agri-food companies are key agents for the development and adoption of climate actions, as well as for the generation or strengthening of enabling factors (FAO, 2021b).

2.3 The sector is highly vulnerable to CC, as it faces impacts that may affect the different actors differently, given their heterogeneity in terms of size, technologies

---

[5] This section presents a general approach to the subject. The Agriculture Sector Framework Document (GN-2709-10) and the Climate Change Sector Framework Document (GN-2835-8) present related aspects.

[6] Agriculture Sector Framework Document (GN-2709-10).

used, use of inputs and type of products they generate (FAO, 2021a). In turn, the sector contributes to GHG emissions but, at the primary production level, it is the only sector with the potential to be a net carbon sink (IFPRI, 2022).

2.4 In consequence, the relevance of the sector in climate action is twofold (IFPRI, 2022; OECD, 2016), requiring an agri-food system where both adaptation and mitigation measures are implemented (IFPRI, 2022; Ali and Erenstein, 2017; Fanzo et al., 2017; Campbell et al., 2016; Behnassi et al., 2014). Within this framework, actions in LAC are preponderant given that the sector is the main net exporter of food and agricultural products worldwide and contains around a third of the CO_2 reserves stored in forests and of renewable water resources, and approximately a quarter of the forest area (Díaz Bonilla et al., 2022; IDB, 2020). The agri-food sector also has the greatest potential to create synergies between mitigation and adaptation (Crumpler and Meybeck, 2020) as well as to generate socioeconomic and environmental co-benefits derived from the implementation of climate actions (FAO, 2016).[7]

2.5 The 2015 PA[8] strengthens the global response to the challenge of CC within the framework of sustainable development and the eradication of poverty, emphasizing efforts to: (i) keep the global temperature increase below 2ºC with respect to pre-industrial levels and promote efforts to limit this increase to 1.5ºC; (ii) increase the implementation of actions to adapt and mitigate climate change, as well as to increase resilience[9] in such a way that food production is not at risk; and (iii) make financing flows consistent with low emissions and climate resilient trajectories. The progressive nature of the efforts of the countries is also highlighted in the PA, as well as the need to provide support to developing countries to facilitate their implementation of more ambitious actions.

A. The Agri-food sector and the mitigation goal of the PA

2.6 The PA emphasizes efforts to keep global temperature rise below 2ºC pre-industrial levels and promote efforts to limit this increase to 1.5ºC. This section addresses the main sources of GHGs from the agri-food sector, with the aim of identifying opportunities to support low-emissions pathways consistent with the PA.

2.7 **Emissions from the agri-food sector.** In 2019 the sector contributed 31% of GHG global emissions (FAO, 2021c). In contrast, in LAC over 40% of emissions are associated with agri-food (Morris et al., 2020), with considerable differences at the regional level and with respect to the main sources of emissions. For example, in 2019, in South America the agri-food sector represented 72% of total emissions, while in the Caribbean and Central America it contributed 42% and 37%, respectively; In addition, the change in land use had a greater preponderance in South America (where it contributed 47%), followed by Central America (16%) and the Caribbean (2%).[10]

---

7 Co-benefits such as poverty reduction, employment generation, health, and ecosystem conservation.
8 United Nations (2015).
9 Resilience is "the ability of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, by responding or reorganizing in ways that maintain their essential function, identity and structure, while maintaining the ability to adapt, learn and transform" (IPCC, 2018).
10 Data from FAOSTAT "Emissions Share", accessed in June 2022.

2.8 The main sources of emissions for the agri-food sector are: (i) carbon dioxide (CO_2), which comes primarily from deforestation associated with land use change for food production and the use of fossil fuels in the post-production of the same; (ii) methane (CH_4), which is associated with ruminant farming[11] and rice production, while in post-production it is related to waste disposal; and (iii) nitrous oxide (N_2O) emissions from fertilizer use (FAO 2021a).

2.9 **At the regional level, Agriculture is the main source of emissions, but its absolute contribution is moderate.** In LAC, 42% of GHG emissions come from Agriculture and land use change (where Agriculture is the main cause), in turn these contribute 3.5% of total global emissions (IDB, 2019). For their part, GHG emissions per unit of product have been reduced (Nin-Pratt and Valdés Conroy, 2020) but there has been a stagnation in the carbon efficiency of production (IDB, 2019).

2.10 **CO_2 associated with land use change.** LAC contains about 36% of the world's reserves of CO_2 stored in forests (IFPRI, 2022) and contributes 47% of emissions from deforestation (IDB, 2019). This deforestation, together with contamination by agrochemicals, is among the main factors causing soil degradation (Niemeyer at al., 2017). In this regard, the forest area of the region declined by around 13% between 1990 and 2020, which resulted in an increase in GHG emissions and had repercussions in a reduction in the provision of environmental services (Díaz-Bonilla et al., 2022). In fact, an expansion of agriculture into the tropical forest has occurred, particularly in the Amazon (Lamb et al., 2021), and in the savannahs (Mbow et al., 2019). For example, in 2010, 70% of deforestation in the region was linked to land use change towards livestock (IDB, 2019). However, it should be noted that during the period 1990-2019, the percentage contribution of GHG emissions in the agri-food system due to land use change has been reduced, while emissions generated at the level of pre and post-production processes have gained prominence (Tubiello et al., 2022).[12]

2.11 **CO_2 associated to energy.** The agri-food system is also a major consumer of energy. Without considering energy used for transportation, 22% of emissions are caused by on-farm energy consumption (Morris et al., 2020). Moreover, the agri-food sector could significantly contribute to water security. In fact, in LAC 72% of extracted fresh water is for agricultural purposes, water demand is expected to increase up to 127%, the expansion of non-technified irrigation and agricultural activities are affecting the availability and quality of water resources (BID, 2019). Therefore, greater efficiency in water use is a key opportunity for climate action.

2.12 On the other hand, the transport of agricultural products contributes approximately 6% of the emissions linked to the agri-food sector globally (Poore and Nemecek, 2018). In terms of emissions related to transport linked to exports, Agriculture is the third main item in LAC, representing 12% of said emissions' total (Li, 2021).

2.13 **Emissions not linked to CO_2.** The reduction of methane emissions is essential to achieve the goals of the PA. Around 40% of global methane emissions come from Agriculture (Searchinger et al., 2021), two thirds of these are attributed to ruminant livestock and they are closely related to production efficiency (Searchinger and Herrero, 2022). The second largest source of methane emissions from agriculture

---

11 Especially for beef and dairy production.

12 For example, at the subregional level, in Central America the contribution in land use change was reduced by around 40%; and in South America, 32% (estimations based on FAOSTAT Data's "Emissions Share").

is rice production (FAO, 2020a). Likewise, the FAO (2020a) reports that agriculture generates approximately 80% of total nitrous oxide emissions, mainly due to the use of fertilizers.

B. The Agri-food sector and the adaptation goal of the PA

2.14 The PA highlights the need to increase the implementation of adaptation actions. To guide these actions, the following paragraphs present in a general way some key impacts of CC in the sector.

2.15 Projected changes in temperature, precipitation patterns, glacier retreat and the incidence and magnitude of extreme weather events, among others, will have a negative impact – with some exceptions – on the availability, as well as on access, use and stability of food. Reductions in agricultural yields, increases in food prices, decrease in water availability, disturbances in supply chains, effects on post-production stages, as well as damage to public infrastructure, are among the effects of CC with repercussions for agri-food systems (FAO and PAHO, 2017).

2.16 Agricultural productivity is affected by CC (Descheemaeker et al. 2018; Hristov et al., 2018; Myers et al, 2017; SCPAL, 2014 and 2013; Fernandes et al., 2012). Changes in temperature and precipitation, shorter production cycles with less time for grain filling and reduction in water availability, are identified as some causes of productivity loss (Fernandes et al., 2012). Changes in soil suitability also affect this sector (Mbow et al., 2019; Ovalle-Rivera, 2015; Bourconcle et al., 2015; Laderach et al., 2009).

2.17 Negative effects are generally expected in livestock productivity, due to the increase in temperature; anticipating that, among others, CC will affect the amount and quality of forage (e.g., protein content and digestibility), the fertility of cattle, and increase animals' energy demand for productive activities (Hristov et al., 2018).

2.18 The link between climatic conditions, on the one hand, and the incidence and geographical distribution of pests and diseases in plants and animals on the other, is widely documented (Mbow et al., 2019; Adedayo et al., 2014; Lau et al., 2013). In fact, CC favors the proliferation of certain pests (Huot et al., 2017; Evans et al., 2014; Ghini et al., 2011), the emergence or re-emergence of infectious diseases and alterations in the localities where they are present (Van den Bossche and Coetzer, 2008). This results in losses in the production of agricultural products and in their quality (Ovalle Rivera, 2015; Chakraborty and Newton, 2011).

2.19 CC also impacts fishing and aquaculture. Fishery resources are affected by ocean acidification, and rising sea temperatures and levels (Pörtner et al., 2022;[13] Ding et al., 2017; Allison et al., 2009). A redistribution of these resources is projected, increasing the fishing potential by more than 30% in high-latitude areas, reducing it by up to 40% in the tropics (Cheung et al., 2010). For their part, extreme weather events have reduced fishing and aquaculture productivity. On the other hand, it is expected that the increase in temperature and the intensity of rains will increase

[13] This report is part of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

risks in terms of food safety associated with fishery products (Pörtner et al., 2022).[14]

2.20 Along agri-food chains, food trade volumes and patterns can be altered due to the impact of CC on production, prices, transport, logistics and supply chains (Ahammad et al., 2015). IFPRI (2022) indicates that higher levels of temperature and humidity will increase post-harvest losses via, for example, contamination with aflatoxins and other molds, as well as through reduced shelf life for perishable products. In addition, the time required for grain drying is expected to increase.

2.21 CC influences food insecurity, but it also affects the availability and pressure placed on natural resources and the ecosystem services they provide, (Pörtner et al., 2022; IFPRI, 2022; Mccarl and Hertel, 2018). At the same time, it is anticipated that CC will lead to greater conflict over the use of these resources, as well as migrations (Mbow et al., 2019; Myers et al., 2017).

C. The Agri-food sector and climate action

2.22 The previous Sections (A and B) have presented the relevance of the agri-food sector for the achievement of PA goals, given its vulnerability to the impacts of CC, as well as its potential to reduce emissions. This section details alternatives and/or approaches to materialize the opportunities for mitigation, adaptation, and increased resilience. The description also covers critical enabling factors for the advancement of these actions, factors such as security of land tenure, access to technical assistance and financing.

2.23 **Forest cover, conservation of habitats and ecosystems.** Forests and forest cover play a fundamental role in the transformation into a low carbon and climate resilient agri-food sector by sequestering carbon, increasing resilience, protecting biodiversity, as well as providing income, food, and ecosystem services (Ickowitz et al., 2022).[15] In fact, the greatest mitigation potential focused on Agriculture and other land uses lies in the management, conservation and restoration of forests and other natural ecosystems (Nabuurs et al., 2022). For its part, the recovery of degraded lands can contribute to increases in productivity and reductions in emissions (Mbow et al., 2019), as well as protection of biodiversity (Díaz-Bonilla et al., 2022).

2.24 Nevertheless, as pointed out by Nabuurs et al. (2022), achieving this potential requires overcoming challenges of financing, governance, institutional capacity, accountability, long-term investment uncertainty, land ownership, and policy stability, among others. The availability of information regarding deforestation and the valuation of ecosystem services, the implementation of incentives for sustainable forest management, the establishment and management of conservation areas, as well as the prevention and control of forest fires, are also relevant (Fazekas et al., 2022). Regarding supply chains, commitments and certifications focused on, for example, reducing deforestation (Nabuurs et al., 2022) and guaranteeing sustainable production are some important measures for forest protection (IFPRI, 2022).

---

[14] This because of an increase in pathogens, toxic algae, and mercury content, among others.

[15] Ecosystem services include, among others, microclimate control, water and nutrient recycling, pollinator habitat, nitrogen fixation, and protection against soil erosion (Ickowitz et al., 2022).

2.25 **Climate-smart agriculture and agroecology.** There is a wide range of options for the transformation towards low-emission and resilient agri-food systems, which have the potential to increase productivity as well (IFPRI, 2022). Evidence indicates that climate-smart agriculture practices are effective measures to mitigate and adapt food systems to CC. These practices have the potential to reduce the impacts of CC and GHG emissions (Pörtner et al., 2022; Fernandes et al., 2012) and can also contribute to increasing the income of the producers who adopt said practices (Descheemaeker et al., 2018).

2.26 Agroecology also has the potential to contribute to sustainable production while improving climate resilience and providing multiple co-benefits via, for example, provision of environmental services (Pörtner et al., 2022; Snapp et al., 2021), while at the same time reducing energy use (Snapp et al., 2021).

2.27 **Livestock.** Improving livestock feeding efficiency plays a fundamental role as it is a critical determinant of productivity, emission intensity and use of resources (Herrero et al., 2013). In intensive livestock models, mitigation measures include sustainable waste and effluents management –e.g., using biodigesters, energy efficiency measures and the adoption of renewable energies, measures to improve the efficiency of food production, and actions to avoid deforestation and potentially associated land use change. In this framework, increases in productivity, linked to improved varieties of grass, genetic improvement of animals, supplementation and other forms of nutrition management have been shown to have positive effects on GHG reduction per kilogram of cattle produced (Nin-Pratt et al., 2019). In addition, adaptation in livestock may include management practices (e.g., sustainable intensification, integration with crops, water management, pasture management, forage storage, etc.) and genetic improvement, among others (Mbow et al., 2019).

2.28 **Plant and animal health.** Plant and animal health activities contribute to CC mitigation and adaptation (FAO, 2021c and 2020b; Mbow et al., 2019; Rosenzweig and Tubiello, 2007). Mitigation benefits could accrue through reduced emissions associated with pesticide use and through avoided emissions resulting from land use change. Pesticides are extremely carbon intensive, so reducing their use and improving their efficiency is an important alternative to reduce GHG emissions (Lal, 2004). This aspect is of particular importance given that LAC is the region with the highest use of pesticides (IDB, 2019).

2.29 The strengthening of animal health inspection and diagnostic capacities, as well as integrated pest management practices, have been identified as key actions for adaptation to CC (FAO, 2020b; Forman et al., 2008; Van den Bossche and Coetzer, 2008), as well as integrated pest management (Shuckla et al., 2019). Furthermore, Black et al. (2008) emphasize that it is necessary to support health services to adequately control and manage transboundary diseases and food safety problems, which may be aggravated by CC. The need for extension programs to train in the proper use of pesticides and disease management options are equally as important (Pautasso et al., 2012; Savary et al. 2011). Likewise, evidence shows that better animal health increases productivity and reduces the carbon footprint associated with livestock (Ahmed et al., 2020; Kenyon et al., 2013; Stott et al., 2010).

2.30 **Food losses and waste.** Reducing food losses and waste[16] is a mitigation measure (IFPRI, 2022; Pathak et al., 2022; Ahmed et al., 2020; Mbow et al., 2019) that increases the resilience of the agrifood system (Shukla et al., 2019). Among the technical options to reduce these is the improvement of harvesting techniques, storage and/or refrigeration systems with energy efficiency and/or that use renewable energy (IFPRI, 2022; Schulte et al., 2020; Shukla et al., 2019).[17]

2.31 **Behavior changes**. Change in human diet is frequently referred to as a measure to reduce emissions linked to livestock (IFPRI, 2022; Pathak et al., 2022; Ahmed et al., 2020). Regulations around intuitive food labeling and expiration date management can also actively promote a reduction in food waste and a shift to more nutritious, healthy, and low-emission diets (Shangguan et al. 2019).

2.32 **Innovation and technology.** The sustainable transformation of agri-food systems can be accelerated through the implementation of technological innovations (e.g., gene editing technologies, solar-powered cold chain technologies, and digital innovations, among others) (Swinnen et al., 2022). There is potential for emission reductions through gene technology and emerging technologies such as cultured meat and plant-based alternatives (Pathak et al., 2022). Within these, Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) have facilitated the recent increase in the use of gene editing for crop and livestock improvement in response to CC and has a wide potential application in the future (Karavolias et al., 2021). For their part, digital technologies can contribute to improving efficiency in the use of resources and reducing vulnerability (IFPRI, 2022).

2.33 Returns on investment in research and development have been widely documented as a benefit-cost ratio of at least 10:1 (Swinnen et al., 2022) and a social rate of return on public investment in agricultural research and development greater than 40% (Fuglie et al., 2020).[18] Likewise, it is necessary to have conditions that favor private investment, public-private partnerships and the adoption of technologies and practices (IFPRI, 2022; Fuglie et al., 2020; Searchinger et al., 2018).

2.34 **Information, technical assistance, financing, and risk management.** In order to assist in making decisions on climate action at the local level, it is key to strengthen knowledge and information on production systems, as well as emission factors (Vermeulen and Wollenberg, 2017). Likewise, access to financial services and the provision of technical assistance are required for the adoption of new technologies and practices for climate action (IFPRI, 2022; Mbow et al., 2019; Vermeulen and Wollenberg, 2017). Mechanisms for risk management, reduction and transfer are also important adaptation measures (Portner et al., 2022; IFPRI, 20222; Mbow et al., 2019).

2.35 **Land ownership and use.** The IPCC (2022b) indicates that insecurity in property rights and land use is a limiting factor for the implementation of climate activities. IPCC also shows, for example, that the adoption of adaptation strategies with short- and long-term benefits requires security in land tenure (Murken and Gornott, 2022; Katusiime and Schütt, 2020). For its part, the formal titling of indigenous communities has favored forest conservation in the Amazon (Blackman et al.,

[16] It refers to as losses to the decrease in edible food that occurs in production, post-harvest and processing, waste occurs at the consumer level.
[17] In LAC, half of food losses and waste occur in production, handling and storage (Searchinger et al., 2018).
[18] Average rate of return for developing countries.

2017). However, interventions related to land ownership must be carefully considered and designed as conflicting findings in the literature have been reported regarding its impact on deforestation (see, for example, Buntaine et al, 2015). Moreover, inclusive and collective rights as well as individual ones need to be considered to favor the climate response (IFPRI, 2022; Murken and Gornott, 2022).

2.36 **Other enabling factors.** To reduce the costs associated with the transition from the agri-food system to a low-emission model and meet multiple sustainable development goals, integrated policy packages that combine administrative, information, market and behavior change measures are required (Pathak et al., 2022). Public investment in development and research; the strengthening of mechanisms to share knowledge, experiences and lessons learned; and the existence of factors that encourage investment and participation of the private sector are also essential elements for the advancement of climate action in the agri-food sector; likewise, it is necessary to review existing regulations and incentives to guarantee their alignment with mitigation and adaptation actions (IFPRI, 2022).

D. Economic impacts and transition risks

2.37 Under the PA, the transition to low-emission and climate-resilient pathways carries potential impacts on assets. This section addresses this perspective, describing what stranded assets represent in the sector, and their characteristics.

2.38 **Stranded assets and transition risks**. CC and responses to it may result in stranded assets. Stranded assets are those that depreciate, lose their value, or become liabilities in a premature or unexpected way (Caldecott et al., 2016). In the agri-food system, the risk of stranded assets is associated with physical factors and economic factors linked to policies and responses from society in the face of the urgency of moving towards net zero or low emission models (regulations, trade restrictions, behavioral change or preferences consumption, trends towards green supply chains, etc.) (Caldecott et al., 2013). These policies and societal responses as well as technological changes constitute transition risks associated with decarbonization goals (Caldecott et al., 2021). Potential stranded assets include production and processing units that do not meet new requirements or that have lost demand (Rautner et al., 2016), land and associated improvements on it that lose value due to shifts in agricultural suitability, as well as plantations and/or farms that lose part or all their value due to pests or diseases (Caldecott et al., 2013).

2.39 In this context, Rautner et al. (2016) indicates that (i) the risk is differentiated since it depends on the sub-sector, practices used, geographic location and size of the farm; (ii) all actors in the chain may be affected, with less risk for those closest to the consumer; (iii) the focus on sustainable agriculture[19] is a way to reduce regulatory risks; and (iv) the implementation of adaptation measures can reduce some of the physical risks.

---

[19] Sustainable agriculture includes production systems, institutions, and policies that support food security while ensuring profitability as well as social and environmental aspects.

E. Opportunities to support a transition

2.40 As shown above, the agri-food sector presents ample opportunities for the transition towards resilient policies and lower emissions. These opportunities are even greater because numerous options simultaneously present mitigation and adaptation benefits, as will be further explained. Subsequently, considerations for the advancement of climate action in the sector are emphasized.

2.41 **Synergies between mitigation, adaptation, and food security.** Within the agri-food sector, there are synergies between the objectives of mitigation, adaptation, and food security (FAO, 2016). Multiple options have the potential to contribute to climate change mitigation and adaptation, several of these having a simultaneous effect of improving food security (Mbow et al., 2019; Lankoski et al., 2018; FAO, 2016). Indeed, activities related to improvements in land use (e.g., forest conservation, forest restoration, sustainable forest management, agroforestry, among others) and the reduction of methane and nitrous oxide in agriculture can, in addition to contributing to climate action, have multiple synergies with the sustainable development goals (IPCC, 2022).

2.42 The reduction of desertification and soil degradation are also potential co-benefits (Smith et al., 2019), as well as the generation of employment (FAO, 2016). For example, Smith et al. (2019) indicate that alternatives such as agroforestry, forest fire control and management, improved livestock management and sustainable productivity contribute to mitigation, adaptation, food security and soil quality.

2.43 Figure 1 presents options for climate action with their respective mitigation and adaptation potential. In the Annex, Table A1 provides detailed information set of specific alternatives and their impact on productivity, mitigation, and adaptation.

Figure 1. Options for climate action in the agri-food sector and potential contribution in mitigation and adaptation[20]

Response options	Mitigation	Adaptation
Improved crop management		
Increased soil organic matter content	Very High	High
Change in crop variety	Limited	Very High
Improved water management	Limited	Very High
Adjustment of planting dates	None	Very High
Precision fertiliser management	High	High
Integrated pest management	None	High
Counter season crop production	None	High
Biochar application	High	Very High
Agroforestry	High	Very High
Changing monoculture to crop diversification	Limited	Very High
Changing in cropping area, land rehabilitation (enclosures, afforestation) perennial farm	High	Very High
Residue management	Very High	Very High
Crop–livestock systems	High	High
Improved livestock managment		
Silvopastural system	Very High	Very High
New livestock breed	Limited	Limited
Shifting to small ruminants or drought-resistant livestock or fish farming	Limited	High
Feed and fodder banks	High	High
Methane inhibitors	Very High	None
Thermal stress control	Limited	Very High
Seasonal feed supplementation	High	Very High
Improved animal health and parasites control	High	Very High
Climate services		
Early warning systems	None	Very High
Planning and prediction at seasonal to intra-seasonal climate risk	None	Very High
Crop and livestock insurance	None	Very High
Improved supply chain		
Food storage infrastructures	Limited	Very High
Shortening supply chains	Limited	Limited
Improved food transport and distribution	High	Very High
Improved efficiency and sustainability of food processing, retail and agrifood industries	High	Very High
Improved energy efficiencies of agriculture	High	High
Reduce food loss	Very High	High
Urban and peri-urban agriculture	Limited	High
Bioeconomy (e.g. energy from waste)	None	Limited
Demand management		
Dietary changes	Very High	High
Reduce food waste	Very High	Very High
Packaging reductions	Limited	High
New ways of selling (e.g. direct sales)	Limited	Limited
Transparency of food chains and external costs	High	High

Potential contribution

Very High

High

Limited

None

[20] Source: Mbow et al., 2019.

2.44 **Climate action requires building new capacities by individuals and companies.** The planning, design, implementation, and monitoring of activities leading to the achievement of PA goals require updating and/or developing specific knowledge and skills. It is expected that the sectoral transformation in LAC is particularly accompanied by a greater demand for individuals with medium qualifications. Updating educational curricula, providing training (including on-the-job training) as well as strengthening companies for the adoption and use of new technologies and practices will also be needed (Saget et al., 2020). The lack of skills is, in fact, one of the main barriers for the implementation of mitigation and adaptation measures in the sector (Shuckla et al., 2019).

2.45 **Unit size and climate action**. In the context of climate action, Vermeulen and Wollenberg (2017) estimate the contribution of small-scale agriculture[21] to the total emissions of the sector in developing countries. In their approach,[22] the authors point out that small farmers account for about a third of total emissions from Agriculture and a third of total emissions from agriculture-related land-use change. However, small-scale agri-food systems are emissions intensive compared to other production systems (Cohn et al., 2017). Indeed, they face broad barriers to reducing emissions due to insufficient access to information, knowledge, skills, practices, technologies, and innovations that are crucial to be able to transform agricultural systems and land use, so their treatment in the process of transition to low emissions must be differentiated (UNFCCC, 2021b).

2.46 Small-scale agriculture is a priority for the implementation of adaptation actions, since vulnerability to CC impacts is high in these producers (Pörtner et al., 2022). In fact, small and medium producers in the region as well as indigenous groups will be especially affected by production reduction, areas suitable for production and water availability (IPCC, 2022).

2.47 **Transition support for small producers and micro, small and medium-sized enterprises (MSMEs).** Mitigation opportunities in smaller-scale systems are primarily related to efficiency gains. Despite these opportunities, a major transition challenge for small producers and MSMEs is the growing pressure to ensure the traceability of industrial-scale agricultural companies value chains. The costs of inventorying, monitoring, and evaluating practices to ensure non-deforestation and environmental sustainability of their products can generate barriers to participating in the supply to large-scale agribusinesses. This aspect must be addressed with policies, regulations and corporate commitments that recognize the need for a just transition perspective that supports small producers and MSMEs to have access to technologies, information, and tools.

2.48 **The main objective of aligning operations with the PA is to support the transition of countries and clients in the sector.** The process of aligning operations with the PA will not only strengthen the design of investments financed

---

21 There is no common definition of small agricultural producers. The term is frequently used to refer to systems smaller than 2 hectares in size, although in some country contexts these can reach 200 hectares (Cohn et al., 2017). A related concept that is relevant is family farming, characterized mainly by the preponderant use of the family labor force (FAO & IDB, 2007). These definitions are presented in contrast to large-scale commercial plantations, whose production is generally characterized by intensive models destined for export (Dixon et al., 2011).

22 In their approach, the authors use an estimate that covers emissions within the production unit and does not include carbon sequestration, among others.

by the IDB Group in the region, but above all, this systematic analysis process will make it possible to identify opportunities for dialogue and support for the countries to achieve their own goals vis-a-vis the PA. The implementation of such opportunities will often require technical assistance resources, such as for the development of robust, inclusive, and ambitious long-term strategies that detail the role of the agri-food sector in the transition. There are other actions, some listed in this section, that the IDB Group will reinforce in its collaboration with the Ministries of Agriculture, livestock, research institutes, and knowledge networks in the region, as well as with private sector clients, to promote the implementation of lower-GHG and climate resilient agri-food systems in LAC.

III. ASSESSMENT OF OPERATIONS: ALIGNMENT WITH THE PA MITIGATION GOAL (BB1)

3.1 The joint MDB methodology serves as the basis for determining the alignment of operations with the PA. The application of the guide will result in two possible scenarios: “aligned” or “not aligned”. In this context, an operation is “aligned” if it does not go against the mitigation (BB1) and adaptation and resilience (BB2) goals of the PA. This section presents and describes the procedure to determine the alignment with the mitigation goal.

3.2 BB1 focuses on whether the operation in question is consistent with a low GHG development trajectory in the country where the operation is located and does not hinder or harm the transition to a decarbonized economy, both at the country and global levels.

A. Alignment universally aligned with the PA mitigation goal

3.3 **Activities considered universally aligned**. According to Annex 1 of the Joint MDB Assessment Framework for Paris Alignment for Direct Investment Operations, some activities can be considered to be aligned to the mitigation goal of the PA across countries and under all circumstances. In the agri-food sector, Box 1 captures universally aligned activities as long as i) their economic feasibility does not depend on the extraction, processing and/or transportation of fossil fuels; ii) their economic feasibility does not depend on fossil fuel subsidies; and iii) the operation does not depend significantly on the direct use of fossil fuels.

3.4 In addition, the MDB Joint Framework also suggests that the design of operations should reinforce the preservation of high carbon stocks (HCS),[23] an aspect that should be reviewed in conjunction with the IDB’s Environmental and Social Policy Framework (ESPF) and IDB Invest’s Environmental and Social Sustainability Policy (ESSP), as applicable.

3.5 Box 2 presents definitions to support the interpretation of these activities in the context of IDB operations.

[23] Under this approach, it is recognized that secondary forests provide essential carbon storage services and forest products for local communities that are often not considered to be of conservation value and therefore are not protected.

Box 1. Activities considered by MDBs to be universally aligned[24]

Sector[25]/Theme area	Eligible operation type	Conditions and guidance
Agriculture, forestry, land use and fisheries	Afforestation, reforestation, sustainable forest management, forest conservation, soil health improvement.[26]	With the exception of operations that expand and promote expansion into areas of high carbon stocks or high biodiversity areas and taking into account (international) transport. This aspect must be assessed by teams based on environmental safeguards as well as environmental and social policies.[27]
	Climate-smart agriculture and agroecology.[28]	
	Conservation of natural habitats and ecosystems.	
	Sustainable fishing and aquaculture.	
Water supply	Efficiency in water management and/or use; water management at watershed level; irrigation systems with renewable energy; drought management.	Desalination plants need to go through specific assessment
Information and communications technology (ICT) and digital technologies	Information and communication, including digital technologies focused on sustainably increasing productivity and reducing/removing GHG emissions. Excludes data centers.	
Research, development, and innovation	Professional, scientific, research and development (R&D), and technical activities. Among them, research, development, and innovation focused on sustainably increasing productivity and reducing/removing GHG emissions.	

Source: Joint MDB Assessment Framework for Paris Alignment for Direct Investment Operations, Annex 1.

24 Regarding the list of the Joint Framework of the MDBs, “low emission agriculture” and “livestock of non-ruminant animals with insignificant GHG emission levels” are excluded to avoid ambiguity about what is considered low or insignificant.

25 Categories are presented as “sectors”, consistent with terminology used in the Joint MDB Framework.

26 This activity covers recuperation of degraded lands or degraded ecosystems.

27 This aspect will be validated in projects, building upon what is already analyzed as part of the application of Standard 6 in the ESPF and the ESSP. Also, the promotion and use of exotic invasive species should be avoided in line with the ESPS Standard 6 and the Exclusion List of the ESPF, and in line with national regulations for biosafety and invasiveness assessments (main species to avoid due to high risk: Eucalyptus, Pinus, and Tilapia).

28 The IDB Group adds “agroecology” due to its integral and long-term approach to achieve a sustainable and equitable agri-food system.

Box 2. Relevant definitions

Afforestation. Planting trees where historically there was no forest cover.

Sustainable forest management. Activities focused on maintaining or increasing the economic, social and environmental benefits of the forest.[29] These activities include pruning, thinning, weeding, reforestation and restoration activities, forest management plans, fire prevention and control, pre and post-harvesting practices, favoring or improving the regeneration of desired species, enrichment with tree species and management of wildlife, among others.[30]

Climate Smart Agriculture (CSA).[31] This is an approach aimed at the achievement of sustainable development and food security in a CC context (FAO, 2013). CSA must have a context-specific approach to identify production systems that, to the extent possible, contribute to food security, better respond to CC impacts, and mitigate GHG emissions (FAO, 2017b). This definition will serve to assess whether specific investments qualify as CSAs in each operation. Alignment with CSA requires presenting context-specific technical justification for GHG mitigation, CC adaptation and contribution to food security. Specifically, this entails three conditions:

a. Mitigation data that allow an estimation of GHG emissions reduction through:
   (i) Increased efficiency (per unit of product generated) in the use of inputs such as soil, water, fuel, energy, food, fertilizers, and other agrochemicals; and/or
   (ii) Total or partial reduction in the use of fossil fuels and inputs associated with them (e.g., energy, agrochemicals such as fertilizers, pesticides, and herbicides).
b. Adaptation via reduction of possible CC impacts [32]
c. Sustainably increased productivity and/or with reduced variability.[33]

Some examples of CSA practice:[34]

a. Integrated system – For example, integrated landscape management, agroforestry.
b. Production practices – Such as selection of varieties, genetic improvement, efficient use of inputs (water, fertilizers, etc.), sustainable intensification,[35] conservation agriculture, irrigation, integrated pest management, integrated water management and soil management.
c. Forest – Among these, sustainable forest management, genetic improvement, and the integration of CC in regulations and practices.
d. Transformation and commercialization processes – Energy management, efficient use of water, reduction of food losses and waste, sustainable value, and supply chains, etc.
e. Capacity building and knowledge generation related to CSA.
f. Actions that favor a long-term vision in the management and sustainable use of resources. For example, security of land tenure, access to finance for CSA implementation.
g. Innovation and technological development for CSA.

Agroecology. Context-specific management of food and agricultural systems that integrates ecological and social concepts and principles with the aim of achieving a sustainable and fair food system (FAO, 2018b).[36] Agroecology has a comprehensive and long-term approach. It combines science with traditional knowledge, uses non-renewable resources sparingly, phases out the use of chemicals, and emphasizes the rights of vulnerable groups (FAO, 2018b and 2010). Agroecology practices include, for example, agroforestry systems, intercropping, crop rotation, fish

---

29 Based on the FAO "Sustainable Forest Management (SFM) Toolbox".

30 It takes as reference the FAO's "Sustainable Forest Management (SFM) Toolbox" and AIDER (2017).

31 Consistent with the conditions of the MDBs, this definition will apply if ecosystem services are not directly or indirectly negatively affected, including carbon sequestration and biodiversity.

32 See the BB2's section.

33 See the BB2's section.

34 For a broader list of CSA examples see, among others, FAO (2018a), FAO (2017b), McCarthy (2014) and FAO page on "Climate-Smart Agriculture".

35 Examples of sustainable intensification approaches provided by the IPCC are presented in Table A2 of the Annex.

36 Similarly, the bioeconomy, by focusing on the sustainable use of renewable biological resources (terrestrial and oceanic) for food, materials and energy, will be considered as universally aligned, applying the elements of technical justification described in CSA.

polyculture, integrated aquaculture, pest management with natural products, and biological pest control.[37] To validate alignment technical justification covering the three conditions described in CSA must be present.

Sustainable fishing and aquaculture. The sustainability approach must be based on management that uses up-to-date and reliable information/data, particularly in the case of fishing, because scientific evidence indicates that marine areas that lack research have little and/or poor fishing management, which negatively affects the stocks of said areas (e.g., Hilborn et al., 2020). To validate alignment, project teams must present the technical justification covering the three conditions described in CSA.[38]

B. Activities that must validate their alignment with the mitigation goal of the PA

3.6 Regardless of operation-related items under consideration, the application of five Specific Criteria (SC) is carried out in operations that do not appear within the aforementioned list of universally aligned activities or whose justification for inclusion within said list is not validated.[39] Based on the projects omitted from the list of universally aligned activities and the active portfolio of the IDB Group, the following types of investments and associated policies will require a specific analysis of alignment with the CC mitigation goal of the PA. Please note that this list is <u>not exhaustive</u> and may be supplemented over time:

a. Project teams will pay particular attention to those components and operations that promote the production of items that may be associated with high levels of GHG emissions (e.g., livestock, flooded rice systems, etc.) or associated with sectors with potential links with land use change.[40]

b. Likewise, in those cases where the specific origin and destination of items can be identified, the emissions linked to their transportation must be especially considered.

c. In addition, based on the MDB guidance, any of the following operations will require a specific analysis: (i) operations whose economic viability depends on external activities for the extraction, processing and transportation of fossil fuels; (ii) operations whose economic viability depends on existing fossil fuel subsidies (e.g., a fishing fleet that would be unviable without fossil fuel subsidies); and (iii) operations that depend significantly on the direct use of fossil fuels (e.g., a production plant or irrigation system that relies entirely or substantially on fossil fuel pumps).

C. Criteria for the specific assessment

3.7 The analysis considers particular aspects of the operation, the country's context, as well as national and sectoral strategies. An affirmative answer to any of these SCs implies non-alignment. SCs have no hierarchy, focusing on:

---

37 This indicative list was prepared taking as reference FAO (2018b) and the review of practices carried out by Wezel et al. (2014).

38 Within this topic, for example, the FAO (2015) presents a manual for saving fuel in small fishing boats.

39 In operations with multiple components, the SCs will be applied only to those components that do not appear within the universal criteria or whose justification for inclusion within said criteria is not validated.

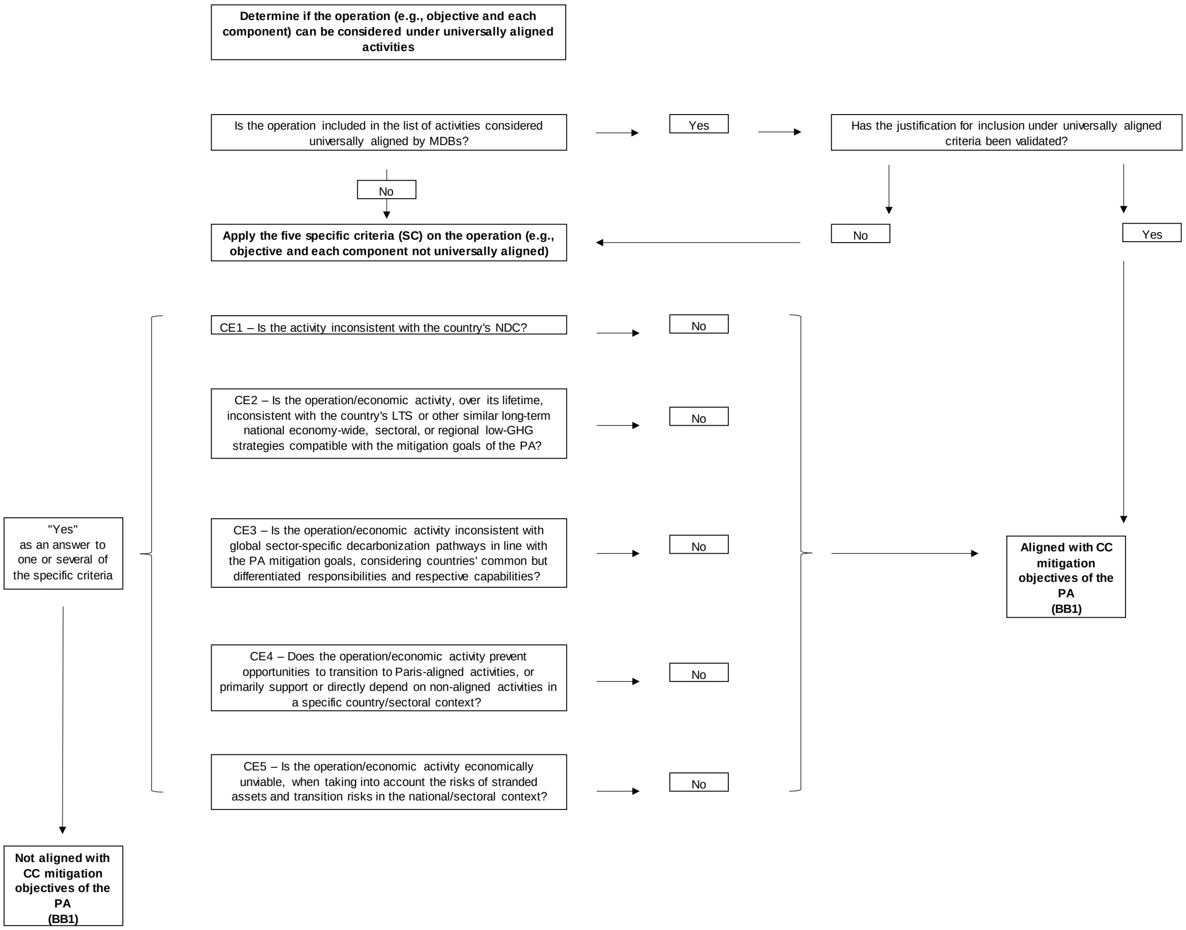
40 Depending on the context, in some instances, land use change has been linked to soy and palm oil amongst others.

Table 1. Specific criteria of the Joint MDB Framework for PA Alignment of Direct Investments

Specific Criteria (SC)
SC1: Is it inconsistent with the Nationally Determined Contribution of the country where it is carried out? *The NDC of the country should not explicitly or implicitly phase-out this type of operation/economic activity.*
SC2: Is it inconsistent with the Long-Term Strategy of the country where it is carried out? *The LTS (or other similar long-term national economy-wide, sectoral, or regional low-GHG strategies) of the country should not explicitly or implicitly phase-out this type of activity in its lifetime.*
SC3. Is it inconsistent with the global sector-specific decarbonization pathways in line with the PA, considering countries' common but differentiated responsibilities and respective capabilities? *The operation/ economic activity should be checked against widely accepted data and findings in the global literature to inform the assessment, considering the local context and principle of equity.*
SC4: Does it prevent the transition to PA-aligned activities or primarily support or directly depend on non-aligned activities? *The type of operation/ activity should be compared to lower-carbon alternatives and consider the risk of (i) carbon lock-in or (ii) preventing future deployment of Paris-aligned activities*.
SC5: Do transition risks or stranded assets make it economically unviable? *Once climate change considerations are included in the economic and/or financial analysis of the operation, it should meet IDB Group thresholds for viability.*

Note: Insufficient information will not lead to non-alignment. Information to answer SC4 is expected to be available for all operations.

Figure 2. Decision tree to determine alignment with BB1



3.8 Figure 2 shows the evaluation flowchart to determine alignment with BB1.

3.9 The following tables present guidelines for each SC, including elements or guiding questions for their approach.

Box 3. SC1 – NDCs

SC1 - Is the operation inconsistent with the country's NDCs?

General guidance:

Verify if the operation contravenes the country's NDCs.

Specific guidance:

In general, the answer is "no" when the activity or sector does not appear in the mitigation section of the NDCs. Activities with minor/negligible emissions are not commonly listed in NDCs.

Example:

If the NDCs indicates the goal of reducing emissions intensity in food production, then an operation that implements activities along these lines - e.g., that reduce the amount of GHG emissions (such as CO_2, CH_4 and/or N_2O) per unit of product (e.g., kilograms of meat or liters of milk), is not inconsistent with the NDCs.

Source of information:

NDC Registry

Box 4. SC2 – Long-term strategies

SC2 - Is the operation, throughout its lifetime, inconsistent with LTS or other similar long-term low GHG, national economy-wide, sectoral, or regional strategies that are compatible with the mitigation goal of the PA?

General guidance:

Verify if the operation contravenes LTS or other strategies or official national, sectoral or subnational policies (including drafts in public consultation processes).

Specific guidance:

To date, only seven LAC countries have submitted their LTS to the UNFCCC (Argentina, Chile, Colombia, Costa Rica, Guatemala, Mexico, and Uruguay), so low GHG national, sectoral or subnational official strategies or policies can be inputs to address this question.

Example:

In a scenario where the LTS, the national government strategy or the national plan, among others, point to a low-carbon agri-food system, an operation is not inconsistent if it focuses on the identification, development, transfer and/or adoption of technologies or practices that reduce emissions (Section II-C presents examples of these).

Under the same scenario, an operation that favors the development or consolidation of enabling factors for the implementation of these practices will not be inconsistent either (see, for example, ¶2.31-2.36).

Sources of information:

LTS Registry, as well as national, sectoral or subnational strategies, plans or policies.

Box 5. SC3 – Decarbonization pathways

SC3 - Is the operation inconsistent with the global decarbonization pathways specific to the sector, in line with the mitigation objectives of the PA, considering the common but differentiated responsibilities of the countries and their respective capacities?

General guidance:

Verify if the operation contravenes, at the sector level, decarbonization pathways or scenarios. The foregoing, based on studies carried out by international organizations, academia, and industrial associations, among others.

Specific guidance:

This SC considers that the decarbonization capacity is affected by the context (e.g., stage of development, resources and capacities). Thus, for an operation, the response to SC-3 may vary depending on the context.

Consider the progressive nature of efforts and differentiated capabilities (¶2.45-2.47).

The SC3 application will be especially useful for:

a) Operations where in the SC2 analysis it is not feasible due to the lack of an LTS or national strategy
b) Operations in high-emitting sectors for which a global trajectory with specific milestones exists
c) Transactions that cover multiple countries or that are directly associated with international markets

Example of decarbonization pathways

To illustrate a possible source of information, the decarbonization pathways adopted by the IPCC report,[41] in general and at a global level:

a) reduction in land used for food production due to sustainable intensification (greater product unit per unit area), changes in consumption patterns and policies with better controls on land;
b) reduction in methane emissions due to improvements in livestock management and rice production, as well as genetic improvement in these and changes in diets towards livestock products with lower emission intensity;
c) reduction in N_2O emissions due to increases in the efficiency of nitrogen use and manure management;
d) constant or increasing forest cover, elimination of deforestation.

Specifically, at a global level, these decarbonization goals for the agri-food sector foresee net zero CO_2 emissions in land use, land-use change, and forests by 2025-2030,[42] and a transformation of the agriculture and food sector towards carbon negative by 2050.[43] This would imply that to reach said goal globally:

CO_2	CH_4	N_2O
Eliminate total emissions by 2050. Sequester 0.1 $GtCO_2$ annually by 2030 and 2.3 $GtCO_2$ annually by 2050.	Reduce emissions by 25% to 35% by 2030 Reduce emissions by 50% to 60% by 2050 (compared to the 2010 baseline)	Reduce emissions by 10 to 15% by 2030 Reduce emissions by 20 to 30% by 2050 (compared to the 2010 baseline)

The foregoing requires:

a) Emissions from the loss and degradation of remaining primary forests and other natural terrestrial ecosystems reduced by at least 70% by 2030 from 2020 levels and become a net sink by 2050.
b) Emissions from agriculture and food systems reduced by 50Gt CO2eq by 2030, and the sector becoming a carbon sink by 2050.
c) Food loss and waste reduced to 50% by 2030 and up to 75% by 2050, compared to 2020.
d) Eliminate net deforestation by 2025. By 2030, priorities include emission reductions, significant tree cover restoration, degraded land restoration, productivity improvement, and waste reduction, including resilience and productivity improvement of agricultural land.
e) Non-deforestation policies in commodity supply chains and compliance with said policies, as well as changes in approaches and production techniques.
f) Sustainable intensification of food production by implementing resource efficiency measures to produce the same amount of food with less land.

Guiding questions:

a) Does the operation favor agri-food models that reduce the land used for food production due to sustainable intensification[44] and/or changes in consumption patterns towards less land-intensive models?
b) Does the operation favor agri-food models that reduce GHG emissions due to greater efficiency in the use of inputs (e.g., agrochemicals, fossil fuels, etc.) or a total or partial reduction in the use of fossil fuels and associated inputs to said fuels?
c) Does the operation favor agri-food models that reduce CH_4 emissions (e.g., through improvements in livestock management or rice production under flooding, as well as genetic improvement in these models)?

---

41 Rogelj et al. (2018). The decarbonization pathways considered vary in assumptions such as policies, technological advances/efficiency improvements, and changes in consumption patterns.
42 Roe et al. (2019).
43 UNFCCC (2021b).
44 Examples of sustainable intensification approaches are presented in Table A2 of the Annex.

d) Does the operation favor agri-food models that reduce N_2O emissions (e.g., increases in the efficiency of nitrogen use and manure management)?

e) Does the operation favor agri-food models that favor a constant or increasing forest cover and do not promote the expansion of activities towards areas of high value due to their absorption of carbon or high biodiversity?

f) Does the operation favor agri-food models that seek to improve soil health and fertility and/or restore degraded land?

Examples:

The IPCC report[45] indicates that sustainable intensification of Agriculture (e.g., greater quantity of product per unit area or per animal) contributes to reaching the goal of the Paris Agreement by reducing the amount of land needed to feed the population.[46]

In this context, the transition towards a sustainable intensive agriculture may be more feasible and/or expeditious depending on the country, geographical area, sector, market, and characteristics of the producer. To illustrate, differences in the type of technologies and practices applicable between various sizes of livestock units are expected.

The same applies to the implementation of certain measures, technologies or new trends (including, among these, synthetic and plant-based proteins, value chain traceability, use of molecular biology and methane or nitrification inhibitors)[47] that are suggested for the achievement of 1.5 to 2ºC where the context determines its applicability and, if applicable, the possible speed of implementation.

Example of common but differentiated responsibilities of the countries and their respective capacities

Small producers (as defined in ¶2.45-2.47) face economic, social, and technological barriers specific to their context. Small and medium-sized companies also face challenges, since they often lack the installed capacity to ensure robust environmental and social management systems and/or are subject to practices required by the broader links in the value chain. Therefore, to facilitate a transition of these in a context of food security, it will be necessary to focus with particular emphasis on locating opportunities to: (i) increase access to information and resources that strengthen the adoption of climate-smart models; (ii) reduce transaction costs that could result from new policies and regulations in the sector due to the transition; and (iii) training regarding the risks associated with regulatory, technological and market changes applicable to their particular context.

Sources of information:

Studies on specific sectoral decarbonization pathways carried out by international organizations, academia, and industry associations, among others – these include Buira et al. (2021), De La Torre Ugarte et al. (2021), Lallana et al. (2021), Svensson et al. (2021), Villamar et al. (2021), Ahmed et al. (2020), Bataille et al. (2020a, 2020b), Delgado et al, (2020), and Rogelj et al. (2018).

45 Rogelj et al. (2018).

46 Governance arrangements that prevent the expansion of the agricultural frontier and ensure that ecosystems are legally and programmatically protected are important accompanying elements for the sustainable intensification of agriculture. (Searchinger et al., 2018).

47 Referred to in IPCC reports - Mbow et al. (2019), de Coninck et al. (2018) and Rogelj et al. (2018).

Box 6. SC4 – No obstruction of the transition

SC4 - Does the operation obstruct opportunities for the transition to PA-aligned activities, or primarily support or directly depend on non-aligned activities in a specific country/sector context?

General guidance:

Compare the operation with lower carbon alternatives and considers the risks of (i) generating committed emissions; or (ii) that prevent the possibility of implementing activities aligned with the PA. SC4 considers the broader influence the operation may have in achieving the transition to low GHG development consistent with the PA goals, beyond the direct scope of the operation. These risks may arise from technological dependency and/or from avoiding or impeding the present or future implementation of activities aligned with low emission trajectories (economic or sector-specific trajectory).

The evaluation of these risks may use as inputs the documentation used in SC2, studies carried out under activities of involvement and support for public policies development (BB4) and analyzes or diagnoses carried out by multilateral development banks.

Specific guidance:

It should consider the progressive nature of the efforts, be feasible considering the country context, the best available technologies, and the client's capabilities.

<u>Approach</u>

Determine if transition to PA-aligned activities is blocked. Here are some general guiding questions whose affirmative answer indicates that there is alignment:[48]

a) Considering the feasibility (technical, economic, and institutional) and the starting point, does the operation implement activities that represent progress towards a low GHG trajectory? That is to say: (i) does the supported model represent a viable alternative that does not impede the progressive reduction of GHG emissions, compared to other current models on the market? and (ii) considering the useful life of the operation, are the activities consistent with the trajectory identified in SC2 (or failing that, with SC3)?

Guiding questions:

In addition to those presented in SC3, consider:

b) Are there viable technological alternatives with less dependence on fossil fuels or with lower associated emissions? How does it compare with these?
c) Does it have mechanisms that favor the reduction of deforestation or a low carbon footprint (e.g., does the operation have traceability in the supply chain or does it have certifications)?
d) Are there viable transport alternatives that have a lower carbon footprint?
e) In case of flooding, does it include efficient water management practices and CSA practices that include emissions reduction?
f) Is there an intensive use of agrochemicals that it is feasible to reduce?
g) Do you use or rely on fossil fuels (e.g., for irrigation, cooling, processing, etc.)? If so, have alternatives been considered to reduce or eliminate this dependency?
h) How versatile is the supported technology or practice? Can it be adapted to more sustainable agri-food models??

Sources of information:

Technical and economic feasibility analysis of the operation. Documentation used in SC2, studies carried out under activities of involvement and support for the development of public policies and analyzes or diagnoses carried out by multilateral development banks, among others.

[48] These questions are guidelines and are not considered exhaustive, operation officers may apply specific questions to specific cases as appropriate.

Box 7. SC5 – Stranded assets and transition risks[49]

SC5 - Is the operation/economic activity unviable, considering the risks of stranded assets and transition risks in the national/sectoral context?

General guidance:

Consider CC in the economic or financial analysis of the operation by assessing the benefits and costs of risks linked to the impacts of CC and important climate policies (see Section II-2, ¶2.37-2.39). Infeasibility occurs when the operation does not meet the minimum threshold required in the economic or financial analysis.

Specific guidance:

To meet this criterion, it is necessary to determine whether there are material transition risks in the subsector of the operation, and if so, incorporate them into the financial sensitivity analysis, estimating their impact on the feasibility of the project, to assess whether the design may be considered robust before the transition. In this context the main guiding questions will be:

a) What is the contribution of the project to GHG emissions and, therefore, to what extent could it be impacted by policies and regulations?

b) What is the potential impact of low GHG emissions technology improvements on the subsector?

c) What is the potential impact of changes in the markets?

Additionally, to characterize the risks of transition and potential stranded assets, consider:

a) Context: subsector, practices used, geographical location, market, and size of the farm.

b) Policies that result or may result in a loss of income, as well as in an accelerated or unforeseen depreciation or reduction in value of the operation. Responses from society or companies can be included.

   (i) Climate policies and regulations. It encompasses policies, regulations, and standards that address goals or requirements linked to climate action. For example, commitments established in the NDCs, commercial requirements, national policies that affect or regulate a certain sector or item, tax or tariff schemes, etc.

   (ii) Responses of the markets, society, or companies to CC such as consumer trends or the business model. Certain markets may require the implementation of specific measures in response to certain trends or regulations. For example, chain traceability measures or carbon footprint labeling, which are commonly related to export markets and/or item(s) associated with the movement of the agricultural frontier.

c) Activities of the operation to reduce physical risks of stranded assets, and transition regulatory risks.

   (i) The implementation of adaptation measures reduces physical risks.

   (ii) Regulatory risks can be reduced by focusing on sustainable agriculture.

   (iii) The extent to which stranded assets may arise is determined based on the useful life of the investment in relation to the speed of implementation of climate decarbonization policies, changes in business practices and/or consumption behavior and interest of investors. This speed in the implementation of measures can vary between countries and items. Changes in behavior or preferences, as well as the implementation of policies, can have a more immediate effect on operations aimed at export markets and in certain products.

Sources of information:

For examples of contributions to emissions, see Section II-B; opportunities for synergies between mitigation and adaptation are presented in Figure 1; Table A1 in the Annex provides detailed examples of management practices and their impacts on mitigation, productivity, and adaptation.

An approach to responses from markets, society or companies to CC is provided in ¶2.37-2.38.

Adaptation measures are presented in Section II-C, Section III, Figure 1 and Table A1 of the Annex.

[49] The evaluation of items that have been associated with deforestation deserve special attention.

IV. ASSESSMENT OF OPERATIONS: ALIGNMENT WITH THE PA ADAPTATION GOAL (BB2)

4.1 The evaluation of alignment with PA adaptation goal focuses on establishing whether the operation manages its climate vulnerability and risk[50] and is consistent with a climate-resilient development of the country. Specifically, it focuses on determining whether the long-term achievement of the operation's development objectives is vulnerable to the effects of climate change, and whether the activities are consistent with climate resilience trajectories defined at the national or subnational level. For this purpose, it focuses on three criteria:

a. **Criterion 1–Climate risk and vulnerability context.** Determine if the operation is vulnerable to CC, identifying and evaluating its exposure to physical climate impacts. Depending on the type of operation, these may be impacts on assets, on the services it plans to provide, on human and natural systems, and/or on its beneficiaries. If the operation is considered to be at risk, it continues with Criterion 2. Operations with low or immaterial climate risk can skip Criterion 2 and go directly to Criterion 3.

b. **Criterion 2–Definition of climate resilience measures**. Have climate adaptation and resilience measures been identified and incorporated into the operation to manage physical climate risks and/or to contribute to climate resilience?

c. **Criterion 3–Does not contravene plans for climate resilience.** Depending on relevance and availability, consider policies, strategies, and plans at the territorial, local, national, or regional level, as well as community or private sector priorities. The operation should not be inconsistent with them.

4.2 In the case of the IDB and IDB Lab, the first two of the three criteria must follow what is established in the Bank's policies, in particular in IDB's Environmental and Social Policy Framework (ESPF), which, under the Environmental and Social Performance Standard 4 reinforces the resilience of projects to anticipate and avoid adverse impacts on the project itself in the face of natural disaster hazards and climate change during the project cycle. In these cases, the "Disaster and Climate Change Risk Assessment Methodology for IDB Projects" (DCCRA) will determine those instances where greater consideration of the physical impacts of climate change is necessary to ensure alignment of agri-food projects. All projects complying with the DCCRA methodology will be considered aligned under the first two alignment criteria with the adaptation goal established by the MDBs. The third criterion will be applied in the formulation of the project in accordance with the provisions of the PAIA, identifying whether the operation is related to the national or subnational priorities of the country in terms of adaptation, and if so, how the planning efforts have been considered.

4.3 In the case of IDB Invest, the alignment in terms of the first two criteria will be done in accordance with the provisions of IDB Invest Environmental and Social

[50] The Disaster and Climate Change Risk Assessment Methodology for IDB projects (DCCRA) includes specific measures according to the type of infrastructure after evaluating the criticality.

Sustainability Policy (ESSP) and IDB Invest Climate Risk Assessment methodology (CRA).

4.4 Boxes 8 to 10 describe the approach for each criterion:

Box 8. Criterion 1 – Climate risk and vulnerability context

Criterion 1 – Is the operation at risk?

General guidance:

Determine if the operation is vulnerable to CC, identifying and evaluating its exposure to physical climate impacts. Depending on the type of operation, these may be impacts on assets, on the services it plans to provide, on human and natural systems, and/or on its beneficiaries.

a) If the operation is considered to be at risk, it continues with Criterion 2.

b) Operations with low or immaterial climate risk can skip Criterion 2 and go directly to Criterion 3.

Specific guidance:

Consider: (i) the context; (ii) exposure and sensitivity to Climate hazards; and (iii) determine whether it is necessary to carry out a climate risk assessment.

Guidance for operations covered by the ESPF:

This criterion is considered fulfilled if the operation applies the Disaster and Climate Risk Assessment (DCCRA) methodology which is required as part of Standard 4 in the ESPF. The narrative is the same one as the paragraph included in the "Initial ESRS" (*Environmental and Social Review Summary*).

Guiding questions:

This criterion must address two key elements:

a) Determine the level of exposure and sensitivity of the operation within its boundaries, considering:

   (i) Operation's boundaries. Based on the direct and indirect physical, economic, social, and temporal realms of reasonable impacts. These boundaries can be physical, economic, social, temporal.

   (ii) Level of exposure to specific climate-related hazards.

   (iii) Sensitivity to CC: to what extent can climate change and climate vulnerability impact the operation?

b) Establish overall vulnerability to climate hazards. This implies:

   (i) Determining overall vulnerability to climate hazards within the operation's boundaries: are financed activities vulnerable to CC? Was the operation deemed to require a climate risk/vulnerability assessment? What type of assessment was conducted to define climate resilience measures?

   (ii) Determining the need for a system-level risk assessment; meaning, beyond the operation's boundaries. Depending on the type of operation, it may be adequate to: (1) consider possible indirect climate impacts and risks and (ii) examine opportunities for partial and/or collaborative (with partners beyond the project's scope) management.

Sources of information and guidance:

The justification for this criterion will be the same narrative as the one included in the *"Initial ESRS"* (*Environmental and Social Review Summary*).

The IDB's Disaster and Climate Risk Assessment (DCCRA)[51] methodology provides full guidance in the assessment of disaster and climate change risks. The document does not only present the methodology, but also contains the definition of key concepts (risk, exposure, vulnerability, and hazards). IDB Invest has developed the tool "AgriADAPT" to evaluate physical climate change risks that are relevant to private sector transactions related to agriculture.

There is information to be consulted in NDCs, National Communications on CC, strategies and/or adaptation plans, among others. Examples of possible CC physical impacts that may be considered are presented in section II-A (¶2.5 to 2.12).

[51] Barandiarán et al., 2019a. También disponible un resumen ejecutivo de esta (Barandiarán et al., 2019b).

Box 9. Criterion 2 – Definition of Climate Resilience Measures

Criterion 2 - have climate adaptation and resilience measures been identified to manage the assessed physical climate risks and/or contribute to building climate resilience?

General guidance:

Ensure the incorporation of resilience measures to manage Climate risks identified under Criterion 1.

Specific guidance:

Cover the following aspects:

a) Measures to address identified climate risk and opportunities to enhance climate resilience

b) The potential for maladaptation (if relevant). Assess is there is a possibility that proposed measures could lead to climate vulnerability being exacerbated or re-distributed in ways that create new sources of vulnerability.

c) The documentation of the selected climate resilience response. Ideally, this will include a description of the measures, explanation of their pertinence, assigned budget, timeline, and responsibility arrangements.

Guidance for operations covered by the ESPF:

This criterion is considered fulfilled under the application of the DCCRA methodology which is required as part of Standard 4 of the ESPF.

Sources of guidance and information:

Examples of possible Climate adaptation measures are presented in Section II-C, Section III, Figure 1, and Box A1 in the Annex.

Annex G of the IDB's Disaster and Climate Risk Assessment (DCCRA) provides key measures. IDB Invest has developed the tool "AgriADAPT" to define adaptation measures that are adequate to the types of transaction in the private sector.

Some relevant publications by the IDB Group:

- Vulnerabilidad al Cambio Climático e Impactos Económicos en el Sector de Agricultura en América Latina y el Caribe
- Investing in Reversing: Sustainable Finance Strategies Against Climate Change

Elements that contribute to reduce maladaptation risks include: (1) knowledge of the vulnerability context, addressing causes instead of symptoms; (ii) the participation of key stakeholders in the process of designing and implementing the project, and (iii) a monitoring and evaluation framework that stresses long-term outcomes or impacts, and takes into consideration how the success in adaptive terms may vary depending on the context, and that identifies the possible negative impacts beyond the area of influence of the project (Eriksen et al., 2021).

Aspects that have been indicated under "The documentation of the selected climate resilience response" should be incorporated in the Risk Management Plan of the operation.

Box 10. Criterion 3 – Assessment of National/Broad Context for Climate Resilience

Criterion 3 - Is the operation consistent with relevant policies/strategies and with private sector or community-driven priorities for climate resilience?

General guidance:

Ensure consistency with guidelines for a climate resilient development.

Specific guidance:

Depending on the relevance and availability, consider policies, strategies, and plans at a territorial, local, national, or regional level, and the priorities of communities and the private sector.[52]

Sources of information:

NDCs, National Communications on CC, laws, strategies, action plans, and documents with private sector or community priorities, among others.

[52] In case no guidelines or priorities on Climate adaptation exist, the general context of climate resilience in the country should be assessed.

APPENDIX 1

Box A1. Examples of management practices and their impact in productivity, adaptation, and mitigation[53]

Examples management practice	Productivity impacts	Climate adaptation benefits	Greenhouse gas mitigation potential
Cropland Management			
Improved crop varieties or types (early-maturing, drought resistant, etc.)	Increased crop yield and reduced yield variability	Increased resilience against climate change, particularly increases in climate variability (prolonged periods of drought, seasonal shifts in rainfall, and the like)	Improved varieties can increase soil carbon storage
Changing planting dates	Reduced likelihood of crop failure	Maintained production under changing rainfall patterns, such as changes in the timing of rains or erratic rainfall patterns	Unknown, although higher yields are likely to increase soil carbon
Improved crop/fallow rotation/rotation with legumes	Increased soil fertility and yields over the medium to long term due to nitrogen fixing in soils; Short-term losses due to reduced cropping intensity	Improved soil fertility and water holding capacity increases resilience to climate change	High mitigation potential, particularly crop rotation with legumes
Use of cover crops	Increased yields due to erosion control and reduced nutrient leaching; Potential trade-off if cover crops replace grazing area in mixed crop– livestock systems	Improved soil fertility and water holding capacity increases resilience to climate change	High mitigation potential through increased soil carbon sequestration
Appropriate use of fertilizer and manure	Higher yields due to appropriate use of fertilizer/manure	Improved productivity increases resilience to climate change; Potential greater yield variability with frequent droughts	High mitigation potential through reduced nitrous oxide emissions when nitrogen fertilizer has been over-applied relative to crop needs
Incorporation of crop residues	Higher yields due to improved soil fertility and water retention in soils; Trade-offs exist if crop residues would have otherwise been used as animal feed	Improved soil fertility and water holding capacity increases resilience to climate change	High mitigation potential through increased soil carbon sequestration
Reduced or zero tillage	Increased yields over the long term due to greater water-holding capacity of soils; limited impacts in the short term; Potential trade-offs in terms of weed management and potential waterlogging	Improved soil fertility and water holding capacity increases resilience to climate change	Some mitigation potential through reduced soil carbon losses

[53] Adapted from Bryan et al. (2011) as cited in Lankoski et al. (2019).

Examples management practice	Productivity impacts	Climate adaptation benefits	Greenhouse gas mitigation potential
Agroforestry	Uncertain impacts on yields: Yields could increase on adjacent cropland due to improved rainwater management and reduced erosion; Potential reduced yields if smaller crops compete with trees for light, water and soil nutrients	Increased resilience to climate change due to improved soil conditions and water management; Benefits in terms of livelihood diversification	High mitigation potential through increased soil carbon sequestration
Soil and Water Management			
Irrigation and water harvesting	Higher yields, greater intensity of land use	Reduced production variability and greater climate resilience when systems are well designed and maintained	Low to high depending on whether irrigation is energy intensive or not
Bunds	Higher yields due to increased soil moisture; Potentially lower yields during periods of high rainfall	Reduced yield variability in dry areas; potential increase in production loss due to heavy rains if bunds are constructed to retain moisture	Positive mitigation benefits minus soil carbon losses due to construction of bunds
Terraces	Higher yields due to increased soil moisture and reduced erosion; Potential to displace some cropland	Reduced yield variability under climate change due to better soil quality and rainwater management	Positive mitigation benefits minus soil carbon losses due to construction of terraces
Mulching or trash lines	Increased yields due to greater water retention in soils	Reduced yield variability under drier conditions due to greater moisture retention	Positive mitigation benefits
Grass strips	Increased yields due to reduced runoff and soil erosion	Reduced variability due to reduced soil and water erosion	Positive mitigation benefits
Ridge and furrow	Increased yields due to greater soil moisture	Reduced yield variability in dry areas; Possible production losses with heavy rains	Positive mitigation benefits minus initial losses due to construction of ridges and furrows
Diversion ditches	Increased yields due to drainage of agricultural lands in areas where flooding is problematic	Reduced yield variability under heavy rainfall conditions due to improved water management	Positive mitigation benefits through improved productivity and hence increased soil carbon
Management of livestock or grazing land			
Diversify, change, or supplement livestock feeds	Higher livestock yields due to improved diets	Increased climate resilience due to diversified sources of feed	High mitigation potential because improved feeding practices can reduce methane emissions
Destocking	Higher yields due to greater forage availability and quality; Potential short-term trade-off in terms of	Increased forage availability over the long term, providing greater climate resilience	High mitigation potential because reduced livestock numbers lead to reduced methane emissions

Examples management practice	Productivity impacts	Climate adaptation benefits	Greenhouse gas mitigation potential
	numbers of livestock supported		
Rotational grazing	Higher yields due to greater forage availability and quality; Potential short-term trade-off in terms of numbers of livestock supported	Increased forage availability over the long term, providing greater climate resilience	Positive mitigation potential due to increased carbon accrual on optimally grazed lands
Improved breeds and species	Increased productivity per animal for the resources available	Increased resilience of improved species or breeds to withstand increasing climate extremes	Varies, depending on the breeds or species being traded
Restoring degraded lands			
Revegetation	Improved yields over the medium to long run; improved yields on adjacent cropland due to reduced soil and water erosion	Reduced variability due to reduced soil and water erosion	High mitigation potential
Applying nutrient amendments	Improved yields over the medium to long run	No known benefits for adaptation	High mitigation potential

Box A2. Examples of approaches for the sustainable intensification of agriculture[54]

Approach	Sub-category	Examples
Improving efficiency	Precision agriculture	High- and low-technology options to optimize resource use.
	Genetic improvements	Improved resource use efficiency through crop or livestock breeding.
	Irrigation technology	Increased production in areas currently limited by precipitation (sustainable water supply required).
	Organizational scale-up	Increasing farm organizational scale (e.g., cooperative schemes) can increase efficiency via facilitation of mechanization and precision techniques.
Substitution	Green fertilizer	Replacing chemical fertilizer with green manures, compost (including vermicompost), biosolids and digestate (by-product of anaerobic digestion) to maintain and improve soil fertility.
	Biological control	Pest control through encouraging natural predators.
	Alternative crops	Replacement of annual with perennial crops reducing the need for soil disturbance and reducing erosion.
	Premium products	Increase farm-level income for less output by producing a premium product.
System redesign	System diversification	Implementation of alternative farming systems: organic, agroforestry and intercropping (including the use of legumes).

[54] Source: Pretty et al. (2018) and Hill (1985), cited in Mbow et al. (2019).

Approach	Sub-category	Examples
	Pest management	Implementing integrated pest and weed management to reduce the quantities of inputs required.
	Nutrient management	Implementing integrated nutrient management by using crop and soil specific nutrient management – guided by soil testing.
	Knowledge transfer	Using knowledge sharing and technology platforms to accelerate the uptake of good agricultural practices.

APPENDIX 2

GENERAL ANALYSIS OF AGRICULTURE IN NDCS

1. At the global level, the United Nations Framework Convention on Climate Change (UNFCCC - 2021) provides a synthesis of the NDCs. This report shows the relevance of the agri-food sector for climate action in countries, where food production and nutritional security is the main priority in terms of adaptation (as shown in more than 80% of said countries' NDCs).[55] In fact, the report also stresses the need to implement actions that contribute to adaptation and mitigation, while guaranteeing food security. Below is a summary of the main actions referred to in the NDCs:

Mitigation

a) Improved management of crops, fertilizers, agricultural land, herds, and manure.
b) Improvement of agricultural productivity.
c) Afforestation, reforestation, revegetation, sustainable forest management, reduction of deforestation and forest degradation, forest conservation and agroforestry systems.

Adaptation

a) Expansion of protected areas, increase in forest areas, recovery of degraded lands, reforestation, and sustainable forest management.
b) Basin management, protection, and restoration of critical ecosystems for water supply (e.g., forests, rivers, and wetlands), efficiency in the use of water and irrigation.
c) Early warning systems, risk management and transfer mechanisms such as insurance and post-disaster aid.

Synergies between adaptation and mitigation

a) Afforestation, reforestation, climate-smart agriculture, food waste reduction, nature-based solutions, vertical farming, and conservation plans for protected areas, among others.

2. Based on the review of NDCs, UNFCCC (2021) also points out that countries have specified: (i) capacity building in terms of policy formulation, integration of climate considerations in planning, access to financing and information as a prerequisite for the implementation of NDCs; and (ii) technology transfer and development for the implementation of climate actions, especially in Agriculture, one of the main sectors with this need.

3. Regarding updated or new NDCs from IDB member countries,[56] analysis based on the Rose et al. (2021) database, indicates that NDCs prioritize mitigation and adaptation measures related to carbon sequestration and livestock (more than 87% of the countries include such NDCs). Agroforestry and wetland management are critical for the implementation of climate actions in said areas. In terms of livestock, silvopastoralism and manure management are key instruments. NDCs also highlight

[55] Consider NDCs with information on adaptation.
[56] Database that includes updated or new NDCs submitted to the UNFCCC as of November 1, 2021. In the case of IDB member countries, there are 16 countries that made the submission as of that date.

the importance of climate-smart agriculture, agroecology, water management in rice under flooding, and nutrient management.

References

Adedayo, V., M. Fasona, and T. Kuti. (2014). Trend and Linkages between Climate Elements, Pest Activities and Pesticide Usage in Urban Farms Communities in Lagos. *Journal of Gography and Geology* 6(3): 178-186.

Ahammad, H., E. Heyhoe, G. Nelson, R. Sands, S. Fujimori, T. Hasegawa, D. van der Mensbrugghe, E. Blanc, P. Halik, H. Valin, O. Kyle, D. Mason d'Croz, H. van Meijil, C. Schmitz, H. Lotze-Campen, M. von Lampe, and A. Tabeau. (2015). The Role of International Trade Under a Changing Climate: Insights from Global Economic Modelling. In *Climate Change and Food Systems Global Assessments and Implications for Food Security and Trade.* Editor: A. Elbehri. FAO.

Ahmed, J., E. Almeida, D. Aminetzah, N. Denis, K. Henderson, J. Katz, H. Kitchel, and P. Mannion. (2020). *Agriculture and Climate Change: Reducing Emissions through Improved Farming Practices*. McKinsey & Company.

AIDER. (2017). Manual de Buenas Prácticas de Manejo Forestal Sostenible para el Bosque Tropical Seco.

Ali, A., and O. Erenstein. (2017). Assessing Farmer Use of Climate Change Adaptation Practices and Impacts on Food Security and Poverty in Pakistan. *Climate Risk Management* 16: 183-194.

Allison, E.H., A.L. Perry, M Badjeck, W. Neil Adger, K. Brown, D. Conway, A.S. Halls, G.M. Pilling, J.D. Reynolds, N.L. Andrew, and N.K. Dulvy. 2009. Vulnerability of National Economies to the Impacts of Climate Change on Fisheries. *Fish and Fisheries* 10: 173-196.

Barandiarán, M., M. Esquivel, S. Lacambra, G. Suárez and D. Zuloaga. (2019b). Resumen Ejecutivo de la Metodología de Evaluación del Riesgo de Desastres and Cambio Climático: Documento Técnico de Referencia para Equipos a Cargo de Proyectos del BID. BID Nota Técnica IDB-TN-01583.

Barandiarán, M., M. Esquivel, S. Lacambra, G. Suárez and D. Zuloaga. (2019a). Metodología de Evaluación del Riesgo de Desastres and Cambio Climático para Proyectos del BID: Documento Técnico de Referencia para Equipos a Cargo de Proyectos del BID. BID Nota Técnica IDB-TN-01771.

Bataille, C., H. Waisman, A. Vogt-Schilb, M. Jaramillo, R. Delgado, R. Argüello, L. Clarke, T. Wild, F. Lallana, G. Bravo, G. LeTreut, G. Nadal, G. Godinez, J. Quiros-Tortos, E. Pereira, M. Howells, D. Buira, J. Tovilla, J. Farbes, J. Ryan, D. De La Torre Ugarte, M. Collado, F. Requejo, X. Gómez, R. Soria, D. Villamar, P. Rochedo, M. Imperio, Y. Briand, and J. Svensson. (2020a). Net-zero Deep Decarbonization Pathways in Latin America: Challenges and Opportunities. IDB Working Paper 1157.

Bataille, C., H. Waisman, Y. Briand, J. Svensson, A. Vogt-Schilb, M. Jaramillo, R. Delgado, R. Argüello, L. Clarke, T. Wild, F. Lallana, G. Bravo, G. Nadal, G. LeTreut, G. Godinez, J. Quiros-Tortos, E. Pereira, M. Howells, D. Buira, J. Tovilla, J. Farbes, J. Ryan, D. De La Torre Ugarte, M. Collado, F. Requejo, X. Gómez, R. Soria, D. Villamar, P. Rochedo, and M. Imperio, (2020b). Net-zero Deep Decarbonization Pathways in Latin America: Challenges and Opportunities. *Energy Strategy Reviews* 30: 100510.

Behnassi, M., M. Boussaid, and R. Gopichandran. (2014). Achieving Food Security in a Changing Climate: The Potential of Climate-Smart Agriculture. In *Environmental Cost and Face of Agriculture in the Gulf Cooperation Council Countries: Fostering Agriculture in the Context of Climate Change*. Editores: Shahid S.A., and M. Ahmed.

BID. (2018). Documento de Marco Sectorial de Medio Ambiente and Biodiversidad. Banco Interamericano de Desarrollo.

BID. (2019). Documento de Marco Sectorial de Agricultura. División de Medio Ambiente, Desarrollo Rural and Administración de Riesgos por Desastres. Banco Interamericano de Desarrollo.

Black, P.F., J.G. Murray, and M.J. Nun. (2008). Managing Animal Diseases Risk in Australia: The Impact of Climate Change. *Rev. Sci. Tech.* 27(2): 536-580.

Black, P.F., J.G. Murray, and M.J. Nun. (2008). Managing Animal Diseases Risk in Australia: The Impact of Climate Change. *Rev. Sci. Tech.* 27(2): 536-580.

Blackman, A., L. Corral, E. Santos Lima, and G.P. Asner. (2017). Titiling Indigenous Communities Protects Forests in the Peruvian Amazon. *PNAS* 114(16): 4123-4128.

Bouroncle, C., P. Imbach, P. Läderach, B. Rodríguez, C. Medellín, E. Fung, M.R. Martínez-Rodríguez, and C.I. Donatti. (2015). La Agricultura de Honduras and el Cambio Climático: ¿Dónde están las Prioridades para la Adaptación? CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhague.

Buira, D., J. Tovilla, J. Farbes, R. Jones, B. Haley, and D. Gastelum. (2021). A Whole-Economy Deep Decarbonization Pathway for Mexico. *Energy Strategy Reviews* 33: 100578.

Buntaine, B.T., S.E. Hamilton, and M. Millones. Titling community land to prevent deforestation: An evaluation of a best-case program in Morona-Santiago, Ecuador. *Global Environmental Change* 33: 32-43.

Caldecott, B., A. Clark, K. Koskelo, E. Mullholand, and C. Hickey. (2021). Stranded Assets: Environmental Drivers, Societal Challenges, and Supervisory Responses. *Annu. Rev. Environ. Resour.*46: 417-47.

Caldecott, B., E. Harnett, T. Cojoianu, I. Kok, and A. Pfeiffer. (2016). Stranded Assets: A Climate Risk Challenge. [A.R. Rios (ed.)]. IDB Series IDB-MG-481.

Caldecott, B., N. Howarth, and P. McSharry. (2013). Stranded Assets in Agriculture: Protecting Value from Environment-Related Risks. University of Oxford, Smith School of Enterprise and the Environment.

Campbell, B.M., S.J. Vermeulen, P.K. Aggarwal, C. Corner-Dolloff, E. Girvetz, A.M. Loboguerrero, J. Ramírez-Villegas, T. Rosenstock, L. Sebastian, P.K. Thornton, and E. Wolllenberg. (2016). Reducing Risks to Food Security from Climate Change. *Global Food Security* 11: 34-43.

CEPAL. (2013). Impactos Potenciales del Cambio Climático sobre los Granos Básicos en Centroamérica. Naciones Unidas.

CEPAL. (2014). Impactos Potenciales del Cambio Climático sobre el Café en Centroamérica. Naciones Unidas.

Chakraborty, S., and A.C. Newton. (2011). Climate Change, Plant Diseases and Food Security: An Overview. *Plant Pathology* 60:2-14.

Cheung, W. W. L., Lam, V. W. Y., Sarmiento, J. L., Kearney, K., Watson, R., Zeller, D. and Pauly, D. (2010). Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. *Global Change Biology* 16(1): 24-35.

Cohn, A., P. Newton, J. Gil, L. Kuhl, L. Samberg, V. Ricciardi, J. Manly, and S. Northrop. (2017). Smallholder Agriculture and Climate Change. *Annual Review of Environment and Resources* 42:347-375.

de Coninck, H., A. Revi, M. Babiker, P. Bertoldi, M. Buckeridge, A. Cartwright, W. Dong, J. Ford, S. Fuss, J.-C. Hourcade, D. Ley, R. Mechler, P. Newman, A. Revokatova, S. Schultz, L. Steg and T. Sugiyama. (2018). Strengthening and Implementing the Global Response. In: *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty* [Masson-Delmotte,V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M.Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA.

De La Torre Ugarte, D, M. Collado, F. Requejo, X. Gomez, and C. Heros. (2021). A Deep Decarbonization Pathway for Peru's Rainforest. *Energy Strategy Reviews* 36: 100675.

Delgado, R., T. Wild, R. Arguello, L. Clarke, and G. Romero. (2020). Options for Colombia's Mid-Century Deep Decarbonization Strategy. *Energy Strategy Reviews* 32: 100525.

Descheemaeker, K., M. Zijlstra, P. Masikati, O. Crespo, and S.H. Tui. (2018). Effects of Climate Change and Adaptation on the Livestock Component of Mixed Farming Systems: A Modelling Study from Semi-arid Zimbabwe. *Agricultural Systems* 159: 282-295.

Descheemaeker, K., M. Zijlstra, P. Masikati, O. Crespo, and S.H. Tui. (2018). Effects of Climate Change and Adaptation on the Livestock Component of Mixed Farming Systems: A Modelling Study from Semi-arid Zimbabwe. *Agricultural Systems* 159: 282-295.malcom

Díaz-Bonilla, E., C. Navarrete-Frias, and V. Piñeiro. (2022). Latin America and the Caribbean. In: IFPRI, 2022*: Global Food Policy Report: Climate Change and Food Systems.* Washington, DC. International Food Policy Research Institute.

Ding, Q., X. Chen, R. Hilborn, and Y. Chen. (2017). Vulnerability to Impacts of Climate Change on Marine Fisheries and Food Security. *Marine Policy* 83: 55-61.

Dixon, J., A. Gulliver, and D. Gibbon. (2011). Sistemas de Producción Agropecuaria and Pobreza: Cómo Mejorar los Medios de Subsistencia de los Pequeños Agricultores en un Mundo Cambiante. M. Hall (ed). FAO and Banco Mundial.

Eriksen, S., E.L.F. Schipper, M. Scoville-Simonds, K. Vincent, H. Nicolai Adam, N. Brooks, B. Harding, D. Khatri, L. Lenaerts, D. Livermanm, M. Mills-Novoam, M. Mosberg, S. Movik, B. Muok, A. Nightingale, H. Ojha, L. Sygna, M. Taylor, C. Vogel, and J.

Joy West. (2021). Adaptation Interventions and their Effect on Vulnerability in Developing Countries: Help Hindrance or Irrelevance? *World Development* 141:105383.

Evans, N., A. Baierl, M.A. Semenov, P. Gladders, and B.D. Fitt. (2008). Range and Severity of a Plant Disease Increased by Global Warming. *Journal of the Royal Society Interface* 5(22): 525-531.

Fanzo, J., R. McLaren, C. Davis, and J. Choufani. (2017). Climate Change and Variability: What are the Risks for Nutrition, Diets, and Food Systems. IFPRI Discussion Paper 01645.

FAO and OPS. 2017. *Panorama de la Seguridad Alimentaria and Nutricional en América Latina and el Caribe*. Santiago de Chile.

FAO. (2013). Climate-Smart Agriculture Sourcebook.

FAO. (2015). Ahorro de Combustible en Pequeñas Embarcaciones Pesqueras.

FAO. (2016). *The State of Food and Agriculture: Climate Change, Agriculture and Food Security.*

FAO. (2017b). Climate-Smart Agriculture Sourcebook: Summary. Second Edition.

FAO. (2018a). *Climate Smart Agriculture: Building Resilience to Climate Change.* [Lipper, L, N. McCarthy, D. Zilberman, S. Asfaw, and G. Branca (eds.)]. Springer.

FAO. (2018b). Los 10 Elementos de la Agroecología: Guía para la Transición Hacia Sistemas Alimentarios and Agrícolas Sostenibles.

FAO. (2021a). *The State of Food and Agriculture 2021: Making Agrifood Systems More Resilient to Shocks and Stresses*. Rome.

FAO. (2020b). Emissions due to Agriculture: Global, Regional and Country Trends 2000-2018. FAOSTAT Analytical Brief 18.

FAO. (2020c). Animal Health and Climate Change: Protecting the Health of Animals to Help Reduce the Effects of Our Changing Climate on Hunger and Poverty.

FAO. (2021a). The Share of Food Systems in Total Greenhouse Gas Emissions. Global, Regional and Country Trends, 1990-2019. FAOSTAT Analytical Brief Series No.31. Rome.

FAO. (2021b). *The State of Food and Agriculture 2021: Making Agrifood Systems More Resilient to Shocks and Stresses*. Rome.

FAO. (2021c). Plant Health and Climate Change.

Fasekas, A., C. Bataille, and A. Vogt-Schilb. (2022). Prosperidad Libre de Carbono: Cómo los Gobiernos Pueden Habilitar 15 Transformaciones Esenciales.

Fernandes, E.C.M., Soliman, A., Confalonieri, R., Donatelli, M., and Tubiello, F. (2012). *Climate Change and Agriculture in Latin America, 2020–2050: Projected Impacts and Response to Adaptation Strategies*. World Bank, Washington, DC.

Forman, S., N. Hungerdord, M. Yamankawa, T. Yanase, H.-J Tsai, Y.-S. Joo, D.-K Yang, and J.-J Nha. (2008). Climate Change Impacts and Risks for Animal Health in Asia. *Rev. Sci. Tech.* 27(2): 1-17.

Fuglie, K., M. Gautam, A. Goyal, and W.F. Maloney. (2020). *Harvesting Prosperity: Technology and Productivity Growth in Agriculture*. Washington, DC: World Bank.

Ghini, R., W. Bettiol, and E. Hamada. (2011). Diseases in Tropical and Plantation Crops as Affected by Climate Changes: Current Knowledge and Perspectives. *Plant Pathology* 60: 122-132.

Herrero, M., P. Havlik, H. Valin, A. Notenbaert, M.C. Rufino, P.K. Thomton, M. Blümmel, F. Weiss, D. Grace, and M. Obersteiner. (2013). Biomass Use, Production, Feed Efficiencies, and Greenhouse Gas Emissions from Global Livestock Systems. *PNAS*, 110(52): 20888-20893. December.

Hilborn, R., R.O. Amoroso, C.M. Anderson, J.K. Baum, T.A. Branch, C. Costello. C.L. de Moor, A. Faraj, D. Hively, O.P. Jensen, H. Kurota, L.R. Little, P. Mace, T. McCanahan, M.C. Melnychuk, C. Minto, G.C. Osio, A.M. Parma, M. Pons, S. Segurado, C.S. Szuwalski, J.R. Wilson, and Y. Ye. (2020). Effective Fisheries Management Instrumental in Improving Fish Stock Status. *PNAS* 117(4): 2218-2224.

Hristov, A.N., A.T. Degaetano, CA.A. Rotz, E. Hoberg. R.H. Skinner, T. Felix, H.Li, P.H. Patterson, G. Roth, M. Hall, T.L. Ott, L.H. Baumgard, W. Staniar, R.M Hulet, C.J. Dell, A.F. Britto, and D. Y. Hollinger. (2018). Climate Change Effects on Livestock in the Northeast US and Strategies for Adaptation. *Climatic Change* 146: 33-45.

Huot, B., C.D.M. Castroverde, A.C. Velásquez, E. Hubbard, J.A. Pulman, J. Yao, K.L. Childs, K.T. Tsuda, B.L. Montgomery, and S. Yang He. (2017). Dual Impact of the Elevated Temperature on Plant Defense and Bacterial Virulence in Arabidopsis. *Nature Communications* 1808:1-12.

IFPRI. (2022). *2022 Global Food Policy Report: Climate Change and Food Systems.* Washington, DC. International Food Policy Research Institute.

Ickowitz, A., S. McMullin, T. Rosenstock, I. Dawson, D. Rowland, B. Powell, K. Mausch, H. Djoudi, T. Sunderland, M. Nurhasan, A. Novak, V. Gitz, A. Meybeck, R. Jamnadass, M.R. Guariguata, C. Termote, and R. Nasi. (2022). Transforming Food Systemas with Trees and Forests. *Lancet Planet Health* 6: e632-39.

IPCC. (2018). Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 541-562.

IPCC. (2022). Fact Sheet – Central and South America: Climate Change Impacts and Risks. Sixth Assessment Report, Working Group II – Impacts, Adaptation and Vulnerability.

IPCC. (2022). Summary for Policymakers. In: *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, and J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA.

Karavolias, N.G., W. Horner, M.N. Abugu, and S.N. Evanega. (2021). Aplication of Gene Editing for Climate Change in Agriculture. *Front. Sustain. Food. Syst.* 5: 685801.

Katusiime, J., and B. Schütt. (2020). Linking Land Tenure and Integrated Watershed Management: A Review. *Sustainability* 12: 1667.

Kenyon, F., J.M. Dick, R.I. Smith, D.G. Coulter, D. McBean, and P.J. Skuce. (2013). Reduction in Greenhouse Gas Emissions Associated with Worm Control in Lamb. *Agriculture* 3: 271-284.

Laderach, P., A. Jarvis, and J. Ramírez. (2009). The Impact of Climate Change in Coffee-Growing Regions: The Case of 10 Municipalities in Nicaragua. Cooperación Público-Privada “AdapCC” Adaptación al Cambio Climático para los Pequeños Productores.

Lal, R. 2004. Carbon Emission from Farm Operations. *Environment International* 30: 981-990.

Lallana, F., G. Bravo, G. Le Treut, J. Lefevre, G. Nadal, and N. Di Sbroiavacca. (2021). Exploring Deep Decarbonization Pathways for Argentina. *Energy Strategy Reviews* 36: 100670.

Lamb, W., T. Wiedmann, J. Pongratz, R. Andrew, M. Cripps, J.G.J. Oliver, D. Wiedenhofer, G. Mattioli, A. Al Khourdajie, J. House, S. Pachauri, M. Figueroa, Y. Saheb, R. Slade, K. Hubacek, L. Sun, S. Kahn Ribiero, S. Khennas, S. de la Rue du Can, L. Chapungu, S.J. Davis, I. Bashmakow, H. Dai, S. Dhakal, X. Tan, Y. Geng, B. Gu, and J. Minx. (2021). A Review of Trends and Drivers of Greenhouse Gas Emissions by Sector from 1990 to 2018. *Environ. Res. Lett.* 16: 073005.

Lankoski, J., A. Ignaciuk, and F. Jésus (2018). Synergies and Trade-offs between Adaptation, Mitigation and Agricultural Productivity: A Synthesis Report. OECD Food, Agriculture and Fisheries Papers, No. 110, OECD Publishing, París.

Lau, C., Jarvis, A., and Ramírez, J. (2010). Colombian Agriculture: Adapting to Climate Change, Policy Brief, CIAT.

Li, Kun. (2021). Footprint of Export-Related GHG Emissions from Latin America and the Caribbean. IDB Working Paper Series No. IDB-WP-01265.

Mbow, C., C. Rosenzweig, L.G. Barioni, T.G. Benton, M. Herrero, M. Krishnapillai, E. Liwenga, P. Pradhan, M.G. Rivera-Ferre, T. Sapkota, F.N. Tubiello, and Y. Xu. (2019). Food Security. In: Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Portner, D.C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, and J. Malley, (eds.)].

McCarl, B. A., and T.W. Hertel. (2018). Climate Change as an Agricultural Economics Research Topic. *Applied Economic Perspectives and Policy*, *40*(1), 60–78. https://doi.org/10.1093/aepp/ppx052

McCarthy, N. (2014). Climate-Smart Agriculture in Latin America: Drawing on Research to Incorporate Technologies to Adapt to Climate Change. IDB Technical Note IDB-TN-652.

MDB. (2021). Joint MDB Assessment Framework for Paris Alignment for Direct Investment Operations. BB1 and BB2 Technical Note. November.

MDB Working Group. (2020). *MDB Just Transition High-Level Principles.* Obtenido de https://www.adb.org/sites/default/files/related/238191/MDBs-Just-Transition-High-Level-Principles-Statement.pdf

Morris, M., A.R. Sebastian, and M.E. Perego. Con J. Nash E. Díaz-Bonilla, V. Piñeiro, D. Laborde, T.S. Thomas, P. Prabhala, J. Arias, C.P. De Salvo, and M. Centurion. (2020). *Future Foodscapes: Re-imagining Agriculture in Latin America and the Caribbean.*

Murken, L., and C. Gornott. (2022). The Importance of Different Land Tenure Systems for Farmers' Response to Climate Change: A Systematic Review. *Climate Risk Management* 35: 100419.

Myers, S.S., M.R. Smith, S. Guth, C.D. Golden. B. Vaitla, N.D. Mueller, A.D. Dangour, and P. Huybers. (2017). Climate Change and Global Food Systems: Potential Impacts on Food Security and Undernutrition. *Annu. Rev. Public Health* 38:259-277.

Nabuurs, G-J., R. Mrabet, A. Abu Hatab, M. Bustamante, H. Clark, P. Havlík, J. House, C. Mbow, K.N. Ninan, A. Popp, S. Roe, B. Sohngen, and S. Towprayoon. (2022). Agriculture, Forestry and Other Land Uses (AFOLU). In: IPCC, 2022: *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, and J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA.

Naciones Unidas. (2015). Acuerdo de París.

Niemeyer, J. C., S. Chelinho, and J.P. Sousa. (2017). Soil Ecotoxicology in Latin America: Current Research and Perspectives. *Environmental Toxicology and Chemistry* 36(7): 1795–1810.

Nin-Pratt, A., H. Freiría, and G. Muñoz. (2019). Productividad and Eficiencia en la Producción Ganadera Pastoril en América Latina: los Casos de Uruguay and Paraguay. Documento de Trabajo del BID IDB-WP-01024.

Nin-Pratt, A., and H. Valdés Conroy. (2020). After the Boom: Agriculture in Latin America and the Caribbean. Technical Note No IDB-TN-02082.

OECD. (2016). Agriculture and Climate Change: Towards Sustainable, Productive and Climate-Friendly Agricultural Systems.

Ovalle-Rivera O., P. Läderach, C. Bunn, M. Obersteiner, and G. Schroth. (2015). Projected Shifts in Coffea arabica Suitability among Major Global Producing Regions Due to Climate Change. PLoS ONE, 10(4):1-13.

Pathak, M., R. Slade, P.R. Shukla, J. Skea, R. Pichs-Madruga, and D. Ürge-Vorsatz. (2022). Technical Summary. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, and J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA.

Pautasso, M., T.F. Döring, M. Garbelotto, L. Pellis, and M. J. Jeger. (2012). Impacts of Climate Change on Plant Diseases: Opinions and Trends. *Eur J. Plant Pathol.*133: 295-313.

Poore, J., and T. Nemecek. (2018). Reducing Foods Environmental Impacts through Producers and Consumers. *Science* 360: 987-992.

Pörtner, H.-O., D.C. Roberts, H. Adams, I. Adelekan, C. Adler, R. Adrian, P. Aldunce, E. Ali, R. Ara Begum, B. Bednar-Friedl, R. Bezner Kerr, R. Biesbroek, J. Birkmann, K. Bowen, M.A. Caretta, J. Carnicer, E. Castellanos, T.S. Cheong, W. Chow, G. Cissé, S. Clayton, A. Constable, S. Cooley, M.J. Costello, M. Craig, W. Cramer, R. Dawson, D. Dodman, J. Efitre, M. Garschagen, E.A. Gilmore, B. Glavovic, D. Gutzler, M. Haasnoot, S. Harper, T. Hasegawa, B. Hayward, J.A. Hicke, Y. Hirabayashi, C. Huang, K. Kalaba, W. Kiessling, A. Kitoh, R. Lasco, J. Lawrence, M.F. Lemos, R. Lempert, C. Lennard, D. Ley, T. Lissner, Q. Liu, E. Liwenga, S. Lluch-Cota, S. Löschke, S. Lucatello, Y. Luo, B. Mackey, K. Mintenbeck, A. Mirzabaev, V. Möller, M. Moncassim Vale, M.D. Morecroft, L. Mortsch, A. Mukherji, T. Mustonen, M. Mycoo, J. Nalau, M. New, A. Okem (South Africa), J.P. Ometto, B. O'Neill, R. Pandey, C. Parmesan, M. Pelling, P.F. Pinho, J. Pinnegar, E.S. Poloczanska, A. Prakash, B. Preston, M.-F. Racault, D. Reckien, A. Revi, S.K. Rose, E.L.F. Schipper, D.N. Schmidt, D. Schoeman, R. Shaw, N.P. Simpson, C. Singh, W. Solecki, L. Stringer, E. Totin, C.H. Trisos, Y. Trisurat, M. van Aalst, D. Viner, M. Wairu, R. Warren, P. Wester, D. Wrathall, and Z. Zaiton Ibrahim. (2022). Technical Summary. [H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, and A. Okem (eds.)]. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, and B. Rama (eds.)]. Cambridge University Press. In Press.

Rautner, M., S. Tomlinson, and A. Hoare. (2016). Managing the Risks of Stranded Assets in Agriculture and Forestry. Chatham House Research Paper.

Roe, S., C. Streck, M. Obersteiner, S. Frank, B. Griscom, L. Drouet, O. Fricko, M. Gusti, N. Harris, T. Hasegawa, Z. Hausfather, P. Havlik, J. House, G. Nabuurs, A. Popp, M.J. Sanz Sánchez, J. Sanderman, P. Smith, E. Stehfest, and D. Lawrence. (2019). Contribution of the Land Sector to a 1.5ºC World. *Nature Climate Change* 10.1038.

Rogelj, J., D. Shindell, K. Jiang, S. Fifita, P. Forster, V. Ginzburg, C. Handa, H. Kheshgi, S. Kobayashi, E. Kriegler, L. Mundaca, R. Séférian, and M.V. Vilariño. (2018). Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)].

Rose, S., A. Khatri-Chhetri, M. Stier, T. Vu Hong, and K. Nelson. (2021). Agricultural sub-sectors in new and updated NDCs: 2020-2021. CCAFS dataset version 2.0. Wageningen, Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Rosenzweig, C., and F.N. Tubiello. (2007). Adaptation and Mitigation Strategies in Agriculture: An Analysis of Potential Synergies. *Mitig. Adapt. Strat. Glob. Change* 12: 855-873.

Saget, C., A. Vogt-Schilb, and T. Luu. (2020). *Jobs in a Net-Zero Emissions Future in Latin America and the Caribbean.* Inter-American Development Bank and International Labour Organization, Washington D.C. and Geneva.

Savary, S., A. Nelson, A.H. Sparks, L. Willocquet, E. Duveiller, G. Mahuku, G. Forbes, K. A. Garrett, D. Hodson, J. Padgham, S. Pande, M. Sharma, J. Yuen, and A. Djurle. (2011). International Agricultural Research Tackling the Effects of Global and Climate Changes on Plant Diseases in the Developing World. *Plant Disease* 95(10): 1204-1216.

Schulte, I., H. Bakhtary, S. Siantidis, F. Haupt, M. Fleckenstein, and C. O'Connor. (2020). Enhancing NDCs for Food Systems Recommendations for Decision-Makers. WWF, UN Environment Programme, EAT and Climate Focus.

Searchinger, T., M. Herrero, X. Yan, J. Wang, P. Dumas, K. Beauchemin, and E. Kebreab. (2021). Opportunities to Reduce Methane Emissions form Global Agriculture. Princeton University and Cornell University Discussion Paper, November.

Searchinger, T., R. Waite, C. Handon and J. Ranganathan. (2018). *Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050*. WRI Synthesis Report, December 2018.

Searchinger, T., and M. Herrero. (2022). Suggestions for Livestock Improvement Projects to Reduce Methane Emissions and Carbon Dioxide from Land Use Change. February.

Shukla, P.R., J. Skea, R. Slade, R. van Diemen, E. Haughey, J. Malley, M. Pathak and J. Portugal Pereira (eds.) Technical Summary. (2019). In: *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems.* [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M, Belkacemi, and J. Malley, (eds.)]. In press.

Smith, P., J. Nkem, K. Calvin, D. Campbell, F. Cherubini, G. Grassi, V. Korotkov, A.L. Hoang, S. Lwasa, P. McElwee, E. Nkonya, N. Saigusa, J.-F. Soussana, and M.A. Taboada. (2019). Interlinkages Between Desertification, Land Degradation, Food Security and Greenhouse Gas Fluxes: Synergies, Trade-offs and Integrated Response Options. In: *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems.* [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Portner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat,

E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, and J. Malley, (eds.)]. In press.

Snapp, S., Y. Kebede, E. Wollenberg, K.M. Dittmer, S. Brickman, C. Egler, and S. Shelton. (2021). Agroecology and Climate Change Rapid Evidence Review: Performance of Agroecological Approaches in Low- and Middle-Income Countries. Wageningen, The Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Stott, A., M. Mac Leod, and D. Moran. (2010). Reducing Greenhouse Gas Emissions through Better Animal Health. Scottish Agricultural College. Rural Policy Centre, Policy Briefing RPC PB 2010/01.

Svensson, J, H. Waisman, A. Vogt-Schilb, C. Bataille, P. Aubert, M. Jaramilo-Gil, J. Angulo-Paniagua, R. Arguello, G. Bravo, D. Buira, M. Collado, D. De La Torre Ugarte, R. Delgado, F. Lallana, J. Quiros-Tortos, R. Soria, J. Tovilla, and D. Villamar. (2021). A Low GHG Development Pathway Design Framework for Agriculture, Forestry and Land Use. *Energy Strategy Reviews* 37: 100683.

Swinnen, J., C. Arndt and R. Vos. (2022). Climate Change and Food Systems: Transforming Food Systems for Adaptation, Mitigation, and Resilience. In: IFPRI, 2022*: Global Food Policy Report: Climate Change and Food Systems.* Washington, DC. International Food Policy Research Institute.

Tubiello, F.N., K. Karl, A. Flammini, J. Gütschow, G. Obli-Laryea, G. Conchedda, X. Pan, S. Yue Qi, H. Halldórudóttir Heiðarsdóttir, N. Wanner, R. Quadrelli, L. Rocha Souza, P. Benoit, M. Hayek, D. Sandalow, E. Mencos Contreras, C. Rosenzweig, J. Rosero Moncayo, P. Conforti, and M. Torero. (2022). Pre- and Post-Production Processes Increasingly Dominate Greenhouse Gas Emissions form Agri-Food Systems. *Earth Syst. Sci. Data* 14: 1795-1809.

UNFCCC. (2021a). Nationally Determined Contributions under the Paris Agreement: Synthesis Report by the Secretariat. 17 September.

UNFCCC. (2021b). Climate Action Pathway: Land Use Action Table. Global Climate Action & Marrakech Partnership.

Van den Bossche, P., and J.A.W. Coetzer. (2008). Climate Change and Animal Health in Africa. *Rev. Sci. Tech.* 27(2): 551-562.

Vermeulen, S., and E. Wollenberg. (2017). A Rough Estimate of the Proportion of Global Emissions from Agriculture Due to Smallholders. CCAFS Info Notes, CGIAR.

Villamar, D., R. Soria, P. Rochedo, A. Szklo, M. Imperio, P. Carvajal, and R. Schaeffer. (2021). Long-term Deep Decarbonisation Pathways for Ecuador: Insights from an Integrated Assessment Model. *Energy Strategy Reviews* 35: 100637.

Wezel, A., M. Casagrande, F. Celette, J. Vian, A. Ferrer, and J. Peigné. (2014). Agroecological Practices for Sustainable Agriculture: A Review. *Agron. Sustain. Dev.* 34:1-20.