Protected Agriculture: Mexico

The Climate Bonds Standard & Certification Scheme's Protected Agriculture Criteria for Mexico

Background document

May 2019

Prepared by:

Dr. Christine Negra, Versant Vision LLC
Lawrence Pratt
Juan Manuel Ortega
Katie House, Climate Bonds Initiative
Ujala Qadir, Climate Bonds Initiative

In collaboration with:

Inter-American Development Bank

Supported by:

GFL Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

Acknowledgment

We would like to thank all those that helped review the Protected Agriculture Criteria for their time and valuable expertise that helped shape these Criteria. A full list of reviewers can be found in Appendix 1. The Climate Bonds Initiative gratefully acknowledges the important contributions of Lawrence Pratt, Juan Manuel Ortega, Isabelle Braly-Cartillier (IDB) and Enrique Nieto (IDB) to these Criteria, and special thanks are given to Dr. Christine Negra (Versant Vision LLC), the lead specialist coordinating the development of the Criteria.

In collaboration with: Inter-American Development Bank

Supported by: GFL Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

Definitions

Climate Bonds Initiative (CBI): An investor-focused not-for-profit organisation, promoting large-scale investments that will deliver a global low carbon and climate resilient economy. The Initiative seeks to develop mechanisms to better align the interests of investors, industry and government to catalyse investments at a speed and scale sufficient to avoid dangerous climate change.

Green Bond: A Green Bond is one in which the proceeds are allocated to green projects and labelled accordingly by the issuer. The vast majority of these green projects are focused on climate change mitigation or adaptation, but there is a small share of the market, which also funds green, non-climate projects, such as green spaces.

Certified Climate Bond: A green bond that is certified by the Climate Bonds Standard Board as meeting the requirements of the Climate Bonds Standard, as attested through independent verification.

Climate Bonds Standard (CBS): A screening tool for investors and governments that allows them to identify green bonds where they can be confident that the funds are being used to deliver climate change solutions. This may be through climate mitigation impact and/ or climate adaptation or resilience. The CBS is made up of two parts: the parent standard (Climate Bonds Standard v2.1) and a suite of sector specific eligibility Criteria. The parent standard covers the certification process and pre- and post-issuance requirements for all certified bonds, regardless of the nature of the capital projects. The sector-specific Criteria detail specific requirements for assets identified as falling under that specific sector.

Climate Bonds Standard Board (CBSB): A board of independent members that collectively represents $34 trillion of assets under management. The CBSB is responsible for approving i) Revisions to the Climate Bond Standard, including the adoption of additional sector Criteria, ii) Approved verifiers, and iii) Applications for Certification of a bond under the Climate Bonds Standard.

Climate Bond Certification: allows the issuer to use the Climate Bond Certification Mark in relation to that bond. Climate Bond Certification is provided once the independent Climate Bonds Standard Board is satisfied the bond conforms with the Climate Bonds Standard.

Technical Working Group (TWG): A group of key experts from academia, international agencies, industry and NGOs convened by the Climate Bonds Initiative. The TWG develops Sector Criteria - detailed technical criteria for the eligibility of projects and assets as well as guidance on the tracking of eligibility status during the term of the bond. Their draft recommendations are refined through engagement with finance industry experts in convened Industry Working Groups and through public consultation.

Industry Working Group (IWG): A group made up of potential green bond issuers, potential investors in horticulture related green bonds, financial intermediaries in the bond issuance process, and Climate Bonds Standard approved verifiers who are responsible for assessing whether bonds meet the Criteria. The purpose of the IWG is to advise and review the Criteria being developed by the TWG, testing the practicality of the Criteria for green bond market participants and providing recommendations for further improvement.

Protected Agriculture: a general term that encompasses horticultural greenhouses and refers to a variety of crop production technologies and techniques in which partial or full control of the plant micro-climate targets species' requirements, greatly improving growing conditions relative to open field agriculture. By reducing variability (e.g. in soil conditions, water availability, temperature, evaporation, pest and disease vectors, input use efficiency) and protecting crops from different environmental, biological and climatological elements, greenhouses and other forms of protected agriculture can: (i) achieve higher and more consistent productivity; (ii) meet market demand for crop quality and timing; (iii) increase control over sanitary and phytosanitary conditions; (iv) reduce crop risk and damage.

In collaboration with: Inter-American Development Bank

Supported by: GFL Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

Table of Contents

In collaboration with: Inter-American Development Bank

Supported by: GFL Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

1 Introduction

1.1 Overview

This Background Document serves as a reference document to the Criteria Document for Protected Agriculture. The purpose of the Background Document is to provide an overview of the key considerations and issues that were raised during the course of development of the Protected Agriculture Criteria.

The Criteria are developed through a consultative process with consultants and reviewers, and through public consultation. The reviewers comprise academic and research institutions, civil society organizations, multilateral banks and specialist consultancies. A period of public consultation offers the opportunity to any member of the public to comment on the Criteria. This document aims to capture these various dialogues and inputs and substantiate the reasoning behind the Protected Agriculture Criteria.

This Background Document begins with an introduction to the challenges in financing a low carbon and climate resilient world and the role that bonds can play in meeting this challenge, particularly through the standardization of green definitions. This is followed by Section 2, which introduces the protected agriculture sector and the implications of climate change on the sector in terms of both emissions and climate risks. Section 3 gives background about the investment need in the protected agriculture sector. And, Section 4 synthesizes the research and discussions arising from the development of the Criteria and presents the resulting requirements that have been finalized and published by Climate Bonds Initiative.

Supplementary information available in addition to this document include:

1. Protected Agriculture Criteria Brochure: a 2-page summary of the Bioenergy Criteria.
2. Protected Agriculture Criteria Document: the complete Criteria requirements.
3. Climate Bonds Standard V2.1: the umbrella document laying out the common requirements that all Certified Climate Bonds need to meet, in addition to the sector-specific Criteria (V2.1 is the most recent update version).
4. Climate Bonds Standard & Certification Scheme Brochure: an overview of the purpose, context and requirements of the Climate Bonds Standard & Certification Scheme.

For more information on the Climate Bonds Initiative and the Climate Bond Standard & Certification Scheme, see https://www.climatebonds.net/standards. For the documents listed above, see https://www.climatebonds.net/standard/protected-agriculture

1.2 Funding needs of a transition to low-carbon development trajectory

The current trajectory of climate change is expected to lead to a global warming of 3.1-3.7°C above pre-industrial levels by 2100[1], posing an enormous threat to the future of the world's nations and economies. The effects of climate change and the risks associated with a greater than 2°C rise in global temperatures by the end of the century are significant: rising sea levels, increased frequency and severity of hurricanes, droughts, wildfires and

[1] According to Climate Tracker, under current policies we could expect 3.1-3.7°C: 2018. Temperatures: Addressing global warming. Accessed on 17.05.2018. Available from: http://climateactiontracker.org/global.html

In collaboration with: Inter-American Development Bank

Supported by: GFL Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

typhoons, and changes in agricultural patterns and yields. Avoiding such catastrophic climate change requires a dramatic reduction in global greenhouse gas emissions.

Meanwhile, the world is entering an age of unprecedented urbanisation and related infrastructure development. Global infrastructure investment is expected to amount to USD 90 trillion over the next 15 years, which is more than the entire current infrastructure stock.[2]

To ensure sustainable development and slow climate change, this infrastructure needs to be low-carbon and resilient to climate change, without compromising the kind of economic growth needed to improve the livelihoods and wellbeing of the world's most vulnerable citizens. Ensuring that the infrastructure built is low-carbon is estimated to raise annual investment needs by 3–4% to USD 6.2 trillion.[3] Climate adaptation needs add another significant amount of investment, which is estimated at USD 280–500 billion per annum by 2050 for a 2°C scenario.[4]

According to the Task Force on Climate-related Financial Disclosures (TCFD), there are two broad channels through which climate change can present risks to business activities and assets[5]:

1. Physical risk: the risk of impacts from climate- and weather-related events, such as floods and storms that damage property or disrupt supply chains and trade;
2. Transition risk: the financial risks that could result from the process of adjustment towards a lower-carbon economy. These include sudden shifts in demand; legal risk due to parties who have suffered loss or damage seeking compensation; and changes in policy favouring lower carbon technologies.

All of these could prompt a reassessment of the value of a large range of assets as costs and opportunities become apparent, and widespread inadequate information on these risks could even threaten the stability of the financial system. Risks to financial stability will be minimised if the transition begins early and follows a predictable path, thereby helping the market anticipate the transition to a 2°C world.

1.3 Role of bonds

Traditional sources of capital for infrastructure investment (governments and commercial banks) are insufficient to meet capital requirement needs to 2030; institutional investors, particularly pension and sovereign wealth funds, are increasingly looked to as viable actors to fill these financing gaps.

Capital markets enable issuers to tap into large pools of private capital from institutional investors. Bonds are appropriate investment vehicles for these investors as they are low-risk investments with long-term maturities, making them a good fit with institutional investors' liabilities (e.g. pensions to be paid out in several decades).

Bond financing works well for low-carbon and climate-resilient infrastructure projects post-construction, as capital markets also facilitate risk management. Across investors and financial markets, different entities face different types and severities of risks related to climate change, depending on many factors including degree of long-term exposure, likelihood of negative climate impacts, and ability to mitigate impacts or shift positions.

[2] The Global Commission on the Economy and Climate, 2016a. The Sustainable Infrastructure Imperative: Financing for Better Growth and Development The 2016 New Climate Economy Report. (n.d.).
[3] The Global Commission on the Economy and Climate, 2016b. The Sustainable Infrastructure Imperative: Financing for Better Growth and Development The 2016 New Climate Economy Report. (n.d.).
[4] UNEP, 2016
[5] TFCD. 2017. Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures. Accessed on 17.05.2018. Available from: https://www.fsb-tcfd.org/publications/final-recommendations-report/. Accessed on 04.06.2018.

In collaboration with: Inter-American Development Bank
Supported by: GFL Green Finance for Latin America and the Caribbean
Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
based on a decision of the German Bundestag

Bonds offer relatively stable and predictable returns, and long-term maturities. This makes them a good fit with institutional investors' investment needs. Labelled green bonds are bonds with proceeds used for green projects, mostly climate change mitigation and/or adaptation projects, and labelled accordingly. The rapid growth of the labelled green bond market has shown in practice that the bond markets provide a promising channel to finance climate investments.

The green bond market can reward bond issuers and investors for sustainable investments that accelerate progress toward a low carbon and climate resilient economy. Commonly used as long-term debt instruments, green bonds are issued by governments, companies, municipalities, commercial and development banks to finance or re-finance assets or activities with environmental benefits. Green bonds are in high demand and can help issuers attract new types of investors.

Green bonds are regular bonds with one distinguishing feature: proceeds are earmarked for projects with environmental benefits, primarily climate change mitigation and adaptation. A green label is a discovery mechanism for investors. It enables the identification of climate-aligned investments with limited resources for due diligence. By doings so, a green bond label reduces friction in the markets and facilitate growth in climate aligned-investments.

However, currently green bonds only account for less than 0.2% of all bonds issued globally, whereas the global bond market stands at USD 100 trillion. The potential for scaling up is tremendous. The market now needs to grow much bigger, and quickly.

1.4 Introduction to Climate Bonds Initiative and the Climate Bonds Standard

The Climate Bonds Initiative is an investor-focused not-for-profit organisation whose goal is to promote large-scale investments through green bonds and other debt instruments to accelerate a global transition to a low-carbon and climate-resilient economy.

Activating the mainstream debt capital markets to finance and refinance climate-aligned projects and assets is critical to achieving international climate goals, and robust labelling of green bonds is a key requirement for that mainstream participation. Confidence in the climate objectives and the use of funds intended to address climate change is fundamental to the credibility of the role that green bonds play in a low carbon and climate resilient economy. Trust in the green label and transparency to the underlying assets are essential for this market to reach scale but investor capacity to assess green credentials is limited, especially in the fast-paced bond market. Therefore, the Climate Bonds Initiative created Climate Bonds Standard & Certification Scheme, which aims to provide the green bond market with the trust and assurance that it needs to achieve scale.

The Climate Bonds Standard & Certification Scheme is an easy-to-use tool for investors and issuers to assist them in prioritising investments that truly contribute to addressing climate change, both from a resilience and a mitigation point of view. It is made up of the overarching Climate Bonds Standard detailing management and reporting processes, and a set of Sector Criteria detailing the requirements assets must meet to be eligible for certification. The Sector Criteria covers a range of sectors including solar energy, wind energy, marine renewable energy, geothermal power, low carbon buildings, low carbon transport, and water. The Certification Scheme requires issuers to obtain independent verification, pre- and post-issuance, to ensure the bond meets the requirements of the Climate Bonds Standard.

1.5 The need for Sector Criteria

This Background Document supports the development of sector-specific eligibility Criteria for investors, industry, and governments that will catalyze increased investment and drive transparency and better reporting for projects and assets linked to Mexican Protected Agriculture Certified Climate Bonds. The general approach is based on a review of a broad set of information sources and considerations and balancing two over-arching objectives: (i) credibly verifying environmental outcomes of activities supported by bond issuances, and (ii) maximizing 'viable' bond issuances (i.e. eligibility Criteria are feasible for issuers to use and enable a wide range of suitable sector interventions).

1.5.1 The need for Criteria for protected agriculture

Protected agriculture has the ability to greatly reduce greenhouse gas (GHG) emissions per unit of food produced in comparison to open agriculture. As agriculture is responsible for a large share of global GHG emissions, lessening emissions per unit of food produced is vital to transitioning to a low carbon economy. However, not all protected agriculture does achieve lower GHG emissions per unit of food produced (see Section 4.3 for more information). For this reason not all protected agriculture assets or projects should be accepted in climate financing. The Protected Agriculture Criteria give the requirements that need to be met if a project or asset is to prove it is compatible with a low carbon and climate resilient economy.

1.5.2 Developing Criteria specifically for Mexico

Mexico is seeing dramatic growth and geographic expansion in the use of protected agriculture with greenhouse-based production rising from 790 hectares in 2000 to over 23,000 hectares in 2015, representing a compounded 25% annual growth rate over this period. Production is highly concentrated in a few products (70% tomato, 16% bell peppers, 10% cucumbers, and < 2% in berries) with just over half of national production concentrated in 4 of 31 Mexican states (Sinaloa, Jalisco and the Baja Californias) and 5 additional states compromising the balance.

Mexican tomato production is estimated at 3.4 million metric tons on 49,600 hectares with exports of 1.7 million metric tons for 2018-2019. Following a period of rapid expansion, new horticultural greenhouses are now being deployed on less than 1,000 hectares per year. The recent trend overall has been declining acreage planted with higher production due to the shift from open-field to horticultural greenhouses. While total production area has expanded somewhat in the states of Baja California Sur, Michoacán, and San Luis Potosi, geographic concentration of production could be limited by concerns about overproduction (leading to market over-supply) as well as interest in capitalizing on both summer and winter export windows (which requires producing in different regions). Future growth in protected agriculture in Mexico will be influenced by the demand in the US market (the destination for an estimated 80% of greenhouse-based production) as well as the trade policy context (e.g. the 5-year cycle revision of the Tomato Suspension Agreement sets seasonal floor prices for open-field and protected agriculture).[6]

There has also started to be interest from the Mexican market in financing or refinancing protected agriculture projects and assets through various types of climate finance. It is in response to the growing of the market and the perceived demand particularly from the Mexican market, that the Protected Agriculture Criteria have been developed for Mexico first. These Criteria are expected to be expanded to also cover other geographies soon.

1.5.3 The development process

The information presented in this Background Document relies extensively on the report "Protected Agriculture in Mexico: Discussion of Environmental and Social Impacts Compared to 'Business as Usual' Agricultural

[6] Mexico Tomato Annual: Protected Agriculture Production Expanding. USDA FAS GAIN report no. MX8025. https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Tomato%20Annual_Mexico%20City_Mexico_5-30-2018.pdf

Production," which was completed in May 2018 by Lawrence Pratt and Juan Manuel Ortega for the Interamerican Development Bank (IDB). This report investigated relevant environmental and social criteria for greenhouse-based production in comparison to a 'business as usual' scenario (BAU) of open-field production in the Mexican context, relying on literature review (noting that relevant peer-reviewed literature on the environmental impacts of protected agriculture is sparse), interviews with technical and sector experts, loan documentation, and official sources of policy information and data.[7]

Technical review of this Background Document has included IDB; a set of greenhouse and climate specialists operating as a sub-group of the Land Use Technical Working Group; the full Land Use Technical and Industry Working Groups; and a 30-day public comment period.

1.6 Revisions to these Criteria

These Criteria will be reviewed two years after launch, or potentially earlier if the need arises, at which point the TWG will take stock of issuances that arise in the early stages and any developments in improved methodologies and data that can increase the climate integrity of future bond issuances. After the first review, the Criteria will be reviewed again periodically on a needs basis as technology and the market evolves. As a result, the Criteria are likely to be refined over time, as more information becomes available. However, certification will not be withdrawn retroactively from bonds certified under earlier versions of the Criteria.

2 Sector Overview

2.1 What are protected agriculture assets?

Protected agriculture enables full or partial control of the micro-climate, allowing for optimization to plant requirements and protection from different environmental, biological, and climatological elements to improve production. Crops grown in greenhouses are more likely to achieve higher yield compared to other 'real world' production situations,[8] particularly when greenhouse operations integrate precision systems that can reduce use of water, agrichemical, and fuel inputs.[9]

Greenhouses and other forms of protected agriculture can vary considerably based on factors such as available technology and crop value.[10] The more sophisticated the technology used, the more production variables that can be controlled. The highest tech hydroponic greenhouse processes can resemble manufacturing operations much more than traditional agricultural operations. For example, they commonly involve complete closure / isolation; use of inert substrates instead of soils; drip or microspray precision irrigation; automation of water; and precision application of fertilizers and other agrichemicals with constant adjustment for crop cycle and weather. While this level of technology is highly capital intensive, it can be commercially profitable due to the higher productivity, product quality, and income. At the other end of the spectrum, rudimentary structures (e.g. plastic tunnels on semi-

[7] While there is a gap in peer-reviewed literature comparing protected agriculture and open-field systems, regional experience, expert opinion (i.e. agronomic researchers; technical field experts involved in financing; senior managers of protected agriculture oriented production companies), official sources of policy information and data, and 'soft' literature provide a consistent, quantitative foundation that is well-aligned with existing peer-reviewed literature.
[8] Jones JW. 2017. Toward a new generation of agricultural system data, models, and knowledge products: State of agricultural systems science. Agricultural Systems, 155: 269-288.
[9] Zeigler M, Steensland A. 2017. 2016 Global Agricultural Productivity Report (GAP Report). Global Harvest Initiative, Washington, D.C.
[10] Mexico Tomato Annual: Protected Agriculture Production Expanding. USDA FAS GAIN report no. MX8025. https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Tomato%20Annual_Mexico%20City_Mexico_5-30-2018.pdf

rigid supports) that protect crops against the elements (e.g. hard rain; drought; excessive sun and heat) can reduce vulnerability, increase productivity and quality, boost farm income, and improve the viability of small-scale farmers that commonly supply local markets.

Protected agriculture is generally characterized in four categories based on the technology being used; high, medium and low technology and shade houses. While there is no official unified definition of these technology levels, there is general agreement on the definitions given in the following sections.[11]

2.1.1 High Technology Protected Agriculture

Characterized by complete closure or isolation, use of inert substrates instead of soils, drip or microspray precision irrigation automation of water, precision fertilizer and other chemical use with constant adjustment during crop cycles and for weather (short term and long term). In most edible crops the systems are hydroponic (nutrients delivered in solution in the irrigation water). This technology is highly capital intensive, based on adaptation to principally Dutch technology, and, in Mexico, is primarily for export markets. The business case is that higher productivity with higher quality product provides superior income, justifying the investment.

The higher tech, controlled environment also allows growers to manage and meet more demanding sanitary requirements well, respecting USEPA and USFDA requirements on pathogens and pesticides.

In Mexico, the growing spaces are generally not heated. Additional heat to maintain growing conditions is used on rather limited basis during night-time hours in the coldest months, and is generally through radiated circulated water. Use of this heating avoids crop-losses, ensures production at highest prices of the year, and allos year-round employment for workers.

2.1.2 Medium Technology Protected Agriculture

Medium technology is a catch-all term referring to production systems that are: completely or nearly completely enclosed to air and rain using shading mesh cover; frequently producing in non-soil substrate or a combination of substrate and soils; very controlled, but not always automated water use; and utilizing precision plant nutrition (but not usually hydroponic systems). Medium tech operations may supply both domestic and export markets (when they meet sanitary requirements). As a first and relatively low-cost step into protective agriculture, open-field producers may erect a shade-house structure that holds a permeable mesh over existing open-field production land, commonly in combination with drip irrigation. These producers generally achieve significant benefits, including: decreased vulnerability, higher productivity, increased water and chemical input efficiency and better capacity to serve profitable 'shoulder season' markets.

2.1.3 Low Technology Protected Agriculture

This refers to rather rudimentary protective structure (plastic tunnel structures on semi-rigid supports) to help protect crops against the elements (hard rain, drought, excessive sun and heat). Production from farms employing this technology is almost without exception for local market consumption. This technology has been promoted aggressively to improve farm income through productivity increases and reduced vulnerability – primarily as a mechanism to keep small-scale farmers viably in the agricultural business. Farmers can expect significant productivity

[11] Pratt and Ortega, 2018, Protected Agriculture in Mexico: Discussion of Environmental and Social Impacts Compared to "Business as Usual" Agricultural Production

In collaboration with: Inter-American Development Bank

Supported by: GFL Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

increases, but biggest economic advantage is mostly the ability to maintain quality and related prices due to lack of damage from sun, rain and pathogens.

2.1.4 Shade Houses

Shade houses are a specific version of low-tech protected agriculture generally financed in larger scale operations, which is an increasingly common approach taken by producers. It consists of putting protective, permeable, cover over land – nearly always previously in extensive open field (i.e. business-as-usual agriculture) production systems, in order to increase productivity and decrease various production risks.

For open field producers, this is a common first step in protected agriculture. For a relatively low investment (compared to high tech), producers achieve significant benefits, including: decreased vulnerability, higher productivity, increased water and chemical input efficiency and better capacity to serve the profitable winter market. Along with high tech operations, it is currently the fastest growing technology in Mexico (in terms of hectare and total investment). The technology consists of erecting a structure that holds a permeable mesh over existing open field production land, nearly always with drip irrigating. The structure reduces risk from insect infection, wind and hail damage, and allows growers to use more productive "indeterminate" varieties.[12]

2.1.5 Nomenclature Clarifications

For the sake of simplicity, it is worth mentioning that under the Climate Bonds Initiative Protected Agriculture Criteria, when reference is made to greenhouses this comprise high, medium and low technology assets with the characteristics described above. Shade houses will be referred to by their name.

2.2 Mexican protected agriculture and climate change

Greenhouse-based production of fruit and vegetable crops occupied 408,890 hectares globally in 2013.[13] As of 2016, 102,242 hectares under greenhouses and plastic tunnels (producing tomatoes, sweet peppers, strawberries, cucumbers, melons, raspberries, watermelon, flowers, courgettes, and lettuce) were certified against the GLOBALG.A.P. standard.[14] Increased adoption of greenhouse and other protected agriculture technologies will be influenced by economic feasibility and may be limited to high-value crops.[15]

Major commercial drivers include:

- Higher and more consistent productivity;
- Meeting market demand profitably during colder months; and

[12] "Indeterminate" platns grow, flower and set fruit over the entire growing season. "Determinate" plants grow to a certain height and then stop. They also flower and set all their fruit within a relatively short period of time.
[13] FAO and ITPS. 2015. Status of the World's Soil Resources (SWSR) – Main Report. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy.
[14] Lernoud J et al. 2017. The State of Sustainable Markets – Statistics and Emerging Trends 2017. ITC, Geneva.
[15] Müller C, Elliott J. 2015. The Global Gridded Crop Model Intercomparison: Approaches, insights and caveats for modelling climate change impacts on agriculture at the global scale, In: Climate change and food systems: global assessments and implications for food security and trade, Aziz Elbehri (editor). Food Agriculture Organization of the United Nations (FAO), Rome, 2015.

- Better control over sanitary and phytosanitary conditions to meet market requirements (increasingly this includes expectations for worker protection) and to reduce crop risk and damage (and associated loss in sales) including from severe weather (e.g. strong rain, hail, drought).

These drivers have been complemented by business strategies focused on high-value export products, public recognition of the associated employment and foreign earnings benefits, and government subsidies designed to assist farmers in increasing their productivity and reducing their vulnerability to severe weather and numerous pathogens. The Mexican government has also specified greenhouses and other forms of protected agriculture as part of their strategy to mitigate greenhouse gas emissions and to respond to chronic water stress and increased frequency of severe weather events.[16]

2.2.1 Greenhouse gas emissions

Energy use varies significantly across different greenhouse systems. In colder climatic regions such as northern Europe, greenhouse systems are commonly heated nearly year-round to maintain optimum growing temperatures.[17] In warmer climatic regions, where optimum temperatures are naturally occurring, simple ventilation can be used during the hottest periods and heating may be used on a limited basis (i.e. when cold could threaten crop viability or severely impact growing). In high tech operations in Mexico, water-circulated radiated floor heating may be used during night-time hours in the coldest months to avoid crop losses, to ensure production at highest prices of the year, and to allow for year-round employment (increasingly important for operations requiring highly-skilled laborers).

Compared to open-field crop production, more precise and efficient use of nitrogen-based fertilizers in greenhouses ensures that a much higher percentage of the fertilizer reaches the plant, decreasing waste, improving productivity, and significantly lowering emissions of nitrous oxide, a powerful GHG.

In some cases, protected agriculture can greatly reduce GHG emissions per unit of food produced. The requirements of the Protected Agriculture Criteria will be set up to ensure that Climate Bonds Certification is only awarded to projects and assets that are reducing GHG emissions per unit of food produced compared to open agriculture (business-as-usual agriculture).

2.2.2 Climate change impacts

Productivity gains (commonly measured as kilogram of product per year per hectare of land) relative to open-field systems derive from higher productive capacity, avoided losses (due to severe weather and pathogens), and more efficient use of fertilizers, water, labor, and other inputs. In Mexico, compared to open-field production, productivity increase with protected agriculture can range from 2.5 times higher with low tech systems to as much as 35 times higher with high tech greenhouse systems (not accounting for losses due to severe weather experienced primarily in open-field systems).[18] There are opportunities for ongoing improvements in technology that offer additional potential for improvements in productivity, energy use, and pesticide selection and strategy.

---

[16] Federal Government of Mexico, Special Climate Change Program 2014-2018 (SCCP 2014-2018), English Translation, original in Spanish found at http://dof.gob.mx/nota_detalle.php?codigo=5342492&fecha=28/04/2014 (2014), accessed January 2018.
SEMARNAT, Mexico's Climate Change Mid-Century Strategy November 2016, p52, https://unfccc.int/files/focus/long-term_strategies/application/pdf/mexico_mcs_final_cop22nov16_red.pdf
[17] European Union. 2012. State of the Art on Energy Efficiency in Agriculture.
[18] FIRA. 2009. Agricultura Protegida para pequeños y medianos productores en Michoacán. Boletín Informativo Nueva Época Num 5.
FIRA. 2016. Panorama agropecuario 'Tomate Rojo.' Mexico.

Use of greenhouses can enable up to five harvests annually in agricultural systems, generating income and food supply benefits. However, without appropriate management, high harvest frequency can lead to reduced soil quality (e.g. compaction, acidification, salinization, biological deterioration), increased disease pressure,[19] and negative effects on ecosystems and human health (i.e. from intensive use of fertilizers, pesticides, and herbicides).[20] Soil quality loss can be mitigated by use of non-soil substrates in greenhouse production.

Some regions of Mexico have seen widespread deployment of horticultural greenhouses. As a relatively recent phenomenon, it is not yet possible to detect cumulative effects on land and resource use. Such effects could be positive. For example, higher per hectare productivity could lower demand for agricultural land and reduce conversion of natural habitats or production on degraded land. Cumulative effects could also be negative. For example, higher profitability could incentivize deployment of greenhouse-based production beyond the carrying capacity for local water resources.

2.3 Climate targets and transition trajectory

Greenhouses and other forms of protected agriculture can be an environmentally and socially preferable alternative to open-field agriculture for cash crops in regions where operational energy requirements are low (e.g. minimal supplementary heating) and solid waste (especially plastic) can be adequately managed. Improvements in productivity, water efficiency, vulnerability reduction, worker conditions, and GHG emissions can be significant relative to open-field modes.

While there are differences among high, medium, and low tech greenhouses, most technologies can deliver mitigation, adaptation, and resilience improvements through greater productivity, more efficient fertilizer and water use, and reduced vulnerability to weather.

3 Investments in protected agriculture

3.1 Investment need

The Protected Agriculture Criteria are designed for certification of assets and projects that align with:

(i) A global economic transition that limits global warming to 2°C (ideally 1.5°C);
(ii) Adaptation and resilience to unavoidable climate change, which include addressing the conservation and sustainable use of land.

Increasing awareness among governments, companies, and financial institutions has spurred interest in green labelled bonds and other investment vehicles as a mechanism to reduce risk and increase sustainability. Investor interest in protected agriculture is likely to rise given increasing recognition of the growing demand for food produced in a sustainable and resilient manner. Green bonds represent a viable financing strategy for protected agriculture projects (e.g. installation, operation, maintenance, decommissioning). Investment opportunities need to be calibrated to specific geographic contexts as regional climate can alter energy requirements and total emissions substantially. These Criteria are specific to Mexico.

---

[19] FAO and ITPS. 2015. Status of the World's Soil Resources (SWSR) – Main Report. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy.
[20] Guo et al. 2010. Significant acidification in major Chinese croplands. Science, 327: 1008-1010.

Provision of finance to support deployment of protected agriculture in Mexico is contingent on a producer's ability to re-pay, which hinges on some combination of higher productivity, better market access, and greater water and other input use efficiency. Green finance will also seek non-financial performance such as net reduction in GHG emissions and reduced vulnerability to weather extremes. The likelihood of these improvements is closely aligned with the type of protected agriculture infrastructure to be deployed, which, in turn, correspond to the size of financing required. Also, incentives are aligned for lenders and borrowers as agronomic, financial, and environmental performance are correlated (e.g. reduced water and input use lowers costs for producers).

3.2 Implication for Criteria

Bonds certified under the Protected Agriculture Criteria must be used to finance assets and activities that promote: (i) GHG mitigation through reduced emissions in line with rapid decarbonisation pathways consistent with the goals of the Paris Agreement; and (ii) adaptation to climate change and increased climate resilience in the systems in which they are located.

For bond issuers, eligibility Criteria should:

- Allow a relatively wide scope for eligible activities;
- Indicate scientifically robust references and approaches for calculating climate benefits (e.g. guidelines for selecting among existing methodologies and tools);
- Cater to a range of potential issuers (and users of the guidance), including: (a) relatively large companies, including banks, that can aggregate across sectors and industries, (b) smaller companies and organizations, where there may need to be some aggregation and, or, concessional support, and (c) government agencies.

For bond investors, eligibility Criteria should promote bond issuance that is:

- Relatively straightforward, predictable, and easy to understand in terms of the climate credentials;
- Transparent regarding use of bond proceeds and intended impacts, allowing independent third-party scrutiny.

Use of bond proceeds should follow industry best practices that are based on scientifically credible sources and approaches. Bond issuers are encouraged to align investments with government plans and priorities including Nationally Determined Contributions (NDCs) under the UNFCCC (the TWG notes that, given significant country-by-country variation, strict requirements for adherence to host government targets may have unintended outcomes or create a non-level playing field).[21]

4 Discussion and Eligibility Criteria

4.1 Guiding principles

The Climate Bonds Standard needs to ensure that the protected agriculture assets and projects included in Certified Climate Bonds deliver on GHG mitigation potential and climate resilience benefits, in line with best available scientific knowledge and compatible with the goals of the Paris Agreement. At the same time, the Protected Agriculture Criteria need to be pragmatic and readily usable by stakeholders in the market, to maximise engagement

[21] No international or national programs (e.g. NAMA) have been identified that could provide guidance or benchmarks for conversion from open-field to protected agriculture so Criteria development has been based on quantification of relevant technical parameters and definition of best practice.

and use. High transaction costs run the risk of reducing uptake of the Criteria in the green bond market. Keeping the costs of assessment down while maintaining robust implementation of the Criteria is important.

Table 1 sets out the principles guiding the development of the Protected Agriculture Criteria to meet and balance on these two goals.

Table 1. Key principles for the design of a Climate Bond Standard Horticultural Greenhouse Assets Criteria

Principle	Requirement for the Criteria
Level of ambition	Compatible with meeting the objective of 2°C, or less, temperature rise above pre-industrial levels set by the Paris Agreement, and with a rapid transition to a low carbon and climate resilient economy.
Robust system	Scientifically robust to maintain the credibility of the Climate Bond Standard.
"Do not reinvent the wheel"	Harness existing robust, credible tools, methodologies, standards and data to assess the low carbon and climate resilient credentials of any technology, endorsed by multiple stakeholders where possible.
Level playing field	No discrimination against certain groups of producers (such as smallholders) or geographies.
Multi-stakeholder support	Supported by key stakeholders; those within the relevant industry, the financial community and broader civil society.
Continuous improvement	Subject to an evolving development process with the aim of driving continuous improvement and credibility in the green bond market.

4.2 Scope

Issues

Climate-related benefits of greenhouses and other forms of protected agriculture, relative to open-field production, are directly and highly correlated with infrastructure and technology choices, which can be linked to verifiable criteria. While there are differences among high and low tech greenhouse technologies, most technologies can deliver mitigation, adaptation, and resilience improvements through greater productivity, more efficient fertilizer and water use, and reduced vulnerability to weather. Quantifiable benefits associated with various forms of greenhouse-based production facilitate establishment of climate bond certification criteria and verification of issuer compliance.

Proposed scope of assets and projects that should be eligible for Certification

High, medium, and low tech greenhouse / protected agriculture assets (technologies, practices) are eligible for certification pending compliance with Mitigation, Adaptation & Resilience, and reporting requirements (as detailed below). Bond issuers are required to demonstrate compliance at the portfolio level (rather than project-by-project), based on pre-defined technical criteria (i.e. rather than GHG impact assessment or *ex post* performance criteria). Table 2 gives the full details of the proposed scope.

Setting boundaries with other Sector Criteria

Due to the way that Sector Criteria are used for verification against the Climate Bonds Standard, it is imperative that clear guidance is given regarding which Sector Criteria is relevant for different types of assets and projects. The Climate Bonds Standard uses the asset-based approach, that is, the decision of which Sector Criteria to apply depends on what types of assets issuers have. With an initial intention to establish a broadly scoped Land Use Criteria, the Climate Bonds Initiative has since adopted a granular approach in which guidance is provided separately for different land use sub-sectors. Criteria have been developed for Forestry and Ecosystem Conservation and Restoration and further Criteria will be developed for other types of land use and agricultural activities.

For the Protected Agriculture Criteria, there is potential for overlap with the Water Criteria, which are intended to apply to a broad array of water investments and asset classes. The Water Criteria will generally apply if the asset will primarily deliver water services, such as water treatment, flood or drought management, or water storage, transport, or supplies. Where sector boundaries are not clear, the issuer should discuss with Climate Bonds Initiative to determine the best sector Criteria fit. The primary intended purpose should be the basis for deciding on the appropriate sector Criteria to apply. In the case where a single issuance includes more than one asset in a portfolio, and these assets span several sectors, the most appropriate Criteria should be applied to the individual components of the issuance – see Table 4 for further details.

4.2.1 Assets in scope

These Criteria apply to assets and projects relating to:

- Protected agriculture facilities in Mexico
- Dedicated infrastructure and support facilities to protected agriculture in Mexico
- The production of tomatoes, bell peppers, cucumbers, berries, and other horticultural crops that exhibit similar characteristics.

Further details of the scope are in Table 2, below.

Table 2 presents indicative protected agriculture related assets that could be included in a Certified Climate Bond, subject to meeting the specific Criteria described in Section 4. Table 2 is provided for illustrative purposes and is not an exhaustive list of every possible asset that would be eligible. Bonds financing multiple projects may also have to prove compliance with other Sector Criteria to be eligible for Climate Bonds Certification. For example, if a bond included both protected agriculture assets and water related assets on the same site it would be necessary for the issuer to prove compliance with both the Protected Agriculture Criteria and the Water Criteria.

To guide the interpretation of the requirements, Table 2 provides signposting as follows:

- A green circle indicates these assets, when fully described and documented, automatically meet the Criteria requirements, with no further disclosure or documentation required
- An orange circle indicates that the eligibility of these assets is conditional on meeting specific requirements
- A red circle indicates that these assets are not eligible for certification under any circumstances

Table 2: Illustrative use of bond proceeds eligible under the Mexican Protected Agriculture Criteria

Assets	Example use of proceeds	Mitigation	A&R
Protected agriculture, horticultural greenhouses and shade-houses that operate or are under construction to operate.	The establishment, acquisition, expansion or ongoing management of protected agriculture facilities in Mexico, including: ▪ PVC film or glass greenhouses ▪ Shade houses ▪ Systems for closure / isolation, precision fertilizer and other chemical use ▪ Non-soil substrates	● (orange)	● (orange)
	The establishment, acquisition, expansion or ongoing management of infrastructure and support facilities dedicated to protected agriculture in Mexico, including: ▪ Air and light control systems ▪ Precision plant nutrition systems ▪ Insect protection	● (orange)	● (orange)

4.2.2 Assets out of scope

Table 3 presents the assets and projects that are not eligible for Certification under the Protected Agriculture Criteria.

Table 3: Assets and projects not eligible for Certification under the Mexican Protected Agriculture Criteria

Assets/projects	Explanation for exclusion
Pesticide or fertilizer production	Pesticide or fertilizer production is considered out of scope of the Protected Agriculture Criteria even if the production is dedicated to protected agriculture facilities. It can be a very energy and chemical intensive process and these Criteria do not have requirements to ensure that process is low carbon or climate resilient.

4.2.3 Alignment with other Sector Criteria

Table 4 explains where potential crossovers with other Climate Bonds Standard Criteria could be and presents which Criteria apply to these assets and project types.

Table 4: Assets and projects related to protected agriculture, but eligible for Certification under other Sector Criteria

Assets/projects	Covered under…	Explanation
Installation vehicles	Low Carbon Transport Criteria	Vehicles must comply with the Climate Bonds Standard Low Carbon Transport Criteria. They are not automatically eligible under dedicated support facilities, as can have material impacts on the emissions profile of the crop production if they are not low emission vehicles.
Irrigation and other water related infrastructure	Water Criteria	The Climate Bonds Standard Water Criteria are designed to cover all types of water infrastructure, including drip and micro-aspersion irrigation. To prevent confusing crossovers all water infrastructure will remain certifiable under the Water Criteria.

4.3 Mitigation

Issues

Greenhouses and other protected agriculture operations can achieve lower GHG footprints per unit of production compared to open-field production. While some impacts can be higher relative to open-field, notably waste from plastics, these impacts can be compensated in other areas of the entire production system, particularly when considering embedded versus ongoing emissions.

Life cycle analyses of food products often show that agricultural production generates a major environmental impact (although significant impacts also commonly accrue from transport, household refrigeration, and food waste). The energy use associated with out-of-season fruit and vegetable production in heated greenhouses tends to be quite

In collaboration with:

Inter-American Development Bank

Supported by:

GFL Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

high.[22] Consequently, greenhouses that are heated year-round will be less likely to deliver net environmental benefit, except in cases where heat is provided by renewable energy sources or where water use efficiencies significantly alleviate water scarcity challenges.[23]

In open-field production, energy may be used for irrigation and mechanized activities such as planting, agrichemical application, weed control, or harvesting. In high tech greenhouse systems, most energy use is associated with pumping water (from a well or other source for storage); powering automated systems for drip irrigation and ventilation, and heating (where this is used). Greenhouse gas (GHG) emissions associated with these energy uses will depend on the energy source (e.g. grid electricity, diesel for pumps and backup generators and natural gas for heating water). In shade-houses and low and medium tech operations, energy use is primarily for pumping water. Even in low tech protected agriculture, farmers frequently employ more efficient drip irrigation systems that use less water, and likely less energy than open-field systems.

The major determinants of GHG emissions associated with horticultural greenhouse assets include:

- Construction (i.e. infrastructure): this relates to the amount of concrete, metal, and plastic required for a greenhouse / protected agriculture set up.
- Cultivation: this relates to the amount of irrigation water and fertilizer required for production.

For example, in Table 5, GHG emissions are estimated for tomato production in Mexico under open-field and various types of protected agriculture (normalized to $kgCO_2e$ per kg of tomato). (See Annex 4 for further details.) Note that, unlike the steel and concrete components, plastic requires replacement every three to five years.

Table 5. Estimated total GHG footprint associated with cultivation and construction of greenhouses and other protected agriculture systems for tomato production in Mexico.

	Cultivation plus construction		Cultivation plus plastic only		Cultivation only	
	kg of CO_2e per ton of tomatoes	Diff. vs. open-field	kg of CO_2e per ton of tomatoes	Diff. vs. open-field	kg of CO_2e per ton of tomatoes	Diff. vs. open-field
Open-field	337.71		337.71		337.71	
High tech	173.71	-49%	161.97	-52%	98.19	-71%
Medium tech	326.09	-3%	302.61	-10%	175.05	-48%
Low tech	396.85	18%	302.90	-10%	272.74	-19%
Shade-house – year-round	277.30	-18%	245.99	-27%	235.94	-30%
Shade-house – seasonal	394.80	17%	332.18	-2%	317.20	-6%

More efficient use of energy, water, and chemical inputs lead to efficiency gains of greenhouses and other forms of protected agriculture relative to open-field. The estimations show that medium and high tech greenhouse systems resulted in considerably lower GHG footprints, even when including plastic. Shade-houses also show clear reductions under year-round production, and modest reductions under seasonal production.

Deployment of protected agriculture is generally associated with reduced area under cultivation and higher overall production levels (see section 2.2). While it is conceivable that greater productivity and profitability of greenhouse-based production could lead to widespread deployment in excess of local land or water carrying capacity, such an

[22] Heller MC et al. 2013. Toward a Life Cycle-Based, Diet-level Framework for Food Environmental Impact and Nutritional Quality Assessment: A Critical Review. Environmental Science & Technology, 47: 12632–12647.
[23] Stoessel F et al. 2012. Life cycle inventory and carbon and water footprint of fruits and vegetables: application to a Swiss retailer. Environ Sci Technol, 46:3253-3262.

In collaboration with: Inter-American Development Bank
Supported by: GFL Green Finance for Latin America and the Caribbean
Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
based on a decision of the German Bundestag

outcome is moderated by several factors including: (i) limits on market capacity to absorb greatly expanded production without a corresponding drop in prices and profitability (especially in the context of trade policy uncertainty); (ii) geographically specific capacity to produce for summer and winter export markets; (iii) the much higher land and water use efficiency associated with greenhouse-based production.

The following conclusions can be drawn from the information presented above:

- Choice of protected agriculture infrastructure strongly determines the type and magnitude of climate-related outcomes so it is feasible to make *ex ante* assessments at the time of bond financing so long as use of proceeds are appropriately specified (e.g. lending criteria exclude energy-intensive systems). High tech, medium tech and year-round shade houses are the types of protected agriculture that deliver substantial GHG emissions savings per unit of food produced. It is these types of operations that the Climate Bonds Standard will recognize through Climate Bonds Certification
- Protected agriculture operators' management objectives (i.e. higher productivity; greater water and other input efficiency; maximizing 'life' of plastic covers) are well-aligned with achievement of climate-related objectives. Managers are unlikely to discontinue or significantly modify use of protected agriculture infrastructure (which has no real 'salvage' value) or revert to open-field or lower tech production modes.
- Operational changes (intentional or by oversight or error) are unlikely to significantly change or diminish the expected climate-related benefits associated with greenhouse-based production relative to open-field.

Given that high and medium tech greenhouses as well as shade-houses under year-round production are associated with reductions in GHG emissions relative to open-field production (see Table 5), eligibility is restricted to these types of protected agriculture operations. It is possible to easily identify high tech, medium tech and year-round shade houses with the rules that are set out in 4.3.1:[24]

4.3.1 Mitigation Criteria

Assets listed in Table 2 with an associated orange circle in the mitigation column must adhere to the following requirements:

1. Operations are fully enclosed with permeable or non-permeable air envelope and designed for year-round production
2. Where heating is used, it is only for defense against cold in winter months
3. Only uses passive cooling, active ventilation is permitted only for managing heat and relative humidity
4. Where irrigation[25] is used, it must be drip, micro-aspersion or fertigation only, with monitoring
5. Commitment to reuse or recycle used plastic sheeting and tubing, with a demonstrable policy or plan

Notes: Heating of a greenhouse can be provided either by passive or active modes. A passive mode uses the sun's rays to heat a surface inside the greenhouse directly. In comparison, an active mode uses additional thermal energy, which is fed inside the greenhouse using an air or water heating system.

[24] These restrictions are based on consultations with Mexico-based experts, who indicated these limits were suitable proxies for greenhouse operations at medium or greater level of technological sophistication.

In collaboration with: Supported by:
Inter-American Development Bank
GFL Green Finance for Latin America and the Caribbean
Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
based on a decision of the German Bundestag

4.4 Adaptation & Resilience

Issues

Different agricultural operations vary in important ways, but all forms of agricultural production are vulnerable to negative impacts of climate change such as severe weather events, hotter temperatures, and more frequent and intense droughts. Climate change impacts can reduce resilience through biophysical (e.g. eroded soils; higher pest or disease pressure; water stress or inundation) and socio-economic (e.g. lost income lowers capacity for investing in future production) effects.

Compared to open-field production, greenhouses and other forms of protected agriculture represent a favorable strategy for increasing resilience through the following:[26]

1. **Greatly reducing vulnerability and increasing resilience to changing meteorological conditions and related physical (e.g. soil erosion) and pathogen (i.e. insects generally, and in the case of high-tech systems, also bacteria and fungi) impacts.**

Globally, an estimated one-third of agricultural yield variability is attributable to inter-annual climate variations[27] and open-field agriculture is vulnerable to severe weather (e.g. droughts, severe rain and flooding events, extreme temperature events). Greenhouses can reduce farmers' vulnerability to partial or total crop loss as well as quality impacts (due to weather and weather-driven pathogen outbreaks) that could reduce profitability.

Under open-field and many low and medium tech forms of protected agriculture, crops are grown in natural soils, which must support their agronomic requirements (e.g. nutrient and water supply; appropriate pH; adequate drainage). Without management to replenish nutrients and organic matter, soils will become degraded. Low and medium tech greenhouse operations will still be subject to erosion losses from rainfall wash-over and river rises (where exposed), but erosion from direct impact of rainfall is greatly reduced, compared to open-field, as the plastic cover blocks the direct impact and splash and bounce from heavy rain. High and medium tech operations using non-soil substrates can be located on any type of land with less than a 2% slope, allowing for intensive production on marginal lands. In these operations, natural soils are covered with thick plastic, virtually eliminating the potential for soil erosion.

Medium and high tech greenhouses, which are nearly completely sealed (i.e. a non-permeable envelope) to the outside environment, can greatly reduce insect presence and damage and dramatically reduce infection vectors (i.e. that are brought to the plant by air, water, or carried in by workers on shoes or clothes). In these higher tech systems, production facilities are isolated from soils, water is controlled (or cleaned if needed, as in the case of re-use), workers follow protocols for shoes and clothing before entering, and the air is separated or the facility positively pressured when opened. In closely controlled and monitored systems, the decision to use pesticides and selection of type can be more precise, outbreaks can be better anticipated (e.g. based on weather conditions), and non-chemical strategies can be employed (e.g. control of temperature and humidity through simple ventilation; biological controls). In open-field and low tech protected agriculture operations, pathogens arrive by wind, water,

[26] Additional benefits may accrue in higher tech greenhouse-based operations, such as potential for future improvements in productivity and water management.
[27] Ray et al. 2015. Climate variation explains a third of global crop yield variability. Nature Communications, 6:5989.

In collaboration with: Inter-American Development Bank

Supported by: GFL Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

and other vectors and pesticides are commonly applied on a preventative or routine basis, which can include farm-wide treatment with aggressive and dangerous (red band) chemicals.[28]

2. **Reducing water consumption through efficiency and recovery and even use of lower quality desalinized (non-drinking quality) water for some crops (e.g. tomato).**

Greenhouses and other protected agricultural systems often deliver significantly improved water management (e.g. in Mexico, protected agriculture systems have 20% to 80% greater efficiency than open-field).[29] In open-field production, water needs are met by rainfall or irrigation (e.g. high-volume gasoline or diesel pumps) and significant quantities of water are commonly lost to soil, runoff, or evaporation. In high tech and many medium tech greenhouse operations, water is precisely allocated based on plants' real-time requirements using drip and micro-aspersion irrigation system, frequently using energy-efficient (e.g. driven by small, low-voltage, low-amperage motors), computer-controlled, sensor-based systems. These systems increasingly use hydroponic systems in which nutrients are delivered through irrigation water. Evaporation is minimal and there is little lost water given the economic incentives for efficient use and recovery and reuse of lost water. High tech operations require reliable water supplies and may use deep wells to ensure year-round quantity and quality, while open-field and low tech systems use a mixture of rainwater, surface water (pumped irrigation) and occasionally wells in drier climates. In water-stressed regions, broad adoption of well-managed greenhouses can represent an important opportunity for reducing agricultural vulnerability by increasing water use efficiency, where controls are in place to ensure net reduction in water use.

Compared to open-field production, the amount of water and chemicals lost as waste is a very small fraction in greenhouse systems. High tech operations can recover and reuse residual water and the nutrients it contains through filtering and ultraviolet light to remove bacteria, such that wastewater in these operations can be limited to water used for cleaning and repairs. Under medium tech systems, wastewater may be passed through a filter or decanter and in low tech systems, the final liquid wastes are discharged directly into soil.

3. **Improving farm income through productivity increases, improved crop price based on quality and seasonality, and reduced crop damage and loss.**

Use of fertilizers (nutrients) and pesticides can be much more precise in greenhouses, dramatically increasing efficiency of chemical use per unit of output. In open-field agriculture and very low tech protected agriculture, scheduled fertilizer applications are linked to total land area with variable rates of plant uptake and loss to runoff or leaching. In high tech and most medium tech systems, nutrients are supplied directly to the plant either through water (in solution in hydroponic operations), or in the individual plant's bag or pot. This ensures a much higher percentage of the fertilizer reaches the plant, decreasing waste, improving productivity, and also decreasing available nitrogen that could convert to nitrous oxide, a powerful GHG. In shade-houses, fertilizers are applied directly to the plants, as in open-field, but generally with greater precision.

The main waste produced by greenhouses, besides readily reusable and degradable biomass from expired plants, is the plastic sheeting or netting that is used as a cover and which must be changed every 3-5 years, resulting in significant quantities of waste. Old plastic covers can be re-used as ground cover and growing containers (plastic 'buckets') for plants in low tech and some medium tech operations. Public or private sector initiatives can provide adequate waste management options such as recycling in areas with large concentrations of greenhouse-based

[28] Agrichemical selection is strongly influenced by market expectations. For example, products grown in Mexico with the intention to export to the United States are produced with rather safe USEPA and USFDA substances exclusively, while production for local markets is much more variable.
[29] FIRA. 2011. Consejos Prácticos para Invertir en Invernaderos. Boletín Informativo Nueva Época Num14. FIRA. 2010. Oportunidades de Negocio en Agricultura Protegida." Boletín Informativo Nueva Época Num7.

production or requirements that companies selling new plastic sheeting offer take-back programs. It may be appropriate to require bond issuers to demonstrate that there are relevant public policies or programs as well as significant commercial incentives to improve plastic recovery and reuse in the region where bond-financed horticultural greenhouses will be deployed.

4.4.1 Adaptation & Resilience Criteria

As is discussed above, all protected agriculture controls the microclimate to some degree, reducing the variability and vulnerability that crops usually experience in open agriculture. It also allows much more targeted and efficient use of resources, such as water and fertilizer. In other Sector Criteria of the Climate Bonds Standard, showing climate resilience is largely based on showing that the future changes to the climate have been considered and any risks those may pose are being mitigated. In this sense, protected agriculture is resilient by nature, particularly the high and medium tech protected agriculture. Protected Agriculture technology and practice controls the microclimate and mitigates future climate risks, particularly arising from increased frequency and intensity of floods and droughts, temperature rises, changing wind patterns, erratic seasonality or precipitation patterns and changes in water quality.

Compared to open-field production, greenhouses and other forms of protected agriculture represent a favourable strategy for increasing resilience through the following: (i) Greatly reducing vulnerability and increasing resilience to changing meteorological conditions and related physical (e.g. soil erosion) and pathogen (e.g. insects, bacteria, fungi) impacts; (ii) Reducing water consumption through efficiency and recovery; and (iii) Improving farm income through productivity increases, improved crop price based on quality and seasonality, and reduced crop damage and loss.

For these reasons, there is just one requirement on the adaptation & resilience component:

1. No use of chemicals in the Stockholm Convention[30] or 1a or 1b in the WHO classification of pesticides by hazard[31]. Compliance with the Rotterdam Convention[32] where relevant

4.5 Recommended best practice

For higher levels of transformative impact, it is recommended that issuers also comply with the below:

1. Have sealed operations with non-permeable soil cover and integral (non-permeable) air envelope
2. Produce in substrates
3. Use water recovery and re-use systems
4. Disclose the use of chemicals in class 2 of the WHO classification of pesticides by hazard[33]

Issuers that do comply with any of the above should disclose this to demonstrate their best practice.

Climate Bonds Certification is not dependent on compliance with 4.3.

[30] http://www.pops.int/
[31] https://www.who.int/ipcs/publications/pesticides_hazard/en/
[32] http://www.pic.int/
[33] https://www.who.int/ipcs/publications/pesticides_hazard/en/

4.6 Reporting requirements

4.6.1 Reporting to demonstrate compliance with the Criteria

In accordance with the Climate Bonds Standard, it is the issuers responsibility to provide to the verifier the information necessary to demonstrate compliance with each component of these Criteria as described below. Verifiers must include this information in the scope of verification.

In accordance with the overarching reporting requirements as laid out in the Climate Bonds Standard V2.1, issuers are required to provide this information as follows:

- Pre-issuance reporting (supported by independent verifiers report): Full disclosure information relating to all nominated assets and projects at time of issuance.
- Post-issuance reporting (supported by independent verifiers report): Any amendments relating to all nominated assets and projects, including any additions or changes to allocated use of proceeds.
- Annual reporting thereafter: Any amendments to the previously provided information should be reported by the issuer by exception as changes arise. If there has been a reallocation of proceeds after post-issuance reporting, the issuer is required to re-engage the verifier to assess whether the newly identified assets and projects meet these Criteria.
- All requirements for certification must be maintained in compliance for the duration of the bond.

4.6.2 Additional reporting encouraged, but not mandatory for certification

In the interests of transparency and disclosure, issuers of Certified Climate Bonds are encouraged to publically disclose the following in respect of the assets and use of proceeds incorporated in that issuance. This is for transparency purpose only. There is no need for the verifier to check this information.

- Additional/innovative GHG monitoring techniques such as using remote sensing methods or tracking supply chain documentation of exports;
- Project location and size;
- Projected lifespan of the asset/project;
- Key stakeholders involved;
- Description of project activities including details on installation, operation, and decommissioning activities;
- Details of water use and estimated impact on local water resources;
- The planning standards, environmental regulations and other regulations that the project has been required to comply with.

In collaboration with:
IDB Inter-American Development Bank

Supported by:
GFL Green Finance for Latin America and the Caribbean

Supported by:
Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
based on a decision of the German Bundestag

Appendix 1: Criteria Reviewers

Peter Chege, Hydroponics Kenya
Rama Chandra Reddy, World Bank
Will Nicholson, Food Climate and Research Network
Henrik Selin, Boston University
Salvador Gonzales, Independent Consultant

Appendix 2: Public consultation

2.1. Summary of public consultation

No.	Feedback received	Response
1	We found out a point in your standard that could have a big impact on the potential use of the certification for our clients in the region. It seems that you are putting a minimum scale for projects to be eligible of 10ha for shade houses and 1ha for non-permeable envelopes. Our clients are banks focusing on financing small producers and those thresholds would basically invalid most of their portfolio. Those thresholds – especially the 10ha for shade houses - seem really disproportionate with the reality at least in Mexico: we are talking about 300,000 sq ft of shade house?	By analyzing all parameters of interest (e.g. Mexican government policy and sustainable agriculture more broadly), the scale effects are significant (but only linked to management practices). However, from an energy and fertilizer point of view (GHG emissions), vulnerability (water and direct impact), the scale issue is not compelling, hence why, we removed the requirement which set minimum hectareage on projects. A more detailed analysis of the rationale behind this decision is provided in table 2.2. below.
2	Why are fertilisation aspects not part of the recommended Criteria?	Fertilisation aspects are out of scope due to their energy and chemical intensive nature. There is no Criteria to ensure the production process is low carbon or climate resilient. The Protected Agriculture focuses explicitly on the physical infrastructure (e.g. type of 'covering).
3	Re: Where heating is used, it is only for defense against cold in winter months. Specify that this Criteria only apllies to greenhouses (high and medium tech). This is because only greenhouses use heating since it is not efficient to use heating with shade houses (mesh) due heat loss.	Suggestion has been incorporated into the Criteria.
4	Re: Only uses passive cooling, active ventilation is permitted only for managing heat and relative humidity. Specify that this Criteria only applies to greenhouses (high and medium tech) becuse it only appiies to greenhouses because the shade houses by definition allows air to flow.	Suggestion has been incorporated into the Criteria.
5	Re: Where irrigation is used, it must be drip or micro-aspersion only, with monitoring.	We believe 'monitoring and 'demonstrating compliance' are essential to the Criteria because it strengthens the

In collaboration with: Inter-American Development Bank (IDB)

Supported by: GFL Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

No.	Feedback received	Response
	We suggest to remove the monitoring part, as all irrigation systems must and are monitored in some way or another; we consider it redundant to indicate "with monitoring".	reason not to change an existing good practice. The Criteria will continue to specify this element.
6	Re: Commitment to reuse or recycle used plastic sheeting and tubing, with a demonstrable policy or plan. The Criteria should not include the word "demonstrable". It is important that there is an adequate disposal of plastics once they have reached their useful life, however, obtaining a demonstrable policy or plan can be operationally complicated, expensive or impossible to obtain.	Wording has been removed, however the issuer must still demonstrate to the verifier in some way that they are adhering to recycling and reusing plastic sheeting and tubing.
7	Eliminate the Criteria on no use of 'red band' agriculture chemical products and use of non-EPA and FDA registered products for export market. The use of prohibited chemicals is already regulated by law and the Mexican authorities monitor compliance.	We see no issue with keeping this criterion despite the fact that this aspect is already regulated by Mexican law. Issuers much demonstrate compliance with this requirement now and in the future.
8	Defining BAU: There can be significant variation in the practices of BAU. Therefore, a requirement to sample baseline/reference fields with different practices to estimate BAU metrics along with confidence intervals around the BAU estimates	Scope for future work if the Protected Agriculture Criteria becomes global. No changes have been made to the Criteria.
9	Heterogeneity of technology: Considering the heterogeneity of technologies, categorization of high, medium and low technology scenarios, it will be useful to define key criteria for technology categorization that can be relevant for multiple contexts	Definitions for the various types of protected agriculture assets scan be found in Section 2.1 of this document. As a principle we take a technology agnostic view with criteria development so try not to set different criteria for different technologies, is possible
10	Upward bias in mitigation: The document states that consultants have elected to use data from "best practices" to reflect forward-looking scenarios. Such an approach introduces upward bias to the mitigation estimates in relation to the BAU/reference scenario. A suitable approach would be to consider the data of a sample of each technology category and identify the PA systems corresponding to the median of high/medium/low technology categories to reflect the representativeness of the PA systems.	The forward looking data favors the type of projects that would be eligible for green bond issuance. The consultants have elected to base the data and analysis on current "best practices" for each of the various PA technologies. This decision was made to more accurately reflect forward-looking scenarios for PA rather than historic, and to be more representative of the requests to and desired financing from, financial institutions. Consequently, some variables in this report– most notably for productivity – are based on current expert opinion and observed data, and are considerably higher than "averages" reported in official sources.
11	Mitigation outcomes: The literature review to identify the metrics seems reasonable in absence of ready information. However, for designing the standard, metrics should be based on a sampling of technology categories so that BAU and program estimates have confidence intervals around them.	Responded to get better clarity on what is being suggested
12	Adaptation outcomes: In addition to the focus on mitigation, the standard should highlight the adaptation outcomes of protected agriculture (PA) in terms of – water use efficiency, reduced pest incidence, and reduced weather-related vulnerability.	This comment came before the background document had been sent. It is now addressed in the background document

In collaboration with:

Inter-American Development Bank

Supported by:

GFL Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

No.	Feedback received	Response
13	Ex ante/deemed additionality: Based on the data on productivity, input and emissions intensity per unit of output, the standard can identify PA technologies that can be deemed additional considering significant mitigation benefits and barriers to investment, thereby making a case for automatic eligibility for green financing.	There wasn't anything that could be easily defined and identified as automatically eligible
14	Monitoring PA systems: The standard can highlight the feasibility and steps for financial institutions to cost effectively monitor the functioning of PA systems using remote sensing methods or tracking supply chain documentation of exports.	Scope for future work if the Protected Agriculture Criteria becomes global. No changes have been made to the Criteria.
15	PA module as part of climate smart agriculture standard: PA could form a module/sub-component/annex to the climate smart agriculture standard as a technology (that may be approved by CBI in future). A version of PA is vertical farming that is relevant for urban areas.	Scope for future work if the Protected Agriculture Criteria becomes global. No changes have been made to the Criteria.

2.2. Rationale for removing proposed hectarage limits in the Criteria requirements

Parameter of Analysis	Potential risks related to "small scale
Productivity	None. Significant gains will be realized with shade houses and higher tech. And this is the underlying loan value driver and the principal driver of "GHG-efficiency"
Land and soil requirements	None
Water use	May exist. But, determined by technology employed, not specific to size. If using drip, aspersion or fertilized irrigation, there are no issues with scale.
Vulnerability	None. Related to technology, not scale per se
Chemical inputs (fertilizers and pesticides)	Observed but addressed in Section 4.3.1. Key issues are market destination and management practices. Large facilities tend to be export-oriented and more compliant with chemical selection and use. However, implications are not related to GHG emissions performance
Energy used	None. Energy use is directly proportional to size and water strategy within a given climate zone
Waste	Suspected but addressed in Section 4.3.1. This is a management practices. Requested commitment to reuse or recycle is equally viable for large and small.
GHG footprint	None, if the specified Criteria are complied with, then the GHG per unit of product should not vary by size. There are no particular economies of scale that would substantially alter the target parameter (CO_2e per ton of output).

Appendix 3: Estimating GHG emissions for greenhouses

To develop total GHG emissions estimates for greenhouses and other protected agriculture in Mexico, the following emissions factors were used.

In collaboration with:

Inter-American Development Bank

Supported by:

GFL Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

Variable	Value	Unit	Notes
Concrete	0.15	kg CO_2 / kg of concrete	Industry standard*
Galvanized steel	2.90	tons CO_2 / ton of iron	Assumed US profile*
Polyethylene (PE)	2.40	kg CO_2 / kg of PE	Industry standard
Chemical fertilizers	1.25%	kg CO_2 / kg of N-fertilizer	IPCC Fertilizer guidelines for Nitrogen**
Diesel	2.60	kg CO_2 / liter	Standard based on formulation in Mexico***
LPG	1.58	kg CO_2 / liter LPG	Standard based on formulation in Mexico***
Electricity	0.45	tons CO_2 / MWh	Standard based on formulation for Mexican grid****

Sources:
*City of Winnipeg, "Emission factors in kg CO2-equivalent per unit", Canada 2012.
** "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines) methodology for agricultural sources of N2O" (IPCC, 1997; Mosier et al., 1998), and
Smith, Keith, Lex Bouwman,and Barbara Braatz (ICF Consulting, Washington, DC., USA), IPCC, "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories."
***Instituto Nacional de Ecología y Cambio Climático (INECC), "Factores de emisión para los diferentes tipos de combustibles fósiles y alternativos que se consumen en México", México 2014.
****Secretaría de Medio Ambiente y Recursos Naturales (SERMANAT), "Factor de Emisión", México, octubre 2015.
Global CCS Institute, "CCS for iron and steel production", 2013.

Estimates associated with construction of tomatoes in greenhouses and other protected agriculture in Mexico are reported in the table below, and compared to open-field systems.

	Concrete	Metal	Plastic*	kg of CO_2e per ton of Tomatoes
Open field	0.00	0	0	0
High tech	0.87	10.88	63.78	75.52
Medium tech	1.73	21.75	127.56	151.04
Low tech	6.93	87.02	30.16	124.11
Shade-house – year-round	2.31	29.00	10.05	41.36
Shade House - seasonal	4.62	58.00	14.98	77.6

Estimates associated with cultivation of tomatoes in greenhouses and other protected agriculture in Mexico are reported in the table below, and compared to open-field systems.

	Irrigation	Fertilizers[34]	kg of CO2e per ton of Tomatoes
Open field	337.32	0.39	337.71
High tech	98.06	0.13	98.19
Medium tech	174.79	0.26	175.05
Low tech	235.63	0.31	235.94
Shade-house – year-round	316.89	0.31	317.20
Shade House - seasonal	272.40	0.34	272.74

[34] The estimated reductions shown above for GHG from fertilizers in high and medium tech, as well as shade-houses, are likely very conservative (i.e. real GHG reductions are likely much higher). In open-field and lower tech systems, nitrogen fertilizer is broadcast widely so only a portion actually reaches the plant and the remainder is environmentally available for conversion to nitrous oxides (NOx). In higher tech operations (particularly hydroponic), nearly 100% of the fertilizer reaches the plant (in the initial application or reapplied after capture). Consequently, much less nitrogen is made available to the environment to become NOx. Thus, the general IPCC nitrogen conversion factor is likely too high for protected agriculture operations, but is used here in the absence of other literature-based conversion factors.

Appendix 4: Mitigation benefits of protected agriculture

Appendix 4 explains the greenhouse gas mitigation benefits of protected agriculture facilities. The climate-aligned rationale for allowing Climate Bonds Certification for protected agriculture assets is that we must reduce the GHG emissions intensity of the production of food. Some protected agriculture facilities achieve great reductions in the GHG emissions intensity compared to open field business-as-usual (BAU) agriculture. The mitigation requirements have been designed so that only those facilities that achieve substantial mitigation benefits will pass.

Table 1: GHG emission per technology type

	Cultivation plus construction and plastic		Cultivation plus plastic only		Cultivation only		Cultivation plus construction (but not plastic)	
	$kgCO_2e$/ton of tomatoes [A]	Diff. vs. open-field [B]	$kgCO_2e$/ton of tomatoes [C]	Diff. vs. open-field [D]	$kgCO_2e$/ton of tomatoes [E]	Diff. vs. open-field [F]	$kgCO_2e$/ton of tomatoes [G]	Diff. vs. open-field [H]
Open-field (BAU)	337.71		337.71		337.71		337.71	
High tech	173.71	-49%	161.97	-52%	98.19	-71%	109.93	-68%
Medium tech	326.09	-3%	302.61	-10%	175.05	-48%	198.53	-41%
Low tech	396.85	18%	302.90	-10%	272.74	-19%	366.69	8%
Shade-house – year-round	277.30	-18%	245.99	-27%	235.94	-30%	267.25	-21%
Shade-house - seasonal	394.80	17%	332.18	-2%	317.20	-6%	379.82	12%

The lines highlighted in red will not pass Climate Bonds Certification. Table 2 shows how we are screening those out.

Notes on table 1:

- Column B shows the difference between GHG emissions in BAU agriculture and protected agriculture when all embedded and cultivation emissions are considered
- From there, the consultant looked at cultivation and plastic emissions and cultivation only and we pulled out the values for cultivation and construction (but not plastic). This exercise was done to understand how each element of the emissions is affecting the overall GHG emissions of protected agriculture
- In the values in table 1, it was assumed that plastic was neither reused nor recycled. By including a requirement that all plastic must be reused or recycled, the emissions savings achieved will be in the region of those in column H
- By this rationale, Climate Bonds Certification seeks to certify high tech, medium tech and shade-houses (year-round)

In collaboration with: Supported by:

Inter-American Development Bank

Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

- The advice from the technical committee and public consultation is that is it not feasible to ask protected agriculture issuers to do a GHG emissions assessment of their operations. Therefore, we must find screening proxies that distinguish the facilities that will have substantial GHG emissions savings. The screening proxies identified are presented under the mitigation requirements section of table 2

Table 2: How the requirements of the Protected Agriculture Criteria screen in or out different types of protected agriculture facilities

	Mitigation requirements					Resilience requirements
	Heating is only for defence against cold	Cooling only for managing heat and relative humidity	Irrigation must be drip or micro-aspersion	Plastic must be reused or recycled	Operations are fully enclosed and designed for year-round production	No use of chemicals in the Stockholm Convention or 1a or 1b in the WHO classification of pesticides by hazard. Compliance with Rotterdam Convention where relevant
High tech	✔	✔	✔	✔	✔	✔
Medium tech	✔	✔	✔	✔	✔	✔
Low tech	✔	✔	✘	✔	✘	✔
Shade-house – year-round	✔	✔	✔	✔	✔	✔
Shade-house - seasonal	✔	✔	✔	✔	✘	✔

✔ *Represent that this type of technology is capable of meeting this requirement.*

✘ *Represents that this type of technology is NOT capable of meeting this requirement.*

s

In collaboration with:

IDB Inter-American Development Bank

Supported by:

GFL Green Finance for Latin America and the Caribbean

Supported by: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag