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INVESTING IN CARBON NEUTRALITY: UTOPIA OR THE NEW GREEN WAVE?

CHALLENGES AND OPPORTUNITIES FOR AGRIFOOD SYSTEMS

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Foreword

Global agrifood systems are both a cause and a victim of climate change. Agrifood systems generate some of the largest contributions to global greenhouse gas (GHG) emissions. At the same time, agrifood systems are also victims of climate change, which jeopardizes food systems and the natural systems on which they rely. Climate change mitigation and adaptation are now two additional pillars of food security and nutrition. For these reasons, redesigning agrifood systems to leverage their potential to remove emissions, while adapting them to climate change, have become key global political and economic objectives. The 26th United Nations Climate Change Conference (COP26) has reaffirmed the urgency of this agenda.

Promoting environmentally sound investments, policy and technical cooperation is a core component of the European Bank for Reconstruction and Development's (EBRD) mandate. As of 2021, the EBRD has signed EUR 36 billion in green investments and financed over 2000 projects, which are expected to reduce over 100 million tonnes of carbon emissions annually. The EBRD has reaffirmed its commitment to addressing the climate crisis by adopting a more ambitious Green Economy Transition approach in 2020 (GET 2.1).

The new Strategic Framework (2022–2031) of the Food and Agriculture Organization of the United Nations (FAO) articulates the organization's vision of a more sustainable and food secure world for all, with actions organized around the '*four betters*' of better production, better nutrition, better environment and better life. This framework underscores FAO's commitment to greening agrifood systems by protecting, restoring and promoting the sustainable use of terrestrial and marine ecosystems and combating climate change.

Throughout their longstanding partnership, EBRD and FAO aim to mobilize public and private stakeholders towards more environmentally sustainable agrifood systems in EBRD's regions of operation. The two organizations have a robust track record of collaborating to deliver technical assistance, tools and policy advice, to support the transition to a green and low-carbon economy.

As countries and development partners discuss the road ahead, this report provides a detailed analysis of where agrifood systems stand on decarbonization. It provides useful insights on how to achieve low carbon pathways. It thoroughly reviews the status quo of carbon neutrality in agrifood systems and discusses current incentives for agrifood systems players to adopt carbon neutrality practices. It highlights the heterogeneity and complexity of agrifood systems and the challenges they face.

The report underlines how subsector specificities and market situations need to be taken into consideration when designing interventions to promote investment in decarbonization, particularly in a context where carbon and other GHGs are not priced according to their social cost. It sheds light on key governance shortcomings in applying carbon neutrality concepts – from quantifying emissions to labelling carbon neutral products. It critically evaluates trends such as sustainable investing or whether carbon can become 'the new calorie' in food labelling. The report ultimately looks at challenges and opportunities to promote low carbon investments from a policy standpoint, and also from the private sector perspective, with important recommendations for development partners.

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Abbreviations and acronyms

ACCU	Australian Carbon Credit Unit
ACORN	Agroforestry in Action
ADEME	Agency for Environment and Energy Management
AFD	Agence Française de Développement
AFOLU	Agriculture, forestry and other land use
AHDB	Agriculture Horticulture Development Board
ART	Architecture for REDD+ Transactions
AWD	alternate wetting and drying
B2B	business-to-business
BAU	business-as-usual
BC	British Colombia
BRC	British Retail Consortium
BSI	British Standards Institution
CA	conservation agriculture
CAI	Climate Accounting Infrastructure
CAM	Cambiamenti Ambientali Minimi
CAP	common agricultural policy
CAR	Climate Action Reserve
CB	certification body
CBAM	Carbon Border Adjustment Mechanism
CBBS	Climate, Community and Biodiversity Standard
CBT	carbon border tax
CCAFS	Research Program for Climate Change, Agriculture and Food Security
CCB	Climate, Community and Biodiversity Standard
CCS	carbon capture and storage
CDM	Clean Development Mechanism
CDP	Carbon Disclosure Project
CDR	carbon dioxide removal
CER	Clean Energy Regulator
CER	certified emission reduction
CFF	Climate Finance Facility
CFP	carbon footprint
CH4	methane
CIAT	Centre for Tropical Agriculture
CNGP	British Colombia Carbon Neutral Government Program
CN NET	Climate Neutral Network
CO2	carbon dioxide
CO2eq yr-1	CO2 equivalent per year
COP	Conferences of the Parties
CORSIA	Carbon Offset and Reduction for International Aviation
CSO	civil society organization

CSR	corporate social responsibility
CTF	Clean Technology Fund
CVC	carbon voluntary credit
DBSA	Development Bank of Southern Africa
DEG	Deutsche Investitions- und Entwicklungsgesellschaft (a.k.a. German Development Finance Institution)
DFI	development finance institution
DLT	distributed ledger technology
EBRD	European Bank for Reconstruction and Development
EDFI	Association of European Development Finance Institutions
EGIP	Embedded Generation Investment Programme
EIB	European Investment Bank
EIP-AGRI	European Innovation Partnership for Agricultural Productivity and Sustainability
EMAS	Eco-management and Audit Scheme
EOR	enhanced oil recovery
EPD	Environmental Product Declaration
EPP	European People's Party
ERF	Emissions Reduction Fund
ERR	emission reduction removal
ESG	environmental, social and corporate governance
ETF	Enhanced Transparency Framework
ETP	Ethical Tea Partnership
EU ETS	European Union Emissions Trading Scheme
EX-ACT	Ex-Ante Carbon-balance Tool
EX-ACT VC	Ex-Ante Carbon-balance Tool for value chains
FAO	Food and Agriculture Organization of the United Nations
FAPAR	fraction of absorbed photosynthetically active radiation
FCPF CF	Forest Carbon Partnership Facility Carbon Fund
FDA	United States Food and Drug Administration
FGRMS	feedback and grievance mechanisms
FINTECC	Finance and Technology Transfer Centre for Climate Change
FMCG	fast-moving consumer goods
FMO	Dutch Entrepreneurial Development Bank
FMS	farm management software
FOLU	Food and Land Use Coalition
FONAFIFO	National Forest Financing Fund
FRPERC	Food Refrigeration and Process Engineering Research Centre
FTE	full-time employee
GCF	Green Climate Fund
GCI	Ganaderia Climaticamente Inteligente
GDP	gross domestic product
GEF	Global Environment Facility
GFLI	Global Feed LCA Institute

GHG	greenhouse gas
GIC	Global Investor Coalition on Climate Change
GIIN	Global Impact Investing Network
GIZ	German Development Agency
GLAD	Global LCA Data Access network
GLEAM	Global Livestock Environmental Assessment Model
GLEAM-*i*	Global Livestock Environmental Assessment Model-*interactive*
GLP	Green Loan Principles
GLOBIOM	Global Biosphere Management Model
GPP	Green Public Procurement
GRI	Global Soil Organic Carbon – Monitoring, Reporting and Verification Protocol
GS	Gold Standard
GS4GG	Gold Standard for the Global Goals
GSIA	Global Sustainability Investment Alliance
GSOC-MRV	Global Soil Organic Carbon – Monitoring, Reporting and Verification Protocol
GSOC17	Global Symposium on Soil Organic Carbon
GSP	FAO Global Soil Partnership
Gt	Gigatonne or 1 000 000 000 tonnes
GWP	global warming potential
HCC	High Council for Climate Change
HORECA	hotel, restaurant and catering
IALL	Insetting via Agroforestry at Landscape Level Standard
IASB	International Federation of Accountants
IBRD	International Bank for Reconstruction and Development
ICAO	International Civil Aviation Organization
ICMA	International Capital Market Association
ICROA	International Carbon Reduction and Offset Alliance
IDB	Inter-American Development Bank
IETA	International Emissions Trading Association
IFAD	International Fund for Agricultural Development
IFI	international financing institution
IFRS	International Financial Reporting Standards Foundation
IIASA	International Institute of Applied Systems Analysis
IIGCC	Institutional Investor Group on Climate Change
INCR	Investment Network on Climate Risk
IPCC	Intergovernmental Panel on Climate Change
IPCC GPG	Intergovernmental Panel on Climate Change Good Practice Guidance
IPI	International Platform for Insetting
IPS	Insetting Program Standard
IRRI	International Rice Research Institute
ISO	International Organization for Standardization
ISRIC	International Soil Reference and Information Centre
ITC	International Trade Centre

ITPS	Intergovernmental Technical Panel on Soils
IWA	InterWork Alliance
JNR	VCS Jurisdictional and Nested REDD+
KPI	key performance indicator
KTDA	Kenya Tea Development Agency
LAI	Leaf Area Index
LCA	life cycle assessment
LCI	life cycle inventory
LCIA	life cycle impact assessment
LCP	low carbon procurement
LDC	least developed country
LEAP	Livestock Environmental Assessment and Performance Partnership
LLCP	long-lived climate pollutant
LMA	Loan Market Association
LPELC	Livestock and Poultry Environmental Learning Community
LRF	Land Restoration Fund
MDB	multilateral development bank
MMBI	World Economic Forum's Mining and Metals Blockchain Initiative
MRV	monitoring, reporting and verification
N2O	nitrous oxide
NAMA	Nationally Appropriate Mitigation Action
NCOS	National Carbon Offset Stan
NDC	Nationally Determined Contribution
NDVI	normalized difference vegetation index
NEXT	Nationally Determined Contribution Expert Tool
NFU	National Farmers' Union
NGO	non-governmental organization
NRT	Nori Carbon Removal Tonne
NZI	Net Zero Initiative
OECD	Organization for Economic Co-operation and Development
OTC	over-the-counter
PAS	Publicly Available Specification which is developed through the British Standards Institution
PAT	precision agricultural technology
PE	private equity
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category
PES	payment for ecosystem service
PPSA	Payment for Environmental Services Program
PRI	Principles for Responsible Investment
PVC	Plan Vivo Certificates
QES	Qualifying Explanatory Statement
RECSOIL	recarbonization of global agricultural soils

REDD+	Reducing Emissions from Deforestation and Forest Degradation
RGGI	Regional Greenhouse Gas Initiative
RSPO	Roundtable on Sustainable Palm Oil
SBG	Sustainability Bond Guidelines
SBP	Social Bond Principles
SBTi	Science Based Targets initiative
SCIG	Soil Carbon Industry Group
SDG	Sustainable Development Goal
SHAMBA	Smallholder Agriculture Monitoring and Baseline Assessment tool
SLBP	Sustainability-Linked Bond Principles
SLCP	short-lived climate pollutants
SLLP	Sustainability-Linked Loan Principles
SMEs	small and medium enterprises
SOC	soil organic carbon
SRI	System of Rice Intensification
SRP	Sustainable Rice Platform
SSM	sustainable soil management
TBL	triple bottom line
TCFD	Taskforce on Climate-related Financial Disclosures
TNFD	Taskforce on Nature-related Financial Disclosures
TREES	REDD+ Environmental Excellence Standard
TSVCM	Taskforce on Scaling Voluntary Carbon Markets
UDB	Uganda Development Bank
UNCCD	United Nations Convention to Combat Desertification
UNCCD-SPI	Science-Policy Interface of the United Nations Convention to Combat Desertification
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNEP FI	UNEP Finance Initiative
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
VCS	Verified Carbon Standard
VCU	verified carbon unit
VGSSM	Voluntary Guidelines for Sustainable Soil Management
VRI	variable rate input
WBCSD	World Business Council for Sustainable Development
WCI	Western Climate Initiative
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WMA	World Meteorological Association
WRI	World Resources Institute
WSC	World Soil Charter
WTO	World Trade Organization
WWF	World Wide Fund for Nature
ZEV	zero emission vehicle

Executive summary

TURNING CLIMATE CHANGE INTO AN OPPORTUNITY: WHY IT MATTERS

The world's agrifood systems are on the frontline of climate change, both as a cause and a victim (Tubiello *et al.*, 2021). Agrifood system emissions account for 21 percent to 37 percent of total anthropogenic greenhouse gas (GHG) emissions (10.8 and 19.1 GtCO2eq yr^{-1}) depending on estimates (IPCC, 2020). At the same time, climate change adversely affects agrifood system actors in different ways, from smallholder farmers to large food manufacturers (FAO, 2016a). Rising temperatures, changing rainfall patterns and supply chain disruptions already impact food production, undermining global efforts to end hunger. As a result, the number of people facing hunger could reach one billion by 2050.

In theory, carbon neutrality is achieved when anthropogenic emissions are balanced by anthropogenic removals over a specified period (IPCC, 2018a). However, in practice, the definition of carbon neutrality and related terminology have been widely debated, particularly on aspects related to emissions scope boundaries, trajectories and approaches to address residual emissions (Carbon Trust, 2019). While there are at least a dozen definitions, with more cropping up as private and public players decide to tackle their emissions, there is no widely accepted definition of carbon neutrality. That said, carbon neutrality usually involves four main steps: quantification; reduction; offsetting and/or insetting of GHG emissions; and validation and declaration of carbon neutrality. The carbon footprint (CFP) calculation[1] can be applied to a product, an organization or an entire value chain to quantify emissions, expressed as carbon equivalent units (CO2eq) (FAO, 2013).[2] Following the GHG Protocol[3] approach, emissions can be categorized into three groups: Scope 1 (direct emissions from activities within the organization's control); Scope 2 (indirect emissions from any electricity, heat or stream purchased and used); and Scope 3 (other indirect emissions from sources outside the organization's direct control). Once emissions have been quantified, efforts and investments focus on step two (emissions reduction) and step three (offsetting or insetting). Finally, carbon neutrality is validated and publicly declared.

Carbon neutrality is becoming a key policy theme globally, and many companies are genuinely concerned about sustainability. The increased attention on low carbon and carbon neutral agriculture has been aligned with national and transnational policy efforts since the late 1990s,[4] with governments and private sector players – including from agrifood systems – pledging to go carbon neutral. Countries are increasingly including agriculture in their Nationally Determined Contributions (NDCs), and governments are pushing through legislation needed to achieve ambitious carbon reduction targets. This legislation has clear

1 The term 'carbon footprint' directly derives from the ISO 14067:2018 and is referred to by the PAS 2060.

2 The different effects of GHGs can be compared using the metric of global warming potential (GWP), which is used to measure all emissions in 'carbon equivalent' units.

3 The GHG Protocol is a multistakeholder partnership of businesses, non-governmental organizations (NGOs), governments and others convened by the World Resources Institute (WRI), whose mission is to develop internationally accepted GHG accounting and reporting standards for business and to promote their broad adoption.

4 The first climate neutral certification was established in 1999, while carbon neutrality as a theme arose in the context of global policy goals linked to international agreements aiming to combat climate change, such as the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and the Kyoto Protocol in 1994.

implications and potential opportunities for agrifood systems, with businesses gearing up to comply with these regulations and respond to more stringent emissions control requirements. It also sets the stage for agricultural support policies that are more directly linked to environmental performance.

While there is a wide range of estimated costs and societal benefits for engaging food and land use systems in the fight against climate change, most suggest very high returns for society. The total economic mitigation potential of crop and livestock activities, including soil carbon sequestration and better grazing land management, is estimated at 3 percent to 7 percent of total anthropogenic emissions by 2030 – based on 2020 data (Smith *et al.*, 2014). The potential economic value of mitigating these emissions can amount to USD 45 billion to USD 300 billion, according to assumed shadow price and offsetting costs.[5] More broadly, reducing emissions, halting and restoring biodiversity loss, improving health and nutrition, and achieving inclusive growth can produce an annual societal return of USD 5.7 trillion by 2030 (Food and Land Use Coalition, FOLU, 2019). This is 15 times greater than the related investment cost of USD 300 billion to USD 500 billion per year (less than 0.5 percent of the global gross domestic product [GDP]) and would generate new business opportunities amounting to USD 4.5 trillion annually (World Bank, 2017).

Climate change is causing a shift in the investment universe, and agrifood actors need to adapt to attract investments. While there are questions about the credibility of many sustainable investment strategies, investments focused on environmental and social outcomes are becoming the 'new normal'. In 2018, sustainable investments reached USD 30 trillion and constituted 25 percent of assets professionally managed around the world, representing a three-fold increase since 2012 (GSI-Alliance, 2018).

This report presents a comprehensive assessment of the challenges and opportunities of carbon neutrality and scopes out the road ahead for agrifood systems. It covers key technical aspects related to the existing methodologies and standards to measure and track carbon neutrality and their application to agrifood systems. It does so with a critical eye, to identify blind spots and challenges as well as opportunities for improvement. It also provides strategic insights on the steps needed to move the carbon neutrality agenda forward, including an assessment of financing opportunities and public policy priorities. The recommendations are expected to benefit a wide range of agrifood actors, including representatives from governments, agrifood businesses, international organizations and civil society, as well as sustainability- and environment-minded investors.

WHAT AGRIFOOD SYSTEMS ARE DOING TO TACKLE GHG EMISSIONS

Agrifood sector experiences show that the impact of GHG emissions from the production, processing and transport of different goods – and even the same goods – is highly heterogeneous. Generally speaking, animal products require more carbon offsetting or insetting, resulting in greater costs related to compensation. However, the problem is complex, as the high emissions associated with forest conversion linked to some vegetable production systems, such as palm oil, often significantly increase the CFP of such products (Meijide *et al.*, 2020). Furthermore, the economic value of an agrifood product per tCO2eq

5 Shadow prices of carbon that are consistent with achieving the Paris Agreement objective of keeping temperature rise below 2 °C, provided there is a supportive policy environment, are: USD 40 to USD 80 per tonne of CO2eq in 2020, rising to USD 50 to USD 100 per tonne of CO2eq in 2050 (High-Level Commission on Carbon Prices, led by Joseph Stiglitz and Nicholas Stern).

emitted varies considerably across agrifood chains. For instance, beef has a carbon intensity (KgCO2 eq) up to 60 times greater than citrus fruit (Our World in Data, 2020).[6] Overall, agrifood supply chains have big differences in terms of costs and time spent pursuing carbon neutrality for the same or similar products across different companies, business models and geographies.

So far, carbon neutrality processes are voluntary. When it comes to applying carbon neutrality standards and methodologies, only some agrifood actors rely on third-party independent certification. Other actors do it in-house, which means they typically set their own standards and devise their own labels. This approach lacks independent validation, undermining the credibility of any carbon neutrality claims. A few large food retailers have initially followed the approach of branding single product lines as carbon neutral, applying CFP labels on a selection of their own products. Other agrifood companies have gone much further, accounting and compensating for their full CFPs, including Scope 1, 2 and 3 emissions, thus claiming to have gone 'carbon neutral'.

Carbon neutrality can present practical advantages for agrifood actors, yet agrifood enterprises currently follow different strategies and speeds. Carbon management and emissions measurement force businesses to closely examine their processes and map their products' journeys. In doing so, they compel businesses to look at their resource efficiency, as GHG emissions are strictly correlated with resource consumption (especially energy consumption), deforestation and forest degradation, but also the use of other inputs such as fertilizers and pesticides. As they attempt to tackle carbon emissions, some companies target only Scope 1 and 2 emissions, while others attempt to reduce and/or offset Scope 3 emissions across their entire value chains. This choice is driven partly by costs, particularly in large agrifood supply chains with multiple suppliers from different locations. In practice, this means that for many agrifood actors it is much easier and cheaper to focus on Scope 1 and 2 emissions.

Companies can leverage innovative farm-level CFP calculators and methodologies developed by a broad range of stakeholders to improve the accuracy of measuring emissions up to the smallholder level. Innovations in digital technology, including remote sensing and distributed ledger technology (DLT), are accelerating the development of more reliable agrifood value chain CFP calculators. Many CFP calculators require inputs at farm-level and have a specific farm-scale, decision-support focus. Large companies and retailers are increasingly relying on CFP calculators to refine existing methodologies and GHG emissions calculations. Furthermore, methodologies, tools and protocols developed by international financing institutions (IFIs) and specialized UN agencies can be leveraged to estimate mitigation potentials at the smallholder level.[7]

6 Despite apparent differences, it is important that when comparing emissions per kilogram against different food commodities, that nutritional density perspectives are considered.

7 Some of these methodologies and tools include: FAO Ex-Ante Carbon Balance Tool (EX-ACT), Ex-Act for Value-Chain (EX-ACT VC) and FAO Global Livestock Environmental Assessment Model-*interactive* (Gleam-*i*). Protocols related to sustainable soil management and soil organic carbon stocks include the Protocol for the assessment of Sustainable Soil Management (SSM) and Global Soil Organic Carbon – Monitoring, Reporting and Verification (GSOC-MRV). Both protocols underpin the MRV efforts of the Recarbonization of Global Agricultural Soils (RECSOIL) initiative, which focuses on enhancing soil health and the provision of multiple ecosystem services through SOC sequestration.

An increasing number of companies are showing an interest in aligning carbon neutrality with their corporate strategies by working directly with supply chain actors to reduce emissions. However, smallholder farmers generally lack the human or financial capacity to implement practices to improve soil health and decarbonize their own operations. They will likely require full-scale support to adopt such initiatives. Not all companies and stakeholders are interested in or can afford the investments required to reach, organize and train smallholder farmers who are operating in highly fragmented supply chains. New voluntary carbon marketplaces that focus exclusively on compensating farmers for implementing regenerative agricultural practices that enhance soil carbon sequestration are gaining ground.[8] As such, these carbon marketplaces are providing more opportunities for companies to directly invest in farm-level sustainability and soil carbon sequestration. Although these carbon marketplaces are only applicable in certain geographical areas, they illustrate what could be done to develop similar marketplaces around the world.

Transformational initiatives seeking to address major challenges, such as deforestation, have employed jurisdictional approaches and sought to address different types of land use to trigger changes in agricultural practices. Ecosystem payment services and IFI support are providing farmers with financing to decarbonize and enhance soil health. More specifically, Reducing Emissions from Deforestation and Forest Degradation (REDD+)[9] and Payments for Ecosystem Service (PES) are serving, via national institutions, as an income source for smallholders to prevent additional deforestation, conserve forests and enhance carbon stocks. Voluntary carbon offset markets function outside of compliance markets[10] and can serve as important instruments for the private sector, governments and individuals to act on carbon neutrality ambitions.

BEYOND THE HYPE, COMPLEX ISSUES REMAIN

Although carbon neutrality has the advantage of being seemingly simple in theory, it is also a narrow concept, which can be challenging. Due to its quantifiable and measurable nature, carbon neutrality has gained appeal among investors, policymakers and companies alike. However, carbon neutrality does not include wider environmental implications such as biodiversity, water consumption or various types of pollution. Environmental social and corporate governance (ESG) rating agencies already go beyond solely considering carbon emissions to integrating wider environmental and social impacts into their metrics and reporting practices. Additionally, some companies are expanding carbon labelling efforts to include wider environmental impacts.

The costs of becoming carbon neutral can be significantly higher for smaller companies, and (at current prices) offsetting costs are generally lower than reduction costs across emissions-intensive sectors. This report includes a simple model of the diverse costs of becoming carbon neutral, based on interviews with agribusinesses and certification service providers. The scenarios indicate that the annual costs of becoming carbon neutral could be significant for smaller companies and that reduction costs are higher than offsetting costs.

8 Such as Nori, Indigo AG, Soil Carbon Industry Group (SCIG) and AgriProve.

9 REDD+ provides mechanisms, where developed nations pay governments throughout developing countries to avoid deforestation and forest degradation.

10 This report uses the compliance terminology introduced by the European Union Emissions Trading Scheme (EU ETS), which is based on a cap-and-trade system based on annual compliance to a governing authority and GHG permit and monitoring plan. For exact definition see: European Commission. 2015. EU ETS Handbook. https://ec.europa.eu/clima/sites/clima/files/docs/ets_handbook_en.pdf

Costs will vary, depending on the emissions reduction practice and offsetting strategy pursued through the type of carbon credits purchased. The analysis in this report supports the observation that agrifood companies tend to offset emissions rather than directly reduce them.

Limited reliable and up-to-date inventory data on food production processes hinder accurate CFP assessments. While approaches for measuring emissions exist, they have not always been designed specifically for the agrifood sector. These approaches – which include measuring carbon sinks related to agricultural practices such as soils – continue to be refined. However, they can be technically difficult and costly to apply (Value Change, 2018). This means there are serious limitations to the carbon inventories for agrifood systems produced with traditional life cycle assessment (LCA) methods. When data is available, it is often not at the spatial and temporal resolution needed to provide an accurate representation of complex agricultural practices. This spatial variability is seldom considered in LCA databases and models, which tend to adopt blanket figures from global inventories that often exclude land cover changes and other aspects in the calculations. Furthermore, reliable aggregated data for GHG emissions and soil carbon stock changes are largely lacking.

Although farm-level innovations and methodologies hold promise, they are far from perfect. Innovative institutional approaches are still required to cut transaction costs, and there are several governance challenges. Various methodological challenges hamper the development and functionality of CFP calculators. Even if new digital technologies are effectively deployed, many agrifood systems rely largely on smallholder farming. This implies the need to develop and apply innovative solutions that create incentives for market actors across fragmented supply chains to measure the CFP of commodities and reduce emissions throughout different supply chain stages. Furthermore, governance challenges in verifying the effectiveness and reliability of innovative tools and approaches remain.

Besides technical and methodological problems, the lack of a clear governance framework hinders more decisive action on the part of agrifood businesses, and also fails investors and consumers. There are several reasons for this. First, the multiple terms and definitions confuse consumers and businesses alike. Second, the lack of transparency on how carbon reductions are achieved can undermine the public understanding and perception of carbon neutrality. This is especially true when companies and organizations employ internal approaches to reduce emissions, as these approaches may not be subjected to independent oversight or transparent disclosure practices. Third, confusion arises from the absence of comparable standards and databases for measuring carbon offsets. And finally, the proliferation of carbon and environmental labels and lack of governance on climate-related disclosure practices undermine credibility for consumers and investors.

Carbon markets are also challenged by governance problems. Unlike compliance offset markets – such as the European Union Emissions Trading Scheme (EU ETS) which accounted for around 90 percent of the total global value of carbon markets and by volume in 2020 (Refinitiv, 2020) – voluntary carbon marketplaces (for offsets and removals) have been developed by the private sector with carbon credits verified through standards created by a range of actors. Furthermore, voluntary carbon marketplaces do not have a centralized repository for price and volume data, and credits are transacted bilaterally and over the counter (European Commission, 2015; Forest Trends' Ecosystem

Marketplace, 2020).[11] Instead, voluntary credits are stored in decentralized registries managed by governments, non-profits and private sector players (GHG Management Institute and Stockholm Environment Institute, 2021).[12] These dynamics may contribute to a lack of trust in carbon credits, due to challenges related to additionality, carbon leakage, permanence and accounting. Another related challenge concerns a large volume of legacy credits (credits from older projects registered in previous years with poorer quality controls) (Trove Research, 2021). Finally, several studies suggest carbon markets are expected to grow substantially as companies beyond agriculture look for carbon offsetting and removal options. However, there are concerns about the amount of available capacity from consultancy firms and other specialists that are needed to develop such offsetting and removal projects, which will translate into credits.

While sustainable investments are gaining ground, smallholder farmers and smaller companies may not stand to immediately benefit from developments in sustainable finance. In the agrifood sector, institutional investors tend to invest in listed equities or agrifood company bonds rather than directly in primary agriculture. Working with smaller actors in agrifood systems can involve significantly higher transaction costs and risks. Therefore, many agrifood system actors may not be directly eligible for sustainable financing. Nevertheless, smaller actors often form part of global food chains that include large companies, and these companies are increasingly being pressured to involve smallholder farmers to address their Scope 3 emissions.

Beyond access to sustainable financing, a lack of standardized ESG reporting practices, limited transparency in ESG rating methodologies, and inconsistent disclosure requirements hinder comparability and the integration of sustainability factors in investment decision-making. These factors present challenges to both investors and companies alike in converting sustainability-based commitments into practice. Diverse outputs across major ESG rating providers, compared with traditional credit ratings, can generate confusion among investors and fund managers as to what a high ESG-rated company entails. If not addressed, this could undermine their confidence in ESG scores, indices and ESG-based portfolios. Inconsistent disclosure requirements make it difficult for investors and corporate stakeholders to communicate ESG-based decisions, outcomes and performance criteria to beneficiaries and shareholders. Relevant protocols, the EU Taxonomy for Sustainable Activities and the Task Force on Climate-related Financial Disclosures (TCFD), could prove to be crucial in streamlining climate-related disclosures and the use of consistent ratings methodologies.

Questions about consumer preferences and willingness to pay a premium are largely unanswered. In several parts of the world, citizens are demanding action on climate change. While these demands reflect increasing awareness of the urgency of climate action, their impact on purchasing decisions

11 In the beginning, the majority of trading in the EU ETS also took place via brokers in the over-the-counter (OTC) markets as most of the products were not liquid or standardized enough to be traded on exchanges. However, derivative contracts have become more standardized over time, reducing the need for customized deals executed through brokers. Market commentators suggest that uncertainty over the ETS and Kyoto Protocol progress has led to the lack of appetite for long-term forward contracts; traded contracts are thus very near-date and homogenous. This has facilitated the shift in trading from OTC-dominated to exchange-traded.

12 Some of the main voluntary registries include the American Carbon Registry, APC Inc. (which manages the Gold Standard and Climate Action Reserve, CAR, registries, Markit (which administers the Social Carbon and Plan Vivo registries) and Verra (which manages the Verified Carbon Standard (VCS) and Climate, Community & Biodiversity Standards (CCBS) registries.

has not been investigated comprehensively, and no consensus exists on how to promote individual climate action (Nisa *et al*., 2019). Evidence from high-income countries suggests that most consumer choices today are unlikely influenced by carbon-related labels (Feucht and Zander, 2018). The situation may evolve quickly as the impact of climate change becomes more visible. But the current situation calls for simpler, more transparent and reliable consumer communication on environmental impacts of products, as well as other complementary measures to provide incentives for adoption of lower carbon strategies in the agrifood sector.

While carbon has been touted as the 'new calorie', there is still a lot that can be done to promote effective environmental labelling in the agrifood sector. Carbon labelling has gained more traction through wider awareness of climate change. This renewed interest can be seen in large conglomerates and multinational companies pledging to carbon label their full product portfolios. While these announcements, combined with some retailer initiatives, create new momentum, widespread adoption of carbon labels is still a challenge. The vast array of environmentally friendly labels makes it difficult for consumers to recognize and compare product emissions through labels (Lacey, 2020). Lessons and best practices from the development of nutritional labels could provide insight on the effectiveness of carbon labels. Furthermore, public action, particularly on standardization, increased transparency and reliability could help accelerate the adoption of environmental labelling.

In short, the agrifood sector's experiences with carbon neutrality show that it is a long process; it takes time before results appear, and it requires sustained corporate commitment. A carbon neutrality strategy requires significant financial and human resources, often with unclear financial benefits, especially in the short term. Working towards carbon neutrality in agrifood systems is not just a box-ticking exercise that can be outsourced to external consultants and third-party verifiers. It does not just involve the costs of getting certified. It is a much broader endeavor. It requires executives to empower technical staff to mainstream carbon neutrality concepts and approaches across a company's operations and support broader changes in organizational culture and practices. Unless there is strategic corporate commitment, it will be difficult to pursue carbon neutrality in practice.

While the prospect for carbon neutral agrifood systems seems distant today, there is a need to push this agenda forward because of the critical links between agriculture and climate change. The private sector can genuinely embrace shared values to reduce costs, mitigate risks, protect brand value, ensure long-term supply chain viability and gain competitive advantages. Yet, the level of effort is uneven, and agribusinesses rarely go all the way in achieving carbon neutrality (i.e. Scope 3) with the current set of market incentives. This is largely due to the voluntary nature of carbon neutrality and market failures. To reduce the distance towards achieving carbon neutrality in agrifood systems, the following set of actions could be considered non-sequentially.

ACTIONS

ACTION 1

STRATEGICALLY TARGET CARBON NEUTRALITY

Policies, strategies and roadmaps with clear targets at central government and decentralized/sector level are important signals to agrifood systems players. These policies, strategies and roadmaps can set the tone for how policy evolves and can support agrifood systems players in preparing for regulatory changes and developing their targets and strategies. They can also provide incentives for simplifying and harmonizing standards. Where possible, strategies, decarbonization roadmaps and targets should be aligned with and support the achievement of pledged NDCs. Governments play a central role in adjusting incentives for the private sector to move towards carbon neutrality. At present, consumer demand does not seem to be a major driver of companies' efforts on carbon neutrality. Therefore, additional market incentives and regulations are required to drive the accurate valuation and pricing of carbon. Governments can also actively develop new opportunities to achieve carbon neutrality, including the creation of national carbon marketplaces specific to agriculture and the use of Green Public Procurement (GPP).

ACTION 2

IMPROVE TOOLS AND METHODS

The development and promotion of policies, strategies and roadmaps should be underpinned by methodologies and CFP calculators that support data collection and estimation efforts. Alliances between governments, international agencies and the private sector should be formed to support data availability and establish and harmonize information systems. Standardized approaches for monitoring, reporting and verification (MRV), database development and accounting methodologies must be leveraged to measure emissions and removals from the agrifood sector. Standardized carbon accounting disclosures in line with financial reporting approaches need to be employed to enable greater transparency among consumers and investors. Given the global nature of climate change, government, industry-wide organizations, IFIs and international organizations need to provide oversight and harmonize carbon neutrality standards.

ACTION 3

DEVELOP AND PROMOTE SOUND GOVERNANCE MECHANISMS FOR LOW-CARBON PATHWAYS

Increasing the accessibility of MRV systems and methods should be supported by sound governance mechanisms to ensure that these are appropriately endorsed and used by the private sector. Improving the governance for offsetting schemes can serve as a reference to orient decarbonization investment and communication efforts. In particular, governments should promote high quality national offsetting programs, clearly distinguishing between removals and avoided emissions, and establish clear guidelines on carbon neutrality based on international standards. Public action, particularly on standardization, increased transparency and reliability, can help accelerate the adoption of environmental labelling and climate-related disclosure practices. Streamlining climate-related disclosure practices can provide agribusinesses with opportunities to adequately price risks and attract capital.

ACTION 4

DIRECT SUPPORT FOR DECARBONIZATION EFFORTS

Costs for achieving carbon neutrality differ widely, both in terms of low-carbon pathways and whether these pathways are employed by large and small companies or smallholder farmers. Public intervention and IFI support are often required to subsidize MRV efforts when carbon related externalities are not correctly priced. Clear pathways should be developed to allow companies to inclusively compete in the space for carbon neutrality. Direct support through concessional financing, subsidies, and other forms (such as GPP instruments) can all help companies' decarbonization and MRV efforts on a wider scale. Companies need to systematically support agrifood actors in their wider supply chains to qualify for carbon marketplaces and PES schemes to ensure they are compensated for sustainably applying agricultural regenerative practices. Direct support also applies to the development of green financial products and financing options for agrifood systems players who adequately carry out carbon reductions. The promotion and implementation of de-risking solutions especially tailored to reducing transaction costs and risks associated with Scope 3 emissions are important. Finally, decarbonization will also require maintaining and protecting carbon sinks. Halting deforestation and leveraging the role of farmers as suppliers of environmental services are vital to address climate change.

ACTION 5

DEVELOP CAPACITIES AND SHARE KNOWLEDGE

Due to greater climate change awareness, carbon labelling has gained more traction amongst consumers. Public action, particularly on standardization, increased transparency and reliability, can help accelerate the adoption of environmental labelling. Integrating terminology related to decarbonization, MRV practices, carbon accounting methodologies and green financing tools into education agendas can support the greening of agrifood systems and generate opportunities for collaboration between international organizations and the private and public sectors. IFIs and technical agencies can play an important awareness-raising role and collaborate with agri-consultancy companies, local advisory services and research institutions to mainstream the business case for adopting climate change mitigation and adaptation practices. Furthermore, governments and technical international agencies can support the dissemination of best practices, and governments can fund the research required for labelling and LCA efforts. Streamlining climate-related disclosure practices can provide agribusinesses with opportunities to adequately price risks and attract capital.


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Introduction

Victim, culprit or cure? Agrifood systems at the crossroads of climate change and carbon neutrality

OVERVIEW

Agrifood systems are some of the biggest culprits of climate change. Decades of deforestation, intensive monoculture, poor soil management practices and, most importantly, livestock production have made agrifood systems major contributors to climate change. Food systems – including agriculture and land use, storage, transport, packaging, processing, retail and consumption – accounted for an estimated 21 percent to 37 percent (10.8–19.1 GtCO2eq yr^{-1}) of total anthropogenic GHG emissions during 2007–2016 (IPCC, 2020) (Figure 1). This estimate includes emissions of 9 percent to 14 percent from crop and livestock activities (4.8–7.6 GtCO2eq yr^{-1}) within the farm gate and 5 percent to 14 percent from land use and land-use change, including deforestation and peatland degradation (2.4–7.4 GtCO2eq yr^{-1}) (IPCC, 2013). Supply chain activities further contribute to an estimated 5 percent to 10 percent (2.6–5.2 GtCO2eq yr^{-1}) of total anthropogenic greenhouse gas emissions (IPCC, 2020).

At the same time, agrifood systems are also victims of climate change. Increases in temperature and changing rainfall patterns linked to climate change drive risks to food systems and the natural systems on which they rely. Agricultural ecosystems are by far the largest managed ecosystems in the world, with crops and pasture occupying almost 5 billion hectares of the world's total land area of about 14 billion (FAO, 2007). This means that agriculture and farmers provide environmental service providers and have a key role to play in reducing and offsetting emissions worldwide.

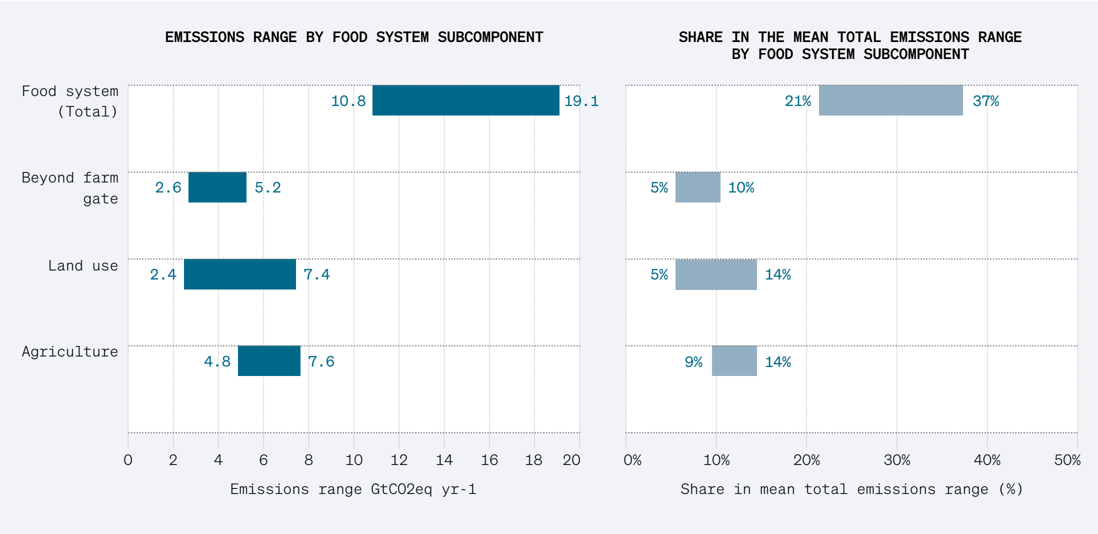


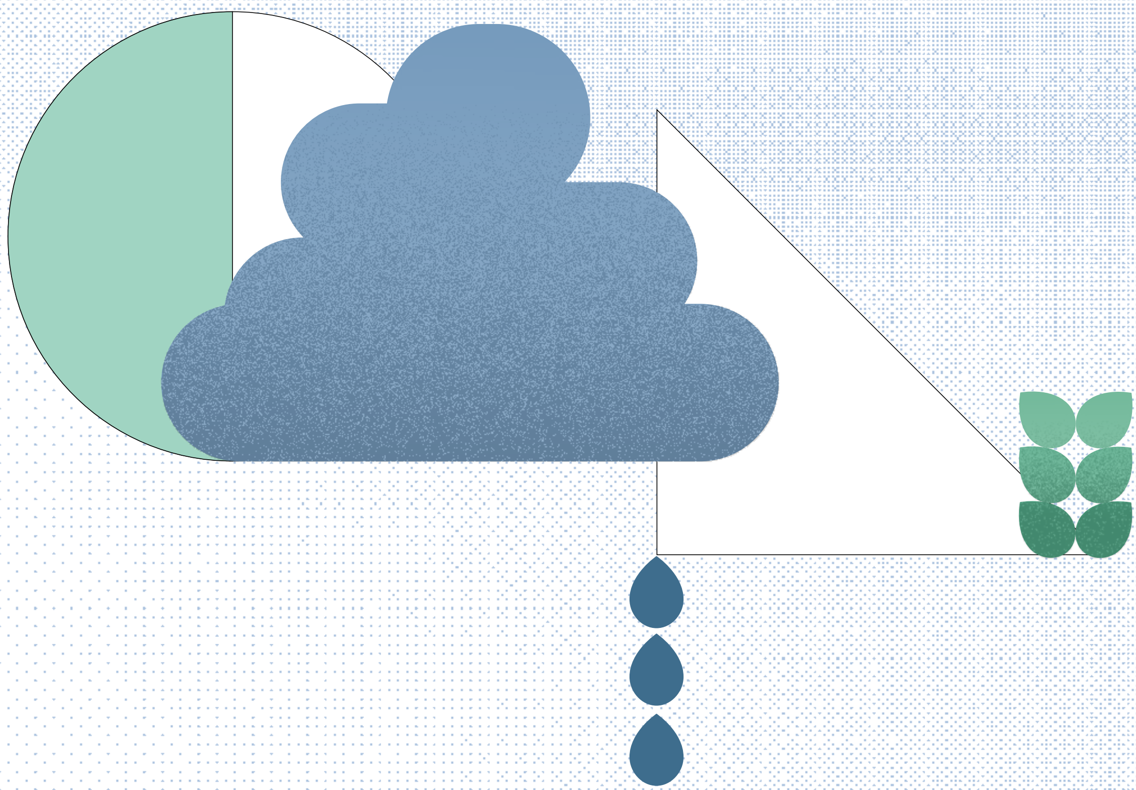
Figure 1
GHG emissions (GtCO2eq yr-1) from the food system and their contribution (percent) to total anthropogenic emissions. Mean 2007–2016 period.

SOURCE: IPCC. 2020. 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, J. Malley, (eds.)]. In press.

As the world gears up to fight climate change, agrifood systems are expected to play their part. The sector is increasingly being targeted worldwide, with citizens, companies and governments calling for cuts in the GHG emissions generated by agrifood systems. Following the Paris Agreement in 2015, there was widespread recognition that agricultural practices, food processing and manufacturing, and consumption are key to help keep global temperatures from rising more than 2 °C by 2100 (Wollenberg *et al*., 2016). Approximately 90 percent of national climate plans, known as nationally determined contributions (NDCs), refer to the agriculture sectors. However, only a few countries include quantified sector-specific targets for emissions reductions from agriculture and land use (FAO, 2016b) and even fewer have enforced legislations to limit emissions from other agrifood systems activities.

To tackle the agrifood-climate conundrum and as part of their broader efforts to address climate change issues, governments and companies are increasingly pledging to go 'carbon neutral'. Across the public and private sectors, the commitment to the carbon neutrality goal is gaining traction. The EU strategy to create a carbon-neutral economy by 2050 is a notable example of this new policy focus, but examples exist also from the private sector, with recent announcements made by large food (Danone and Nestlé) and non-food corporations (Amazon and Microsoft) (Danone, 2021; Nestlé, 2021; Shepardson and Bose, 2019; Microsoft, 2020).

While the concept of net zero emissions is appealing and intuitive in theory, going carbon neutral is not as simple as it sounds. The lack of internationally agreed standards to measure carbon neutrality, the voluntary nature of any carbon neutrality efforts and the misunderstandings about the concept itself are the first challenges in implementing its principles in practice. For example, As the world gears up to fight climate change, agrifood systems are expected to play their part.



in the beverage industry, this report finds companies selling the same product which have very different views of what it means to achieve carbon neutrality, with some not even pursuing carbon offsetting. A second challenge arises from the fact that there might be some types of emissions that are too costly to account for, eliminate or offset. Some types of emissions are difficult to compensate for by creating either a carbon sink, which absorbs emissions (for example, a forest), or through carbon capture and storage underground. This can be the case for Scope 3 emissions, which may require companies to tackle complex supply chain challenges and commit to large upstream investments. For further details on this, please refer to Chapter 4. For example, in some parts of the world, agrifood companies' electricity options might be restricted to fossil fuel-based energy generation. This highlights the local challenges faced by global companies in their efforts towards carbon neutrality. There are also challenges for policymakers and researchers to figure out best practices, policies and investments to support the sector's efforts to reduce farm-level emissions of carbon dioxide and other GHGs.

This report asks a deceptively simple question: can the world's agrifood systems achieve net zero carbon emissions? The report draws on original research, informant interviews and analysis to: (i) describe the concept of carbon neutrality and present existing methodologies for measuring carbon neutrality; (ii) evaluate challenges in achieving carbon neutrality in different parts of the agricultural supply chain; and (iii) offer recommendations for public intervention and private investment.

This report builds on the five assessment reports published by the Intergovernmental Panel on Climate Change (IPCC). On 27 February 2022, the IPCC finalized its Sixth Assessment Report: Climate change 2022: Impacts, Adaptation and Vulnerability. The Working Group II contribution to the IPCC Sixth Assessment Report assesses the impacts of climate change, looking at ecosystems, biodiversity, and human communities at global and regional levels. It also reviews vulnerabilities and the capacities and limits of the natural world and human societies to adapt to climate change. Since the writing for this report was finalized prior to the publication of the IPCC Sixth Assessment Report, this report does not directly integrate the findings from this latest publication. However, the IPCC Sixth Assessment Report confirms that past and current development trends have not advanced global climate resilient development, and that societal decisions and actions implemented in the next decade will determine the extent to which medium and long-term pathways deliver on resilient development. Importantly, the IPCC Sixth Assessment Report states that climate resilient development prospects are increasingly limited if current GHG emissions do not rapidly decline, particularly if 1.5°C global warming is exceeded in the near term.

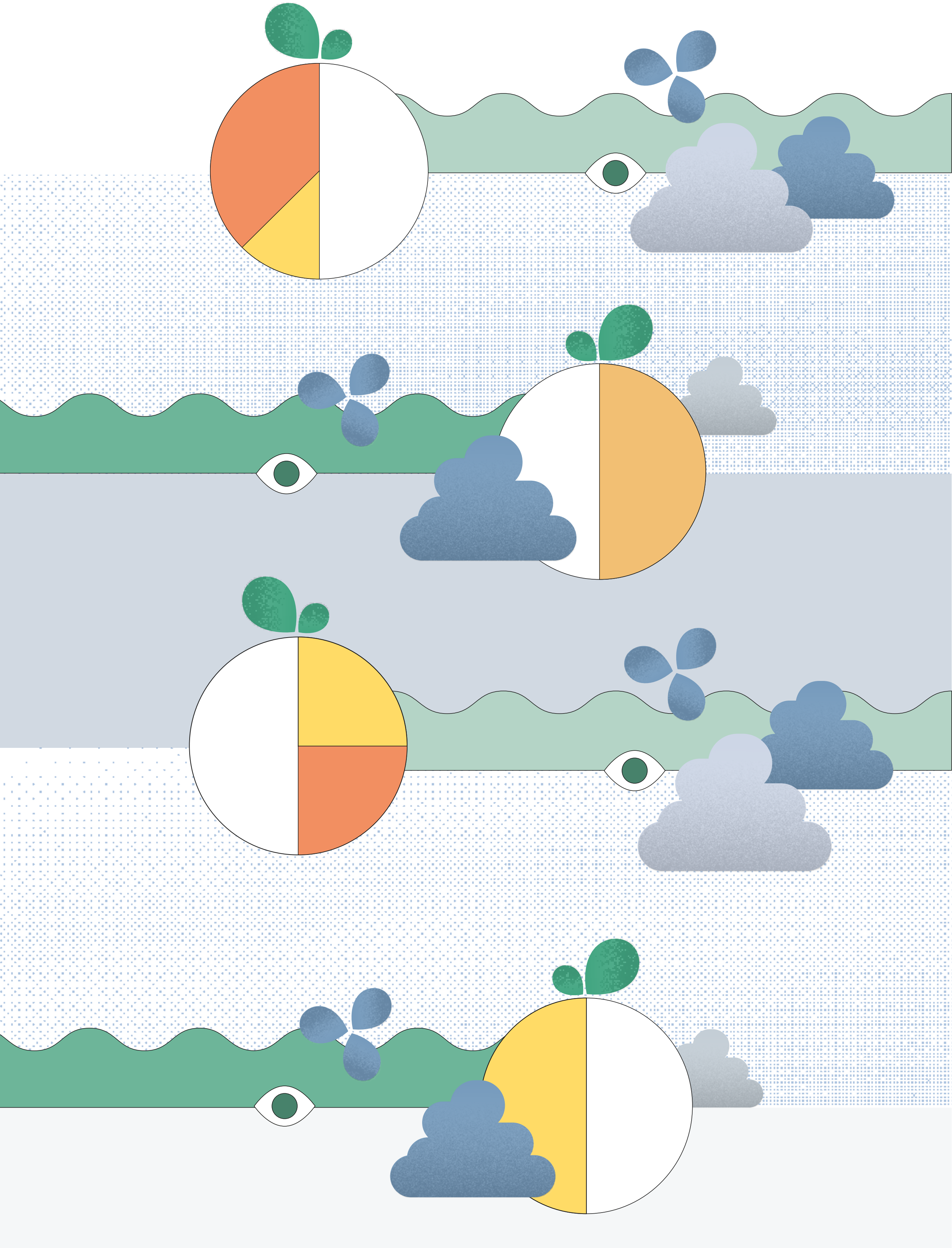
AIM AND STRUCTURE OF THE REPORT

This report presents the first comprehensive assessment of the challenges and opportunities of carbon neutrality for agrifood systems. Clearly, the story is not simple. Beyond the hype and commitments about carbon neutrality lurk complex questions around how to measure it and how to achieve it in practice. As recent scandals related to car emissions testing (Schiermeier, 2015) and reporting have shown, carbon and carbon neutrality measurement and accounting is far from perfect. This report covers key technical aspects related to the existing methods and standards to measure and track carbon neutrality in agrifood systems. It does so with a critical eye, to identify blind spots and challenges. It also provides strategic insights into the steps needed to move the carbon neutrality agenda forward in agrifood systems, including an assessment of financing opportunities and public policy priorities.

The objective of this report is to provide a diagnostic and candid set of recommendations for agrifood actors to support the carbon neutrality agenda. As such, this report is of interest to representatives from governments, international organisations, and civil society, as well as agrifood businesses and sustainability investors.

The report is structured into eight chapters, each covering a different aspect of the carbon neutrality story in agrifood systems:

- **Chapter 1** describes the dynamic climate policy setting where the carbon neutrality agenda is increasingly coming to the fore and explains the relevance of this agenda for agrifood systems.
- **Chapter 2** provides a technical introduction to the topic. It describes the methods and standards available to assess carbon neutrality, examining the pros and cons of the most commonly adopted standards, including their time and cost requirements and their applicability to different parts of the agrifood value chain.
- **Chapter 3** examines the complex governance issues surrounding carbon neutrality assessments and certification. The chapter discusses increasing concerns over greenwashing and the validity of existing labelling mechanisms, which risk compromising consumers and investors. It also examines the complexities related to data collection, measurement and quantification of emissions. Cost simulations were developed to show potential impacts on revenue across company sizes and sectors.
- **Chapter 4** discusses the business opportunities related to carbon neutrality, in particular in relation to raising efficiencies and building resilience, leveraging new market opportunities and responding to changing investor expectations. It also sheds light on key barriers to carbon neutrality, including tenure and land property rights and access to infrastructure, technology and financing. The chapter also presents stories of carbon neutrality from different agrifood chains. Examples from coffee, livestock and tea show that agrifood chains differ in the modality and extent to which they can work towards and achieve carbon neutrality.
- **Chapter 5** gives an account of existing carbon labels and their successes and failures. It describes the impact of carbon labelling on consumer preferences and attempts to map out a potential evolution for carbon labelling in agrifood systems.
- **Chapter 6** focuses on the role of sustainable investing in supporting the transition towards a carbon neutral agrifood system. It examines key drivers, trends and financial instruments in sustainable investing, paying attention to the role that these aspects can play in driving agrifood companies' initiatives for lowering carbon emissions.
- Finally, **Chapter 7** summarizes the key findings from the report and concludes with a set of proposed action areas which can be implemented by different actors.



Chapter 1
An international green wave: challenges and opportunities in a dynamic setting

The aim of this chapter is to describe the changing priorities and themes of global climate policy and why they matter to agrifood systems. The chapter provides a short historical overview of the concept of carbon neutrality and summarizes how carbon neutrality is being interpreted in theory and practice. The chapter concludes by highlighting the importance of carbon neutrality for agrifood systems.

1.1 WHERE DOES CARBON NEUTRALITY COME FROM? A SHORT HISTORY FROM GLOBAL AGREEMENTS TO NATIONAL COMMITMENTS

Carbon neutrality arose as a global policy goal in the context of international agreements to combat climate change. At the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted with the aim of stabilizing the concentrations of GHGs in the atmosphere at sustainable levels and preventing serious environmental consequences. The Convention entered into force in 1994 and, since then, Signatory States meet at regular intervals during the Conferences of the Parties (COP) to discuss further actions on climate protection. In 1997, the COP was held in Kyoto, Japan, in which the 'Kyoto Protocol'– the first document with legally binding obligations for CO2 limits and reductions– was adopted. In line with the Kyoto Protocol recommendations, the first climate neutral certification was established and trademarked originally through the Climate Neutral Network (CN Net), an Oregon-based alliance of companies and organizations committed to developing products, services, and enterprises that have a net zero impact on global warming, founded in 1999 (UNEP, 2009). The aim of the CN Net was to persuade companies that being climate neutral was potentially cost saving as well as environmentally sustainable, but few companies have actually attained this certification from CN Net.

Carbon neutrality has emerged as a key goal of global climate policy following a series of developments in international agreements and commitments. In 2014, UNEP issued a communication stating that, in order to limit global temperature rise to 2 °C and head off the worst impacts of climate change, global carbon neutrality should be attained by mid- to-late century. In the same year, the UN Climate Summit brought together 100 Heads of State, together with government ministers and leaders from international organizations, business, finance, civil society and local communities, to mobilize the political support and momentum necessary to reach a global agreement on climate change and galvanize action on the ground across all sectors. In 2015, the B Team Leaders, a non-profit organization that brings together global leaders in business and civil society, urged governments to reach an agreement towards net zero GHG emissions by 2050. Figure 1.1 shows other important milestones in relation to the emergence of carbon neutrality in the climate policy debate.

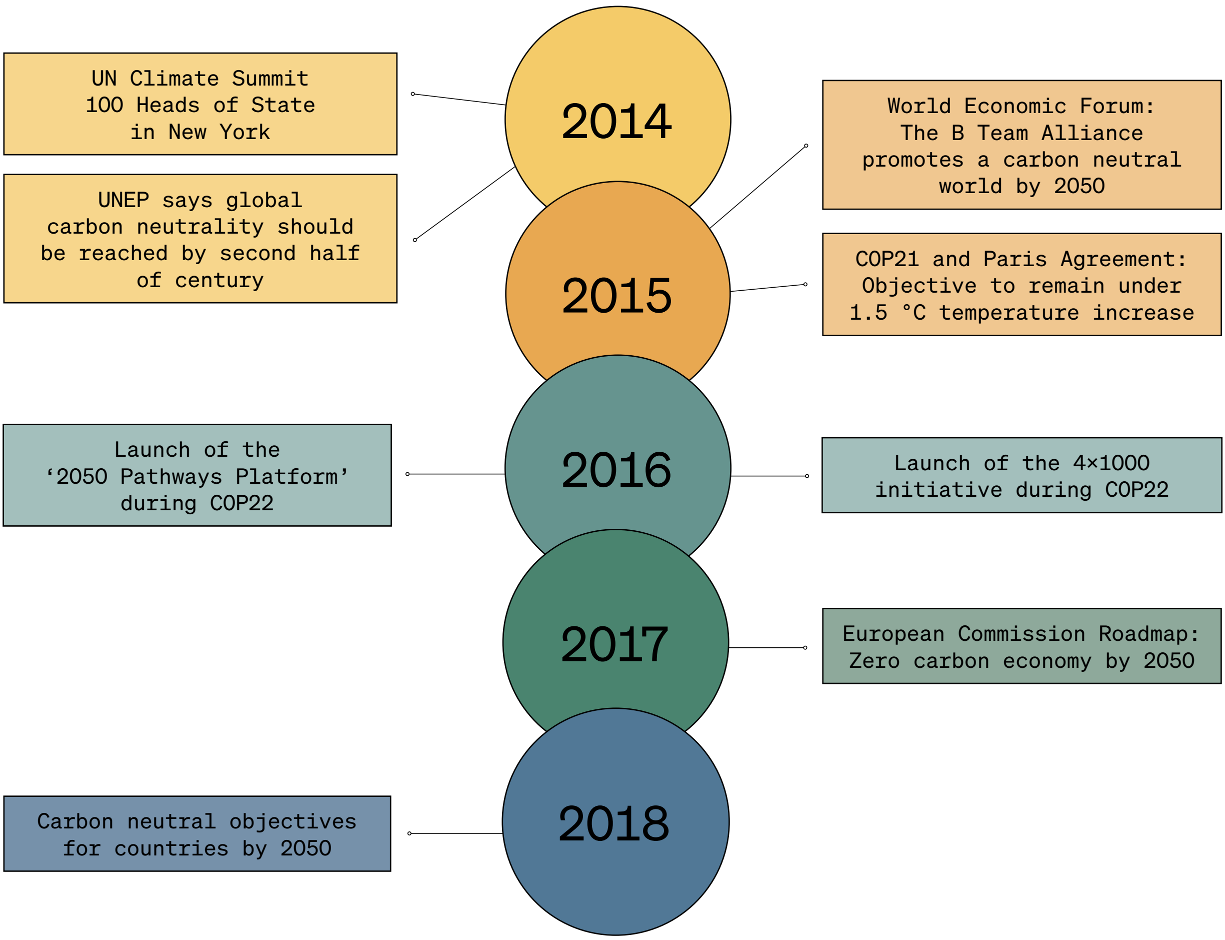


Figure 1.1
Timeline of major international declarations and agreements on carbon neutrality

SOURCE: Acampora, A., Mattia, G., Pratesi, C.A. and Ruini, L. 2020. Investing in Carbon Neutrality in the agrifood sector: challenges and opportunities in a dynamic setting. Unpublished background paper prepared for this report. Carbon Neutrality Lab, Roma Tre University

The last international agreement on climate change negotiated in Paris in December 2015 set clear and unequivocal targets for climate policy. The 'Paris Agreement', on the reduction of GHG emissions, was signed by several countries. In the agreement, the signing parties committed themselves to limiting the increase of global warming to less than 2 °C compared to pre-industrial levels. For the first time in 20 years of climate-related negotiations, a universal climate agreement containing binding commitments was signed, which will require widespread and structural changes from governments, businesses and citizens.

At the transnational level, the European Union is the first economic block to have explicitly pledged to become carbon neutral by 2050. In November of 2018, the European Commission released its strategic long-term vision for a climate neutral economy by 2050 with the communication 'A Clean Planet for all – A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy' (European Commission, 2018). This strategy is unparalleled because of its ambition, geographic scope and level of financing required, with at least one trillion euros worth of public and private investment needed over the next decade alone (European Commission, 2020). The EU bloc aims to reduce GHG emissions by 50 percent in 2030. Beyond 2030, the European Union will move towards a reduction target of 55 percent compared to 1990 levels (European Commission, 2019a). However, some member states have argued to increase the reduction target to 65 percent, as this would enable compliance with the Paris Agreement. Nevertheless, the European People's Party (EPP) decided that it would not go below the target of 50 percent as this would not be science-based, but also determined that it would not raise the target beyond 55 percent without a thorough cost-benefit analysis and comparable commitments from other large polluters, such as China and the United States of America (Euractiv, 2020).

As part of these efforts and of the European Green Deal, large European companies and financial institutions are now required to disclose non-financial information, including climate-related information. The Non-Financial Reporting Directive (2014/95/EU) requires large public interest entities with over 500 employees, such as listed companies, banks, and insurance companies, to disclose climate-related information (European Commission, 2014). These include any GHG emissions targets, and how company targets relate to national and international targets and to the Paris Agreement in particular (European Commission, 2019b). The impact of these measures extends well beyond European borders, given that non-European sources of emissions remain linked to Europe via the international supply chains of European companies (Skelton, 2013). Within the vision of the European Green Deal, the European Commission has put forward a European Climate Law with a legally binding target of net zero GHG emissions by 2050. The European Green Deal has given a significant boost to climate-related efforts in Europe, not just those aimed at achieving net zero emissions, but also those aimed at reinforcing the stock of natural capital in the European Union, developing and implementing adaptation strategies to strengthen resilience and reduce vulnerability to the effects of climate change, and protecting citizens' health.

The European Green Deal goes beyond achieving carbon neutrality, requiring significant investment. To deliver on the European Green Deal, nearly every major aspect of the European economy will have to be overhauled. It will necessitate a re-evaluation of policies for clean energy supply across the economy, industry, production and consumption, large-scale infrastructure, transport, food and agriculture, construction, taxation and social benefits (European Commission, 2019a). To achieve the current 2030 climate and energy targets will require EUR 260 billion of additional annual investment, about 1.5 percent of the 2018 GDP (European Commission, 2019a). Beyond 2030, decarbonizing Europe will entail the combined private and public investment of EUR 230 billion each year from 2031 to 2050, for a total of EUR 4.6 trillion over two decades (Mathiesen, 2020). Although these ambitions will require significant investments, they may be contributing to a growing momentum, as countries within the European Union, but also beyond the union are pledging carbon neutrality targets. Furthermore, these ambitions reflect a more holistic and strategic approach in the fight against climate change, especially within agrifood systems. It can be argued that the ambitions of the deal correlate well with assuming a food-systems approach to agriculture in achieving the Sustainable Development Goals (SDGs).

National governments are also increasingly aiming for carbon neutrality, with at least twenty countries having already committed or legislated to reach net zero emission. However, carbon neutrality targets are not uniform in terms of timeline or scope. For example, Bhutan and Suriname are reportedly already carbon neutral and Norway, Sweden and Denmark have already set their targets in national legislation, while Costa Rica has launched a country-wide Decarbonization Plan. However, not all these initiatives are straightforward in terms of design and implementation. Bhutan, for one, may need to build its capacity on GHG inventories, set up a robust MRV system and address several existing challenges (Yangka, Rauland, and Newman, 2018; UNFCCC, 2020a). Moreover, Suriname committed to maintain 93 percent forest cover but requires 'significant international support for the conservation of this valuable resource in perpetuity' (UNDP, 2020). Cost Rica submitted its full Decarbonization Plan to the UNFCCC in December 2019 with an aim to become a decarbonized country by 2050. Within this roadmap, a shorter-term action plan was developed and used to update their Nationally Determined Contribution (NDC) in 2020. Among other things, the plan commits Costa Rica to increase the forest cover percentage from 52 percent (2019) to 60 percent by 2050 (Costa Rica Bicentennial Government, 2019). Planning and strategies on climate action and, in particular, carbon neutrality have often taken place hand-in-hand with international financial institution (IFI) commitments. In Costa Rica, the government has borrowed USD 230 million from the Inter-American Development Bank (IDB) to support the implementation of political reforms that strengthen the management and monitoring of climate action (IDB, 2020), particularly focusing on conserving and restoring high-carbon ecosystems, replacing emitting agricultural practices, and encouraging the use of electric energy in transportation (IDB, 2020). Another 17 countries have set or have declared they will set net zero emissions targets, with target dates in or before 2050. Of these four countries (United Kingdom of Great Britain and Northern Ireland, France, Spain and New Zealand) are in the process of legislating and the other nine have issued commitments in policy declarations while four are discussing targets to reach carbon neutrality at the time of writing (Figure 1.2). Some of this legislation sets direct targets for the agrifood sector. In New Zealand, for example, the Zero Carbon Amendment Bill passed in 2019 aims to reduce livestock emissions by 10 percent below 2017 levels by 2030 (New Zealand Government, 2019). Furthermore, the European Union has adopted zero emission targets and 100 more nations are considering whether to set targets (WRI, 2020). Current targets use different horizons, yet many countries reference specific target years, most commonly 2030 and 2050. The European Union is collectively the third-largest global emitter and it has committed to become carbon neutral by 2050. Some countries, such as Singapore have stated that they intend to reach peak emissions by 2030, with a view to achieving net zero emissions as soon as viable in the second half of the century, while others such as Australia and the United States have yet to disclose long-term carbon neutrality targets (National Climate Change Secretariat, 2020; WRI, 2020). Other countries, such as Japan, have not altered their targets since 2016, which is set at reducing emissions by 26 percent below 2013 levels by 2030 (Climate Action Tracker, 2020). Notably, China has announced its target of peaking emissions by 2030 and achieving carbon neutrality by 2060. India also pledged its target of reaching net zero by 2070 at COP26.

Beyond national governments, local governments, cities and businesses are committing to carbon neutrality, in a context where sustainable food systems thinking is gaining traction. As of 2018, more than 20 cities and over 100 companies have committed to becoming carbon neutral and an alliance of 60 plus state/regional, city governments and multinational businesses are now committed to 100 percent zero emission targets through the zero emission vehicle (ZEV) challenge. In 2010, British Columbia (BC), Canada, became the first government at the provincial, territorial, and state level in North America to take 100 percent responsibility for GHG pollution from all 128 of its public-sector organizations and express carbon neutrality targets in its Carbon Neutral Government Program (Box 1.1). Such initiatives show promise, especially in a context where food systems need to be reshaped to be more productive, inclusive of marginalized populations, environmentally sustainable and resilient and be able to deliver healthy and nutritious diets (FAO, 2018a). Importantly, civil society movements, including peaceful protests, have in recent years been gaining traction and have contributed to bringing greater awareness and enhancing the debate on climate change.

Corporate ambitions on carbon neutrality and sustainability are growing. Since the early 1990s companies started adopting climate-related targets in their plans. In some countries, entire agrifood subsectors, such as US Dairy in the United States (which comprises the National Dairy Council, the Innovation Center for US Dairy, Dairy Management Inc., GenYouth and the US Dairy Export Council) have announced ambitions to achieve carbon neutrality by 2050 (US Dairy, 2021). In this regard, the Net Zero Initiative (NZI) is an industry-wide, on-farm effort aimed at making technology and best practices more accessible and affordable to different farm sizes across geographies. NZI's focus areas include, feed production, manure handling and nutrient management, animal health and efficiency, and farm-level energy usage. More recently, company goals across agrifood systems are getting bolder. Corporations are accelerating their commitments to go carbon neutral or carbon negative, and set science-based targets and aggressive carbon reduction plans. For example, the Kellogg company has committed to a 65 percent reduction in emissions by 2050 from its 2015 base (Science Based Targets Initiative, 2021), while Wasa (Barilla), the world's largest crispbread producer, announced in 2019 that its global operations are 100 percent carbon neutral, according to the PAS 2060 reporting requirements (WASA, 2018). Furthermore, there is a renewed interest in carbon-labelled products. For instance, Quorn, a meat substitute producer, began in 2020 to include CFP labels on its most popular products, while Oatly, a brand of oat milk, started to use CFP labels in 2019 (Financial Times, 2020). Moreover, Unilever claimed in 2020 that it aims to eventually carbon label its entire product portfolio; Nestlé is also reportedly considering carbon labelling (Financial Times, 2020).

Already negative	–	Bhutan
	–	Suriname
In law	2030	Norway
	2045	Sweden
Proposed legislation	2050	United Kingdom
		France
		Spain
		New Zealand
In policy document	2030	Uruguay
	2035	Finland
	2040	Iceland
	2050	Denmark
		Chile
		Portugal
		Costa Rica
		Fiji
		Marshall Islands
Target under discussion	2050	European Union
		Germany
		Netherlands
		Ireland

Figure 1.2
Countries with carbon neutrality commitments in 2019

SOURCE: Energy and Climate Intelligence Unit. 2019. Countdown to Zero. https://ca1-eci.edcdn.com/reports/ECIU_Countdown_to_Net_ Zero.pdf.

Box 1.1

RISING CARBON NEUTRALITY COMMITMENTS WORLDWIDE

British Columbia's Carbon Neutral Government Program
In 2010, British Columbia (BC), Canada, became the first government at the provincial, territorial, or state level in North America to take 100 percent responsibility for GHG pollution from all 128 of its public-sector organizations, by measuring their emissions, reducing them where possible, and purchasing offsets to cover the remainder. The public sector, which consists of provincial government ministries, crown corporations, health authorities, school districts, universities, and colleges, has successfully achieved carbon neutrality each year from 2010 to 2017. Provincial government investments in cleaner energy and in energy efficiency in BC are paying off, through more efficient buildings and fleets, and hence, more efficient delivery of public services. These efforts have also contributed to lowering GHG emissions from the provincial public sector operations by 3.4 percent in 2010 relative to the 9 percent increase in the population it serves.

BC's Carbon Neutral Government Program (CNGP) is leveraging its offset purchases to generate even greater private sector investment in clean technologies and jobs, as well as preserving BC's environmental capital through forest sequestration projects. The Program's investments in offset projects have enabled proponents to realize the financial, environmental, and social benefits that would not have been possible in the absence of that investment. In addition to the 128 provincial public sector organizations that it supports, the CNGP has also expanded some of its support services to more than 70 of BC's 190+ cities, towns and villages, and has made itself available to offer advice to other jurisdictions.

The CNGP could be replicated by other jurisdictions at the provincial, state, and federal levels. In fact, the provincial governments of Ontario and Manitoba, the territorial government of Yukon, and the neighbouring state of Washington in the United States of America have all made public commitments to become carbon neutral by 2050 (UNFCCC, 2020b).

France sets its 2050 carbon neutral target
Approved in June 2019, France's new energy and climate law sets carbon neutrality as the main objective for domestic energy policies, while also setting ambitious objectives. This bill sets out a renewed framework for climate policy as well as a list of actions, targets, solutions and ways to simplify their roll-out. France's previous law on energy transition aimed to reduce fossil fuel consumption by 30 percent by 2030, while the new law now says 40 percent. The bill establishes the High Council for Climate Change (HCC), which is operational since January 2019, with the aim of providing an opinion on the effectiveness of government measures to reduce GHG emissions. The law also prescribes the future of thermal power plants, and increases the power of the French energy minister, who will be able to limit the annual operating time of thermal power plants with highly carbonated emissions. From January 2022, an emission cap should be defined by the administrative authority.
A more recent policy document, which was promulgated by the French National Assembly and Senate in August 2021, is the Climate and Resilience law. Overall, the law contains 15 flagship measures, including: (i) the standardization of a compulsory environmental label, specifying a CO2 score on goods and services consumed by the French; (ii) banning the advertisement of fossil fuels; (iii) establishment of low emission zones in large cities, and (iv) banning of flights when an alternative route by train exists for a journey of less than 2.5 hours (UNFCCC, 2020c)

Sweden's law to reach carbon neutrality by 2045
Sweden has committed to becoming a net zero carbon emitter by 2045, following a 2017 law. Parliamentarians voted overwhelmingly in favour of the proposal, accelerating the nation's previous target to become carbon neutral by 2050. The legislation came into force in January 2018, with the establishment of an independent Climate Policy Council in addition to a four-year cycle for updating the nation's climate action plan. After 2045, the country ambitiously aims at negative emissions, meaning that GHG emissions from activities are less than, for example, the amount of carbon dioxide absorbed by nature, or less than the emissions Sweden helps to reduce abroad by investing in various climate projects. Sweden now has long-term climate goals which go beyond 2020 and an independent climate policy council that reviews climate policy. The new Climate Act will provide the long-term conditions for business and society to implement the transition needed to solve the challenge of climate change.
(UNFCCC, 2017)

Denmark
In 2019, the Danish government through a broad coalition reached an agreement on an ambitious and binding climate law. The Climate Act ensures that Denmark works to reduce its emissions by 70 percent in 2030 compared to 1990 levels and towards climate neutrality by 2050 at the latest. The Climate Act contains a mechanism for setting sub-targets whereby in every five years, a sub-goal with a ten-year perspective must be set. (Klima-. Energi- of Forsyningsministeriet, 2019)

Nonetheless, public opinion across a number of countries is divided on the role that technology, individual consumption and other incentives will play in the fight against climate change. In a survey conducted by the European Investment Bank (EIB) in 2020, more than 30 000 people across 30 countries responded to a series of questions related to expectations for public policies to tackle climate change (EIB, 2021). Interestingly, the survey showed that American and Chinese respondents (34 percent and 35 percent respectively) deem that technological innovation (digitalization, development of renewable energy sources, etc.) is the most effective way to address climate change (EIB, 2021). On the other hand, EU and British nationals placed less emphasis on technological innovation (29 percent and 24 percent respectively) and instead believe that changing individual habits (consumption, transportation, etc.) (39 percent and 36 percent respectively) are more important in the fight against climate change (EIB, 2021). Nonetheless, the survey shows a consensus among respondents across all countries on prioritizing the energy sector in the fight against climate change, especially in terms of increasing the use of renewable energy sources. As a sector, agriculture (improving where, how and what kind of food is produced) was prioritized less by respondents across the United States of America, China, the United Kingdom and the European Union, in comparison to the energy, transportation and industrial sectors (EIB, 2021). For further information on demand drivers and consumer willingness to pay for sustainable products including carbon neutrality attributes, please refer to Chapter 5.

The carbon neutrality story starts from a simple fact: anthropic GHG emissions are generated from actions by individuals, companies and governments.

1.2 CARBON NEUTRALITY IN THEORY: DEFINITIONS AND APPROACHES

The carbon neutrality story starts from a simple fact: anthropic GHG emissions are generated from actions by individuals, companies and governments. These emissions consist of various GHGs, including carbon dioxide (CO2). These emissions are quantified through the estimation of the CFP, which as defined by ISO 14067:2018 is 'the sum of GHG emissions and GHG removals in a product system expressed as CO2 equivalents (and based on a LCA) using the single impact category of climate change)'.

Although many definitions exist (see Box 1.2), the IPCC considers that carbon neutrality is achieved when anthropogenic emissions are balanced by anthropogenic removals over a specified period (IPCC, 2018a). In general, this is attained through a process, which starts from quantification and reduction of the carbon intensity of the country, company, individual, or service in question. Subsequently, emissions that cannot directly be reduced can be offset, through for instance, third-party certified offsetting projects (as explained later in this report). More recently, the idea of insetting has come to the fore as another opportunity to compensate for emissions. It can be argued that insetting has emerged as a response to the growing criticism of offsetting, which is deemed by some agrifood system actors to insufficiently address or reduce emissions at the source. The rationale being that compared to offsetting, where the purchase of carbon credits is unrelated to the company considered, insetting mandates that the location of a carbon offset project be within a company's supply chain and scope of operations. For further details on the differences between offsetting and insetting, please refer to Chapter 2.

Although the IPCC clearly defines carbon neutrality, the approaches to apply the IPCC definition, especially for scope and period of reference, appear broad and do not include a specific trajectory. Various actors are debating the necessity to adopt clear and structured definitions of carbon neutrality or are moving independently to define and apply these. As a result, the number of definitions and approaches available in literature and in practice is rich and constantly evolving (Table 1.1). While many definitions exist for carbon neutrality, few provide practical guidance, as described in Chapter 2. For the application of carbon neutrality, this report relies on the one outlined by the British Standards Institution (BSI) in the standard PAS 2060. PAS 2060 defines carbon neutrality as the condition in which, during a specified period, there has been no net increase in the global emission of GHG to the atmosphere as a result of the GHG emissions associated with the subject during the same period (BSI, 2014).

Box 1.2

SEARCHING FOR THE PERFECT DEFINITION: NET ZERO, CARBON NEUTRAL AND CLIMATE NEUTRAL

The different effects of GHGs can be compared by the metric of global warming potential (GWP), which is used to measure all emissions in ‘carbon equivalent’ units (WRI, 2015). The term carbon is often used interchangeably to describe both CO2 emissions and CO2 (or ‘carbon’) equivalent units, with the latter covering GHG removals expressed in CO2 equivalent (CO2eq). It is worth noting that GHG neutrality concepts are not always straightforward in the literature and in real world applications. For instance, some claim that climate neutrality is the same concept as carbon neutrality, but rather than focusing solely on CO2 emissions, climate neutrality extends to net zero anthropogenic GHG emissions (WRI, 2015). For instance, some claim that carbon neutrality only focuses on CO2 emissions (not CO2 equivalent emissions, which go beyond CO2 emissions) and climate neutrality always consider CO2eq emissions, extending to net zero anthropogenic GHG emissions (World Resources Institute, 2015). Despite their different scopes, in this report carbon emissions always refer to CO2eq units. Therefore, carbon neutrality will be considered equivalent to climate neutrality for the purposes of this report. A second important and related distinction is the one arising between the use of net zero (GHG emissions) and terms such as carbon neutral or climate neutral. In this regard, besides the IPCC definition (Table 1.1), many interpretations have been put forward in the literature, by private actors and civil society. These have outlined more nuanced differences between carbon neutrality, climate neutrality and net zero GHG emissions. For instance, Carbon Trust, a private company, has been collaborating with the Science Based Targets initiative (SBTi) in outlining the differences between carbon neutrality and net zero. The main distinction, according to this initiative, is that carbon neutrality (using the PAS 2060 definition) has a minimum coverage of Scope 1 and Scope 2 emissions, with Scope 3 emissions being mandatory if they are above 1 percent of total emissions. Net zero (based on the SBTi draft definition) needs to cover all Scope 1, 2 and 3 emissions (Carbon Trust, 2021). Furthermore, using the SBTi interpretation of net zero, the definition implies reducing emissions along a 1.5 °C trajectory, while carbon neutrality does not impose this ambition. Lastly, Carbon Trust and the SBTi state that specific GHG removals in certain instances are required to achieve net zero, while for PAS 2060 carbon offsets are accepted to reach carbon neutrality. Ultimately, concepts and definitions are used interchangeably, and reconciliation is required at public and policy levels, as well as for private sector use. Table 1.1 outlines some of these main concepts and definitions.

Table 1.1
Carbon and climate neutrality definitions

Category	Concept	Definition	Source	Reference
CARBON NEUTRALITY	CARBON NEUTRALITY/ NET ZERO CO2 EMISSIONS	Net zero carbon dioxide (CO_2) emissions are achieved when anthropogenic **CO_2 emissions** are balanced globally by anthropogenic CO_2 removals over a specified period. Net zero CO_2 emissions are also referred to as carbon neutrality.	IPCC	(IPCC, 2018a)
	CARBON NEUTRAL	Achieve a balance between anthropogenic emissions by sources and removals by sinks of **GHGs** in the second half of the century.	Paris Agreement art. 4	(UNFCCC, 2015)
	ISO 14067:2018	The sum of GHG emissions and GHG removals in a product system expressed as CO_2 equivalents.	ISO	(ISO, 2018)
	CARBON NEUTRALITY	Condition in which during a specified period there has been no net increase in the global emission of **GHG** to the atmosphere as a result of the GHG emissions associated with the subject during the same period.	PAS 2060	(BSI, 2014)
	CARBON NEUTRALITY	Carbon neutrality means having a balance between emitting carbon and absorbing carbon from the atmosphere in carbon sinks. Removing carbon dioxide from the atmosphere and then storing it is known as carbon sequestration. In order to achieve net zero emissions, all worldwide GHG emissions will have to be counterbalanced by carbon sequestration.	European Parliament	(European Parliament, 2019)
	CARBON NEUTRALITY/ NET ZERO CARBON EMISSIONS	Carbon neutrality, or having a net zero CFP, refers to achieving **net zero carbon emissions** by balancing a measured amount of carbon released with an equivalent amount sequestered or offset.	UNEP	(UNEP, 2019)
	CARBON NEUTRAL	Carbon neutral is a term used to describe the state of an entity (such as a company, service, product or event), where the **carbon emissions** caused by them have been balanced out by funding an equivalent amount of carbon savings elsewhere in the world.	CFP	(CFP Ltd., 2019)
CLIMATE NEUTRALITY	CLIMATE NEUTRALITY	Climate neutrality is achieved by balancing the amount of **emissions** generated with the Earth's natural capacity of to absorb them. Some use the term 'carbon neutrality' or 'net zero' for synonyms of climate neutrality.	UNFCCC	(UNFCCC, 2019b)
NET ZERO	NET ZERO GHG EMISSIONS	Net zero emissions are achieved when anthropogenic emissions of **GHGs** to the atmosphere are balanced by anthropogenic removals over a specified period.	IPCC	(IPCC, 2018a)
	NET ZERO EMISSIONS	Achieving a state in which the activities within the value chain of a company result in no net impact on the climate from GHG emissions. This is achieved by reducing value chain GHG emissions, in line with 1.5°C pathways, and by balancing the impact of any remaining GHG emissions with an appropriate amount of carbon removals.	SBTi / Carbon Trust	(SBTi, 2019)

SOURCES: Emele, L., Marignac, Y. and Petrović, S. 2019. Modelling net zero emissions. 10.13140/RG.2.2.22568.11524; Acampora A., Mattia G., Pratesi C.A. and Ruini L. 2020 Investing in Carbon Neutrality in the agrifood sector: challenges and opportunities in a dynamic setting. Unpublished background paper prepared for this report, Carbon Neutrality Lab. Roma Tre University.

1.3 AGRIFOOD SYSTEMS ARE KEY TO DELIVER THE AMBITIONS OF THE CLIMATE AGREEMENT

Within the framework of the Paris Agreement, countries express their commitments in the Nationally Determined Contributions (NDCs), which explain how they plan to contribute to the collective global goals of the agreement. For the most part, the first round of NDCs targeted 2025 or 2030. Agrifood systems are among the most commonly included sectors in countries' mitigation contributions. Around 90 percent of the countries' NDCs refer to the agriculture sector, land use change and forestry (157 countries) (FAO, 2016b). When looking at the agriculture sector alone (crops and livestock), this share declines to 148 countries which include agriculture in their mitigation contributions (FAO, 2016b). Countries that include agriculture collectively account for 92 percent of global agricultural GHG emissions. Almost all developed countries cover mitigation in agriculture in their NDCs (FAO, 2016b) (Figure 1.3). In the case of developing countries, the share of NDCs covering agriculture decreases to about 70 percent. Least developed countries (LDCs) put a particular emphasis on value chain management, with almost all of them mentioning various aspects of food value chains and actions to reduce associated emissions in their NDCs (Wieben, 2019).

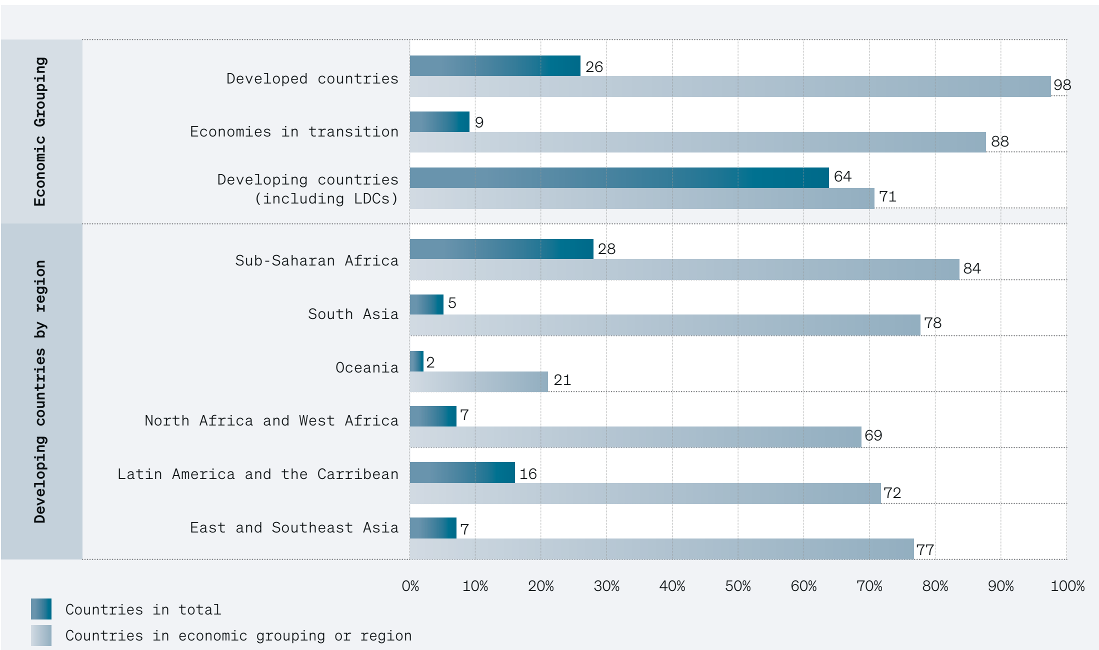


Figure 1.3
Percentage of countries that cover mitigation in agriculture, by economic grouping and region

SOURCE: FAO. 2016b. The agriculture sectors in the Intended Nationally Determined Contributions: analysis. FAO Environment and Natural Resources Management Working Paper 62.

NOTE: Given the low number of updated NDCs that have been publicly disclosed at the time this report was developed, the figure cannot be updated.

Differences in length, structure, content and target setting methodologies render it challenging to systematically compare NDCs. Comparing NDCs across countries is difficult, because they vary in terms of mitigation targets, the years by which objectives are to be achieved and the measurement of targets against different baseline years. Although agriculture is mentioned throughout the NDCs of 148 countries, few have included quantitative targets within agriculture-based mitigation contributions. The wide range of mitigation potentials and marginal abatement costs make it especially challenging to integrate agriculture into national and global climate change mitigation policy frameworks (Fellmann *et al*., 2018). Various target setting methodologies exist, including: reduction relative to business-as-usual (BAU), base year emissions targets, intensity targets, fixed-level targets and trajectory/peaks. GHG intensity targets specify emissions reductions relative to productivity or economic output, for instance, tonnes of CO2 equivalent (tCO2eq) per quantity of agricultural produce or tCO2eq per USD million, whereas absolute emissions targets relate to reductions measured in tonnes against a historical baseline (WRI, 2006). Most countries have adopted absolute emissions reduction targets. Intensity targets represent reductions in GHG emissions per unit of GDP or per capita relative to a base year/ absolute level of *per capita* emissions by 2025 or 2030 (FAO, 2016b). It can be argued that these targets are the most quantitative, however, in 2016, only nine countries, including four emerging economies in Asia, adopted intensity targets (FAO, 2016b).

NDCs have also been criticized for not being ambitious enough in reaching the goals set out by the Paris Agreement. Throughout the NDCs, mitigation action in the agricultural sector is promoted most prominently in cases where co-benefits are possible and production is not impacted negatively. Consequently, it is estimated that only 38 percent of agricultural emissions are accounted for under the NDCs (Hönle, Heicecke and Osterburg, 2019). Research also indicates that nations will need to mitigate agricultural BAU emissions by a median of 10 percent to enable the mitigation of 1 gigatonne of CO2 equivalent emissions per year (GtCO2eq-1), which will likely be required to achieve the 1.5 °C and 2 °C scenario goals by 2030 (Richards, Wollenberg and Vuuren, 2018). Some studies assert that food loss and waste account for 8 percent of total GHG emissions, equivalent to 4.5 GtCO2eq-1 (World Wildlife Fund, 2020). However, only 11 countries mention food waste in their NDCs (World Wildlife Fund, 2020). Although 15 NDC updates were submitted through August 2020, none of these revisions address food loss and waste (World Wildlife Fund, 2020). Furthermore, shifting towards plant-based diets could contribute to reductions of 8 GtCO2eq-1, however, a limited number of NDCs address changes in consumer consumption levels (Wiese, Alcántara-Shivapatham and Wollenberg, 2019). Furthermore, McKinsey & Company project that adhering to a 1.5 °C pathway will require global consumption of ruminant animal protein to be halved from 9 percent to 4–5 percent by 2050 and half of the global population would have to adopt a flexitarian diet to meet the methane reduction targets of 20 percent to 30 percent (McKinsey & Company, 2020). Regarding soil organic carbon (SOC) potential, a gap exists between ambition and potential, as only ten countries refer to SOC targets within their NDCs (Wiese, Alcántara-Shivapatham and Wollenberg, 2019). Although 40 countries have committed to SOC practices, only ten nations specify targets. Countries that do not specify targets related to SOC sequestration attribute it to the fact that it is of secondary importance compared to enhancing agricultural production, that SOC sequestration is better suited as an adaptation measure than mitigation and that it is costly and challenging to collect data, measure and monitor soil carbon stocks (Wiese, Alcántara-Shivapatham and Wollenberg, 2019).

While it is not easy to model how much agrifood systems need to contribute to global mitigation efforts, most estimates suggest they have an important role to play. The complexity of modelling sustainable global agrifood systems in 2050 is a result of the interaction of many variables that determine this outcome. This starts with the global warming scenario used (for example 1.5 °C or 2 °C), but also includes a number of other factors; for example, the amount of food calories needed in 2050 above today's level will depend, in part, on measures that reduce demand and increase supply. In addition, increases in food supply may result from productivity increases and expansion in agricultural land. Finally, the amount of emissions reduction required will also depend on what other sectors are able to achieve by 2050 and where the lowest marginal abatement costs lie at each point in time (including from the use of carbon capture and storage technologies). The projected agrifood system emissions in 2050 and the amount of reduction relative to today will therefore depend on the many assumptions used. For example, WRI uses a target of 21 GtCO2eq emissions (across all sectors) in 2050 corresponding to a 2 °C scenario and compares that level to a 2010 level of 48 GtCO2eq and a 2050 baseline scenario of 85 GtCO2eq: emissions would therefore need to be reduced by 75 percent in 2050 compared to the baseline scenario (WRI, 2019). To close the gap between GHG emissions resulting from agriculture and land-use change, which are expected to amount to 15 GtCO2eq by 2050 and achieving the target of 4 GtCO2eq (agriculture's contribution is based on a concept of equal sharing of the required reduction), a reduction of 11 GtCO2eq will have to be realized (WRI, 2019). Beyond reductions in GHG emissions from agricultural production, WRI and other forward-looking modelling exercises underline the need for both reductions in demand for food, increased productivity (raising food production without expanding agricultural land) and protecting and restoring ecosystems to reach the desired emissions targets for the sector in 2050.

Most importantly, the GHG mitigation potential for agriculture is significant. The 2018 IPCC Special Report on Global Warming of 1.5°C suggests that emission reductions for agriculture of 0.03–2.6 GtCO2eq-1 are possible at USD 50 tCO2eq-1, and 0.2–4.6 GtCO2eq-1 at USD 100 tCO2eq-1 in 2030 (IPCC, 2017b). Considering the agriculture GDP in 2017 of USD 3 trillion, a reduction of 4.6 GtCO2eq at USD 100 would constitute an investment cost of 15 percent of the agriculture GDP of that year (FAO, 2019a). This wide range reflects the different coverage of mitigation sources and methodologies used and different assumptions with regards to the potential of soil carbon sequestration, which is by far the greatest carbon 'sink' in agrifood systems (Smith *et al.*, 2007). The storage of SOC differs between countries on the basis of environmental conditions, soil properties, land use systems and historical carbon loss patterns. Figure 1.4 provides an overview of estimated SOC stocks (in t C / ha) in 2020, at a soil depth of 0–30 cm (FAO, 2021a). The FAO Global Soil Partnership (GSP) has, in collaboration with member countries, developed maps estimating annual rates of SOC stock exchange under various scenarios. These include a BAU scenario and scenarios where sustainable soil management (SSM) practices generate a 5 percent, 10 percent and 20 percent increase in carbon inputs over 20 years, respectively (FAO, 2021a). In 2016, the mean global potential for soil carbon sequestration in agricultural soils is 1.5 GtCO2eq yr-1 and 2.6 GtCO2eq yr-1, at carbon prices of USD 20/tCO2eq and USD 100/tCO2eq, respectively (Smith, 2016). More recent estimates from 2018 suggest that the global technical potential of carbon sequestration in soils from manageable lands[13] is 1.7–4.6 GtCO2 yr-1 and 0.48–1.93 GtCO2 yr-1 from agricultural lands, exclusively (Rattan *et al*., 2018). However, the magnitude and rate of carbon sequestration in soils can vary greatly, depending on the different land uses and practices, soil texture and other soil characteristics, vegetation, topography and climate, which contributes to the challenges of quantifying SOC stocks and changes at a farm scale (FAO, 2020a). As an example, Figure 1.5 estimates what could be the global distribution of the SOC sequestration potential in grazing lands (rangelands and pasturelands combined) (Henderson *et al*., 2015). Beyond soils, the mitigation potential from increasing carbon stocks in vegetation is substantial. These include the sequestration of carbon in forest biomass, particularly from avoided deforestation and the conversion of forest to agricultural land (i.e. from changes in the extensive margin between forestry and agriculture) (OECD, 2019). The IPCC estimates with high confidence that the strength of the ocean sink for anthropogenic carbon has increased in the last two decades in response to the growth of atmospheric CO2 (IPCC, 2019b). Multiple lines of evidence indicate that it is very likely that the ocean has taken up 20 percent to 30 percent of the global emissions of CO2 since the mid-1980s (IPCC, 2019b). Deep ocean storage could help reduce the impact of CO2 emissions on surface ocean biology, but at the expense of effects on marine organisms, who could experience reduced rates of calcification, reproduction, growth and circulatory oxygen supply, as well as increased mortality rates (Melaku Canu, 2015). It is not known whether governments and the wider public will accept the deliberate storage of carbon in the ocean as part of a climate change mitigation strategy (IPCC, 2005).

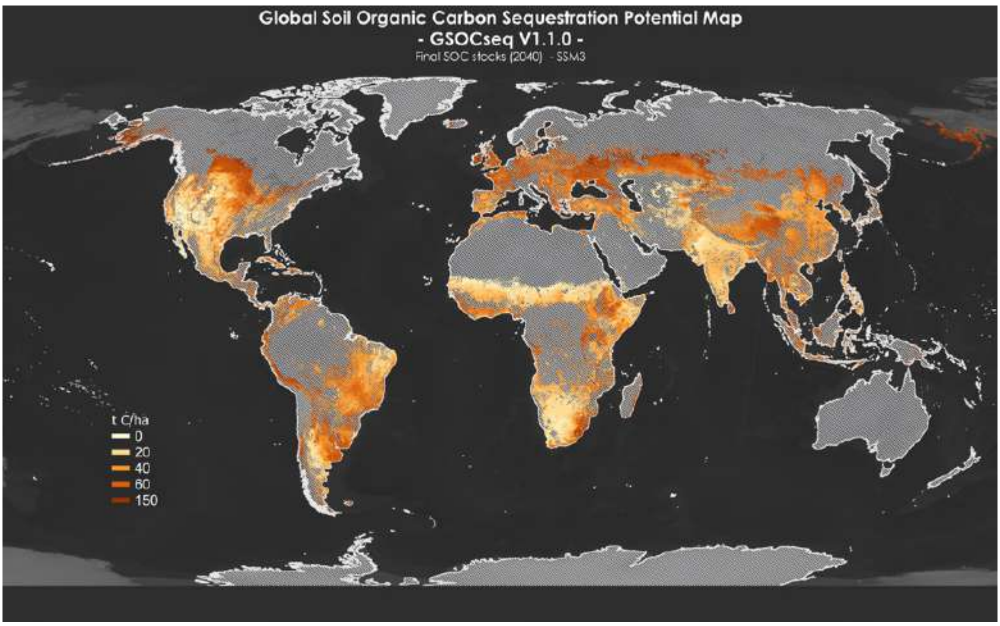


Figure 1.4
Estimate of current soil organic carbon stocks (in t C/ha) in 2020, at a soil depth of 0–30 cm

SOURCE: FAO. 2022. Global Soil Organic Carbon Sequestration Potential Map. GSOCseq V1.0.0. www.fao.org/global-soil-partnership/gsocseq-map/en/.

13 IPCC (2006) defines managed lands as land 'where human interventions and practices have been applied to perform production, ecological or social functions'.

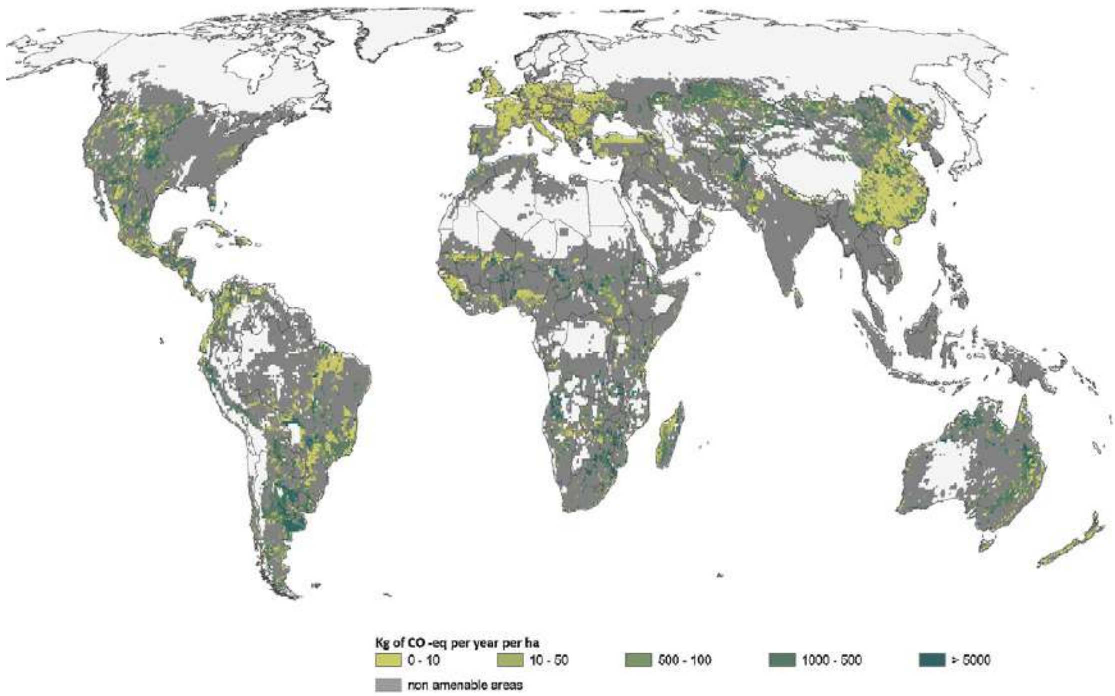


Figure 1.5
Global distribution of SOC sequestration potential, from improved grazing management in the world's grazing lands (rangelands and pasturelands combined)

SOURCE: Henderson *et al.* 2015. Greenhouse gas mitigation potential of the world's grazing lands: Modeling soil carbon and nitrogen fluxes of mitigation practices. http://dx.doi.org/10.1016/j.agee.2015.03.029.

Sustainable land management emerges as a key response area to limit warming and reduce emissions. All modelled IPCC pathways that limit warming to 1.5 °C or well below 2 °C require land-based mitigation and land-use change, with most including different combinations of reforestation, afforestation, reduced deforestation, and bioenergy (IPCC, 2020). The total technical mitigation potential from crop and livestock activities, and agroforestry is estimated as 2.3–9.6 GtCO2eq yr-1 by 2050 according to the IPCC Special Report on Climate Change and Land (IPCC, 2020). The total technical mitigation potential of dietary changes is estimated as 0.7–8 GtCO2eq yr-1. Enhancing land management and reducing and reversing land degradation, at scales from individual farms to entire watersheds, can provide cost effective, immediate, and long-term benefits to communities well-beyond limiting emissions (see Figure 1.5). The figure shows response options that could be implemented without or with limited competition for land, with the letters within the cells indicating confidence in the magnitude of the impact.

Response options based on land management		Mitigation	Adaptation	Desertification	Land degradation	Food security	Cost
Agriculture	Increased food productivity	L	M	L	M	H	
	Agroforestry	M	M	M	M	L	●
	Improved cropland management	M	L	L	L	L	●●
	Improved livestock management	M	L	L	L	L	●●●
	Agricultural diversification	L	L	L	M	L	●
	Improved grazing land management	M	L	L	L	L	
	Integrated water management	L	L	L	L	L	●●
	Reduced grassland conversion to cropland	L		L	L	L	●
Forests	Forest management	M	L	L	L	L	●●
	Reduced deforestation and forest degradation	H	L	L	L	L	●●
Soils	Increased soil organic carbon content	H	L	M	M	L	●●
	Reduced soil erosion	L ⇔	L	M	M	L	●●
	Reduced soil salinization		L	L	L	L	●●
	Reduced soil compaction		L		L	L	●
Other ecosystems	Fire management	M	M	M	M	L	●
	Reduced landslides and natural hazards	L	L	L	L	L	
	Reduced pollution including acidifcation	M ⇔	M	L	L	L	
	Restoration and reduced conversion of coastal wetlands	M	L	M	M	L ⇔	
	Restoration and reduced conversion of peatlands	M		N/A	M	L	●

Response options based on vaue chain management		Mitigation	Adaptation	Desertification	Land degradation	Food security	Cost
Demand	Reduced post-harvest losses	H	M	L	L	H	
	Dietary change	H		L	H	H	
	Reduced food waste (consumer or retailer)	H		L	M	M	
Supply	Sustainable sourcing		L		L	L	
	Improved food processing and retailing	L	L			L	
	Improved energy use in food systems	L	L			L	

Response options based on risk management		Mitigation	Adaptation	Desertification	Land degradation	Food security	Cost
Risk	Livelihood diversification		L		L	L	
	Management of urban sprawl		L	L	M	L	
	Risk-sharing instruments	L ⇔	L		L ⇔	L	●●

Options shown are those for which data are available to assess gobal potential for three or more land challenges. The magnitudes are assessed independently for each option and are not additive.

Key for criteria used to define magnitude of impact of each integrated response option

		Mitigation *GtCO2eq yr-1*	Adaptation *million people*	Desertification *million km²*	Land Degradation *million km²*	Food Security *million people*
Positive	Large	More than 3	Positive for more than 25	Positive for more than 3	Positive for more than 3	Positive for more than 100
	Moderate	0.3 to 3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
	Small	Less than 0.3	Less than 1	Less than 0.5	Less than 0.5	Less than 1
	Negligable	No effect	No effect	No effect	No effect	No effect
Negative	Small	Less than -0.3	Less than 1	Less than 0.5	Less than 0.5	Less than 1
	Moderate	-0.3 to -3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
	Large	More than -3	Negative for more than 25	Negative for more than 3	Negative for more than 3	Negative for more than 100

Confidence level
Indicates confidence in the estimate of magnitude category

- **H** High confidence
- **M** Medium confidence
- **L** Low confidence

No data

N/A Not applicable

Variable: can be positive or negative

Cost range
See technical caption for cost ranges in USD tCO_2e^{-1} or USD ha^{-1}

- ●●● High cost
- ●● Medium cost
- ● Low cost
- No data

Figure 1.6
Potential global contribution of response options to mitigation, adaptation, combating desertification and land degradation, and enhancing food security

Cost estimates are based on aggregation of often regional studies and vary in the components of costs that are included. One coin indicates low cost (<USD10 tCO2eq-1 or <USD20 ha-1), two coins indicate medium cost (USD10-USD100 tCO2eq-1 or USD20-USD200 ha-1), and three coins indicate high cost (>USD100 tCO2eq-1 or USD200 ha-1). Thresholds in USD ha-1 are chosen to be comparable, but precise conversions will depend on the response option.

SOURCE: IPCC. 2020. 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.

Programmes such as the United Nations REDD+ can support developing countries to stabilize incomes, prevent additional deforestation, conserve forests and enhance carbon stocks. The REDD program was superseded by the REDD+ program and expanded to include the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (for an explanation of the REDD+ program, please refer to Box 1.3). In essence, the REDD+ program can be used by countries to finance PES schemes that are provided by individual farmers (see Box 1.4 for more details on PES). Forest sector mitigation efforts often cover several scales and, in the context of REDD+, countries may initiate implementation through national policies. On the other hand, nations may have existing forest carbon projects which generate and trade carbon units and that have been launched and implemented before the adoption of the REDD+ national strategy.

There are potential benefits in providing access to and integrating a range of financial streams, from which local conservation and other projects can benefit. Local projects and national REDD+ efforts could be mutually beneficial, but since both tend to be developed following different guidelines or requirements, they need to be reconciled in terms of accounting and the MRV process for emission reduction removals (ERRs) (as well as the payments obtained from the reductions). For instance, if ERRs have already been accounted for and sold at local level, the country will have to discount them from its national (or subnational) reports when claiming payments at that scale. While there are challenges in implementation, some progress has been achieved. For instance, in some countries, a national registry centralizes each project developer's new project proposals. Developers have to declare their intention to undertake a new project and eventually introduce a system for prior permission. Since an increasing number of countries have already been moving from initial REDD+ readiness to demonstration and implementation, greater emphasis has been placed on accessing finance for verified ERRs. REDD+ supports processes that have responded to the Green Climate Fund (GCF), under the auspices of the UNFCCC, as these have been identified as having a key role in providing result-based payments for REDD+ under the creation of the Forest Carbon Partnership Facility Carbon Fund (FCPF CF).

While there is a wide range of cost and societal benefit estimations for transforming food and land use systems in the fight against climate change, most of them suggest very high returns for society. The wide range of estimates derives from the use of different future scenarios for population and many other variables, as well as the scope of the estimation exercise. For example, the Food and Land Use Coalition (FOLU) projects that emission reductions, halting and restoring biodiversity loss, ameliorating health and nutrition and achieving inclusive growth can, by 2030, produce an annual societal net benefit of USD 5.7 trillion (and USD 10.5 trillion by 2050) (FOLU, 2019). This value is based on avoiding hidden costs that include predominantly health (obesity, undernutrition, pollution, pesticides and anti-microbial resistance) and environment related costs (GHG emissions and natural capital costs). According to FOLU, the estimated societal net benefits are 15 times greater than the related investment costs of USD 300 billion to 500 billion per year (less than 0.5 percent of the global GDP) and would generate new business opportunities that amount to USD 4.5 trillion, annually (FOLU, 2019). Furthermore, in 2018 it was estimated that the hidden environmental, health and poverty costs of USD 12 trillion a year, exceeded the global agrifood system value of USD 10 trillion measured in market prices (FOLU, 2019). The estimates of FOLU rely on many assumptions and modelling including the International Institute of Applied Systems Analysis' (IIASA) Global Biosphere

Box 1.3

REDUCING EMISSIONS FROM DEFORESTATION AND FOREST DEGRADATION (REDD+)

REDD+ aims to create a financial value for the carbon stored in forests by offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths. REDD+ goes beyond considering deforestation and forest degradation and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. The concept of REDD+ was introduced into the framework of the UNFCCC in 2007. In 2010, Parties adopted the Cancun safeguards, and in 2013 the Warsaw Framework for REDD+, which together provide further guidance for countries. In 2017, the GCF launched a pilot programme for results-based payments to countries based on their REDD+ reporting to the UNFCCC. Some elements of the Paris Agreement regarding REDD+ (e.g. additionality, permanence and no-overestimation) remain under discussion (UNFCCC, 2021). As no definitive solutions to elements under discussion were reached at COP26, it is expected that the debate on REDD+ will gain a centre stage at COP27 (S&P Global, 2022).

In parallel to the UNFCCC process, the private sector has in many developing countries continued investing into forest protection at the project-level, often with an expectation to access the so-called 'voluntary carbon markets', driven by interest of corporations and individuals in voluntary emissions abatement. Such voluntary REDD rely on private-sector led certification schemes, notably using the Verified Carbon Standard (VCS). More recently, carbon standards have also been launched for jurisdictional-scale REDD+, targeting the voluntary carbon markets, including through the Architecture for REDD+ Transactions (ART), the REDD+ Environmental Excellence Standard (TREES) and VCS Jurisdictional and Nested REDD+ (JNR).

As action consolidates to reduce deforestation and access international carbon finance, governments continue playing a key role. Governments are key actors in reducing deforestation, they are potentially developers of jurisdictional programmes, and governments provide the enabling conditions to the private sector for claiming carbon finance, including appropriate systems for forest monitoring, MRV, safeguards, and also regarding carbon rights.

Box 1.4

PAYMENT FOR ECOSYSTEM SERVICES

Payment for Ecosystem Services (PES) can theoretically be defined as 'voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services' (Wunder, 2015). Of importance is the element of conditionality, where payments are conditional on the execution of certain agreed natural resource management practices. However, the definition of PES has been widely discussed and it can be argued that few schemes actually comply with all definitional elements. Nevertheless, as PES schemes are rarely implemented as stand-alone policy tools, it is important to consider the extent to which these are integrated in and adapted to existing institutional structures and how these are executed (Prokofieva, 2016).

Management Model (GLOBIOM) and have a broad scope that results in suggested interventions (ten critical transitions) ranging from nutrition to rural livelihoods, gender and demography. The estimated USD 12 trillion in global food and land use systems' hidden costs in 2018 include USD 1.5 trillion in costs related to GHG emissions and USD 1.7 trillion relative to natural capital depletion.

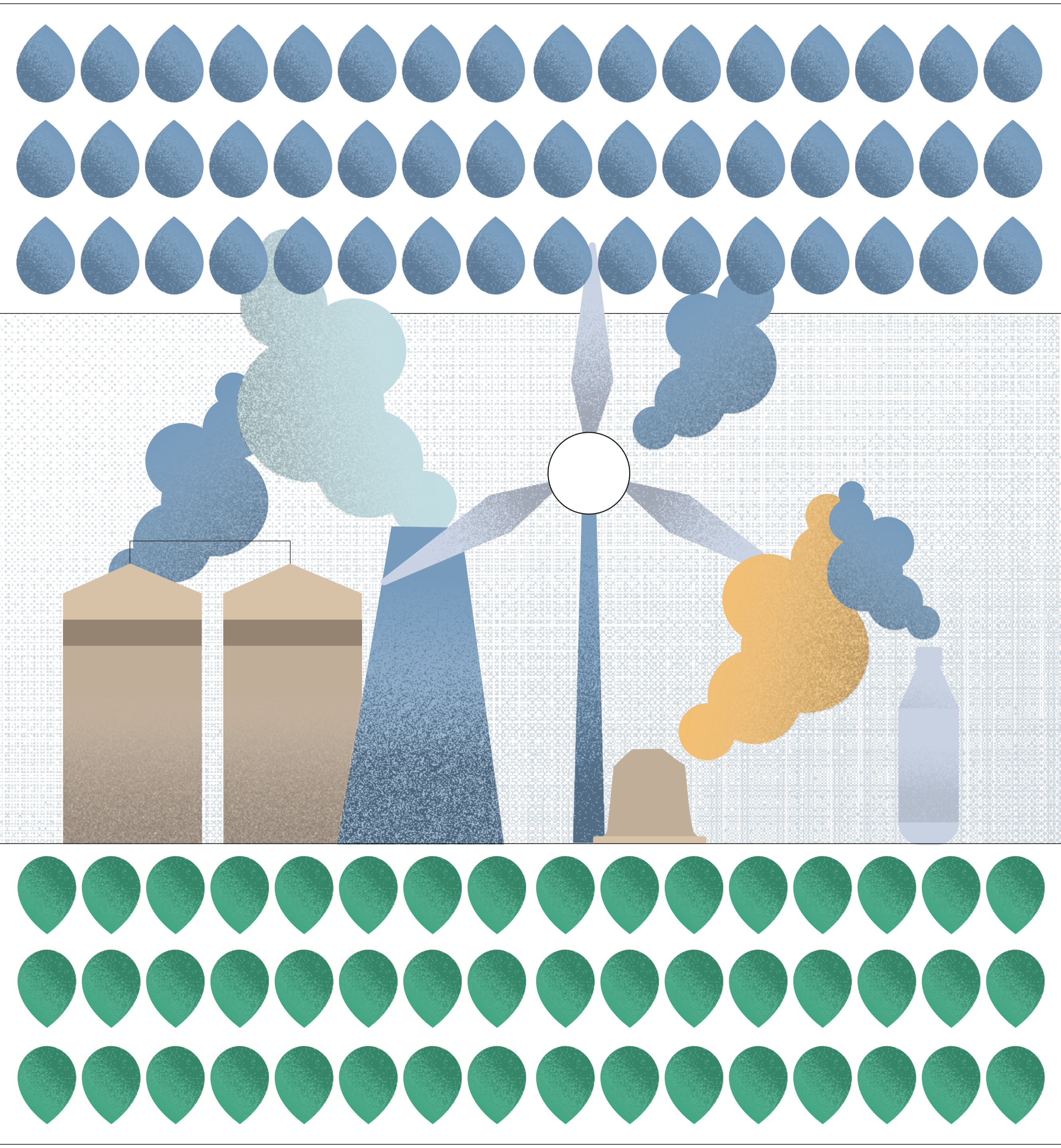
Part of the urgency of reducing aggregate GHG emissions is the deep uncertainty about unknowns and the potentially enormous downside of significant damage to global food systems. For instance, the likelihood of simultaneous production shocks affecting more than 10 percent of production in the top four maize-exporting countries, which account for 87 percent of global maize exports, rises from close to zero at present, to 6 percent under a 2 °C warming scenario and to a staggering 86 percent under a 4 °C warming scenario (Tigchelaar *et al*., 2018). From a disaster perspective, over the past 50 years, 11 000 disasters involving climate and water-related hazards have claimed the lives of 2 million people and resulted in the economic loss of more than USD 3.5 trillion (World Meteorological Association, WMA, 2020). In 2018, 108 million people have sought aid in coping with natural disasters and the United Nations Office for Disaster Risk Reduction (UNDRR) predicts that this number in 2030 could increase by 50 percent at a cost of approximately USD 20 billion per year (WMA, 2020). Similarly, the World Health Organization (WHO) estimates that natural disasters along with changes in clean air, safe drinking water and food sufficiency will cause approximately 250 000 deaths per year between 2030 and 2050 (WHO, 2018). The WHO also foresees direct costs to health amounts to USD 2 billion to USD 4 billion per year by 2030 (WHO, 2018). Overall, a significant structural uncertainty about the unknowns coupled with an essentially unlimited downside liability on possible planetary damage can de denominated as a 'longtail' scenario in the extremes of critical probability distributions (Weitzman, 2011). These longtail scenarios can present extreme risks to global food systems and beyond.

From an offsetting perspective, the overall value of offsetting GHG emissions through sequestration and agricultural management activities could amount to USD 60 billion to USD 360 billion. The total economic mitigation potential of crop and livestock activities, including soil carbon sequestration and better grazing land management, is estimated at 1.5 to 4.0 GtCO2 eq yr-1 by 2030 (equivalent to about 3 percent to 7 percent of total anthropogenic emissions in 2020) (IPCC, 2014). Assuming a shadow price of carbon in the range of USD 50–100 per tCO2eq-1 up to 2030 as recommended by the High-Level Commission on Carbon prices (World Bank, 2017) and assuming a cost per tonne offset of USD 10, the expected benefit of removing one tonne of carbon through agricultural mitigation would be in the range of USD 40 to USD 90. Globally, this could translate to an economic value in the order of hundreds of billions of USD by 2030, ranging from USD 60 billion to USD 360 billion according to the assumed shadow price and offset costs.

Given the estimated costs that climate change can generate, a sense of urgency should be instilled in society to mitigate risks. A central challenge in the fight against climate change is that the full quantification of impacts is difficult to generate and evaluate. This is primarily attributed to the fact that the full extent of the effects is unlikely to manifest itself for decades, or even centuries. For this reason, economists are increasingly adopting an insurance-based stance against the risks of climate change. Since the risks of climate change are largely unknown, some economists are urging public and private actors to pay the premiums required to reduce the risks of extreme outcomes (Financial Times, 2007). This is comparable to insurances taken out on assets, such as real-estate and cars, where individuals are willing to pay for the protection of their assets, because the costs of the unforeseen damage are higher than those paid to protect against the risks (Financial Times, 2007). In this context, with the adequate investments and focus, agrifood systems can play a significant role in driving mitigation efforts to reduce unforeseen and possibly extreme impacts resulting from climate change.

Carbon neutrality can transform agrifood systems from a cause and victim of climate change to a driver of mitigation. Agrifood systems are a victim of climate change, which threatens the stability of global food supply and efforts towards eradicating global hunger. They are also some of the major contributors to climate change. By pursuing the carbon neutrality agenda, agrifood systems can contribute to climate mitigation, prevent its most dangerous impacts on food security and avoid the additional costs of adaptation. Put simply, the carbon neutrality agenda is very much in agrifood systems' self-interest if these systems are to thrive in the future and open up to new possibilities and products. This includes the potential to become the largest provider of offsetting and insetting products (e.g. agroforestry and soil carbon removals).

While significant measurement and implementation challenges remain, it is clear that carbon neutrality presents a potential source of attention and investments for agrifood systems. Agrifood systems may increasingly become targeted for offsetting and for sustainable investing. Forest and soil conservation projects can offset emissions generated elsewhere and are a key instrument to achieve carbon neutrality. They are also often income sources for communities involved in these projects, thus providing financial incentives for forest conservation and also a mechanism for poverty reduction. Furthermore, the existence of carbon neutrality targets is also important as it determines the type and direction of public and private interventions in agrifood systems. To match their ambitious carbon reduction targets, governments are likely to revise agricultural subsidies and introduce various fiscal reforms. For instance, the World Bank argues that a number of fiscal reforms can positively influence forest conservation, while freeing up resources that can be used for other development goals (World Bank, 2021). Some of these reforms include the implementation of environmental commodity taxation, reducing distortionary agricultural subsidies and introducing ecological fiscal transfers as a revenue-neutral instrument. The European Commission's long-term strategy is a case in point; it aims to use at least 40 percent of the common agricultural policy's overall budget and at least 30 percent of the maritime fisheries fund to contribute to climate action (European Commission, 2019a). Similarly, investors are more likely to finance projects with a climate impact, as demonstrated by the exponential growth of climate- and sustainability-related financing mechanisms. To ride the carbon neutrality wave and capture these new financing opportunities, agrifood systems need to demonstrate they are indeed it is capable of achieving carbon neutrality and generating climate value for investors and policymakers alike. This is particularly the case for subsectors of agrifood systems, which are more impactful in terms of emissions and face greater transition risks.



Chapter 2
Putting a farm into an emissions test lab?

The aim of this chapter is to provide a technical overview of carbon neutrality concepts, methods and related standards and labels. The focus is mainly, but not exclusively, on definitions, measurement approaches, standards and the challenges of implementing them in the context of agrifood systems. Although a wide range of carbon neutrality labels now exist, their uptake in the agrifood systems is challenging because of the sector's characteristics and dearth of data. The chapter suggests that the growth in carbon neutrality labels hides significant challenges of carbon neutrality certification in practice, highlighting the need to expand relevant databases and develop specific guidelines for agrifood systems.

2.1 CARBON NEUTRALITY 101

This report defines carbon neutrality as the condition in which, during a specified period, there has been no net increase in the global emission of GHGs into the atmosphere as a result of the GHG emissions associated with the subject during the same period. This definition is based on PAS 2060, the first carbon neutral standard that provides specifications for compliance for companies that wish to claim carbon neutrality (Thorn *et al.*, 2011). As described below, carbon neutrality is achieved through a series of steps. First, the amount of GHG emissions is calculated. Second, the emissions are reduced through new practices, technologies or processes. Third, offsetting or insetting are used to compensate for remaining emissions. In general, only about 3 percent to 10 percent of emissions can be reduced, with the rest having to be compensated (ECOCERT, 2020).[14] Finally, the carbon neutrality process is validated. It should be noted that at this stage, no clear best practices exist in the choice of quantification methods, verification and certification processes, offsetting, insetting and reduction options and disclosure practices. This is largely due to the pathway to carbon neutrality being dependent on a number of factors, including the subsector in which the entity in question operates the business model employed, supply chain structure and complexity, the formalization of linkages between the various actors, and the achievable margins. Chapter 4 sheds light on some of the variegated practices employed across different agrifood subsectors.

Step 1: Calculation

The first step towards carbon neutrality is the quantification of GHG emissions. This is achieved through the carbon footprint (CFP), a means for measuring, managing and communicating GHG emissions related to an entity. The CFP of a product can be quantified using a life cycle assessment (LCA) approach, which results in the measurement of the GHG emissions emitted to produce it. The result of an LCA is the CFP of a product at a given time, expressed in tCO2eq. It should be noted that LCAs were first developed for industrial processes and adapting LCAs to the agriculture sector presents a number of challenges, including the fact that agricultural products are not limited to a crop or an animal, but include many other related goods, services and inputs. Furthermore, metrics and key performance indicators for measuring warming-equivalent emissions are constantly evolving. Some research questions the use of CO2eq using GWP over the span of the 100 years, as this relies on a single scaling factor and does not adequately capture behaviours of long-lived climate pollutants (LLCPs) (for example CO2 emissions) and short-lived climate pollutants (SLCPs) (for instance, methane [CH4] emissions) (Cain *et al.*, 2019; Lunch *et al.*, 2020). As a result, alternative warming-equivalent emissions are being developed and this is elaborated in Chapter 4. CFP analysis can also be based on input-output (I/O) analysis. The third possibility is to use a hybrid approach, combining LCA and I/O analyses. This allows a company to decide, for example, whether to include transportation of their products into the CFP calculation and is typically used to quantify the CFP of an organization rather than a single product. Most quantifications of GHG emissions in agrifood systems are carried out following the LCA approach, with many datasets, mostly privately held, available to inform LCA exercises (OpenLCA Nexus).

In the context of agrifood systems, CFPs are typically linked to organizations or products. An organizational CFP measures GHG emissions from all activities across an organization. This includes energy used in warehouse and food manufacturing processes, owned vehicles and may measure indirect emissions associated with activities outside an organization's own operations – the value chain. This latter set of emissions can be quantified with a value chain analysis, which looks at every step that a business goes through, from raw materials to the end-user. On the other hand, a product CFP measures the GHG emissions over the life cycle of a product. This involves calculating emissions from the extraction of raw materials and manufacturing, through to emissions associated with the use and disposal of a particular food product. A value chain analysis can also include the impact linked to the extraction of key raw materials and end of life emissions; however, this depends on the scope of emissions considered.

14 Estimations collected by ECOCERT through interviews with agrifood companies and certification service providers.

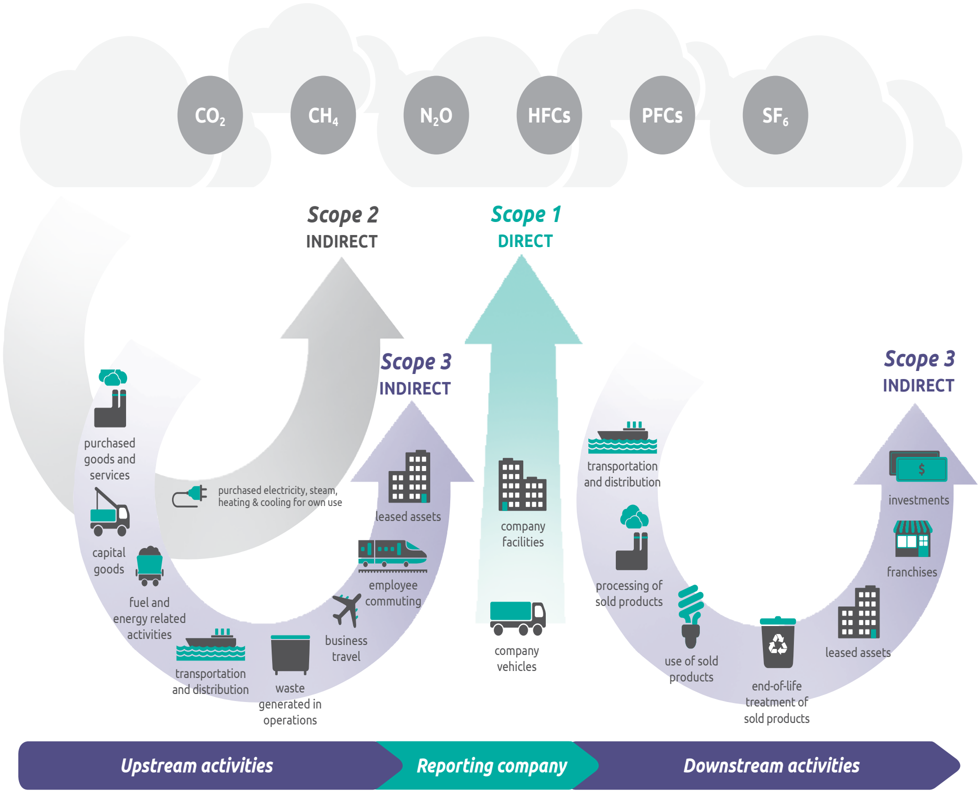


Figure 2.1
Overview of GHG Protocol scopes and emissions across the value chain

SOURCE: Greenhouse Gas Protocol. 2016. GHG Protocol Agricultural Guidance. Interpreting the Corporate Accounting and Reporting Standard for the agricultural sector. https://ghgprotocol.org/sites/default/files/standards/GHG%20Protocol%20Agricultural%20Guidance%20%28April%2026%29_0.pdf.

Three scopes of emissions are considered when quantifying GHGs (Greenhouse Gas Protocol, 2015). First, direct GHG emissions, called Scope 1 emissions occur from sources that are owned or controlled by the organization in question, for example emissions from combustion in owned tractors or emissions from chemical production in owned or controlled process equipment (Figure 2.1). Second, electricity and heat indirect GHG emissions (Scope 2 emissions) are generated from purchased electricity and heat consumed by the organization in question. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary. Scope 2 emissions physically occur at the facility where the electricity is generated. Finally, other indirect GHG emissions ought to be taken into account (Scope 3). This is a reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities of an organization, but also occur from sources not owned or controlled by that organization. Some examples of Scope 3 activities are the extraction and production of purchased materials (e.g. fuel for tractors), the transportation of purchased fertilizers and the use of sold goods and services. According to the PAS 2060 carbon neutrality standard described later in this Chapter, the CFP measurements should include 100 percent of Scope 1 and Scope 2 emissions plus all Scope 3 emissions that contribute more than 1 percent of the total footprint (e.g. extraction, processing and production), as shown in Figure 2.2. While there is no internationally agreed standard that lists which activities need to be considered when assessing Scope 3 emissions in agrifood systems, the GHG Protocol has published a set of guidelines for agriculture (Greenhouse Gas Protocol, 2016).

Developing a full GHG emissions inventory – incorporating Scope 1, Scope 2 and Scope 3 emissions – enables agrifood actors to understand their full value chain emissions and to focus their efforts on the greatest GHG reduction opportunities. Several companies now account and report on the emissions from their direct operations (Scopes 1 and 2). In agrifood systems, especially for food manufacturers, emissions along the value chain (Scope 3) often represent a company's largest GHG impacts. These include transporting products by train, sea or flight, refrigerating and cooking the product throughout its useful life and, and the way it is disposed of or recycled (including consumer-related emissions). GHG emissions generated by suppliers also add to a company's Scope 3 emissions. For example, Kraft Foods found that Scope 3 emissions comprise more than 90 percent of the company's total emissions (WRI and WBCSD, 2004). Therefore, hundreds of companies are already setting Scope 3 reduction targets and dozens are in line with best practices according to the SBTi, which assesses and approves corporate emissions reduction targets in line with climate science. The SBTi is the lead partner of the Business Ambition for 1.5°C Campaign, which is a global coalition of UN agencies, business and industry leaders that call on companies to set science-based targets in line with a 1.5 °C future. The SBTi provides defined pathways and approaches that companies can use to specify by how much and how quickly they need to reduce their GHG emissions. The initiative outlines sector, absolute and economic based approaches for reducing emissions and verifies the targets adopted by companies for a fee.[15] Although the SBTi is voluntary, it provides guidance and verification services that companies can leverage to validate approaches and targets aimed at reducing emissions. Decarbonization roadmaps can also be utilized as reference points for emission reduction approaches and target setting. In this context, the WBCSD published in 2020 the SOS 1.5. roadmap, which provides a step-by-step framework for companies of any size and sector to build and deliver their own decarbonization journey (WBCSD, 2021). Notable examples of decarbonization roadmaps include the UK Dairy Roadmap developed by the National Farmers' Union (NFU), the Dairy UK trade association and the Agriculture Horticulture Development Board (AHDB), as well as the Delivering on Net Zero Roadmap in Scottish Agriculture developed by World Wide Fund for Nature (WWF) (WWF, 2019). Recently, the British Retail Consortium (BRC) developed the BRC Climate Action Roadmap, which outlines five pathways that 66 retailers will follow in the United Kingdom of Great Britain and Northern Ireland to become carbon neutral by 2040 (BRC, 2020). These pathways will tackle Scope 1, 2 and 3 emissions and focus on (BRC, 2020): (i) GHG data to be at the core of decision making; (ii) decarbonization of retail sites; (iii) low carbon logistics; (iv) sustainable sourcing of materials, and (v) support for employees and customers to lead low carbon lifestyles. Furthermore, businesses can apply for the B Corporation (B Corp) certification, which goes beyond service or product level certification and measures a company's entire social and environmental performance (B Corp, 2021).

15 Target validation costs amount to USD 4950 + applicable VAT for companies with > 500 employees and USD 2490 + applicable VAT for subsequent resubmissions; Target validation costs amount to USD 1000 + applicable VAT for companies with employees < 500. https://sciencebasedtargets.org/step-by-step-process.

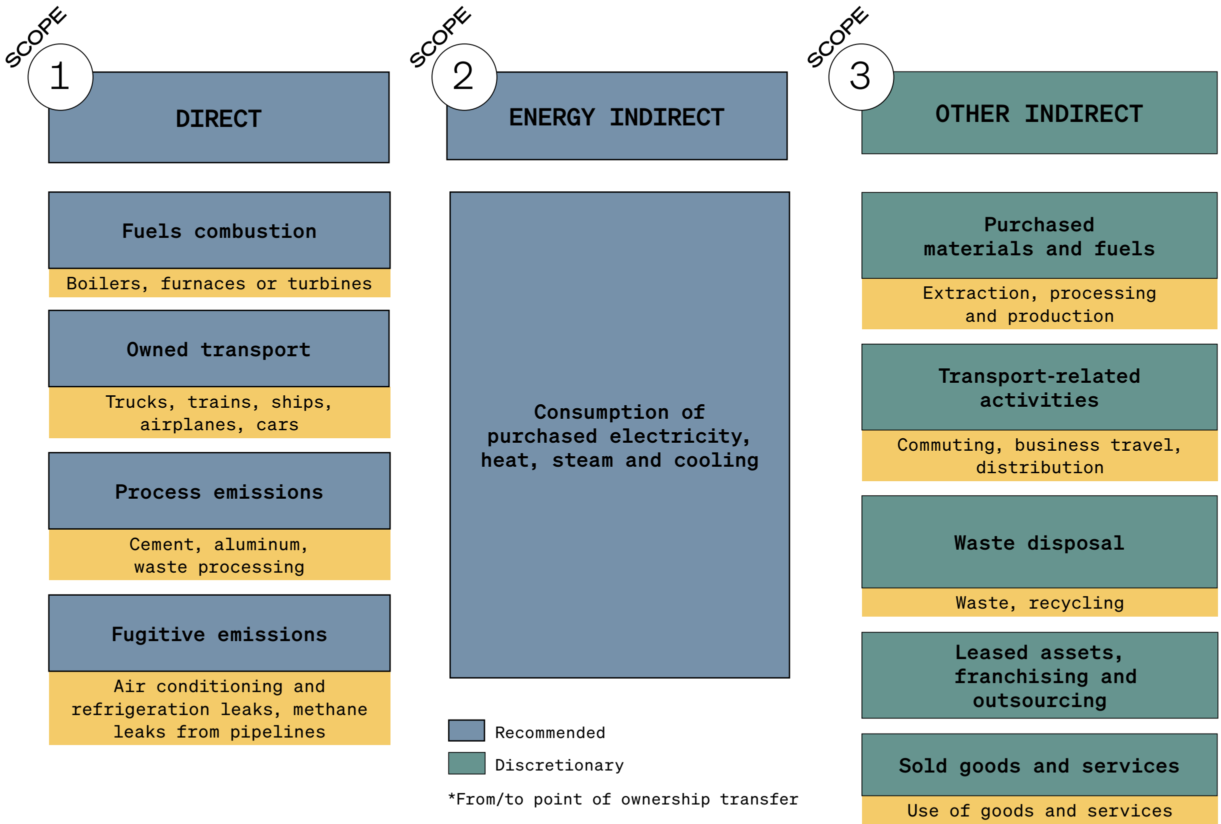


Figure 2.2

Organizational CFP according to the GHG Protocol

SOURCES: WRI and WBCSD. 2004. GHG Protocol revised. https://ghgprotocol.org/sites/default/files/standards/ghg- protocol-revised.pdf.

Step 2: Reduction

Once emissions have been quantified, efforts and investments should focus on reducing them. Initiatives taken to reduce GHG emissions usually start with a commitment and a related action plan to achieve carbon reduction targets over a given timescale. These commitments and targets are fully voluntary and not specified by standards. For any given organization, the way to choose to tackle emissions will depend on its broader strategy as well as other sustainability goals. In many corporate organizations, cutting emissions can help maximize efficiency throughout the value chain; redesign products to be lower carbon; or improve brand reputation. In practice this means that carbon reduction targets are often embedded into broader corporate environmental/climate strategies.

Indirect emissions reduction (Scope 3) is key to achieving carbon neutrality in agrifood systems. According to the GHG Protocol, Scope 3 emissions refer to 'all indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions'. Scope 3 emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company. Some examples of Scope 3 activities are the extraction and production of purchased materials, the transportation of purchased fuels and the use of sold goods and services. To account for Scope 3 emissions, food industry players need to consider emissions from the production of raw materials and manufacture, followed by packaging, distribution, and delivery. If products are transported by train, sea or flight, those would also be counted as Scope 3 emissions. Refrigerating and cooking the product throughout its useful life and the way it is disposed of or recycled also generate indirect emissions.

Best practices related to the identification, tracing and sharing of emissions data are yet to be defined and diffused. To scan products in terms of environmental impact and GHG emission intensity, management and sourcing departments can rely on CFP and LCA analyses, Environmental Product Declarations (EPDs), carbon and ecolabels and Eco-management and Audit Schemes (EMAS) (ISO 14001). Currently, there are no defined best practice tools and methods that companies can use to identify, track and monitor Scope 3 emissions along their supply chains. As elaborated in Chapter 3, some companies are directly investing in the collection of emission data on a number of pilot farms, to be integrated into the Cool Farm Tool and within the company emission calculation methodology. Furthermore, blockchain technology is gaining ground in automating the sharing and tracing of reliable LCA data.

Once a company has identified the major sources of indirect emissions in their value chain, they can begin to focus efforts – and investments – on reducing them. The way to tackle Scope 3 emissions will depend on the company's sustainability goals and its wider corporate strategy. More importantly, this will depend on the capacity of suppliers and providers to embrace and implement carbon neutrality processes and measurements. Cutting indirect emissions can help maximize efficiency throughout the value chain; redesign products to be lower carbon; or improve brand reputation. Reducing Scope 3 emissions can also start in the procurement department. First, by purchasing the same products from suppliers with a lower CFP. Second, by shifting towards different low-carbon alternative products. Another way to reduce Scope 3 upstream emissions is by engaging with suppliers and supporting the joint implementation of sustainability initiatives. The company can improve efficiency and cut costs along the supply chain, gaining a competitive advantage and increased margins.

Step 3: Inset

Carbon insetting signifies reducing GHG emissions or sequestering carbon through an activity linked to the supply chain of a given actor or an activity in its direct sphere of influence. As introduced in Chapter 1, insetting can be considered a direct extension of offsetting, but where carbon offsetting projects are initiated within a company's supply chain or wider supply chain operations. As a carbon management strategy, insetting is comparable to offsetting in terms of the following requirements (ICROA, 2016): (i) a voluntary corporate investment in a project that generates carbon credits; (ii) verification of a project that generates carbon credits by a carbon offset standard; and (iii) the application of purchased credits to offset the company's own emissions. However, it can be argued that a fundamental difference between offsetting and insetting is that insetting will most likely require distinct managerial and technical capabilities and financing efforts, as it will likely require a company to invest in the stages of project development, implementation and maintenance. Due to time and investment requirements, insetting may only be viable to a narrow subset of companies that source from strategic large-scale suppliers (ICROA, 2016). The former will also be conditioned by the structure of the supply chain, in which a given company operates, as well as the sourcing strategies employed by the company. For instance, companies that operate in fragmented supply chains and source from a number of tactical suppliers, may not be incentivized or capable to invest the time and the money required to develop insetting projects. Furthermore, while offsetting implies the trading of carbon credits on an open market, insetting often

Box 2.1

INSETTING – INCONSISTENTLY UNDERSTOOD

The term 'insetting' is often interchanged with offsetting. In fact, offsetting can overlap with the notion of insetting, in the sense that both practices can involve verification and certification via carbon standards. Insetting essentially means verifying the offsetting of emissions on a project basis using a carbon standard throughout the scope of a company's operations, while offsetting encompasses the compensation of emissions through the purchase of carbon credits from projects not related to a company's operational scope. Compared to reduction, it can be argued that insetting and offsetting practices are subjected to more accurate verification processes through checks and balances. This is because reduction does not envisage the usage of carbon verification standards as it implies the direct abatement of emissions within a company's operations and/or wider supply chain activities. Furthermore, companies often apply internal approaches and verification methods to validate reductions and these are not always subjected to independent oversight. Moreover, emissions reductions may be better linked to the corporate objectives of a company and contribute to the generation of a competitive advantage and development of supply chain resiliency. Finally, when compared with offsetting, insetting and emissions reductions can present climate change adaptation and mitigation benefits, as well as corporate social responsibility (CSR) and marketing benefits. This is largely because offsetting implies the purchase of credits that can present limited relatability to a company's operations, service and/or product offering.

relies on closed market transactions, as the company in question commits to the purchase of all generated carbon credits (ICROA, 2016). Lastly, insetting compared to offsetting presents the opportunity to generate co-benefits, including ameliorating supplier relations, improving quality and guarantee of supply (ICROA, 2016). As elaborated in Box 2.1, although the two carbon management strategies of offsetting and insetting are different, they do present some overlaps.

Insetting could be a game changer for agrifood systems, because it allows direct investment to improve efficiency and climate resilience in their own value chains. In the case of offsetting (step 4), the emissions and reductions are discrete activities and there is no interaction between the parties except a financial transaction. In the case of insetting, there is exploration and partnership with various stakeholders within a supply chain to identify emission reduction opportunities (Gallemore and Jespersen, 2019). Through these interactions, agrifood companies are better able to connect with their various suppliers along the value chain and identify points where improvements can be made, in terms of efficiency of input usage for example or reduced transport costs.

While insetting holds significant promise for agrifood systems, its application is still challenged by the lack of international standards. Several initiatives have attempted to develop standards for insetting, but resulting standards diverge in recommended approaches and definitions. For example, Plan Vivo Standard defines insetting as reducing GHG emissions or sequestering carbon through an activity linked to the supply chain of a given actor or an activity in its direct sphere of influence. These activities may or may not be monetized through the formal carbon markets (Plan Vivo, 2014). On the other hand, the International Platform for Insetting (IPI) definition represents the actions taken

Box 2.2

INSETTING EXPERIENCES

Nespresso is using insetting to increase coffee yields, reduce input costs and diversify revenues for coffee farmers in Colombia and Guatemala. In partnership with Pur Projet, agroforestry systems are being implemented including shade trees, boundary planting, woodlots and integration with animal pasture. The objective is to regenerate coffee ecosystems and help farmers to adapt to climate change, by making their farms more resilient.

All the projects are verified against the Insetting via Agroforestry at Landscape Level Standard (IALL) developed by the IPI, while the program is being certified against the Insetting Program Standard (IPS). Then all the program aspects, from its inputs and commitments to the verified outcomes, are registered in the IPI blockchain registry.

by an organization to fight climate change within its own value chain in a manner which generates multiple positive sustainable impacts (International Platform for Insetting, 2020). These approaches were not developed specifically for agrifood systems, and thus were adapted by a few agrifood companies which pursued carbon insetting (see Box 2.2).

Step 4: Offset

Offsets are a key element of the carbon neutrality equation. A carbon 'offset' is essentially a measure of GHG emissions reduction or carbon sequestered, relative to an initial baseline level. An offset represents the reduction, removal or avoidance of GHG emissions, measured in tCO2eq, from a sector/region not subject to an emissions cap (International Emissions Trading Association, 2019). Offsetting must demonstrate actual emission reductions compared to what would have otherwise happened, ensure emissions are not simply released at a later date, or are displaced elsewhere (International Emissions Trading Association, 2019). The criteria used in existing GHG offset programs are listed in Box 2.3. Recently, the University of Oxford has outlined a taxonomy to categorize offsets in its Principles for Net Zero Carbon Offsetting (University of Oxford, 2020). These include avoided emissions (for instance, replacing carbon intensive energy sources with renewables), emission reduction offsets (projects that stop emissions being released into the atmosphere through, for instance, avoided deforestation and carbon capture and storage – [CCS]) and emission removal offsets (the physical removal of emissions from the atmosphere through, for instance, afforestation and mineralization). The taxonomy also differentiates offsets based on ability to store carbon and the extent to which storage is short or long-lived. Since short-lived storage offsets have a higher risk of being reversed over decades, the Oxford Offsetting Principles stress the importance of improving and scaling solutions that enable long-lived storage and in creating demand for long-lived offsets to incentivize the market development of such offsets. Likewise, carbon dioxide removals (CDRs) are gaining traction (IPCC, 2018a).[16] It can be

16 The IPCC defines CDRs as: 'anthropogenic activities removing CO2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products'. CDRs include existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage, but exclude natural CO2 uptake not directly caused by human activities.

Box 2.3

CRITERIA USED IN GHG OFFSET PROGRAMS

- **REAL:** offsets must represent real emission reductions that have already occurred (i.e. the reduction is not projected to occur in the future).
- **ADDITIONAL:** offsets must represent emission reductions that are in addition to what would have occurred otherwise.
- **PERMANENT:** offsets must represent emission reductions that are non-reversible, or must typically be sequestered for X number of years in the case of carbon biosequestration projects.
- **VERIFIABLE:** sufficient data quantity and quality must be available to ensure emission reductions can be verified by an independent auditor against an established protocol or methodology.
- **QUANTIFIABLE:** emission reductions must be reliably measured or estimated, and capable of being quantified.
- **ENFORCEABLE:** offset ownership is undisputed and enforcement mechanisms exist to ensure that all program rules are followed and the market's environmental integrity is maintained.
- Uniquely numbered and transparently listed.

SOURCE: International Emissions Trading Association. 2019. Offsets: The Basics. www.ieta.org/resources/Resources/101s/Offsets.pdf.

expected that, in the coming years, the market for CDRs will evolve and gain importance.

When a carbon offset is traded, it is referred to as a carbon 'credit'. One carbon credit represents one tCO2eq traded on either the voluntary or compliance carbon market. Carbon credits have been defined by the ICROA as a 'unit of carbon dioxide equivalent which has been reduced, avoided or sequestered by a carbon reduction project and is a tradeable commodity' (ICROA, 2016). Compliance markets are created and regulated by mandatory regional, national, and international carbon reduction regimes, such as the Kyoto Protocol and the European Union's Emissions Trading Scheme. Voluntary offset markets function outside the compliance markets and enable private companies and individuals to purchase carbon offsets on a *voluntary* basis.

The voluntary offset market enables private companies to buy carbon credits on a voluntary basis, most often as a tool for corporate social responsibility. These credits are bought and sold in the so-called 'voluntary' market, which is not backed by any government standard or mandatory goals, but rather based on specific organizations certifying that emission reductions have environmental integrity (called 'GHG programs'). Therefore, the entire market rests on the relationship of trust between buyers and the GHG programs and the claim that the credits sold on the market truly contribute to reducing emissions (Carbon Market Watch, 2019). As explained in Chapter 3, this voluntary nature of the markets and the lack of government oversight gives rise to several practical challenges, including ambiguous procedures for selecting emission reduction projects and related monitoring (Gillenwater *et al.*, 2007).

PATH TOWARDS CARBON NEUTRALITY

Key steps for reaching and maintaining the carbon neutrality according to the reference standard

1	**QUANTIFY**	Quantification of GHG emissions, using an LCA based protocol to calculate the carbon footprint. The carbon footprint measurements should include 100% of Scope 1 and Scope 2 emissions plus all Scope 3 emissions that contribute more than 1% of the total footprint.
2	**REDUCE**	Includes the development of a Carbon Management Plan, with a timescale for achieving carbon neutrality, clear and accurate carbon reduction targets, and the offset strategy; this plan must be presented and verified.
3	**OFFSET**	Requires the remaining emissions to be offset through high-quality, independent third-party certified carbon credits.
4	**VALIDATE AND DECLARE**	The elaboration of a Qualifying Explanatory Statement (QES) in which the commitment to carbon neutrality and the achievement of carbon neutrality are declared. All documents that support carbon neutrality claims must be publicly available.

Figure 2.3
Schematic representation of carbon neutrality process according to the PAS 2060 standard

Reference standard: PAS 2060:2014
Specification for the demonstration of carbon neutrality

SOURCE: Acampora A., Mattia G., Pratesi C.A. and Ruini L. 2020 Investing in Carbon Neutrality in the agrifood sector: challenges and opportunities in a dynamic setting. Unpublished background paper prepared for this report, Carbon Neutrality Lab. Roma Tre University.

Step 5: Validation and declaration

The final step is the validation and declaration of carbon neutrality. Several standards and related labels exist for one or all of the steps of the carbon neutrality process shown in Figure 2.3, for instance for CFP measurements and offsets. For many of these standards, third-party validation is available at a cost, meaning that companies can get an independent evaluation showing that their practices comply with given standards. The international standard for carbon neutrality, the PAS 2060 standard, prescribes the elaboration of a Qualifying Explanatory Statement (QES) in which the commitment to carbon neutrality and the achievement of carbon neutrality are declared. Additionally, the standard requires that all the documents that support carbon neutrality claims have to be publicly available. The PAS 2060 certification has a maximum validity period of 12 months, after which it can be renewed. As discussed in the next section, the PAS 2060 standard is the only international standard that truly defines the carbon neutrality process as a whole 'package'. Nonetheless, carbon neutrality can be achieved by combining other standards, including GHG Protocol and ISO standards. In practice, most efforts towards carbon neutrality in agrifood systems to date do not use the PAS 2060 standard, instead relying on a multiple standards and approaches for the different steps of the carbon neutrality process.

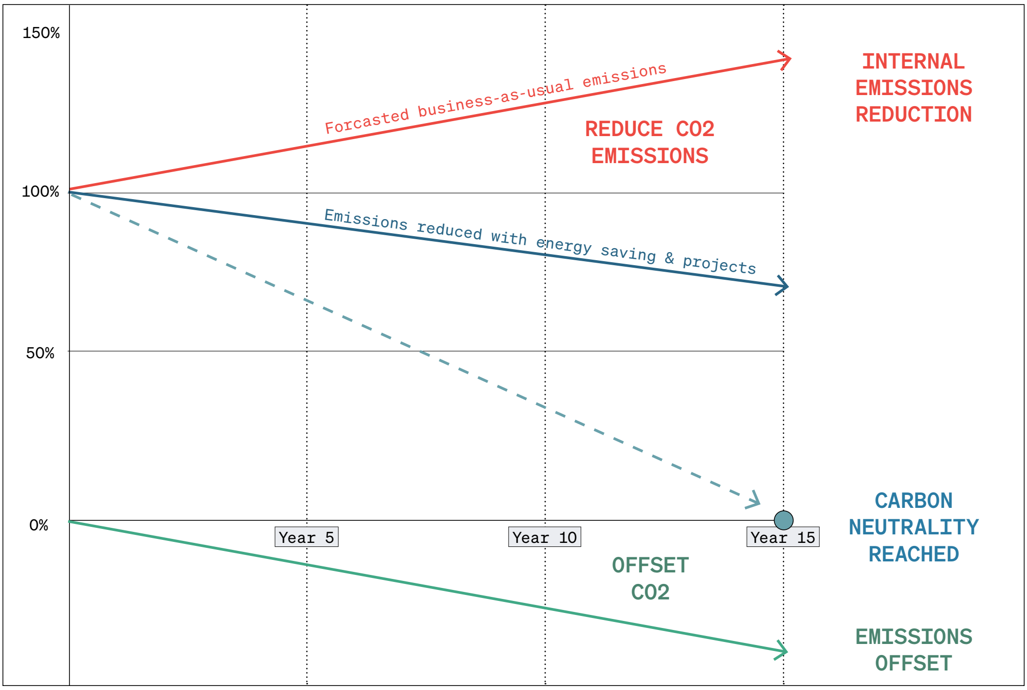


Figure 2.4
Emission trajectories under three scenarios:
BAU emissions, emission reductions, and emission offsets

SOURCE: Acampora A., Mattia G., Pratesi C.A. and Ruini L. 2020 Investing in Carbon Neutrality in the agrifood sector: challenges and opportunities in a dynamic setting. Unpublished background paper prepared for this report, Carbon Neutrality Lab. Roma Tre University.

2.2 STANDARDS, CERTIFICATION AND LABELS

Overview and definitions

To understand current and future efforts towards carbon neutrality, it is important to examine the pros and cons of existing standards, certification approaches and labels. Before presenting standards and labels for carbon neutrality, this section provides a short overview and definition of the concepts of standards, certification and labelling, based on existing FAO definitions (Dankers, 2003). Standards contain technical specifications or other precise criteria to be used consistently as rules, guidelines or definitions, to ensure that materials, products, processes and services are fit for a given purpose (for example, carbon neutral). Standards can be voluntary (without any legal obligation) or mandatory (required or commanded by an authority). Standards can also be differentiated depending on the standard-setting body. International standards are set by private–public partnerships, including civil society organizations (CSOs), academia, regulators and industry representatives. Compliance with relevant requirements is in principle voluntary, but it can become mandatory if standards are incorporated in law. Private standards are set and operated by private companies, CSOs, or joint initiatives. Compliance with requirements is voluntary, but it can become *de facto* mandatory when the standard setter, such as a large distributor, has a particularly dominant position in a given product value chain or in a geographic market (for example, a large retailer).

Standards become operational through certification and labelling. Certification is a procedure by which a third-party verifies and then gives written assurance that a product, process or service is in conformity with certain standards. To ensure that the certification bodies have the capacity to carry out certification programs, they are evaluated and accredited by an authoritative body.

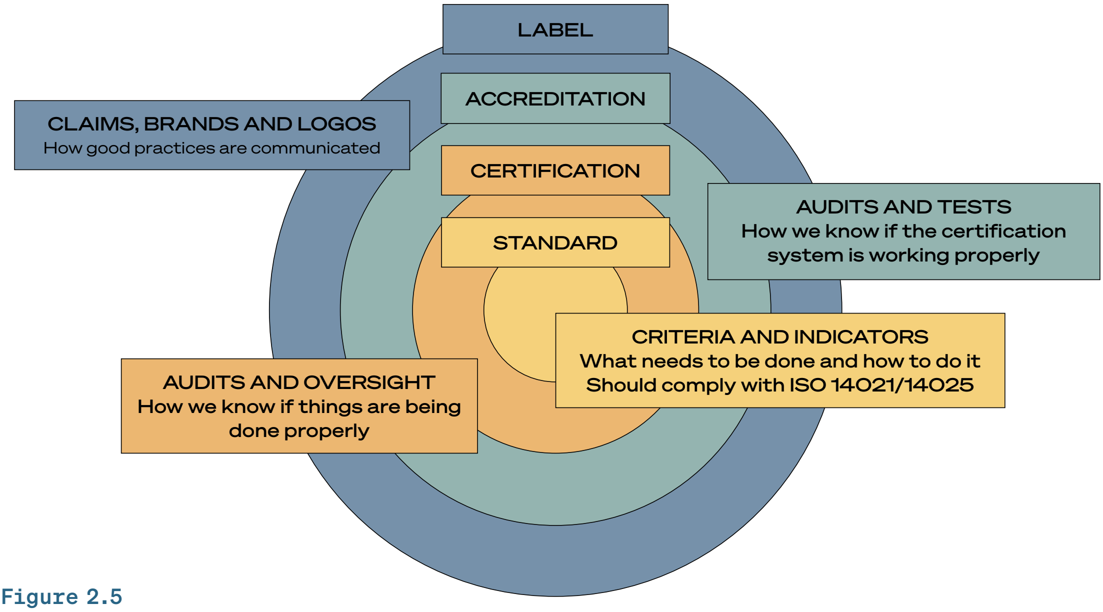


Figure 2.5
Standards systems

SOURCE: Loconto, A. and Dankers, C. 2014. Impact of international voluntary standards on smallholder market participation in developing countries: a review of the literature. FAO.

A certification label is a label or symbol indicating that compliance with standards has been verified. Use of the label is usually controlled by the standard-setting body. Where certification bodies certify against their own specific standards, the label can be owned by the certification body. While the certificate is a form of communication between seller and buyer, the label is a form of communication with the end consumer. Labels can be owned by the company, the private standard or by the international standard. The relationship between standards, certification, accreditation and labels is shown in Figure 2.5.

While standardization and certification procedures seem straightforward in principle, they face a series of challenges in practice. Standards differ in multiple ways and this affects their robustness and ease of application. Since any party can set a standard, conflicts of interest might arise (Loconto and Dankers, 2014). The producer (first-party) can set the standard, in which case the producers' interests are likely to be reflected in the standard. Also, the buyer (second-party) can set the standard, in which case business interests will be reflected in the standard. Different standards have different means of verification and assessment of compliance, as detailed in Annex I.

Standards related to carbon neutrality

Several standards and related certification processes are relevant for carbon neutrality. Some have been directly developed for carbon neutrality, while others relate to a specific step of the carbon neutrality process, either CFP or carbon offsetting. In terms of CFP, there are two broad categories of standards to measure emissions: organization standards and product/service standards. GHG Protocol Corporate Standard is an example of an organizational CFP standard, while ISO 14067 is a product standard (see Annex II for a longer description of CFP standards). More examples of carbon related standards are provided in Table 2.1.

Table 2.1
Comparison of carbon-related standards

Name	Title	Owner	CFP	LCA	Removals; GHG sinks	Label / reporting guidelines	Scope
LCA methodology related standard							
ISO 14040	Environmental management – life cycle assessment – principles and framework	ISO	X*	V	X	X	
ISO 14044:2006	Environmental management – life cycle assessment – requirements and guidelines	ISO	X	V	X	X	
ISO 14072	Environmental management – life cycle assessment – requirements and guidelines for organizational life cycle assessment	ISO	V	V	X	X	
Communication							
ISO14064-3	GHG specification with guidance for the verification and validation of GHG statements	ISO	V	V	V	V	
Product carbon footprint							
ISO 14067	GHGs – CFP of products – requirements and guidelines for quantification	ISO	V	V	X	X	Cradle-to-grave; cradle-to-gate; gate-to-gate and partial life cycle**
PAS 2050	Specification for the assessment of the life cycle GHG of goods and services	BSI	V	V	V	V	Cradle-to-gate and cradle-to-grave
GHG Protocol	Product life cycle accounting and reporting standard	WRI/WBCSD	V	V	V	V	Cradle-to-gate and cradle-to-grave
Organizational CFP							
ISO 14064-1	GHGs Specification with guidance at the organization level for quantification and reporting of GHG emissions and removals	ISO	V	V	V	V	Direct, energy indirect, other indirect
GHG Protocol	A corporate accounting and reporting standard	WRI/WBCSD	V	V	X	V	Scope 1; 2; 3
GHG Protocol	Corporate value chain (Scope 3) accounting and reporting standard	WRI/WBCSD	V	V	X	V	Scope 3
Bilan Carbone®	Emissions factors and their calculation to allow GHG reporting under the Bilan CarboneTM Method	Agence de l'Env. et de la Maîtrise de l'Energie (ADEME)	V	X	X	V	Direct, energy indirect, other indirect
Project CFP							
ISO 14064-2	GHG specification with guidance at the project level for quantification, monitoring and reporting of GHG emission reductions or removal enhancements	ISO	X	V	V	V	Offsetting projects
GHG Protocol	The GHG Protocol for Project Accounting	WRI/WBCSD	X	V	V	V	Offsetting projects
Carbon neutrality							
PAS 2060	Specification for the demonstration of carbon neutrality	BSI	V	V	V	V	Scope 1; 2; 3

SOURCE: Acampora A., Mattia G., Pratesi C.A. and Ruini L. 2020 Investing in Carbon Neutrality in the agrifood sector: challenges and opportunities in a dynamic setting. Unpublished background paper prepared for this report, Carbon Neutrality Lab. Roma Tre University.

NOTES:
*X signifies that the standard does not consider and/or provide guidance for a practice or approach, while V means that the standard does provide guidance for the practice or approach specified in the heading.
**Cradle-to-grave, includes cradle-to-gate, however, the standard offers both assessments individually.

Table 2.2
Main carbon offset standards

	Owner	Name	Year of creation	Objectives	What is certified?
	Gold Standard	Gold Standard (GS)	2006	Certify carbon-offset projects	Voluntary Emission Reduction (VER)
	Verra	Verified Carbon Standard (VCS)	2006	Certify carbon-offset projects	Verified Carbon Units (VCUs)
	Plan VIVO	Plan Vivo Standard	2007	Certify carbon-offset projects with focus on co-benefits	Plan Vivo Certificates (PVCs)
	United Nations Framework Convention on Climate Change	UNFCCC Clean Development Mechanism (CDM)	2008	Certify carbon-offset projects	Certified Emission Reductions (CERs)
	Ecologica Institute	SocialCarbon	2003	Certify social, environmental, economic benefits of carbon-offset projects	Social quality for Voluntary Emission Reduction (VER)
	CCBA (VCS assumed management of the CCB Program in November of 2014)	Climate, Community & Biodiversity (CCB) Standard	2005	Certify social, environmental, economic benefits of carbon-offset projects	Biodiversity and Community quality for Verified Carbon Units (VCUs)

SOURCE: Acampora A., Mattia G., Pratesi C.A. and Ruini L. 2020 Investing in Carbon Neutrality in the agrifood sector: challenges and opportunities in a dynamic setting. Unpublished background paper prepared for this report, Carbon Neutrality Lab. Roma Tre University.

Carbon offset standards play a key part in helping to quantify and certify carbon credits. The main carbon offset standards are: the Gold Standard, the VCS, the Plan Vivo Standard, UNFCCC's Certified Emission reduction, SocialCarbon and the Climate, Community and Biodiversity (CCB) Standard. Their main characteristics are compared in Table 2.2 and each of the standards is described in more detail in Annex III.

Some industries and governments are beginning to respond to the need for oversight of carbon neutrality. On a national level, the Climate Active Carbon Neutral Standard (formerly the National Carbon Offset Standard, name was changed in 2019) is an example of a national carbon neutrality standard, developed by the Australian Government and Australian businesses to drive voluntary climate action. Climate Active provides a carbon neutral certification and label (the Climate Active Stamp), which has been internationally recognized as a mature and effective model to help businesses and incentivize emission reductions. Similarly, France developed the French Carbon Standard in 2018 to regulate company offsetting projects and promote local environmental programs that contribute to national and sectoral emission reduction targets (Box 2.4). The Clean Development Mechanism (CDM) defined in Article 12 of the Kyoto Protocol, allows a country with an emission reduction or limitation commitment under the Protocol to implement an emission reduction project in developing countries (UNFCCC, 2020). Such projects can earn certified emission reduction (CER) credits, which can be counted towards meeting the Kyoto Protocol targets. However, the CDM only applies to developing countries and it is not specific to the agricultural sector. On a sectoral level, the case of the aviation sector that has been found effective in catalysing the sector to take action towards carbon neutrality and this may have a disruptive role in agrifood systems. The case of the aviation sector is elaborated in Box 2.5.

Box 2.4

THE CASE OF THE FRENCH 'LABEL BAS-CARBONE' STANDARD

The French 'label bas-carbone' was developed to respond to the need for oversight of growing voluntary carbon neutrality standards and certifications. The label bas-carbone is a framework for voluntary carbon reduction that was adopted by the French Government in November 2018 (CARBON AGRI, 2021). It presents one of the first of its kind and it is a government-driven attempt to regulate the governance of carbon neutrality. Environmental integrity is ensured through the utilization of standardized methodologies in line with the overarching rules set in the regulation. To date, it includes approved accounting methodologies for forestry (afforestation, coppicing and restoration) and for agriculture (CARBON AGRI, 2021).

CARBON AGRI provides a method for project developers in France to account for practices in agriculture (cattle, beef, dairy and crop production systems) that reduce emissions and/or increase carbon storage. The absence of standards specific to the agricultural sector has led the French government to develop CARBON AGRI, which outlines methods for project developers in France to account for emissions in the agricultural sector. Validated emission reductions from these types of practices can be traded for payment: (i) herd management and feeding; (ii) animal manure management; (iii) crop and grassland management; (iv) consumption of fertilizers; (v) energy usage; and (vi) carbon storage. Using a LCA approach, CARBON AGRI quantifies both reductions on the farm, as well as associated upstream emissions. Emission change is calculated using the national tool CAP2ER®, a whole farm calculator, that is based on changes in emissions intensity (i.e. kg of GHG per kg of output). Each project runs for five years and can be renewed.

Label bas-carbone and CARBON AGRI set guidelines for carbon reduction and offsetting. The methodologies outlined above add value as they guide actors on how to establish eligibility criteria, calculate baseline scenarios and demonstrate additionality of a project and its environmental integrity (i.e. co-benefits). Furthermore, such methodologies set the requirements for identifying and managing non-permanence risks, calculating emission reductions relative to the baseline and conforming to MRV requirements and methods. For instance, only projects that provide additionality will be approved.

The PAS 2060 Standard is the key international standard for carbon neutrality. PAS 2060 was first launched in 2010 by the BSI and then revised in 2014. This standard is applicable to activities, products, services, buildings, projects, towns, cities and events, and provides a strong foundation to understand and quantify carbon neutrality. Notably, technical standards illustrated in Table 2.1 (ISO standards and GHG protocols) provide technical guidance on how to account for emissions, but they are often seen as an add-on to carbon neutrality project development. PAS 2060 can be expanded to standardize the pathway to carbon neutrality, however further development and diffusion of nationally developed carbon standards may contribute to the proliferation of standards and it is therefore recommended that these are aligned to existing standards.

Box 2.5

SECTOR DRIVEN CARBON NEUTRALITY – LESSONS FROM THE AVIATION INDUSTRY

The aviation industry has set a path to achieve carbon neutrality. The aviation sector will potentially generate between 1.6 billion tonnes to 3.7 billion tonnes of demand for offsets between 2021 and 2035 (ICAO, 2020a). This effort is spearheaded by the ICAO, a specialized agency of the United Nations. In 2010, ICAO member states agreed on two goals regarding aviation emissions, namely the improvement of fuel efficiency by 2 percent annually through 2050, and a so-called carbon neutral growth target to offset all pollution above 2020 levels. To reach this goal, a market-based measure, the Carbon Offset and Reduction Scheme for International Aviation (CORSIA) was adopted in 2016. The scheme came into force in 2021, but participation is voluntary until 2027. Originally, CORSIA required individual airplane operators to compensate for their calculated share of emissions above their 2020 baselines using eligible emissions units and sustainable alternative fuels with demonstrably lower emissions (based on international aviation activity and fuel emissions). However, due to the COVID-19 pandemic and to safeguard airline operators against inappropriate economic burdens, the council agreed in 2020, that 2019 emissions will be used to determine annual offsetting requirements during CORSIA's pilot phase (2021–2023) (ICOA, 2020b). Furthermore, depending on how the sector grows in the coming years and depending on the long-lasting impacts of the COVID-19 pandemic, CORSIA may generate between 1.6 billion tonnes to 3.7 billion tonnes of demand for offsets between 2021 and 2035 (Hamrick and Gallant, 2018). The medium-term deal is expected to provide more than USD 40 billion in funding for climate projects and offset 2.6 billion tCO2eq between 2021 and 2035 (Lambert, 2019). Airlines from 80 countries representing 77 percent of international air traffic have joined the deal's voluntary first phase between 2021 and 2026. It becomes mandatory from 2027 for states with large aviation industries.

While agrifood systems face different challenges, the example from the aviation industry holds important lessons.
Compared to the aviation industry, it is clear that agrifood systems face a more complex set of challenges when it comes to accounting for and reducing GHG emissions. Processes are more varied, value chains much more complex and a higher number of heterogeneous actors are involved, which means that in practice measuring and reducing emissions in agrifood systems is much more costly and difficult. Nonetheless, the aviation case has some useful insights for agrifood systems. First, it demonstrates that industry-wide commitments and targets can be set and guidance on how to achieve them provided. Second, it shows that UN agencies can play a key role in convening discussion around carbon neutrality and facilitate the establishment of international targets. Furthermore, this example shows that it is important to set mandatory requirements when it comes to carbon emission reduction and offsetting. Finally, the aviation example shows how actions towards decarbonization may also impact other sectors such as agriculture, which is not directly related to it but that could become a paramount source of offsets if effectively framed by transparent and internationally recognized standards.

Carbon neutrality labels

As for standards, there are a range of carbon neutrality labels. Ecolabel schemes can be characterized according to the ownership of the standard, notably whether they are private, public, non-profit or hybrid. They can be developed by private entities, by public agencies, or jointly by stakeholders and experts from the public and private sectors. The Climate Active Carbon Neutral label is an example of a public-driven label, while the Carbon Trust's Carbon Neutral label is an example of a private-driven label (Box 2.6). Table 2.3 presents the main characteristics of the main carbon neutral labels available for agrifood actors that want to certify their commitment towards carbon neutrality goal. Currently, PAS 2060 demonstrates promise in providing a robust guarantee for carbon neutrality, while SBTi targets can serve as complimentary commitments that companies can make in terms of target and strategy setting. As of yet, none of these standards enforce overarching minimum GHG reduction requirements, nor do they mandate the percentages to which emissions should be offset, inset or reduced.

Box 2.6

CARBON NEUTRAL LABELS

CLIMATE ACTIVE CARBON NEUTRAL

Provider name: Australian Government

Location: Australia

Number of clients: 100

Number of agrifood companies served: 5

Geographical area of influence: Australia

Label name: Climate Active (formerly NCOS)

Year of creation: 2010

Scope: Organizations, products and services, events and precincts

Verification of the CFP: Yes

Verification of the offset program: Yes

CFP Methodology: GHG Protocol, ISO 14064, ISO 14040, ISO 14044

Accreditation system of the certification body (CB): Yes

Control system: Third-party required for full neutrality process

Main control bodies: Included on the Register of Greenhouse and Energy Auditors, or accredited to the international standard ISO 14065:2013, or accredited to recognized international standards based on ISO 14040.

CARBON TRUST CARBON NEUTRAL

Provider name: Carbon Trust

Location: United Kingdom

Geographical area of influence: World

CFP analysis: Yes

Set targets and reduce emissions: Yes

Offsetting: Yes

Insetting: No

Label name: Carbon Trust Carbon Neutral

Scope: Company, sector, product

Verification of the CFP: Yes

Verification of the offset program: Yes

The company can invest in chosen sustainable compensation projects: No

Certification of generated/purchased carbon credits is compulsory: Yes

CFP methodology: PAS 2060

Offset certification standard: GS

Accreditation system of the CB: Yes

Control system: Verification by the label owners.

Table 2.3
Main carbon neutrality labels
Descriptions are based on publicly available information

Label	Owner	Objectives	Boundaries	Control system
CARBON NEUTRAL® CERTIFICATION	Natural Capital Partners	Certify net zero emissions	Companies, sectors, products and events	Third-party required for the entire neutrality process
CARBON TRUST CARBON NEUTRAL CERTIFICATION	Carbon Trust	Certify net zero emissions	Companies, sectors and products	Verification by the label owner
NOCO2 CERTIFICATION	Carbon Reduction Institute	Certify net zero emissions	Companies, sectors and products	Verification by the label owner
CO2 NEUTRAL LABEL	CO2Logic	Certify net zero emissions	Companies	Third-party required for the entire neutrality process
CLIMATE NEUTRAL LABEL	Fondation MyClimate	Certify net zero emissions	Companies, sectors, products and events	Verification by the label owner
CLIMATE NEUTRAL NOW	UN Climate Change	Certify net zero emissions	Companies, organizations, governments and citizens	Third-party required for the entire neutrality process
CERTIFIED CARBON NEUTRAL	SCS Global Services	Certify net zero emissions	Organizations, products or brands	Verification by the label owner
ENGAGEMENT CLIMAT	ECOCERT	Reduce carbon emissions	Companies and public organizations	Verification by the label owner
CARBONO NEUTRO CERTIFICADO HUELLA DE CARBONO	Icontec	Certify net zero emissions (Carbono neutro); Reduce carbon emissions (huella de carbono)	Companies, products, services and processes	Verification by the label owner
AENOR MEDIO AMBIENTE DE EMISIONES DE CO2	AENOR	Reduce carbon emissions; Compensated carbon emissions; calculated carbon emissions	Products and services	Verification by the label owner
NATIONAL CARBON OFFSET STANDARD (NCOS)	Australian Government	Certify net zero emissions	Organizations, products, services, events and precincts	Third-party required for the entire neutrality process
CLIMATE NEUTRAL	South Pole	Certify net zero emissions	Companies, products and events	Third-party required for the entire neutrality process
KLIMAATNEUTRAAL PRODUCT	Climate Neutral Group	Certify net zero emissions	Organizations	Verification by the label owner
CARBONNZERO AND CEMARS	Toitū Envirocare	Certify carbon reduction and carbon zero	Companies	Third-party
LABEL BAS-CARBONE	French Government	Carbon reduction	Public or private organizations (reduction projects)	Third-party
CO2 NEUTRAL	NEPCon	Certify net zero emissions	Companies or products	Third-party required for the entire neutrality process
CARBON NEUTRAL	CFP Ltd.	Certify net zero emissions	Organizations, products, services and events	Third-party required for the entire neutrality process
CARBON NEUTRAL QUALITY MARK	Quality Assurance Standard	Certify net zero emissions	Organizations	Third-party required for the entire neutrality process
CERTIFIED CARBON NEUTRAL	Verus Carbon Neutral	Certify net zero emissions	Organizations, products, sites, transportation, and businesses	Verification by the label owner
CLIMATE NEUTRAL	Climatepartner	Certify net zero emissions	Companies, products, packaging, websites and printing	Third-party required for the entire neutrality process

SOURCE: Acampora A., Mattia G., Pratesi C.A. and Ruini L. 2020 Investing in Carbon Neutrality in the agrifood sector: challenges and opportunities in a dynamic setting. Unpublished background paper prepared for this report, Carbon Neutrality Lab. Roma Tre University.

Chapter 3
Carbon neutrality in practice: complex governance, need for harmonization and settling the bill

The aim of this chapter is to provide an overview of the application of carbon neutrality concepts and labels in practice. The chapter describes ongoing efforts by agrifood companies towards carbon neutrality, showing how these efforts differ considerably in their scope and achievement. Efforts towards carbon neutrality and greenwashing concerns reflect a newfound reality; consumers, investors and governments want companies to tell their green stories and possibly prove them. However, the chapter explains how only some companies use independent third-party verification to certify their carbon-related commitments. The limited uptake of third-party verification is partly due to the lack of harmonization across standards and methodologies, which may undermine the credibility and legitimacy of companies and labels involved, heightening the risk of greenwashing. Furthermore, the lack of harmonization is shown to negatively impact the financing prospects for carbon neutrality, as investors, consumers and governments call for better harmonization and more transparent governance of carbon neutrality standards to inform their purchasing decisions and investments.

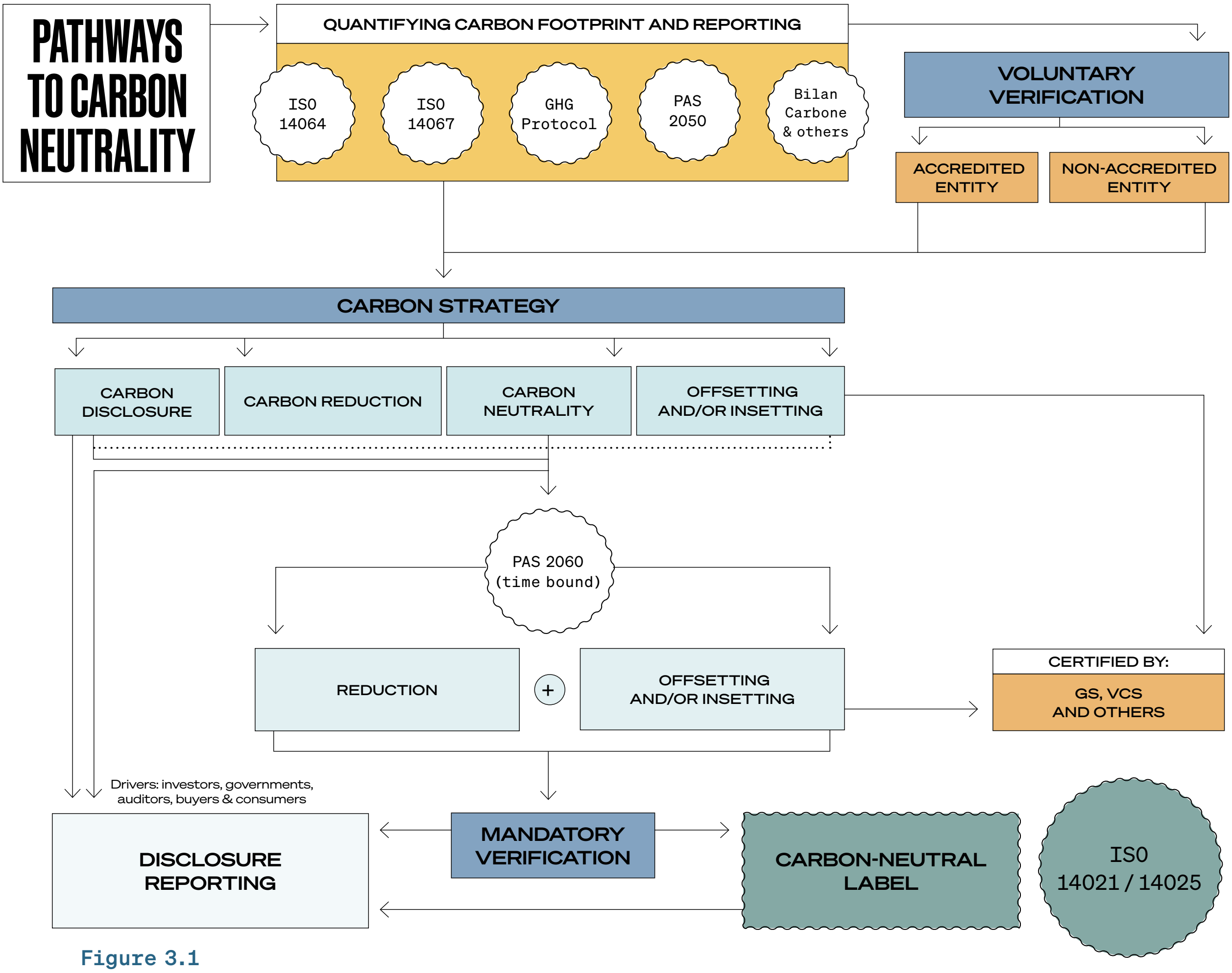


Figure 3.1
Strategies to pursue carbon neutrality

SOURCE: Authors' own elaboration.

3.1 GROWING INTEREST AND MULTIPLE CARBON NEUTRALITY PATHS

As they attempt to tackle carbon emissions, agrifood businesses follow different strategies. Figure 3.1 provides a generic workflow for these carbon neutrality strategies. Some businesses stop at the very top of the workflow, only pursuing CFP and voluntary certification. Other businesses go the extra mile, developing a carbon strategy comprising reduction, offsetting and insetting targets and related actions. As described in Chapter 4, drivers and resulting strategies can also differ depending on the size of the company and its role in agrifood systems (a smallholder farmer *vs.* a large agribusiness or a food retailer), the scope of operations (national level *vs.* a multinational business) and the subsector in which the enterprise operates (for example, tea vs. meat). Overall, a multitude of strategies exist and these are only some of the aspects that can condition which path to carbon neutrality is adopted and the extent to which selected strategies are pursued and combined. The subsequent sections outline some of the possible strategies adopted by agribusinesses and retailers, highlighting the number of approaches that can be pursued.

As a first step, agribusinesses may focus on measuring and certifying CFP measurements. For instance, the Kingsmill Bread company, which is owned by Allied Bakeries, was the first UK bread brand to certify the CFP of its bread products (Willis, 2011). Launched in 2008 and supported by a carbon reduction company, Sustain, the assessment was developed in accordance with PAS 2050 and certified by the Carbon Trust (Willis, 2011). Three sub-brands constituting 80 percent of Kingsmill's sales volume were subjected to the assessment and certification (Willis, 2011). However, the sales volume subjected to CFP certification, varies from company to company. Some companies focus on certifying a large share of their sales volume, while others exert efforts in fully certifying the footprint of individual product lines and brands. As elaborated throughout Chapter 4, the drivers for certifying CFP measures will differ and can include regulatory pressures, shareholder demands, opportunities to gain a competitive advantage and the fact that more service providers are certifying CFPs in a cost-efficient manner. Nonetheless, certifying Scope 3 and upstream emissions can be operationally challenging and require significant investment and therefore, certified footprints for these types of emissions are less common.

To achieve carbon neutrality, some companies focus on directly reducing emissions. For instance, Project Gigaton is a Walmart initiative to cut one billion metric tonnes (a gigaton) of GHG from the global value chain by 2030 (Walmart Sustainability Hub). Under Project Gigaton, suppliers can take their sustainability efforts to the next level through goal-setting and receive credit from Walmart for the progress they make. Since the program was introduced in 2017, hundreds of Walmart suppliers have come on board by committing to reduce emissions. Similarly, Heineken in 2018 announced its 'Drop the C' program for reducing CO2 emissions in line with the SBTi and a company-wide CFP using the GHG Protocol was developed (Heineken, 2018). With Drop the C, the company aims to grow its share of renewable thermal energy and electricity in production from the current level of 14 percent to 70 percent by 2030 (Heineken, 2019). Other key targets of the program include lowering emissions in production by 40 percent compared to 2008 levels and by 20 percent in distribution in Europe and the Americas (Heineken, 2019). According to Heineken's 2019 sustainability report, progress on only some of the Drop the C targets is on track (Heineken, 2019). For instance, Heineken exceeded the target of reducing production level emissions by 40 percent compared to 2008 levels, achieving a 49 percent decrease in CO2 emissions in 2019 (Heineken, 2019). The company also states that it is on track to increase the share of renewable energy, with 19 percent of energy coming from renewable sources in 2019 (Heineken, 2019). However, the company has yet to achieve a 20 percent reduction in emissions from distribution in Europe and the Americas and in 2018 a 13 percent reduction compared to 2008 levels was reported (Heineken, 2019). The company relies on the Global Reporting Initiative (GRI) to support data collection and reporting efforts and on the Carbon Disclosure Product (CDP) to score and benchmark sustainability performance against other companies (Heineken, 2020). Although a number of companies are directly reducing emissions, a lack of uniformity in terms of the extent and scope of reduction initiatives can be observed. Some companies target only Scope 1 and 2 emissions, while others attempt to reduce and offset emissions across their entire value chains.

As an entry point to achieving carbon neutrality, agribusinesses may focus on offsetting emissions. A notable example of companies offsetting emissions rather than reducing them includes Flinders + Co., an Australian food service meat distribution company. In 2018, Flinders + Co became the first meat company globally to fully offset all carbon emissions from every kilogram of meat the company sells (Carbon Reduction Institute, 2018). The company has chosen an offsetting strategy, because although it recognizes that consumers are increasingly showing interest in carbon neutrality, this has yet to translate into price premiums (Carbon Reduction Institute, 2018). Flinders + Co purchases non-local carbon credits to offset the impact of their business from projects that have been certified by the Voluntary Carbon Standard and the Gold Standard (Carbon Reduction Institute, 2018). The company has ambitions to inset, but deems that local credits are currently too costly. Furthermore, in the long-term, Flinders + Co aims to encourage their suppliers to reduce emissions by sending price signals upstream in the supply chain (Meat & Livestock Australia, 2019).

Some niche companies that specialize in responsible food production are moving towards carbon neutral or even carbon positive targets. For instance, the food company Alter Eco specializes in the production and sale of fair trade and responsible chocolate-based products. The company is certified by the Climate Neutral Certified Standard and in 2019 Alter Eco's footprint was 3 964 tCO2eq (Alter Eco, 2020). Every year, to offset and inset their carbon emissions, Alter Eco works with its cacao producing partners to reforest the San Martín region of Peru. According to the company's reporting, Alter Eco farmers are now cultivating high-quality cacao while strategically planting native and high-value trees within their cacao fields to naturally sequester carbon and maintain the microclimate necessary for successful cacao cultivation. The company also claims that the emissions from supply chain practices that cannot be inset are being offset through tree planting and protection, as well as sustainable agroforestry practices.

However, a carbon neutrality agenda is also pursued by companies that do not necessarily market the limited environmental impact of the products they sell or cater to niche markets. Wasa, a brand owned by the Barilla s.p.a. group, became carbon neutral in 2018 according to the PAS 2060 (Scope 1, 2 and 3) standard, while the group continues to invest in sustainability and in reducing its overall CFP (Wasa, 2019). Another example of an individual product line that has carbon neutrality ambitions, but is sold by a company that does not necessarily cater to a niche market, is Pukka Herbs, which was acquired by Unilever in 2017. Pukka Herbs has been pursuing a carbon neutrality agenda prior to the Unilever acquisition and in 2016 the company publicly committed to setting science-based targets in its goal to become carbon neutral. The SBTi targets include reducing Scope 1 and 2 GHG emissions 100 percent by 2030 from 2017 base-year (Carbon Intelligence, 2019). The company also aims to reduce its Scope 3 GHG emissions from crop to cup to 50 percent per million units of products by 2030 from a 2017 base year (Carbon Intelligence, 2019). These targets were signed off by the SBTi in 2018. The parent company of Pukka Herbs, Unilever, has also recently set the goal of becoming carbon neutral by 2039. Some key targets include the elimination of carbon emissions from its own operations and halving the GHG footprint of its product by 2030 (Unilever, 2020). Going forward, the company states that, among other initiatives, it will set up a system for suppliers to declare on each invoice the CFP of the goods and services provided (Unilever, 2020). Unilever also claims that it will actively develop partnerships with other businesses and organizations to standardize data collection, sharing and communication.

Furthermore, various retailers have concentrated on measuring their CFP and labelling products. For example, Tesco, Britain's largest retailer, started a project in 2007 to use CFP labels on more than 100 of its own-brand products, including pasta, milk, orange juice and toilet paper. However, in 2013 the project was terminated due to a low level uptake by consumers and the challenges related to processing LCA and CFP studies (Vaughan, 2012). Another example of a company measuring and labelling the CFP of its products is Groupe Casino, a French mass-market retail group. In 2008, Groupe Casino launched The Casino Carbon Index, which is a measure of the GHGs emitted during five key stages in the life cycle of each Casino brand product: production, manufacturing, transport from the field to the Casino warehouses, packaging from raw material extraction to recycling and distribution from the Casino warehouses to final point of sale. The CFP is expressed in terms of grams of CO_2 generated per 100g of product. The Carbon Index is only valid in France (further details are available in Chapter 5, which focuses on labelling).

While these experiences show that there is significant interest in carbon neutrality, they also show that there are multiple paths to carbon neutrality for agrifood companies. The scope, objectives and results achieved vary immensely. Some companies have gone 'all-in', in an attempt to carbon neutralize their brand and organization. In these cases, carbon neutrality often represents an additional element to the sustainability strategy of the group. Others have worked to achieve carbon neutrality for certain product lines, services or events. These paths differ because of different objectives, operational constraints, know-how, as well as type and complexity of value chains. Table 3.1 provides some examples of different companies that illustrate such diversity. It should be noted that beyond third-party verification, best practices in transparency levels are subjected to interpretation. Regarding levels of effort and investment in carbon neutrality, it is important that these efforts are compared on a like-for-like basis. For instance, it is often simply assumed that companies directly investing in insetting and reducing emissions are more committed to achieving carbon neutrality than companies that employ offsetting strategies. This is not always the case because of the number of variables involved. In understanding the choices made by different private sector actors (from smallholder farmers to large agribusinesses and retailers) in terms of carbon neutrality paths to take (or not) several factors need to be considered. These include the nature of the subsector and complexity of the supply chain, which condition how difficult it may be to become carbon neutral. The conditioning factors may also include the ownership structure, the size of the enterprise, its ability to internalize some of the benefits from carbon neutrality investments (for example through improvements in operating performance), the regulatory context, as well as other external and internal factors that directly impact the incentive structure facing agrifood system actors. It can therefore be argued that to date, no defined or best-in-class pathway to carbon neutrality exists and that companies are driven by context and company-specific factors when determining a strategy for carbon neutrality. For further details on these drivers, please see Chapter 4.

EXAMPLES OF CARBON NEUTRALITY EFFORTS AND ACHIEVEVMENTS FOR SELECTED AGRIFOOD COMPANIES

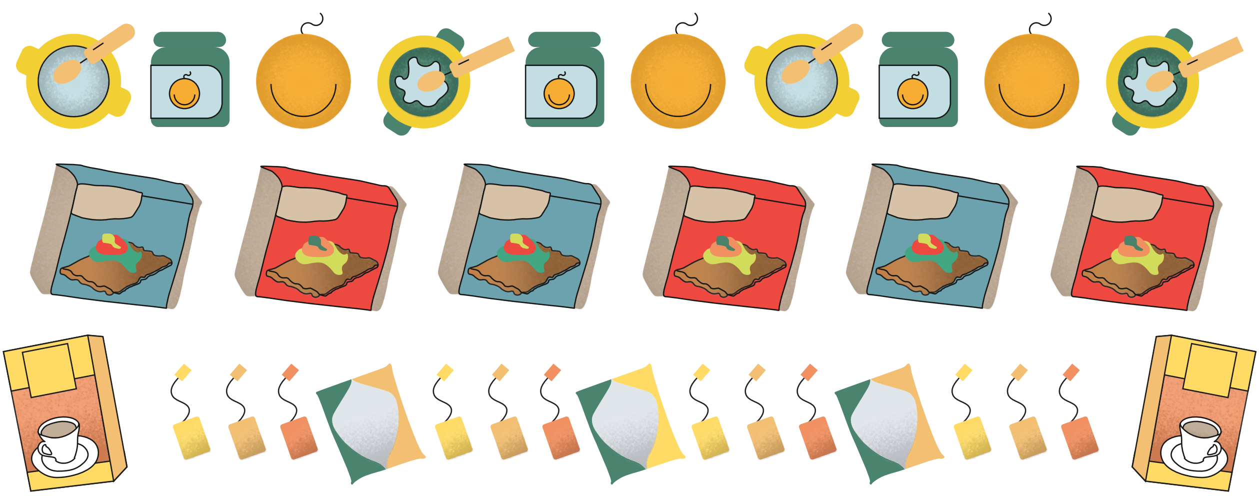
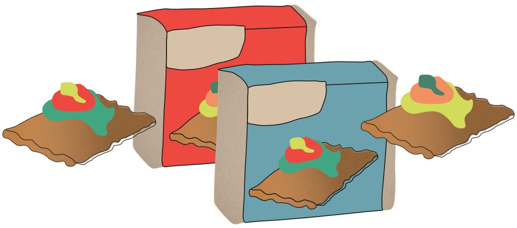


Table 3.1
Examples of carbon neutrality efforts and achievements for selected agrifood companies

The list represents a small selection of the companies which have disclosed their carbon neutrality information (process, standard, data, certifications) online.

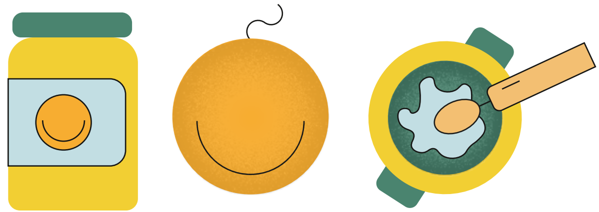
SOURCE: Acampora A., Mattia G., Pratesi C.A. and Ruini L. 2020 Investing in Carbon Neutrality in the agrifood sector: challenges and opportunities in a dynamic setting. Unpublished background paper prepared for this report, Carbon Neutrality Lab. Roma Tre University.

WASABRÖD
SCANDINAVIAN STYLE CRISP BREAD



Scope of carbon neutrality	Scope 1, 2, 3
Country	Italy
Ownership	Barilla SPA
Revenue	EUR 3.6 billion (Barilla SPA 2019 revenue) (Barilla, 2019)
CFP measurement	GHG protocol; ISO 14064; ISO 14025; third-party verification; 71 percent of volume produced covered by LCA analysis; 66 Environmental Product Declarations (compliant with ISO 14025) published covering 69 percent of 2018 production
Carbon neutrality standard	DNV – GL, third-party certification for PAS 2060:2014
Reduction strategy	**Reduction:** energy saving programs, green logistic projects, and purchasing Renewable Origin (GO-Guarantee of Origin) electricity for manufacturing plants. From 2010-2019 Barilla has reported a 21 percent reduction in water consumption and a 30 percent reduction in CO2 emissions compared to 2010
Offset strategy and certification	**Offsetting:** Peruvian Madre de Dios REDD+ project, labelled by VCS and the CCBA; Indian solar project – multisite – also labelled by VCS
Label	Co2 Compensated Private label

HOLLE
BABY FOOD

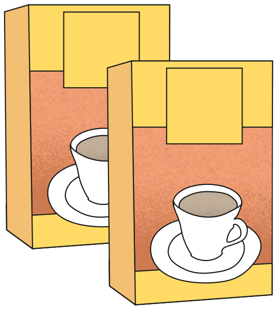


Scope of carbon neutrality	Baby formula products (since 2013); milk cereals and baby porridges (since 2014); goat milk (since 2016) Scope 1, 2, 3
Country	Switzerland
Ownership	Holle Baby Food AG
Revenue	CHF 47.8 million (2019 revenue) (Holle, 2020)
CFP measurement	GHG Protocol, measurement undertaken by a third-party measuring emissions from field to shelf
Carbon neutrality standard	CO2 reduction projects are certified by TÜV Nord Cert GmbH
Reduction strategy	**Reduction:** reducing material used in packaging; use of solid cardboard with a high proportion of recycled material (between 85 and 95 percent); reducing energy use and using renewable energy; installing solar panels on buildings; optimizing transport through IT software to reduce emissions
Offset strategy and certification	**Offsetting:** since 2013 claims to have been offsetting emissions from the production of baby formula products by supporting Soil & More's compost projects in Egypt and South Africa
Label	Co2 Neutral Private label

PUKKA
HERBAL TEAS

Scope of carbon neutrality	Scope 1, 2
Country	United Kingdom (Unilever is listed on the London Stock Exchange)
Ownership	Unilever
Revenue	EUR 52 billion (Unilever 2019 revenue) (Unilever, 2020)
CFP measurement	Unclear; second-party party verified by Carbon Footprint Ltd. according to ISO 14064 Part 3 (2006)
Carbon neutrality standard	CFP standard; Carbon Neutral Organization à Private standard; second-party verification
Reduction strategy	**Reduction:** Pukka has committed to reduce absolute Scope 1 and 2 GHG emissions 100 percent by 2030 from a 2017 base-year; reduce Scope 3 GHG emissions from crop to cup to 50 percent per million units of products by 2030 from a 2017 base-year (Science Based Target validated)
Offset strategy and certification	**Offsetting:** claims to offset total operational emissions, plus a few additional measures including staff commuting; offset volume reported in 2018 was 2294 tCO2eq; purchased VCS-certified offsets to support forest conservation in the Amazon rainforest; and Pukka also plants trees in southwest England
Label	Carbon Footprint Ltd.

DILMAH
TEA



Scope of carbon neutrality	Scope 1, 2, 3
Country	Sri Lanka
Ownership	MJF Holdings Ltd.
Revenue	RS 10.13 billion (2018/2019 revenue) (Dilmah, 2019)
CFP measurement	GHG Protocol
Carbon neutrality standard	N/A
Year project started	2013
Reduction strategy	**Reduction:** energy efficiency measures in plant operations and in transportation; substitution of fossil energy with renewable energy; recycling of waste
Offset strategy and certification	**Offsetting:** offsetting UNFCCC Clean Development Mechanisms (CDM)
Label	Private label

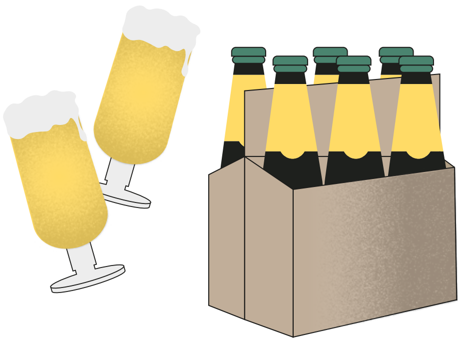
EVIAN
BOTTLED WATER

Scope of carbon neutrality	Scope 1, 2, 3
Country	France (Danone is listed on Euronext Paris)
Ownership	Danone
Revenue	EUR 25 billion (Danone 2019 revenue) (Danone, 2019)
Year project started	2008
CFP measurement	LCA of a bottle of Evian
Carbon neutrality standard	PAS 2060: after announcing the ambition in 2015, Evian® previously achieved carbon neutrality in the United States of America, Canada, Germany, Switzerland and at its bottling site; in April 2020, the company was certified carbon neutral across all the countries where the brand has a presence
Reduction strategy	**Reduction:** reported the reduction of total industrial energy consumption by 25 percent per liter of Evian between 2008 and 2017. Company has communicated the following reductions: investment in a bottling site, which is powered entirely by renewable energy and certified by ISO 50001 and ISO 14001; shifting towards lower carbon logistics, including the use of one of the largest private railway stations in France (75 percent of Evian's volume is shipped directly by train from the plant to harbors because trains produce 10x smaller footprint than trucks), and increasing the proportion of recycled content in packaging globally, moving from 25 to 50 percent across the range today to 100 percent by 2025
Offset strategy and certification	Company claims that emissions that are not directly reduced are offset with the support from the Livelihood Carbon Fund, which Danone co-founded in 2008. The fund planted nearly 130 million trees to capture carbon emissions naturally
Label	Carbon Trust label

MARKS AND SPENCER
MULTINATIONAL RETAILER

Scope of carbon neutrality	Scope 1, 2
Country	United Kingdom (Marks and Spencer is listed on the London Stock Exchange)
Ownership	M&S
Revenue	GBP 10.2 billion (2020 revenue) (M&S, 2020)
Year project started	2012
CFP measurement	GHG Corporate Reporting and Accounting Standard
Carbon neutrality standard	PAS 2060
Reduction strategy	**Reduction:** in June 2017 M&S published a Science Based Target Initiative-approved goal to reduce absolute Scope 1 and 2 GHG emissions 80 percent below the company's 2007 levels by 2030, and has a longer-term vision to achieve absolute emissions reductions of 95 percent below 2007 levels by 2035. M&S intends to be a net zero Scope 3 business across its entire supply chain and products by 2040
Offset strategy and certification	**Offsetting:** offsetting with credits certified by VCS and Gold Standard
Label	Carbon Trust label

CARLSBERG
BREWERY



Scope of carbon neutrality	Scope 1, 2 Breweries by 2030
Country	Denmark
Ownership	Carlsberg Foundation
Revenue	DKK 65.9 billion (2019 revenue) (Carlsberg Breweries Group, 2019)
Year project started	2015
CFP measurement	CFP analyses undertaken with guidance from the Carbon Trust
Carbon neutrality standard	N/A
Reduction strategy	**Reduction:** Carlsberg reports it has reduced carbon emissions at its breweries by 30 percent since 2015, with five of its sites already carbon-neutral by the end of 2019; and that it has also reduced its relative emissions by 13 percent since 2015. Working with SBT, Carlsberg has set the following targets for 2030: zero carbon emissions at its breweries (including a 50 percent reduction by 2022 versus 2015), and a 30 percent reduction in emissions across its full value chain (including a 15 percent reduction by 2022)
Offset strategy and certification	Reported the 100 percent use of renewable electricity at all sites in western Europe; 52 percent of electricity usage in China covered with International Renewable Energy Credits (I-RECs)
Label	Carbon Trust label

3.2 THIRD-PARTY VERIFICATION: WHY COMPANIES ARE PURSUING IT AND WHY NOT

As with other sustainability-linked efforts, carbon neutrality is gaining some traction among agrifood companies as a tool to improve their environmental footprint and business performance. Since the early 2000s, some agrifood companies have started to certify their products or services and, to a lesser extent, their whole organizations in relation to all or some of the steps of the carbon neutrality process. More and more agrifood companies tend to certify their carbon neutral process. However, their proportion is still small compared to the total number of companies in the sector. For instance, desk research conducted for this report shows that out of 74 agri-businesses, 28 companies have publicly communicated carbon neutrality ambitions, while 13 companies are selling products with a carbon neutrality label. Furthermore, only 13 companies have relied on a third-party certification body to develop and verify CFP and reduction analyses. Lastly, only one company has fully certified its Scope 1, 2 and 3 emissions through a third-party (PAS 2060).

Companies that have pursued carbon neutrality and related certification have done so in an attempt to boost their credibility and climate-related claims. A third-party verification system can provide credibility and transparency to a company's efforts and provide a calculation framework to guide the carbon neutrality process. For example, the Science-Based Target Initiative helps companies chart their carbon trajectory calculation and set up reduction activities using a coherent set of concepts and definitions. Moreover, the third-party verification procedures combined with an effective communication strategy may help companies to independently validate their processes, strengthening the credibility of their 'green' claims. For instance, compared to internal reduction and insetting practices, offsetting is typically subjected to rigorous third-party verification, depending on the issuing standard. It can therefore be argued that offsets issued by recognized standards can contribute to enhanced visibility and create awareness. For further details on this, please refer to Chapter 3.3.

At the other end of the spectrum, there are many reasons why companies choose not to pursue carbon neutrality through a full process including third-party verification. First, some companies developed their own in-house logos as promotion tools. Second, companies may find that labels do not provide clear and unequivocal information on the type of emissions, and that the lack of a globally accepted framework undermines the credibility of any third-party certification. Third, there is a possible mismatch between a company's strategic priorities and marketing strategies and the focus of the labels. For example, some agrifood companies aim to assure a no deforestation supply chain, while others want to lower their carbon emissions or become fully carbon neutral. This means that in practice companies may decide not to invest in a carbon neutrality certification process because it does not align with their corporate social responsibility strategy. Finally, cost may also act as a barrier especially for small producers and small and medium enterprises (SMEs) with fewer resources and less developed management information systems. In addition, cost is more of a deterrent for agrifood companies operating in value chains that are particularly complex and where tracking and reducing Scope 3 emissions can be a costly endeavor. For further details on costs across the various steps of achieving carbon neutrality and for different company sizes and sectors, please see Chapter 3.7. Please refer to Chapter 4 for some of the barriers and challenges that SMEs and smallholders face in becoming carbon neutral.

3.3 LACK OF HARMONIZATION HEIGHTENS RISK OF GREENWASHING AND FAILS INVESTORS AND CONSUMERS

Is carbon neutrality a new greenwashing opportunity?

As hype around carbon neutrality grows and certification standards and approaches proliferate, so does the risk of greenwashing. Greenwashing happens when a company intentionally misleads or deceives consumers with false claims about its environmental practices and impact (Terrachoice, 2010). In today's world of climate change and increasing concerns about emissions, there is a risk that companies may market rather than implement carbon neutrality strategies and actions to appease customers or regulators. Greenwashing has come to the fore in other industries and to different degrees; one of the most famous cases is the diesel-gate or emissions-gate scandal that rocked the automotive industry (European Court of Auditors, 2019). Media coverage on greenwashing and related consumer perceptions may undermine efforts by genuinely committed agrifood system players to reduce GHG emissions.

There are several reasons why carbon neutrality and in particular carbon offsetting can be perceived as greenwash even when no intentional action is behind it (Birkenerg and Birner, 2018). First, the existence of multiple terms and definitions, such as zero carbon, carbon neutral, carbon free and climate neutral confuses consumers and regulators. Lack of transparency on how carbon reductions were achieved and where and how carbon credits were purchased are a second set of reasons undermining public understanding and perception of carbon neutrality. Third, confusion arises from the absence of comparable standards and databases for measuring carbon reductions and offsets and the extent to which measurement and certification processes are reliable. Finally, carbon offsetting projects are usually questioned because of double-counting issues and the unintended negative social and environmental impacts of carbon sequestration interventions. Box 3.1 elaborates on some of the challenges related to double-counting and management of trade-offs in achieving carbon neutrality.

Greenwashing is a real threat on the path towards carbon neutrality, as it can distort perceptions and undermine efforts. The threat is valid both for companies taking a corporate approach to carbon neutrality (aiming to certify the whole company) or just focusing on a product. For example, companies trying to label their products as carbon neutral may be undermined by consumer skepticism regarding the reliability of such labels and related carbon neutrality efforts. In addition, investor confidence on environmental reporting by companies may also be disrupted, which could potentially lead to lost financing opportunities for agrifood system players.

The practice of offsetting has caused debate, as some view it as a greenwashing, while others deem that it can contribute to enhanced visibility and awareness. One key dimension of carbon neutrality, carbon offsetting, has often been seen by consumers and investors alike as a greenwashing practice and is generally perceived with skepticism (Polonsky, Grau and Garma, 2010). This criticism regarding carbon offsets has led to the diffusion of the phrase 'buying your way out of the guilt' (Hobbes and Kilvert, 2020). Offsetting has also been criticized as a way for companies to pay to pollute rather than adjusting their production to more eco-efficient solutions and to reduce their emissions (Hyams and Fawcett, 2013). Although offsetting has long been associated with the concept that companies are buying their way out of their obligations, some research suggests otherwise. For example, research conducted by the Ecosystem Marketplace shows that companies who integrate offsetting into their overall carbon-management strategies and rely on offsetting for emissions that cannot

Box 3.1

CHALLENGES IN CARBON ACCOUNTING

Some analyses assume that the same land or biomass required to fulfil one set of needs is also available to meet another set of requirements. For instance, it has commonly been perceived that potential and marginal croplands (i.e. forests and savannas) can be utilized to generate bioenergy, without considering the values of biodiversity and carbon storage that these lands are currently providing. GHG bioenergy savings are often attributed to carbon absorbed by plant growth as an offset for burning biomass, even though the plant growth would have occurred anyway and removed carbon from the atmosphere. Furthermore, utilizing mulch to enhance carbon soil levels can lead to the double-counting of carbon, which would have contributed to carbon storage elsewhere. Using crop residues to enhance soil quality, which would have otherwise been used for animal feed, implies that other sources need to be considered to produce the feed. This often translates into larger carbon costs because it requires more agricultural land to grow the feed. Importantly, risks of double-counting for a given project focusing on deforestation or the implementation of sustainable agricultural practices, can be driven by who is reporting the emissions reductions, be it the company that has invested in the reduction and/or offsetting practices or the government in its achievement of NDCs, as these stakeholders may have differing incentives. Another important trade-off that deserves merit is the notion of utilizing grazelands for reforestation purposes, as this will have a cost on food production required to meet growing demand. Consequently, large-scale reforestations will most likely require significant reduction in food demand and large increases in agricultural productivity and yields. Overall, land should be treated as a fixed and limited resource. Therefore, to meet the growing demand for food and carbon storage, demand and production efficiencies need to be achieved (WRI, 2018).

be reduced or priced internally, typically spend more than ten times more on climate change efforts, compared to a company that does not offset (Ecosystem Marketplace, 2018). Furthermore, compared to internal reduction and insetting practices, offsetting is typically subjected to rigorous third-party verification, depending on the issuing standard. It can therefore be argued that offsets issued by recognized standards can contribute to enhanced visibility and create awareness. Nonetheless, it is important to note that some research suggests that carbon offsetting is not designed to reduce net amount of emissions in the atmosphere, but rather that it is designed to avoid increasing net emissions. This means that for every tonne removed, a tonne is emitted elsewhere (Brink, 2021). Proponents of this argument do not deem that offsetting can be used as a means to achieve net zero emissions and that offsetting should not be used to allow the continuous burning of fossil fuels (Brink, 2021).

While greenwashing is risky and distortive, it can raise awareness about carbon neutrality in the short-term. Claims about environmental sustainability, even if they are false, may still contribute to raise awareness about the issue and, over the long-term, might push companies towards more sustainable practices.

As doubtful as many 'green' adverts look, they signal appetite and awareness for a new green revolution among consumers which is increasingly being picked up by agrifood actors.

3.4 OPERATIONALIZING DEFINITIONS AND STANDARDS IN AGRIFOOD SYSTEMS REMAINS A CHALLENGE

Achieving carbon neutrality hinges heavily on accurately measuring CFPs, particularly Scope 3 emissions. While the approaches described here allow for measuring emissions of agrifood system actors, they have not been designed specifically for agrifood systems. This means that there are serious limitations to the carbon inventories for agrifood systems produced with traditional LCA methods, as these methods do not comprehensively assess some aspects that are critical for long-term sustainable food production (Notarnicola *et al.*, 2017). Some of these aspects include the multi-functionality of biological systems, ecotoxicity-related impacts, soil fertility and structure, dietary shifts, consumption patterns and food waste (Notarnicola *et al.*, 2017). Broadly, quantifying Scope 1 and Scope 2 emissions in agrifood systems is easier than quantifying Scope 3 emissions. Scope 3 emissions are difficult to quantify because of the absence of temporally and geographically focused data and the difficulties in accounting GHG emissions and removals for yields, fertilizers and pesticides. Increasing and improving carbon disclosure and environmental reporting along supply chains could make it easier to estimate Scope 3 emissions. In this regard, initiatives such as the Carbon Disclosure Project, a nonprofit organization that runs a global disclosure platform for investors, companies, cities, states and regions can help build up the necessary databases.

Lack of reliable and up-to-date inventory data on food production and processes is a key challenge for realizing accurate CFPs. Several databases have been developed, but most of them are characterized by a lack of transparency and they are often incomplete because they take into account only a few input-output flows (Notarnicola *et al.*, 2017). Furthermore, these databases are often outdated and not regionalized. Finally, the databases are often inconsistent with each other, because of their different approaches and assumptions. An example of this is the inconsistency between emission inventory modelling and impact assessment of pesticides (Rosenbaum *et al.*, 2015). In fact, there are various debates on how pesticides should be modelled, with the consensus being that primary flows to soil, air and water should be included in the life cycle inventory (LCI) (Rosenbaum *et al.,* 2015). However, efforts are underway to improve the transparency and standardization of LCA databases, such as the Global LCA Data Access network (GLAD) which aims to achieve better data access and interoperability.

When data is available, it is often not at the spatial and temporal resolution needed to provide an accurate representation of complex agricultural practices. Agricultural management decisions with direct impacts on emissions, such as land management or fertilizer application, typically change depending on the temporal and spatial scale considered. Yet, current data available in food LCA databases and life cycle impact assessment (LCIA) models, is mostly non-spatially and temporally resolved (Hauschild *et al.*, 2013). In practice, the lack of detailed data may lead to the usage of assumptions and approximations when developing LCIAs. Such problems also emerge clearly from stakeholder interviews conducted as part of this report. For instance, a global beverage producer claimed that the company mainly relies on statistical data, rather than field level data. The beverage producer primarily purchases emission factors per raw material used in each supply chain by country, from a consultancy firm. These emission factors

Box 3.2

PRACTICAL CHALLENGES IN ESTIMATING EMISSIONS – THE CASE OF THE LIVESTOCK SECTOR

LCAs for livestock often omit soil and biomass carbon sequestration potentials. Pastoralist systems, which are usually known to have high emission intensities (per kg of product), can actually become neutral, when the balance is calculated on an ecosystem level and if grazing is managed sustainably (Assouma *et al*., 2019a). It can be argued that emissions from pastoral systems have been over-estimated because of a lack of references on actual feed intakes and by assessing livestock emissions without assuming an ecosystem perspective. However, there is a growing area of work related to improving references for existing pastoralist systems to adjust for emission factors and also to account for the entire ecosystem (Assouma *et al*., 2019b, Assouma *et al*., 2018). While potential for carbon sequestration in the world's grasslands and rangelands is significant, more needs to be done to better estimate its longevity, including under different management practices and production systems. Another limitation to current GHG estimates for livestock is the fact that emissions are often estimated with an allocation method to the final product, for instance to meat, milk or eggs. Partly due to the lack of data, no emissions are usually allocated to by-products or co-products such as edible offal, blood, substances used in medicine (e.g. heparin) or leather and material used for pet food. Reportedly, the CFP of meat, milk or eggs would be lower if part of their emissions were allocated to these by- and co-products (Opio *et al*., 2013).

are then multiplied by the actual volume of raw material purchased. Similarly, a Fast-Moving Consumer Goods (FMCG) company stated that it mainly relies on industry averages when developing LCAs. Given that assumptions and approximations are plausible and justifiable, such approaches can be cost- and time-efficient. Also, the way approaches are applied matters; they can be used conservatively in estimating emissions, thereby reducing the risk of miscommunicating results. Overall, this is a key debate in carbon neutrality today. Greater standardization and simplification of methodologies and protocols would increase reliability of approaches (often involving approximations and assumptions) and help provide a clearer path to agrifood system players for lowering GHG emissions. This is discussed extensively throughout this report.

The spatial variation in agricultural practices and food production is challenging to capture in LCA methods and databases. Spatial variation is a characteristic of agrifood systems, where there is potential for considerable variability between agrifood actors and also within them. Some of the aspects that underly this variability include different management practices – crop and wood residue management, soil tillage, soil amendments and application of fertilizers and irrigation – soil types and climates, seasonality, the life cycle of perennial crops. Other factors include the distances – and related transportation modes – between locations of activities in the product value chain. More challenges in estimating emissions specific to the livestock sector are highlighted in Box 3.2. For example, the impact of land cover and land use changes on emissions may change depending on the soil types considered, the climate and the extent of soil erosion. This spatial variability is seldom considered in LCA databases and models, which tend to adopt blanket figures from global inventories, often not including land cover changes and other aspects in the calculations (De Rosa, 2018). However, the lack of accurate and spatially variable data can be overcome through consensus, clarity and a common understanding on the assumptions and methodologies utilized, as well as the steps required to update the models employed. For further information, please see Chapter 7 – The Road Ahead.

The end-of-life and industrial phases are often omitted in agrifood system emission assessments. In LCAs the end-of-life phase is often omitted, thus excluding an important means of making more complete the evaluation of emissions arising, for example, from improper disposal of lost and wasted food. For instance, an analysis on Dongshan tea shows that electricity use during water boiling in the consumer use phase can account for up to 45.5 percent of the CFP (Hu *et al*., 2019).[17] Other examples of the share of emissions from the consumer use of tea include 51 percent of the emissions for Darjeeling tea[18] and 85 percent for Kenyan tea,[19] with the latter emissions doubling when the amount of water boiled is doubled (Chichorowski *et al*., 2014; Azapagic *et al*., 2016). For commodities, where the majority of emissions arise from consumer use practices, these emissions are often not accounted for, as it is challenging for companies to control and influence these. For instance, Unilever recognizes that consumer use constitutes on average two-thirds of the CFP of its products and has set the ambitious target of halving consumer-based emissions (Unilever, 2020).[20] Furthermore, for many supply chains a grey area exists with regard to the industrial phases of food production, as companies are often not willing or able to track and therefore release information about their industrial processes. This is especially applicable to Scope 3 emissions, which can include emissions from inputs used in production and processing phases, as the ownership of these emissions is not always clear between suppliers and companies. Assumptions and estimates may therefore have to be made which do not reflect the reality of the processing system under analysis. However, the increasing emphasis on the circular economy, particularly recycling and waste management approaches, may favor improved accounting of the end-of-life phase.

17 For this study, the point of production of Dongshan Township (Yilan Country) in east Taiwan was considered, while final consumption takes place in Taipei, Taiwan. For the consumer use phase, tap water, boiling of water and wastewater contribute 3.207 CO2eq/kg from 10 g tea and 0.5 L water. The main source of carbon emissions in the tea product life cycle is electricity consumption from boiling a pot of water at 0.06 KWh using an electric kettle with grid electricity.

18 The functional unit of 1 kg loose black Darjeeling is considered and produced in West Bengal, India and final consumption takes place in Germany.

19 The functional unit is defined as 1 kg of dry tea and the tea is assumed to be produced in Kenya and consumed in the United Kingdom. The results suggest that the total impact of tea is equal to 12.45 kg CO2 eq./kg of dry tea for the large-scale and 12.08 kg CO2 eq./kg for the small-scale production, indicating that the scale of production does not influence the impact.

20 Unilever environmental targets (Sustainable Living Plan) are expressed against a baseline of 2010 and on a 'per consumer use' basis. This means a single-use portion or serving of a product.

When data is available, it is important that similar system boundaries and metrics are utilized to compare CFPs of similar and diverse foods from different LCAs. It is important to ensure that the same system boundaries and metrics are applied when comparing the CFPs of the same and different foods estimated from different LCAs. Though LCA is the most systematic and comprehensive method for assessing environmental impacts according to the IPCC, there is currently no life cycle estimate available for all types of food and for a diversity of production systems. This limitation makes comparison between different and related food groups challenging. In particular, the lack of harmonized methods is an obstacle to private sector investments in greening agrifood systems and to policy makers.

In terms of soil carbon stocks, reliable databases that present aggregated data for GHG emissions and soil carbon stock changes, are largely lacking (Bispo *et al*, 2017). This can be attributed to a number of challenges, as the accuracy levels in direct field measurements depend on: (i) achieving a sufficient sampling intensity depending on the variability and magnitude of carbon stocks (Smith, 2004); (ii) the magnitude of changes which impact the sampling intensity and required resampling frequency; and (iii) the accuracy of the actual analytical methods used for carbon stock determination (Paustian, 2020). Spatial variability at a field level often dictates the requirement of multiple samples to reach a sufficient sampling intensity. Additionally, typical change rates require re-sampling efforts to occur at an interval of five years or more to measure significant changes in stocks (Paustian, 2020). Analytical methods commonly require destructive sampling methods and laboratory analyses to ensure accuracy and applicability.

The costs to design and implement a SOC sequestration monitoring system will vary considerably. They depend on many factors: topography, spatial variability, minimum detectable changes, whether individual or composite samples are analysed, farm size and local laboratory costs, as well as labour costs. Access to functional local laboratories is fundamental in conducting soil sampling analyses. As an example, sampling costs range between USD 17 and USD 20 per hectare at a 143 hectare dairy farm in New Zealand (Mudge *et al.*, 2020). To illustrate the costs of measuring SOC stocks on a national level, let us consider the benchmark of USD 17[21] per hectare and apply this to the 4.7 million hectares of arable land in Ghana recorded in 2018 (World Bank, 2018). This would equate to USD 80 million or 1 percent of the agriculture, forestry, and fishing value added of around USD 12 billion in 2018 (World Bank, 2020) (at 2020 prices). Nonetheless, considering carbon's shadow price of USD 50 to USD 100 per tCO2eq-1 up to 2030 (World Bank, 2017), and the total approximate SOC stock of 5.4 million tonnes stored in the top 0–30 cm of soil in Ghana in 2018 (Owusu *et al.*, 2020), the economic value of sequestering carbon could exceed monitoring and measurement costs by USD 190 million to USD 460 million. It should be noted that, for broad-scale applications at the state or national level, the sampling intensity (samples/ha) to detect changes in SOC over a five- to ten-year period will be considerably lower than that required at farm-scale. Hence, monitoring costs per hectare can be expected to be significantly reduced by selecting a larger geographical unit as reference (Conant and Paustian, 2002). Nevertheless, it can be argued that direct measurement methods are still too costly to be used on a routine basis and it is recommended that these be used strategically (Conant and Paustian, 2002). More importantly, research has shown that aggregated data on a regional and subregional scale generates higher confidence and lower

21 This benchmark is hypothetical and does not consider a farm-level sampling intensity applied on a national scale.

uncertainty levels, reinforcing predictive capabilities on a meta-analysis level (Conant and Paustian, 2002).

Management practices change depending on context and geography, meaning that international databases often miss context-specific emission patterns. Spatial variability issues arise for emissions from the use of machinery where fuel consumption is dependent not only on hours of work but also on aspects such as tractor power and conditions, type of operation, terrain and soil conditions. When tractors rely on an optimal aggregation of agricultural equipment, soil compaction could be impacted less, leading to an optimized torque or amount of work that an engine can perform. However, low tractor loads require more passes on the same field and this can lead to higher fuel consumption for the same plot of land. On the other hand, large tractor loads can cause wheel slippage, which can damage the soil structure (Juostas and Janulevičius, 2009). Some research has demonstrated that a lower engine speed, rather than rate speed, can lead to 5 percent savings in fuel and reduce emissions related to fuel consumption (Juostas and Janulevičius, 2009). Furthermore, the application of a pesticide and fertilizer is not only dependent on the plant but also on on-site issues such as the type of soil, the weather conditions, the location of the water table. This means that it is not ideal to simply assume that a given quantity of pesticide and fertilizer will be used to generate a given quantity of produce. The amount of plant residues returned to soils as carbon inputs will also vary greatly within a field. Soil variability within a field will also determine site-specific carbon decomposition rates, which should be taken into account when measuring, estimating and projecting SOC changes. Specific to pastures and rangelands, factors that affect SOC include: grazing pressure, fertilization, droughts or floods, timing of grazing and association of species. Grazing successively by cows and small ruminants also stimulates regrowth because they target different species.

3.5 PROMISING INNOVATIONS CAN SIMPLIFY THE PRACTICE OF CARBON NEUTRALITY

Work is underway to produce new guidance on carbon emissions and removal related to land use. The GHG Protocol is a private international standard that establishes comprehensive global standardized frameworks to measure and manage GHG emissions from private and public sector operations, value chains and mitigation actions. The Greenhouse Gas Protocol, building upon the partnership between the WRI and the WBCSD, launched a process to develop new standards and guidance on how companies should account for land use change, bioenergy and carbon removal and sequestration in their GHG inventories. The draft guidance is expected to be available for review by the second quarter of 2021, followed by pilot testing throughout the end of 2021, with publication planned for 2022 (Greenhouse Gas Protocol, 2020). In addition, many public and international institutions (such as FAO and WWF) are also moving towards that direction. The IPPC in 2006, 2014 and in 2019 provided a series of guidelines for National Greenhouse Gas Inventories, specifically related to Agriculture, Forestry and Other Land Use (AFOLU) (IPCC, 2006; IPCC, 2014; IPCC, 2019). These guidelines present mathematical equations that relate data on land use and management to emission and storage factors to estimate fluxes. The methodology is based on a tiered approach depending on the scale and the quality of the data available (Bispo, 2017). Furthermore, a number of public farm-scale oriented MRV protocols and platforms have been developed, including the Australian Government Carbon Farming Initiative (Australian Government, 2021), the Alberta Government Conservation Cropping Protocol (expired 31 December 2021) (Alberta Government, 2021) and the United States Department of

Agriculture's (USDA) COMET, which is a farm GHG accounting system (USDA, 2021). However, each platform focuses on different productive systems and management practices that can influence SOC in specific geographical locations. This results in an outline of different models and timescales to quantify and monitor SOC.

New technologies can support quantification and monitoring of emissions and carbon soil stocks at various spatial scales. These include the usage of rapid, accurate and cost-effective technologies such as drones and sensors coupled with remote sensing and field-based infrared spectroscopic measurements to enable the frequent monitoring of various productivity indexes. Some examples are the Normalized Difference Vegetation Index (NDVI), Leaf Area Index (LAI), Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), Plant Phenology Index (PPI) and soil carbon data (e.g. the Global Soil Organic Carbon Map – GSOCmap)[22] on a large scale. However, remote sensing is not new and historically, it has been utilized by governments for a variety of purposes including understanding trends and forecasting (USDA Foreign Agricultural Service), but also as a cost-efficient means to implement policies (for example agricultural subsidies under the CAP). More recent government-led initiatives include MethaneSAT, which is a planned American–New Zealand space mission currently scheduled for launch in 2022 (Ministry of Business Innovation and Employment, 2021). The mission is designed to be an earth observation satellite that will monitor and assess global methane emissions to combat climate change. Specific to famers, the use of information gathered from remote sensing can serve as base maps in variable rate applications of fertilizers and pesticides as well as in mapping the health of ecosystems and their capacity to remove carbon from the atmosphere. Geospatial data allows farmers to identify issues before their negative impacts can be visually seen, thereby allowing farmers to treat only affected areas of a field. In the context of soil carbon stocks, remote sensing can support the collection of management activity data including tillage practices, crop types, crop cover presence, productivity levels and forest management performances. This management activity data can be used as inputs for data simulations and contribute to increasing accuracy of data collected on a local scale. Using satellite imagery products as covariates can also be used to predict SOC maps at various depths using point observations and satellite imagery products (Hengl *et al.*, 2017). Furthermore, combining direct measurements (at the plot scale) and modelling can greatly help defining the efficacy of different land management practices in enhancing SOC sequestration (Smith *et al.*, 2020; Minsny and McBratney, 2016). For instance, Verra VCS's Methodology for Improved Agricultural Land Management (VM42) combines soil sampling to estimate base SOC stocks and SOC modelling to monitor changes (Verra, 2020). Finally, remote sensing can support the MRV process of public and private carbon accounting from AFOLU and enhance the verification processes of ecosystem related offsetting schemes including those including smallholder farmers and rural communities (Porras *et al.,* 2016). While remote sensing and related technologies present a series of opportunities, further efforts are required to integrate spatial data layers into measurement systems in order to increase the accuracy levels of data collected on a local scale. It should be noted that remote sensing cannot entirely substitute the classic sampling methods and laboratory analyses required to establish SOC baselines, as these need to be

22 GSOCmap is the first global soil organic carbon map ever produced through a consultative and participatory process involving member countries that was prepared by countries under the guidance of the Intergovernmental Technical Panel on Soils and the Global Soil Partnership Secretariat.

BOX 3.3

ALTERNATIVE METHODS TO MEASURE SOIL ORGANIC CARBON STOCKS

An alternative to repeated measurements is to infer SOC stock changes from flux measurement (estimating a full carbon budget) (Smith *et al*., 2020). The measurements of the net balance of carbon fluxes exchanged can also be achieved by chamber measurements or by the eddy covariance method (Baldocchi, 2003). Recent developments in instrumentation (analyser performance and set-ups), data acquisition and processing (i.e. data loggers, software and quality assurance/ quality control checks) have greatly improved the reliability of estimates (Fratini and Mauder, 2014). Furthermore, new spectral methods for measuring SOC concentration and stocks are rapidly becoming available for direct point measurements in the field and in the lab and for the measurement of patterns at larger scales across landscapes and regions (Smith *et al*., 2020). The methods for measuring SOC concentration mainly rely on the reflectance of light on soil in the infrared region. Using a statistical model based on a spectral library, the soil carbon percentage can be predicted from spectral measurements of the unknown samples. Laboratory costs could be reduced by using fourier transform mid-infrared (MIR) diffuse reflectance spectroscopy for estimation of total carbon, organic carbon, clay content and sand fraction (Viscarra Rossel *et al*., 2006; Nuwan *et al*., 2018). Cost-efficient alternatives include in-field NIR (near-infrared) spectrometers for point measurements (Tang *et al*., 2019). New spectral methods may also offer the possibility to measure the extracted soil core in the field with NIR and active gamma radiation for (total) bulk density and, therefore, SOC stock estimations (Lobsey and Viscarra Rossel, 2016).

done at various soil depths. Some alternative measurement methods outlined in Box 3.3 may gain greater traction in supporting efforts to measure SOC stocks.

Furthermore, a variety of farm-level CFP calculators have been developed and are constantly being improved that can help farmers identify the main GHG emission sources along with possible reduction strategies (Tuomisto *et al.*, 2014; Sykes *et al.*, 2017). For example, the Cool Farm Tool is an open-source software integrating several globally determined empirical models in a GHG calculator. The software requires inputs at farm-level and has a specific farm-scale, decision-support focus (Hillier *et al.*, 2011). It has been used in a variety of initiatives to report progress in GHG emissions at farm-level. Furthermore, large companies and retailers are increasingly relying on the Cool Farm Tool to refine existing methodologies and GHG emission calculations. For instance, throughout the interviews conducted, a global beverage producer confirmed that it aims to select 500 pilot farms, where farmers will report on their data through the Cool Farm Tool. The field-level data collected will then be integrated into the company's emission calculation methodology. The main crops include barley, maize and sugar cane as these constitute 90 percent of volume purchased. The company selected farms from the top eight countries from which it sources. Furthermore, the company actively worked with its largest suppliers to identify the pilot farms and corresponding cooperatives to develop a protocol on sustainable farming practices and emission reduction measures. The cooperatives will assist the farmers in measuring their CFP under the new farming practices and compare emissions, on the plots of land where these practices have not been applied. The company expects to invest a total of EUR 5 million in the provision of three- to five-years of support per farm. During the interviews conducted, a global herbal tea producer also confirmed that it relies on data obtained from the Cool Farm Tool and Soil & More for the top 20 herbs that represent 80 percent of volume sourced. Nonetheless, some limitations of the Cool Farm tool include the fact that it uses a different set of algorithms to estimate nitrous oxide (N2O) emissions from fertilizers compared to IPCC 2006 or 2019 Guidelines. This could be a limitation in terms of harmonizing procedures and in integrating software in protocols that require IPCC methods to estimate emissions from this source. The Cool Farm Tool also uses the IPCC Tier 1 approach to estimate SOC changes, thus not contemplating site-specific soil and management factors to estimate CO2 emissions or removals from managed soils. Such limitations are valid to all GHG accounting tools, as there is no central guiding authority that recommends the use of IPCC methodologies. Furthermore, integrating IPCC Tier 2 methodologies will depend on the purpose of the tool, end-users and how the methodology will be compared against other tools and methodologies. Lastly, it can be argued that the Cool Farm Tool was designed to be applied at the farm-level and is therefore not as suitable for larger-scale initiatives (e.g. project evaluations) and currently, it is not designed to cover all types of production systems (e.g. pastoralist systems).

The usage of distributed ledger technology (DLT) such as blockchain and analytics to enhance the traceability and reliability of emissions data reporting, is gaining ground. The World Economic Forum's Mining and Metals Blockchain Initiative (MMBI) (Mine, 2021), established in October 2019 as the first test case for collaboration between mining and metals companies, has released a proof of concept that blockchain can track embedded GHG emissions. A supply chain recording carbon emissions onto a DLT can help by tracking various emissions on a single platform that is trustworthy, tamper-proof and immutable. This encourages accountability among the supply chain actors. Various implementations of DLTs have different energy consumptions, while consensus mechanisms used in bitcoin blockchain is energy intensive, others such as Corda or Fabric are much more energy efficient and this plays a major role in scalability of the initiative. Although blockchain has largely been under-utilized for tracking environmental data, KMPG recently announced the launch of a blockchain Climate Accounting Infrastructure (CAI) designed to enable KPMG's clients to more accurately measure and manage their GHG emissions (Ledger Insights, 2020). The solution was developed in response to the increased demand for companies to report on sustainability practices to meet ESG targets. To support emission data reporting efforts, KMPG says that the blockchain platform can 'integrate an organization's existing systems, including IoT sensors, with external data sources to establish a verifiable trail of emissions and offsets recorded on blockchain' (Ledger Insights, 2020). CAI was launched in 2020 and will first be applied on clients working within the real estate, critical infrastructure and oil and gas sectors (KPMG, 2020). To date, KPMG has not announced whether CAI will be implemented on agribusiness sector clients. Other companies that have announced their intention to use blockchain technologies to support GHG emission reporting include Mercedez-Benz, Volvo and Porsche (Ledger Insights, 2020). Furthermore, the InterWork Alliance (IWA) is a group that seeks to standardize tokenized assets and multi-party contracts; IWA comprises Accenture, Microsoft and blockchain energy firms (Ledger Insights, 2020). The initial objective of the IWA is to standardize carbon offsets. Nori, a carbon marketplace specific to compensating farmers for applying regenerative agricultural practices, relies on blockchain technology to solve the issue of double counting by separating the carbon certificate from the method of payment. When a farmer sells a Nori Carbon Removal Ton (NRT) to a buyer, it is immediately retired in that buyer's account and can never be resold, and blockchain is used to prove this (Nori, 2021). DLTs such as blockchain could be used in sustainably monitoring, verifying and reporting on green or climate bonds (see more on sustainable finance including green and climate bonds in Chapter 6). With the increase in green bond value, it is necessary to have effective tracking, traceability and verification mechanisms to help increase investor trust in climate-smart-initiatives. Companies such as Poseidon are working on a blockchain-based system to track an individual or company's CFP and then provide opportunities to offset it. IBM works with Veridium to tokenize carbon credits that are verified by third parties according to international standards. These are then used to incentivize companies to be more environmentally friendly and to offset their CFP (FAO, 2019a). UNEP and the International Rice Research Institute (IRRI) co-convened the Sustainable Rice Platform (SRP) in 2011, along with 16 founding members, including Olam, Mars and the German Development Agency (GIZ) (Eco-Business, 2020). In 2019, the SRP became an independent body and now has over 100 member organizations and 500 000 farmers enrolled in 25 projects across 21 countries (Eco-Business, 2020). To monitor the impact of projects, the SRP is using Olam's business-to-business (B2B) sustainable sourcing platform, AtSource. While at an early stage, it is expected that the usage of analytics can allow rice brands and manufacturers to track the CFP of their rice via a digital dashboard (Eco-Business, 2020). Also, according to proponents of the analytics platform, expected higher levels of transparency should provide the opportunity for producers to better engage consumers on the story behind their rice products, which may contribute to more sustainable consumer purchasing behaviour (Eco-Business, 2020).

Methodologies and tools developed by international financing institutions and specialized UN agencies can be leveraged to estimate mitigation potentials on a smallholder level. Estimating the mitigation potential of smallholder activities requires two key sources of information: activity data (information describing the change in agricultural practice that is expected to take place), and an emission factor (the net change in emissions expected from the change in practice) (IFAD, 2019). Reducing the uncertainty of the mitigation potential of an intervention can be done by using more accurate activity data, a better emission factor, or both (IFAD, 2019). As illustrated above, some companies are directly investing in obtaining more precise data on activity and emission factors. However, not all companies can afford the investments required to reach, organize and train smallholder farmers that are operating in highly fragmented supply chains. For further details on this, please see section 4.2 in this report – barriers to carbon neutrality. On the other hand, IFIs such as the International Fund for Agricultural Development (IFAD) are significantly vested in directly supporting smallholder farmers in measuring and reducing emissions. In fact, the combined mitigation potential of agricultural practices in the IFAD's 2011-2014 portfolio was estimated at 0.7–1.7 million tCO2eq-1 (IFAD, 2019). To decrease monitoring burdens, IFAD identifies mitigation practices and integrates these into its project designs. Mitigation objectives of these practices are then embedded in project monitoring systems, data collection efforts and project baselines. Analyses conducted during and post implementation serve the purpose of evaluating the accuracy of assumptions made during the project design phase and provide room to adjust assumptions (IFAD, 2019). Another example is that of the FAO Ex-Ante Carbon-balance Tool (EX-ACT). EX-ACT has been developed as an appraisal system to estimate the impact of agriculture and forestry development projects, programs and policies on net GHG emissions and carbon sequestration (CCAFS, 2016), and has been extensively used by IFIs in sovereign lending operations with countries around the world.[23] Furthermore, the Global Livestock Environmental Assessment Model (GLEAM) and the interactive tool GLEAM-*i*, are increasingly being recognized as complementary methodology to EX-ACT for livestock projects.

FAO has been involved in initiatives aimed at improving the range of tools and data available for emissions quantification and supporting carbon neutrality processes at different levels. Through the Ex-Ante Carbon-balance Tool for Value Chains (EX-ACT-VC), the EX-ACT tool was extended to serve as a quantitative multi-appraisal instrument that aims to support policymakers in identifying GHG emissions along the entire agrifood value chain (FAO, 2021b). The EX-ACT-VC tool analyses GHG fluxes from farm-gate-to-shelf, as well as potential entry points for socio-economic improvements at each value chain stage, supporting the development of projects and policies for low carbon value chains. Both tools are based on the IPCC methodology and supplemented with peer-reviewed literature on sectors and actors relevant to the value chains assessed. Additionally, the Protocol for the assessment of Sustainable Soil Management (SSM) was developed by FAO in collaboration with the Intergovernmental Technical Panel on Soils (ITPS) and the Secretariat of the GSP (FAO-ITPS, 2020).[24] The SSM can be leveraged to assess whether field interventions have been carried out in accordance with the SSM definition that is included in the Voluntary Guidelines for Sustainable Soil Management (VGSSM).

The protocol outlines a number of recommended indicators to evaluate the soil's ability to maintain prioritized ecosystem services and therefore improve farmers' productivity and income sustainably. The 2017 Global Symposium on Soil Organic Carbon (GSOC17) organized by FAO, GSP and ITPS, IPCC, the Science-Policy Interface of the United Nations Convention to Combat Desertification (UNCCD-SPI) and the World Meteorological Organization (WMO) produced a series of recommendations. The recommendation to establish a working group to develop implementable and regionally contextualized guidelines for MRV of SOC stock led to the development of the GSOC-MRV Protocol (FAO, 2020b). The GSOC-MRV was finalized in 2020 and provides a conceptual framework and standard methodologies for the MRV of changes in SOC stocks and GHG emissions/removals from agricultural projects that adopt SSM practices at farm-level. It should be noted that both protocols are voluntary and are living technical documents subject to continuous improvement. Both protocols underpin the MRV efforts of the Recarbonization of Global Agricultural Soils (RECSOIL) initiative, described in detail in BOX 3.4. To date, RECSOIL pilot projects have been designed for Costa Rica and Mexico, as outlined in BOX 3.5.

However, in the long term, there is a need for tools that link existing, spatially explicit data on soil and climate characteristics. Such tools are available through programs such as the International Soil Reference and Information Centre (ISRIC)–World Soil Information, with advanced models of soil carbon dynamics (ISRIC, 2021). These tools are currently available at the national level in countries such as the United States of America and Canada, but not yet globally. Furthermore, it is recommended that methodologies of pro-

23 GLEAM-*i* has also been recognized as complementary to EX-ACT for livestock projects and it is used by World Bank and IFAD.

24 The SSM is built on existing work of the FAO-GSP, the revised World Soil Charter (WSC) (FAO, 2015), the Status of the World's Soil Resources (SWSR) report (FAO and ITPS, 2015), and the Voluntary Guidelines for Sustainable Soil Management (VGSSM)

ject-level mitigation impacts should be consistent with national MRV systems, as these effects can contribute to country-level NDCs and establishment of national GHG inventories. However, in practice, there is often limited alignment between

national and project based MRV in terms of protocols for sharing data and datasets and calculation methodologies used. For example, some countries such as Colombia are developing data management systems to harmonize the bottom-up approaches used by projects and the top-down approach used to prepare national inventories (Valenta *et al.,* 2018). In this context, FAO is in the process of developing the Nationally Determined Contribution Expert Tool (NEXT) (FAO, 2021d). Launched at the end of 2021, NEXT has been designed to support governments, national experts and practitioners to assess the potential of climate change mitigation on a national level and the tool is aligned to the Enhanced Transparency Framework (ETF). Using a 30-year reading grid, NEXT is expected to be used to assess climate mitigation actions of multiple projects, with plans to pilot the solution using data from seven countries.

Innovative carbon marketplaces that compensate farmers for adopting sustainable farming practices could financially support smallholders in measuring and quantifying emissions. A new subset of voluntary carbon marketplaces, such as Nori, Indigo AG, Soil Carbon Industry Group (SCIG) and AgriProve focus exclusively on compensating farmers for the implementation of regenerative farming. These carbon marketplaces also provide support to farmers in collecting data and verifying emissions. To measure and verify impacts of management changes on farm-based net GHG emissions and to generate carbon credits, Indigo AG will use the Soil Enrichment Protocol developed by the Climate Action Reserve, a nonprofit organization that manages GHG offset project registries (Successful Farming, 2020).

Box 3.4

RECARBONIZATION OF GLOBAL AGRICULTURAL SOILS (RECSOIL)

RECSOIL is an initiative focused on enhancing soil health and the provision of multiple ecosystem services (increasing water retention and filtration, enhancing nutrient cycling, enhancing soil biodiversity, incrementing yields) through soil organic carbon sequestration (FAO, 2021c). RECSOIL is guided by the Global Soil Organic Carbon Map (GSOCmap), which has been developed by 110 countries and the Global Soil Organic Carbon Sequestration Potential Map (GSOCseq) (FAO, 2020a), which estimates the SOC sequestration potential at 1km x 1km resolution and detects regions with greater potential to sequester SOC, using simulation models and best available local data.

Farmers are at the core of RECSOIL, which includes six steps: (i) technical feasibility of current SOC stock and SOC sequestration potential; (ii) commitment from farmer associations; (iii) agreement between farmers and RECSOIL; (iv) provision of technical support and financial incentives; (v) adoption of good practices by farmers; and (vi) MRV. MRV of soil organic carbon is done using the GSOC-MRV Protocol, while other ecosystem services are measured and verified by the SSM Protocol. RECSOIL can follow different paths, including a Carbon Market Path, which allows the generation of carbon credits at the end of the cycle (eight years).

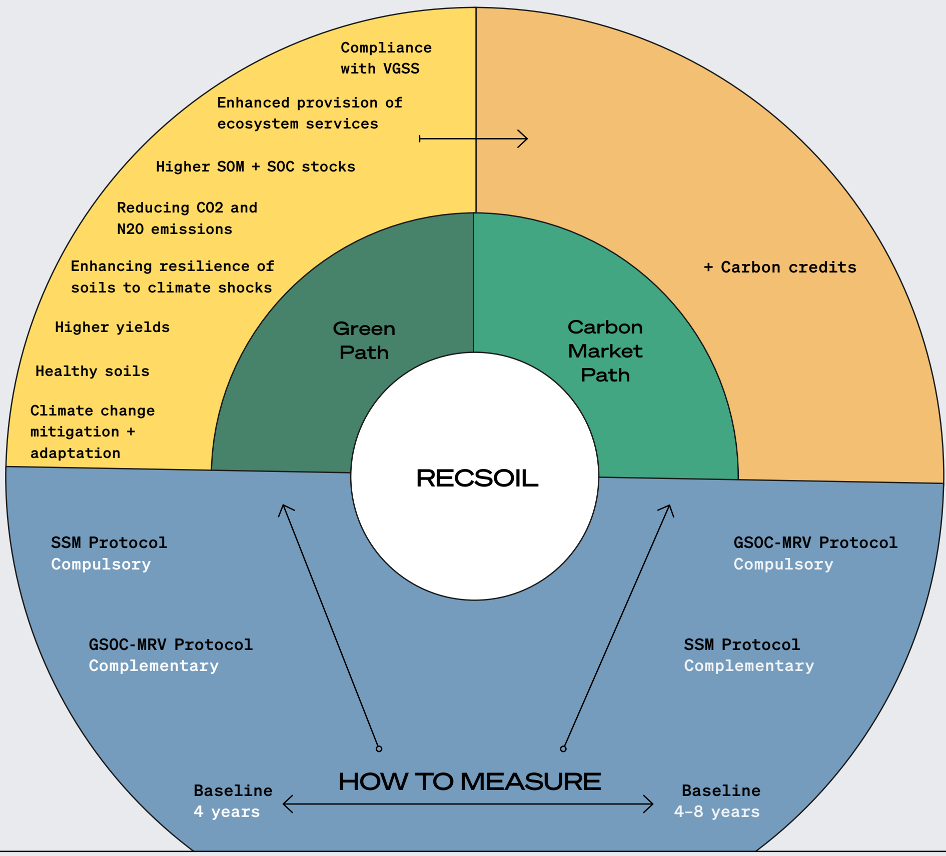


Figure 3.2
Recarbonization of global agricultural soils (RECSOIL)

SOURCE: RECSOIL.

Box 3.5

PILOTING RECSOIL – THE CASES OF COSTA RICA AND MEXICO

Cost Rica was selected as a country for RECSOIL implementation due to its advanced level of institutionalization towards the environment, with public policy instruments, such as the National System of Conservation Areas, the Payment for Environmental Services Program (PPSA), the Nationally Appropriate Mitigation Action (NAMAs) in the coffee and livestock subsectors and its National Decarbonization Plan. Through the National Forest Financing Fund (FONAFIFO), the PPSA will intermediate between beneficiaries of ecosystem services (especially in terms of reduction of CO2eq emissions) and producers. The coffee subsector was selected because of the involvement of a large number of smallholders. Livestock was also prioritized, as it occupies the largest production area nationally (more than one million ha). Both subsectors have experience with PES schemes and have been exposed to MRV methodologies.

The RECSOIL pilot project across both subsectors will cover approximately 14 000 ha (400 cattle farms averaging 30 ha and 400 coffee farms with an average size of 5 ha) for the first contracts and the total cost of the program for the eight years of validity is estimated to amount to over USD 14 million.[25] Once funds are available, the project will be initiated, with the expectation that the design can be adjusted and adopted to other subsectors and countries.

Mexico has also been selected as a country for RECSOIL implementation with a soil recarbonization budget of USD 38 million to intervene across 114 000 hectares. At the time of this report, RECSOIL is identifying locations across Mexico where there are opportunities to support SSM and soil recarbonization efforts based on potential for soil carbon sequestration and mitigation of GHG emissions (FAO, 2021c).

In contrast to Indigo AG, Nori does not rely on a defined standard. Instead, Nori has partnered with COMET-Farm, a USDA-approved technology for quantifying carbon removals in soils, Granular, a Farm Management Software (FMS) service provider and Techstars Sustainability Cohort, which will provide mentorship and guidance services (Nori, 2020). Nori claims that this partnership-based approach will ‘ensure that the grower is in full control of generating and selling the asset’ and will focus on ‘building a carbon market where the revenue model is aligned with the farmer getting paid as much as possible’ (Nori, 2020). To qualify for the Indigo AG and Nori marketplaces, farmers will have to have adopted one or more of the following practices within the last ten years: (i) adding cover crops; (ii) increasing crop diversity or growth period; (iii) reducing tillage or fertilizer use, or (iv) diversifying rotations (Nori, 2020; Indigo AG, 2020). In contrast to Nori and Indigo AG, SCIG and AgriProve work with the Emissions Reduction Fund (ERF), a voluntary standard developed by the Australian government. As such, projects are eligible to earn Australian Carbon Credit Units (ACCUs), which are issued by the Clean Energy Regulator (CER) and registered to carbon projects under the ERF (AgriProve, 2020a). One ACCU is equivalent to 1tCO2eq. Another significant

25 This estimation includes administrative costs (assuming that they correspond to 10 percent of the value of the National Fund for Forestry Financing, FONAFIO, contracts).

difference is based on the fact that AgriProve and SCIG mandate farmers to conduct baseline soil sampling to measure soil carbon levels, rather than using modelled approaches. AgriProve requires the measurement of carbon down to one meter in accordance with audited sampling protocols and tests performed by accredited laboratories, while SCIG requires sampling to be done at least 30 cm in depth (Agriprove, 2020b; Soil Cabon Industry Group, 2020). AgriProve conducts soil sampling tests every two- to four-years, to determine the carbon credits to be paid (AgriProve, 2020b). Both carbon marketplaces provide the option for farmers to nominate projects for either a 25-year or 100-year performance period. For a 100-year project, there is no deduction of ACCUs over the 25-year crediting period, however after that time, farms have a carbon maintenance obligation to keep soil carbon levels for the next 75 years (Soil Carbon Industry Group, 2020). On the other hand, for a 25-year project, 20 percent of the ACCUs will be deducted over the crediting period, provided that increases are measured and after 25 years there is no obligation on the project area in terms of carbon levels (Soil Carbon Industry Group, 2020). This flexibility may better suit farmers' operational requirements. Furthermore, SCIG is open to other discount methods that diminish over time and these are discussed on an individual case basis. Overall, participation in the abovementioned schemes can bring multiple advantages to farmers: (i) the opportunity for farmers to develop a sellable asset in the form of a carbon credit; (ii) support on target setting for carbon removals, reduction of input costs, improvement of soil health; and (iii) possible price premiums for applying production changes. Arguably, while credits from the AgriProve and SCIG marketplaces are verified by a national standard, generating greater transparency and reliability, the upfront investments for soil sampling may undermine inclusiveness and scalability.

Although these carbon marketplaces are narrowly focused, they are paving the way for the development of similar initiatives on a global scale. Indigo Ag and Nori marketplaces are currently only available to farmers in the United States of America, while AgriProve and SCIG are only applicable to farms in Australia. However, given the traction gained in the United States of America, Indigo AG has in 2020 expanded pilot testing to growers in Germany (Indigo Agriculture, 2020). For the time being, the Nori and Indigo AG marketplaces will focus on annual crops from larger farms, with Nori prioritizing projects of 1000 acres and more. Exceptions can be applied to smaller projects that combined generate a sample greater than 1000 acres (Nori, 2020). In contrast, SCIG has a wider scope, which extends to most agricultural systems, including cropping, pasture, horticulture and mixed enterprises (Soil Carbon Industry Group, 2020). Importantly, to extend operations to smallholder farmers, comparable carbon marketplaces need to ensure that potential hidden costs, including transaction costs and investments towards capacity building, are accounted for and that farmers are provided with up-front capital to implement regenerative practices. Encouragingly, Verra recently released a new VCS methodology. The VCS Methodology for Improved Agricultural Management (IALM) was developed in collaboration with Indigo AG and TerraCarbon LLC (Verra, 2020). The IALM methodology incentivizes a range of agricultural land management practices that reduce emissions, enhance storage of soil organic carbon and contribute to increase soil health and agricultural resilience overall. The quantification approach incorporates the use of both direct measurements of soil organic carbon stocks and usage of biogeochemical models such as DNDC and COMET-Farm that rely on previous management practice, soil, and weather data to quantify changes in soil organic carbon stocks and GHG fluxes over time (Verra, 2020). In contrast to the carbon marketplaces mentioned above, this methodology is applicable to any project developer throughout Verra's global VCS Program. Similarly, the Soil Organic Carbon Framework Methodology released by Gold Standard in 2020 provides three approaches to quantify SOC improvements: (i) on-site measurements to directly document baseline and project SOC stock levels; (ii) using peer-reviewed publications to quantify baseline and project SOC stock levels; and (iii) application of default factors (IPCC Guidelines for National Greenhouse Gas Inventories, 2019 – using Tier 2 level approach wherever possible) (Gold Standard, 2020). At the smallholder level, the Research Program for Climate Change, Agriculture and Food Security (CCAFS) in collaboration with the University of Edinburgh launched the Smallholder Agriculture Monitoring and Baseline Assessment (SHAMBA) tool. SHAMBA aims to support smallholders in calculating expected climate benefits of planting trees, agroforestry, increasing organic inputs to soils and reducing the amount of crop residues (CGIAR, 2021). The tool has been designed to be user friendly and seeks to support smallholders in determining climate benefits in a cost-efficient manner, so that farmers can gain access to carbon credits (CGIAR, 2021). SHAMBA makes use of the RothC model for estimating changes in soil carbon stocks and modules developed by the IPCC for non-CO2 GHGs (SHAMBA, 2021). The tool is a free-of-charge computer package and can be used either through a user-friendly interface or through the running of computer code in conjunction with an Excel-based questionnaire (SHAMBA, 2021). To date, SHAMBA has been piloted in Mexico, Mozambique and Uganda. If proven successful, the Plan Vivo Foundation will integrate the tool throughout its projects in sub-Saharan Africa (CGIAR, 2021). Another initiative at the smallholder level is the Agroforestry in Action (ACORN) Project, initiated, managed and funded by Rabobank. The ACORN project seeks to support smallholders that sequester carbon through the increase of biomass, with the aim of providing farmers with 90 percent to 95 percent of credit revenues (Rabobank, 2021a). RaboBank has partnered with Microsoft to develop the carbon removal unit marketplace that connects large corporations with smallholder farmers who can sequester carbon through agroforestry. As of 2021, Rabobank has been piloting this together with ReNature and the Laikipia Permaculture Centre in Kenya (Rabobank, 2021b). However, as elaborated in Chapter 3.7, many of these initiatives are still in a startup phase, face challenges on methodologies (particularly for soil carbon accounting), and do not have major coverage on a geographic and crop-based scope. Nevertheless, they do point to opportunities that lie ahead in reducing the distance to a carbon neutral global agrifood system. Part of the solution lies in harmonizing and constantly updating accounting methods, ensuring good governance and developing well-regulated markets for agricultural carbon credits (Wollenberg *et al.*, 2012).

Despite progress, there is a strong need for standardized guidance on how to estimate and quantify carbon soil stocks at various spatial scales across all sectors. Due to the high costs and complexities involved in the measurement and monitoring of carbon soil stocks at various spatial scales, it is recommended that guidance and standards focus on supporting the generation of low-cost estimates that present a low bias and moderate uncertainty levels on a project scale. Such guidance can enable a more effective use of technologies, such as remote sensing. Focus should also be placed on the generation of strategic and high quality direct measurements, reducing uncertainty of local-scale predictive models and the ease of incorporating farm-level activity data into integrated measurement activity data platforms. Importantly, data collection systems and interfaces should be user-friendly and intuitive so that land managers and relevant parties on the ground can use these with ease and frequency (Paustian, 2020). Simplified proxy measurements (e.g. soil pH, organic matter and bulk density) can serve as indicators on how soil is functioning (Rosenbaum *et al.,* 2015). However, the absence of an internationally recognized and harmonized methodological framework often leads to an inconsistent use of these indicators. Currently, it is up to the LCA community to articulate how soil quality measures will be integrated into impact assessments, involving the development of new impact pathways and integrating these with existing impact pathways (Rosenbaum *et al.,* 2015). Consequently, greater standardization and guidance on the evaluation, selection and use of indicators, could contribute to the ease in developing consistent LCAs and related LCIs used to measure soil quality levels.

3.6 ILLUSTRATING COMPLEXITIES IN OPERATIONALIZATION OF CARBON NEUTRALITY CONCEPTS: THE CASE OF THE LIVESTOCK SECTOR

The livestock sector provides a good example of some of the complexities of operationalizing carbon neutrality concepts. First, in terms of overall approach to quantification and reporting of emissions, different methodological choices lead to diverse interpretations of emission levels, emission reduction potentials and have wider implications. The emissions from production of inputs to processing and transport of animal products, including those related to feed production and pasture management as well as land-use change, are estimated using the LCA approach to account for 14.5 percent of total anthropogenic GHG emissions (Gerber *et al.,* 2013; FAO 2021d). However, different approaches can be taken: the IPPC, for example, reports only direct emissions of livestock, i.e. the methane from enteric fermentation and manure management. Therefore, when looking at direct emissions only, livestock contributes 5 percent of total anthropogenic emissions, or 21 percent of total AFOLU emissions (IPCC, 2019a). The differences in methods used for calculating emissions and the way they are reported have resulted in confusion about the exact share of livestock emissions, especially when compared to transport or other sectors and industries (Figure 3.3). Similar confusion exists in the role of livestock in sustainable and healthy diets. This is discussed in Box 3.6.

Calculating emissions from livestock supply chains is data intensive, arguably more than for crop production or fisheries and aquaculture. This is first due to the very large diversity of livestock production systems, which include small-scale mixed crop-livestock farms, backyard poultry or pig production as well as large-scale specialized poultry and pig production, pastoralism etc. It is also due to the wide range of emission sources to consider, starting with direct emissions (enteric methane and emissions from manure management) but also including emissions coming from feed production and pasture management (such as N2O from fertilizer application, CO2 emissions from machinery using fossil energy such as tractors to plough feed crop fields or from deforestation to expand feed crop production or pastures in some cases). Emissions from energy consumption on farm (for example to run a cooling tank for milk storage) as well as off farm (for example to transport feed, to process and transport animal products) are usually also included in the CFP of animal products.

However, the livestock sector has also been particularly dynamic in developing guidelines for calculating and measuring GHG emissions. An example of the progress achieved is the Livestock Environmental Assessment and Performance (LEAP) Partnership: a multi-stakeholder initiative that issues guidelines for calculating GHG emissions in livestock supply chains using a harmonized methodology, which is the result of a consensus between various stakeholders of the sector, including the private sector (FAO, 2021e). The LEAP guidelines have been used as a reference for the Product Environmental Footprint

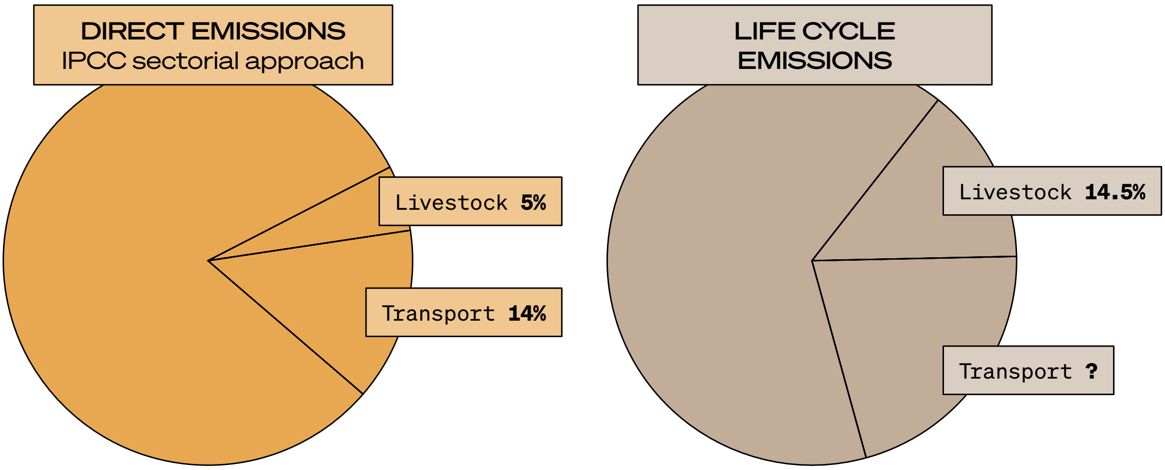


Figure 3.3
The pitfalls of simplification when looking at GHG emissions from livestock

SOURCE: Mottet, A. and Steinfeld, H. 2018. Cars or livestock: which contribute more to climate change? *Thomas Reuters Foundation News*. https://news.trust.org/item/20180918083629-d2wf0

© FAO/Riccardo De Luca

Box 3.6

THE LIVESTOCK SECTOR, DIETS AND EMISSIONS

In the last few years, the number of mediatized reports and content questioning the role of livestock in sustainable and healthy diets has significantly increased, while scientific consensus has not been reached (Leroy, Hite and Gregorini, 2020). Part of the reason for the diverse conclusions derive from the methodological choices made in each analysis (e.g. system boundaries, assumptions in modelling studies, units and metrics used to report the results). For example, consumption studies multiplying the mass of a food product by an emissions factor tend to favor less or no animal product in diets. However, these studies often ignore the destination of crop by-products and residues, industrial by-products, and the land that would, other than providing biomass for livestock, be underutilized (e.g. grasslands and rangelands). They are usually based on analysis of diets that do not account for the whole nutritional value of food products, especially the very high density of livestock products in essential micronutrients such as vitamin B12, iron, calcium and zinc and their role in improving the nutritional status of vulnerable populations (see for example Adesogan *et al.*, 2020; Alonso *et al.*, 2019). These analyses also do not account for the role of livestock in providing fertilization and drought power for crops or other ecosystem services beyond the provisioning of food, including key functions for producers in low- and middle-income countries such as insurance, financial assets and social status. In particular, the role of livestock in many communities is difficult to address in the short to medium term and therefore this has to also be taken into consideration. Recommendations on dietary choices for consumers and their consequences for the environment should acknowledge these current limitations and address them. While some research indicates that efforts to reduce emissions from livestock are likely to have more mitigation impact than encouraging reduction in consumption of meat, eggs and dairy (Chang *et al.,* 2021), there is limited consensus on the effectiveness of supply- versus demand-side levers in reducing emissions.

Category Rules (PEFCR) of the European Commission. Based on the LEAP methodology regarding feed supply chains and compliant with PEFCR, the Global Feed LCA Institute (GFLI) database has been developed to become a reference tool for assessing and benchmarking feed industry impact and environmental improvements (GFLI, 2021). Furthermore, in 2020 the Cool Farm Alliance announced that it would enrich the Cool Farm Tool by connecting it to the GFLI database (Cool Farm Alliance, 2020). Another example of application of the LEAP guidelines includes the Livestock and Poultry Environmental Learning Community (LPELC), which – through USDA funding – conducted a national assessment of the environmental impacts of beef cattle production across the United States of America in 2019 (LPELC, 2019). The LEAP methodology has also been used to guide the OverseerFm model, (livestock and ruminant subcomponents), which models the cycles of nutrients that are brought into and created on farms, with the aim of developing nutrient budgets for seven key farm nutrients, as well as GHG reports and a carbon stock report for forestry. The OverseerFM model is being used by over 11 000 farms across New Zealand (OverseerFM, 2021). Also aligned with the LEAP guidelines, the FAO Global Livestock Environmental Assessment Model (GLEAM) (FAO, 2021f) provides estimates for IPCC Tier 2 GHG emissions in livestock supply chains at various scales. The open online version GLEAM-*i* (FAO, 2021g) is a calculator that can be used to estimate baseline emissions in a livestock production system with different orientations, a project or a farm and to test mitigation options. An example of its application is the Ganaderia Climaticamente Inteligente (GCI) or Climate Smart Livestock project in Ecuador, driven by FAO-Ecuador and BanEcuador BP; it relies on GLEAM-*i* to quantify the GHG emissions of livestock production (GCI, 2018) and at the same time identify livestock practices that support emission reductions.

A balance between incorporating wider sustainability goals and standardizing methodological choices needs to be achieved. Within the livestock sector there is a need to better consider the diversity of diets and production systems in CFPs and LCAs. Indeed, current LCAs used to establish the CFP of a product, and therefore to recommend specific foods/diets, have a number of limitations, starting with an overview of the nutritional needs of different groups of people (women, children and elders) and of the nutritional content of food, which is usually limited to calories and amount of protein. Second, methodologies to better account for carbon sequestration in production systems should also be developed, as most ASF LCAs currently do not include it. Third, comparisons of studies with different methodological choices, system boundaries and metrics need to be done carefully and need to acknowledge the technical features of the models and the limitations of the assumptions in these studies. Fourth, a better balance between climate objectives and other sustainability goals is needed, not only with food security and nutrition but also other dimensions, such as livelihoods, access to markets, and animal welfare. For example, Sustainable Development Goal (SDG) trackers may be incorporated to multi-dimensional assessments including the environmental externalities, social and economic aspects (e.g. FAO's new EX-ACT VC tool).

3.7 COSTS ACROSS CARBON NEUTRALITY STAGES: TOO LITTLE MONEY AND TIME?

Costs vary across the carbon neutrality process

The cost of pursuing carbon neutrality in practice varies tremendously. Becoming carbon neutral can entail a number of cost elements, including quantification, reduction, offsetting, verification and certification and labelling as well as communication costs. The level of investment will largely depend on the number of steps taken, whether these steps are outsourced to external parties and the strategic decision to selectively pursue or combine offsetting, insetting and reduction practices. Costs can also depend on other factors, including the size and type of the company, the type and level of external consulting support, internal capability levels, data availability and the sophistication of information management systems, the complexity of the supply chain organization, as well as the scope of emissions considered. Another significant factor that can influence the costs and time for achieving carbon neutrality is the level of formalization of the supply chain, as high formalized and fragmented supply chains will likely incur higher due diligence costs and effort to measure, reduce and certify emissions. For further details on this, please refer to Chapter 4. Furthermore, the emission intensity of the commodity will also play a role in determining costs, as less emission-intensive supply chains will have higher footprint scopes that need to be accounted for, compared to the supply chains of less emission-intensive commodities. Lastly, perishability could play a role in contributing to footprint values, as perishable goods may need to conform to enhanced quality standards, as well as energy intensive storage practices, such as cold chains.

Costs for quantifying emissions depend on a number of factors, such as data availability, including the number of product lines in scope, and whether data collection efforts and LCA calculations are outsourced. Quantification costs will largely depend on whether a company decides to calculate the footprint on an organization-wide level or whether it will delimit the analysis to one or more product lines. The level of investment will also be conditioned by the number and complexity of the supply chains considered, as well as data availability and the level of data collection effort required. Collecting data to calculate a company-wide CFP, will typically require two full-time employee (FTEs) for three months (ECOCERT, 2020).[26] However, these estimations are based on the availability of data from a company's existing management information system and the sophistication of such systems will determine the actual time and costs of collecting data. Large agrifood companies typically measure CFPs relying on their own staff and expertise. When the CFP process of quantifying emissions is outsourced to a consulting firm, prices can vary from EUR 10 000 to EUR 30 000 for the consultants' time (ECOCERT, 2020). If an LCA is required to calculate the CFP of a product line this will roughly amount to EUR 10 000 to EUR 15 000 for the LCA (ECOCERT, 2020).

The cost of insetting is typically highly variable, potentially reaching several million euros for large agrifood companies. While the cost of emission credits via existing verified offsetting projects has an approximate market range of EUR 2 to EUR 30 per tCO2eq, the cost of an insetting project varies greatly depending on the size, location and skills required (Forest Trends' Ecosystem Marketplace, 2019). For the first few years of a project, it is usually at

26 Research conducted by ECOCERT for the development of this report.

least EUR 1 million (actual value depends on size of the insetting project) and then it decreases over the following 20–30 years, which is the typical duration of a project for carbon credits (ECOCERT, 2020). This cost includes monitoring and evaluation of project's implementation and regular external audits, which typically account for 20 percent of total costs of carbon projects in agriculture (ECOCERT, 2020). In certain situations, insetting costs can be comparable to costs of directly reducing emissions, but could be higher as insetting also covers the costs of verifying and certifying projects.

Offset prices on voluntary carbon markets can range dramatically. For example, in 2018, according to data collected by the Ecosystem Marketplace, the average price of carbon credits was USD 2.40 tCO2eq for the first quarter of the year. Data collected showed also a large pricing range from under USD 0.1 tCO2eq to just over USD 70 tCO2eq (see Figure 3.4 for the volume and number of transactions by price reported in the first quarter of 2018).

Costs of offsetting can vary significantly depending on the type of carbon credits purchased; location of the underlying project, the specific sector and activities involved, the range of benefits and reliability (third-party verification). The Ecosystem Marketplace has over a number of years tracked the average prices for transacted voluntary carbon credits (Forest Trends' Ecosystem Marketplace, 2019; Forest Trends' Ecosystem Marketplace, 2020). Table 3.2 indicates that in 2017 the weighted average price for carbon credits was highest for household devices. However, by 2019, carbon credits within the forestry and land use sector presented the highest weighted average price of USD 4.30. The data collected from the Ecosystem Marketplace and the interviews conducted with companies and certification service providers as part of this report suggest common features in terms of pricing. Offsetting costs will largely depend on the sectors and project categories for which carbon credits are purchased, as well as the standards issuing the carbon credits. Lastly, third-party verification and the add-on of co-benefits will also influence the prices of credits and consequently, the offsetting costs a company will face. Table 3.3 shows the various average carbon credit prices across a number of years for some of the most renowned standards. These findings can be summarized as follows:[27]

- **Premium units**: third-party verified carbon credits and third-party verified add-on of co-benefits: EUR 10–EUR 30 tCO2eq;
- **High-Quality units**: third-party verified carbon credits: EUR 5–EUR 10 tCO2eq;
- **Low-quality units**: no third-party verification EUR 2–EUR 5 tCO2eq.

27 Ranges gathered from interviews with certification service providers and agribusinesses, as well as secondary research.

Figure 3.4
Volume, number and price of transactions on the voluntary carbon market, Q1 2018

SOURCE: Hamrick, K. and Gallant, M. 2018. Voluntary Carbon Market Insights: 2018 Outlook and First- Quarter Trends. Forest Trends. Ecosystem Marketplace.

Table 3.2
Transacted voluntary carbon offset weighted average price by project category, 2017–2019

	Average price per year		
Type of project	2017	2018	2019
Forestry and land use	USD 3.4	USD 3.2	USD 4.3
Renewable energy	USD 1.9	USD 1.7	USD 1.4
Waste disposal	USD 2.0	USD 2.2	USD 2.5
Household devices	USD 5.0	USD 4.8	USD 3.8
Chemical processes/industrial manufacturing	USD 1.9	USD 3.1	USD 1.9
Energy efficiency/fuel switching	USD 2.1	USD 2.8	USD 3.9
Transportation	USD 2.9	USD 1.7	USD 1.7

SOURCE: Ecosystem Marketplace. 2019. Financing Emissions Reductions for the Future. State of the Voluntary Carbon Markets 2019. www.forest-trends.org/wp-content/uploads/2019/12/SOVCM2019.pdf.

Table 3.3
Comparison of major voluntary standards average prices for carbon equivalent emissions credits tC02eq by reference year

Standard	Average Price
Gold Standard	USD 4.6 (2016)
Verified Carbon Standard (VCS)	USD 2.7 (2018)
Climate, Community and Biodiversity Standard (CCBA)	USD 2.5 (2018)
Woodland Carbon Code	GBP 7 – GBP 20 (2019)*
Climate Action Reserve	USD 3 (2016)
CDM-UNFCCC	USD 1.4 (2016)
CDM-UNFCCC	USD 1.4 (2016)

SOURCE: Ecosystem Marketplace. 2017. Unlocking Potential. State of the Voluntary Carbon Markets 2017. www.forest-trends.org/wp-content/uploads/2017/07/doc_5591.pdf

NOTE: *Within the the United Kingdom, companies are paying between GBP 7 and GBP 20/tC02 for purchases of Pending Issuance Units (carbon credits). As only a small number of verified Woodland Carbon Units have been sold, whether the price for these differs. https://woodlandcarboncode.org.uk/buy-carbon/how-to-buy#price

Voluntary carbon credit prices sold from carbon marketplaces that focus on compensating farmers for regenerative practices are significantly higher than average voluntary carbon credit prices from traditional carbon marketplaces. Historically, private investors' interest in agricultural carbon marketplaces has been low, limiting the scope for farmers to participate in voluntary carbon marketplaces (Wollenberg, *et al.*, 2012). However, the carbon voluntary market has over time evolved to develop arrangements that are better suited to farmers' needs and account for agricultural risks through discounted credits (Wollenberg, *et al.*, 2012). Still, limited project scales and low carbon prices have rendered agricultural projects uncompetitive in comparison to other sectors. Recently, a subset of voluntary carbon marketplaces specific to agriculture have emerged. As elaborated in Chapter 3.5, Nori and Indigo AG are two US-based carbon marketplaces that exclusively focus on compensating farmers for investing in sustainable farming practices. Currently, Nori and Indigo AG credits are sold at approximately USD 15 per credit, respectively. Indigo AG offers a floor price of USD 10 per credit for any field enrolled in 2020, with price increases based on demand for credits sold before the end of 2022 (Indigo AG, 2020). Nori also sets a floor price, but which is determined by the growers (Nori, 2020). In addition to receiving premiums for carbon credits, Nori offers farmers a Nori token with each carbon credit, which is a cryptocurrency that will fluctuate in value based on market supply and demand forces, with the option to sell the token back to Nori for cash at a predetermined floor price (Nori, 2020). Indigo AG estimates that on average, growers are able to generate 0.3–1 credits per acre in the first year and increase credit production over time (Indigo AG, 2020). Similarly, Nori estimates that growers who recently adopted practices like planting cover crops or switching to minimum tillage can remove between 0.2 tonnes and 1.5 tonnes of CO2 per acre per year (Nori, 2020). Compared to other voluntary carbon marketplaces, Nori and Indigo AG are able to maintain relatively high carbon credit pricing as these are considered valuable because credits result from practice-based changes and represent new benefits to soil carbon and emission reductions that go beyond business-as-usual practices (Indigo AG, 2020). Such aspects render these credits comparable to premium quality carbon credits from conventional carbon marketplaces, which provide co-benefits.

Similar carbon marketplaces that are governed by national standards offer the same level of premium pricing, but at elevated project costs, which can be subsidized in various ways. As outlined in Chapter 3.5, SCIG and AgriProve will compensate farmers in Australia with government-based ACCUs, which in August 2020 had a spot value of AUD 15.90 per credit (Australian Government Clean Energy Regulator, 2020a). AgriProve estimates that a 1 percentage point increase in soil organic carbon in the top 30 centimeters of soil can deliver 124 carbon credits per hectare (AgriProve, 2020b). Furthermore, AgriProve provides flexibility to farmers on how they can sell ACCUs, through either a set price, on the spot market or held for future sale, with the possibility of combining these options to generate a blended price per credit (AgriProve, 2020d). As mentioned in Chapter 3.5, to qualify for SCIG and AgriProve marketplaces, farmers will have to invest in conducting baseline soil sampling and will have to engage in at least another test to measure changes. Costs for soil sampling can amount to AUD 3500 for a farm size of 0 to 100 hectares and up to AUD 20 000 for farms of 901 to 1000 hectares (AgriProve, 2020d). Farmers therefore face a risk of not recovering the costs incurred for soil sampling, should there be no increase in soil organic carbon levels. However, this risk is capped to two soil sampling tests, since farmers are not obligated to conduct more than two tests, if levels of soil organic carbon remain unchanged or have decreased. Furthermore, the ERF provides advancements of up to AUD 5000 for sampling conducted for projects within the registry, to be paid back within five years to the CER (Australian Government Clean Energy Regulator, 2020b). Other possibilities for support include a prize offered by AgriProve of AUD 20 000 to farmers achieving the targets of 20 tonnes of dry matter yield plus an additional 20 tonnes of soil carbon abatement per hectare in a 12-month period.[28] Furthermore, the Land Restoration Fund (LRF) purchases credits from applicants at agreed prices and offers annual payments for projects in Queensland that deliver co-benefits associated with the sequestration of soil. The fund also offers a support package of AUD 10 000 to farmers for project-related costs, which may include professional services, project developer and environmental consultancy costs (AgriProve, 2020).

Although carbon marketplaces that compensate farmers for applying regenerative practices hold promise, most are in their early stages of development and roll-out. PES began emerging in the 2000s and a wide variety of schemes have been implemented which highlight the potential opportunity but also implementation challenges. Through Indigo's Atlas satellite technology, as well as ground and historical agronomic data, Indigo AG developed a US map that was used to develop a field study covering 90 percent of the US farmland. Using 2017–2019 data, the study estimates that if every state achieved only 15 percent adoption of cover crops and no-till on its corn, soybean and wheat acres, those farmers could collectively receive an additional USD 600 million in profits (from reduced inputs, yield uplifts and carbon credits) (Indigo AG, 2020). Furthermore, the study estimates that the scale of the regenerative opportunity could be as much as USD 4 billion, if the three practices of crop rotations, cover crops and no-till saw widespread implementation (Indigo AG, 2020). It should be noted that this will likely require specific advisory services and the purchase of specialized inputs, which could impact the magnitude of profits achieved. However, Indigo AG has yet to widely roll out its carbon marketplace and it is currently in the process of obtaining buyer commitments. In late 2020, a number of companies, banks and organizations, including Boston Consulting Group, Barclays, JP Morgan Chase and IBM committed to a credit purchase price of USD 20 per tCO_2eq sequestered and abated throughout the 2020 growing season (AGFunder, 2020). Similarly, Nori is currently recruiting farmers to participate in the pilot project for its carbon marketplace. AgriProve and SCIG are also in start-up phases, with AgriProve having AUD 150 million at its disposition to invest in building soil carbon stocks in the next ten years (AgriProve, 2020). Verra released the first version of its IALM methodology in October 2020. Although these carbon marketplaces present significant potential, it is too early to evaluate their actual effectiveness.

Finally, the costs of third-party verification are also high and vary depending on context. Third-party audits and validation costs, as well as time requirements vary significantly, depending on the footprint of the product or organization and the number of desk-based and on-site audits required. In terms of certifying the footprint of an organization, a desk-based audit can range between 0.25 and 1 day at the cost of EUR 100 to EUR 1500, depending on the scope of the footprint in question and the number of audits required.[29] On-site audits can range from 0.5 to 1.5 days at the cost of EUR 200 to over EUR

28 Prize is applicable to any ERF project that has been registered prior to 31 December 2020. AgriProve. 2020. Financials https://agriprove.io/financials.

29 Values have been collected via interviews and discussions conducted by ECOCERT with various certification providers. Price range determined by the daily auditor rate, which can vary from a minimum of EUR 400 for a junior auditor to a maximum of EUR 1500 for a senior auditor.

2000, depending on the number of audits required and the footprint of the organization. On a product or service level, desk-review audits can range between EUR 200 to EUR 3000 for 0.5 to 2 days, whereas on-site audit costs, can range between EUR 400 and EUR 4500 for 1 to 3 days. The latter will once again be conditioned on the number of audits required and the scope of the footprint, as well as the extent to which the audits are extended throughout the supplier tiers.

Emission scope, company size and value chains are key determinants of cost

The decisions of which emissions scope to include in the CFP assessment has significant impact on overall costs of pursuing carbon neutrality. Scope 1 is easy to measure because it is internal to the organization. Thus, collecting the data needed for the calculation can be easier. Calculating Scope 2 emissions can take more time and resources (both human and financial), due to data collection requirements. However, the data sources to quantify Scope 2 emissions are mostly administrative and can be found through company accounting and management information systems, meaning that there is no need to undertake expensive field work to collect data and measure emissions. Hence, cost and time needed to calculate Scope 1 and 2 emissions are typically in the range of a few thousand euros and a few weeks of work. However, this assumes that companies have adequate information systems. For more informal businesses, SMEs in the agrifood sector, cooperatives and smallholder farmers it may take longer and require more resources in proportion to the business size.

When it comes to accounting for Scope 3 emissions, costs and time requirements increase significantly particularly in agrifood supply chains. This is because data needs to be collected from the field and from multiple actors along the supply chain to quantify Scope 3 emissions. This requires deep expertise of the different sectors involved in the supply chains as well, access to reliable LCA data bases, as well as the ability to work with and harmonize complex datasets. In practice, this means that tracing Scope 3 emissions and including them in a company or product's CFP can cost tens of thousands of euros and require several months of work of highly qualified technical specialists. For instance, throughout the interviews conducted as part of this report, a global company expressed its ambitions to source 50 percent of its volume through sustainable procurement. However, the company has expressed the challenges in linking sustainably procured raw materials to their diverse brands and collecting data up to the farm-level without involving buyers and other intermediate stakeholders in the supply chain. Similarly, a FMCG interviewed claimed that it costs around GBP 30 000 per LCA; and therefore estimating Scope 3 emissions for many products and geographies requires substantial investment and efforts. Interestingly, the process appears more linear and accessible to those companies that started investing – irrespective of the company's size – in sustainability years ago and that are now just adding complexity rather than unravelling it to chase new market opportunities.

Economies of scale mean that pursuing carbon neutrality is often cheaper for large agrifood companies. Companies that have invested in carbon neutrality for a number of years and are of a certain size, can also expect to be able to leverage economies of scale. Economies of scale are a key advantage of large-scale businesses, especially when it comes to applying standardized procedures which allow companies to spread costs over a very wide range of products and services. For example, pursuing carbon neutrality has some fixed costs in terms of staff and consultant times and fees to access LCA databases. Large producers can typically get much more mileage out of these fixed costs because they can spread them over their entire range of products and services which they are certifying. Similarly, this could discourage small- and medium-sized companies from engaging if not adequately supported or incentivized. Finally, larger businesses usually have modern management information systems that can often be adjusted at a low cost to incorporate information and data on emissions and environmental footprint in general. Such information systems can also be leveraged to achieve short term emissions optimization through, for example, improved selection of input sources (incorporating emissions data) that are used in a specific food product.

Putting it all together: simulating the costs of becoming carbon neutral

Costs were simulated for three different sectors and two company sizes. To illustrate the costs of becoming carbon neutral, the cost data obtained from interviews conducted with the 20 agribusinesses and 12 certification service providers were combined with that obtained from the literature review and experts' views to produce simple cost models. The main cost elements obtained were extrapolated to two different company sizes and across three different sectors. For simplification and comparability purposes it is assumed that the companies modelled are fully vertically integrated. The revenue of USD 100 million was used to represent a large company, whereas the revenue of USD 1 million was used for a small company. The emission-intensive sectors of sheep and beef were utilized, as was the less emission-intensive tea sector. The costs included the following steps in the carbon neutral process: (i) quantification of GHG emissions; (ii) reduction activities, including the development of a carbon reduction management plan, reduction targets and timeline, verification of targets and reduction project costs; (iii) offsetting costs through the development of an offsetting strategy and purchase of carbon voluntary credits (CVCs); (iv) final validation including desk-based and onsite auditing and license costs, and (v) labelling and communication costs. For each of the stages, the cost types of external and internal full-time employee (FTE), verification and certification and CO2eq costs were extrapolated from the interviews. The different costs were expressed as a percentage of the annual revenue of each company size.[30]

The models were used in different simulations depending on assumed emissions reduction and offsetting strategies that could potentially be followed. These range from fully offsetting emissions through carbon credits to following a partial reduction in emissions through different management reduction practices, combined with the purchase of offsetting credits. The simulations considered are the following: (i) fully offsetting emissions across the tea, sheep and beef subsectors using high quality CVCs (Figure 3.5); (ii) combining reduction practices and offsetting through the purchase of high quality CVCs for the sheep subsector (Figure 3.6) and (iii) and applying reduction practices and offsetting remaining emissions for beef via high quality CVCs (Figure 3.7). Additionally, Figure 3.8 illustrates the impacts on revenue of offsetting through the purchase of different credit types, across company sizes and subsectors. All simulations model the potential costs of achieving carbon neutrality (reducing and/or offsetting all CO2 emissions) and all costs are annualized. Details of these simulations are elaborated below.

30 For simplification purposes, the ratio of costs as a percentage of annual revenue was used. However, different ratios can be used, such as total emissions to sales, growth of emissions to growth of sales, etc. Ratios and indicators should always be selected based on applicability and relevance.

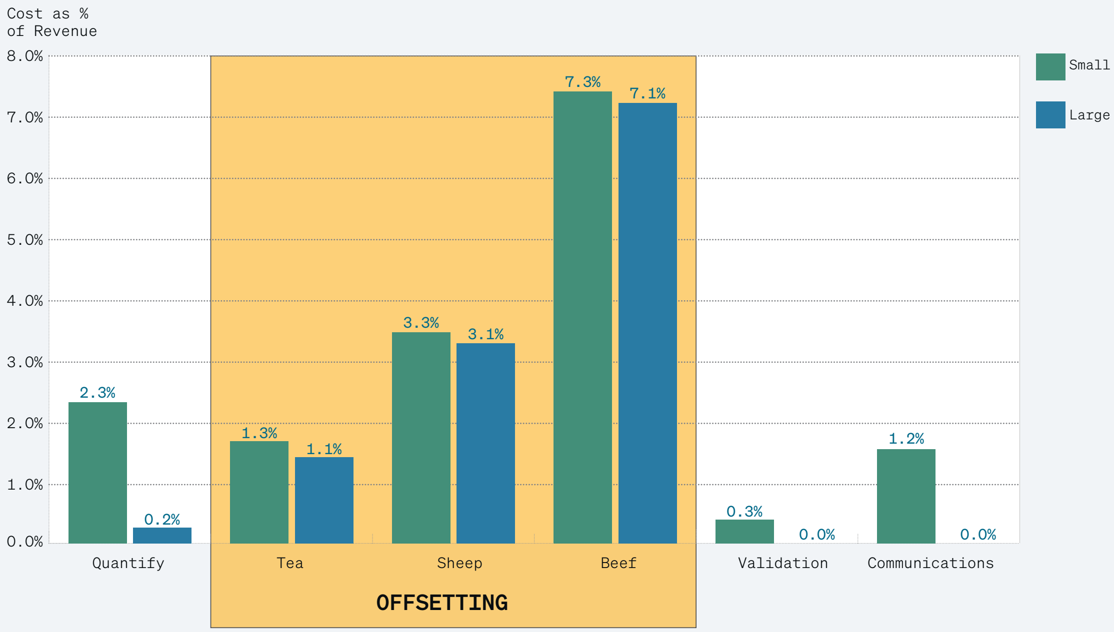


Figure 3.5

Simulation 1: Offsetting total annual emissions through high quality credits across subsectors and company sizes

SOURCE: Calculations developed by the authors.

1. Scenario 1 simulates the costs of becoming neutral when total emissions are offset via high quality CVCs, or third-party verified credits across the commodities of tea, sheep and beef as a percentage of revenue.

2. High quality CVCs are estimated to have an average price of USD 7.50 (average of range USD 5–10 per tC02eq).[31]

3. The annual emissions for a small and large tea company have been estimated to be 1487 and 148 672 tC02eq yr–1 respectively, and are multiplied by the high quality CVC price (USD 7.50) and divided by the annual revenue for a small and large company (USD 1 million and USD 100 million respectively).[32]

4. Sheep annual emissions for a small and large company are 4067 and 406 673 C02eq yr-1, respectively, while for beef these values are 9513 and 951 274 C02eq yr-1. The annual emissions for a small and large company producing sheep and beef have been multiplied by the high quality CVC price and divided by the revenue to generate the percentage of revenue values.[33, 34]

5. For simplification purposes, quantification, validation and communication/labelling costs are assumed to differ across company sizes, but to be the same across the commodities. These costs have been estimated through the insights gathered from the interviews with certification service providers and agribusinesses and are expressed as a percentage of the revenue by company size.

31 Range gathered from expert views from interviews with certification service providers and agribusinesses, as well as secondary research.

32 Annual 2019 tea average price: USD 2.65 per kg from the World Bank Pink Sheet September 2020; IPCC 2007 100a method for establishing the CFP of products; Dongshan Black tea: 3.81 kgC02eq – does not include consumer and disposal: 3.207 and 0.022 kgC02eq respectively; www.mdpi.com/1996-1073/12/1/138.

33 Average EU price for 2020 for heavy lamb bone-in meat without byproducts (73 percent of carcass price): USD 4.82 per Kg; Average emissions for grassland production systems in Western Europe with allocation to byproducts (10 percent reduction): 19.60 kgC02eq.

34 Young male Bovines 12>24 m - category A-R3. EU average price for 2020 of beef boneless meat without byproducts (58 percent of carcass price): USD 2.31 per kg; Average emissions from grassland production systems in Western Europe; with allocation to by-products (10 percent reduction): 22.0 kgC02eq.

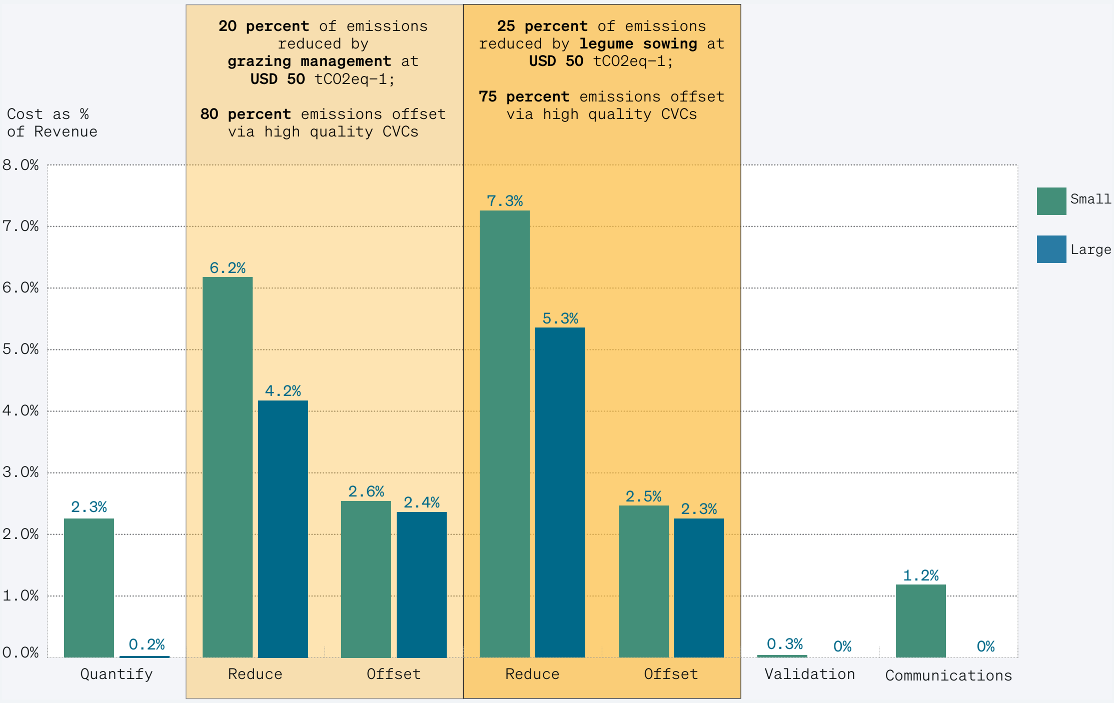


Figure 3.6
Simulation 2.a: Two different reduction options and offsetting the remainder via high quality credits – sheep

SOURCE: Calculations developed by the authors.

1. Simulations present diverse combinations of reduction practices and offsetting via high quality CVCs to achieve carbon neutrality. Global marginal abatement cost (MAC) curves developed by Henderson *et al.* (2017) for the ruminant sector were selected as these have demonstrated the most promise based on feasibility in different regions and production systems on a global scale.

2. The study selected five abatement practices, that when summed together, the singularly applied abatement options are estimated to abate a total of 453 tC02-eq yr–1 GHG emissions, annually. However, after eliminating overlaps between practices, the total falls to 379 tC02eq yr–1. For simplification, this simulation uses the total of 453 tC02eq yr–1 GHG emissions.

3. For the simulation, the two reduction practices (out of the five practices presented in the study) of grazing management and legume sowing were selected as these demonstrated the greatest abatement potential in terms of volume of emissions and are relevant in the Western Europe region. These two practices have the annual abatement potential of 91 and 115 MtC02eq yr–1, respectively, representing 20 and 25 percent of the total potential of 453 MtC02eq yr–1.

4. The percentage of 20 percent for grazing management was extrapolated to the total emissions of a small and large company producing sheep (4067 and 406 673 tC02eq yr–1, respectively) at the cost of USD 50 to generate the reduction costs as a percentage of revenue. The remaining 80 percent of the emissions are offset using high quality CVCs at the price of USD 7.50.

5. Similarly, the abatement potential of 25 percent for legume was applied to the total annual emissions for a small and large sheep producer at the cost of USD 50, while the remaining 75 percent of emissions are offset using high quality CVCs.

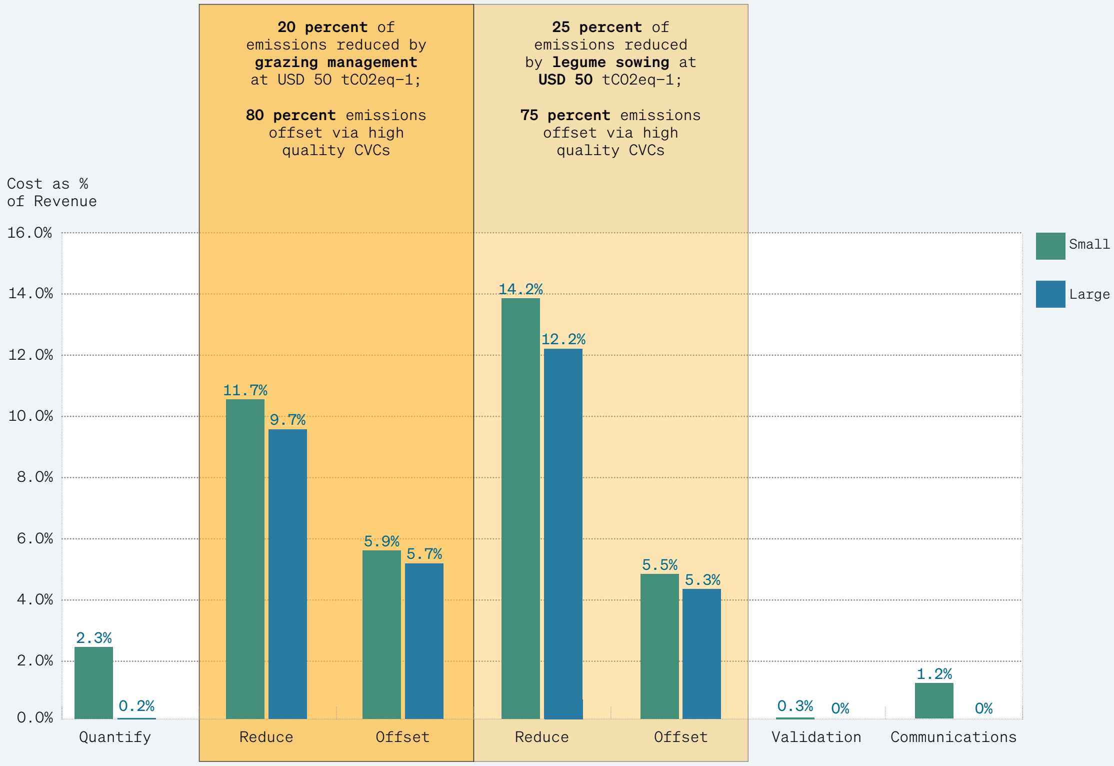


Figure 3.7
Simulation 2.b: Two different reduction options and offsetting the remainder via high quality credits – beef

SOURCE: Calculations developed by the author.

1. The percentage of 20 percent for grazing management was extrapolated to the total annual emissions of a small and large company producing beef (9513 and 951 274 tCO_2eq yr-1, respectively) at the cost of USD 50 to generate the costs as a percentage of revenue. The remaining 80 percent of emissions are offset using high quality CVCs at the price of USD 7.50.

2. Similarly, the percentage of 25 percent for legume sowing was extrapolated to the total emissions of a small and large company producing beef at the cost of USD 50 to generate the costs as a percentage of revenue. The remaining 75 percent of emissions are offset using high quality CVCs at the price of USD 7.50.

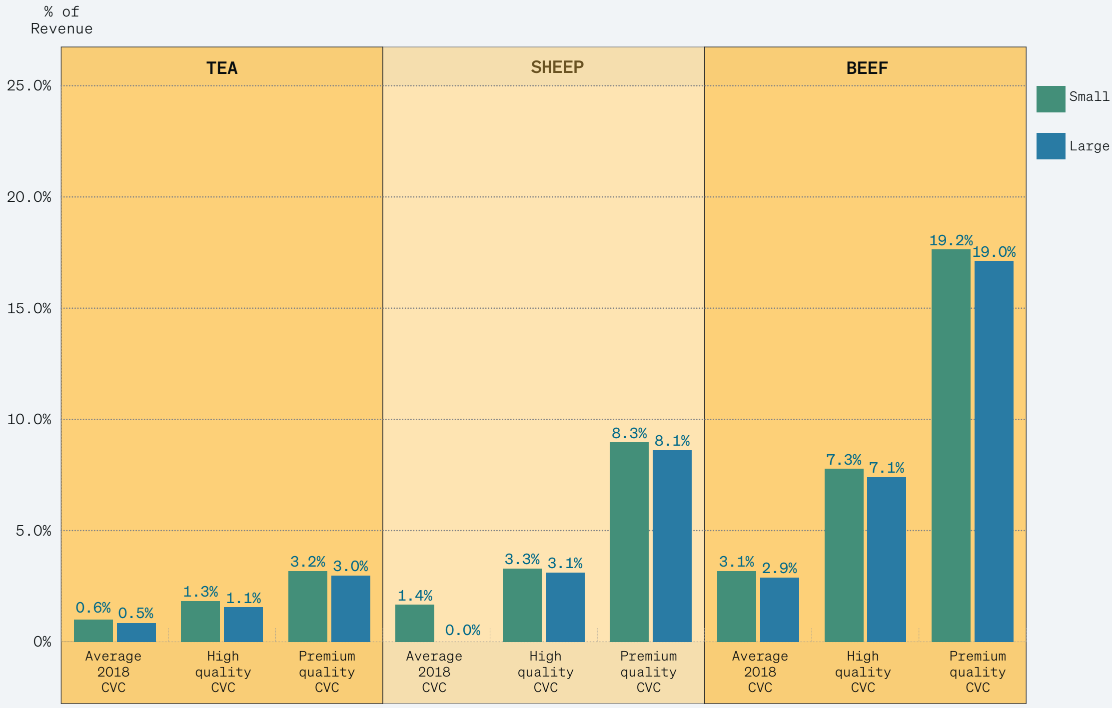


Figure 3.8
Illustrating impact on costs of using different offsetting options to achieve carbon neutrality (cost as a percentage of annual revenue across company sizes and subsectors)

SOURCE: Calculations developed by the author.

1 Scenario 1 simulates the percentage of revenue that offsetting total annual emissions would amount to, using different CVC options across the commodities of tea, sheep and beef.

2 The different offsetting prices are: average 2018 CVC price: USD 3.01;[35] High quality CVC: third-party verified credits – average price of USD 7.50; Premium quality CVC: third-party verified credits and add-on of verified co-benefits – average price of USD 20.[36]

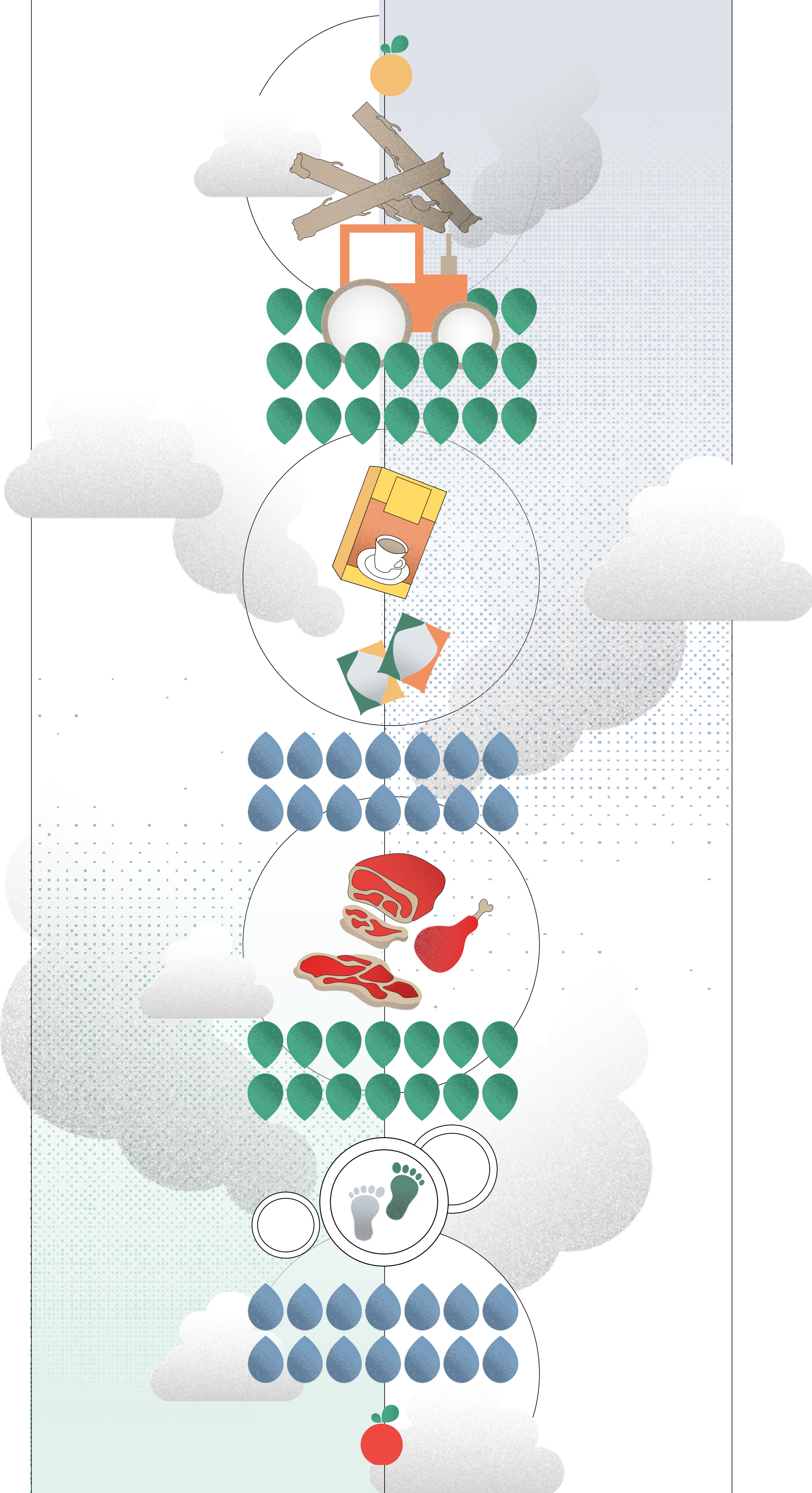
3 The annual emissions for a small and large tea company are 1487 and 148 672 tC02eq, respectively and have been multiplied by the different CVC prices and divided by the annual revenue of a small and large company.

4 Sheep annual emissions for a small and large company are 4067 and 406 673 tC02eq respectively, while for beef these values are 9513 and 951 274 tC02eq.

35 Forest Trends' Ecosystem Marketplace. 2019. Financing Emission Reductions for the Future: State of Voluntary Carbon Markets 2019. Washington DC: Forest Trends.

36 Prices gathered from interviews with certification service providers and agribusinesses, as well as secondary research.

Cost modelling simulations unsurprisingly show that offsetting costs can be higher across emission-intensive sectors and that an emissions reduction strategy is usually more expensive than a pure offsetting one. The findings from the simulations indicate that annual costs for becoming carbon neutral for smaller companies (with a revenue of USD 1 million) can be significant. This is especially applicable to the quantification costs, the costs for calculating footprint and LCA analyses. For tea, completely offsetting emissions using high quality CVCs can comprise 1.3 and 1.1 percent of the revenues of small and large companies respectively. However, the price for credits may vary in accordance with the amount purchased and the timing of the purchase, for instance through the attainment of volume discounts. Attention needs to be placed on whether and how the volume and timing of purchases of carbon credits may favor larger buyers. On the other hand, purchasing high quality CVCs to offset all emissions for beef can amount to 7.3 percent and 7.1 percent of the revenues for small and large companies, respectively. This can be 6 percent higher than the share of revenue that small and large companies in the tea sector potentially incur. Overall, reduction costs for the different reduction practices are higher than offsetting costs of purchasing high quality carbon credits across both sheep and beef commodities. For beef, grazing management reduction costs as a share of revenue can be 5.8 percent and 4 percent higher than offsetting shares of revenues for small and large companies. The differences are more apparent for legume sowing, where reduction costs can be larger than 4.8 percent and 3 percent for sheep and 8.7 percent and 6.9 percent for beef compared to offsetting costs, across small and large companies, respectively. Overall, the cost modelling scenarios indicate that reduction costs can be higher than offsetting costs, and these indications can serve as evidence as to why companies tend to offset emissions rather than directly reduce them. It should be noted that some of the costs, such as the quantification costs, can be considered one-off costs, unless investments are made to update LCAs. It can therefore be expected that in a real-life scenario, costs will decrease over time. Furthermore, technology developments will also likely contribute to the reduction of costs over time.



Chapter 4
Can carbon neutrality be achieved? Perspectives from various agrifood chains

Businesses are increasingly pursuing carbon management and reduction strategies, including carbon neutrality, to show their commitment to global climate change mitigation. A growing number of agrifood actors, large and small, are taking steps to adapt to climate change, reduce their GHG emissions and invest in low-carbon practices and technologies. While there are multiple reasons for businesses to consider carbon neutrality in their strategies, marketing and regulatory pressures are clear underlying drivers. This chapter builds on previous chapters to outline the diverse CFPs across supply chains and foods, provide examples of carbon neutrality efforts from different agrifood chains and to analyse key barriers facing agrifood system actors.

4.1 BY THE NUMBERS: THE CFP OF FOOD PRODUCTION AND FOOD PRODUCTS

The CFP of different food products is highly variable and depends on many factors including specific production systems and the metrics used (the most common one being emissions per kilogram of product). Still, it is clear that the typology of food product is an important determinant of emission intensity. Applying this metric, it is usually estimated that livestock products have a larger CFP than plant-based foods, with some exceptions for vegetable production systems involving deforestation. Some estimates suggest that when all emissions from production of inputs to the processing and transport of animal products are considered, livestock accounts for 14.5 percent of total GHG emissions (Gerber *et al.*, 2013). Considering a supply chain perspective, an assessment of global GHG emissions of agrifood systems (from food production to retail) (Our World in Data, 2020)[37] suggest that 31 percent of emissions come from livestock and

37 Our World in Data is produced as a collaborative effort between researchers at the University of Oxford, who are the scientific contributors of the website content, and the non-profit organization Global Change Data Lab, who owns, publishes and maintains the website and the data tools.

fisheries, 27 percent from crop production, 24 percent from land use and 18 percent from the supply-chain – including retail (3 percent), packaging (5 percent), transport (6 percent) and food processing (4 percent), as shown in Figure 4.1. Another important insight from quantifying the CFP of food is that direct emissions from livestock production are dominated by pre-farm and on-farm emissions, while post-farm emissions are often considerably smaller (Figure 4.2) (Peters *et al*., 2020). For plant-based foods, pre-farm and post-farm stages can make a significant contribution to the total CFP. This is because emissions from land-use change and transport can be a major contributor to the total CFP for fruit and vegetables (Sim *et al.*, 2007). For red meat, the majority of the emissions are concentrated in the livestock farm and pasture. These emissions are much greater than the emissions related to packaging, processing and distribution. For instance, 47 percent of the livestock sector's GHG emissions result from enteric fermentation and 24 percent of GHG emissions arise from nitrous oxide emissions from feed production and nitrogen deposits during grazing (Opio *et al*., 2013). For the CFP of apples, processing and distribution are the most impacting phases, compared to agricultural production and packaging. While these estimates give a first order approximation, emissions linked to specific supply chains and products may show variation. For example, some plant-based products that are produced in heated greenhouses, transported by air or produced in low-yielding systems or are linked to deforestation have very high CFPs (Stoessel *et al.*, 2012). Other agricultural commodities, if sustainably managed and if their planting did not originate from deforestation, such as tea, present opportunities for carbon sequestration. When the crop is taken purely from the top leaves or 'flush', it generally leaves the largely woody frame of the tree intact. The former combined with a large root system can act as a long-lasting carbon sink. With an average useful lifespan of 50 years, each bush can deliver up to 125 kg of carbon to the soil or given an average planting density of 10 000 bushes per hectare,[38] 1250 tonnes per hectare (Melican *et al*., 2009).[39] On an aggregate level, the total sequestration potential of tea production (for producers managing over 10 000 ha across 17 countries), given the average sequestration capability per tea bush of 2.6 kg/hectare (Melican *et al.,* 2009) can be estimated to be over 114 million tCO2eq (International Tea Committee, 2020).[40]

38 Tea planting density averages confirmed by the Tea Research Association (TRA Tocklai) and Tea-Link Colombo PVT LTD (Sri Lanka).

39 A tea plant can live beyond 100 years, but the average lifespan in yield focused areas is between 40–50 years. Depending on where the plant is grown and how it is cultivated will determine whether the tea plant will be a net contributor or not on a carbon basis.

40 Estimation assumes 4 819 030 hectares across 17 countries for producers managing of 10 000 hectares and weighted average of planting density of 9150 bushes per hectare. At the time of this report, exact areas of shade and therefore planting densities per country could not be calculated.

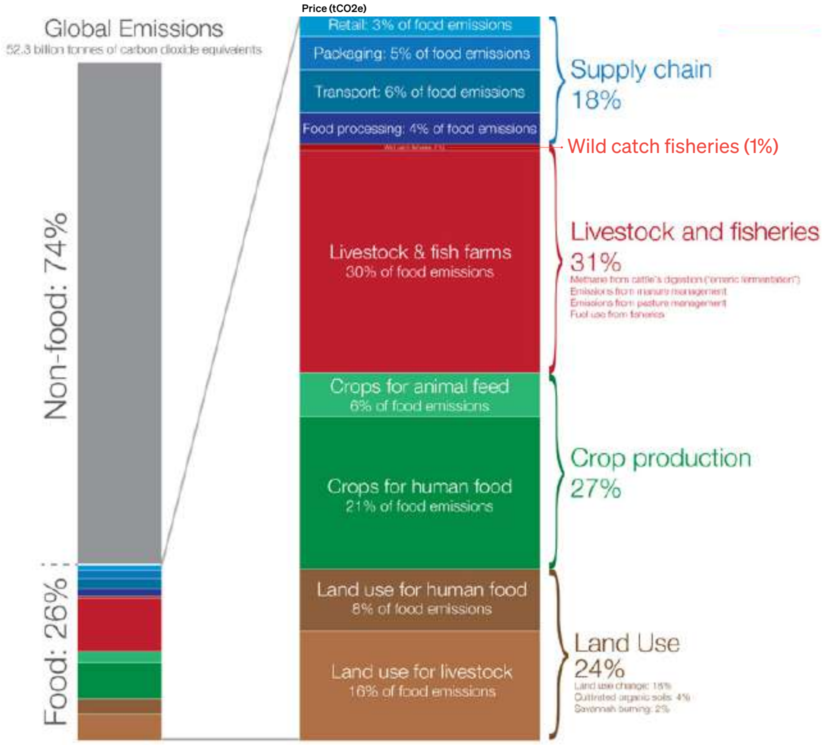


Figure 4.1
Global GHG emissions linked to the agrifood sector from production to retail

SOURCE: Our World in Data. 2020. Environmental impacts of food production.

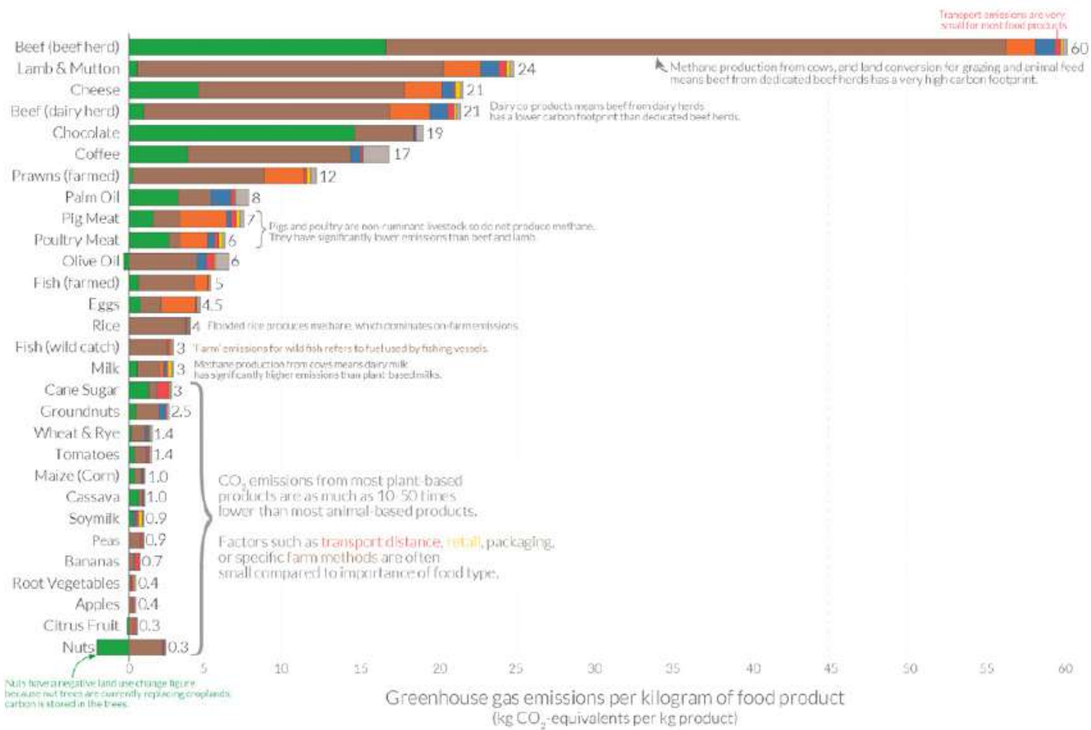


Figure 4.2
GHG emissions along the supply chain for different products*

SOURCE: Our World in Data. 2020. Environmental impacts of food production.

NOTE: *The figure does not consider consumption and end-of-life emissions and taking these into account (as well as their respective locations) will alter emission profiles.

There have been many attempts at comparing GHG emissions across food products including efforts to account for emissions at consumption stage. In this regard, the CFP pyramid gives a first order approximation of the GHG emissions associated with different food products. The inverted food pyramid (Figure 4.3) was built according to the LCA methodology, taking into account all the GHG emissions associated with different food products throughout their entire life cycle, from farm to fork, including emissions related to consumption stages (Barilla Center for Food and Nutrition, 2016). The left side of the pyramid lists food products and shows how GHG emissions associated with their production increase towards the top. The right side shows their measured CFP and also emissions associated with cooking (yellow and orange colours respectively). Given the uncertainty surrounding these estimates, the figure also presents the range of emissions associated with different food considered in different academic studies with the red hashed bars, from the minimum values when the red bars start to the maximum values when the red bars end. Finally, at the end of each food bar, the average CFP value of different food products has been reported. Beef and lamb meat have exceptionally high CFPs, followed by cheese, due to the contribution of CH_4 from enteric fermentation in ruminants. Meat from monogastric animals, such as pigs and poultry, show lower CFP values than products from ruminants, but still higher than most foods of vegetal origin, due to the large amount of feed needed in livestock production and emissions from manure handling (Barilla Center for Food and Nutrition, 2016).

Conventional metrics can mask substantial heterogeneity across emissions within and across agricultural subsectors. As an example, the share of emissions produced by the livestock sector is still being debated, as well as the related metrics to measure emissions (for further details on this please refer to Box 4.7). Furthermore, when comparing emissions per kilogram of different

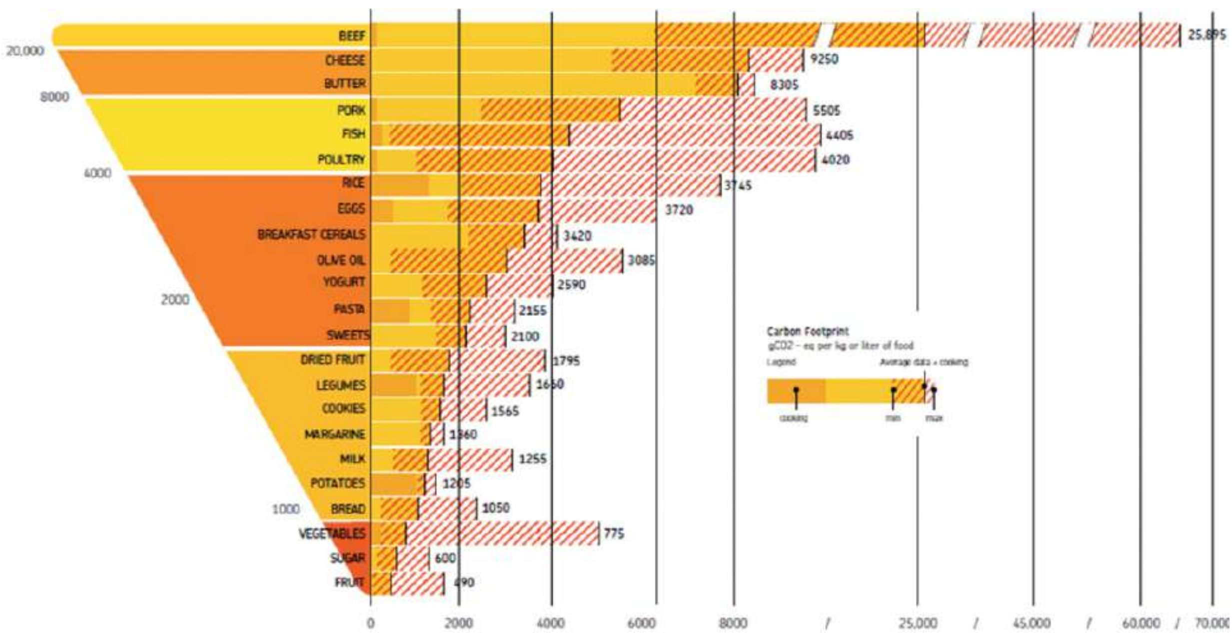


Figure 4.3
The CFP pyramid

SOURCE: Barilla Foundation. 2016. DOUBLE PYRAMID 2016 Eat better Eat less: Food for all.

commodities, nutritional density (Seuss-Baum and Nau, 2011)[41] and monetary value (value added) per kilogram of product can also be taken into account and bring additional insights on emissions in a food systems perspective (as illustrated in Figure 4.4). Emissions from foods are usually reported in CO2 equivalent per kg of product, what is referred to as emission intensity. This is a useful metric which allows direct comparison between different foods. However, one kg of any animal product is very different in nutrient terms compared to plant products and cannot be mechanically substituted, without a change in the nutrient balance of the diet (Randolph *et al.*, 2007; Murphy and Allen *et al.*, 2003). When nutrition considerations are accounted for, for example through a nutrient density metric, the classification of foods based on their CFP is very different from the usual picture (Figure 4.4), especially for eggs and cheese.

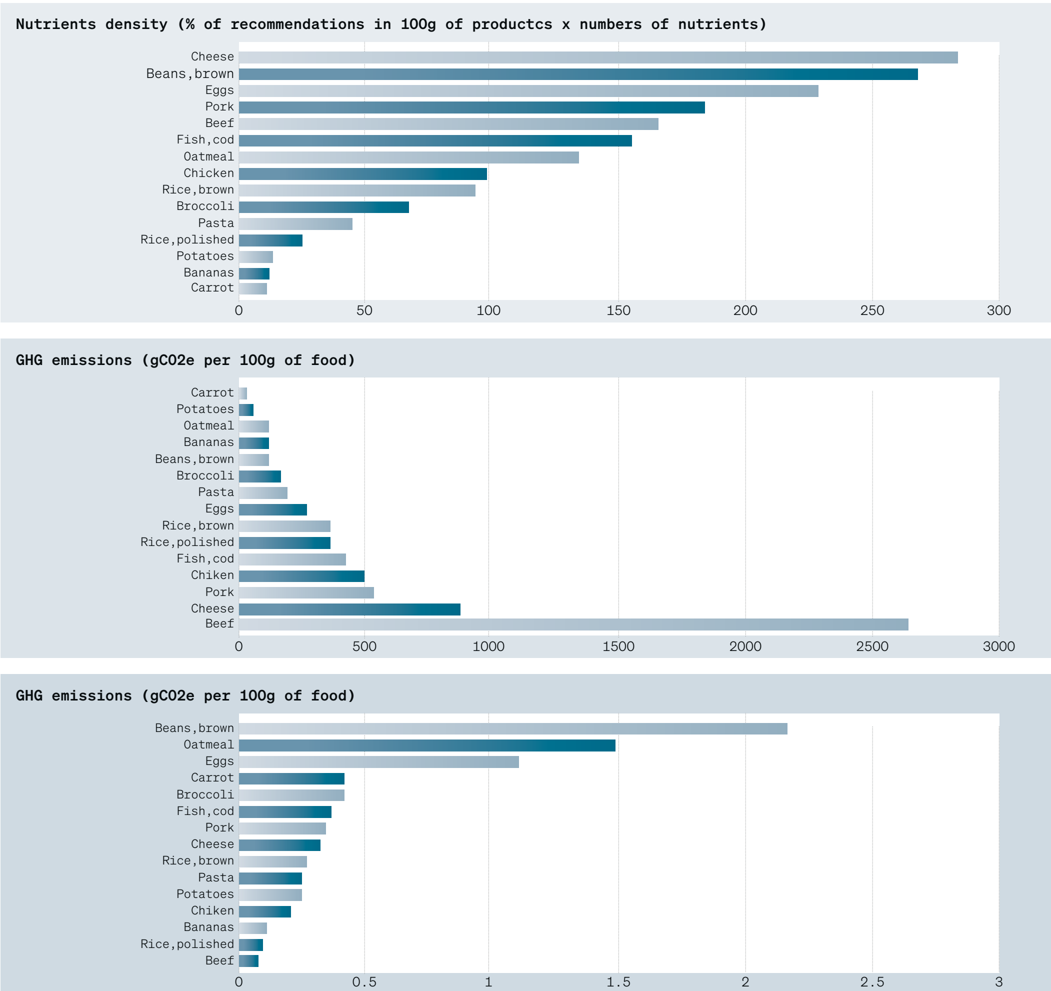


Figure 4.4

Classification of foods based on their nutrient density and their GHG emissions

SOURCE: Werner, L.B., Flysjö, A. and Tholstrup, T., 2014. Greenhouse gas emissions of realistic dietary choices in Denmark: the carbon footprint and nutritional value of dairy products. Food & nutrition research,58(1), p.20687.

41 Nutritional or nutrient density reflects the ratio of the nutrient content to the total energy content of the food.

4.2 THE BUSINESS CASE FOR CARBON NEUTRALITY

There are many possible market drivers for climate change action by agrifood system actors. In a profit maximization context, firms may start by seeing climate action as an opportunity to simply sell more through improved product quality, development of specific markets around green products and/or improved pricing of existing products and their operating margins. Investments in reducing emissions can, in some instances, also have positive implications on operating profitability through reduced costs (for example use of more efficient renewable electricity sources in processing or in water pumping). Furthermore, companies and specific food products may see their 'brand' being reinforced by low carbon or carbon neutrality claims resulting in enhanced customer loyalty and market advantages. In many cases, companies also act as part of their corporate social responsibility efforts. In a dynamic setting, agrifood system players that invest early on in sustainability (often with climate mitigation effects) can improve the resilience of their supply chains and thereby make their businesses more sustainable. Not considering the impact of current and future emissions can not only lower operational effectiveness, but also reduce supply chain resiliency. Risk management in the face of climate change is therefore increasingly important from the smallholder up to the multinational agribusiness (Porter and Reighhardt, 2007); for the latter, risk management strategies and disclosure is increasingly being demanded by investors.

While markets produce some incentives for agrifood system players to act on climate change 'markets only work their magic when prices reflect their true cost' (Henderson, 2020). Market incentives towards sustainability may, in some respects, be even stronger for agrifood system companies relative to other sectors given how primary production processes still depend to a great extent on the climate and natural resources where they are located. With rising temperatures, a cement factory may be able to continue operating, but a coffee plantation may disappear. Indeed, agrifood companies have already started acting on climate change and many of these initiatives and approaches have been documented in this report. Given that climate change induced by GHG emissions is often labelled as the 'mother of all externalities' (Tol, 2009), regulation and pricing of GHG emissions is extremely important in aligning the private sector's incentive structure with global sustainability goals for food systems. As indicated in Figure 4.5, and also discussed in throughout this report, the anticipation of regulations on emissions, on climate reporting and also of possible changes to pricing of emissions-related inputs and outputs are all, along with reputation, key drivers of climate action by agrifood system actors. Besides adopting disincentives ('sticks') such as taxation, positive public interventions ('carrots') – that create markets for emissions reduction, harmonize carbon labelling of products, or support research, awareness and adoption of greener practices and technologies – are also extremely important.

The multitude of reasons for addressing climate change suggests that a one-size fits all approach to putting food systems on a low carbon path does not exist. For example, at a corporate level, there is a need to look 'inside out' to understand the impact of the firm's operations on the environment and 'outside in' at how the changing climate from a physical and regulatory standpoint may affect the business environment in which the firm is competing (Tol, 2009). Through the inside-out perspective, management should evaluate the price of emissions along the value chain. Utilizing the ratio of total emissions to profits can lead the management a long way in determining the potential impact of climate change on profits (Tol, 2009). Supply chain efficiencies such as just-in-time management systems, cross-docking solutions and automation may not be

Figure 4.5
Reasons for corporate climate action, grouped by category

SOURCE: We Mean Business. 2015. The Climate Has Changed. https://s3.amazonaws.com/assets.wemeanbusinesscoalition.org/wp-content/uploads/2014/09/03183839/The-Climate-Has-Changed_3.pdf.

NOTE: This figure shows how many companies identified each driver as being important (the higher it is on the vertical axis, the more companies reported it) and the emphasis they placed on it being a risk (to the right of the line) versus an opportunity (to the left of the line). Based on interviews and data from 1455 international companies across all sectors.

as efficient, if companies operate in an environment where emissions are taxed and paid for. On the other hand, an outside in viewpoint allows firms to evaluate the extent to which climate change will affect availability and costs of resources and inputs, competition, access to certain markets and the incentives and rules governing the industry where the company is operating (Tol, 2009). Trade-offs between vertical integration and supply chain flexibility need to be evaluated, considering how and to what extent climate change can affect these strategic decisions and the food systems in which firms are operating and serving. While these considerations apply to larger agribusinesses, they are also becoming a reality for farmer groups, cooperatives and other agrifood system actors. For instance, climate change through weather pattern shifts, temperature changes and resource scarcities is affecting the ability of smallholders to produce volumes at given qualities to satisfy growing demand. Larger agribusinesses and participating value chain actors have a responsibility to evaluate the extent to which current operations are accelerating climate change impact, which ultimately will not only affect the bottom line of businesses, but also the livelihoods of smallholders engaged.

Raise efficiency and business resilience

Some practices aimed at reducing emissions present a strong business case, yet may still face obstacles for adoption, including market failures that require public intervention. As an example, regenerative agricultural practices have the potential to contribute to raising efficiency and resiliency levels in primary agriculture. Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security, while preserving and enhancing resource base and environment (FAO, 2021h).[42,43] Yet adoption rates of CA practices remain low in many countries and locations that are considered to have a high technical potential for adoption at scale (FAO, 2021h).

Actions aimed at halting deforestation can be aligned to productivity and market demand. As an example, for the production of tea, deforestation can be limited by: (i) ensuring that any increase in tea productivity from existing areas is brought about in a manner that reduces carbon emissions; (ii) selection of clones appropriate for market type demand, yields required and local climate change conditions; and (iii) replanting of bushes based on considerations made on impacts for surpassing optimal yield levels. Partnership-based approaches can especially be used to accelerate the accounting for carbon emissions and climate proofing key commodities, such as tea. In this regard, Box 4.1 outlines some of the actions taken by the Ethical Tea Partnership (ETP) in collaboration with the German Development Agency (GIZ), the International Trade Centre (ITC) and the Kenya Tea Development Agency (KTDA). Although climate-smart practices are increasingly being applied to develop best-practice examples, adoption rates have yet to reach scale. To achieve scale, CA and climate-smart practices need to account for the interests of a range of stakeholders and the development of tailor-made business cases to stimulate private sector investment (FAO, 2018b).

42 According to FAO, CA is characterized by three linked principles: (i) continuous minimum mechanical soil disturbance (no-till, direct seeding); (ii) maintenance of permanent soil cover (residues and cover crops); and (iii) diversification of crop species grown in sequences and/or associations (a diversified cropping system).

43 The implementation of the complementary CA principles through locally devised and tested practices can support climate change mitigation; it reduces the risk of soil erosion and compaction, loss of organic matter, inappropriate use of water, and hence ensures better soil management, conservation of biodiversity, safety application of plant protection products and avoids the build-up of pest populations.

Many other technologies applied upstream and further downstream in the supply chain can contribute to achieving emission reductions and efficiencies. Several examples of these technologies include low-emission tractors and equipment, precision agricultural technologies (PATs) and biogas solutions; these are outlined in Box 4.2. Furthermore, funding sources (as outlined in Box 4.3) aimed at supporting innovative low-carbon technologies are gaining prominence.

Box 4.1

FORECASTING ENVIRONMENTAL IMPACTS TO ADAPT TO AND MITIGATE CLIMATE CHANGE IN TEA PRODUCTION

The ETP project in Kenya is to date, the largest carbon project in the tea sector, globally. The partnership began in 2010 and currently supports approximately 600 000 tea farmers in Kenya (Impakter, 2015). Since tea is a perennial crop, besides inputs and soil management techniques, most investments in climate change adaptation and mitigation will be long-term (20–40 years). Therefore, understanding the future conditions for the local area in terms of climate change, is critically important. In this context, the ETP project in Kenya was initiated by the GIZ and the Centre for Tropical Agriculture (CIAT), to develop climate change forecasting maps that will enable assessment of how climate change will affect tea growing in Kenya up to 2050 (Ethical Tea Partnership, 2021a). The maps served as a basis for data-driven discussions with industry players, farmers and key institutions including the Kenya Tea Research Association, resulting in a range of actions to enable the sector to prepare for the changes ahead. Some of the resulting actions include: (i) training of over 40 000 farmers on climate change issues and agricultural practices to mitigate its effects; (ii) support to plant more than half a million drought and frost resistant tea clones; (iii) replanting of over 1 million trees and 2.5 million seedlings raised in tree nurseries to support farmers in developing their own sources of wood and regrow forest areas, and (iv) installation of 27 000 energy-efficient cookstoves to reduce fuelwood consumption (Ethical Tea Partnership, 2021b). On the other hand, for many herbal crops, which are annuals, the response to climate change can be much shorter (approximately 12 months), so forecast mapping can be equally as important toconsider changes in crop selection and rotations. These examples highlight the need for an aggregation tool, which measures production and demand data within the tea sector; this is applicable both to annual and perennial crops.

Box 4.2

TECHNOLOGIES THAT HAVE THE POTENTIAL TO REDUCE EMISSIONS

At the farm-level, shifting from fossil-fuel equipment and machinery (tractors, harvesters and dryers) to zero-emission alternatives could enable the abatement of over 500 million tCO2eq by 2050 and a cost saving of USD 229 per tCO2eq, globally (McKinsey & Company, 2020).[44] For instance, in 2019, New Holland Agriculture launched its T6 Methane Power tractor, which delivers the performance and durability of its Diesel equivalent, with the advantage of reducing running costs up to 30 percent (New Holland Agriculture, 2021). The natural gas engines also contribute to a production of 99 percent less particulate matter than Diesel engines and a reduction of CO2 emissions by a minimum of 10 percent and overall emissions by 80 percent (New Holland Agriculture, 2021). Other novel technologies that can be applied on the farm level include PATs, which – through variable rate input technologies (VRI) – can accurately determine fertilization, irrigation and pesticide field-level requirements. As a result, VRI technologies through distributed input application can not only generate significant input cost savings, but also reduce GHG emissions (Soto *et al.,* 2019). The potential advantages of VRI technologies are not delimited to a specific crop type, but are also particularly relevant to large fields with spatial inequalities as this allows for an optimized distribution of inputs (AGTech Ukraine, 2020). At present, there are a lack of estimates on the effectiveness of applying PATs. This has resulted in the absence of benchmarks, which farmers can use to evaluate potential costs and benefits of application. Nonetheless, various individual studies that detail the economic and environmental benefits of PATs have been produced (Soto *et al.*, 2019; Purdue University, 2021; USDA, 2016), but greater availability of nationally developed benchmarks could significantly support adoption. To support adoption of low-carbon technologies in developing countries, it is important that existing standards for machinery and equipment are reviewed at the country and regional levels and possibly benchmarked against standards in OECD countries. This would serve as a basis to develop strategies aimed at strengthening the capacity to manufacture and/or source quality machinery, build standards for testing and optimize required subsidies and incentives. Further downstream in the supply chain, expanding the adoption of anaerobic digesters to generate biogas can present revenue generating opportunities and an interesting option in specific situations. Biogas can serve as an alternative energy source for farm-level operations or be sold back to the grid as electricity or natural gas. Further developments on price and sizes of digesters can increase the attractiveness and the long-term farmer demand for biomethane (McKinsey & Company, 2020). Nonetheless, deploying biogas solutions at scale may face a number of technical, regulatory and market challenges both in developed and developing countries (see e.g. Patinvoh *et al*. 2019).

44 McKinsey & Company utilized a bottom-up assessment of mitigation potential and cost based on a synthesis of available literature; comparison across models of the Global Biosphere Management Model, Common Agricultural Policy Regionalised Impact, and Netherlands Environmental Agency; and discussions with relevant experts and practitioners. Cost shown includes capital expenses, operating expenses, and potential cost savings. For all measures, the level of uptake and implementation was assessed to be as ambitious as possible while also being aware of the potential economic and noneconomic barriers to implement across regions, farm scales, and production systems.

Box 4.3

THE EUROPEAN COMMISSION'S INNOVATION FUND

The European Commission's Innovation Fund is one of the largest funding programs for innovative low-carbon technologies, globally. The fund will provide EUR 20 billion from 2020 to 2030 depending on the carbon price to support the commercial demonstration and the implementation of go-to-market strategies of innovative low-carbon technologies, aiming to bring to the market industrial solutions to decarbonize Europe and support its transition to climate neutrality (European Commission, 2021a). The EU ETS, through the auctioning of 450 million allowances, as well as the unspent funds from the NER300 Program will be the main financing source of the fund. An example of a private sector led fund is the Microsoft Climate Innovation Fund, which aims to invest USD 1 billion in technology development and deployment of new climate innovations through equity and debt capital (Microsoft, 2021). The fund will base its investments on: climate impact, underfunded markets, shared alignment and climate equity.

Carbon management and emission measurement also force businesses to closely examine their processes and map their products' journeys. Achieving carbon neutrality forces businesses to evaluate their resource efficiency, as GHG emissions are correlated with resource consumption (especially energy consumption), but also with other inputs such as fertilizers. Hence, CFPs can serve as useful indicators of overall business efficiency to help identify hotspots in a process or in a product's journey which are particularly resource intensive and wasteful. Once these efficiency gaps are identified, businesses can apply corrective efficiency improvement actions in line with carbon reduction or neutrality targets and at the same time reduce their energy and input costs. Palsgaard, the world's largest food stabilizer and emulsifier supplier, has leveraged the synergetic effects of achieving carbon neutrality through resource efficiency measures. In 2010, the company set the target to become carbon neutral. Since then, Palsgaard has cut its net carbon emissions from 12 029 tonnes in 2010 to zero in 2018 (Palsgaard, 2018a). Palsgaard has achieved its carbon neutrality target by changing the energy sources of its six global structures. The company did this by utilizing new heat recovery and insulation techniques, switching from heavy fuel oil to certified biogas and by using renewables (Palsgaard, 2018a). In the future, Palsgaard will invest further in green optimization projects, as it deems this will provide the company a competitive advantage, especially as it plans to double its production capacity to keep up with demand (Palsgaard, 2018a). However, efficiency measures can be challenging to implement across complex supply chains. For instance, Palsgaard primarily offsets the emissions generated from its sites in Malaysia, because the energy green infrastructure market is not developed enough to be leveraged for resource efficiency investments (Palsgaard, 2018b). Consequently, the extent to which companies can render operational efficiency measures strategic can depend on internal and external supply chain-specific factors and market conditions.

For agrifood system players, achieving efficiencies in line with emission reductions can also go beyond a firm's operations and be extended throughout the supplier network. For instance, Walmart in 2017 launched Project Gigaton and encouraged its suppliers to view emissions as a form of waste with financial value or inefficiency in the value chain (Walmart Sustainability Hub, 2021). Through this project, Walmart encouraged suppliers to eliminate 1 billion tonnes of GHG emissions from their operations by 2030 (Walmart Sustainability Hub, 2021). Supplier performance and achievements are publicly communicated and suppliers that excel are recognized as 'Giga-Gurus' (Walmart Sustainability Hub, 2021). However, it should be noted that the effectiveness of extending similar initiatives throughout supplier networks depends on the leverage, size and power of the buyer involved. Furthermore, it is unclear whether Walmart is financially incentivizing its suppliers to commit to emission reduction targets. Nonetheless, interviews conducted for this report confirmed the importance that large agrifood companies place on improving the enabling conditions for CFP measurements and reduction projects for their suppliers. The companies especially believe that suppliers should receive support and subsidization for the development of CFP analyses and for emission reduction projects. This was also recently affirmed by the Carbon Disclosure Project (CDP) Supply Chain Program, which brings together 115 major purchasing organizations around the world, representing USD 3.3 trillion in procurement spending (Carbon Disclosure Project, 2019). In 2018, the 115 members made disclosure requests on relevant climate change impacts to 11 692 suppliers, of which over 5 600 suppliers across 90 different countries responded to. Suppliers reported a combined annual Scope 1 and 2 GHG emissions equivalent to 7 268 million tonnes of CO2 and emission savings corresponding to 633 million tonnes of CO2, representing an amount greater than 1 percent of the total global emissions across all sectors in 2018. Emission savings concretely translated into the combined annual monetary amount of USD 19.3 billion (Carbon Disclosure Project, 2019). These figures indicate that large companies can drive effective change throughout their supply chains by using their significant procurement spending as leverage, leading suppliers to cascade commitments and action further upstream in the supply chain. Agrifood companies that received an 'A' grade in supplier engagement include Coca-Cola, Danone, Nestlé, Barilla and the Kellogg Company. In 2017, 23 percent of suppliers were cascading efforts to generate positive change and this increased to 35 percent in 2018, indicating that more first tier suppliers are engaging second and third tier suppliers on climate change (Carbon Disclosure Project, 2019). Nevertheless, the CDP Supply Chain program stresses that this level of engagement will have to become more widespread to achieve global ambitions on climate change. Accordingly, for the highest impact sectors, agrifood suppliers only made up 14 percent of the supplier respondents, covering 4 percent of the total Scope 1 and 2 GHG emissions reported by a total of 5 159 suppliers in 2018 (Carbon Disclosure Project, 2019).

One key driver to decarbonize and become carbon neutral for farmers is that in doing so they can safeguard incomes and build resilience. Farming is strictly dependent on the natural environment and changes in rainfall and increasing temperature extremes are considered to be significant risks to primary agriculture production. As mentioned above, staple crops, such as rice, are especially subjected to climate change impact risks, with likely effects on yields. In fact, the demand for rice is estimated to increase from 510 million tonnes in 2017 to over 565 million tonnes in 2025 (Gonzalez-Diaz *et al.,* 2020). However, the OECD estimates that projected climate change in areas such as Southeast Asia, could reduce rice yields by 16 percent and 17 percent for non-irrigated and irrigated rice respectively, leading to potential price increases of up 50 percent

Box 4.4

MEASURES TO RAISE EFFICIENCIES, BUILD RESILIENCE AND SAFEGUARD INCOMES IN RICE PRODUCTION

Sowing seeds directly into rice paddies reduces the time a field needs to be flooded by a month and limits activities of methane-producing microorganisms, potentially cutting emissions by 45 percent per hectare (McKinsey & Company, 2020). The reduction of labour required to transplant rice and manage flooding can lead to cost savings. Other management practices and technologies relevant to reducing emissions and costs, as well as increasing yields in rice production include: (i) rotation crop cultivation can reduce CH4 emissions up to 40 percent to 45 percent, although at the risk of increasing N20 emissions; (ii) biochar application can lead to a reduction of CH4 emissions by 10 percent to 60 percent depending on the type of soil; (iii) alternate wetting and drying (AWD) (at least twice during cultivation and as compared to continuous flooding) can reduce water usage by 30 percent, fuel use by 30 percent and CH4 emissions by 40 percent on average for irrigated rice; (iv) application of tailor-made fertilizer based on soil testing can reduce fertilizer cost by 21 percent and increase crop yield by 15 percent; and (v) system of rice intensification (SRI) can improve rice yields, reduce fuel consumption and can reduce water consumption by 19 percent to 64 percent compared to conventional rice cultivation techniques (FAO, 2018b).

by 2050 (FAO, 2018b). Furthermore, it is estimated that rice contributes as much as 10.7 percent of the emissions in Southeast Asia (FAO, 2018b). To reduce climate change impacts and thereby protect yields, a number of climate adaptation measures, management practices and technologies can be adopted. These practices include rotating crop cultivations, biochar application, multiple drainage methods, AWD practices, application of customized fertilizers based on soil testing and using the system of rice intensification (SRI) approach (FAO, 2018b). Some of these practices are outlined in Box 4.4. However, rice is not traditionally considered a crop that benefits from price premiums that are linked to higher levels of quality or sustainability. Consequently, public incentives are imperative for unlocking private sector investment in climate smart rice production. Other climate-smart and adaptation measures for commodities such as coffee include the usage of brush turners and efficient kilns, planting shade trees in coffee plantations, or reducing the use of fertilizers (Central American Bank for Economic Integration, 2019). CA practices and climate change adaptation measures can therefore play a significant role in building resiliency for farmers by enabling them to safeguard yields and pricing levels.

Carbon neutrality also offers agribusinesses an opportunity to build resiliency against risks that may impact the bottom line. For multinational agribusinesses with very high CFPs and extensive supply chains that are exposed to climate risks, carbon neutrality offers a way to act in their self-interest and contribute to mitigate the adverse consequences of physical climate risks on agriculture. Climate change can also generate resulting impacts that may affect the quality and property characteristics of products, which may not be aligned to or fulfill consumer expectations. This may for instance, apply to companies operating in the tea industry, as changes in temperature and rainfall patterns can affect the growing season, flavor and health benefits of tea (Nowogrodzki, 2019). For example, the efforts and achievements towards carbon neutral processing of Sri Lanka's Bogawantalawa Tea company have been partly motivated by awareness of climate change impacts on tea quality and yields and the need to contribute to their mitigation. In this case, adopting CA techniques can help store carbon, while also supporting enhanced soil and water conservation, thus reducing risks from water scarcity and variability (IUCN, 2016). Furthermore, carbon can be used as an incentive to reverse the trend in solely increasing tea productivity levels at the expense of quality. One observed trend is that producers tend to respond to decreasing tea prices by increasing tea production volume and this is not only economically unsustainable, but also results in a higher CFP due to increased input requirements (Hajiholand, 2017). Although lower fertilizer application rates do result in reduced tea outputs, it can contribute to higher quality tea leaves and improving the bottom line for farmers (Box 4.5).

Complying with regulations and anticipating them

Carbon emissions are becoming a key policy theme around the world, with many governments pushing through legislation needed to achieve ambitious carbon reduction targets. This wave of climate legislation focusing on carbon emissions reduction has clear implications for the agrifood sector, with businesses gearing up to comply with these regulations and respond to the more stringent emission control and requirements. In this sense, businesses are developing carbon emission reduction plans and starting to pursue carbon neutrality to remain aligned with policy, comply with international and national regulations and anticipate what might soon become mandatory. Of relevance is the European Green Deal, which outlines the detailed roadmap the European Union will follow to become climate neutral by 2050. The first climate initiatives under the Green Deal include the European Climate Law, which will enshrine the 2050 climate neutrality objective into EU law, the European Climate Pact, which aims to engage citizens and all parts of society in climate action and the 2030 Climate Targe Plan, which seeks to further reduce net GHG emissions by at least 55 percent by 2030 (European Commission, 2021b). A central pillar of the Green Deal, is the EU Biodiversity Strategy, which aims to: (i) place at least 10 percent of agricultural area under high-diversity landscape features and (ii) render at least 25 percent of agricultural land under organic farming (European Commission, 2021c). The Green Deal also includes the Farm to Fork Strategy, which will support the production of food that has a neutral or positive environmental impact. The strategy outlines various targets, including: (i) increasing the share of organic agricultural land in the European Union from 7 percent to 25 percent by 2050; (ii) 50 percent reduction of pesticides by 2030; (iii) 20 percent reduction in the use of fertilizers by 2030; (iv) reduction of nutrient loss by 50 percent, while ensuring that there is no deterioration of soil fertility; (v) reducing the use of antimicrobials in agriculture and aquaculture by 50 percent by 2030; and (vi) 50 percent reduction in food waste by 2030 (European Commission, 2021e).

Box 4.5

CARBON CAN DRIVE TEA QUALITY LEVELS AND IMPROVE THE BOTTOM LINE OF FARMERS

Carbon neutrality can drive the reduction of nitrogen fertilizer in tea production, which in turn can help farmers improve quality levels and improve their bottom line for the following reasons: (i) nitrogen application rate has a linear relationship with growth (Melican, 2009); (ii) reduction of nitrogen fertilizer reduces cost to the farmer and slows growth; (iii) reducing nitrogen application can increase Theaflavin content, responsible for flavor and brightness in tea (Cloughlet, Grice and Ellis, 2008); (iv) reducing harvest quantities will enable farmers to pluck fine leaves and employ less labour; (v) a fine leaf (two leaves and a bud) has a higher polyphenol content than leaves and a bud so it will produce higher quality tea (Tea Research Association, 2017); (vi) fine leaves require less energy to reduce the moisture content during withering (saving energy costs); (vii) fine leaves make a higher percentage of main-grade tea (less waste) and require less sorting (saving electricity costs); and (viii) evidence shows that flavor and brightness is rewarded with higher auction prices. Despite mounting evidence, a globalized study assessing the impact that reduced nitrogen application has on tea quality levels and farmer incomes has yet to be produced. Even if – in a worst-case scenario – reducing nitrogen application does not increase farmer incomes, it lowers the cost of inputs while reducing their CFP.

The nature of the strategy and the targets set will impact businesses significantly. To contribute to the targets, businesses in the European Union will, to various degrees, have to change the way they operate, disclose information and communicate to consumers. Importantly, many businesses will most likely have to re-evaluate their CFP.

Anticipating market trends and policy is a key reason for pursuing carbon neutrality. When businesses are able to get ahead of policy in a certain area, they often have the possibility of shaping regulation on the topic. This also allows them to foresee and mitigate potential corporate risks arising from carbon regulation, for example, a carbon consumption tax. Getting ahead of market trends also allows companies to secure a market position. Businesses taking action on carbon will also be among the best situated to take advantage of the growing demand for low-carbon goods and services. For instance, companies are increasingly becoming aware that alternative proteins can serve as a driver of business growth. In 2016, the FAIRR's collaborative investor engagement on sustainable proteins engaged the 25 largest food retailers and manufactures to determine the business case for protein diversification (Ramachandran, 2020). It was found that 87 percent of the retailers have accelerated the development of plant-based branded products, since they view alternative proteins as a way to gain competitive differentiation. The five companies of Unilever, Tesco, Nestlé, Marks & Spencer and Conagra Brands recognize that a high dependence on animal-based ingredients represents a material risk to their business. These companies are therefore undertaking risk assessments throughout their supply chains and proactively investing to increase their plant-based product portfolios (Ramachandran, 2020). Furthermore, since 2020 the European Commission has been carrying out an impact assessment on regulatory and non-regulatory options on demand-side measures to minimize risks that products linked to deforestation are sold on the European Union market (European Commission, 2021d). These examples allude to the fact that agrifood companies need to increasingly be aware of and anticipate future regulations and policies to remain competitive.

Leverage new market opportunities, including sustainable procurement opportunities and building reputation and brand loyalty

Decarbonization pathways can support companies to enter new market segments. The pursuit of carbon neutrality can offer companies opportunities to diversify product offerings and – in theory – enjoy premium prices. For instance, as mentioned, many companies are accelerating the development of plant-based branded products, not only to anticipate regulatory changes, but also to gain a competitive advantage in entering seemingly niche market segments, which are expected to gain ground in the future. Carbon neutrality can offer opportunities for companies to enter new market segments as well as building reputation and brand loyalty for existing product lines. Furthermore, entering new carbon neutral market segments could also provide opportunities for aligning sourcing practices to recognized Green Public Procurement (GPP) standards, which as elaborated below, could open up further business opportunities. However, consumer willingness to pay for carbon neutral certified products is far from clear and this was confirmed by several agribusinesses interviewed. Taking the tea sector as an illustration, both Jalinga organic carbon neutral tea and Sewpur organic tea, share the same origin and are sold in bulk globally. The two teas are only one quality standard apart, Sewpur being of better quality. While Jalinga tea is certified carbon neutral it trades at a 30 percent discount compared to Sewpur tea, which is not carbon accredited.[45]

Carbon neutrality can also give a reputational boost to companies. Given the growing awareness of the impacts of climate change, businesses increasingly pursue and publicize their carbon-related plans to enhance their reputation. In turn, this allows businesses to be perceived by consumers as providing climate value, which can, in some instances allow them to charge a premium. Businesses building a positive climate reputation can also differentiate themselves from other market players and construct a base of loyal customers (for further details, please refer to Chapter 6). Large multinationals such as IKEA, Unilever, Tesco, General Mills, L'Oreal, Walkmart, Syngenta and McDonalds have committed themselves to the SBTi (Financial Times, 2020b). For instance, Syngenta has set the target of reducing the carbon intensity of Syngenta Seeds and Syngenta Crop Protection operation by 50 percent by 2030 through SBTi (Syngenta, 2021). Although the SBTi is voluntary and few tangible sanctions for non-performance exist, the companies are aware that performance achieved against the targets set by the SBTi are reported publicly. These multinationals are also aware that the absence of achievement or reporting on emission reduction targets can deteriorate reputation and brand value. Setting and achieving emission targets is increasingly being viewed by companies as a way to boost corporate reputations and to remain competitive. Furthermore, investors are increasing their skepticism towards long-term targets based on unproven new technologies and are calling for companies to define their ambitions using standard frameworks, such as SBTi (Financial Times, 2020b).

The move towards sustainable procurement is a practical driver of carbon neutrality. Producers increasingly may be pushed to adopt carbon neutrality to meet the low-carbon requirements of manufacturers and retailers. In 2020, public procurement accounted for 12 percent of the GDP in OECD countries, while this share amounts to almost 20 percent in many developing countries (One Planet Network, 2020). At the same time, governments are increasingly adopting targets towards carbon neutrality. In this context, sustainable procurement can be used as a powerful lever to achieve carbon neutrality targets. Accordingly, almost all OECD countries have developed strategies or policies to support GPP and about 70 percent are measuring results of GPP policies and strategies (OECD, 2015). As green procurement practices are on the rise globally and especially in Europe, companies may decide to go 'low carbon' to better position themselves on these public and B2B markets. Contractors and suppliers that can demonstrably meet GPP policies in a cost-effective way will be better positioned when tendering and bidding for public sector contracts. In this sense GPP is one key policy instrument to support the diffusion and uptake of climate friendly labels.

Green Public Procurement in the context of the European Union has demonstrated potential to influence tendering processes and the market for more credible carbon labels. GPP has been defined by the European Union as a 'process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured' (Commission of the European Communities, 2008). Around 2010, Low Carbon Procurement (LCP) also emerged as a possible direction and a subset of GPP (Cheng *et al.,* 2018). LCP has been defined as a 'process whereby

45 Pricing obtained from Van Rees. 2021. Van Rees North America and confirmed by company personnel.

Box 4.6

THE ITALIAN GPP ACTION PLAN

In Italy, the GPP National Action Plan, first released in 2008, was integrated in 2011 with the definition of Minimum Environmental Criteria, or Cambiamenti Ambientali Minimi (CAM) for catering and food distribution services. In the Italian CAM, besides including criteria of food from organic production and integrated production systems, as well as food quality, freshness and health-related criteria and regional food specificities, carbon foot-printing was inserted as a 'further rewarding criterion', for which: 'It is possible to assign scores to the bid with the lowest number of GHG emissions associated, expressed in terms of CO2eq, related to the entire life cycle of the service covered by the contract'. However, according to a 2012 report by Ecosistemi (Ecosistemi, 2012), only in 9 percent of the cases analysed by the report, a rewarding criterion is inserted for those catering services who take CFP into consideration. Nonetheless, through art. 34 of the legislative decree 18 April 2016, n. 50, the suppliers are mandated to apply the CAM when providing food supplies for collective catering services for schools, offices, universities, socio-sanitary structures and prisons (Confcooperative Lavoro e Servizi, 2020).

SOURCE: Italian Ministry for the Environment, Land and Sea, 2011.

organizations seek to procure goods, services, works and utilities with a reduced CFP throughout their life cycle and/or leading to the reduction of the overall organizational CFP when considering its direct and indirect emissions' (Correia *et al*., 2013). This process is often achieved through the definition of specific environmental criteria or standards in the call for tenders for food products and catering services contracted for the public sector (e.g. hospitals, schools). Indeed, in the context of the European Union, GPP has been shown to hold great potential to bring about the development of a more sustainable agrifood system (Soldi, 2018). For instance, the 'Organic for Children' project was initiated in 2006 in Munich, Germany by the private company Tollwood and the Department of Health and Environment of the City of Munich (Soldi, 2018). The pilot project ended in 2012 and managed to introduce 100 percent organic food into the catering services of 32 diverse facilities, including kindergartens, after-school and school institutions (Soldi, 2018). Another relevant GPP initiative developed by the Italian government, which is elaborated in Box 4.6. Furthermore, the City of Malmö, Sweden set the ambition of reducing GHG emissions by 40 percent from 2002 to 2020 (One Planet Network, 2020). To support the achievement of this target, the city aims to source sustainable ingredients for 65 000 lunches per day, which amounts to over 21 million lunches annually (One Planet Network, 2020). Additionally, cooking staff, teachers and healthcare workers will receive training on preparing lunch menus to introduce plant-based meals twice per week and preparing meals with sourced leftovers (One Planet Network, 2020). Through GPP, governments have influenced the market for more credible labels by defining procurement criteria, thereby enhancing the reputation of labels that adhere to this criterion (OECD, 2016). This can be attributed to the fact that labels included on approved lists for government procurement will likely enjoy increased credibility in the wider marketplace, leading to broader uptake by consumers and businesses (OECD, 2016). Despite the growing number of GPP policies and strategies, it must be noted that to date, most GPP for food seems to be based on promoting the procurement of organic, high quality, fair trade and seasonal products, rather than on products that have a low CFP. Although some GPP programs focus on the procurement of sustainable packaged foods, more can be done in terms of introducing criteria that take into account the CFP of products.

Respond to increasing investor expectations

Climate change is causing a shift in the investment universe, and businesses have to adapt in order to attract investments. Investors are increasingly betting on low carbon and climate friendly principles becoming one of the criteria for investment decisions. Hence, many businesses are considering carbon neutrality activities and labels as key to tap into the growing sustainable finance opportunities. Investors are increasingly incorporating ESG factors into their investment decisions. In 2018, sustainable investments constituted 25 percent of the global asset base professionally managed, which is equivalent to USD 30 million (Global Sustainable Investment Alliance, 2019). Investors are considering ESG factors to account for and mitigate risk and to exploit long-term opportunities. However, lack of standardized ESG reporting practices, limited transparency in ESG rating methodologies and inconsistent disclosure requirements hinder comparability and the integration of sustainability factors into investment decision-making. These factors present challenges to both investors and companies alike in converting sustainability-based commitments into practice. For further details on sustainable investing, please refer to Chapter 6.

Leveraging green financing opportunities can enable companies to reduce the weighted average cost of capital for sustainability-related investments. For instance, the agrifood business Olam International Limited and its owned subsidiary, Olam Treasury Pte. Ltd. (OTPL), secured a revolving sustainability-linked credit facility in 2020, aggregating USD 250 million linked to meeting key performance indicators (KPIs) for sustainability (Olam, 2020). The interest margin on the facility is linked to the achievement of sustainability KPI improvement targets and could be lower than comparable conventional loans if the sustainability targets are met (Olamn, 2020). Furthermore, Cofco International, a Geneva-headquartered overseas entity for Cofco Corporation, China's largest food and agriculture company, announced in 2019 a USD 2.3 billion syndicated financing facility (TXF, 2019). Cofco arranged the loan with 21 banks, including ABN Amro, BBVA, ING and Rabobank. Margins on each of the facilities are linked to the company's sustainability performance and targets including year-on-year improvement of Cofco's ESG rating by Sustainalytics and certain KPIs, including increasing traceability of specific commodities (TXF, 2019). Additionally, the United Overseas Bank Limited (EOB) announced in 2020 that it is supporting Wilmar International Limited, a leading Asian agribusiness group, with a two-year USD 200 million sustainability-linked loan (UOB and Wilmar, 2020). Similar to the Cofco loan, the interest rate on the UOB loan will be pegged to Wilmar's achievement of sustainability targets, subject to monitoring and verification by Sustainalytics on an annual basis (UOB and Wilmar, 2020). However, for these loans, it is unclear the extent to which sustainability related KPIs are linked to corporate KPIs. Furthermore, it is also not clear how outsourced parties, such as Sustainalytics will concretely monitor and report company performance against the sustainability-related KPIs.

Table 4.1
Farm-level barriers to adoption of climate-friendly agricultural practices

Type of barrier	Description	Indicative relative weight of barrier	Suggested role for policy
Structural	Tenure	Mixed, depending on practice	Not a policy priority
Structural	Infrastructure and complimentary inputs	Low	May consider investment infrastructure
	Farm succession, age and structure	High	Not a policy priority
Economic	Lack of financial benefits; effects on production	Moderate	Communication and education
	Cost of adoption	Moderate	May consider investment support for certain measures but evidence is mixed
	Hidden and transaction costs	Moderate	Simplification of regulation
	Access to credit	Moderate	Depending on underlying reason, public/private finance
Social and cultural	Cultural capital	Moderate	Communication and engagement
Behavioural and cognitive	Beliefs about climate change	Low	Communication and engagement
	Perceived long-time horizons, uncertainty and risk management	Low	Communication and engagement. Provide certainty where possible, for example regulatory certainty
	Competing pressures	Low	Not a policy priority

High
Moderate
Low
Mixed

SOURCE: Wreford, A., Ignaciuk, A. and Gruère, G. 2017. Overcoming barriers to the adoption of climate- friendly practices in agriculture. OECD Food, Agriculture and Fisheries Papers, No. 101, OECD Publishing, Paris, https://doi.org/10.1787/97767de8-en.

4.3 BARRIERS TO CARBON NEUTRALITY

As they pursue carbon neutrality, producers, farmers, food manufacturers and retailers, can encounter barriers. These barriers arise as a result of multiple factors and may affect each actor in agrifood systems differently and also can impact specific food value chains and geographies differently. The barriers discussed below are in addition to the obstacles that have been discussed in other chapters of this report: barriers stemming from methodological and technical difficulties of a typical carbon neutrality path (Chapter 2) and problems deriving from lack of harmonization of procedures and governance gaps in the processes and institutions involved in carbon neutrality monitoring, reporting and verification (Chapter 3). Agrifood systems face several barriers to carbon neutrality adoption. For example, at the farm-level, break down barrier types into: (i) structural, (ii) economic, (iii) social and cultural and (iv) behavioural and cognitive (see TABLE 4.1) (Wreford *et al.*, 2017). In the sections below we go through some of these barriers for both farmers and agribusinesses.

Land property rights

It is important to understand how reducing emissions and increasing sequestration by forests interacts with land rights and in many cases the livelihoods of smallholder farmers and indigenous communities. Box 4.7 highlights some of the considerations that governments can make in defining and regulating carbon rights, which can be considered as a direct extension of the right to land. Nonetheless, land rights are characterized by layers of often contested rights, including customary and statutory rights, governing land use, which in some cases can lead to incidences of violence and conflict. It can therefore be argued that carbon rights may add another conflicting layer to an

already complex set of claims to land tenure (Ecosystem Marketplace, 2020). Therefore, in developing and registering a project to a carbon standard, it is important that all relevant actors are consulted and agree on how to share rights and responsibilities. Some unregulated REDD+ projects have been questioned in terms of additionality, that is the ability to demonstrate that deforestation was actually avoided (Arts, Ingram and Broackhaus, 2019). Nonetheless, results from smaller scale and unregulated REDD+ projects on the effects on tenure security are not conclusive: while there is limited evidence that such REDD+ projects have worsened smallholder tenure security, there is also little evidence such projects have positively addressed the problem (Sunderlin *et al.,* 2018). For regulated REDD+ projects, governments are responsible for negotiating results-based payments for ERRs and can therefore catalyse incentives to regulate forest and land sectors, however, this needs to be done considering people's right to land (Ecosystem Marketplace, 2020). In this context, integrating voluntary REDD+ projects into existing national systems can mitigate risks of violating pre-existing rights, while enrolling local actors in forest and land protection (Ecosystem Marketplace, 2020). Importantly, integrating or nesting projects into national accounting systems can support reconciliation efforts in accounting for emission reductions. Private sector engagement may be required to develop incentive schemes (through the creation of voluntary marketplaces) and the rights of indigenous communities may be strengthened through formal contracts with governments (Ecosystem Marketplace, 2020). Overall, PES schemes can complement and eventually replace voluntary avoided deforestation projects, transferring results-based logic to larger population segments and creating long-term incentives to safeguard forest resources (Sterck, 2020). However, this will greatly depend on the level of development of forest governance, including land tenure reform, land-use planning and law enforcement. PES schemes can raise funds and protect ecosystems, while results-based and other climate finance can support the transition towards stronger governance (Rights and Resources Initiative, 2018). In this process, carbon rights serve as a valuable instrument to recognize the needs and rights of the stewards of existing forests, as well as those that invest in conservation.

Box 4.7

CHALLENGES IN DEFINING AND REGULATING CARBON RIGHTS

Governments face the challenge of achieving NDCs, while recognizing and meeting the rights of private land-owners and communities that manage and use forests. A discussion that is gaining ground is whether and the extent to which calculated emission reductions under voluntary carbon market standards should be accounted for in NDCs (Rights and Resources Initiative, 2018). Although standard issuers are responsible for ensuring that double-counting issues do not occur, in anticipation of regulating carbon markets, governments will need to decide whether to follow guidance set by standards or comply with conditions set by donors. In defining forest carbon ERRs, the UNFCCC framework competes with national emission trading systems and domestic REDD+ legislation, as well as private standards that define units traded on voluntary markets (Rights and Resources Initiative, 2018). Importantly, carbon rights in relation to land property laws need to be defined and understood. A clear definition of carbon rights is a prerequisite for accessing carbon markets linked to international standards or multilateral mechanisms of result-based payments. However, defining carbon rights is not an easy task for governments, as this often has legal implications and needs to consider existing tenure rights, including collective ownership of land by Indigenous People and other communities. Accordingly, a survey conducted in 2017, shows that 19 out of 24 countries surveyed do not have a national legal framework establishing and regulating carbon markets and only four of these countries (Brazil, Costa Rica, Guatemala and Peru) have explicitly defined carbon rights in national law (Rights and Resources Initiative, 2018). Furthermore, only three countries (Chile, Costa Rica, and Mexico) have designed both benefit-sharing mechanisms and feedback and grievance mechanisms (FGRMs), which are crucial elements of functional REDD+ projects and programs (Rights and Resources Initiative, 2018). As of 2017, no countries have operationalized their approach to benefit-sharing and only two have implemented FGRMs (Rights and Resources Initiative, 2018). Ultimately, only a few countries have defined carbon rights, including New Zealand, where the forestry sector is covered in the national emission trading system and where landowners can apply for government credits. In New Zealand, emissions reduction values are defined by the rules and regulations outlined in the national trading scheme. Similarly, in Guatemala the national law on climate change defines the rights to emission reduction units and reductions are generally based on principles of laws (including those that confirm a pre-existing right). Defining a carbon right could potentially also enable actors to use that right to qualify for government permits, services, goods or financial instruments. It can be argued that carbon rights relating to specific ecosystems services can be considered as an extension of the right to the land held by an individual, a community, a national government, or a subnational jurisdiction or depending on who owns and manages the land (Rights and Resources Initiative, 2018).

Property rights need to also be considered in determining the feasibility of adopting farm-level climate-friendly practices and for efforts related to monitoring, reporting and verification. Farmers who do not own the land that they cultivate are less inclined to adopt long-term sustainability actions and to invest in them (Claassen and Morehard, 2011). To obtain financing for capital-intensive improvements, land is commonly utilized as a form of collateral. However, although land does not have a life expectancy or depreciation, limited marketable collateral often results in higher write-offs (Lundblad and Rissanen, 2018). Furthermore, land is often not formally registered, and this generates further uncertainties on land ownership rights. These factors commonly lead to a reduction in the supply of loans for agriculture and sustainability-based investment projects and consequently, an increase in the price for financing. Many farmers are also skeptical in using land as collateral in fear of losing their land on default. In some cases, ownership rights are owned by agricultural holdings and enterprises. Therefore, to invest in up-to-date equipment and capital-intensive improvements required for low carbon practices farmers may either not be interested or will need to request permission from agricultural holdings and enterprises that own the land. In this regard, land property rights may also disincentivize MRV efforts. One way to circumvent some of these challenges is for agricultural enterprises that own the land to extend the scope of lease agreements, including specific clauses that outline requirements for MRV. MRV requirements can also include specific clauses for regular soil testing and reporting with a requirement to maintain soil organic content levels. Such requirements will likely incentivize farmers to adopt low carbon practices to maintain and increase soil organic carbon content levels. These requirements can also be used for decision-making on whether or not to renew a lease and can provide the data required for farmers and companies to qualify for carbon marketplaces. Extending lease scopes to specify MRV requirements may increase complexity, but this can serve as a valuable lever to formalize these requirements and for farmers to be compensated for engaging in MRV practices by qualifying for carbon marketplaces.

Infrastructure and access to technology

A move towards carbon neutrality often requires infrastructure and access to technologies, whose absence can hinder producers' efforts in particular regions or specific food chains. Transportation modalities can have a very important impact on emissions for specific food chains with alternative transportation modalities yielding very different emissions results. For instance, the distribution of 1000 kg of bananas from farms in Costa Rica to supermarkets in Europe can amount to 938 grCO2eq per kg, while the equivalent for pineapples is around 864 grCO2eq per kg (Kilian *et al.*, 2011). In both cases, maritime emissions (refrigerants, bunker and diesel) constitute the largest share of emissions, 85 percent and 92 percent for bananas and pineapples, respectively (Kilian *et al.*, 2011). Furthermore, transportation by rail of produce might be optimal in specific circumstances to comply with stringent carbon standards, yet in many places this type of transport infrastructure may be absent. Throughout the interviews conducted as part of this report, availability of low emissions-based energy sources has been flagged as an important aspect of achieving lower processing emissions for food companies. However, low emissions energy sources (such as renewables) are not always readily available and for many companies it is not feasible to develop their own energy sources. Another important example of infrastructure's importance for achieving lower emissions is that of food loss and waste, which globally in 2019 accounted for approximately 14 percent from post-harvest up to, but not including, the retail level of food produced (FAO, 2019c). The global CFP of food loss and waste, excluding emissions from land use change, was estimated in 2013 to account for 3.3 GtCO2eq-1, corresponding to about 7 percent of total GHG emissions that year (FAO, 2013). Significant losses are caused by inadequate storage conditions as well as upstream supply chain decision-making, which may predispose products to a shorter shelf life (FAO, 2019c). While it is a complex problem, one key determinant of food loss and waste is access to technology and cold-storage infrastructure throughout the production, transportation and storage stages.

The optimal path to reach carbon neutrality is constantly evolving with new technologies being made available to agrifood system actors, but often at a high initial cost. Food systems production and energy-related technologies (energy production, transportation, etc.), soil management techniques, heat and cooling system technologies up to carbon and methane capture and storage, among others, are being constantly improved. As a result, agrifood system players need to continuously update their strategies to reach lower carbon equivalent emissions. Furthermore, market penetration and maturity levels of zero-emission alternative technologies will in many instances, condition emission abatement potentials. As outlined in Chapter 4.2, methane power tractors such as the T6 Methane Power Tractor can potentially reduce CO2 emissions by a minimum of 10 percent and overall emissions by 80 percent (New Holland Agriculture). Although the T6 Methane Power tractor is yet to be distributed on a wide scale, pricing for similar 2020 models suggest that prices can be greater than EUR 100 000 per tractor across a number of European countries (Machinio, 2021). Moreover, while such technologies show promise, investment costs for these can be prohibitively high for medium- and small-sized farmers, particularly in developing countries. This is especially relevant for technologies that have not reached market maturity (including maintenance and supporting services) and widespread adoption may therefore take time. On the other hand, other technologies can be more mature and in some instances can benefit from economies of scale. Consequently, farmers and agribusinesses alike need to continuously re-evaluate existing and expected regulations, as well as potentially useful technologies to make decisions regarding the speed of climate technology adoption and related investment plans. In this context, it is unsurprising that some companies strategically delay immediate adoption of promising technologies as long as regulation and other factors (for example, shareholder expectations) allow for this. Such a strategy may result in lower investment costs. Other companies may seek to benefit from first mover advantages and therefore immediately opt to implement a technology.

Despite the promising developments and the fact that market leaders are piloting proof-of-concepts, many technologies are simply unknown and global penetration is yet to be achieved (McKinsey & Company, 2020). Total cost of ownerships (TCOs) and defined business cases for the introduction and adoption of zero-emission technologies need to be further developed and customized to country-specific contexts. Moreover, in many cases farmers, agri-SMEs and other local actors may simply not know what technologies are available in their specific agrifood chains, or have heard about them but lack knowledge about costs, benefits and probabilities of success. Several government and donor-led programs have sought to reduce this knowledge gap to foster technology adoption. For example, the World Bank project of Integrating Climate Change in the implementation of the Plan Maroc Vert Project (*Projet d'intégration du changement climatique dans la mise en œuvre du Plan Maroc Vert* – PICCPMV) piloted climate adaptation as a climate technology, through the introduction of direct and dry seeding technologies in several regions of Morocco. The total geographical scope amounted to 3 000 hectares (about 65 percent of the total surface under CA in Morocco at present) (World Bank, 2014). Technologies introduced included direct and dry seeding technologies (World Bank, 2014). Furthermore the EBRD, through its Finance and Technology Transfer Centre for Climate Change (FINTECC) program supports companies operating in the EBRD country portfolio to implement innovative climate technologies. As an example, one project will support the introduction of sustainable packaging technologies to extend the shelf life of dairy products and reduce commercial waste amounts in Uzbekistan. EBRD will provide a loan to Hamkorbank of up to EUR 2.92 million, which will in turn provide financing to Midas Plastics, to introduce a new production line that will produce lighter and recycled packaging materials (Azernews, 2021). In addition, there are many examples of platforms and knowledge networks developed by governments, donors and the private sector to share best practices, promote dialogue and accelerate the adoption of specific or groups of technologies. For example, World Intellectual Property Organization (WIPO) which was established by the WIPO in 2013, includes an extensive database of around 3000 technologies and tries to serve as a link between technology suppliers and users. Still, there is much to be done to make more technologies known, particularly to smaller businesses and farmers. One key area to support technology discovery is that of countries signaling their intent to move ahead with regulation and decarbonization through national policies and international agreements. Such a process helps create an environment for diverse private sector entities such as consultancy and audit firms, farmer groups or cooperatives to support technology diffusion. Overall, there is an important role for public interventions to reduce information asymmetries on technologies and their costs and benefits.

Besides discovery, actual linkages between investments in emission-reducing infrastructure, technology and management practices and higher yields and profitability are not always clearly promoted. For instance, in the case of rice farming many payment and financing schemes do not incentivize the use of wetting, drying and single season drainage methods for water management. This is because, in many instances, flat rates are paid to irrigation agencies and these are not linked to actual water consumption levels (McKinsey & Company, 2020). Water use policies that incentivize irrigation agencies to link pricing to water consumption volume combined with laser-land leveling technologies to expand applicability for implementing improved water management practices, could present resource and cost saving opportunities in rice cultivation (McKinsey & Company, 2020). Another example is the deployment of carbon capture and storage (CCS) technologies in the ammonia process in fertilizer production, which is often overlooked due to its associated costs and lack of economic incentives (Gonzalez-Diaz *et al.,* 2020). Given that ammonia production is estimated to produce over 370 million tonnes of CO2 by 2021, it has been estimated that if CCS technologies are incorporated at a 90 percent capture level in all ammonia plants in the world, more than 300 million tonnes of CO2 per year could be avoided (Gonzalez-Diaz *et al.,* 2020). Furthermore, as part of the business case for CCS technologies, the high purity CO2 generated at the intermedium process can be used for enhanced oil recovery (EOR) (polymers, urea, CH4, methanol, etc.) and sold in high volume to customers (Gonzalez-Diaz *et al.,* 2020). Therefore, revenue for selling CO2 could be an incentive to accelerate the deployment of CCS. Nonetheless, since CO2 utilization is an energy and material intensive process: LCAs should be done to evaluate net GHG impacts (Gonzalez-Diaz *et al.,* 2020). Overall, although many investments in infrastructure, technology and management practices present opportunities to reduce emissions, their linkage to higher yields and profitability are not always clearly promoted. Local advisory services and research institutions can play an important role in expanding farmer awareness on these linkages. Policies and subsidies promoting adoption, as well as the development of clear and context-specific business cases also contribute to accelerate market penetration of such technologies.

Adoption costs and access to finance

Beliefs and norms related to tradition, identity and attachment may affect the change and the implementation of climate-friendly practices and may impact adaptation in rural communities. For example, beliefs and experience of climate change can act as a barrier or an incentive. Very often farmers prefer not to implement climate change adaptation measures because they feel that changing their agricultural practices might result in additional costs and alter the quality of their products, related yields and revenues. In addition, the perceived long-term horizons, uncertainty about climate change effects and perceived relative low risk often hinder or delay action. On the other hand, young and well-educated farmers are more inclined to adopt climate-friendly practices precisely because of their different belief systems (Diederen *et al*., 2003; Vanslembrouck *et al*., 2002). What is more, recent studies demonstrate the relevance of traditional ecological knowledge of forest communities where natural resources management practices are constantly modulated following local climatic conditions and related changes (Hosen, Hitoshi & Hamzah, 2020).

Adopting or upgrading to new technologies usually implies capital investments and also changes to operational performance. For instance, feed-grain processing for improved digestibility through steam flaking reduces particle size and can improve productivity and reduce enteric fermentation. However, capital investment costs of up to USD 300 000 in the United States for feed-grain processing technologies (on-farm steam flaking), presents a constraint to farmers in low- and middle-income regions (McKinsey & Company, 2020). Similarly, investment costs for precision farming will vary greatly in accordance with field size and desired precision levels and such costs may be non-negligible for farmers evaluating whether to invest. However, as elaborated in Chapter 6, various agribusinesses can leverage various green financing opportunities and sustainability-linked loans. Nonetheless, access to financing will largely depend on the private returns of the technology relative to the economic returns, which have factored in externality reduction potentials and the extent to which technologies will contribute to achieving pre-determined sustainability-related targets. Table 4.2 summarizes some of the annual costs per hectare for various sustainable farming management practices across different countries including implementation and maintenance costs. Most importantly, the technologies may present potential adopters with very different cash flow profiles and also important gaps between the financial and economic net present values of adopting them. In this regard, technologies with important mitigation benefits may see a low market penetration for at least two reasons: (i) because they do not yield sufficiently good private returns given the regulatory context and other factors that influence market prices, and (ii) in cases where financial returns are attractive, they may result in cash flow changes and/or risks that are difficult to finance at acceptable cost (*vis-à-vis* returns).

The adoption process in itself may be lengthy and risky resulting in high adjustment costs. Farmers in many cases will need time to learn and apply novel carbon saving agricultural practices, which may result in increased risks of lower yields for some years. In addition, lack of support services for operations and maintenance or simply technical advisory on new technologies may increase risk

Table 4.2
Examples of investment and maintenance costs of sustainable land management options

Technology options	Practices	Case study	Establishment costs USD/ha	Average maintenance costs USD/ha/year
Agroforestry	Various agroforestry practices	Grevillea agroforestry system, Kenya	160	90
		Shelterbelts, Togo	376	162
		Different agroforestry systems in Sumatra, Indonesia	1159	80
		Intensive agroforestry system (high input, grass barriers, contour ridging), Colombia	1285	145
Soil and water conservation	Conservation agriculture (CA)	Small-scale conservation tillage, Kenya	0	93
		Minimum tillage and direct planting, Ghana	220	212
		Medium-scale no-till technology for wheat and barley farming, Morocco	600	400
	Improved agronomic practices	Natural vegetative strips, the Philippines	84	36
		Grassed Fanya juu terraces, Kenya	380	30
		Konso bench terrace, Ethiopia	2060	540
	Integrated nutrient management	Compost production and application, Burkina Faso	12	30
		Tassa planting pits, Niger	160	33
		Runoff and floodwater farming, Ethiopia	383	814
Improved pasture and grazing management	Improved pasture management	Grassland restoration and conservation Qinghai province, China	65	12
	Improved grazing management	Rotational grazing, South Africa	105	27
		Grazing land improvement, Ethiopia	1052	126

SOURCE: FAO. 2011. Climate Smart Agriculture: Smallholder adoption and implications for climate change adaptation and mitigation. Mitigation of Climate Change in Agriculture Working Paper No 3. FAO, Rome, Italy. www.fao.org/docrep/015/i2575e/i2575e00.pdf.

perceptions and contribute to lower adoption rates (compared to what would be socially optimal). This is particularly important for smallholders and SMEs in food systems that have tight financing options and cannot incur major risks. Such market failures again present an opportunity for public intervention in supporting development of support services and reaching critical mass in market development. For instance, through the support of FAO and the Ministry of Water Resources and Irrigation, solar powered pumping technologies were piloted and introduced in the Nile Delta, Egypt. Irrigation canals are often located below ground level and water is pumped using fossil-fuel based technologies, which have proven to be costly and unreliable. Solar powered pumping technologies were therefore introduced by the government and results include the establishment of two solar-powered sites for lifting irrigation water installed for a total capacity of 100.8 Kw and 14 pumps functioning on solar energy and irrigating 488 feddan (FAO, 2018c). Importantly, the Ministry of Water Resources and Irrigation is elaborating a plan to scale-up the use of solar energy to all other pumping stations in the Nile Delta (FAO, 2018c). While large farms can more easily generate economies of scale, costs for smallholder farmers often constitute a significant barrier towards more carbon neutral activities. Overall, smallholder farmers in emerging markets face a particular set of economic barriers and risks in relation to carbon neutrality, as described in Box 4.8.

These costs add to those already mentioned covering quantification, monitoring and verification (see previous chapters). They include: the costs of eventually generating and verifying LCAs (which can present significant costs, especially if these are produced and certified by third-party service providers), the costs of registering and certifying a project on a carbon marketplace or the brokerage costs of becoming carbon neutral. In particular, lack of information and standardization hinders adoption. Carbon neutrality efforts can be damaged by the great number of standards and approaches, which can confuse producers, manufacturers, retailers and consumers. Too much choice can delay implementation, as the proliferation of standards and labels does not support consumers in making decisions and can generate reputational risks, if the applied standards are later found not to meet other requirements (see Chapter 5).

Given the increasing interest of the private sector to directly reduce emissions, smallholder farmer incentives should be factored into carbon reduction projects and initiatives. An increasing number of companies are showing an interest in aligning carbon neutrality with their corporate strategies by working directly with supply chain actors to reduce emissions. However, smallholder farmers commonly do not have the human or financial capacity to decarbonize their own operations and will likely require full-scale support to reduce emissions. Not all companies can afford the investments required to reach, organize and train smallholder farmers that are operating in highly fragmented supply chains. Furthermore, smallholder farmers are unlikely to adopt new mitigation practices if trade-offs against farm productivity and food security exist. Therefore, to increase the attractiveness of mitigation measures, practices must demonstrate potential to generate tangible benefits related to increases in productivity and livelihoods (Wollenberg, *et al.,* 2012). Financial and non-financial incentives that could render mitigation practices more attractive to smallholder farmers include (Wollenberg *et al*., 2012): (i) improved farm production, efficiency and adaptability to climate change; (ii) income and other benefits from selling offsets in carbon markets and/or PES schemes; (iii) improved opportunities to attract investment; (iv) ability to access new markets and improved pricing or simply keeping market access; and (v) better alignment with values and social norms. Getting incentives right at the farm-level may require institutional adaptations and innovations to reduce transaction costs (for example working with farmer organizations or large buyers/traders), but also public interventions to align incentives along specific supply chains (for example, combinations of regulation with subsidization of first movers). For instance, as elaborated in Chapter 3, throughout the interviews conducted, a global beverage producer will work with 500 pilot farms to implement sustainable farming practices. To reduce the transaction costs of this initiative, the company has worked with its largest suppliers to identify the pilot farms and corresponding cooperatives to develop a protocol on sustainable farming practices and emission reduction measures. The cooperatives will assist the farmers in measuring their CFP under the new farming practices and to compare emissions on the plots of land where these practices have not been applied. Finally, it is important to note that a corollary of the analysis above is that an approach of purely setting high standards for foodstuffs including in environmental terms may also create major disruptions for smallholders. This is the case if there are high costs of compliance to standards for smallholders, which could result in reduced market access. It is therefore important that regulations and policies in general aimed at incentivizing decarbonization of agrifood value chains take these different factors into consideration.

Box 4.8

RISKS OF CARBON LABELLING AND TARIFFS FOR SUPPLIERS IN EMERGING MARKETS

Carbon labelling can be a risk for some producers, as it can potentially exclude uncertified agricultural products and small-scale producers in low-income countries from global markets or make them dependent on external aid for certification. Indeed, suppliers in low-income countries are concerned about the idea that carbon standards will become mandatory and that this will therefore jeopardize their ability to sell in international markets (Macgregor, 2010). Carbon labelling may also result in trade issues with the label becoming a non-tariff yardstick. Due to spillover effects in developing countries, carbon labelling may represent a non-tariff barrier and act as a trade protection measure. Moreover, GHG emission calculations or CFP calculations may be more difficult to compute in developing country contexts, creating disadvantages (Plassmann *et al.*, 2010).

This transition is taking a more structured and organized shape as the European Union plans for the Carbon Border Adjustment Mechanism (CBAM). The CBAM is a legislative proposal presented in 2021 that seeks to prevent GHG emissions leakage and to level the playing field between European and foreign emitters (Marcu, *et al.*, 2020). However, developing countries heavily dependent on 'brown' sector exports could become exposed to the effects of the CBAM. This includes oil producing trade partners in Africa and Arab states in the Persian Gulf (Allianz Research, 2020). This new form of carbon tariff will impact mostly the industrial sector in the short and medium term, with minor effects on the agrifood business. In fact, cement, iron, steel and petroleum products are likely to be most affected, with basic chemicals, fertilizers, industrial gases, aluminum and paper following (Allianz Research, 2020). To accurately implement the carbon border tax (CBT) for goods that encompass supply chains spanning across countries, will require complex calculations on how much value was added and where (Financial Times, 2020c). Consequently, the planned pilots for the CBT will be focused on commodities that are characterized by short and easily traceable supply chains (Financial Times, 2020c). Nonetheless, the CBAM may have a disruptive effect on global food trade with unprecedented implications on the decarbonization process. This is especially applicable to agriculture, where a tariff imposed nationally would not be able to equitably address the fact that similar food outputs in a country are produced using diverse methods, generating different emission levels (Financial, 2020). Moreover, at the World Trade Organization (WTO) Committee on Market Access meeting in November 2020, several members stated that the CBAM should be "designed and implemented in a fair manner and recognize carbon pricing systems in place in other countries (including at the subnational level), while aligning with international obligations and standards" (World Trade Organization, 2020).

Limitations in access to finance can be an important barrier to adoption of greener technologies that can support a carbon neutrality path. As previously noted, investing in technology adoption for farmers or agribusinesses can, in specific circumstances, produce a positive financial net present value. However, time horizons and cash flow patterns can vary tremendously resulting in longer payback periods and short-term liquidity needs. For example, adoption of improved rice paddy water management practices and direct seeding techniques have the potential to abate 296 million and 217 million tCO2eq, respectively at a cost saving of USD 12 and USD 41 per tCO2eq reduced. Furthermore, animal health monitoring and illness prevention, expansion of the use of feed-grain processing for improved digestibility and using low and no-tillage practices can potentially reduce emissions by 411 million, 219 million and 119 million tCO2eq at a cost saving of USD 5, USD 3, and USD 41 per tCO2eq abated (McKinsey & Company, 2020). However, the cost savings calculations will depend on the time horizon considered and there is a need to determine when in time cost savings will be achieved and whether the rate at which savings are achieved changes over time. Sustainable agricultural practices usually require time to generate benefits and cost savings, with many not actually generating cost savings or higher yields in the short-term. Such cash flow patterns need to be addressed through appropriate financial products but these are not always available, particularly for smaller players in food systems. In this regard, carbon neutrality and sustainable finance could serve as an important lever to overcome this constraint (see more in Chapter 6).

Public financing programs, agricultural investment policies, payment for ecosystem services and IFI support can all contribute to improved financing of agricultural GHG mitigation practices. Financing programs and green credit lines extended by public institutions and IFIs can play a significant role in removing adoption barriers. For instance, the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) was formed in 2012 to integrate the different European Union funding streams for green agricultural innovation projects. Funding streams include the European Rural Development policy and the EU research and innovation program, Horizon 2020. Since 2012, EIP-AGRI has channeled funding to over 200 projects supporting precision technologies (European Union, 2021). Other relevant credit facilities that support the adoption of green technologies include EBRD's FINTECC program which supports EBRD clients with loans and capex grants for demonstration projects that implement the best available climate technologies, within a specific sector and country. In addition, designing agricultural investment and policy to provide up-front finance and longer-term compensations for mitigation practices can support outreach and scalability efforts. Overall, public financing programs can address market failures beyond the provision of the capital required to overcome implementation barriers, but also by creating awareness and developing best practices in addressing externalities that can be applied by a range of stakeholders. As elaborated above, REDD+ can be used to finance PES, which in turn can serve as income sources for smallholders to prevent additional deforestation, conserve forests and enhance carbon stocks.

Carbon marketplaces that compensate farmers for adopting sustainable farming practices could provide farmers with the financing required to adopt emission reduction practices. It should be recognized that climate change is already a reality for many smallholders as it directly affects yields, food prices and consequently their livelihoods. Synergies between adaptation and mitigation exist in many cases and climate-smart agriculture, an approach to agriculture that sustainably increases productivity, enhances adaptation and mitigates emissions where possible, is gaining ground (IFAD, 2019). Private sector interventions can support smallholder farmers in qualifying for carbon marketplaces. Although low prices for voluntary carbon credits within the AFOLU sector have hindered opportunities for farmers to capture agricultural mitigation benefits, new carbon marketplaces that focus on compensating farmers for investing in regenerative farming practices have emerged. These include Nori and Indigo AG, two US-based carbon marketplaces that sell carbon credits at rates above the average voluntary carbon credit prices (USD 15 per credit). Other relevant carbon marketplaces include SCIG and AgriProve, which compensate Australian farmers for increasing soil carbon stocks through government-based ACCUs, which in August 2020 had a spot value of AUD 15.90 per credit (Australian Government Clean Energy Regulator, 2020c). For further details on these carbon marketplaces, please refer to Chapter 3.5 and Chapter 3.7 in this report. Although these carbon marketplaces apply only to farmers in the United States of America and Australia, the VCS methodology proposed by Verra holds promise to be expanded to smallholder farmers globally. However, it is advisable that to encourage adoption of innovations , it is recommended that carbon marketplaces provide upfront capital to smallholder farmers (Wollenberg *et al.*, 2012). Commonly, carbon payments are made once carbon credits have been generated and verified, meaning that farmers need to self-finance the transition to new practices. Increasingly, carbon marketplaces, including Plan Vivo, are providing payment streams to farmers at the beginning of project cycles (Plan Vivo, 2021). Furthermore, carbon marketplaces may need to consider potential hidden costs, as implementation and farmer organization costs can be significant and in the case of donor-funded projects, these costs have usually been absorbed or subsidized (Plan Vivo, 2021). Therefore, to accurately determine potential for replicability and scalability, it is important that the private sector and carbon marketplaces correctly account for these costs in their business plans.

4.4 REDUCING CARBON IMPACT REQUIRES CONSIDERING ALL STAGES OF AGRIFOOD CHAINS

Carbon emissions associated with agrifood systems arise along the supply chain from agricultural production to the processing, wholesale and retail levels, to the consumer and finally at the waste management level. Hence, emissions levels and reduction potential will vary along the supply chain and for different types of supply chains. Teasing out the emission contribution of each actor in any given supply chain has proven to be elusive and uncertain, because of highly variable management practices, the case-dependent conditions, different types of food products, and different calculation methods. Nonetheless, one global meta-analysis (WWF, 2012) suggests that most emissions happen at the production level, including agricultural inputs, followed by end-consumers as shown in Figure 4.6 and discussed in Chapter 2. For other stages of the supply chain, uncertainties come into play meaning that it is more challenging to pin down their different emission contributions.

Despite the measurement and accounting challenges, some agreement exists on the type of interventions that should be put in place to reduce emissions at each stage of the agrifood supply chain. Different measures can be adopted at each stage of the supply chain, each with an alternative potential to reduce emissions. Some measures, such as investments in research to improve agrifood system performance, are relevant for all food supply chain stages. Other measures, such as influencing consumer choices and demands, are only applicable to the final stages of the supply chain. Table 4.3 summarizes the major measures that can be taken at each stage of the agrifood supply chain. Although

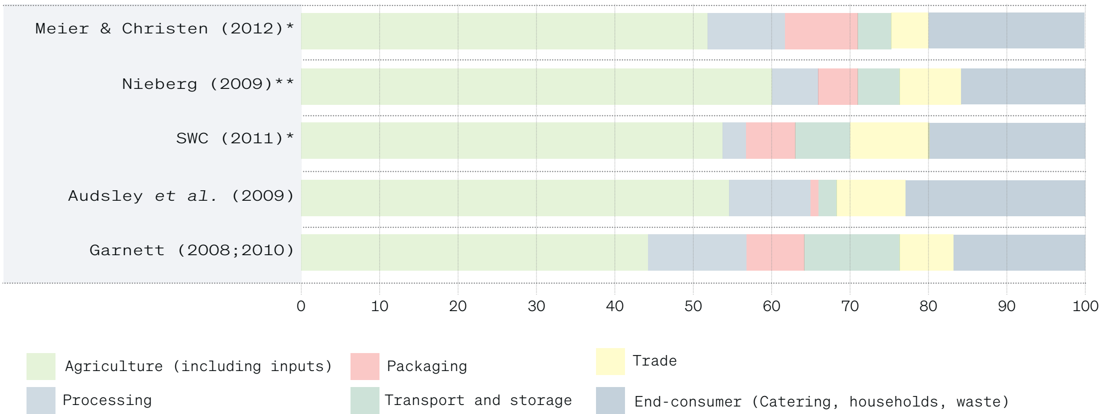


Figure 4.6
Shares of food supply chain stages in food-related GHG emissions in Germany (not yet considering emissions arising from land use change) (in percent)

SOURCE: WWF. 2012. Climate change on your plate. WWF Germany, Berlin. www.wwf.de/fileadmin/fm-wwf/Publikationen- PDF/Climate_change_on_your_plate.pdf.

* Including pro-rata end-consumer level GHG emissions not cited in the sources but which other sources give as 20 % on average.

** Calculated using a reasoned average per value chain segment as cited in the source text which draws on information given by other authors.

not included in the table, post-consumption and waste management stages in the supply chain should also be considered. Some research suggests that adequately combining several treatment options and increasing the separate collection of recyclable materials could render municipal solid waste management carbon neutral, as well as more cost-efficient (Fernández-Braña, Feijoo and Dias-Ferreira, 2020). However, institutions have a role to play in updating and harmonizing standards and regulations related to waste management and in ensuring that companies adhere to these.

For each of the main stages and associated actors of the agrifood supply chain, measures can be taken to reduce CFP, starting from input companies. Input companies can reduce their CFP by investing in research on stress tolerant crops, to produce more resilient seed varieties and reduce fertilizers and land and water resources requirements. They can also increase the efficiency of input production systems (notably of fertilizer), shift toward renewable or less greenhouse intensive energy sources for the production of fertilizer, or promote a shift toward more sustainable agricultural inputs for agroecological practices. According to the IPCC (2020), several mitigation response options have the technical potential for >3 GtCO2eq yr–1 by 2050 through reduced emissions and carbon dioxide removal (CDR). These mitigation potentials are illustrated in Figure 4.7. Agriculture measures combined could mitigate 0.3–3.4 GtCO2eq yr–1 (IPCC, 2020). The largest potential for reducing AFOLU emissions according to this source is through reduced deforestation and forest degradation (0.4–5.8 GtCO2eq yr–1), a shift towards plant-based diets (0.7–8.0 GtCO2eq yr–1) and reduced food and agricultural waste (0.8–4.5 CO2eq yr–1) (high confidence) (IPCC, 2020). However, more recent studies suggest that supply side levers (increasing protein-production efficiency) have greater mitigating effects than demand side efforts (e.g. promoting balanced and environmentally sustainable

Table 4.3
Measures to reduce GHG emission along the agrifood supply chain

Measures	Pre-production	Primary production	Manufacture, distribution and retail	Consumption
Investement in research: investing in research to improve agrifood system performace	×	×	×	×
Restoring ecosystems and landscape: restoring soil carbon stocks through re-wilding of farmed land, restoring forests or grassland, or rewetting drained peatland	×			
Agrifood certification	×	×		
Supporting change in farm practices: support on-farm measures outside agrifood certification schemes that could affect GHG emissions or support their suppliers to do so		×		
Carbon certification and offsetting		×	×	
Technical efficiency measures: technical measures to reduce the consumption of energy and other resources within the post-farm supply chain		×	×	
Influencing consumer choice and demand				×

SOURCES: Acampora A., Mattia G., Pratesi C.A. and Ruini L. 2020 Investing in Carbon Neutrality in the agrifood sector: challenges and opportunities in a dynamic setting. Unpublished background paper prepared for this report, Carbon Neutrality Lab. Roma Tre University; Kleemann, L. and Murphy-Bokern, D. 2014. Reducing Greenhouse Gas Emissions in the Food Sector: Effects of Corporate Responsibility. https://ideas.repec.org/p/kie/kieliw/1967.html.

diets) and that therefore should be prioritized in selected developing countries (Chang *et al.*, 2021). The options with largest potential for CDR are afforestation/reforestation (0.5–10.1 CO2eq yr–1), soil carbon sequestration in croplands and grasslands (0.4–8.6 CO2eq yr–1) and Bioenergy with Carbon Capture and Storage (0.4–11.3 CO2eq yr–1) (IPCC, 2020).

Most measures to reduce emissions at the agricultural production stage are based on technologies and practices to improve efficiency. There is a direct link between GHG emission intensities and the efficiency with which producers use natural resources, measures targeting the efficiency of agricultural practices can go a long way in reducing emissions. Precision agriculture (i.e. application of inputs to match crop requirements at the right time and space) and conservation tillage with nitrogen fixing crops (Garnett, 2011) are among the agricultural technologies and practices that can increase the efficiency of agricultural input systems and, in turn, reduce carbon emissions (Michael and Tilman, 2017). Furthermore, NDVI cameras and drones can be used to monitor crop health, moisture levels, surface temperatures, as well as crop performances. Not only can drones reduce crop applications by 30 percent to 70 percent, but such technologies can also support the reduction of environmental runoffs and instances of soil disturbance (Keen, 2019). As climate change forces crops such as tea or coffee into higher elevations, this technology becomes more important, as it can scale any gradient without disruption and can, in time for harvest, inform on the timing for crop deliveries to the factory for processing. In terms of livestock – cows, mainly – the greatest promise involves improving animal and herd efficiency. This includes using better feeds and feeding techniques, which can reduce CH4 generated during digestion as well as the amount of CH4 and N2O released by decomposing manure (Gerber *et al.*, 2013). Farmers can also reduce the carbon intensity of fuel inputs through energy efficiency improvements and

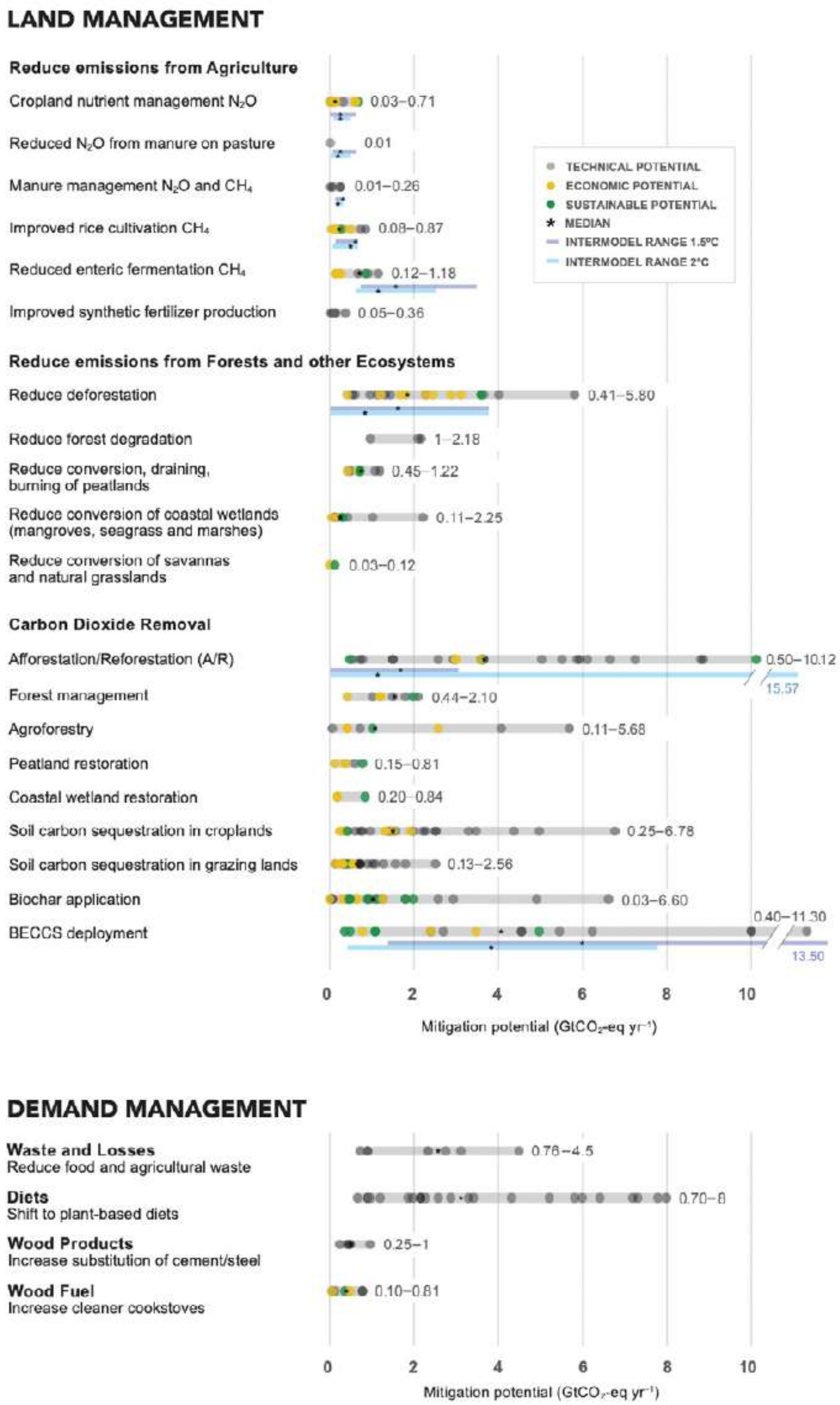


Figure 4.8

Mitigation potential of response options in 2020-2050, measured in GtC02eq yr-1

SOURCE: IPCC. 2020. 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. Shukla, P.R, Skea, J., Calvo Buendia, E. *et al.*, eds.

the use of alternative fuels such as biomass, biogas, wind and solar power and reduce food wastage and storage losses. Anaerobic digestion of livestock manure, as well as of farm residuals is an alternative pathway for managing organic waste and its associated problems encountered in large feeding lots and confined animal feeding operations (Klein, Chad and Jones, 2015). Through anaerobic digestion, manure can be recycled first as biogas and then converted into organic fertilizer (FAO, 2019d). Biogas can result in revenue from energy sales or savings from on-farm energy generation (Klein, Chad and Jones, 2015). Anerobic digestion of manure is especially applicable to livestock that is housed permanently or semi-permanently, as opposed to free-range managed animals, as it allows for the efficient and convenient collection of manure. For instance, one of the largest agroenergy plants in central and southern Italy, the factory of Piana, produces biogas from the manure and waste from adjacent stables, plus the residual whey collected from dairy processing plants. The biogas produces enough electrical energy to meet the needs of 2680 families and the thermal energy required to power dairy processing facilities (Fattoria della Piana, 2021). Other notable technologies emerging for in-house livestock involve the installation of filters that capture methane from indoor air, to use for the development of biogas (Valio Group, 2017).

The location of food production also influences opportunities for carbon reduction. Locating food production in areas with the right soil and climatic conditions can increase agricultural input efficiency and, in some instances, decrease environmental impacts, including carbon emissions (Chaplin-Kramer *et al.*, 2015). For instance, selective expansion of agriculture in areas with the right soil and climatic conditions can help maintain higher levels of carbon storage (Johnson *et al.*, 2014). In this regard, trade can play a role in achieving greater environmental efficiency of food systems. In particular it can also foster the diffusion of carbon neutrality labels and practices. In theory, trade could also contribute to a more carbon efficient allocation of land and water resources, helping to move production to areas where, because of local conditions, there are lower carbon emissions per unit of produce (Zimmermann *et al.*, 2018).

Beyond agricultural production, food manufacturing, processing and logistics companies have a big part to play to reduce carbon emissions. In terms of logistics, adoption of lower-emission modes of transport and more efficient storage can yield significant decreases in emissions. Similarly, enhancing the efficiency of energy and material use can reduce emissions. Food manufacturers also have a key role in terms of adopting, improving and spreading carbon labels, and promoting carbon labels for sustainable procurement. As outlined in Chapter 4.3, food waste in 2019 accounted for approximately 14 percent from post-harvest up to, but not including, the retail level of food produced (FAO, 2019c). Adequate cold storage can be particularly be crucial to prevent food losses. During transportation, good physical infrastructure and efficient trade logistics are important to prevent food losses. Processing and packaging can also play a pivotal role in preserving foods, but losses can be caused by inadequate facilities as well as technical and human errors (FAO, 2019c). Food loss and waste could be reduced by expanding cold storage, but this may lead to higher use of energy and packaging, which could result in higher costs, emissions and the generation of more plastic waste. Due to perishability, fruits and vegetables are especially susceptible to food loss and waste. Analyzing data from 39 countries throughout the period of 1990–2017, shows that roots, tubers and oil-bearing commodities present the highest food loss rates, which was over 25 percent of food lost from post-harvest to distribution. This was mainly driven by cassava and potato losses, as cassava has a perishability of two to three days after harvest and potatoes

At the downstream end of the agrifood supply chain, consumers hold the key for significant emission reductions.

More responsible consumption, including avoidance of carbon intensive products or products that Ware not labelled is a first key step.

require careful handling and proper storage, especially in warmer climates (FAO, 2019c). A number of methods exist to reduce emissions and energy related costs for cold chains at the different stages in a supply chain. Some of these were investigated by the Food Refrigeration and Process Engineering Research Centre (FRPERC) on three stores in the United Kingdom. Simple methods include improving door protection, fitting liquid pressure amplification pumps, optimizing defrosts and fitting suction liquid heat exchangers, which resulted in energy savings of 23 percent in cold store 1, 5 percent in cold store 2 and 39 percent in cold store 3 (James and James, 2010). Furthermore, there is an increased interest in using more efficient storage temperatures, since research has shown that many food products, such as red meats, often produce non-linear time–temperature curves (James and James, 2010). Improved packing and preservation of products can also increase storage life and may allow for higher storage temperatures to be used (James and James, 2010).

Retailers can reduce emissions and support the diffusion of carbon labels in multiple ways. Retailers can set up internal policies to measure and reduce the direct and indirect emissions deriving from their operations in stores, and they can also set up carbon neutrality requirements for their suppliers, excluding carbon intensive products from their stores. Food transport and logistics is also a key area of action, especially for certain food products (see section 5.2). Retailers can take a leading role in mainstreaming carbon labels, providing consumers with carbon information at point of sale and promoting the sale of carbon labelled products.

At the downstream end of the agrifood supply chain, consumers hold the key for significant emission reductions. More responsible consumption, including avoidance of carbon intensive products or products that are not labelled is a first key step. Reducing food waste and improving food storage at home are other key measures through which consumers can reduce emissions. Finally, dietary change and lowering meat consumption are key measures for reducing environmental impacts, including carbon emissions from food (Poore and Nemecek, 2018). Beyond consumers, the hotel, restaurant and catering (HORECA) sector also has a key role to play in reducing emissions through lowering food waste, as well as planning waste to energy facilities through, for example, biogas production (Lindkvist, Karlsson and Ivner, 2019). As an example, the Swedish burger chain 'Max Burgers' has taken this a step further, by accounting for its staff and guest trips to and from restaurants in its carbon accounting calculations (Lindkvist, Karlsson and Ivner, 2019).

While these measures are conceptually straightforward, their application in practice differs because of the heterogeneity of agrifood systems. Implementation also needs to be backed-up by long-term commitment. The effectiveness and feasibility of these measures varies, as it largely depends on the actors in question and the specific barriers faced (as discussed above). In addition, all agrifood actors interviewed for this study, which ranged from beef producers to breweries, stated that successfully pursuing carbon neutrality requires a long-term commitment and active engagement of every employee and especially of management. Unless sustainability is the true north, then it will be difficult to achieve real and sustained reductions in emissions (Bhattacharya, 2019). For instance, for one of the world's largest coffee manufacturers, pursuing sustainability has meant changing its relationships with suppliers, changing organizational structures and management responsibilities. At the broadest level, this comes from the realization that sustainability is not only a goal, but more importantly the starting point of a virtuous cycle which can lead to value creation and well-being of all actors in the value chain (Lavazza, 2017). For some value chains, carbon neutrality is, at present, not the main environmental concern, and comes after other sustainability issues such as reducing plastic pollution and improving water management. This is the case, for example, of Coca-Cola, where GHG emissions seem to have lower priority than packaging, water stewardship and health (e.g. sugar) (Coca Cola Company, 2019). For other agrifood actors, such as meat companies, carbon-related performance is indeed the most important aspect of their wider sustainability strategies.

CASE STUDY

1

COOPEDOTA'S COFFEE: CARBON NEUTRALITY FOR SMALL PRODUCERS

The carbon neutrality story of Coopedota Coffee offers an interesting case study outside the major agribusiness landscape. Coopedota Coffee is a Costa Rican coffee cooperative of 800 associated coffee farmers, that was the first coffee producer in the world to be certified carbon neutral based on a widely recognized international standard, the PAS 2060 (Birkenberg and Birner, 2018).

Coopedota has long been a pioneer in sustainable agricultural practices with its coffee receiving Rainforest Alliance, Coffee Practice of Starbucks, ISO 9001 and 14001 and Fair Trade certifications. The idea of carbon neutral certification was launched in 2008 as a consequence of Costa Rica's commitment to achieve carbon neutrality by 2021. In 2011, Coopedota coffee had already received its first carbon neutral certification. The steps that led Coopedota to the carbon neutral certification are shown in Figure 4.8.

In working towards the PAS 2060 certification, Coopedota encountered a series of challenges. First, data collection and methodologies were an issue. Farm data was difficult to retrieve because smallholders typically do not have the capacity to collect this data. The company overcame this difficulty by engaging farmers already involved with Rainforest Alliance projects, so more farmers were accustomed to collecting farm-level data, including through mobile technologies (The Rainforest Alliance, 2018). In addition, Coopedota encountered challenges applying CFP methodologies, because of issues in setting system and functional boundaries in the calculations. Second, carbon offsetting practices were difficult

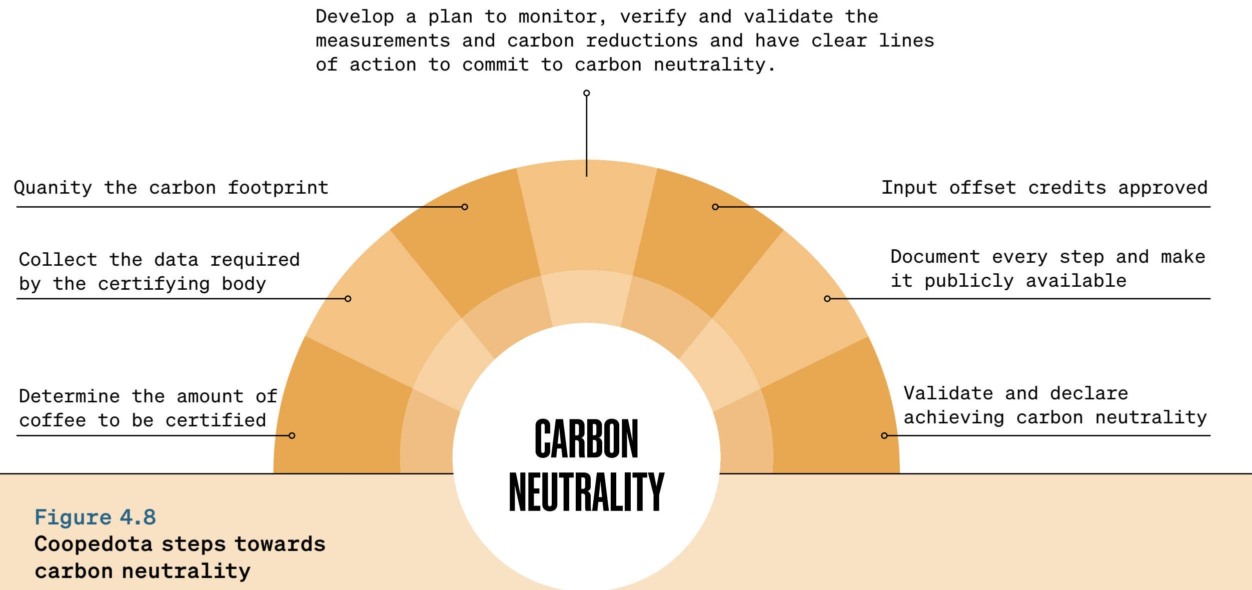


Figure 4.8
Coopedota steps towards carbon neutrality

SOURCE: Jiménez, G.A., Kilian, B., Rivera, L., 2013. Sustainability in the Coffee Growing Business: Coopedota and the path towards carbon neutral coffee.

Table 4.4
Internal and external certification cost

Internal cost budget of Coopedota for carbon neutral certification (USD)			Budget for external costs for carbon neutral certification (USD)		
Internal cost	Certification 2011	Review 2012	External cost	Certification 2011	Review 2012
Travel and per diem	2105	—	Certification (audit)	15 000	4050
Labour	8700	2000	Carbon credits	9400	8442
Other expenses	150.0	—	Professional services	4600	
Coopedota's workforce	8203	1872	—		
Total	19 158	3872	Total	29 000	12 492

SOURCE: Jiménez, G.A., Kilian, B., Rivera, L., 2013. Sustainability in the Coffee Growing Business: Coopedota and the Path towards carbon neutral coffee.

to explain to customers because of the lack of information on the PAS 2060 label regarding GHG emissions generated, reduced and offset. Third, PAS 2060 does not account for on-site carbon sequestration. Nonetheless, perennial crops such as coffee do offer a great opportunity for on-site carbon sequestration, leading to reduced cost for offset. Finally, cost was a significant hurdle: the certification process implied significant costs associated with both emissions' reduction, data collection, certification fees and offsetting (see Table 4.4). However, the certification also presented economic benefits including reduced costs for energy and fertilizers, a price premium and an improved public image.

CASE STUDY

2

LIVESTOCK UNDER THE SPOTLIGHT

While it is clear that reducing GHG emissions (both direct and indirect) from the livestock sector are part of the climate solution, particular attention needs to be given to how this is achieved. Livestock production is of particular importance to carbon neutral agrifood supply chains because of: (i) the size of the sector and its key role in nutrition and livelihoods; (ii) the significance of their CFP, and (iii) its technical but also economic potential for reducing and/or compensating emissions. Since the GHG emissions (both direct and indirect) from the livestock sector are significant, reducing them is part of the climate solution. However, considerations should be given to prioritizing the mitigation options depending on the purposes of livestock production, source and quality of feed, and the existing efficiency of the system. Cattle represent the largest share of GHG emissions compared to other species. This is in part explained by the fact that more than 50 percent of emissions from cattle (whether beef or dairy) come from enteric CH4 (see Box 4.9). The mitigation potential in livestock production is high with three main technical areas usually considered: (i) productivity improvements, (ii) carbon sequestration and (iii) limiting waste and associated emissions (FAO, 2017). Nonetheless, detailed subsector analyses (including those focused on livestock) that list potential emission reduction opportunities as a percentage of agrifood systems remain limited.

Box 4.9

UNWRAPPING CATTLE GHG EMISSIONS

Most of emissions from cattle come from enteric (CH4) which has a higher GWP than CO2. In fact, methane traps 86 times more heat than CO2 over 20 years after it is released into the air and 34 times more over a 100-year period (FAO, 2021j). Methane's lifespan in the atmosphere is only 12.4 years (Mhyre *et al.*, 2013). Therefore, reducing the rate of enteric CH4 emissions would help reduce the rate of warming in the near term and if emissions reductions are sustained, can also help limit peak warming (The Climate Collaborative, 2021). The lifetime of N2O, on the other hand is 121 years, and its GWP is 268 and 298 over a 20- and 100-year time horizon respectively (Mhyre *et al.*, 2013). However, the rate of CO2 emissions currently exceeds its removal, requiring a closer look at the CO2 emissions from fossil fuel combustion.[46] These factors have led to increased debates on the usage of the metric of CO2eq emissions, which are based on GWP-100 and which may slightly underestimate the impact of recent increases in short-lived climate pollutants (SLCP), such as CH4 emissions, on current warming rates because the climate does not respond instantaneously to radiative forcing (Lynch *et al.*, 2020). Such discussions have led to considering alternative uses of GWP, namely GWP*, which incorporates a term for each of the short-timescale and long-timescale climate responses to changes in radiative forcing (Lynch *et al.*, 2020). Using GWP* would therefore lead to the usage of CO2-warming equivalent (CO2we), where SLCPs and cumulative climate pollutants are aggregated separately (Lynch *et al.*, 2020).

Productivity improvements can increase efficiency and reduce emission intensities simultaneously, while carbon sequestration, through improved pasture and grazing management as well as integration of trees holds much promise. Livestock production systems operate at very different levels of efficiency, even within the same country or territory. FAO estimates that implementing the best and already available practices in a given system, region and climate could reduce global livestock emissions by 30 percent without any changes in the overall output (Gerber *et al.*, 2013). Grasslands and rangelands represent about 70 percent of the total agricultural land globally and the majority of this land is not suitable for crop production. FAO estimates that about 25 percent is degraded. Pasture restoration as well as systems that integrate trees can significantly increase soil carbon sequestration.

46 It is important to note that the change in concentration of any trace gas depends in part on the emission and removal of the particular gas over time.

Limiting waste through better livestock integration in the circular bioeconomy can further increase the environmental efficiency of the sector (Aimable *et al.*, 2019). The total amount of livestock manure produced globally contains more nitrogen than the total quantity of applied synthetic fertilizers (Bouwman *et al.*, 2013). However, large amounts of manure are still discharged or not used efficiently, for example for energy (biogas) or fertilizer, which result in GHG emissions (Gerber *et al.*, 2013). FAO estimates that crop-residues and by-products represent 19 and 10 percent of livestock feed in dry matter, respectively (Mottet *et al.*, 2017). However, large amounts of residues, by-products, but also wastes from agrifood systems are still burnt or discharged, contributing to GHG emissions, while they could be used as livestock feed and reduce feed food competition. While nitrogen levels in manure and waste are high and could be used more efficiently, the costs of managing manure need to be factored into its relative value and volume ratio. Regulations and incentives should be promoted to render the costs of managing and transporting manure more efficient, as this would likely contribute to the widespread adoption of improved waste management practices. Furthermore, improving manure management practices depends highly on the type of production system and especially on the type of housing and feed system. For instance, the potential to reduce emissions through manure collection is higher in indoor systems than grazing systems.

A large number of initiatives already exist to respond to the particular challenges that the livestock sector faces in achieving climate goals. These include corporate labels, supply chain initiatives based on public-private partnerships (PPPs) as well as existing certifications. These initiatives differ in terms of their ambition (low carbon or carbon neutral), the scope of emissions included (1, 2 and 3), the extent of the number of actors involved (from a single private company to a whole supply chain in partnership with the government), the methodologies used for calculating emissions and the quality of data used, the type of certification used (and what is certified e.g. approach, offsetting method), and the stage of advancement. The examples listed in Table 4.5 show significant differences between corporate initiatives by private companies and initiatives involving entire supply chains with the support of academia and governments. The first ones (Arla, Danish Crown, Flinders and Max Burger) are directly responding to consumers' demand and include Scope 2 and sometimes 3 emissions. For CFP quantification, these companies rely on third-party service provides or academia. When certification is used, it is for part of the process only. For example, a large number of initiatives refer to the requirements and guidelines for ISO 14067 on CFP quantification of products which provide principles and guidance but not detailed methods and actual calculation processes. In addition, offsetting is usually part of the solution to achieve a carbon neutral claim. This choice has implications in terms of verification of offsets (which is usually done by a third-party), their longevity and the fact that actual emissions from livestock production can remain unaddressed and unchanged.

Initiatives that involve a broader set of actors usually rely on accurate baselines, harmonized measurement methods and collective certification. This second type of initiative includes Carbon Dairy in France and Carbon Neutral Beef in Brazil and involves a broader list of actors, including farmers who undergo regular GHG assessments as part of their commitment. These assessments are able to generate accurate baseline emissions linked to actual practices on farm, instead of using default values or extrapolations. They are based on harmonized methods and tools and a collective certification system for the entire process, which is guaranteed by the national authorities. The industry is associated on a voluntary basis with market low carbon products. The carbon credits generated

Table 4.5
Some examples of low carbon/carbon neutral initiatives in the livestock sector

Entity	Ambition/ target	Scope	Actors involved	Method	How certification is used	Stage of advancement
Arla (dairy) (Arla, 2021)	Reduce emissions by 25 percent between 2005 and 2020; two carbon neutral brands	3	Arla Foods AB and third-party consulting company	LCA with allocation (IDF 2010)	Footprint following ISO 14067 Plan Vivo System for offsetting	Practices being implemented and baseline established
Danish Crown (meat) (Danish Crown, 2019)	Reduce emissions by 50 percent between 2005 and 2030; carbon neutral neutral by 2050	3	Danish Crown+ third-party consulting company (Aarhus Uni and Danish Technological Institute)	LCA with allocation (Aarhus University)	Footprint following ISO 14067	Practices being implemented and baseline established
Flinders + co (meat)	Carbon neutral meat through offsetting	2	Flinders + co and third-party private company (Carbon Reduction Institute)	N/A	Footprint following ISO 14067 offsetting	Implemented (emissions calculated, offsetting purchased)
Max Burger	Carbon neutral meat through offsetting	2	Max Burger and third-party private company	N/A	Plan Vivo System for offsetting	Implemented (emissions calculated, offsetting purchased)
Carbon Dairy (European Union)	Reduce emissions by 20 percent between 2005 and 2020	3	Farmers, processors, advisory services, research institute and government	LCA with tool CAP2ER aligned with LEAP, IPCC Tier 2 and 3 and certified by ECOCERT	Ministry Low Carbon label and third-party certification	Practices being implemented and baseline established in 13 000 farms
Carbon neutral beef (Brazil)	Low carbon and carbon neutral, two different labels	3	Farmers, processors, advisory services, research institute and government	LCA with Cool Farm Tool	N/A	Practices being implemented and baseline established
Pasture restoration in China (Verra, 2014)	Reduction, with no specific target	3	Farmers, international organizations and research institute	VCS methodology based on monitoring grazing management practices	Verified Carbon Standard	Certified method registered, being tested
Smallholder dairy methodology (Kenya) (FAO, 2016c)	Reduction, with no specific target	3	Farmers, international organizations, research institute and government	Gold Standard methodology based on LCA	Gold Standard	Certified method registered, being tested

SOURCE: Compiled by authors.

Low carbon livestock is already being promoted through sovereign lending programs and projects financed by IFIs, however, further involvement from the private sector is required to achieve scale.

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for farmers support investments for improved practices and reduction of emissions. Furthermore, the Australian Beef Sustainability Framework is a set of guidelines that can be used by practitioners in the Australian beef industry. The framework was developed in 2017 and it tracks the industry's performance in addressing priority areas, including animal welfare, economic resilience, environmental stewardship and people and the community against a set of key indicators (Australian Beef Sustainability Network, 2020). The environmental stewardship priority area addresses the improvement of land management practices, mitigating and managing climate change and minimizing waste (Australian Beef Sustainability Network, 2020). In total, the framework has identified 23 priority issues and 50 indicators to track progress against recognized standards and metrics (Australian Beef Sustainability Network, 2020).

Initiatives that are specific to a system and/or country focus on establishing methodologies that support the development and certification of carbon credits. The two last examples in Table 4.5 differ in the sense that they are methodologies for specific systems and countries (restoration of grasslands in China and improvements of practices in small dairy producers in Kenya). Compared to corporate initiatives, they are at the other end of the scope as they do not set up targets to achieve, but start with a methodology for MRV to support development and certify carbon credits. These methodologies can then be used by any company, supply chain or project. They represent the first step taken by initiatives at supply chain level previously described and usually associate farmers, academia and international organizations.

Low carbon livestock is already being promoted through sovereign lending programs and projects financed by IFIs, however, further involvement from the private sector is required to achieve scale. Low carbon livestock or climate smart livestock, is being mainstreamed in large scale livestock projects and investments, such as the ones funded by the World Bank and IFAD, as well as in medium- and small-scale investments, for example with the International Finance Corporation or at national level, the Uganda Development Bank (UDB). This mainstreaming relies on initial capacity building in institutions and governments, and on the provision of user-friendly tools, such as the FAO tools Ex-Act and GLEAM-*i*. There is however much need to go beyond sovereign lending operations only and involve the private sector.

Within carbon-intensive sectors, more systematic support is required to prioritize low carbon investments. Public-private partnerships may play a key role to provide science-based evidence and to ensure the application in practice simultaneously. This includes tools and capacity building and awareness raising for all stakeholders, including governments, private sector and investment officers. While the potential for improvement is extremely large in a carbon-intensive sector such as livestock, the same is also dangerously exposed to defunding or lack of funding on the basis of negative environmental externalities. Therefore, evidence-based initiatives should be favored. Examples exist at supply chain level which are based on systemic calculations of GHG emissions on farms, rather than default emission factors or extrapolations of case studies. Upscaling these initiatives might require: first, a multiplication of initiatives to create sufficient references; and second, finding reasonable middle ground to motivate investments while ensuring credibility, for consumers, but also for the private sector. The recent request by the 27th Committee for Agriculture to FAO to 'establish a comprehensive and evidence-based assessment of livestock to food security, nutrition and healthy diets' should contribute to these points. It is also worth adding the importance of communication by the sector and by influential organizations and the consistency in communication within organizations.

CASE STUDY

3

FACTORY-LEVEL DECISIONS, PACKAGING AND TRANSPORTATION CHOICES CAN ALL MAKE A DIFFERENCE IN TEA

Experiences from the Kenyan tea sector indicate that optimizing energy consumption in tea processing can not only reduce the CFP of tea, but also result in significant cost savings, as energy use can constitute up to 50 percent of factory level costs of production (Niyonzima *et al.,* 2020). Nonetheless, investments in optimizing energy sources need to be financially justified, prior to considering impacts on emissions. Throughout the ETP-driven program in Kenya, a series of energy efficiency activities were undertaken, including: (i) the correct storage of fuel wood to reduce moisture to < 20 percent in order to maximize calorific value; (ii) insulation of boilers; (iii) increased temperature control points to manage consistent product temperature throughout processing; and (iv) amended standard operating procedures to bring focus to heat loss opportunities i.e. keeping furnace door closed and preventative maintenance of heat exchange tubes (ETP, 2021; ITC, 2014). To date, results include a 10 percent reduction in energy use and a 13 percent reduction in biomass consumption. Importantly, this equates to a saving of over USD 3.8 billion and 300 000 trees

Table 4.6
Emissions sources and potential mitigation activities at tea factories

Emissions source	Mitigation activities (reducing emissions from the source)
Electricity consumption	Reducing electricity consumption e.g. low energy lighting Converting to low carbon or renewable sources of electricity e.g. hydropower or solar
Fuel wood consumption	Reducing fuel wood consumption e.g. from drying fuel wood or improving boiler efficiency Sourcing fuel wood from sustainably managed plantations Setting up tree nurseries to support the distribution of native trees to smallholder farmers and to stock fuel wood plantations
Truck fuel consumption	Reducing diesel consumption e.g. through rerouting tea collection trucks
Fossil fuel consumption in backup generators	Provide an onsite renewable or low carbon source of electricity
Fossil fuel consumption in boilers	Improve boiler efficiency Increase security of fuel wood supply
Waste water treatment	Low energy and natural waste water treatment plant

SOURCE: International Trade Centre (ITC). 2014. Mitigating Climate Change in the Tea Sector. www.intracen.org/uploadedFiles/intracenorg/Content/Publications/Climate%20Cha nge%20Tea-%20 Final%20Manual_Low%20Res.pdf.

saved.[47] Furthermore, analyses conducted by the KTDA show the importance that withering (removal of moisture from tea leaves) can have on electricity use and it should therefore be considered as an important lever in reducing energy-related costs and emissions[48] (ITC, 2014).

Energy efficiency measures adopted in the Kenyan tea sector are paving the way for the adoption of such practices on a global scale. Finlays, a tea manufacturer and supplier with Kenyan roots is wholly owned by the Swire Group conglomerate. Similar to the KTDA, Finlays has also applied levers to optimize its energy use on a factory and processing level. The main actions include:[49]

- Solar powered ropeway for the delivery of green leaf to the factory, eradicating the need for diesel transport for much of their estate;
- Solar powered pre-heating of air (to 40°C) for the withering of leaves;
- Introduction of continuous chemical withering (CCW), continuous chain withering machines, reducing the time to wither from 18 to 6 hours;
- A move to renewables including hydroelectric, wind, biogas and solar has rendered 85 percent of their operational needs carbon free;
- Created a private utility to supply mixed renewables (30–40 percent) and grid (60–70 percent) energy to 5600 houses on the estate.

47 Factories use fuel wood in their boilers and reducing the moisture content of wood prior to combustion improves the calorific content and reduces the volume of wood required per tonne of tea produced.

48 KTDA Analyses show that whithering (39 percent), Cut Tear and Curl rolling (CTC) (20 percent), drier (20 percent) and boiler (8 percent) contribute to more than 80 percent of annual electricity use in the tea production process.

49 Figures were obtained by the author on site visits to Finlays factory in Kericho, Kenya.

Experiences from the Kenyan tea sector have inspired Indonesian and Sri Lankan factories to commit to similar energy saving initiatives. The main interventions are summarized in Table 4.6. Overall, it can be observed that large and often multinational tea companies are increasingly employing energy efficiency measures at the tea processing level. Although this may be largely driven by the potential to reduce costs, such measures can also contribute to accelerating the adoption of low carbon operational practices.

Further downstream in the supply chain, the type of packaging and the type of transportation used can significantly affect the CFP of tea products. Sri Lanka has the most developed value-added industry, with 50 percent of exports deriving value, either through brands such as Dilmah or private label packers such as Akbar Brothers and Eswaran (Sri Lanka Export Development Board, 2021). Similarly, Japan and India have highly developed value-added tea sectors and now Kenya is attempting, through the new Tea Act, to conform 40 percent of all exports into this form (Republic of Kenya – Twelfth Parliament, 2020). From a carbon standpoint, value-added tea markets make sense when supplying to domestic markets (Japan and India), but not necessarily for export-orientated countries such as Sri Lanka and Kenya. For example, a 40 ft full container load of Kenya KTDA PF1 teabags packed in bulk paper sacks and palletized can hold 24 tonnes of tea. The same container, carrying 20 teabag cartons (each bag with a net weight of 2 grams) in a palletized case of six, can hold 2 592 kilograms of tea.[50,51] Bulk shipment of tea from Mombasa, Kenya for consumer packaging in London would equate to roughly 0.0673 grCO2eq per cup of tea, whereas the same amount of tea in a valued-added format and shipped to London for direct distribution, would amount to 0.311 grCO2eq per cup of tea.[52] Given that the United Kingdom consumed over 60 billion cups of tea in 2020, this would result in value-added shipments of tea generating on an aggregate level more than 14 500 tCO2eq, than if tea had been shipped in bulk. Finally, if the same amount

50 Calculated through: www.gigacalculator.com/calculators/container-loading-calculator.php.

51 Assumption of a low density teabag carton format (2 grams net weight teabag in a box of 20) and not a loose tea packet or other market format that could show a less dramatic difference, albeit mitigated somewhat by lower density loose leaf tea.

52 Assumptions obtained from interviews with experts and calculations computed using: https://kuhnenagel.ecotransit.org/kuehnenagel/.

of tea were to be transported via air freight for direct distribution, this would equate to 44.7 grCO2eq per cup of tea.[53] Ultimately, these simulations demonstrate that the structure of a value chain especially if value-added activities are initiated (close or far from destination) and transportation types are well chosen.

On the other hand, cost and carbon can be saved where large distances on a national level need to be covered and when the product can be shipped to various ports closer to the final destination. For instance, the majority of iced tea in North America is consumed out of the home and the food service execution uses 85/100 grams filter packs, which can be densely packed into shipping cases (USDA, 2020; Tea Association of the USA, 2021). Given road carrying weight restrictions in certain states, this ready packed format can cube out in a container before it goes overweight and, in this instance, it makes sense to pack at origin. In this particular case, the other significant factor is the size of North America and the road miles that a product has to travel after unloading at the port. Packing at origin enables shipment of the same product to various ports, closest to the final destination, saving both cost and carbon. Using the Kuehne and Nagel calculator, the following values for a twenty foot equivalent unit (TEU) from Buenos Aires, Argentina are generated:[54]

- New York: 1792 kgCO2eq/20'TEU
- Los Angeles 2635 kgCO2eq/20'TEU

Although the carbon cost of shipping to Los Angeles is high, it is still lower than transporting the product from New York by truck, which would add a further 2370 kgCO2eq (half a tractor trailer load), for a total of 4162 kgCO2eq.

Ultimately, although logistics and distribution do not make up the largest share of emissions, through strategic planning, they present a 'low-hanging fruit' opportunity to reduce costs and emissions. These aspects are the easiest to address through strategic planning and the easiest to sell in, as the cost savings can be sizeable. A global tool available for intermodal route planning would enable transport companies and their clients to make informed decisions on the most efficient carbon transit plans. Such a tool could support challenges related to value addition at origin and distribution planning.

The COVID-19 pandemic has significantly altered last-mile logistics, with uncertain effects on emissions. A significant part of consumption during the COVID-19 pandemic has shifted to each individual home. This has an impact on logistics, as a larger share of food products now need to be delivered to individual homes, rather than common points of sale (for instance, restaurants, cafeterias, bars and so on). This implies that the last mile of logistics has altered and in the case of e-commerce transactions, extended. Accordingly, internet sales in 2020 experienced a +50 percent year-on-year growth (Harris, 2020). In the case of tea, it can be argued that only high-value brands and products can justify the additional costs for home deliveries. Nonetheless, the expanded use of e-commerce for consumption of foods will have an impact not only on logistics costs, but also on emissions. To date, it is not possible to assess the extent to which changes in last-mile logistics have impacted emission structures, but this should be closely monitored.

53 Calculations computed using dhl-carboncalculator.com.

54 Assumptions obtained from interviews with experts and calculations computed using: https://kuhnenagel.ecotransit.org/kuehnenagel/.


RENEWABLE RESOURCES
PRODUCTS
PRODUCTS

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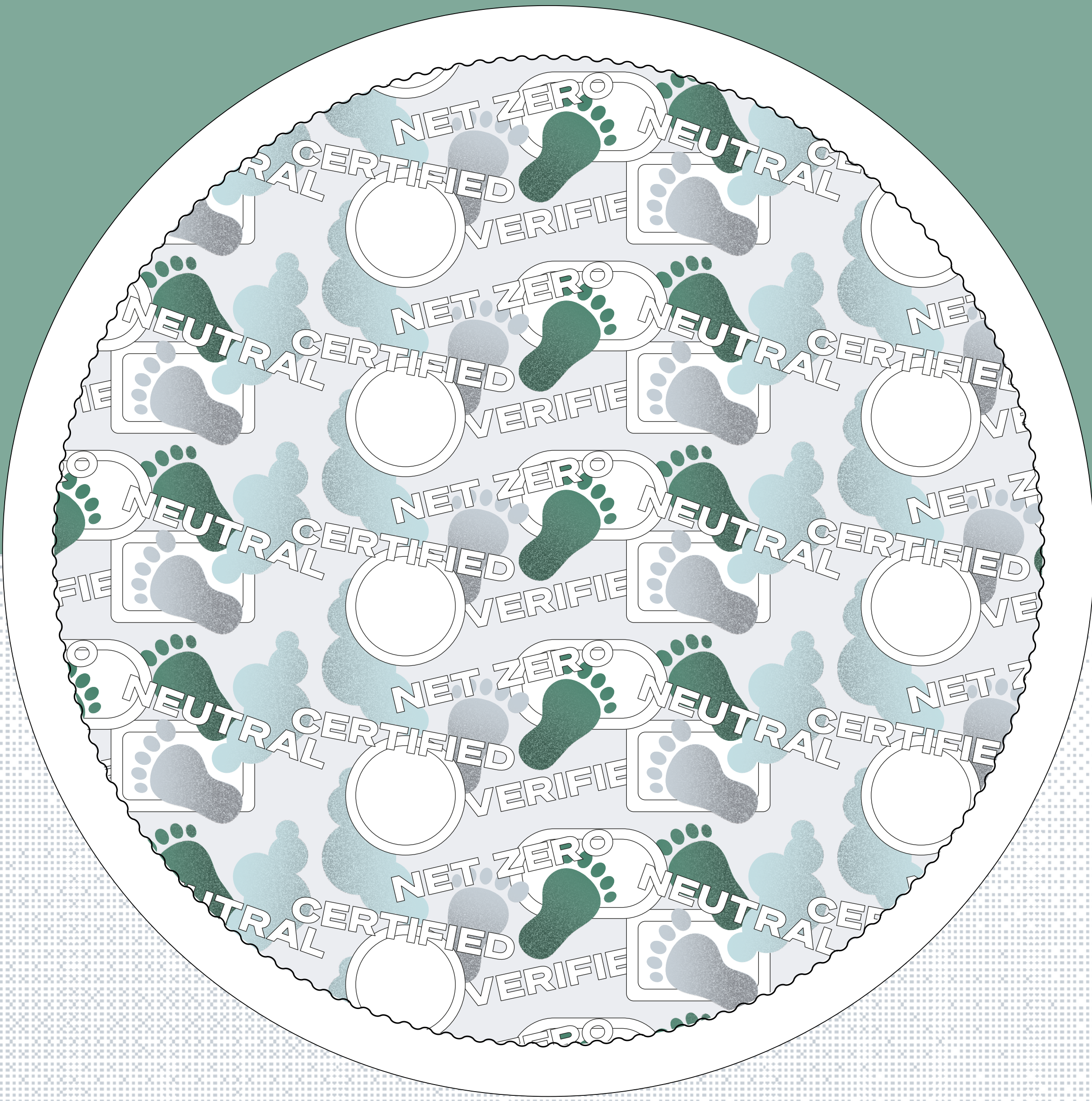
NET ZERO
NEUTRAL
CERTIFIED

Chapter 5
Towards a carbon labelled world?

The chapter reviews existing carbon labels and aims to evaluate their effectiveness at influencing consumer choices and behaviour towards low carbon products. Food labels have long been applied as an instrument to inform consumers and influence their purchasing behaviour and carbon labels are just one type of ecolabel introduced to promote sustainable consumer food choices. This chapter explains some of the challenges related to carbon labelling and explains how the public sector and retailers should step-up their efforts to enhance and promote carbon labelling. The remarks made in this chapter are relevant for high- and middle-income countries where food labelling is widespread and where data on consumer responses to food labels is available.

5.1 CARBON LABELS AND THE GLOBAL ECOLABEL BOOM

Food labels can be an effective approach to guide consumers towards more environmentally friendly choices and to inform and educate them about the environmental impact of the food's life cycle. Labels and certification can be useful in transmitting information to consumers and can help companies to market and communicate their eco-friendly efforts (Siriex *et al.*, 2013). Theoretically, labels can help to overcome the intangibility of the impacts linked with food production and distribution processes. Nonetheless, to act as shopping aid towards low carbon foods choice, labels have to be familiar to consumers (Emberger-Klein and Menrad, 2018). When labels are not familiar or not completely understood, they can affect consumption choices in a negative way.

Over the last decade, there has been a proliferation of labels for food products with environmental or social claims. The exponential increase of these labels is mostly due to the growing environmental and social concerns of consumers. Consumers are increasingly paying attention to the environmental and social impacts of their food choices and ask to be informed about the environmental and social burden of the foods that they are buying (Vecchio and Annunziata, 2015).

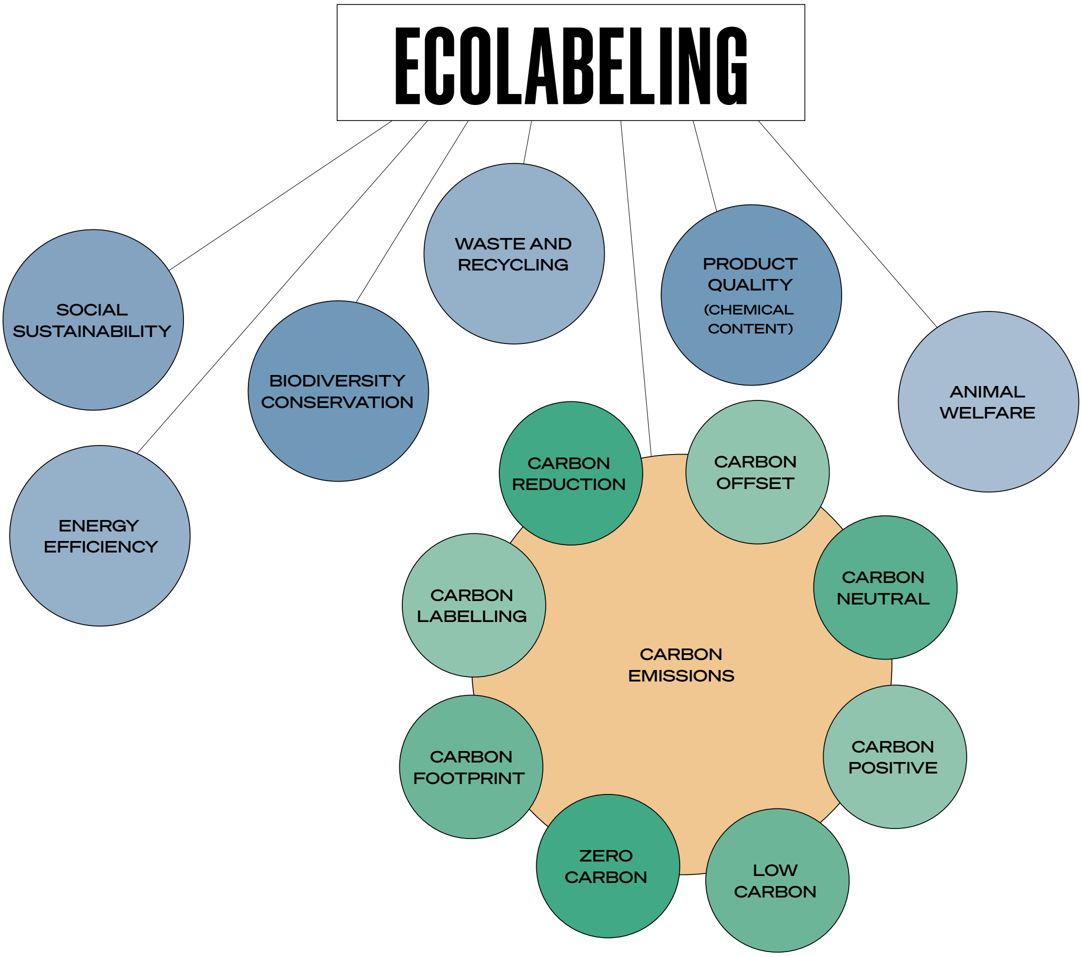

Figure 5.1
Carbon neutrality labels within the larger set of ecolabels to measure environmental performance

SOURCE: Compiled by authors.

Ecolabels are a response to calls for greater environmental sustainability of production and consumption systems and, increasingly, social and health concerns. Within supply chains, sustainability criteria are becoming increasingly important as benchmarks that companies must meet if they want to continue to be suppliers to multinational brands. For this reason, companies take voluntary measures to improve the sustainability of their operations because of consumer or campaign group pressure, and often want to ensure that their efforts to become more sustainable are recognized via an ecolabel – which is normally related to a sustainability initiative (such as the Roundtable on Sustainable Palm Oil, or Bonsucro, or the Better Sugar Cane Initiative).

In this complex ecolabelling system, carbon labelling was developed as a specific instrument to motivate carbon emission reductions. In the case of food products, for example, carbon labels may contain information about the total amount of GHG emissions involved in the whole life cycle of food or just some aspects, for example, emissions taking place during production and processing but not transportation. The voluntary nature of carbon labels, paired with the multiple definitions and standards on which these labels rely, mean that in practice the carbon labelling system is very complex. To add to this complexity, several carbon labels are privately-owned or based on self-certification processes, raising credibility issues, as discussed in Chapter 2.

The diversity of carbon neutrality labels and standards reflects a global growth in the complexity and diversity of ecolabels. According to ISO 14020, environmental labels or ecolabels are claims that indicate the environmental aspects of a product or service. They may take the form of a statement, symbol or graphic on a product or package label, in product literature, in technical bulletins, in advertising or in publicity, amongst other things (ISO 14020:2000). Ecolabelling is a method to certify environmental performance, with different labels emphasizing different criteria and issues in the performance evaluation, as shown in Figure 5.1. In 2015, the Ecolabel Index directory identified more than 450 ecolabels across 197 countries, with the number of labels increasing roughly fivefold between 1988 and 2009 (OECD, 2013). Ecolabelling is administered by a diverse set of actors: labels can be ‘public mandatory’, ‘public voluntary’, promoted by non-profit groups or by industry, or hybrids, for example with joint non-profit and industry input. There are differences in the labels’ geographical extent – regional, national or international – in their governance and transparency, and in the environmental issues they cover. Many ecolabels are considered and/or perceived as actual brands by consumers. Like branded goods, they work on the basis of trust and guarantees on a minimum level of quality or other criteria, with some ecolabels being widely recognized by consumers as ‘brands’ (e.g. The Rainforest Alliance, Forest Stewardship Council, UTZ). For some agrifood subsectors such as cocoa and coffee, ecolabels have a tremendous influence on global markets. For example, standard-compliant coffee reached a 40 percent market share of global production in 2012 (up from 15 percent in 2008). Other ‘ecolabelled’ agrifood commodities with significant market shares (as a share of global production) include cocoa (22 percent in 2012, up from 3 percent in 2008), palm oil (15 percent in 2012, up from 2 percent in 2008) and tea (12 percent, up from 6 percent in 2008) (Potts *et al.*, 2014).

However, this proliferation of ecolabels is also confusing consumers instead of advising them, especially when they are not well informed about environmental problems. The proliferation of labels may be an opportunity for complementarity between labels, but this can also add to the increasing competition among labels available to consumers. This is particularly true for carbon labels, as climate change and climate-friendly products tend to be less important to consumers than other sustainability attributes (Gadema and Oglethorpe, 2011). In a 2019 survey of about 9000 adults in seven countries in Europe and North America (United States of America, Canada, United Kingdom, Italy, Spain, the Netherlands and Sweden), it was found that about two-thirds of consumers support the use of a recognizable carbon label on products and that 66 percent of consumers feel more positive towards a company that can demonstrate efforts towards emission reduction. Finally, only one consumer in five takes a product’s CFP into account before making a purchase (Carbon Trust, 2019b). Carbon labels are voluntary instruments, so there are no specific regulations on their implementation. However, standards that regulate environmental labelling exist, including: ISO 14021/2/3 Environmental Labelling Type II (Self-Declaration Environmental Claims); ISO 14024 Environmental Labelling Type I (Ecolabels) and ISO 14025 Environmental declarations Type III (Environmental labels and declarations).

Box 5.1

TEA – A CARBON LABELLING DILEMMA

Compared to other beverages, tea is renowned for having a relatively low CFP, but this is largely due to the fact that over 50 percent of the footprint is outside direct industry control and attributable to the preparation of the beverage by the consumer (Melican, 2009). Despite the fact that consumers possess a powerful lever in reducing emissions for tea, a scanning of tea and herbal products shows limited recognition of carbon specific marketing efforts through certifications or independent activities.
This can be due to marginal business returns for companies in promoting carbon neutral products, since consumers, at this stage, mostly recognize labels that are managed by sustainable certification and programs, such as the Ethical Tea Partnership, which tends to focus on: (i) sustainable agriculture; (ii) social welfare; (iii) gender; and (iv) deforestation. Nonetheless, some evidence shows that niche brands (Pukka Herbs), focused on delivering health and wellness benefits, are curating messaging and marketing efforts to include carbon (e.g. Pukka, 2019). This is likely due to the growing expectations of the consumer base (for niche products), which has already demonstrated willingness to pay more for high-end products. It can be argued that specialty trade and in particular, caffeine free, herb, fruit and spice infusion categories are more in tune with younger millennial groups (Gen X and Z) as these cohorts may be driven by climate and socially friendly values that are grouped and embedded under 'responsible products'.
Nonetheless, it can be argued that carbon labelling, for purely marketing and communication purposes, is of less importance to mainstream tea companies, who place more focus on cost reduction and margin improvement activities. As part of a cost reduction project, a company may seek to reduce inputs, which can equate to carbon reductions. However, such companies are likely to adopt more carbon positive positions in the least costly way and these efforts are not always singled out to serve marketing and communication purposes.

At the same time, the broad marketing initiatives for 'responsible products' tend to be descriptive and do not address specific facets. Products that are 100 percent organic are often heavily certified, implying that these types of certifications are the most responsive and practical to consumers. It can be argued that a strong consumer desire to support fair trade and climate change mitigation exists, but there is little evidence that a monetary value can be exacted for the latter, due to the fact that carbon neutrality is a complex topic, made more so by the myriad of existing standards. What can be deduced is that more effort is required to help consumers to maximize their influence on CFPs, in ways that are easy to understand, impactful and practically achievable.

5.2 CARBON CONFUSION: UNCLEAR LABELS, UNCLEAR IMPACT

There is a long way to go to mainstream carbon neutrality labels. Many studies suggest a lack of consumer awareness about the environmental impacts of food production and consumption, in particular the impact that their food choices can play in mitigating GHG emissions (Leire and Thidell, 2005; Lombardi *et al.,* 2017; Camilleri *et al.,* 2019). Additionally, consumers do not know the meaning and usefulness of carbon labels (Hartikainen *et al.*, 2014), carbon neutral labels and product CFP (Emberger-Klein and Menrad, 2018).

Consumer willingness to pay more for sustainable products is unclear, varied and dynamic. Findings from a recent survey conducted by the EIB show that mandatory indications of CFPs on products and services consumed, as well as applying a carbon tax on non-sustainable products, were both rated as less important ways to fight climate change by respondents across the United Kingdom, the European Union, China and the United States of America (EIB, 2021). Furthermore, respondents in all four regions, place a greater importance on setting up better recycling systems, than on reducing or increasing the prices of sustainable and non-sustainable products as a means to change behaviour (EIB, 2021). Banning products and services that emit the most GHG emissions was also considered an important lever to address climate change by respondents in China, the United Kingdom and the European Union (50 percent, 41 percent and 44 percent, respectively). These findings suggest that although consumers are increasingly concerned about climate change, they are generally not willing to pay more for environmentally sustainable food products. However, this reluctance varies considerably based on aspects such as geography, wealth per capita and product considered. This heterogeneity helps explain why some companies have moved more quickly into branding carbon neutral products and others not. Box 5.1 outlines some of the dilemmas that are specific to the tea industry in carbon labelling products.

The proliferation of carbon standards and labels does not help in changing consumer behaviour. Consumers are taken back by a confusing set of related terms, such as zero-carbon, carbon-neutral, carbon-free and climate-neutral. In addition, lack of transparency on how carbon reductions were achieved and where the carbon credits come from is a further source of confusion for consumers. Finally, labels often relate to different standards, meaning that they are not directly comparable, leaving consumers in the dark with respect to the GHG emissions and offset amounts associated with food products with different labels. This is particularly relevant for carbon neutrality as there is no single global reference system to measure and achieve it. There are many nuances as to the use of the term 'carbon neutral' and achieving 'carbon neutrality' as it depends on which standards are being followed by a specific company or organization. There are many standards, and a high number of related certificates. Different standards use a different set of methodologies and rely on different control systems, which offer different levels of quality assurance.

Confusion about labels renders them ineffective in moving consumer purchasing towards low-carbon food products. If consumers are not aware that low-carbon options exist, do not understand what factors contribute the most to a food's CFP, or even what is meant by referring to a product's CFP, the carbon label alone avails little (Sharp and Wheeler, 2013). Box 5.2 provides a conceptual assessment of the barriers to sustainable consumer choice and their relevance for carbon labels.

Whilst there is general confusion and misunderstanding about carbon labelling, this is not driven by an unwillingness to learn or an apathetic position. In fact, several studies show that after being educated and informed about climate change and the meaning of carbon labels, consumers are more willing to change their consumption habits towards low carbon choices (Siriex, *et al.,* 2013; Stokes and Turri, 2025; Emberger-Klein and Menrad, 2018). Moreover, the credibility of carbon labels influences consumers' response. In this sense a certifying and auditing system that assures consumers about the truthfulness of labels criteria and information provided to them is essential to influence their decision-making process (Siriexi *et al.,* 2013; Teisl, 2003). In fact, consumers tend to place more trust into products endorsed by a credible and familiar entity (Teisl, Rubin and Noblet, 2008).

Box 5.2

SIX BARRIERS TO SUSTAINABLE CONSUMER FOOD CHOICE

1 **EXPOSURE DOES NOT LEAD TO PERCEPTION.** Labels are not noticed by consumers due to the information-overloaded environment and short time in which they shop and because they make food choices on a habitual basis.

2 **PERCEPTION LEADS ONLY TO PERIPHERAL PROCESSING.** Peripheral processing is a shallow form of processing that leads consumers to note the label, appreciate it, but not make an effort to understand its true meaning.

3 **CONSUMERS MAKE 'WRONG' INFERENCES.** This barrier concerns the difficulties consumers experience in trying to understand the meaning of a given ecolabel. Contrary to the point above, consumers try to understand what the label means but they fail to comprehend the label, due to mistaken inferences they make.

4 **ECO-INFORMATION IS TRADED OFF AGAINST OTHER CRITERIA.** When choosing a food product, consumers have to decide among different criteria, and sustainability criteria are often traded-off with other criteria such as price and quality.

5 **LACK OF AWARENESS AND/OR CREDIBILITY.** The 'literacy' of consumers with regards to sustainability and labels is fundamental in altering their food choices. Consumers have to feel empowered to make sustainability choices and they have to consider the ecolabel credible.

6 **LACK OF MOTIVATION AT TIME OF CHOICE.** The attitude-behaviour gap means that at the time of choice, even if they have a positive attitude towards the ecolabel, this attitude is often not enough to affect consumer choice and their behaviour.

SOURCE: Grunert, K. 2011. Sustainability in the Food Sector: A Consumer Behaviour Perspective. *Journal on Food System Dynamics.* https://doi.org/10.18461/ijfsd.v2i3.232

The ability of carbon labels to help mitigate climate change issues ultimately depends on consumer response to labelling. The success of an eco-label depends on several factors such as: label design, the type of product labelled, and how and where the product is marketed (Elofsson *et al.*, 2016; Hallstein and Villas-Boas, 2013; Onozaka, Nurse and McFadden, 2020; Vlaeminck, Jiang and Vranken, 2014). Designing carbon labels which are easily understood by consumers and that can guide consumers through more climate friendly food choices is key (Uphan, Dendler and Bleda, 2011). However, marketers are faced with a dilemma. On the one hand consumers prefer a short and concise label that does not engage them in a long process of reading and scrutiny. On the other hand, there is a strong need for detailed information at the consumer level to properly understand the carbon labelling.

5.3 MOVING CARBON TRANSPARENCY AND LABELS FORWARD: HAS CARBON BECOME THE NEW CALORIE?

Even if carbon labelling has been created to boost consumer awareness on GHG emissions and to influence their food choices, these labels also exert pressure on manufacturers, distributors and agrifood companies in general. Retailers are particularly well positioned in this sense. Thanks to their privileged position between consumers and producers, they can strongly influence consumers in choosing low carbon products and reducing GHG emissions associated with food consumption (Ekelund *et al.,* 2014). Retailers can also adjust the criteria by which they choose their suppliers by requiring carbon labelling or by removing from their shelf products with a high CFP, having therefore a great impact on suppliers too.

While they have a key role in the carbon neutrality agenda, most retailers have not yet been pushing carbon neutrality labels. One exception is Tesco, the largest groceries retailer in the United Kingdom, which was one of the first retailers to attempt to implement CFP labels as a company policy. With an initial ambitious agenda Tesco abandoned this project mainly because it was not successful among consumers (Financial Times, 2012). In 2007, Tesco pledged to place carbon labels on all of its 70 000 products, however, by 2009 Tesco was only carbon labelling items at a rate of 125 products per year and the company claimed that it would take 'centuries' to carbon label all of its products (Smithers, 2010). Furthermore, this initiative was accounting for around GBP 2 billion per year (Smithers, 2010). The retailer therefore attributed its abandonment of the initiative to carbon labelling not gaining traction among other retailers and the complexities and time required to calculate product footprints (Vaughan, 2012). Importantly, the lagging engagement can also be ascribed to retailers' difficulties or inability to convey environmental impacts through its labelling. Tesco also faced the tradeoff of encouraging consumers to buy less food by reducing waste and maintaining its margins (Ekelund *et al.,* 2013).

Among the experiments in carbon labelling there has also been an attempt to expand the concept to include environmental impacts beyond emissions. In this regard, the large international retailer Casino Group has launched and expanded its carbon labelling into an environmental index. Similar to Tesco, Casino Group, a mass-market retail group in France, began in 2008 to apply carbon labels to its private-label products (Casino Group, 2012). By 2010, the retail group had applied a carbon label on more than 600 products and the initiative had since 2008, involved approximately 200 suppliers (Casino Group, 2012). In 2012, Casino Group expanded its CFP label to an environmental index. The group now offers more than 19 680 products that are certified as environmentally responsible and the environmental index can be found on the Monoprix private label products (Casino Group, 2021). For further details on Casino Group's path towards environmental labelling please see Box 5.4.

Box 5.3

DOES DESIGN MATTER?

The first carbon labels were coloured in black, as it was seen as the 'carbon colour' (Vanclay *et al*., 2011). The black carbon label was initiated by Carbon Trust in 2001 and it was later adopted by Tesco in 2008 (Meyerding, Schaffmann and Lehberger, 2019). However, research pointed out that the black footprint as adopted by Carbon Trust and by the retailer Tesco in the United Kingdom was difficult to understand (Gadema and Oglethorpe, 2011), also leading to the abandonment of the Tesco efforts due to insufficient uptake by consumers. Also, consumers did not understand the label's numbering system as relating to a continuous variable of GHG emissions (Meyerding, Schaffmann and Lehberger, 2019). The traffic light colour ranking (red, yellow, green) was found to be the most successful in guiding consumers towards more low carbon choices (Camilleri *et al*., 2019; Emberger-Klein and Menrad, 2018; Hornibrook, May and Fearne, 2013; Meyerding *et al*., 2019; Thøgersen, Haugaard and Olesen, 2010). Based on insights in consumer decision-making and behavioural economics, researchers from the Copenhagen Business School (CBS) in 2016 proposed to extend the black carbon labelling to include a traffic light colour ranking (Thøgersen and Nielsen, 2016). This colour combination is familiar to consumers, easy to understand and helps them to make comparison between several products (Meyerding, Schaffmann & Lehberger, 2019).

More recent studies suggest including reference values allowing consumers to compare GHG emissions and put information in context, proposing to express GHG emissions in terms of a familiar unit, such as equivalent light-bulb minutes (Camilleri *et al*., 2019). Others suggested to use a five-layers scale helping consumers to compare between a specific food product category (left panel of Figure 5.3). The scale can also be combined with absolute numbers, to allow consumers to make direct comparisons between different food products (Feuchy and Zander, 2018) (right panel of Figure 5.3). Placing the carbon label horizontally on the right in the visual field of the packaging can influence a consumers' purchase intention towards a green product (Zhou *et al*., 2019).

In conclusion, understanding of consumer's response to different designs and understanding for these labels is very scarce. A study (Meyerding, Schaffmann and Lehberger, 2019) of UK consumers reported positive consumers responses to the 'carbon neutral label' and the 'carbon reduction label', even if these demonstrate relatively low part-worth utilities, unlike the 'Carbon Trust label' which shows a negative part-worth utility.

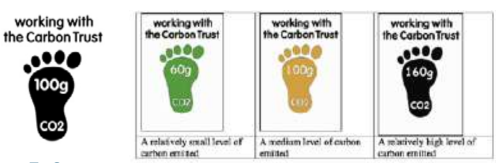

Figure 5.2
The black and green-yellow-red Carbon Trust labels

Sharp, A., Wheeler, M. 2013. Reducing householders' grocery carbon emissions: Carbon literacy and carbon label preferences. Australas. Mark. J. 21, 240-249.

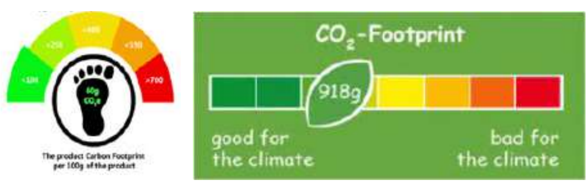

Figure 5.3
Carbon scale and GHG emissions

Feucht, Y., and Zander, K. 2018. Consumers' preferences for carbon labels and the underlying reasoning. A mixed methods approach in 6 European countries. Journal of Cleaner Production, 178, 740-748.

Meyerding, S., Schaffmann, A. and Lehberger, M. 2019. Consumer Preferences for Different Designs of Carbon Footprint Labelling on Tomatoes in Germany - Does Design Matter? Sustainability 2019, 11(6), 1587; https://doi.org/10.3390/su11061587.

Box 5.4

CASINO GROUP'S JOURNEY TOWARDS ENVIRONMENTAL LABELLING

Casino Group's initial carbon label served the purpose of informing customers on the carbon impact of products they consume and it was expressed in terms of grams of CO2 emissions. This was displayed on the front of the packaging and allowed consumers to seek further information on the back panel of the packaging. The back panel offered further explanations of the label and displayed the CFP on a ruler, enabling consumers to understand the product's environmental impact on a graduated scale. The scale was developed in collaboration with the Agency for Environment and Energy Management (ADEME) (Casino Group, 2008). The label also demonstrated the impacts of proper household-level recycling. Figure 5.4 and Figure 5.5 illustrate the carbon label packaging designs utilized by Casino Group.

The environmental index represents the environmental impact of 100 grams of product compared to the total daily food consumption of a French adult (Casino Group, 2012). To appeal to consumers, the label took inspiration from generic nutritional labelling as shown in Figure 5.7. The environmental index includes seven steps of the LCA (farm-level production, manufacturing, transportation, packaging, distribution, consumer use and end of life) and it considers GHGs, water consumption and water pollution (Casino Group, 2012).

Working with suppliers constructively is a key part of the greening transition and critical to carbon labelling. Casino Group has taken a step further in collaborating with its suppliers to understand and calculate environmental impacts. Since July 2017, Casino Group has been providing its food processor suppliers with a free collaborative application, known as 'Mieux Produire', that they can utilize to collect data and calculate the environmental impact of their products (Mieux Produire, 2019). This provides the group greater insight into the environmental impact of its private-label products, while keeping customers aware and informed via a dedicated website. Furthermore, in 2019, the retail group employed steps to encourage its suppliers to commit to the SBTi. Indices presented on the Mieux Produire platform are a result of findings generated from a feasibility study to assess consumer interest in environmental labelling, conducted between 2011 and 2012 by the French government.

Figure 5.4
Casino Group front panel carbon labelling of private-label products

SOURCE: Casino Group. 2012. Carbon Index. www.rspo.org/file/acop2014/groupe-casino/R-GHG-Grower-Emissions-Report.pdf.

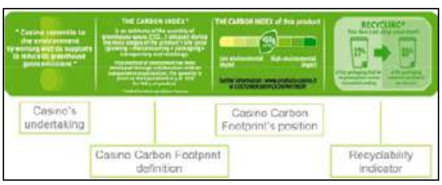

Figure 5.5
Casino Group back panel carbon labelling of private-label products

SOURCE: Casino Group (2012).

Figure 5.6
Casino Group front panel environmental index labelling of private-label products*

SOURCE: Casino Group (2012).

NOTE: The environmental index represents the environmental impact of 100 grams of product compared to the total daily food consumption of a French adult.

Compared to the earlier attempts made more than ten years ago, there is probably an improved environment today to promote carbon labelling. In particular, retailers may be in a better standing to widely adopt carbon and environmental indices for a number of reasons. First, when Tesco and Casino Group launched their carbon labelling initiatives, the effects of the financial crisis were still impacting consumer spending choices and the consequences of climate change were not as widely accepted (The Grocer, 2020). Second, costs for developing LCA analyses have significantly decreased over time as technologies such as automation, blockchain and cloud applications are drastically reducing the efforts and costs of sourcing, analyzing and consuming data. Technology can also aid in increasing the credibility of carbon disclosures and supporting the quantification of reduction and insetting efforts. Third, there is a clear consumer demand for standardized carbon labelling. In fact, Carbon Trust research from 2019 found that two-thirds of consumers in the United Kingdom support the idea of a recognizable carbon label (Business Green, 2020). These factors may have encouraged a number of retailers to respond.

Still, we may not have reached the moment when ‘carbon’ becomes the new ‘calorie’ in the world of labels. Carbon becoming the new calorie was announced by Logitech’s CEO in June 2020: “Just like calories went on the packaging in the food industry years ago, we believe that carbon content level should be a choice factor for the consumers who are interested in it”. As part of this effort, the Swiss technology conglomerate pledged to introduce carbon labelling across its portfolio. The labels will be based on in-house LCA analyses that consider the carbon, toxicity and circularity impact of products across their life cycle through raw materials, manufacturing, distribution, consumer use and end-of-life (Business Green, 2020). In addition, Unilever in July 2020 announced that it will add CFP labels to its 70 000 product portfolio (Cohen, 2021). While these announcements combined with some of the initiatives by retailers create a new momentum for carbon labels there are still many practical obstacles to widespread adoption. First, there is still limited consumer understanding of carbon labelling implications. A lack of data on the meaning of carbon neutrality labels compounded by a wide array of variegated environmentally friendly labels, render it difficult for consumers to develop recognition and comparison-based capabilities (Lacey, 2020). Consumers also lack benchmarks against which they can compare carbon emission values. Furthermore, a standardized system for conducting LCA analyses is largely absent (The Grocer, 2020). A standardized system would enable companies to perform such analyses in-house and with greater accuracy. Standardization efforts should also consider the extent to which carbon labelling should assume broader footprint analyses that include topics such as water, biodiversity and societal tradeoffs. Finally, standardized labels would help consumers to develop the ability to effectively compare emission values against different products, thereby increasing the likelihood that emission levels are factored into their purchase-level decisions.

Similarities and differences in the development of nutritional labels should be leveraged to determine the effectiveness of carbon labels going forward. Importantly, carbon labels in many cases do not directly resonate with consumers as nutritional labels do. Up until the 1960s, no nutritional information was included on food labels. However, as processed foods gained prominence, consumers began demanding more information (Institute of Medicine, 2020). The primary driver for this demand is due to the fact that nutritional intake is directly linked to the individual health of consumers. This led to the United States Food and Drug Administration (FDA) in 1973 to make it compulsory for FDA-regulated foods to include numbers of calories, grams of protein, carbohydrates, fat and the percent of the recommended daily allowance of various nutrients on the packaging of these products (Institute of Medicine, 2010). More recently, the Healthy Eating Plate, promoted by the Harvard School of Public Health, was developed to guide consumers on healthy diets (Harvard School of Public Health, 2021). Such initiatives can be broadened to convey CFP information and values. On the other hand, carbon labels require consumers to selflessly consider societal implications. These challenges need to be considered in determining the effectiveness of carbon labels going forward. Namely, that although consumers are increasingly aware of climate change, their propensity to pay for the reduction of GHG emissions may not be as clear-cut. Furthermore, selectively considering the number of calories as the determinant for one's health may not result in enhanced health benefits. For instance, consuming below the recommended number of calories per day can cause health-related side-effects. This form of reasoning should also be applied to carbon labelling, in the sense that carbon emission reductions alone will most likely not contribute to wider environmental benefits. Carbon labelling should therefore be expanded to include impacts on for instance societal tradeoffs, water and biodiversity. Importantly, consumers need to be convinced by environmental labels and consequently, communications should be centred around scaling challenges, so that consumers can feel that their impact is manageable and realistic. This could also imply setting timelines and comparing impacts to relatable and quantifiable metrics.

Public action, particularly on standardization, can help accelerate the adoption of environmental labelling. Legislative efforts to support transparent and clear environmental information on products can be extremely important, as well as promoting studies to address knowledge gaps and supporting communication with consumers. For example, the 'Grenelle 1' law (article 54) adopted in France in 2009, establishes the right of the consumer to have access to sincere, objective and complete environmental information on products (Ministère de l'Écologie, du Développement durable, des Transports et du Logement, 2010). Between 2011 and 2012 the French government conducted a feasibility study to assess consumer interest in environmental labelling. The study included 168 companies, federations and associations and the results were used to develop harmonized labelling for any voluntary company (Ministère de l'Écologie, du Développement durable, des Transports et du Logement, 2010). Governments can play a pivotal role in introducing focal voluntary labels or standards on which non-government schemes can be based. These actions can contribute to the convergence and streamlining of schemes without compromising stringency and quality. In this context, governments can focus on providing streamlined procedures and a long list of market access requirements for small and medium enterprises, to ensure that all players have equitable access and entry points (OECD, 2016). Furthermore, although a number of NGO and private sector based labelling schemes have been developed, many of these are based on underlining standards promoted by governments. For instance, the European Product Environmental Footprint (PEF) is a multi-criteria life cycle measure of the environmental performance of a good or service (European Comission Joint Research Centre, 2012). Although the PEF program is a labelling scheme *per se*, it aims to improve the coherence across quantitative footprint schemes and reduce trade barriers by limiting the diversity in approaches used to calculate product environmental impacts. Importantly, rather than incentivizing the development of more labels, the integration of carbon reduction modules into existing and prevalent schemes can be encouraged. For instance, in the agrifood sector the Rainforest Alliance has recently reevaluated its scheme to include a Sustainable Agriculture Standard (Rainforest Alliance, 2021).


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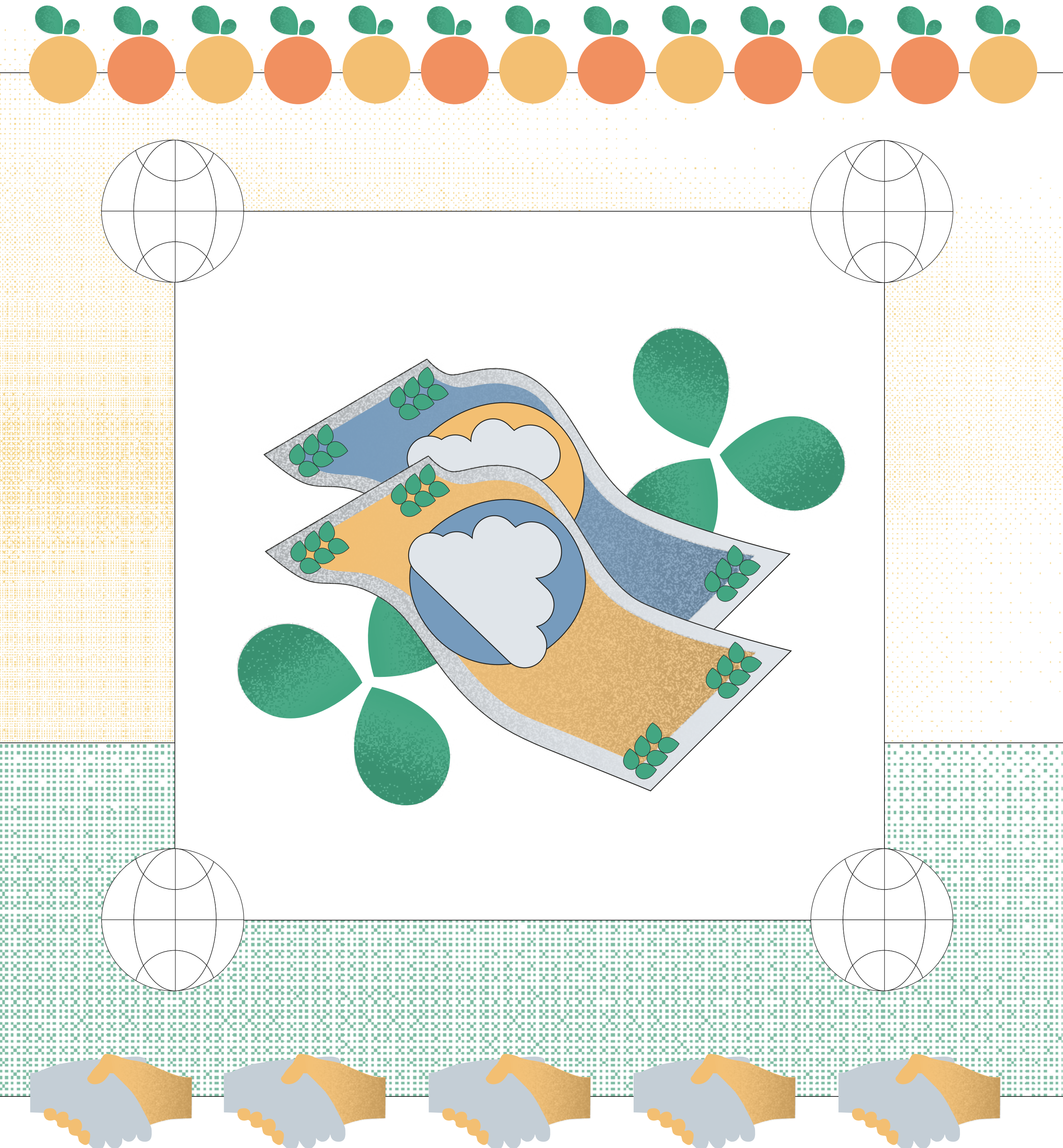

Chapter 6
Sustainable investing: reaping the benefits of greening

The aim of this chapter is to describe current trends in sustainable investing and assess their potential to support a move towards carbon neutrality in agrifood systems, as well as existing challenges to realize this potential. Around the world, climate change is driving a reshaping of finance. Investors increasingly commit to ESG factors and may therefore add pressure on companies to follow a greener path. A powerful illustration of current trends is that for three years in a row in his letters to the CEOs of the world's largest companies, Larry Fink, CEO and Chairman of BlackRock, the world's largest fund manager with USD 7 trillion in assets has emphasized climate change as a key threat to durable value creation. In the 2021 letter and while reflecting on the COVID-19 pandemic, Fink states that "the pandemic has presented such an existential crisis – such a stark reminder of our fragility – that it has driven us to confront the global threat of climate change more forcefully and to consider how, like the pandemic, it will alter our lives" (BlackRock, 2021). Importantly, the UN Secretary-General (SG), Antonio Guterres re-affirmed in 2020 the urgent need to price carbon and to make climate-related financial risk disclosures mandatory. The UN SG also called upon banks to align their lending with the net zero objective, and for asset owners and managers to decarbonize their portfolios (United Nations Secretary-General, 2020). Such pressure can theoretically lead agrifood system participants to push other key stakeholders up and downstream the supply chain to adopt lower carbon production systems. While, as discussed in Chapter 4, greening claims are sometimes characterized as greenwashing under specific circumstances, it is in many ways a demonstration of the changing nature of finance. Combining the agrifood sector's centrality in sustainable development and climate change mitigation with the potentially transformative ability of (particularly private) international finance, this change can possibly set the stage for a new green wave in the agrifood sector.

6.1 SUSTAINABLE INVESTING IS THE NEW NORMAL

Sustainable investing is, like many other terms used in this report, not always clearly defined or applied in a consistent manner. Other terms that are related include responsible investing, socially responsible investing, mission-related investing or ESG investing. ESG and its implementation, in particular, is a term that is still evolving and refers to the incorporation of environmental, social and governance considerations into investors' portfolio decisions alongside financial performance factors. The environmental dimension has been receiving most attention in recent years and is the focus of this report. It measures the company's environmental impact including its GHG emissions, efficient use of natural resources in production, the extent to which it pollutes and creates waste, as well as accounts for any efforts in designing ecological products and other innovations. Importantly, ESG often relates to intangible factors which are usually not taken into consideration in 'traditional' financial statements by corporations. In practice, investors apply sustainable investing principles on several levels: (i) work actively on international standards on ESG, (ii) seek to avoid or reduce exposure to investments that may increase ESG risks and (iii) push companies to invest in improving their ESG alignment.

Sustainable investing is becoming the 'new normal'. In 2018, sustainable investments in major markets globally constituted USD 30 trillion representing more than a threefold increase relative to 2012 (Global Sustainable Investment Alliance, 2019) (Figure 6.1). This means that more than 30 percent of assets under management[55] are invested in Europe, the United States of America, Japan, Canada, Australia and New Zealand according to the premise that ESG factors can affect assets' performance and market value (McKinsey & Company, 2017). In Europe in 2018, for instance, sustainable investing already represented around 50 percent of total assets under management while it represented only about 25 percent in the United States of America (a major increase from around 18 percent in 2014) (Global Sustainable Investment Alliance, 2019). Investments that are managed by professional asset managers are often classified as either retail or institutional, where retail assets are personal investments by individuals in professionally managed funds purchased in banks or through investment platforms, with relatively low minimum investment levels (Global Sustainable Investment Alliance, 2019). On the other hand, institutional investments are commonly managed on behalf of asset owners such as pension funds, foundations, universities and insurers, which require higher minimum investment levels. Notable examples of institutional asset owners include the Japan-based

55 Author's calculations based on Global Sustainable Investment Alliance 2019 data and exchange rates as of 31 December 2018. Data on total assets under management and share of sustainable investing differ slightly according to sources. For example, in 2020, Boston Consulting Group (BCG) reported that total global assets under management were USD 89 trillion in 2019 and that "since 2012 global assets managed by one or more sustainable investing methodologies have grown by 15 percent." (BCG. 2020. Global Asset Management 2020. Protect, Adapt, and Innovate).

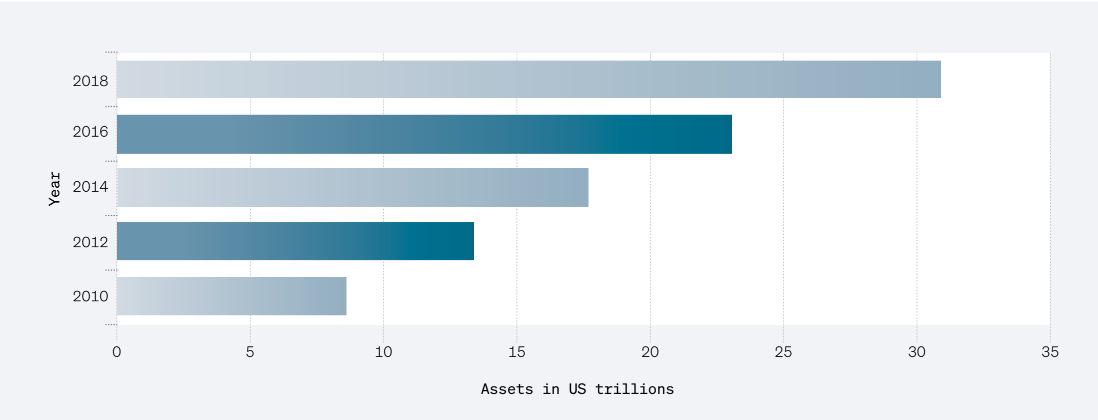

Figure 6.1
Global sustainable investment asset growth (2010-2018)

SOURCE: Global Sustainable Investment Alliance. 2019. 2018 Global Sustainable Investment Review. www.gsi-alliance.org/wp-content/uploads/2019/06/GSIR_Review2018F.pdf.

Government Pension Investment Fund (GPIF) and the Pension Fund Association, which each became signatories to the Principles of Responsible Investment in 2015 and 2016 respectively (Global Sustainable Investment Alliance, 2019). GPIF, the world's largest pension fund, revised the principles applied to its investments in 2017 and declared its intention to make capital markets more sustainable (PRI and UNEP, 2016). More specifically, GPIF reported that it needs to address ESG risks in its portfolio as part of its fiduciary duty (being a long-term cross-generational investor). Finally, another large asset manager, Norges Bank Investment Management (manages Norway's sovereign wealth fund) has increasingly pushed companies in its portfolio to improve corporate governance (since 2012). As of late, Norges Bank Investment Management has also been advocating for environmental issues: supporting adoption of international standards and also demanding management boards to take environmental and social impact into consideration besides improved disclosure on climate change.

From trillions to billions: while multilateral development banks (MDBs) are increasingly active in climate finance, total annual investments are very limited when compared to private-led global sustainable investing. According to data compiled by the MDBs total commitments in climate finance by MDBs reached USD 43 billion in 2018 (including all MDB operations, such as co-financing, the total figure can reach roughly USD 110 billion in climate investing) compared to the USD 30 trillion of ESG-inspired global investing by institutional investors and others. Moreover, MDB finance combines both adaptation and mitigation with the latter accounting for about 70 percent of the total or around USD 30 billion. As an example, the World Bank Group in 2020 revised its earlier target of 28 percent of its financing to have climate co-benefits reaching 35 percent on average over the next five years, of which 50 percent will be dedicated to supporting climate change adaptation and resilience (World Bank, 2020b). Finally, MDB mitigation finance is mostly targeting public recipients or borrowers through investment loans: two thirds of the total or USD 19.7 billion are therefore aimed at the public sector. In addition to these MDBs, the Clean Technology Fund (CTF), the Global Environment Facility (GEF) and the Green

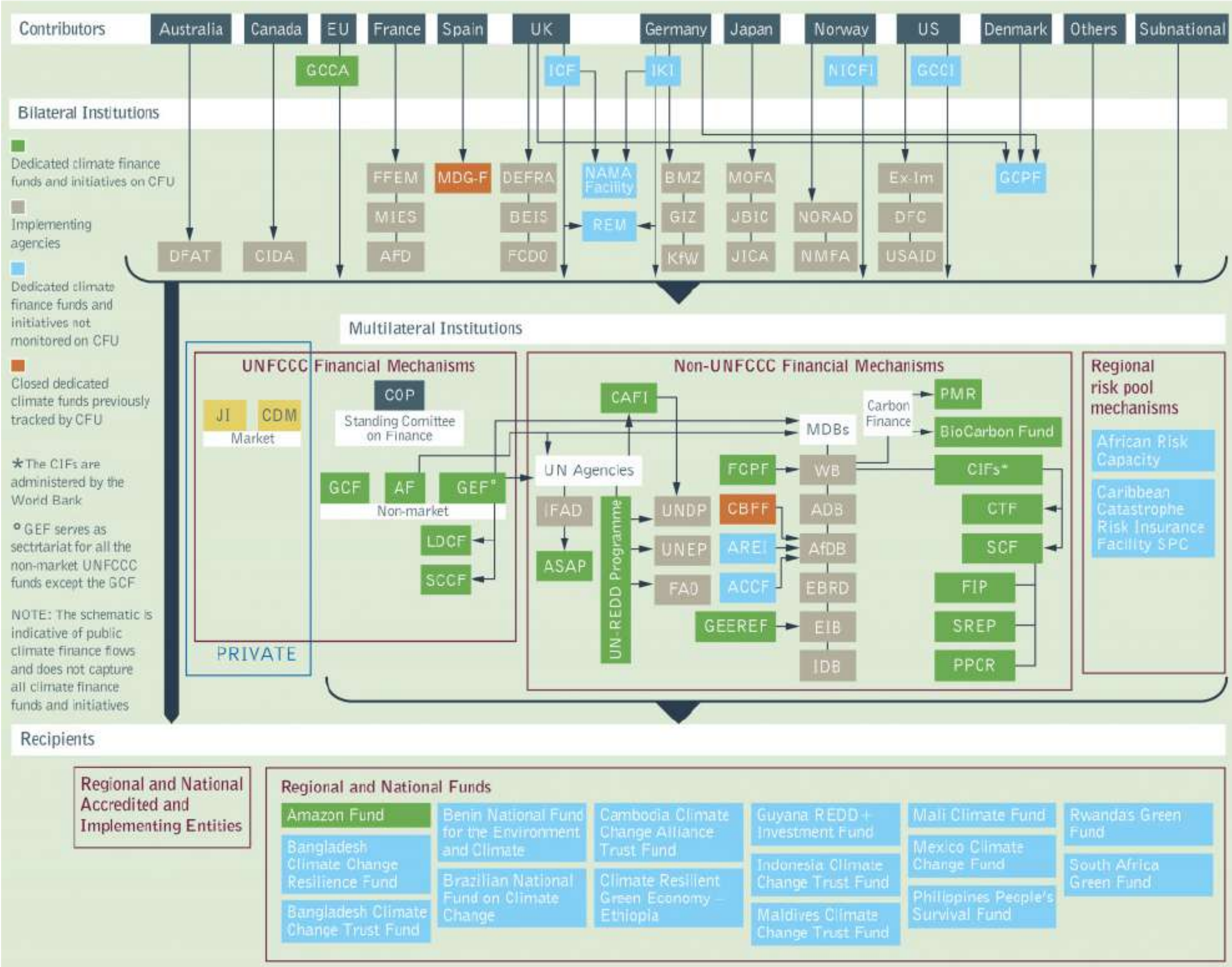

Figure 6.2
Global climate finance architecture

SOURCE: Climate Funds Update (CFU). 2019. Global Climate Finance Architecture. https://climatefundsupdate.org/about-climate-finance/global-climate-finance-architecture/.

Climate Fund (GCF), as well as European Union blending facilities and operations funded by bilateral agencies all contribute to climate finance availability. The CTF has received about USD 5.4 billion since 2008 from donors and deploys its financing through multilateral development banks, GEF's latest replenishment (for the period 2018–2022) was of USD 4.1 billion and the GCF received pledges for USD 9.9 billion in its 2020–2023 replenishment. Furthermore, to scale up GCF's activities and de-risk the delivery of capital flows, GCF has set up the Private Sector Facility (PSF). The PSF is designed to promote private sector investment through concessional instruments. These include low-interest and long-tenor project loans, lines of credit, equity investments and risk mitigators, such as guarantees, first-loss protection and grant-based capacity-building. As of 2021, the GCF has funded USD 3 billion to 35 different private sector projects, which have a total value of USD 12.5 billion (GCF, 2021). Figure 6.2 outlines the architecture behind global climate financing.

Climate change is taking centre stage in this new sustainable investment landscape. Major asset management firms are directing their portfolios towards low carbon and climate resilient investments. In early 2020, the world's largest

Climate change is taking centre stage in this new sustainable investment landscape.

asset management firm, BlackRock, identified climate change as a defining factor in companies' long-term prospects and announced a major shift in its investment approach to climate resilient and low carbon objectives at the centre of its activities (BlackRock, 2021). In doing so, it joined Climate 100+, a major investors' platform gathering 545 investors managing a total of USD 52 trillion in assets (i.e. about 60 percent of the global GDP). In addition, the platform includes 100 very large GHG emitting industrial enterprises and another 67 companies (the 'plus'), which either face major risks from climate change or can be important drivers of the green transition. Climate 100+ calls for companies to detail how climate change affects their business, including the compatibility of their operations with the Paris climate agreement targets (Bloomberg, 2020). In signing up to Climate Action 100+, investors commit to engaging with at least one of 167 focus companies that are strategically significant to the net zero emissions transition and to seek commitments on the initiative's key ambitions, namely: (i) implement a strong governance framework on climate change; (ii) take action to reduce GHG emissions across the value chain; and (iii) provide enhanced corporate disclosure (Climate Action +100, 2020). Asset owners who cannot engage directly, can sign on to the initiative as supporters, which requires them to support the Climate Action 100+ goals and request their managers or service providers to join the initiative (Climate Action 100+, 2020). Amundi, another important signatory of Climate Action 100+ and Europe's largest asset manager, with over EUR 1.7 trillion assets under management has partnered with the International Finance Corporation (IFC) to launch in 2018 the largest targeted green bond fund focused on emerging markets: the Amundi Planet Emerging Green One. The USD 1.5 billion fund has sought to increase the capacity of emerging market banks to finance climate-smart investments (Amundi, 2018) and has been recently followed by an Emerging Markets (EM) Green Bond Fund that seeks to replicate the success of the first one with investors. Box 6.11 provides examples of other sustainability investing initiatives.

Box 6.1

SUSTAINABILITY INVESTING INITIATIVES

Some private initiatives have been launched to promote and accelerate the integration of environmental and social factors into the investment decision of financial actors and into companies' reporting systems.

- **Principles for Responsible Investment** (PRI) is an international network of investors supported by the United Nations to promote responsible investment. When signing up, investors have the obligation to disclose on environmental and social issues. PRI was launched in 2006 at the New York Stock Exchange with the support of 21 financial institutions from 12 countries and 47 funding signatories. The principles are drafted to be compatible with all types of investors. As of 31 March 2020, the number of signatories increased to more than 3038 institutions with cumulative assets under management exceeding USD 103.4 trillion. Twenty-one percent of the signatories are asset owners (Principles for Responsible Investment, 2020). Most of the signatories are large European institutional investors. These include PRI for agriculture and food systems developed by FAO:

PRINCIPLE 1: Contribute to food security and nutrition

PRINCIPLE 2: Contribute to sustainable and inclusive economic development and the eradication of poverty

PRINCIPLE 3: Foster gender equality and women's empowerment

PRINCIPLE 4: Engage and empower youth

PRINCIPLE 5: Respect tenure of land, fisheries, and forests, and access to water

PRINCIPLE 6: Conserve and sustainably manage natural resources, increase resilience, and reduce disaster risks

PRINCIPLE 7: Respect cultural heritage and traditional knowledge, and support diversity and innovation

PRINCIPLE 8: Promote safe and healthy agriculture and food systems

PRINCIPLE 9: Incorporate inclusive and transparent governance structures, processes, and grievance mechanisms

PRINCIPLE 10: Assess and address impacts and promote accountability

- **Global Sustainability Investment Alliance** (GSIA) is an international collaboration of the seven largest sustainable investment membership organizations in the world, with the objective to expand sustainable investment practices. GSIA also provides guidelines and information for investment organizations to implement sustainable practices.
- **The Institutional Investor Group on Climate Change** (IIGCC) is a trade body consisting of 275 institutional investors, with assets under management of USD 35 trillion. IIGCC has signaled to its members that it intends to invest in low carbon assets (The Institutional Investors Group on Climate Change, 2021).
- **The Investment Network on Climate Risk** (INCR) is the North American branch of the Global Investor Coalition on Climate Change (GIC). Based in the United States of America, it is a project of the CERES organization. The INCR working groups offer investors the opportunity to engage with their peers to share updates on key research, develop strategies, share best practices and advance ESG issues on a variety of themes, from corporate disclosure and performance to sustainable policy and regulations (UNEP, 2020). The CERES Investor Network encompasses 175 institutional investors, with assets under management of USD 29 trillion and the aim to increase investments into green asset classes (CERES, 2020).

6.2 UNTANGLING THE SUSTAINABLE INVESTING SPACE

The driving forces

Structural drivers of incorporating environmental concerns in investments include societal change and increased investment regulation. The importance of millennials in the world population and the transfer of wealth from baby boomers to millennials is expected to accelerate the incorporation of ESG factors in investment decisions. For example, a 2019 survey by the Morgan Stanley Institute for Sustainable Investing, sampling high net worth investors concluded that 9 percent of millennials were interested in sustainable investing (Morgan Staeley Institute for Sustainable Investing, 2019). In addition, a survey by US Trust in 2018 suggested that 8 percent of high-net-worth millennials considered ESG performance as important in their investment decisions (US Trust, 2018). This trend creates pressure on institutional investors (who act as agents for their clients) to follow suit and adjust their investment strategies towards sustainable investing in order to attract capital. In addition, regulation of financial markets (e.g. prudential regulations) following the global financial crisis (2007–2008) has led to increased scrutiny of asset owners and investment managers, but also improved disclosure rules for corporations being set by governments and stock exchanges. Most importantly, there is a recognition that advancing the frontier of sustainable investing and scaling it up can help prevent market downfalls and systemic crises, but that this requires complementary policy measures.

An important and often-mentioned argument in favor of sustainable investing is that investors can 'do well by doing good' (Dyc *et al.*, 2019), as it offers the possibility of achieving higher financial returns. Environmental and social performance enabling product market differentiation and insurance against event risk can drive companies to outperform other peers in the long run. Companies working to enhance ESG factors can achieve reduced costs, mitigate risk performance and improve overall financial performance (Dyc *et al.* 2019). Subsequent to the global financial crisis, many institutional investors pointed out that investing in sustainability issues brings a long-term pay off (Dyck *et al.,* 2019). Accordingly, this explains the interest of institutional investors in promoting sustainable environmental and social practices in the companies where they invest; in the long-run, they expect these companies to perform better in financial terms. Nonetheless, many companies do face tradeoffs between selectively maximizing shareholder value and generating robust value for the wider society (Henderson, 2020). Consequently, to address the tradeoffs generated by imperfect markets, costs, incentives and available institutional solutions need to properly be contextualized and understood.

Climate risk is investment risk, therefore institutional investors are increasingly reshaping their investments to better account for these risks in their portfolios. Institutional investors have long-term fiduciary obligations toward their clients and adopt long-term investment strategies to deliver returns and manage risks. Hence, they are inclined to think about the long-term sustainability of financial markets and more generally of the wider economy (Krueger, Sautner and Starks, 2019). Many institutional investors see climate change as a risk to their portfolios, hence they increasingly require climate-related information for their decision-making (McKinsey Global Institute, 2020). However, although the above makes logical sense, not all investors retain a long-term view of risk mitigation and value creation. Generally, in the sustainable investing space, climate change-related risks include two main categories:[56] (i) physical risks – derived from extreme events and others that may result in costs to land, assets, infrastructure and trade; and (ii) transition risks – resulting from regulatory and other processes that are being set in motion to tackle climate change (for example through reduced emissions). Transition risks may result in a range of different cost for enterprises including stranded assets and reduced valuations for specific assets because of policies put in place to curb climate change.

Climate risk may not be easy to escape from and has systemic implications. Indeed, investors may not be able to avoid climate-related risks fully by moving out of certain asset classes, as impacts on future assets will likely come through weaker growth and lower asset returns across a wide range of assets. As such, it is not surprising that policymakers, including those with mandates on financial markets stability, increasingly call for action. As Mark Carney, former Governor of the Bank of England, stated in 2015, "once climate change becomes a defining issue for financial stability, it may already be too late" (Carney, 2015). Organizations investing in activities that do not present long-term viability may be less resilient in the transition to a lower-carbon economy and their investors may experience lower returns. Consequently, investors are increasingly incorporating such risks into their longer-term strategies for capital allocation. In this regard, decarbonization may be critical for businesses to maintain profitability, unlock new growth markets, and protect asset value for investors. However, investors are also often challenged by a lack of adequate information to correctly factor in climate-related risks and long-term returns into their valuations (TCFD, 2017).

Sustainable investors

Sustainable investing is a crowded and heterogeneous space.[57] A useful approach to characterize investors is to look at where they are located in terms of the importance they attach to social and environmental considerations versus financial returns (Figure 6.3). Investors range from foundations to more conventional investors, such as institutional investors. Within each investor type there is also a considerable range depending on the specific funds that are set up (with specific objectives and sustainability targets). These in turn may have different return expectations and use specific investment vehicles. Figure 6.3 provides a rough picture of this complex space. It suggests that philanthropic organizations may tend to use more grant type instruments and place a higher emphasis on social and environmental dimensions, while conventional investors involved in sustainable investing tend to focus on financial returns and go for double- or triple-bottom line equity and debt investments. This applies to the whole sustainable finance space and is applicable to sustainable investments made in agrifood systems.

56 In addition, a third category sometimes mentioned in the literature is liability risk: the risk for which parties who suffer future impacts of climate change may claim compensation.

57 The breakdown provided in the section below does not follow a rigid approach that clearly distinguishes among different types of investors because of the available sources of data and information. There is therefore considerable overlap: for example, impact investors may be philanthropic organizations or institutional investors. Similarly, private equity funds may be established by institutional investors and impact investments may result also in private equity financing.

	SOCIAL				FINANCIAL
Return	Donation of investment	No return; investment only		Concessionary risk-adjusted returns	Financial benchmark return
Investor	Foundations	Governments/ NGOs	High-net-worth	Impact investors	Conventional investors
Vehicle	Grants	Venture philanthropy Subsidized loans		Social impact private equity (PE) or venture capital (VC) funds Impact bonds	Socially responsible investing (SRI) mutual funds Double bottom line PE or VC funds
Label	**Philanthropy**		**Impact**		**For-profit impact, sector VC, SRI**

Figure 6.3
Characterizing sustainable investors

SOURCE: Adapted from Matos, P. and Frank, M. 2019. Perspectives on ESG Investing. Webinar. University of Virginia Darden School of Business.

Institutional investors, including insurance companies, pensions, hedge funds, and sovereign wealth funds (SWFs), are key players in sustainable investing. Institutional clients represented almost 60 percent of global assets under management or about USD 52 trillion in 2019 (Heredi *et al.,* 2020). In addition, a big share of both institutional and private clients' assets are managed by a few top asset managers: the top ten global asset managers manage about Euro 22 trillion and the top 400 hold over EUR 66 trillion in assets or more than 80 percent of global assets under management in 2019.[58] Considering their market share, institutional investors and also the major fund managers have the potential to reshape global financial practices regarding carbon neutrality, besides influencing the wider economy.

Agrifood systems are a key focus of impact investing. Impact investors differ from other investors as they make their investment decisions with a deliberate pursuit of making a positive social and/or environmental impact on top of financial returns (so-called 'double' or 'triple' bottom line).[59] Impact investors may be institutional investors or foundations and are therefore not a type of organization, but rather an investment strategy. Impact investors mainly work by providing equity or debt directly in the form of projects mostly benefiting unlisted companies. According to the Global Impact Investing Network (GIIN) 2020 survey, private debt accounts for around 60 percent of total investments made in 2019. Some impact investors can also invest in public companies and public debt. According to the GIIN survey, the median impact investor invested in 2019 around USD 18 million in six projects (average is much higher at

58 Combines data from BCG 2020 and also from IPE's survey of top global asset managers (Moreolo, C.S. 2019. Top 400 Asset Managers: AUM grows 1% amid market volatility. In: *IPE 2019 Asset Management Guide*. London, IPE. www.ipe.com/top-400-asset-managers-aum-grows-1-amid-market-volatility/10031518.article.)

59 Double bottom line usually refers to having a positive social impact on top of financial profits. A triple bottom line (TBL), as coined by John Elkington in 1994, refers to a company focusing not only on financial performance but also social and environmental impact.

USD 78 million driven by large investors in the sample) and in total, impact investors invested almost USD 47 billion in 2019. The food and agriculture sector is a predominant sector for investment, with the survey conducted by GIIN, suggesting that out of 294 impact investors operating globally, 57 percent have allocated investments to the sector in 2019 (GIIN, 2020). Although the food and agriculture sector has attracted investments from a large percentage of investors, the sector accounted only for 9 percent of the total assets under management. Of the survey respondents, over 54 percent plan to increase their allocations to food and agriculture in the next five years, showing potential for strong growth.

Development finance institutions (DFIs) also play an important role in impact investing and are quickly stepping up their commitments to sustainability. DFIs are government-backed institutions investing in the private sector and as such, benefit from government guarantees, which ensures their creditworthiness. DFIs are therefore able to mobilize private capital to support high-risk projects. DFIs typically apply stringent investment criteria aimed at safeguarding financial sustainability and environmental and social accountability (Association of European Development Finance Institutions [EDFI], 2021). DFIs can be bilateral by serving a government's foreign development and cooperation policy, or multilateral, acting as private sector arms of IFIs (EDFI, 2021). In 2019, 11 DFIs made investments amounting to USD 11 billion and committed USD 19 billion for 2020 across all sectors (GIIN, 2020). Notably, EDFI announced that its 15 publicly-owned institutions will align investment decisions to the objectives of the Paris Agreement by 2022, with aims to achieve net zero investment portfolios by 2050 (EDFI, 2020). Since 2015, EDFI has invested EUR 8 billion in climate finance in low- and middle-income countries (EDFI, 2020). In 2019, the five most active European DFIs in the sector (BIO Invest, Deutsche Investitions- und Entwicklungsgesellschaft [DEG a.k.a. German Development Finance Institution], FinnFund, Dutch Entrepreneurial Development Bank [a.k.a. FMO] and Proparco) provided EUR 543 million of direct financing to agribusinesses throughout 36 projects in Africa, Latin America, Asia and Eastern Europe.[60] The average size of these transactions ranged from EUR 2.4 million (BIO Invest) to EUR 30 million (Proparco). With EUR 305 million of financing via 17 projects, FMO alone represented more than half of this volume.[61] DFIs also include regional and national development banks and these actors are also increasingly engaging in sustainable investing. For instance, the Development Bank of Southern Africa (DBSA) has recently launched its first USD 200 million green bond with the support from the Agence Française de Développement (AFD) and the Coalition for Green Capital (DBSA, 2021). Furthermore, in collaboration with the GCF, the DBSA has implemented the Climate Finance Facility (CFF), which seeks to encourage private sector investment in climate-related projects in Southern Africa; and the Embedded Generation Investment Programme (EGIP), a facility to support embedded generation renewable energy projects in South Africa (DBSA, 2021). At the national level, the Uganda Development Bank (UDB) in partnership with the FAO Investment Centre has launched the blended finance initiative of AgrInvest. AgrInvest relies on EX-ACT and the Gleam-*i* tools to support UDB in its assessment of GHG emissions and carbon balance of loan applications in food and agriculture (UDB, 2021).

Philanthropic organizations have also been moving to support climate-related investments in the agrifood sector. Philanthropic investors mostly use a

60 Figures collected from the 2019 annual reports of BIO Invest, DEG, FinnFund, FMO and Proparco.

61 Figures collected from the 2019 annual reports of BIO Invest, DEG, FinnFund, FMO and Proparco.

venture capital-like approach to finance low-carbon agriculture projects (Alliance for Green Revolution in Africa, 2021). Compared to institutional investors, they can act quickly and support risk-embracing innovations such as experimenting with new agriculture approaches. They can inject medium term equity capital to support early stage project development or implementation of riskier low-carbon technologies (Miller and Wesley, 2010). On top of financial support, philanthropic investors typically grant access to their advisory networks when specific knowledge and experience is required to implement projects. They also provide important contributions in advancing the process of improving standards and other elements that enable agrifood system actors to identify and implement carbon neutrality paths. For example, the Rockefeller Foundation committed USD 1.5 million for the development of climate-smart agriculture, in addition to funding the Rainforest Alliance to develop criteria for low-carbon farming techniques that will be incorporated into the alliance's sustainable agriculture standards (The Rockefeller Foundation, 2021).

PE have increased their interest and investments in the agriculture sector by number and volume globally. PE funds may be established by different types of investors and are an asset class rather than investments. Unlike investments in listed equity, PE funds do not require liquid primary or secondary markets. This can, in principle, be an interesting financing alternative for low-carbon agriculture projects in countries with underdeveloped capital markets, notably in developing countries. PE funds tend to be more engaged with primary agriculture investment and play an active strategic role in operational management, providing asset-related skills and knowledge (often country and market specific). Potential gain of land value appreciation and operating return are two fundamental value drivers for PE investment in agrifood systems. Thus, one of the most common PE investment models in agriculture is the "own and lease" under which the investors are not involved in the day-to-day farming operations. While there is lack of good data on the subject, PE investment in agrifood systems is estimated to be in the order of tens of billions of USD.[62] An example of a large PE fund is the sixth Swedish national pension fund (AP6), which is comprised of five funds (AP1–AP4 and AP6) that combined make up 10 percent–15 percent of the Swedish pension system (AP6, 2020). The AP6 covers its own costs and profits may only be reinvested in unlisted assets. As such, the fund is able to provide small- and medium-sized companies with access to structured capital. Sustainability is weighted equally to other factors when making investment decisions, the holding period and throughout divestment stages. In 2020, AP6 managed over EUR 4 billion in investments with an annual return of 20.4 percent on capital employed (AP6, 2020).

Carbon markets on the rise

While compliance-based carbon trading schemes, notably the EU ETS, can potentially generate incentives for low carbon investments, they currently exclude significant parts of agrifood systems (in primis primary production). Carbon trading schemes aim to reduce emissions by setting emission limits and allowing the trading of the emission units between high emitters and low emitters. As elaborated in Chapter 2, compliance markets are regulated by mandatory regional, national, and international carbon reduction regimes, such as the Kyoto Protocol and the EU ETS), which is a cap and trade system. Voluntary offset

62 A review of funds investing in primary agriculture puts the total value of funds in 2013 at USD 22-24 billion. See Luyt, I. Santos, N. and Carita, A. 2013. Emerging investment trends in primary agriculture. FAO Investment Centre. Directions in Investment (FAO).

markets function outside of the compliance markets and enable private companies and individuals to purchase carbon offsets on a voluntary basis. With a value of around Euro 229 billion in 2020 (Refinitiv, 2020) global compliance carbon markets have registered a 20 percent increase relative to 2019 on the back of expected tightening of emissions regulations globally. The EU ETS is the first and largest emission trading scheme internationally, accounting for about 90 percent of the total value of world carbon markets and covering about 4 percent of the EU total GHG emissions in 2020 (European Commission, 2020a). By volume, the EU ETS hit in 2020 a record global amount of 10.3 Gt CO2eq from over 8 billion emission allowances traded (Refinitiv, 2020). To date, EU ETS mainly covers power generation, heavy industry and aviation (intra-European Economic Area flights) and also only the main GHGs. In particular, the EU ETS does not include methane emissions, which are extremely important for global warming (second to carbon dioxide) and mainly caused by agriculture activity globally. The fact that agrifood systems are to a great extent excluded from the EU ETS and other compliance markets is also due to the difficulties in measuring emissions and quantifying reductions at farm-level (as discussed throughout this report). Since the European Union introduced the ETS in 2005, GHG emissions have decreased considerably: around 35 percent decline between 2005 and 2019 (European Environment Agency, 2019). The EU ETS imposes caps on the total amount of certain GHG gases that can be emitted. Within this cap companies can receive, buy and trade emissions allowances and the limit on the total number allowances ensures that these retain value. Annually, a company must surrender enough allowances to cover all its emissions or it will be subjected to fines. Interestingly, EU ETS carbon prices have been consistently increasing since 2017 and have surged since November 2020 to reach an all-time high of around USD 50 per tCO2eq (EUR 40). While still at an early stage of development, other key carbon markets are also seeing some momentum. The largest are those in North America, i.e. the Western Climate Initiative (WCI) and Regional Greenhouse Gas Initiative (RGGI), which have reached EUR 22 billion and EUR 1.7 billion respectively in 2020 (Refinitiv, 2020). In 2021, China launched its own ETS as part of its plan to curb emissions.

While agriculture remains outside compliance-based carbon trading schemes, farmers could potentially benefit from taking part through monetization of carbon storage. The GHG emission profile of agriculture is different from other sectors, as it includes methane and nitrous oxide, creating significant measurement challenges. Nonetheless, should these challenges be overcome, agrifood systems could benefit from taking part in carbon trading schemes. Participation could encourage farmers to adopt low-carbon farming and support market development of new low-carbon technologies (Svendsen and Brandt, 2010). A project-based approach where the authority pre-defines a list of farming practices considered as valid reduction measures for the EU ETS system can be one option going forward, as well as trying to use improved technologies for MRV at farm-level (some are being piloted at present by Indigo AG, Nori, Agriprove and SCIG and these are detailed in Chapter 3) (Matthews, 2014).

Voluntary carbon markets are seen as increasingly important in driving private sector action on climate change. It is important to distinguish voluntary carbon markets from compliance markets as described above (such as the cap and trade markets established through regulation). Voluntary carbon markets have come about through action by private sector companies and other institutions that decide to purchase and retire carbon credits to mitigate climate change or simply offset part of their emissions. Voluntary carbon markets can be an important instrument for the private sector, but also governments and

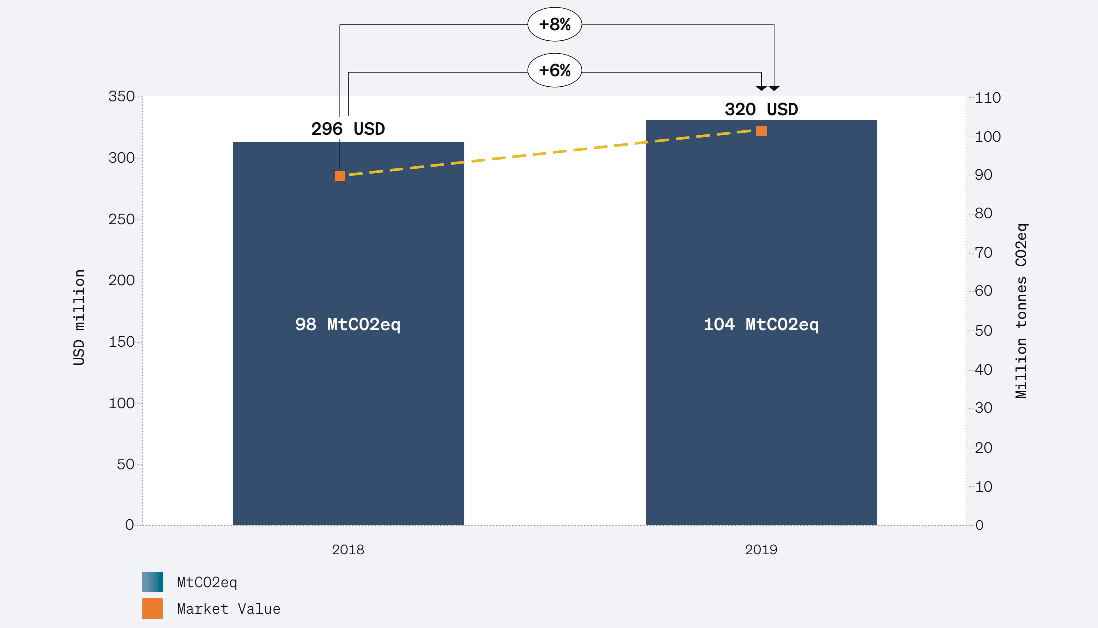

Figure 6.4
Carbon voluntary market transaction volume and value: 2018–2019

SOURCES: Forest Trends. 2019. Demand for Nature-based Solutions for Climate Drives Voluntary Carbon Markets to a Seven-Year High. www.forest-trends.org/pressroom/demand-for-nature-basedsolutions-for-climate-drives-voluntary-carbon-markets-to-a-sevenyear-high/. Forest Trends' Ecosystem Marketplace. 2020. Voluntary Carbon and the Post-Pandemic Recovery. State of Voluntary Carbon Markets Report,Special Climate Week NYC 2020 Installment. Washington DC: ForestTrends Association, 21 September 2020.

individuals, to act on their carbon neutrality ambitions. They allow governments, companies and individuals to buy carbon credits to offset their emissions and achieve carbon neutrality. Voluntary carbon markets started around 2006 with total global traded volume around USD 111 million (average price of USD 4.1 per tCO2eq) and peaked around 2008 with almost USD 800 million traded (average price of USD 7.3 per tCO2eq). Since the 2008–2009 economic crisis, a progressive decline started, but there has been a recent recovery: in 2019, the volume of transactions in voluntary carbon markets hit a nine-year high with transactions for 104 million tCO2eq, achieving a market value of USD 320 million. This also represents a 6 percent increase in volume and an 8 percent increase in value compared to 2018 (Forest Trends' Ecosystem Marketplace, 2020) (Figure 6.4).

Growth in the voluntary offsets markets has been supported by increased interest in nature-based solutions for climate resilience. The Taskforce on Scaling Voluntary Carbon Markets (TSVCM) and McKinsey have estimated that demand for voluntary carbon credits could increase 15 times or more (relative to current demand) by 2030 and by a factor of up to 100 by 2050 (McKinsey, 2021). The overall market for carbon credits could therefore reach a value of USD 50 billion by 2030 (McKinsey, 2021). The interest in nature-based solutions for climate resilience drove a 264 percent increase in volume of offsets generated through Forestry and Land Use activities and made REDD+ (from unregulated voluntary projects) the most popular offset type for the first time since 2015 (McKinsey, 2021). However, in 2019 the volume of offsets within the AFOLU sector dropped 28 percent and renewable energy volume increased by 78 percent (Forest Trends' Ecosystem Marketplace, 2020). Despite the lower volume, the market value of AFOLU offsets was more than twice than that of Renewable Energy offsets. Furthermore, demand for offsets associated with forest management in developing countries (i.e. REDD+) remains strong (Forest Trends' Ecosystem Marketplace, 2020).

Voluntary carbon markets have been challenged by several problems, which impact the pricing and quality of carbon credits issued. Unlike compliance credits such as those traded under the EU ETS, most voluntary credits are transacted bilaterally and over-the-counter (OTC), with no centralized repository for price and volume data (Forest Trends' Ecosystem Marketplace, 2020; European Commission, 2015).[63] Instead, voluntary credits are stored in decentralized registries managed by governments, non-profits and private sector players. Some of the main voluntary registries include the American Carbon Registry, APC Inc. (which manages the Gold Standard and Climate Action Reserve registries), Markit (which administers the Social Carbon and Plan Vivo registries) and Verra (which manages the VC and CC registries) (GHG Management Institute & Stockholm Environment Institute, 2021). Voluntary markets are crucially different from compliance markets in that they have been a product of private sector initiatives with credits verified and validated through standards that have been created by a range of different actors (coalitions of NGOs, corporations and other carbon market stakeholders). Such standards have been the basis for project developers to design specific carbon reduction and removal projects that in turn are certified and result in traded credits. Trust in voluntary carbon credits has also been a problem in the past, although improvements have been made through greater standardization. Some of the key problems raised by studies include emissions reductions being overestimated (this applies to both voluntary- and compliance-based marketplaces). For example, in forest-based carbon credit projects, problems can include carbon leakage (e.g. deforestation not being halted but just moving to another location), permanence (for example tree planting efforts not being durable to produce the expected carbon reduction) and complexity of accounting (for example the ability of different tree species to store carbon). The lack of standardization and adequate governance of the quantification and certification processes, the difficulties in tracking credits and other factors have been recognized as obstacles to the development of voluntary carbon markets (for further details on this please see Chapter 3). Lastly, the volume of legacy credits (credits from older projects that were registered in previous years with poorer quality controls) is sizable (Trove Research, 2021). If such credits (which are based on dubious claims of environmental additionality) are allowed into the voluntary market, these could potentially damage the development of the voluntary market as a mechanism to reduce global carbon emissions.

Several international initiatives have been set up to support the development of voluntary carbon markets through improved standards and governance. The TSVCM is a private sector initiative that includes both buyers and sellers of carbon credits but also organizations that set standards and financial sector representatives. The TSVCM has estimated that carbon markets must grow by 15-fold by 2030 to halve emissions and as such, the taskforce released in early 2021, a blueprint for expanding voluntary carbon markets (Ecosystem Marketplace, 2021). This includes actions such as the creation of

63 In the beginning, the majority of trading in the EU ETS also took place via brokers in the OTC markets as most of the products were not liquid or standardized enough to be traded on exchanges. However, derivative contracts have become more standardized over time, reducing the need for customized deals executed through brokers. Market commentators suggest that uncertainty over the ETS and Kyoto Protocol progress has led to the lack of appetite for long-term forward contracts; traded contracts are thus very near-date and homogenous. This has facilitated the shift in trading from OTC-dominated to exchange-traded.

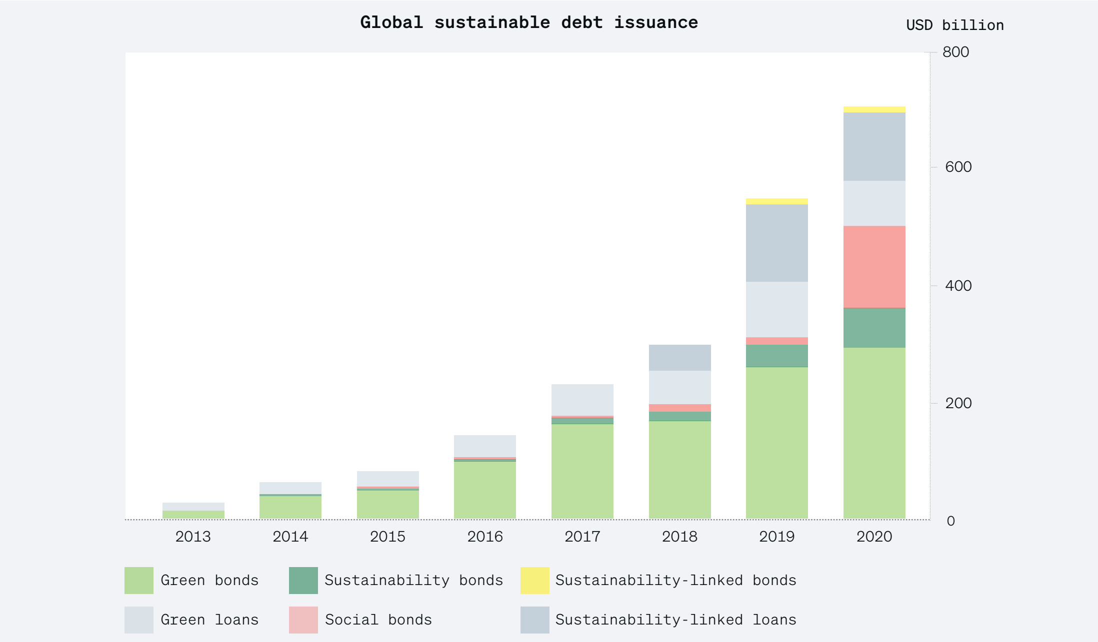

Figure 6.5
Global sustainable debt issuance

SOURCE: Bloomberg. 2020. Sustainable debt is piling up – and for good reason. www.bloomberg.com/news/articles/2020-10-08/sustainable-debt-is-piling-up-and-for-good-reason.

Core Carbon Principles (CCPs) and exchange-traded reference contracts and the establishment of a global regulator to coordinate existing standard-setting bodies (Ecosystem Marketplace, 2021). The taskforce envisions that once CCPs are established, exchange-traded futures contracts will provide a global reference price for a verified emission reduction (Ecosystem Marketplace, 2021). Nonetheless, with consensus, contracts could selectively be amended. Taskforces such as the TSVCM could also play a significant role in deciding how to restrict the use of legacy credits by supporting the establishment of a consensus that serves the interests of both buyers and the carbon offsetting industry alike.

Transition finance: from green bonds to sustainability-linked loans

Loans and bonds whose proceeds are used for investments with a positive environmental and social impact are surging worldwide. According to research company Bloomberg NEF, the sustainable debt market (as a subset of transition finance) has been smashing records in volume of issuances year after year. In 2020, a new all-time record of over USD 730 billion was achieved in terms of the volume of sustainable debt issued globally (Figure 6.5). As of late, growth in green bond issuances seems to be slowing down, while there has been a major increase in new forms such as social bonds (in particular, linked to COVID-19 pandemic healthcare and relief efforts) and sustainability bonds, as well as the emergence of sustainability-linked bonds which bring some of the elements from sustainability-linked loans to bond issuances (more on this below). Sustainability-linked loans and green loans saw a slight decrease in 2020 in terms of new loan volume following exceptional growth in previous years.[64]

Within the broad category of sustainable debt issuances, green bonds account for the largest share of issuances, with proceeds being allocated to

64 Data collected by Bloomberg NEF. Available through the Bloomberg platform.

eligible green projects. Green bonds are just part of a vast space of sustainable bonds that also include: climate bonds, social bonds, sustainable development or sustainability bonds (see Glossary for definitions). Green bonds are different from sustainability and social bonds mainly because of the use of proceeds: green bonds focus on refinancing and new climate- or environment-related projects (ICMA, 2018), while social bonds focus on social welfare investments for an identified target population (and with a neutral or positive impact on the environment). Sustainability bonds are a mix of social and green bonds. Sustainability-linked bonds are more recent and bring some of the elements of sustainability-linked loans (more on this below) to bond issuances: the proceeds from the issuance are not targeted to specific projects but rather used for general purposes (providing greater flexibility), while key performance indicators (KPIs) chosen constitute the key commitment by the issuer (if not achieved, it may entail additional payments to bondholders).[65]

Green bonds allow firms and governments to raise important funding suitable for large-scale sustainability- and climate-related projects with longer return periods. The United States of America, France, the United Kingdom and China are among the largest issuers of such types of bonds (Climate Bonds Initiative, 2019). The surge in green bond issuances have been supported by the definition of the Green Bond Principles by the International Capital Markets Association (ICMA). The principles provide concrete guidance for companies and investors on what green bonds are and how to issue them in order to increase transparency and credibility of this instrument. In particular, they include four components: (i) use of proceeds – the use needs to be detailed in the bond's legal documents and also clarify if any re-financing is taking place; (ii) process for evaluation and selection of projects – eligibility and selection criteria for projects need to be detailed in the context of the environmental sustainability objectives being pursued (the GBP includes a list of typical projects companies may select); (iii) management of proceeds – the net proceeds need to go to a separate account to be tracked by the issuer (in relation to green projects being financed) and preferably be supplemented by the employment of an auditor; and (iv) reporting – detailed data on use of proceeds should be kept (including after full allocation) incorporating list of projects, their activities and expected impact (ICMA, 2017). Another initiative that supports the redirection of assets towards green investments is the Montréal Carbon Pledge. The Pledge was launched in 2014 and is supported by the Principles for Responsible Investment (PRI) and the UNEP Finance Initiative (UNEP FI) (Principles for Responsible Investment, 2014). It allows investors, including asset owners and investment managers to formalize commitments to the goals of the Portfolio Decarbonization Coalition, which mobilizes investors to measure, disclose and reduce their portfolio CFPs (PRI, 2014). Since the United Nations Climate Change Conference (COP21) in 2015, the Pledge has attracted commitments from over 120 investors with over USD 10 trillion in assets under management (PRI, 2014).

International financial institutions are increasingly working with capital markets to expand the green bond market, with increasing commitments in agriculture. Following EIB's first climate awareness bond (EIB, 2021), launched in 2007, many international financial institutions have also launched green bond programs to support member countries in managing and reducing emissions from agriculture, including the Asian Development Bank (Asian Development Bank, 2017) and the World Bank (World Bank, 2019). For instance, in October

65 There is a broader range of transition financial instruments, which also include sustainability-linked convertible bonds and sustainability-linked derivative hedges.

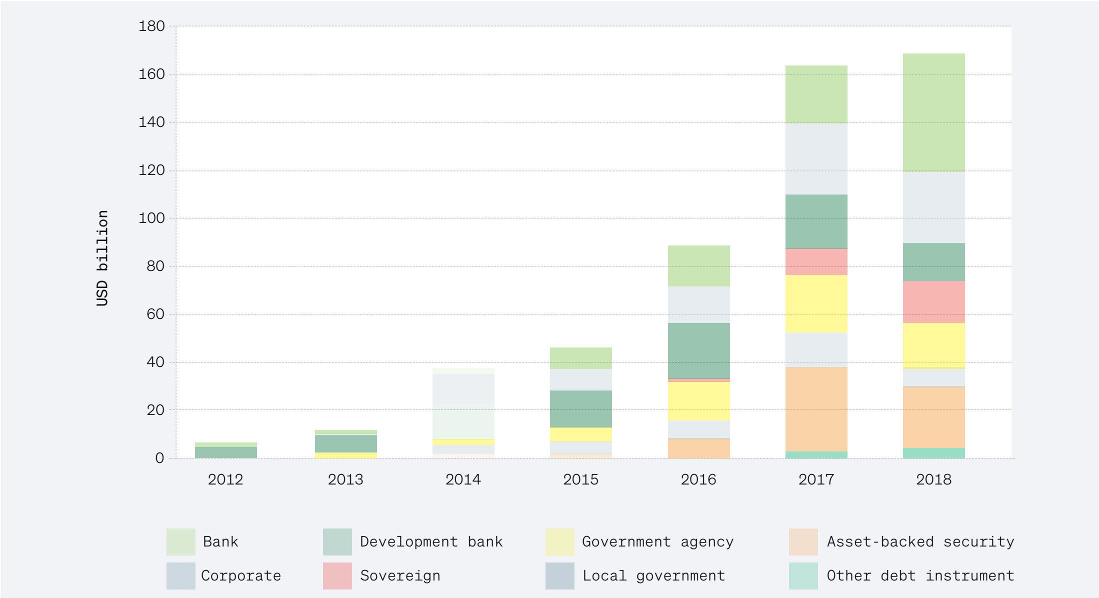

Figure 6.6
Zooming in on green bonds – issuance sources

SOURCES: S&P Global Market Intelligence. 2019. S&P Ratings forecasts moderate green bond market growth in 2019. www.spglobal.com/marketintelligence/en/news-insights/trending/P9Lq4MCmw-HL6iMRUKgEHg2; Climate Bonds Initiative. 2019. Green bonds: The State of the Market. CBI. www.climatebonds.net/resources/reports/green-bonds-global-state-market-2019; Climate Bonds Initiative. 2020a. Agriculture Criteria. The Climate Bonds Standard & Certification Scheme: Criteria Document. www.climatebonds.net/files/files/Agriculture%20Criteria%20Document.pdf.

2019, the EBRD issued USD 700 million of a five-year climate resilience bond which was oversubscribed by USD 200 million, showing strong demand from investors (EBRD, 2019a). Projects financed through these bonds include investments in climate-resilient and low-carbon agrifood systems (EBRD, 2019b). Another example includes the Sustainable Development Bonds priced by the International Bank for Reconstruction and Development (IBRD) (part of the World Bank Group) aimed at engaging Scandinavian investors in raising awareness on combatting food waste and loss (World Bank, 2020c). The bonds are Norwegian krone (NOK) and Swedish krona (SEK) denominated and are linked to SDG 12.3, i.e. halving food wasted by 2030. In 2020, the bonds attracted 30 investors and raised USD 550 million (World Bank, 2020c). Moreover, following a period where IFIs were the key players, the first corporate/bank green bonds were issued in 2012 and since then the market has grown massively (Figure 6.6).

Agrifood corporations are already employing green bonds to signal and finance their carbon reduction activities. Unilever was the first FMCG company to issue in 2014, a four-and-a-half year green sustainability bond at GBP 250 million (Unilever, 2014). Proceeds from the bond have been used to finance projects linked to GHGs, water and waste targets in the Unilever Sustainable Living Plan. Agrifood corporations are part of a larger trend of corporate green bond issuances that were virtually zero before 2013 and reached around USD 96 billion in 2018 (Flamme *et al.*, 2020) across all sectors. This is still just a small part of the global bond market, which stood at more than USD 100 trillion in 2018. Several key reasons have been put forward for companies to use green bonds despite the administrative and compliance costs for third-party verification, and also the constraints on the use of proceeds compared to 'conventional' bonds. While green bonds do not seem to be affected by 'greenwashing' practices, they

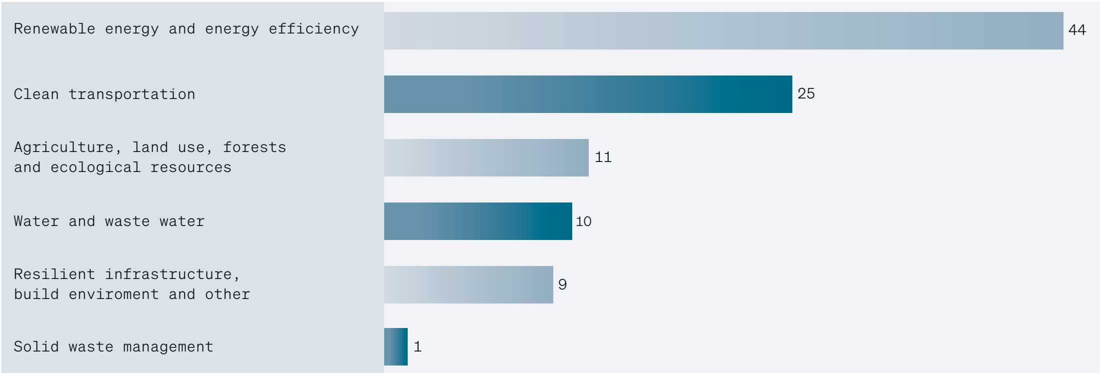

Figure 6.7
Green bonds commitments and disbursement by sector

SOURCE: World Bank. 2018. Green Bond Impact Report 2018. https://thedocs.worldbank.org/en/doc/632251542641579226-0340022018/original/reportimpactgreenbond2018.pdf.

also do not seem to provide a source of inexpensive financing for companies. One study finds no premium versus conventional bonds (Flammer *et al.* 2020), while another estimates only a small negative premium using matching techniques and controlling for liquidity (Zerbib, 2019).[66] These results suggest some opportunities for companies to expand their green bond issuances. Most importantly, green bonds seem to be considered a good way of signaling a company's commitment to greening with investors particularly rewarding third-party certified green bonds and first-time issuers. Fatica *et al.* (2019) also find that certified green bonds benefit from a larger premium compared to self-labelled green bonds, supporting the importance of third-party certification of bond issuances.

Green bonds can lead to the greening of balance sheets, altered risk profiles and improved environmental performance post-issuance. A study conducted by the Joint Research Centre (JRC) of the European Commission in 2019 found that although financial institutions issue a significant volume of green bonds, limited evidence exists in terms of benefits from a pricing advantage with respect to ordinary bond instruments (Fatica *et al.*, 2019). This may be due to the inherent challenges of directly linking the issuance of a bond with specific green projects. However, evidence suggests that financial green bond issuers do reduce lending activities to sectors with larger emission intensities, indicating a greening of balance sheets on the part of both issuers and borrowers (Fatica *et al.*, 2019). Ultimately, this could lead to an altered risk profile of banks' balance sheets, specifically through the direct and indirect exposure to environmental- and climate-related risks (Fatica *et al.,* 2019). Interestingly, Flammer (2020) finds improvements to companies' environmental performance following the issuance of green bonds (measured in terms of third-party environmental scores and CO2 emissions). This is not due to the green bond per se (issuances are very small compared to issuer's asset size), but rather through 'eco-friendly' behaviour, which the green bond both signifies and boosts through the projects it finances.

While the number of green-labelled bond issuances is increasing, especially over the last five years, they still represent less than 1 percent of global bonds (Climate Bonds Initiative, 202a), and most are used to finance renewable

66 See Zerbib (2018) for a discussion of the literature on green bond vs conventional bond prices. Relative valuation estimations suffer from several difficulties including classification of green bonds and controlling for liquidity.

energy projects (Pension Fund Service, 2017). According to the World Bank, agriculture accounted in 2018 for 11 percent of the Green Bond eligible project portfolio (i.e. USD 1.8 billion), a relatively small proportion of the overall climate-aligned bond universe (Figure 6.7) (World Bank, 2018b). Initiatives such as the Agriculture Criteria developed by the Climate Bonds Initiative (Climate Bonds Initiative, 2020b), are likely to catalyse investment and can be utilized by governments in setting regulation or recommendations for decarbonizing agriculture projects, allowing them to better access the green bond market. Moreover, while many recognize that private agribusinesses' sustainability efforts are credible, concerns can be raised by investors that corporate green bonds could open the door for companies to denominate business-as-usual bonds as green (Environmental Finance, 2015). It is therefore important that green bonds are based on indices defined by rules, facts and disclosure requirements (Environmental Finance, 2015).

Sustainability-linked loans are another key instrument to finance carbon neutral projects in agrifood systems. Sustainability-linked loans provide a direct financial incentive for the borrower to achieve agreed sustainability targets (Nordea, 2020): as the proceeds are used to improve corporate sustainability, ESG performance or implement specific measures like GHG emission reductions, the loan interest rate decreases. They are also a means for financial institutions to expand their green lending portfolios. This direct financial incentive linked to environmental performance is a key difference compared to the more traditional green bonds (as described above). Importantly, sustainability-linked loans provide greater flexibility in the use of proceeds when compared to green bonds (LMA, 2020). In practice, contracting a sustainability-linked loan requires setting ex-ante sustainability performance targets to be met by the borrower (to trigger a reduction in loan costs) rather than establishing an ex-ante list of eligible projects that can be financed through the loan proceeds. In fact, sustainability-linked loan proceeds do not need to be used only (or at all) to finance green projects; for example, a specific company may just make changes to its organization that increase productivity or lead to an improved ESG rating, triggering an interest rate reduction (Financial Times, 2020d). The sustainability performance targets vary considerably and may be internal (reduction in GHG emissions, for example) and/or external (for example achieving an improved external sustainability rating). Notably, sustainability-linked instruments could provide greater access to companies operating across different sectors and smaller players to sustainable loan markets, as these actors may not be able to commit entire loan proceeds to specific green projects. More recently, financial institutions have started supporting the development of sustainability-linked bonds. As discussed above, these instruments try to bring some of the 'advantages' from sustainability-linked loans to sustainable bond markets, namely the possibility of a more flexible use of proceeds. Table 6.1 outlines key bond and loan instruments that have been used by investors to date.

Companies in all industry sectors including agrifood systems are taking advantage of sustainability-linked lending. Examples include Danone, which raised a EUR 2 billion sustainability loan in 2018 and aims to become the first multinational to become a Certified B Corporation (B Corp) by 2025 (BNP Paribas, 2018). A total of 27 Danone entities have now earned a B Corp Certification, representing 45 percent of Danone's global sales (Danone, 2020).

Table 6.1
Sustainable financial instruments

Financial instrument	Model/structure	Voluntary principles/ guidelines	Governance	Scope for use of proceeds
Green bonds	Use-of-proceeds to fund or refinance new/ existing pre-defined projects	Green Bond Principles (GBP) (ICMA, 2018)	International Capital Market Association (ICMA)	Environmental/green
Green loans		Green Loan Principles (GLP) (LMA, 2018)	Loan Market Association (LMA)	Environmental/green and social
Social bonds		Social Bond Principles (SBP) (ICMA, 2020a)	International Capital Market Association (ICMA)	Social
Sustainability bonds		Sustainability Bond Guidelines (SBG) (ICMA, 2018)	International Capital Market Association (ICMA)	Environmental/green and social
Sustainability linked loans	Performance-based instruments measured through KPIs and assessed against sustainability performance targets (SPTs); interest rates are subject to performance	Sustainability-Linked Loan Principles (SLLP) (LMA, 2020)	Loan Market Association (LMA)	Based on agreed-upon KPIs
Sustainability linked bonds	Performance-based instruments measured through KPIs and assessed against SPTs; coupon rates are subject to performance	Sustainability-Linked Bond Principles (SLBP) (ICMA, 2020b)	International Capital Market Association (ICMA)	

SOURCE: Compiled by authors.*

NOTE: *This table provides a simplified overview of the key sustainable financial instruments, however each loan agreement and bond issuance will have its own perspectives and detailed legal documents.

Another example is the United Overseas Bank's (UOB) extension of its USD 200 million sustainability loan to Wilmar in 2020, a Singaporean food processing and investment holding company (Wilmar and UOB press releases, 2020). Wilmar and UOB set a list of performance indicators in areas that cover a broad range: from corporate governance to emissions, biodiversity, community relations and supply chain practices. In this case, Sustainalytics, a private provider of ESG and corporate governance research and ratings, assesses whether Wilmar has achieved the targets on an annual basis and this, in turn, will determine the interest rate on the loan. Another food industry giant, Olam has raised a USD 250 million revolving sustainability-linked credit facility in 2020, the third by the group in two years, where the interest rate is linked to year-on-year sustainability performance (Olam Group press release, 2020). When KPI improvement targets are met, Olam will see a reduction in its lending costs compared to the reference market rate. The proceeds are used for general corporate purposes and the KPIs are tracked by Olam's corporate responsibility and sustainability team with Ernst & Young performing an independent assessment. These types of facilities provide a financial incentive for companies to achieve sustainability goals, but it also leaves companies with the decision-making power on the use of proceeds.

How investors think about carbon-related investments

Investors use at least three different types of strategies when making responsible investments in carbon neutrality (not exclusively in agrifood systems). A first group of strategies has to do with the identification of investments. In this regard, investors may use: (i) negative screening (exclusion of certain sectors, companies or practices based on specific ESG criteria); (ii) positive/best-in-class screening (investments are selected because of their specific above-average ESG performance relative to a specific benchmark); or (iii) norm-based screening, which consists in evaluating investments based on minimum standards for business practices as per international norms. For example, many DFIs and impact funds use norm-based screening of investments based on IFC's Environmental and Social Performance Standards[67] or the UN Global Compact Principles. Finally, investors also can focus on thematic investing as an identification strategy. Green bonds, social bonds and other types of thematic assets are all forms of thematic investing. Similarly, thematic investing can take the form of focusing on specific sectors such as renewable energy or conservation and nature-based solutions. A second investor strategy consists of engaging with the investee following the investment decision to trigger greater environmental impact, including a lower CFP. Engagement can take many forms: from being an active shareholder to providing technical assistance; working directly with the investee or in cooperation with other investors. The third investor strategy is integration, which means that ESG data and information are incorporated in the full evaluation of an investment from the initial assessment through to investment monitoring (including in risk assessment) and final impact and returns calculation.

Investment strategies vary but they tend to exclude large parts of agrifood systems. Some of these strategies seek to manage climate-related impacts as an integrated part of the valuation and engagement process, which requires active management and the need for unconstrained portfolio mandates (mostly performed by PE firms). Other strategies are more 'hands-off' as they rely on opportunities that already exist, namely in secondary markets (for example buying a green bond). In particular, secondary market investment strategies clearly favor large global agrifood multinationals, which provide regular sustainability and ESG reporting (Table 6.2). In general, agrifood companies with a good reporting, high ESG standard and clear CFP communication are clearly preferred. Furthermore, in agrifood systems, institutional investors tend to invest in listed equities or bonds of agrifood companies rather than primary agriculture. The barrier to entry for primary agriculture is considered higher in general due to low liquidity, limited available reporting and research and higher demand for assets and project management driving up transaction cost for institutional investors (Luyt, Santos and Carita, 2013). In contrast to agrifood multinationals, agribusinesses and farming enterprises in developing countries, particularly SMEs and smallholder farmers are outside the direct scope of these strategies. They may, however, benefit indirectly or through specific type of investors and investment approaches (more on this below).

The risk-return profile of some agrifood investments makes it challenging to attract private capital. For primary agriculture projects, it is harder to design a standardized risk-return model attractive to private investors and easily replicable. Most private investors still associate the agriculture sector with higher risk, more complicated project management and less predictability. Moreover,

67 The latest version of the IFC's Performance Standards is from 2012. IFC. 2012. Performance Standards on Environmental and Social Sustainability.

Table 6.2
Low carbon indices and agrifood companies

Low carbon index	Methodologies	Agrifood companies
MSCI ACWI Low Carbon Target ETF	Seeking lower carbon exposure using in-house MSCI ESG metrics	Nestlé Procter & Gamble Company The Coca-Cola Company PepsiCo, Inc. McDonald's Costco Wholesale Corporatio Starbucks Corporation Philip Morris International Inc. Naspers Limited Mondelez International, Inc. Unilever PLC Daimler AG
EURO STOXX® 50 Low Carbon	Portfolio allocation performed according to a carbon intensity score (including Scope 1 and Scope 2 emissions) to reduce overall portfolio carbon emissions	Anheuser-Busch InBev Danone S.A. Unilever PLC
EURO STOXX® Reported Low Carbon	Only coverage of companies with available reported carbon intensity data and portfolio allocation performed according to a carbon intensity score (including Scope 1 and Scope 2 emissions) to reduce overall portfolio carbon emissions	Pernod Ricard Danone S.A. Unilever PLC Anheuser-Busch InBev Heineken Kerry Group Rémy Cointreau
STOXX® Europe 600 Low Carbon	Utilizing both estimated and reported carbon intensity scores and portfolio allocation performed according to a carbon intensity score (including Scope 1 and Scope 2 emissions) to reduce overall portfolio carbon emissions	Nestlé Diageo Unilever PLC Anheuser-Busch InBev Danone S.A. Pernod Ricard Heineken Kerry Group Carlsberg Group Mowi ASA Orkla ASA The Coca-Cola Company Associated British Foods plc Davide Campari-Milano N.V. Barry Callebaut Group Rémy Cointreau Britvic plc Royal Unibrew AAk SalMar ASA Glanbia plc Tate & Lyle Viscofan

SOURCE: Compiled by authors.

most private investment firms are often not able to engage at the level of operation and transaction costs of many agrifood projects, particularly at smaller sizes. In order to reduce transaction costs and maximize returns, large institutional investors such as sovereign wealth funds prefer to make investments at a larger scale (Bernstein, Lerner and Schoar, 2013). Even smaller impact funds struggle with small ticket sizes without some level of subsidization of transaction costs (and usually donor involvement with a degree of concessionality).

6.3 UNLOCKING INVESTMENT OPPORTUNITIES FOR AGRIFOOD SYSTEMS

Sustainable investing as an opportunity for agrifood system players

Agrifood systems can in theory reap the benefits of this shift in the way investors prioritize and choose their investments. Sustainable investments can help internalize externalities, support adoption of greener technologies or support development of new markets with consumers. Investors are increasingly realizing the potential of capitalizing on low carbon value sectors, as their market shares are likely to grow in the future. For instance, J.P Morgan and Barclays foresee the plant-based meat sector to capture 10 percent of the meat market in ten to fifteen years, while AT Kearney predicts that plant-based and cultured meat will comprise 60 percent of the market by 2040 (Ramachandran, 2020). Other estimates indicate that plant-based alternative sectors will account for at least 16 percent of the current meat market, with the potential to increase to 62 percent depending on factors such as technology adoption rates, consumer trends and potential carbon taxes imposed on meat production (Jessop, 2020) (for further details please refer to Chapter 4.2). As an example, Beyond Meat, an American producer of plant-based substitutes, went public on the NASDAQ in 2019 with an initial public offering (IPO) price of USD 25, which in early 2021 rose to over USD 130 per share (CNBC, 2019; Nasdaq, 2021). Agribusinesses could also benefit from climate-related investments made by blended finance funds and DFIs. For example, the AGRI3 Fund, which was founded through a partnership between UNEP and Rabobank, guaranteed a USD 5 million ten-year loan from Rabobank to a cattle producer in Brazil (UNEP, 2021). The loan will finance forest replanting and protection activities, as well as renovating degraded pastureland in line with recognized environmental and social management guidelines (UNEP, 2021). DFIs are also supporting green investments in agriculture. For instance, in 2020, the World Bank approved a loan of USD 300 million to develop a green dedicated investment facility that will provide equity investments and on-lending to agribusinesses in the Henan province in China (World Bank, 2020d). Henan is one of the highest output regions of livestock and grains in China and the loan will finance resource-efficient and climate-smart projects that aim to increase the quality and safety of agrifood produce (World Bank, 2020d). The loan also aims to fill the gap in green financing standards in China, by fostering the development of green agriculture financing standards based on globally accepted green investment principles, good practices and performance benchmarks (World Bank, 2020d). An untapped opportunity for financing remains at the sovereign wealth fund (SWF) level, which in 2018 had USD 7.5 trillion in assets under management, of which only 1 percent was made up of environmental investments (UNEP, 2018). Uncertainties in green portfolio performance, weak political demand and high costs of CFP analyses have in the past been obstacles to SWFs making green investments. However, as elaborated below, initiatives to improve disclosure practices combined with SWFs changing risk management strategies may contribute to greater SWF-initiated green financing (UNEP, 2018).

Agrifood system players can also benefit from improved financing conditions and diversification of sources of finance. For larger agrifood companies this means that steps taken in carbon emissions reduction implementation and reporting can help them access a larger pool of investors and possibly better financing conditions. For example, companies with high sustainability engagement activities are more likely to conduct further equity offerings and raise a larger amount of capital (Dhaliwal *et al.*, 2011) to finance their growth. The recent growth in green bonds is also pushing companies to better understand and disclose their climate-related efforts. As proceeds from green bonds can only be used for eligible climate-related projects, companies need to define what they can strategically do in terms of decarbonization. On the secondary market, as sustainability investment strategies get more traction, companies with better long-term sustainable strategies may have a competitive advantage over their peers in the same sector through access to more investors and lower capital costs.[68] Moreover, from a risk perspective, companies that have invested in improved climate resilience may face less sustainability risks, leading to lower credit risk.

Carbon neutrality can be a tool for value chain optimization within agrifood systems. Achieving carbon neutrality requires companies to evaluate the GHG emissions associated with energy consumption as well as the purchase and usage of agricultural inputs and relationships with suppliers up to the farm. In evaluating resource efficiency levels, CFPs can serve as indicators for overall business efficiency to support the identification of process- and product-level GHG emission hotspots. These types of evaluations can not only lead to lower sourcing, production and processing costs, but can generate greater operational resiliency. The importance of having a high degree of operational resiliency has been brought to light through the COVID-19 pandemic: companies operating extensive supply chains have faced challenges that include border closures and labour shortages. Carbon neutrality and footprint assessments can support companies in identifying sources of emissions that are also subject to operational risks. Furthermore, investors are seeking to mitigate against asset devaluations and write-offs in sectors that could be significantly taxed in the future. CFP analyses and disclosures are increasingly enabling policymakers to price GHG impacts, especially across emission-intensive sectors. The IEA World Energy Outlook predicts that the meat sector could – by 2050 – face carbon taxes up to USD 53 per tCO2eq in North America and Europe and USD 27 per tCO2eq across all other geographies (Fairr a Coller Initiative, 2020). This could equate to carbon taxes costing up to USD 11.6 billion of the earnings before interest, taxes and depreciation (EBITDA) of the 40 leading meat producers, representing 5 percent of the revenue for each company (Fairr a Coller Initiative, 2020). Consequently, to safeguard investments, investors are increasingly anticipating regulatory and market changes and relying on carbon neutrality assessments to do so.

Action is required to upscale sustainable finance and make it more inclusive

Across global and local agrifood systems, sustainable finance can support decarbonization efforts; still many actors are left out in the short term. Such dynamics are not exclusive to sustainable finance but rather finance in general: smallholder farmers, agrifood SMEs and other actors particularly in developing countries do not stand to benefit immediately from the developments in

68 See Matos 2020 for a review of the evidence on ESG investing and lower financing costs for companies.

Sustainable investing is creating opportunities, but investors and companies often struggle to convert their commitments into practice.

sustainable finance. In 2015, it was estimated that 570 million farms globally are small and family-run, and that small farms (less than 2 ha) constitute 12 percent of the world's agricultural land (Lowder, Skoet and Raney, 2016). Importantly, it has been estimated that the unmet demand for financing of smallholder farmers in sub-Saharan Africa, South and Southeast Asia and Latin America is approximately USD 170 billion (IFAD, 2021). Financing such critical agrifood system actors translates into high risks and transactions costs, which make them often not directly eligible for many forms of sustainable financial instruments, as discussed above in this chapter. Still, many reasons suggest they can benefit indirectly over the medium term. First, many agrifood systems are global food chains and therefore major global companies under pressure to decarbonize will at some point need to include such smaller players as part of their Scope 3 emissions strategies. Involvement of such actors is needed for quantification of emissions up to reduction and offsetting. As a consequence, there will be a need to work with buyers, suppliers and farmers in decarbonization processes and ultimately this can lead to sustainable investing projects (such as those financed by green bonds or a sustainability-linked loans). This is not entirely new, since a similar trend has been seen in commodities such as palm oil with the Roundtable on Sustainable Palm Oil (RSPO) certification being used by many industry players because of market pressure or in commodities such as tea or cocoa with rainforest alliance certification. For instance, PepsiCo Inc. sourced over 480 000 tonnes of palm oil in 2019, a key ingredient in its snack portfolio (PepsiCo Inc., 2021). PepsiCo Inc. has been a member of RSPO since 2017 and says that through its sustainable farming program, which is based on a partnership-approach with suppliers, the company reached out to 40 000 farmers (PepsiCo Inc., 2019). The approach seeks to pilot adoption of regenerative farming practices, including smart agriculture technologies, irrigation practices and soil health management techniques (PepsiCo Inc., 2019).[69] There is room for international financial institutions, policymakers and development partners to support such processes

69 Results are not conclusive.

(more on this in Chapter 7). Secondly, some forms of sustainable finance such as carbon offset markets and similar mechanisms can support decarbonization of smaller players in global agrifood systems. Developing local carbon offset markets can be a way for countries to support (i) improved natural resources management at local level and (ii) provide payment for carbon, plus associated social and environmental services. As elaborated in Chapter 3.5, carbon marketplaces can provide an entry point to addressing carbon emissions, as well as environmental and social impacts through credits that provide co-benefits and are verified by a third-party.

Sustainable investing is creating opportunities, but investors and companies often struggle to convert their commitments into practice. Efforts so far have concentrated on carbon reporting and disclosure, with fewer experiences demonstrating real impact on the ground in terms of achieved emission reductions. The past 15 years have seen significant growth in disclosure of corporate performance on sustainability. Companies such as Vigeo, MSCI, and Sustainalytics provide ESG analysis and rating for companies and investors. ESG is moving into the mainstream but is mostly a voluntary practice. In late 2020, a survey conducted by KPMG found a record 80 percent of the 5200 leading companies across 52 countries now voluntarily undertake sustainability reporting, with 67 percent using standards developed by the GRI (Cohn, 2020). Ninety-six percent of the largest 250 companies, globally, report their sustainability performance, of which three out of four adopt the GRI standards (Cohn, 2020). Furthermore, most international agrifood companies, like Coca Cola Company, Nestlé S.A., PepsiCo Inc., and Danone S.A. have set carbon reduction targets.

While investors increasingly demand companies to disclose their sustainability and carbon performance, reports show that investors are also questioning existing reporting practices and calling for changes. For instance, McKinsey's 2019 global survey on sustainability reporting, 'More than values: The value-based sustainability reporting that investors want', suggests that investors say they cannot readily use companies' sustainability disclosures to inform investment decisions accurately (McKinsey & Company, 2019). The McKinsey report indicates there is a need to conform companies' sustainability disclosures to shared standards as done for financial disclosures, in order to allow for comparisons among companies. In addition, both executives and investors strongly support a move towards a reduction in the number of standards for sustainability reporting and support legal mandates requiring companies to issue sustainability reports (Figure 6.7). A survey of 400 large institutional investors on views and preferences for companies' climate risk disclosures indicated a majority of investors considered climate risk reports important for decision-making but also suggested that such company reports need improvements in both quality and quantity (Ilhan *et al.,* 2020). Interestingly, the authors find that many institutional investors view climate risk reporting to be at the same level of importance relative to financial reporting (Ilhan *et al.,* 2020).

Although ESG ratings and investment approaches are constructive in driving the disclosure of valuable information, the lack of standardized reporting practices and limited transparency in ESG rating methodologies hinder comparability. ESG investing holds promise, as it seeks to integrate non-financial information to better align financing with long-term value creation. However, ESG methodologies are facing challenges related to comparability, consistency and financial materiality. Despite the hype around sustainable investing, most reporting on ESG or CSR by companies is still entirely voluntary which translates

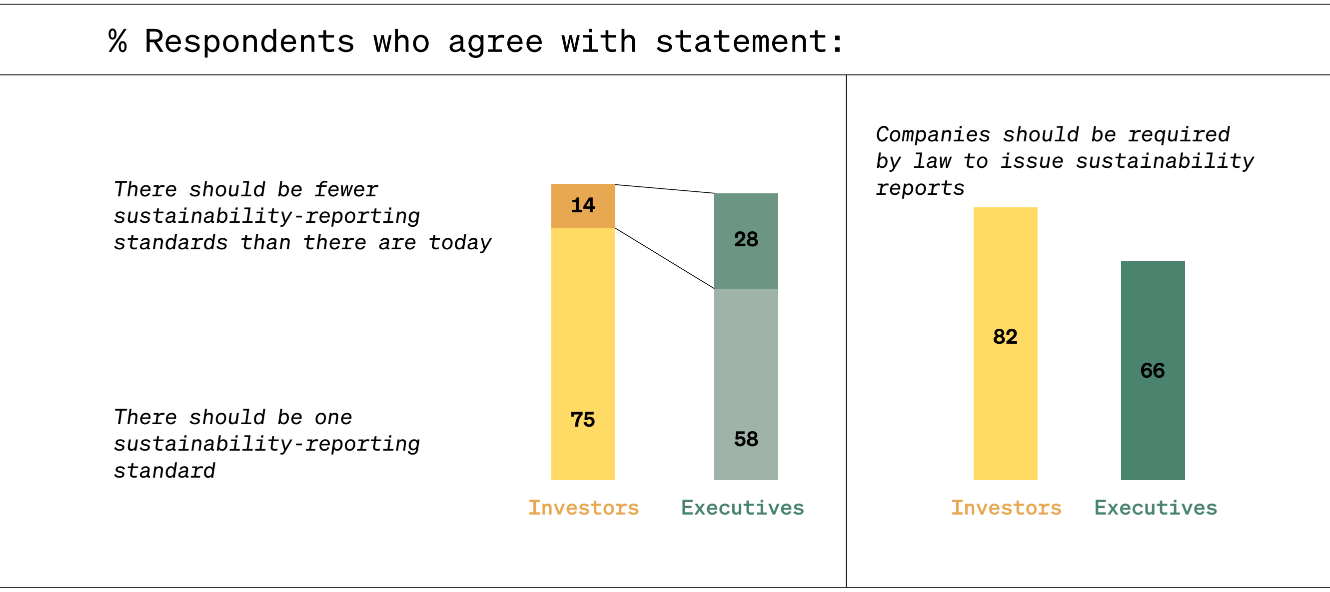

Figure 6.8
Investors' and executives' views of sustainability reporting

SOURCE: McKinsey & Company. 2017. From 'why' to 'why not': Sustainable investing as the new normal. McKinsey & Company, Oct 2017. www.mckinsey.com/industries/private-equity-and-principal-investors/our-insights/from-why-to-why-not-sustainable-investing-asthe-new-normal.

into substantial heterogeneity in reports and difficulties in making objective comparisons across companies (Christensen *et al.*, 2019). In addition, different outputs across major ESG rating providers, compared to credit ratings, can generate confusion amongst investors and fund managers as to what a high ESG-rated company entails. For example, a review by the OECD concludes that environmental scores in ESG performance ratings and carbon emissions can vary considerably both within and across ratings. For example, in some cases, environmental scores correlate positively with high carbon emissions, due to the usage of diverse metrics on separate environmental factors and the weighting of those factors (OECD, 2020).

Inconsistent disclosure requirements are also challenging investors and corporate stakeholders to communicate ESG-based decisions, outcomes and performance criteria to beneficiaries and shareholders. Non-consistent disclosure requirements render it difficult for beneficiaries to assess how savings are utilized and for businesses to attract financing that considers ESG factors at a competitive cost. It has also been noted that that high disclosure costs can favor large players providing an advantage versus SMEs (OECD, 2020). The omission of smaller players may also distort performance results, as growth dynamics of smaller businesses may be underrepresented. Overall, greater attention and guidance from regulators on reporting and disclosure practices is required to standardize practices in disclosure of carbon emissions in a transparent and internationally consistent way.

Incorporating emissions in standardized financial accounting reports can help investors and companies decarbonize agrifood systems. Inconsistency, incomparability, or lack of alignment in standards were identified as the top

challenge associated with current sustainability reporting: almost all the investors in a 2019 McKinsey survey (McKinsey, 2019) – 97 percent – said that sustainability disclosures should be audited in some way, and 67 percent said that sustainability audits should be as rigorous as financial audits. Some progress has been achieved but we are still far away from full incorporation of emissions in financial accounting. Relevant protocols and the TCFD have taken steps towards streamlining climate-related disclosures and the use of consistent ratings methodologies. The TCFD in 2017 released climate-related financial disclosure recommendations to support companies in making informed capital allocation decisions (TCFD, 2017). The recommendations focus on supporting stakeholders with informed investment, credit and insurance underwriting decisions, thereby enabling a greater understanding of carbon-related assets and the financial sector's exposure to climate-related risks (TCFD, 2017). The guidance especially focuses on assisting disclosure preparers by providing context and suggestions for implementing recommended disclosures. A sister-initiative to the TCFD, the Taskforce on Nature-related Financial Disclosures (TNFD), is currently in its preparatory stages, with the aim to launch and promote its uptake by 2023. The TNFD builds upon the TCFD and it provides a framework for financial institutions and corporations to identify and report on climate-related risks. It will harness synergies to avoid repetition and over time, the aim will be to make the two frameworks complementary. In late 2020, the GRI responded to a proposal from the International Financial Reporting Standards Foundation (IFRS) to oversee sustainability standards alongside international accounting standards (Cohn, 2020). Five of the existing sustainability standard-setters, including GRI, pledged to collaborate in aligning their various standards and frameworks (Cohn, 2020). Furthermore, the International Federation of Accountants (IASB) proposed that the IFRS Foundation oversees an international sustainability standards board alongside the IASB. If brought to fruition, such collaborations can support companies to directly integrate sustainability into their financial reporting. As discussed in the next chapter, these efforts need to be accelerated in order to help transition agrifood systems towards a more sustainable path (including low carbon). Given the complexity of a process of formal reporting of emissions in standardized formats and using adequate governance for agrifood system players (similar to that of financial accounts), such efforts would benefit from inputs from sustainable investors, international organizations and development partners. As an example of efforts towards standardization and helping investors, companies and other stakeholders avoid greenwashing, the European Commission published in 2020 the EU Taxonomy for Sustainable Activities. The taxonomy, which includes appropriate definitions on environmentally sustainable economic activities is seen as an important step in helping the European Union scale up sustainable investment and implement the EU Green Deal (European Commission, 2020b).


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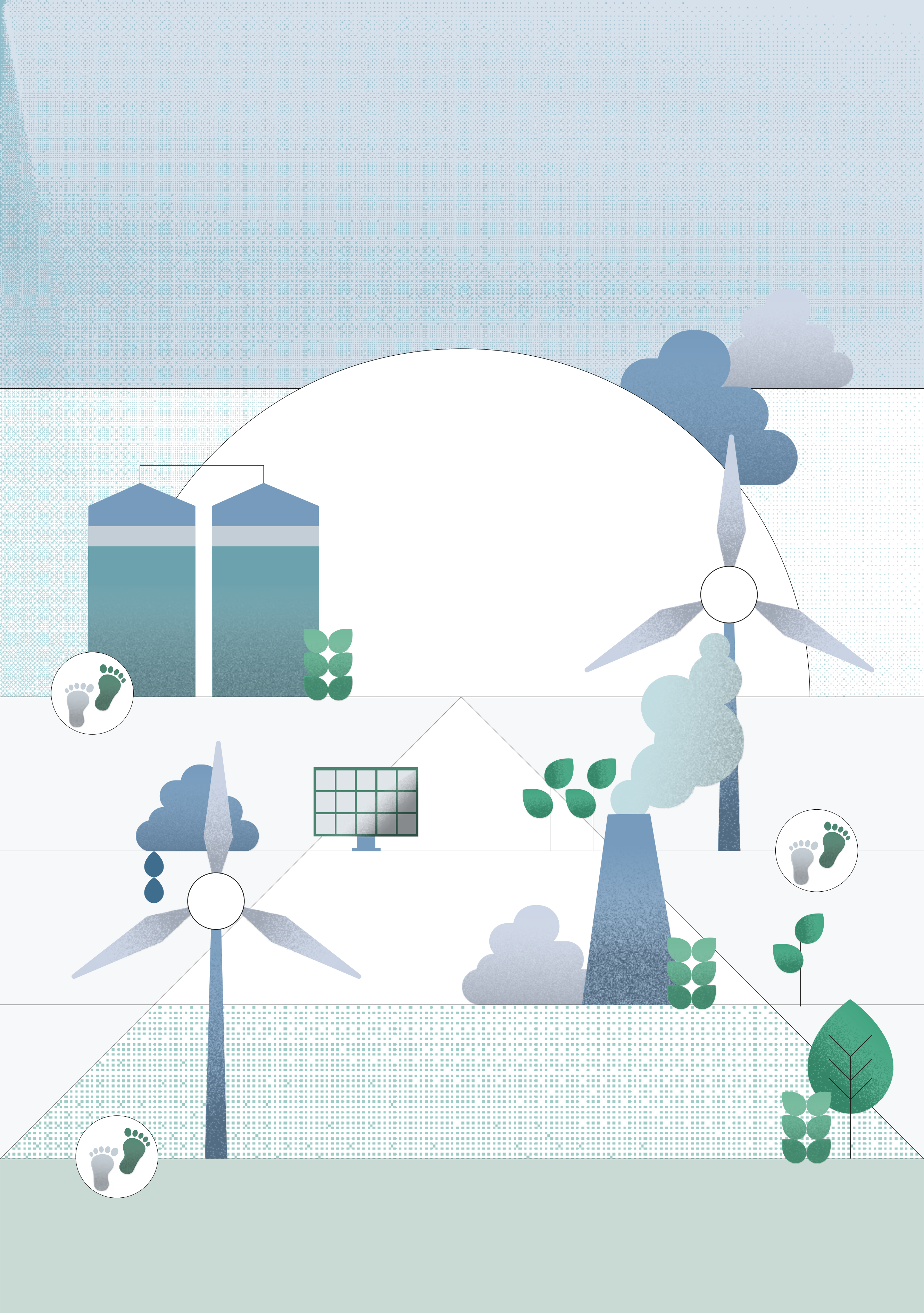

Chapter 7
Reducing the distance to carbon neutrality the road ahead

The analysis in this report highlights that there is not a single path to carbon neutrality for agrifood system actors. The critical review of drivers for carbon neutrality also questions many of the perceived incentives for smallholders, companies and other food systems players to embark in decarbonization. A key conclusion is that the concept and application of carbon neutrality to food systems is a useful, yet, imperfect tool to transform food systems. This chapter starts with a summary (section 7.1) of the main conclusions from previous chapters, particularly highlighting the key challenges on what is perceived at present as a long road towards carbon neutral food systems. In discussing the challenges, this chapter also underlines the transformational potential of the 'carbon neutrality' concept. It concludes in section 7.2 with a set of actions that can be taken by different stakeholders to reduce the distance to a carbon neutral agrifood system.

7.1 CARBON NEUTRALITY TODAY IS A USEFUL, YET IMPERFECT TOOL TO TRANSFORM AGRIFOOD SYSTEMS

Reasons for cautious optimism

Food systems are both a culprit and a victim of climate change, yet they have the potential to play a critical role in the fight against climate change. Food systems, through their production systems, poor soil management practices and deforestation, have been a major contributor to climate change. In totality, food systems accounted for an estimated 21 percent to 37 percent (10.8–19.1 GtCO2eq yr-1) of total anthropogenic GHG emissions during 2007–2016 (IPCC, 2020). At the same time, food systems are a victim of climate change, with changes in temperature and rainfall patterns placing food systems actors and the natural systems upon which they rely, at risk. Agricultural ecosystems are by far the largest managed ecosystems in the world, meaning that agricultural practices and farmers that provide environmental services have a key role to play in reducing and offsetting global emissions. This is increasingly being recognized and as the world gears up in the fight against climate change, food systems are expected to play their part. Food systems are being targeted worldwide, with citizens, companies and governments, to different extents, calling for the reduction of GHG emissions. Simultaneously, as per the analysis summarized in previous chapters, economic returns from engaging in the decarbonization of food systems are also potentially very high.

Carbon neutrality and in particular offsetting, does not lead to immediate business transformation; still it can nudge agrifood actors towards improved climate performance. As discussed throughout this report, developing a carbon neutral strategy can help agrifood actors, especially mid- to large-scale businesses, do more than just set long-term strategies to reduce their CFPs, thereby supporting their transition towards low-carbon agrifood systems. Carbon neutrality represents a long-term umbrella project that can lead to tangible results, including reductions and savings in energy consumption, raw material usage, lead times and logistics. Pursuing a path towards decarbonization can mean that companies implement short-term solutions (offsetting emissions), while aiming at net zero emissions over the long term. A practice that has evolved from offsetting, is insetting, which as highlighted in Chapter 2 may require distinct managerial and technical capabilities as well as greater investment requirements. At the same time, insetting could present the opportunity to fully control carbon reduction flows and avoid depending on external services for the purchase of carbon credits, while generating co-benefits, including, climate-proofing productions, ameliorating supplier relations, improving quality and guaranteeing supply (ICROA, 2016). Offsetting may also lay the path for and incentivize industry players to directly reduce emissions. For instance, in the tea and coffee industries, companies are increasingly recognizing that although offsetting may seem like the cost-effective option to reduce emissions, investments in research and development to develop recyclable cups and packaging can present an equally attractive business case. This option can provide competitive advantages, while balancing CSR messaging towards carbon neutrality through cost-efficiency measures rather than capital investments. Importantly, the implementation of a carbon neutrality strategy can activate long-term supply chain reduction programs where farmers and smallholders may play a new and profitable role as ecosystem service providers.

Agrifood system players can benefit from synergies between climate change adaptation and mitigation measures. Improved agricultural practices can help mitigate climate change by reducing emissions and by storing carbon in plant biomass and soils. Moreover, the sequestration of carbon in soils and vegetation can be used to offset GHG emissions generated by other sectors. This means that other industries, such as aviation and mining, can invest in agrifood systems to offset their emissions. As elaborated above, achieving carbon neutrality often presents a long-term strategy, supported by the adoption of shorter-term solutions to achieve predetermined targets. This is particularly important as carbon reduction programs are generally costly and have long lead times. So for companies it is sometimes difficult to account for the value addition of directly reducing emissions, in pure financial terms. As explained above, this may in part explain why agrifood companies tend to start their carbon neutrality journey through offsetting, which is somewhat comparable to a nudging strategy.

The long road ahead

Despite the important role food systems can play in the fight against climate change, no magic formula to achieve carbon neutrality exists. Agrifood system actors combine the tools available on the market according to their different goals and their specificities. Since no Carbon Rule of Law exists, companies are experimenting with new approaches, where specific definitions and governance are yet to be fully agreed. This is often accompanied by communication campaigns to signal intentions and alignment with climate concerns. In particular, agrifood system actors that have the capacity to decarbonize, optimize their decisions over time taking into consideration the costs and benefits of acting fast and getting closer to carbon neutrality. It is a rapidly evolving situation combining major uncertainties about the availability of new technologies (eventually with lower associated decarbonization costs), about regulations (that could change potential returns to decarbonization through 'carrots' and 'sticks'), but also about consumer purchase decisions and investor sentiment. Often, the optimal result from an individual agrifood system stakeholder perspective may well be delayed decarbonization or a symbolic one. In addition, the lack of clear definitions and the voluntary nature of all carbon neutrality efforts undertaken by agrifood actors so far, mean that in practice it is not possible to chart a single approach to carbon neutrality.

A diverse set of drivers including the prospect of gaining a competitive advantage, increasing efficiencies and complying with or anticipating policy, regulations and investor expectations has resulted in agrifood companies adopting different approaches towards carbon neutrality. The analysis in this report describes how some agrifood companies have identified a specific competitive advantage and are exploiting it to become the pioneers and the reference models for achieving carbon neutrality. The measurement of emissions can also force businesses to closely examine their processes and to evaluate their resource efficiencies, as GHG emissions are correlated with resource consumption (Scope 1 and 2) and the purchase and consumption of inputs (Scope 3). Hence, CFPs can serve as a useful indicator of overall business efficiency to help identify hotspots in a process or in a product's journey, which are particularly resource-intensive and wasteful. Some agribusinesses are using carbon neutrality to enter new market segments and to capitalize on early mover advantages. For instance, companies are increasingly becoming aware that alternative proteins can serve as a driver of business growth. Other companies are pursuing a carbon neutrality path to remain aligned with policy, comply with international and national regulations and anticipate what might soon become mandatory. For instance, through the EU Green Deal, the future common agricultural policy (CAP) aims to increase conditionality to support uptake of sustainable practices by farming enterprises through a range of eco-schemes. Accordingly, all the companies interviewed for this report mentioned anticipating regulation as a key driver for their actions and investments in reducing emissions; a similar result can be found in other surveys and data. Some agribusinesses also see carbon neutrality as a way to respond to investor expectations and to tap into growing sustainable finance opportunities. Lastly, some agribusinesses are simply exploiting carbon neutrality for marketing and promotional purposes. Given the absence of mandatory guidelines, carbon neutrality paths can take different directions, leaving companies with the freedom to choose what best fits their specific context. This variability can lead companies to advertise their products and organizations as carbon neutral, often without having received any independent third-party evaluation. It has also resulted in uneven efforts to achieve carbon neutrality; for example with companies not going all the way to fully address Scope 3 emissions.

Questions about consumers' preferences and willingness to pay a premium for carbon neutral food products are largely unanswered. In several parts of the world, citizens are increasingly demanding action on climate change. These demands reflect increasing awareness of the urgency of climate action; however, their impact on purchasing decisions is not always obvious. For instance, the Australian meat producer, Flinders + Co has decided to offset, rather than inset or reduce all of its emissions. While the company recognizes that consumers are increasingly showing interest in carbon neutrality, it finds that this has yet to translate into price premiums. Existing evidence from high-income countries also suggests that consumer food choices such as food quality, nutrition and price concerns are still largely driven by factors other than carbon neutrality or climate-related performance (Carbon Trust, 2019b; EIB, 2021). These findings may be due to the high proliferation of labels, which generates confusion, but also to a lack of consumer awareness on the choices available to adjust food consumption habits to support low-carbon pathways. Overall, a lack of data on the meaning of carbon neutrality labels compounded by a wide array of variegated environmentally friendly labels, render it difficult for consumers to develop recognition and comparison-based capabilities (Lacey, 2020). Consumers also lack benchmarks against which they can compare carbon emission values (The Grocer, 2020). Importantly, consumers need to buy into environmental labels and consequently, messaging should be centred around scaling challenges, so that consumers can feel that their impact is manageable and realistic. Furthermore, some of the costs and problems associated with labelling are compounded by uncertainty on the standards to apply, as well on the efficacy of governance structures implementing specific labelling schemes. Despite these challenges, compared to earlier carbon labelling attempts made more than ten years ago, agribusinesses and retailers may be in a better standing to widely adopt carbon and environmental indices. This is primarily due to lower labelling implementation costs and greater consumer awareness and demand for environmental labelling. Furthermore, rather than developing new labels, some certification service providers are integrating carbon-specific modules into their existing standards (Rainforest Alliance, 2021).

Although sustainable investing can potentially unlock massive resources and set the stage for agrifood companies to progress along the carbon neutrality path, this will only occur if the sector moves towards an improved standardization of decarbonization measurement and reporting. A significant issue is the proliferation of ESG rating agencies that use distinct evaluation criteria and standards. Research indicates that many investors claim that they cannot readily use companies' sustainability disclosures to inform investment decisions accurately (McKinsey & Company, 2019). Furthermore, there is a demand for aligning company sustainability disclosures to shared values, as done for financial disclosures to allow for greater comparison. Overall, the ESG methodology is facing challenges related to comparability, consistency and financial materiality. Further clarity is required to understand how subcategory scores, metrics and associated weightings contribute to final ESG scores, as this would allow for greater compatibility. Where ESG scores are combined with traditional financial approaches, the two should be clearly separated as this would allow a better assessment on the effects that the ESG approach has on financial results and portfolio composition (McKinsey & Company, 2019). Furthermore, there is a need to assess how and the extent to which financial materiality should be embedded in ESG ratings, benchmarks and portfolios. Ultimately, inconsistent disclosure requirements are challenging investors and corporate stakeholders to communicate ESG-based decisions, outcomes and performance criteria to beneficiaries and shareholders. Greater attention and guidance from regulators on reporting and disclosure practices is to a large extent required to standardize the sustainability reporting. Relevant protocols and the TCFD could prove to be crucial in streamlining climate-related disclosures and the usage of consistent rating methodologies.

ROADBLOCK 1
GOVERNANCE OF STANDARDS AND PROCESSES

The multiple carbon neutrality paths analysed in this report – and related achievements and claims – highlight the need to improve the governance of standards and processes. A common terminology surrounding carbon neutrality is still lacking. Substantial definitional differences exist, with some agrifood system players associating carbon neutrality with CO2 emissions, while others considering all GHG emissions (Wasabröd). This aspect, together with an unclear reference framework on how to achieve carbon neutrality, but more specifically on the tools available to companies to ensure and communicate carbon neutrality efforts, has affected the development and credibility of carbon neutrality. In addition, a significant challenge for carbon neutrality has to do with MRV to ensure that reductions and offsets are being achieved in the manner and quantity communicated (Gillenwater *et al.,* 2007). Independent third-party verification of the various steps of the carbon neutrality process against a common standard is necessary for agrifood system stakeholders at different stages: from consumers that require a reliable and unbiased source of information, which they can use for product comparison purposes to investors that need to understand the physical and other risks associated with specific agrifood systems investments, as well as potential carbon impacts. However, this harmonization and oversight is lacking, meaning that the legitimacy and credibility of some carbon neutrality efforts could be undermined. Most importantly, a lack of standardization and oversight are obstacles for faster adoption of decarbonization strategies. Many companies therefore combine the tools available on the market depending on their different goals and their specific value chains. National and transnational organizations could do more to clarify and simplify this path both for companies that want to achieve carbon neutrality and for consumers who should be able to distinguish a sound commitment to carbon neutrality from greenwashing.

ROADBLOCK 2
KNOWLEDGE, DATA AND TOOLS

Achieving carbon neutrality in agrifood systems is challenged by its intrinsic diversity often resulting in knowledge gaps at several levels. First, companies, farmers and other relevant actors often lack information about the best available low carbon technologies and practices. Second, lack of up-to-date inventory data to inform CFP assessments, as well as aggregated datasets for GHG emissions and soil carbon stock changes. A major challenge analysed in the present report relates to the measurement techniques (largely unstandardized) and the dearth of data to inform accurate CFP measurements in agrifood systems. Specifically, a lack of verified and up-to-date inventory data on food processes and production, challenges the development of accurate CFPs. Third, when data is available it is often not at the spatial and temporal resolution required to accurately represent the complexity of specific agricultural practices and value chains. Furthermore, challenges in retrieving ground-level data to measure carbon stock changes have hindered the development of reliable databases for GHG emissions and soil carbon stock changes. It can be argued that direct measurement methods are still too costly to be implemented routinely and the strategic use of measurement methods should be employed to obtain aggregated data on a regional and sub-regional scale. Finally, consumers are often not aware of the available food consumption choices and habits to support low-carbon pathways. This is largely due to the proliferation of environmentally friendly labels combined with the limited data on the meaning of carbon neutrality labels and a lack of benchmarks, which consumers can use to compare emission values.

ROADBLOCK 3
COSTS

The costs of becoming carbon neutral can be relatively high for smaller sized players, particularly in emission-intensive sectors and for companies operating in fragmented supply chains. Cost modelling simulations presented in this report indicate that annual costs of becoming carbon neutral can be significant for smaller companies, especially throughout emission-intensive sectors (sheep and beef). Furthermore, reduction costs tend to be higher than offsetting costs, however, costs will vary depending on the emission reduction practice employed and the offsetting strategy pursued through the type of carbon credits purchased. Importantly, companies operating in fragmented supply chains, cannot always afford the investments required to reach, organize and train smallholder farmers. Nonetheless, this report sheds light on examples of company-led initiatives to reduce the transaction costs of engaging smallholder farmers. As elaborated in Chapter 3, a global beverage producer will work with 500 pilot farms to implement sustainable farming practices and the company has worked with its largest suppliers to identify the pilot farms and corresponding cooperatives to develop a protocol on sustainable farming practices and emission reduction measures.

ROADBLOCK 4
ENGAGING SMALLER PLAYERS

While some companies are engaging SMEs and smallholder farmers in carbon neutrality efforts, these cases are singular and so far, wide-scale engagement has been minimal. More should be done to involve these actors in carbon neutrality related operations as their role is crucial in ensuring Scope 3 reductions, but also in providing additional options for carbon sequestration (e.g. from soil and trees). In this context, it is important to consider that smallholder farmers are not likely to adopt new mitigation practices if trade-offs against farm productivity and food security exist; particularly as they may be more risk averse when compared to other agrifood system players. Moreover, as discussed in Chapter 4 of this report and related to Roadblock 3, costs incurred in the carbon neutrality process may be relatively larger for smaller companies. Therefore, to increase the attractiveness of mitigation measures, practices must demonstrate potential to generate tangible benefits related to increases in productivity and livelihoods (Wollenberg *et al.,* 2012). One key incentive that could render mitigation practices more attractive to smallholder farmers is the generation of income and other benefits from selling offsets in carbon markets and/or PES schemes (Wollenberg *et al.,* 2012*)* However, the lack of methodologies to account for benefits and emission reductions related to climate-smart agriculture practices has prevented smallholder farmers from participating in most carbon reduction and offsetting efforts. The limited participation of smallholder farmers is also due to the fact that even if several offsetting certification schemes exist globally, there are few international standards for offsetting in agrifood systems. Encouragingly, new methodologies and tools that aim to support smallholder farmers in measuring emission changes for the application of regenerative agricultural practices are being developed and piloted (Verra VCS Methodology and SHAMBA). Further development of standards for offsetting in agriculture could expand the possibilities for the sector and enhance the role of smallholder farmers.

Although sustainable financing is gaining ground, smallholder farmers and smaller companies may not stand to immediately benefit. Low liquidity, small business size, informality and limited reporting are some of the aspects that often characterize primary agriculture. These factors may increase transaction costs and risks and disincentivize institutional and private investments. For these reasons, many food-system actors may not be directly eligible for forms of sustainable financing. However, food systems are often part of global food chains that are managed by large companies and these actors are increasingly being pressured to address Scope 3 emissions, which often involves smallholder farmers. As such, companies may need to involve smaller players to quantify, offset and reduce emissions. Sustainable financial instruments, such as green bonds, sustainability-linked lending and carbon offset markets could be leveraged to finance these efforts.

7.2 POSSIBLE ACTIONS TO REDUCE THE DISTANCE TOWARDS CARBON NEUTRAL FOOD SYSTEMS

Agrifood systems should exploit their potential in reducing the distance towards carbon neutrality. As the findings of this report indicate, the voluntary nature of carbon neutrality compounded with market failures in internalizing and accurately pricing climate change impacts has led to uneven efforts by agribusinesses in pursuing carbon neutrality. Based on these key findings, the main areas for intervention relevant towards agrifood systems are elaborated below.

A call for public and private action

While the prospect for carbon neutral agrifood systems may seem distant today, the subject merits discussion because of the critical links between agrifood systems and climate change. The private sector has the opportunity to genuinely embrace shared value to reduce costs, mitigate risks, protect brand value, ensure long-term supply chain viability and gain competitive advantages. Yet, the level of effort is uneven, and agribusinesses rarely go all the way in achieving carbon neutrality (i.e. Scope 3). This is largely due to the voluntary nature of carbon neutrality, including the constrained value perceptions of shareholders, inaccurate valuation and pricing of carbon and irresponsive consumer demand. To reduce the distance in the prospects of achieving carbon neutrality, the following overarching findings from this report on public and private action should be considered:

- Through greater awareness on climate change, carbon labelling has gained more traction amongst consumers. However, to address persistent consumer value action gaps will require public action, particularly on standardization. Increased transparency and reliability can help accelerate the adoption of environmental labelling.
- Governments need to play a significant role in developing new opportunities for achieving carbon neutrality including adequately pricing carbon and the creation of national carbon marketplaces that cover agrifood systems, as well as accelerating GPP opportunities.
- Supporting market incentives and regulations are required to drive the accurate valuation and pricing of carbon, since consumer demand does not, as of yet, tangibly drive efforts in achieving carbon neutrality.
- Given the global nature of climate change, government, industry-wide organizations, IFIs and international organizations need to provide oversight and harmonize carbon neutrality standards. This can include the subsidization and alignment of MRV efforts to methodologies and databases developed on a national level, as well as supporting the consolidation of the necessary data and information to do so.
- Costs for achieving carbon neutrality differ widely both in terms of pathways and whether these are employed by large and small companies as well as smallholder farmers. Public intervention and IFI support is therefore required, in many instances, for the subsidization of MRV efforts. It is recommended that clear pathways are developed to allow companies to inclusively compete in the space for carbon neutrality.

Based on the above, a set of possible actions to reduce the distance to carbon neutral food systems is detailed below. These actions do not follow a sequential order and can be employed simultaneously.

ACTION

1

STRATEGICALLY TARGET CARBON NEUTRALITY

Policies, strategies and roadmaps with clear targets at central government and decentralized/sector level are important signals to agrifood system players. They set the tone of how policy is evolving and can support agrifood system players prepare for regulatory changes in developing their targets and strategies; they can also incentivize the simplification and harmonization of standards.

Develop decarbonization priorities and targets. Governments at central and decentralized levels need to establish and communicate long-term decarbonization strategies, policy goals and a time-horizon to achieve objectives, and allow companies to anticipate and adjust to regulatory changes. Notable examples of relevant laws and strategies include the Non-Financial Reporting Directive, Directive 2014/95/EU, which will require companies to disclose their climate-related performance; and the EU Green Deal, which lays out the targets and pathways, which member states will have to follow to reduce GHG emissions by at least 55 percent by 2030. It can be argued that policies that are conducive towards achieving carbon neutrality are gaining ground, but that these need to be more closely aligned with science-targets and guided by more advanced governance systems. Nonetheless, policy change announcements are providing positive signals for change. Specific support is needed to ensure participation of the private sector in the definition and preparation of decarbonization strategies. Institutional and international actors should continue to facilitate policy dialogue at a national level, including with the private sector, to support the establishment of decarbonization policies and strategies including commitments such as the NDCs. Focus should be placed on disseminating the results of piloted investment schemes and presenting success stories and best practices on an operational and policy level.

Design and implement sectoral decarbonization roadmaps. Such processes can enable sector organizations to promote GHG reduction targets, as well as support adoption of improved practices. Decarbonization roadmaps can especially serve as reference points for emission reduction approaches, target setting and disclosure practices. Notable examples of decarbonization roadmaps include, Costa Rica's National Decarbonization Plan, the UK Dairy Roadmap, the Delivering on Net Zero Roadmap in Scottish Agriculture and the British Retail Consortium Climate Action Roadmap (Costa Rica Bicentennial Government, 2019; Dairy Roadmap, 2018; WWF, 2019; British Retail Consortium, 2020). It is important to ensure that national and sector level decarbonization strategies, roadmaps and targets are linked back and support the achievements of pledged NDCs.

Regulate emissions and support carbon markets. This is a well-known element of climate policy, whose relevance for carbon neutrality in agrifood systems cannot be understated. This involves regulation of emissions, carbon taxation as well as ensuring international cooperation on expanding carbon markets. Trading schemes and generating responsible carbon offsetting opportunities nationally and internationally can contribute to more rapid decarbonization.

Who and what?

Governments at a national and subnational level can play a critical role in Action 1 by developing and communicating policies, decarbonization strategies and targets, thereby allowing companies to anticipate and respond to regulatory changes. International financial institutions and donors through their policy assistance work streams, as well as UN and other technical agencies can play an important role in supporting such strategic thinking processes and related action globally. In particular, funding for technical assistance may be particularly warranted in situations where there is limited institutional capacity at country and/or subnational level. Furthermore, development partners can play an important role in disseminating best practices in decarbonization strategies, as well as generating knowledge on carbon pricing and lessons learned in developing carbon markets. Several initiatives are already being undertaken in this respect, but more is needed in order to accelerate the transition towards greener agrifood systems.

ACTION 2

IMPROVE TOOLS AND METHODS

Development and promotion of policies, strategies and roadmaps should be underpinned by methodologies and CFP calculators that support data collection and estimation efforts. Alliances between governments, international agencies and the private sector can help boost data availability and establish harmonized information system capacities. Standardized approaches for MRV, development of databases and accounting methodologies must be leveraged to measure emissions and removals from agrifood systems. Furthermore, standardized carbon accounting disclosures in line with financial reporting approaches need to be employed to enable greater transparency amongst consumers and investors alike.

At the farm-level, existing methodologies and tools to account for mitigation potential can be leveraged to support data collection and estimation efforts. As discussed in this report there are methodologies available which have been developed by international organizations, private sector companies and others that can serve as a good starting point to populate new and existing LCA databases for agriculture with spatially and temporally disaggregated information. Ex-ante and post methodologies can also be used to estimate the impact of agriculture, livestock and forestry development projects, as well as programs on net GHG emissions and carbon sequestration.

Still, farm-level CFP calculators will need to be further developed, simplified and promoted for usage. Farm-level CFP calculators that rely on opensource software and integrate globally determined empirical models in GHG calculators can be further developed to enable the private sector, IFIs and smallholder farmers to benefit from usage. Focus should be placed on making new and existing CFP calculators more accessible (on a cost and practical level) to a wider set of agrifood system players. Rendering accounting methodologies and CFP calculators more accessible, simple and cost-efficient can stimulate companies in engaging in decarbonization of their processes and supply chains.

On an international level, technical agencies such as FAO can help coordinate efforts towards more standard approaches for MRV; they can also support improvements in the creation of sectoral databases as well as accounting methodologies to measure GHG emissions and removals from agriculture and its subsectors. Given the diversity of agrifood systems this will require technical expertise from a broad pool of organizations including not-for-profit, academia, as well as the private and public sectors. International organizations can use their 'neutral broker' stance to facilitate discussions with public and private sector stakeholders and to include success stories and best practices into accounting methodologies, as well as push for greater simplification and standardization.

Standardized tools and methods are particularly important on carbon accounting disclosures, following a similar approach to that of financial statements. Carbon accounting disclosures can be very important as they enable both consumers and investors to have more transparency on company CFPs. As discussed in this report, they can be positively disruptive for supply chains as they can help trigger action by the larger players. There is an important opportunity for international organizations and donors in coordinating efforts with key stakeholders (such as the International Accounting Standards Board) towards internationally recognized principles and standards for carbon disclosure in adherence to internationally recognized standards. International organizations and technical agencies can support methodological developments and preparation of guidance materials for carbon accounting practices, estimation of emission impacts and sequestration potentials.

Who and what?

International cooperation including technical agencies and international financial institutions, governments and private sector associations can all contribute to complement existing tools and methods and support greater standardization of tools and methods for MRV of agrifood system players involved in decarbonization processes. Involving key players from the private sector is extremely important to leverage existing tools and also ensure that methods are practical and can be readily deployed.

ACTION

3

DEVELOP AND PROMOTE SOUND GOVERNANCE MECHANISMS FOR LOW-CARBON PATHWAYS

Increasing the accessibility of MRV systems and methods should be supported by sound governance mechanisms to ensure that these are appropriately endorsed and used by the private sector. Government- and industry-led efforts in disseminating and streamlining information can enhance consumer understanding and lead to possible changes in purchasing behaviours. Improving the governance for offsetting schemes can serve as a reference to orient decarbonization investment and communication efforts.

Agrifood system actors need to accept, promote and disseminate a globally recognized and standardized definition of carbon neutrality. The inconsistent use of carbon neutrality definitions and of Scope 1, 2 and 3 emission terminologies have led to confusion, especially on the part of consumers, but also investors. Definitions based on internationally recognized standards need to be applied and communicated.

Governments can play a pivotal role in the provision of knowledge and transparent environmental information, particularly to inform consumers and investors. Legislation efforts to support transparent and clear environmental information on products can be extremely important, as well as promoting and sponsoring research to address knowledge gaps and supporting communication with consumers. Governments can initiate information campaigns and, in parallel fund research institutions and academia, to undertake research that can provide guidance for labelling efforts and LCAs. Such actions will likely contribute to consumers developing the ability to effectively compare emission values against different products, thereby increasing the likelihood that environmental concerns are factored into their purchase-level decisions. For instance, international efforts on regulating the measurement of nutritional value of food and its labelling (such as those pursued by the FDA in the 1970s to guide consumers on recommended daily nutritional allowances) can provide an inspiration for efforts in carbon labelling.

Government regulation and efforts on transparency and governance can help companies to set realistic and data-driven carbon neutrality targets. It is important that agribusinesses set targets that are realistically achievable and are based on data and scientific facts. Although the SBTi is voluntary and a few tangible sanctions for non-performance exist, companies are aware that performance achieved against the tangible targets set by the SBTi are reported publicly. Companies are also aware that the absence of achievement or reporting on emission reduction targets can deteriorate reputation and brand value towards consumers and investors, alike.

Improving international governance on offsetting. Governments should promote high quality national offsetting programs and establish clear guidelines on carbon neutrality based on international standards. The EU Green Deal outlines the detailed roadmap that the European Union will follow to become climate neutral by 2050 and includes the Farm to Fork Strategy. The Farm to Fork Strategy will likely influence the manner in which businesses operate, provide additional opportunities for offsetting, disclose information and communicate to consumers (European Commission, 2021b). Furthermore, France developed the French Carbon Standard in 2018. In the absence of standards specific to the agricultural sector, the French Government also developed CARBON AGRI, which outlines methods for project developers in France to account for emissions in the agricultural sector. Similarly, the Australian government developed the Climate Active Carbon Neutral Standard to drive voluntary climate action. It is important that national standards promote a decarbonization rule of law, which market actors can use as a reference to orient decarbonization investment and communication efforts.

Improved governance settings should also include investors and regulations related to companies' information disclosure. This can help agrifood companies to adopt transparent practices and third-party verification and climate disclosure. Independent third-party verification of reductions and offset projects against a common standard is necessary for investors and consumers to have a reliable and unbiased source of information on reduction and offset quality. This will also address increasing concerns over greenwashing from consumers and investors, which if sustained, risk undermining the sector's efforts towards carbon neutrality.

Who and what?

The private sector has a significant role to play in applying and communicating the use of standardized definitions of carbon neutrality. Importantly, governments can provide knowledge and environmental information to address knowledge gaps at the consumer level. Furthermore, governments can play the critical role of promoting offsetting programs based on agreed-upon and recognized international standards. Importantly, governments should promote high quality national offsetting programs, clearly distinguishing between removals and avoided emissions and establish clear guidelines on carbon neutrality based on international standards. International technical agencies and donors can support dialogue and discussion of best practices in terms of standards for decarbonization.

ACTION

4 DIRECT SUPPORT FOR DECARBONIZATION EFFORTS

Direct support through concessional financing, subsidies and other forms (such as GPP instruments) can all help decarbonization and MRV efforts of companies on a wider scale. There is a need to systematically support agrifood actors in their wider supply chains to qualify for carbon marketplaces and PES schemes to ensure that they are compensated for applying sustainable regenerative practices. Direct support also applies to financing institutions and helping develop green financial products and financing options for agrifood system players that adequately incorporate the economic value of carbon reductions.

Given the costs and expertise required to carry out CFP assessments, governments can consider subsidizing some of the costs of measuring, reporting and verifying emissions. This would, in principle, provide a clear pathway for companies to compete in this space. To internalize costs of achieving carbon neutrality, governments can devise progressive pathways with accompanying measures, including investment grants and subsidies. Governments should consider subsidizing the adoption of technologies such as remote sensing and precision agriculture technologies (PAT) to scale up emissions data collection, monitoring and verification efforts. Such support would likely encourage more companies to employ efforts in measuring and certifying emission reductions.

Deploy investment instruments on blended terms to encourage the decarbonization of agrifood systems and green technology adoption: both public funds and financing structures and IFI interventions can be engineered to better price carbon in its agrifood system financing activities. IFIs can use their capacity to mobilize grant funding from donors to subsidize data collection, monitoring and verification efforts, as well as certification measures. Most importantly, IFIs can provide access to green credit lines on favorable terms, including reduced interest rates and adjusted tenors where long-term revenue streams are aligned to longer loan repayment schedules. These forms of financing can also be tailored to reach and support smallholders working in fragmented supply chains but also for deployment of technologies when economic returns (including carbon mitigation value) are above financial returns. Directly supporting decarbonization can lead to more funds or facilities being developed that help private and public efforts but also improve existing funding sources to account for carbon. Most importantly, there is also an opportunity to help local financial sector players (banks, insurance companies, etc.) to develop green financial products through blending instruments and technical support. IFIs and other development partners can support governments in this agenda for broad food systems green transformation. Finally, there is a case for implementing de-risking solutions (risk guarantees, risk-sharing schemes, incubation financing and blended financing) that create incentives for financial institutions to finance investments aimed at addressing value chain emissions (particularly Scope 3).

Support smallholders in qualifying for carbon marketplaces and participating in PES schemes. Market actors can promote the attractiveness of environmental mitigation and adaptation measures by demonstrating that these practices can generate benefits in productivity and livelihoods for smallholders. Specifically, IFIs can raise capital from donors, grants and governments to support farmers in conforming to the requirements set by carbon marketplaces, so that farmers can be compensated via premium carbon credits. Furthermore, IFIs can link farmers to PES schemes, where up-front financing is provided for the adoption of best management practices, certified against credible standards. In this regard, digital technologies show much promise to reduce transaction costs of working with smallholders.

Voluntary carbon marketplaces that compensate farmers for adopting sustainable farming practices need to be deployed globally and used as a complementary financing instrument by the private sector. To date, marketplaces that focus on compensating farmers for applying sustainable agricultural practices are being piloted and used in certain geographical areas. However, increasingly, similar carbon marketplaces are being developed to be rolled out globally. Companies can consider supporting farmers in their wider supply chains to access such carbon marketplaces to ensure that they are compensated for applying agricultural regenerative practices on a sustainable basis. In some situations, this can be a win-win for both companies and farmers, but in other situations there may be need for public intervention in supporting smallholder farmer access for efficiency and equity reasons.

Further mainstreaming GPP can help create new market opportunities for decarbonization and influence the emergence of credible product/service carbon labels. By defining procurement criteria, GPP can enhance the reputation of labels that adhere to this criteria. Labels included on approved lists for government procurement will likely enjoy increased credibility in the wider marketplace, leading to broader uptake by consumers and businesses. Furthermore, contractors and suppliers that can meet GPP criteria in a cost-effective way will be better positioned when tendering and bidding for public sector contracts.

Who and what?

Governments should consider directly subsidizing MRV efforts and the adoption of relevant supporting technologies through investment grants and subsidies, implemented through stand alone instruments (such as funds) but also indirectly through the local financial sector. IFIs have an important role to play in rendering financial instruments and green credit lines accessible to agrifood actors, including those operating at different levels. IFIs and the private sector can also support in linking smallholder farmers to PES schemes and qualifying them to participate in carbon marketplaces. Finally, governments, through GPP can provide market opportunities to players directly through their procurement decisions but also indirectly through its virtuous impact on the credibility of labels.

ACTION

5

DEVELOP CAPACITIES AND SHARE KNOWLEDGE

Integrating decarbonization MRV practices, carbon accounting methodologies and green financing tools into education agendas can support the greening of agrifood systems and generate opportunities for collaboration between international organizations and the private and public sectors. IFIs and technical agencies can play an important awareness raising role and collaborate with agri-consultancy companies, local advisory services and research institutions to mainstream the business case for adopting climate change mitigation adaptation practices. Furthermore, governments and technical international agencies can support the dissemination of best practices and governments can fund the research required for labelling and LCA efforts. Streamlining climate-related disclosure practices can provide agribusinesses opportunities to adequately price risks and attract capital.

A more ambitious education agenda on carbon paths, technologies and MRV can yield substantial benefits in greening agrifood systems and stands to benefit from collaboration between public, private sector actors and international organizations. First, integrating decarbonization-related MRV mechanisms, carbon accounting methodologies and sustainable financing tools into curricula for managers and technical experts can support the next generation of companies to engage more strategically in decarbonization investments. Second, training service providers and private sector companies and other agrifood system players in developing and using improved MRV systems and supporting technologies can drive the upscaling of decarbonization efforts beyond proof-of-concept stages. Finally, direct provision of capacity building and knowledge to the management and technicians of a company can enhance carbon neutrality target setting, measuring and disclosure efforts. The latter can take the form of technical assistance packages, for example as part of blended finance funds and facilities' interventions.

IFIs and technical agencies can raise awareness of decarbonization and support beneficiaries to identify applicable and viable decarbonization paths. As discussed throughout this report the private sector needs simple, user-friendly and cost-efficient technologies available to food systems actors. Technical agencies and IFIs can help overcome information asymmetries through provision of technical assistance and dissemination of knowledge on relevant climate change mitigation and adaptation technologies and practices to private sector players. This work can be done in collaboration with agrifood system private sector associations and service-providers such as agri-consultancy companies. In fact, many of the technologies and innovations are being developed already by private sector companies. Mainstreaming the business case for adoption of climate change mitigation and adaptation practices through local advisory services and research institutions can also play an important role in expanding farmer awareness on the linkages between adopting environmentally friendly practices and higher yields and profitability when this is the case.

Legislation and information campaigns can support the generation of transparent and clear environmental information on products. This is the role of Governments and technical international agencies can support this process (in terms of best practice dissemination). In parallel, governments can fund academia to undertake the research required for labelling efforts and LCAs. Such initiatives can contribute to consumers developing the ability to compare emission values across different products, thereby increasing the likelihood that environmental concerns are factored into purchasing decisions.

Companies can directly invest in technologies or join consortiums and organizations that support efforts to trace and share environmental data. Although DLT such as blockchain has largely been underutilized in terms of tracking environmental data, it can serve as a platform that can support the reliable and transparent reporting of data emissions. Agribusinesses can consider directly investing in such platforms or joining consortiums or organizations that strive to tokenize the tracing and sharing of environmental data.

An opportunity exists for agribusinesses to streamline climate-related disclosure practices to attract capital. Streamlining disclosure practices can enable a more rapid development of ESG measurement and reporting and allow for more adequate pricing of risks and allocation of capital. Where possible, relevant protocols such as the TCFD can be used to streamline climate-related disclosures and the usage of consistent ratings methodologies. At the same time, there is a need for international coordination at a time when numerous taskforces and initiatives are emerging, and this could present a risk of proliferation of approaches to improve governance.

Who and what?

IFIs and technical agencies can raise awareness of decarbonization paths and provide technical assistance on climate change mitigation and adaptation practices. The private sector has a role to play in directly investing in technologies that trace and track environmental data and to streamline disclosure practices. At the farm level, local advisory groups and research institutions can expand awareness on the business case for farmers to adopt sustainable farming practices.

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Glossary

Bioenergy: Energy derived from any form of biomass.

Biogenic carbon: Carbon derived from biogenic (plant or animal) sources excluding fossil carbon. Note that peat is treated as a fossil carbon in these guidelines as it takes so long to replace harvested peat.

Biomass fuels or biofuels: A fuel produced from dry organic matter or combustible oils produced by plants. These fuels are considered renewable as long as the vegetation producing them is maintained or replanted, such as firewood, alcohol fermented from sugar, and combustible oils extracted from soy beans. Their use in place of fossil fuels cuts GHG emissions because the plants that are the fuel sources capture carbon dioxide from the atmosphere.

Carbon: Carbon is a chemical element which is present in many gases and compounds. For example, carbon combines with oxygen to make carbon dioxide (CO2), and combines with hydrogen to make methane (CH4). The term ‘carbon’ is used in a variety of ways when talking about GHG emissions, and therefore tends to be ambiguous and potentially confusing. “Carbon” is sometimes used as a shorthand for referring to CO2, or GHGs in general (although not all GHGs contain carbon), and it can also be used to express CO2 emissions in terms of the amount of carbon in the CO2. In addition, converting CO2 to carbon is not particularly useful as doing so does not allow comparisons between different GHGs, in the way that converting to CO2eq does. As a result, it is less and less common to see CO2 emissions reported in terms of “carbon”, though shorthand terms such as ‘carbon accounting’ and ‘low carbon economy’ are still used as popular proxies for ‘GHG accounting’ or ‘low GHG economy’.

Carbon budget: The balance of the exchanges of carbon between carbon pools or within one specific loop (e.g. atmosphere – biosphere) of the carbon cycle. This is a generic definition of ‘carbon budget’ in the context of national GHG inventories. This term may be defined with other specific meaning in the other context.

Carbon dioxide: Carbon dioxide (CO2) is the most common GHG emitted by human activities, in terms of the quantity released and the total impact on global warming. As a result, the term “CO2” is sometimes used as a shorthand expression for all GHGs, however, this can cause confusion, and a more accurate way of referring to a number of GHGs collectively is to use the term “carbon dioxide equivalent” or “CO2eq” (explained below).

Carbon dioxide equivalent (CO2eq): A term for describing various GHGs in a common unit. For any quantity and type of GHG, CO2eq signifies the amount of CO2 which would have the equivalent global warming impact.

Carbon footprint (CFP): The total amount of GHGs produced to directly and indirectly support human activities, usually expressed in equivalent tonnes of carbon dioxide (CO2).

Carbon neutrality (PAS 2060): the condition in which during a specified period there has been no net increase in the global emission of GHGs to the atmosphere as a result of the GHG emissions associated with the subject during the same period.

Carbon neutrality (WRI): Annual net zero anthropogenic (human caused or influenced) CO2 emissions by a certain date. Carbon neutrality means every tonne of anthropogenic CO2 emitted is compensated with an equivalent amount of CO2 removed (e.g. via carbon sequestration).

Carbon offsetting: A GHG or 'carbon' offset is a unit of carbon dioxide-equivalent (CO2eq) that is reduced, avoided, or sequestered to compensate for emissions occurring elsewhere. These offset credits, measured in tonnes, are an alternative to direct reductions for meeting GHG targets in a cap-and-trade system.

Carbon sequestration: The process of removing carbon from the atmosphere and depositing it in a reservoir.

Carbon Sink: Any process, activity or mechanism that removes a GHG, an aerosol or a precursor of a GHG from the atmosphere. Forests and other vegetation are considered sinks because they remove carbon dioxide through photosynthesis.

Clean Development Mechanism (CDM): The CDM allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO2. These CERs can be traded and sold, and used by industrialized countries to a meet a part of their emission reduction targets under the Kyoto Protocol.

Climate bonds: Bonds used to finance – or re-finance – projects needed to address climate. They range from wind farms and solar and hydropower plants, to rail transport and building sea walls in cities threatened by rising sea levels. Only a small portion of these bonds have actually been labelled as green or climate bonds by their issuers.

Climate change: A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Climate neutrality: The concept of carbon neutrality which, rather than solely focusing on CO2 emissions, extends to net zero anthropogenic GHG emissions (i.e. including emissions beyond carbon dioxide).

Carbon insetting: The direct investment of a company within its own value chain (up- and down-stream) in order to reduce its CFP. A carbon reduction project, verified by an offset standard, which occurs within a company's supply chain or supply chain communities.

Carbon market: A trading system through which countries may buy or sell units of GHG emissions in an effort to meet their national limits on emissions, either under the Kyoto Protocol or under other agreements, such as that among member states of the European Union. The term comes from the fact that carbon dioxide is the predominant GHG, and other gases are measured in units called "carbon-dioxide equivalents."

Decarbonization: Decreasing the ratio of carbon dioxide (CO_2) or all GHG emissions related to primary energy production.

Emission factor: A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions.

Emissions trading: One of the three Kyoto mechanisms, by which an Annex I Party may transfer Kyoto Protocol units to, or acquire units from, another Annex I Party. An Annex I Party must meet specific eligibility requirements to participate in emissions trading.

Emissions: The release of GHGs and/or their precursors into the atmosphere over a specified area and period of time.

Energy recovery: A form of resource recovery in which the organic fraction of waste is converted to some form of usable energy. Recovery may be achieved through the combustion of processed or raw refuse to produce steam through the pyrolysis of refuse to produce oil or gas; and through the anaerobic digestion of organic wastes to produce methane gas.

Greenhouse gas (GHG): The atmospheric gases responsible for causing global warming and climate change. The major GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Less prevalent – but very powerful – GHGs are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Life Cycle Assessment: A LCA involves four basic steps: 1. Define the calculation goal and scope; 2. Analyse the calculation inventory; 3. Explain the calculation results; and 4. Assess the comprehensive impact.

Mitigation: In the context of climate change, a human intervention to reduce the sources or enhance the sinks of GHGs. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to solar energy or wind power, improving the insulation of buildings, and expanding forests and other "sinks" to remove greater amounts of carbon dioxide from the atmosphere.

Net zero carbon emissions: Considered a synonym for carbon neutrality. One key difference, however, is carbon neutrality can be achieved at the domestic level with offsets from other jurisdictions, while net zero emissions does not have the same connotation (though theoretically could be met via offsets).

Net zero GHG emissions: All GHG emissions decline to zero, as opposed to just carbon dioxide (net zero carbon emissions).

Reforestation: The direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources on land that was forested but has been converted to non-forested land.

Renewable energy: Energy from a source that is not depleted when used, such as wind or solar power.

Green public procurement (GPP): GPP has been defined by the European Union as a: 'process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured'.

Low Carbon Procurement (LCP): LCP has been defined by Correia *et al.* (2013) as a "process whereby organizations seek to procure goods, services, works and utilities with a reduced CFP throughout their life cycle and/or leading to the reduction of the overall organizational CFP when considering its direct and indirect emissions".

United Nations Framework Convention on Climate Change (UNFCCC): The UNFCCC Secretariat (UN Climate Change) is the United Nations entity tasked with supporting the global response to the threat of climate change. The Convention has near universal membership (197 Parties) and is the parent treaty of the 2015 Paris Agreement. The main aim of the Paris Agreement is to keep the global average temperature rise this century as close as possible to 1.5 °C above pre-industrial levels. The UNFCCC is also the parent treaty of the 1997 Kyoto Protocol. The ultimate objective of all three agreements under the UNFCCC is to stabilize GHG concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system, in a time frame which allows ecosystems to adapt naturally and enables sustainable development.

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Annexes

Annex 1
Standard verification and certification

VERIFICATION
Verification is defined as 'confirmation, through the provision of objective evidence, that specified requirements have been fulfilled. An assessor or inspector audits or verifies that requirements of a standard have been fulfilled. The results of verification are used as the basis for a decision on certification.'[70]

Audits can be of three types:[71]

- **First-party audit** is performed within an organization to measure its strengths and weaknesses against its own procedures or methods and/or against external standards adopted by (voluntary) or imposed on (mandatory) the organization. A first-party audit is an internal audit conducted by auditors who are employed by the organization being audited but who have no vested interest in the audit results of the area being audited.
- **Second-party audit** is an external audit performed on a supplier by a customer or by a contracted organization on behalf of a customer. A contract is in place, and the goods or services are being, or will be, delivered. Second-party audits are subject to the rules of contract law, as they are providing contractual direction from the customer to the supplier. Second-party audits tend to be more formal than first-party audits because audit results could influence the customer's purchasing decisions.
- **Third-party audit** is performed by an audit organization independent of the customer-supplier relationship and is free of any conflict of interest. Independence of the audit organization is a key component of a third-party audit. Third-party audits may result in certification, registration, recognition, an award, license approval, a citation, a fine, or a penalty issued by the third-party organization or an interested party.

70 Vorley, B., Beekmans, A. and Hormer, S., 2010. Food-related Voluntary Sustainability Standards: A Strategy Guide for Policy Makers.
71 Cook, E. and Durivage, M.A., 2018. The ASQ CSQP Study Guide.

CERTIFICATION

Certification is the procedure by which a certification body or certifier gives written or equivalent assurance that a product, process or service conforms to certain standards. There are three main types of certification:[72]

- **First-party certification:** by which a single company or stakeholder group develops its own standards, analyses its own performance, and reports on its compliance, which is therefore self-declared.
- **Second-party certification:** where an industry or trade association or NGO develops standards. Compliance is verified through internal audit procedures or by engaging external certifiers to audit and report on compliance.
- **Third-party certification:** where an accredited external, independent certification body, which is not involved in standards setting or has any other conflict of interest, analyses the performance of involved parties and reports on compliance.

The organization performing the certification is called a **certification body** or **certifier.** The certification decision, i.e. the granting of the written assurance or 'certificate', is based on the inspection report, possibly complemented by other information sources. The granting of a certificate of conformity may be subcontracted by the standard owner to the certification body or issued by the standard owner itself.

ACCREDITATION

To ensure that the certification bodies have the capacity to carry out certification programs, they are evaluated and accredited by an authoritative body. Certification bodies may have to be accredited by a governmental or parastatal institute, which evaluates compliance with guidelines set by ISO, the European Union or some other entity for the operation of certification and inspection bodies. In addition, standard-setting bodies might accredit certification bodies for the scope of their particular standard. When the standard-setting body has developed normative standards, they will evaluate whether the specific standard used by the certification body is in line with the generic standard and whether they are satisfied with the method of verification.

72 Washington, S. and Ababouch, L. 2011. Private standards and certification in fisheries and aquaculture: current practice and emerging issues. FAO Fisheries and Aquaculture Technical Paper. https://doi.org/10.1017/CBO9781107415324.004

Annex 2
Carbon footprint standards

There are two broad categories of standards to measure CFP: organization standards and product/service standards.

The main standards to assess the organizational CFP are:

- **ISO 14064-1:** ISO 14064 standard was published in 2006 and is part of the ISO series of International Standards for environmental management. This international standard provides guidance on the principles and requirements for reporting GHG emissions. It provides additional guidance on verification, required levels of data validation and external reporting frameworks, to ensure consistent external communication.
- **GHG Protocol Corporate Standard:** The GHG protocol is an emissions accounting tool used by many businesses and organizations worldwide. The standard was developed to address the need for a consistent approach in corporate carbon accounting and reporting. The Corporate Standard categorizes GHG emissions into three scopes. Scope 1 (direct emissions that result from activities within the organization’s control), Scope 2 (indirect emissions from any electricity, heat or stream the organization purchases and uses) and Scope 3 (other indirect emissions from sources outside the organization's direct control).
- **GHG Protocol Value Chain Standard.** This standard accompanies the GHG Protocol Corporate Standard. It provides additional guidance to companies wanting to assess their entire value chain Scope 3 emissions. Emissions are grouped into 15 categories of Scope 3 activities, both upstream and downstream. Particularly useful for companies that want to report detailed information on their Scope 3 value chain emissions externally. For example, companies reporting to CDP are required to provide extensive value chain emissions assessments.

The main standards for product CFP are:

- **ISO 14067:** Purpose of the standard is to increase the transparency in reporting GHG emissions associated with the entire life cycle of different products and services. ISO 14067 is aligned with previous ISO and PAS 2050 product CFP standards to increase the comparability of product CFPs internationally. The standard includes detailed guidance on requirements for public reporting and external communication, as well as additional guidance on verification and assurance of product CFPs.

- **GHG Protocol Product Life Cycle Accounting and Reporting Standard:** Launched in October 2011 after a three-year multi-stakeholder development process. This standard builds upon existing ISO environmental guidance and aims to provide a general framework for accounting and reporting product life cycle GHG emissions. Public reporting is required to claim conformance to the standard.
- **PAS 2050:** PAS 2050 was developed by the British Standards Institute in response to a desire for a consistent method for assessing the life cycle GHG emissions associated with products or services. The standard is widely recognized, internationally applied and provides a consistent method for assessing product life cycle GHG emissions. The standard can be used on a wide range of product and service types including goods and services, business-to-consumer, manufacturers, retailers and traders. PAS 2050 does not set requirements for product CFP external communication.

Annex 3
Carbon offset standards

The Gold Standard: Launched in May 2006 by WWF-UK (a non-profit foundation). It is a simplified version of the CDM Gold Standard, using the same basic methodologies. Only available for projects in developing countries. They are focused on renewable energy and energy-efficient projects with strong sustainable development benefits. Eligible sectors are renewable energy, end-use energy, waste, land use and forests (afforestation, reforestation and agriculture) and water (supply, purification and conservation) (Gold Standard, 2018f). Under this standard, more than 550 registered projects have achieved emission reductions of about 78 million tCO2eq in the period 2008–2017 (Gold Standard 2018a). The foundation has launched a new generation of standards with the dual objective of pursuing climate action and the fulfilment of SDGs, Gold Standard for the Global Goals (GS4GG) in 2017 (Gold Standard, 2018g).

Verified Carbon Standard: Verra (formerly known as the VCS) is a non-for profit organization founded in 2005, serving as a secretariat to various standards. Verra's flagship is the Verified Carbon Standard (VCS) with CDM-like MRV requirements. It issues Verified Carbon Units (VCUs). In terms of volume, it is the largest voluntary standard in the world, having certified reductions of more than 200 million tCO2eq from more than 1300 projects since 2006 in a wide range of sectors. So far, more than 100 projects covering more than 10 million hectares of land have been validated, with 40 having achieved full verification (Verra, 2019). This standard was developed by the Climate Group and International Emissions Trading Association (IETA). It provides real, quantifiable, additional and permanent project-based emission reductions. Credits are managed through registries to register, transfer and retire Voluntary Carbon Units (VCUs).

Climate, Community and Biodiversity Standard (CCBS): CBBS certifies land-based climate change projects that pursue multiple benefits: improve livelihoods, create employment, protect traditional cultures and endangered species, help secure tenure to lands and resources, increase the resiliency of ecosystems and help to combat climate change. CCBS certification can be applied also to VCS projects. This standard has been developed by the Climate Community and Biodiversity Alliance. It is for land-based projects that can simultaneously deliver compelling climate biodiversity and community benefits. It uses methodologies of the Intergovernmental Panel on Climate Change Good Practice Guidance (IPCC GPG) but can also use approved CDM methodologies for calculating carbon reductions/savings.

UNFCCC Clean Development Mechanism: In 2015, the UNFCCC created a dedicated website where organizations, companies, but also private persons are able to offset their footprint with the aim of facilitating everyone's participation in the process of promoting sustainability on a voluntary basis. This platform features UNFCCC certified projects that reduce, avoid or remove GHG emissions from the atmosphere. The projects are implemented in developing countries and are rewarded with Certified Emission Reductions (CERs), a type of carbon offset measured in tCO2eq. CERs are issued from trustworthy climate-friendly projects called Clean Development Mechanism (CDM) projects. CDM projects take place in developing countries and contribute to their sustainable development. Each project goes through a strict and thorough vetting process. The CDM process involves a variety of stakeholders such as the project participants who own the projects, host-country national authorities who oversee national implementation, independent auditors known as the Designated Operational Entities, the UNFCCC CDM Executive Board and its secretariat. At a higher level, all CDM work is coordinated and directed by the UNFCCC Conference of the Parties to the Kyoto Protocol (CMP), the ultimate body responsible for the implementation of the Kyoto Protocol where all member states take collective decisions.

Plan Vivo: program designed for community- based forest management and agroforestry payments for ecosystem services projects. The system was created over a decade ago by the Edinburgh Centre for Carbon Management and is now developed and overseen by a Scottish charity, the Plan Vivo Foundation. There are currently five fully operational Plan Vivo projects in Mexico, Uganda, Mozambique, the United Republic of Tanzania and Nicaragua and several upcoming projects in developing countries including Malawi, Cameroon, Ethiopia, and Nepal. Plan Vivo maintains a listing of projects on its website and lists credits (Plan Vivo Certificates) on the Markit Environmental Registry. Currently the activities that are eligible to generate Plan Vivo Certificates are: afforestation and reforestation, agroforestry, avoided deforestation, forest conservation and restoration. Plan Vivo projects have engaged tens of thousands of smallholder farmers to plant multipurpose trees on their own land, and an even greater number of rural community participants involved in restoration and protection activities as well as livelihood development initiatives. These deal with land-use change and forestry predominantly, channeling some USD 17.5 million to projects targeting rural communities in developing countries. As of March 2017, these projects have collectively established, and are helping conserve more than 138 000 hectares of forest (Plan Vivo, 2019).

SOCIALCARBON: A standard developed by the Ecologica Institute that certifies carbon reduction projects for their contributions to sustainable development. Six aspects of project sustainability are individually measured using the SOCIALCARBON hexagon: carbon and biodiversity as well as social, financial, human and natural components. As an additional standard for co-benefits, SOCIALCARBON can be implemented alongside any other carbon accounting standard (e.g. VCS, CDM, CAR or others) and may be adapted to suit different types of projects, including hydropower plants, landfills, fuel switching, forestry and others. The theoretical framework of SOCIALCARBON is based on the Sustainable Livelihood Approach (SLA), a worldwide methodology used in planning new development activities and assessing the contribution that existing activities have made to sustaining livelihoods.

The world's agrifood systems are on the frontlines of climate change, both as a cause and a victim. The agrifood sector is increasingly being targeted and curbing emissions is becoming a key global investment and policy theme. **Investing in carbon neutrality: Utopia or the new green wave?** presents a comprehensive assessment of the challenges and opportunities of carbon neutrality, and scopes out the road ahead for agrifood systems. It provides strategic insights on the actions needed to move the carbon neutrality agenda forward in terms of investment opportunities and public policy priorities, with important recommendations for development partners. This publication is part of the Directions in Investment series under the FAO Investment Centre's Knowledge for Investment (K4I) programme.

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