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of the United Nations



Ex-Ante Carbon-balance Tool for value chains | EX-ACT VC

GUIDELINES

Second edition



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G U I D E L I N E S

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Acronyms and abbreviations

ADEME	<i>Agence de la transition écologique</i>
AFOLU	agriculture, forestry and other land use
BAU	business as usual
CFC	chloro-fluorocarbons
COD	Chemical Oxygen Demand
DFID	UK Department for International Development
EF	emission factor
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
FTE	full-time equivalent
GHG	greenhouse gas
GPV	gross production value
GRI	Global Reporting Initiative
GVA	gross value added
GWP	global warming potential
HFC	hydro-fluorocarbons
HH	household
IAMs	Integrated Assessment Models
IEA	International Energy Agency
IFI	International Financial Institutions
II	intermediate input
ILO	International Labour Organization
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISCO	International Standard Classification of Occupations
ISIC	International Standard Industrial Classification of All Economic Activities
LCU	local currency unit
MIMEC	mining, industry, manufacturing, electricity and constructions
NVA	net value added

OECD	Organization for Economic Co-operation and Development
PV	production value
SCC	social cost of carbon
SDGs	Sustainable Development Goals
SMEs	small and medium enterprises
SNA	System of National Accounts
UN	United Nations
USD	United States dollar
VA	value added
VC	value chain
WB	World Bank
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Introduction

Objectives of the guidelines

The guidelines aim at:

- Providing a comprehensive overview of the EX-ACT VC tool and helping users assess the sustainability of agrifood value chains across environmental, economic, and social dimensions using the EX-ACT VC tool (FAO, 2022).
- Describing the various methodological concepts underlying the tool to perform a value chain assessment and calculating several indicators of sustainability.
- Illustrating the structural layout of the tool, explaining data requirements, and providing step-by-step data entry guidance to perform a value chain assessment using the EX-ACT VC tool.
- Discussing the different indicators the tool calculates and how they can be used for project and policy evaluation and design.

Target readership

The EX-ACT VC methodological guidelines are intended to assist potential users of the EX-ACT VC tool including policy makers, project managers, analysts and researchers, among others.

Structure of the document

The present guidelines are organized into four parts. Part 1 introduces and provides a brief overview of the EX-ACT VC tool, describing its objectives, its intended uses, and main outputs, followed by summarizing the scope of the tool and its limitations. Part 2 explains in detail the methodology underlying the tool in a systematic and transparent framework, discussing the different indicators used by the tool to assess the sustainability of agrifood value chain interventions and introducing the technical equations used to calculate these indicators. Part 3 explains how the tool is structured and organized and provides step-by-step data entry guidelines while discussing the data requirements to complete an assessment using the EX-ACT VC tool. Part 4 presents the various results and outputs that EX-ACT VC generates and discusses how users can interpret them.

PART 1. FAO'S EX-ACT for value chain (EX-ACT VC) tool

The Ex-Ante Carbon-balance Tool for value chains (EX-ACT VC), developed by FAO is a multi-appraisal system that evaluates the environmental and socio-economic performance of agrifood value chains (agrifood VC). This section begins with a summary of the tool objectives, its intended uses, followed by introducing the main outputs, describing the scope, and limitations of the tool. **Annex 1** reviews the historical development of the tool.

1.1 Objectives

The EX-ACT VC, an excel-based tool is developed to evaluate the sustainability of agrifood VC simultaneously along the environmental, economic, and social dimensions. The primary objective of the EX-ACT VC tool is to provide decision support to design (*ex ante*) and evaluate (*ex post*) agrifood VC projects and policies by comparing a “current” scenario with baseline information and a “planned” scenario involving a future vision or goal (or implemented activities scenario in case of *ex post* evaluations). Guided by the sustainable food framework (FAO, 2014a), the tool provides a standardized approach for users to measure, analyse, and improve the sustainability of agrifood VCs.

The tool was developed with the following specific objectives:

- to help users “quantify” sustainability performance of agrifood VCs by assessing the environmental, economic, and social dimensions in a consistent and transparent framework;
- to help users “identify” drivers of sustainability across agrifood VCs through comparing a “current” and “planned” scenario of a project or policy;
- to help users “determine” entry points for investments and interventions;
- to help users “evaluate” whether their planned projects and policies meet their objectives; and
- to support users “design” and develop effective projects and policies to improve sustainability in agrifood VCs.

Ultimately, the EX-ACT VC tool is intended to provide an accessible operational resource that can be tailored to address sustainability in agrifood value chains in different contexts and at multiple levels to help achieve environmental, economic, and social objectives.

1.2 Uses

EX-ACT VC tool is intended for any user who is interested in assessing the sustainability of agrifood value chains. The tool does not require specific scientific knowledge. It provides stakeholders operating at multiple levels a cost-effective, consistent, and transparent framework to evaluate the sustainability of agrifood VCs regardless of their context, size, and geographic location. EX-ACT VC tool serves as an effective means for the development community, international financial institutions, public and private investors, policy makers, and governments at local, regional, and national levels to:

- pre-assess the potential impacts of a project or policy in a given time frame at the value chain level (*ex ante* appraisal);
- identify hot-spots for performance improvement by contrasting multiple indicators in a “current” and “planned” scenario;
- determine synergies and trade-offs between the three dimensions of sustainability occurring along each stage of the value chain;
- enable intervention design and investment prioritization to support climate-smart agrifood value chain;
- evaluate the extent to which a project or policy has been successful in achieving its stated objectives at the value chain level (*ex post* appraisal); and
- facilitate informed decision making by providing clear, well-structured, quantified analysis of the effects and consequences of proposed actions.

1.3 Outputs

The EX-ACT VC tool calculates several quantitative indicators and measures which are listed below. Part 2 introduces these indicators in detail, defines them, and describes the methodology and the underlying technical equations and parameters used to compute them. All the indicators across the environmental, economic, and social dimensions together provide a comprehensive picture of the sustainability of agrifood VCs. It is worthwhile to note here that the indicators below are inter-dependent and mutually reinforcing, sometimes overlapping across several dimensions. For example, food loss is not only an environmental cost but entails economic costs and subsequently societal food-(in)security costs. The tool, however, delineates any overlapping indicators for ease of use.

The environmental indicators estimated by the tool are (i) greenhouse gas (GHG) emissions which measure total GHG emissions, net carbon balance, and carbon footprint; (ii) water usage; (iii) food loss; and (iv) monetary value of GHG's emitted in the value chain.

The economic indicators calculated by the tool are (i) value-added, which measures gross production value (GPV) and gross and net value added (GVA); and (ii) distribution of value-added among production factors, which measures net income and average daily wage.

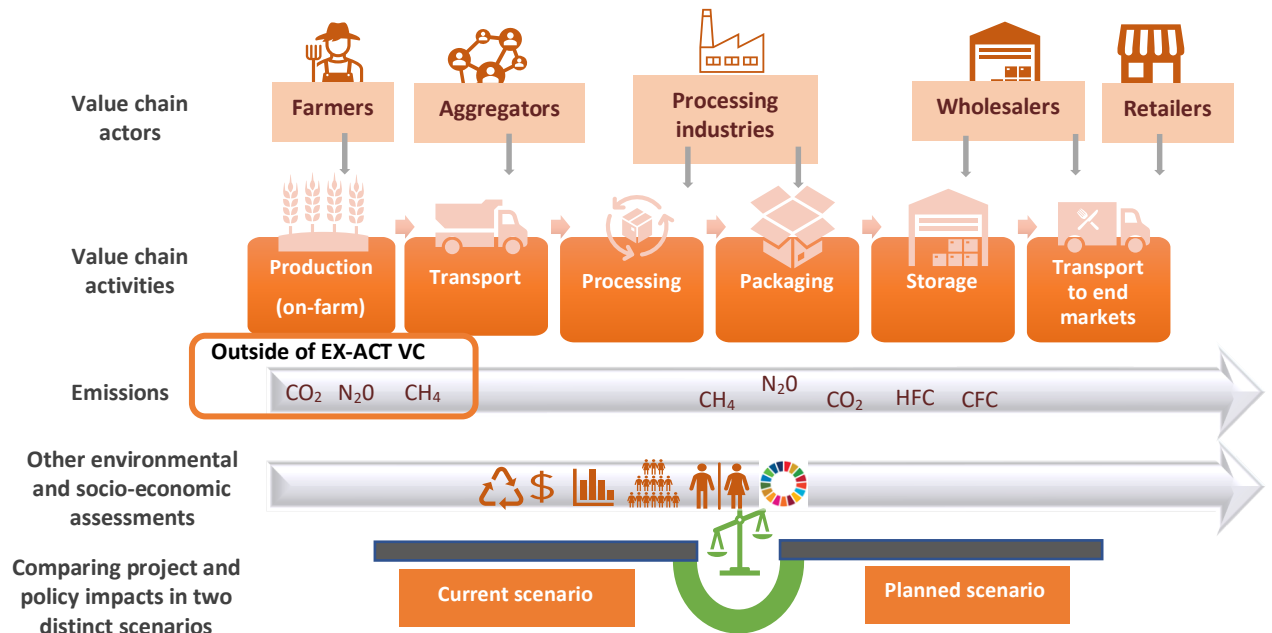
The social indicators computed by the tool are (i) employment which calculates the total number of jobs created along the value chain and disaggregates the number of jobs created across different actors and activities; (ii) women representation which reflects the number of women owning a business, the number of women in managerial positions, and the number of women employed (hired and as family labour); and (iii) Youth participation which indicates the number of jobs disaggregated by age group.

Apart from the above indicators, the tool also tracks a set of Sustainable Development Goals to evaluate the project or policy alignment to reach relevant SDG targets. The main SDGs tracked are zero hunger (2); gender and equality (5); clean water and sanitation (6); industry innovation and infrastructure (9) and responsible consumption (12).

1.4 Scope

The scope of the EX-ACT VC tool is defined by its methodological framework that relates to mapping the value chain, defining actors, describing activities, and quantifying outcomes in a given period. **Figure 1** illustrates the current framework of the tool. Annex 1 reviews the historical development of the tool. The tool framework is straightforward (DFID, 2008), micro-economic theory, and macro-economic accounting frameworks (System of National Accounts (SNA) 2008) to quantify socio-economic indicators; Intergovernmental Panel on Climate Change (IPCC) guidelines (IPCC, 2006, 2019c), and FAO's Global Food Loss Index (2018) and several others to quantify environmental outcomes (see Part 2).

Figure 1. EX-ACT VC framework



Source: Authors' own elaboration.

The tool allows assessment of:

- Five categories of commodities including annuals, perennials, dairy, meat and fish.
- Up to nine unique categories of actors, whereby a "category of actors" refers to "a type of individuals, households, farms, firms, etc., who share similar activities performed and scale (e.g. small, medium, large)".
- Up to five possible activities, in which each category of actor can carry out up to five different activities (e.g. primary production, processing, storage [pre/post storage], transportation, and distribution).
- Annual time-period of accounting or an annual "snapshot". All data (e.g. GHG emissions, costs, revenues, jobs, etc.) are for a specific year.
- Current vs planned scenario as the tool calculates and compares the environmental and socio-economic outcomes for two distinct scenarios (e.g. "current" and "planned" scenarios) (see Section 1.6).

1.5 Limitations

The EX-ACT VC tool assessments are limited to:

- **Single commodity or product:** the tool allows the assessment of a single commodity at a time and does not account for any resulting by-product(s). Assessing by-products would require a parallel analysis (carried out in a second excel file).
- **Minimal level of food processing:** the tool allows assessment of minimal level of food processing, thus products that entail a combination of different commodities, cannot be considered.
- **Micro-meso level of analysis:** the EX-ACT VC tool was initially designed for performing project level value chain analysis at the micro (individual actor) and meso (category of actors) level. Currently, the tool is not best suited to perform macro-level analysis at a national or international level.
- **Static model:** the tool performs a static computation that covers the value chain assessment over an annual time period under two different scenarios. It has, therefore, limited capability in capturing

the dynamic interactions between actors and feedback-loops over time that affect the sustainability of value chain.

- **No uncertainty assessments:** the tool does not capture any uncertainty related to the calculated outcome indicators.

1.6 Outlining the scenarios

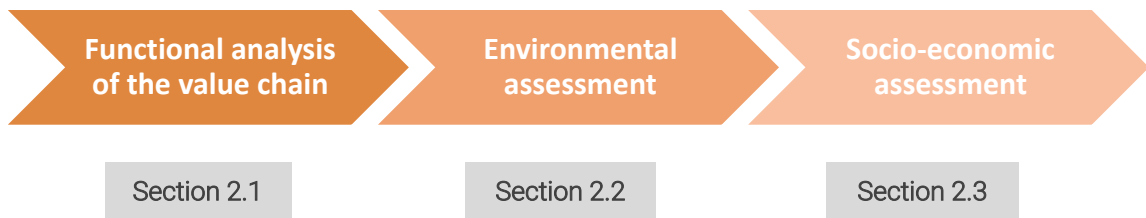
Estimating environmental and socio-economic costs and benefits associated with a proposed agrifood value chain project or policy requires establishing a comparable context to track changes in the value chain at two points in time (e.g. a current or pre-intervention phase with a planned or post-intervention phase). The EX-ACT VC allows users to construct two scenarios to compare and contrast the impact of a project or policy. The impact is then defined as the difference between what the situation is “without the project or policy” and what would be “with the project or policy”. Within EX-ACT VC, the “current” scenario corresponds to the “without project or policy” scenario, and the “planned” scenario corresponds to the “with project or policy” scenario. When performing an *ex ante* analysis, the planned scenario would incorporate the foreseen activities outlined in a Project Design Report, or similar, and it would answer the question “what would happen with the implementation of the project?” In the case of a monitoring or *ex post* analysis, it would correspond to the advances or actual activities implemented as a result of the project. Thus, in the environmental assessment, the final balance is the comparison between the GHG emissions associated with the project implementation and the baseline following a business as usual (BAU) model. Similarly, in the socio-economic assessment, the final balance is the difference between selected economic indicators in the planned and current scenarios.

PART 2. Methodology

This section describes in detail the methodology behind the tool to assess the sustainability of value chains across environmental, economic and social dimensions. This section is organized according to the methodological steps that users should follow to complete an assessment using the EX-ACT VC tool. **Figure 2** provides an overview of the main steps and lists the corresponding sections in which they are explained in detail.

The functional analysis of the value chain draws on common approaches in the literature. The environmental assessment derives methodology from IPCC guidelines (IPCC, 2006, 2019c), GHG protocol (Bhatia *et al.*, 2011, WRI, and WBCSD, 2013), Global Logistics Emissions Council Framework (Greene and Lewis, 2019) and Smart Freight Centre (2019), Institute for Global Environmental Strategies (2020), *Agence de la transition écologique* (ADEME, 2020) and Breisinger (2012) FAO's Global Food Loss Index (2018). The socio-economic assessment borrows from different strands of economic analysis including micro-economic accounting (crop and enterprise budgets), macro-economic frameworks on national accounts (SNA, 2008), FAO (FAO, 2017, 2019c, 2019d), International Standard Classification of Occupations (ISCO-88) of the International Labour Organization (ILO) (ILO, 2012) and International Energy Agency (IEA, 2020).

Figure 2. Methodological steps

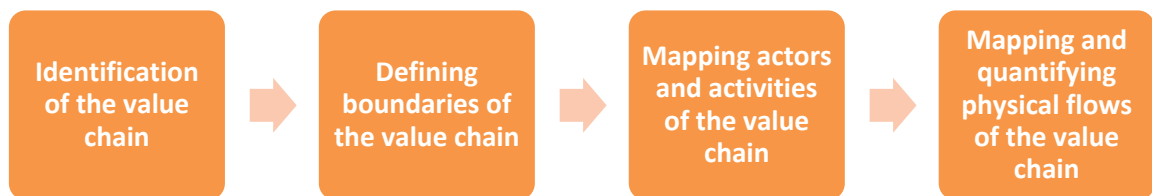


Source: Authors' own elaboration.

2.1 Functional analysis of the value chain

The functional analysis of the value chain examines the production activities in the value chain, different actors contributing to such production activities and physical flows of the commodity across different actors and activities of the value chain. The main steps of a functional analysis are summarized in **Figure 3**.

Figure 3. Main steps of a value chain functional analysis



Source: Authors' own elaboration.

2.1.1 Identification of the value chain

The EX-ACT VC tool currently allows the assessment of a single commodity or product. Therefore identifying a value chain to assess in EX-ACT VC tool will be straightforward for projects and policies dealing only with a single commodity or product. However, agrifood value chains are complex, with often a single commodity being transformed into multiple products. For projects and policies dealing with either multiple commodities or multiple products, it is necessary to identify and prioritize which

commodity or product is to be analysed. Several approaches and tools of priority setting exist to help users. The most common approach is to determine criteria based on the goals of the project/policy (e.g. jobs created, market growth potential and subsidies), develop weighted scores and prioritize highest ranked value chain. It is also important to also note that the EX-ACT VC tool does not account for any resulting by-products of the agrifood VC. However, a user can run multiple parallel analyses of different commodities, products and by-products within the scope of a particular project or policy and aggregate them manually.

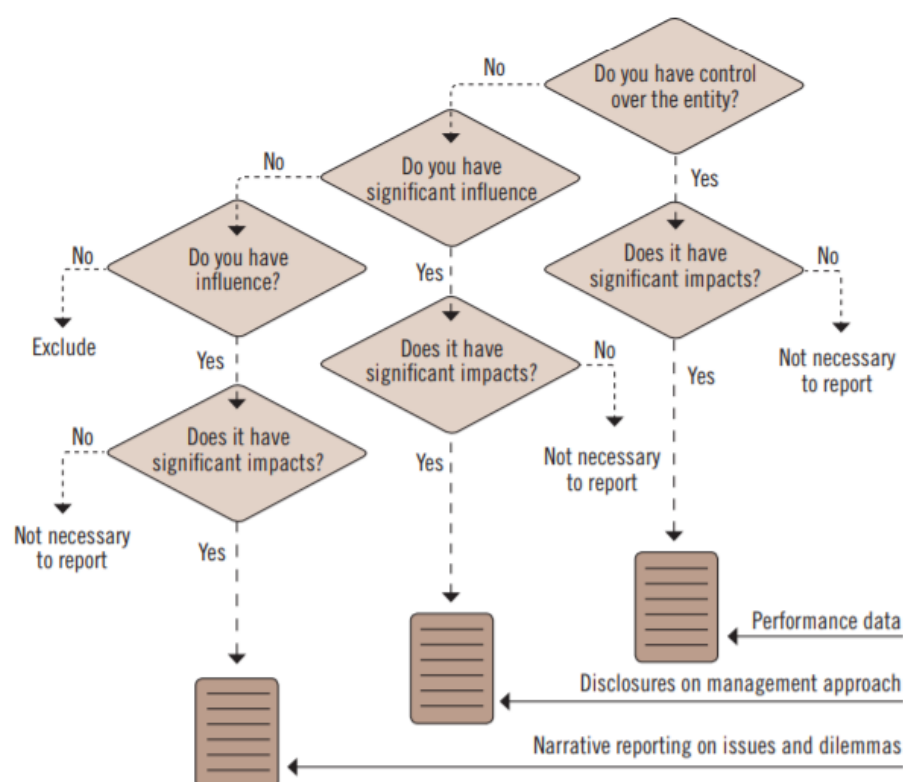
2.1.2 Defining boundaries of the value chain

After identifying the value chain to be assessed, it is important to define the boundaries of the value chain e.g. to define the portion of the value chain the user wants to analyse and map the main actors and activities in the value chain. These two steps are simultaneous, evolving and co-dependent. The needs, objectives and scope of the value chain project or policy define the boundaries of the value chain. Therefore, there is no one-size-fits-all template to perform this exercise,

Defining the boundaries of a value chain assessment is one of the most difficult steps. In reality, almost every actor and every activity is connected with everything else. **Figure 4** provides some guidance on how the user can define the boundaries to evaluate their project or policy.

As elaborated in the Sustainability Assessment of Food and Agricultural Systems guidelines (FAO, 2014b), the decision tree of the Global Reporting Initiative (GRI) G3.1 Guidelines is a broadly tested tool which can be used as a template to guide decisions on defining the boundaries, e.g. to decide what and who is included in the scope of a value chain assessment (GRI, 2011).

Figure 4. Decision tree for boundary setting



Source: GRI. 2011. *Sustainability Reporting Guidelines. Version 3.1*. Amsterdam.
www.globalreporting.org/resource/library/G3.1-Guidelines-Incl-TechnicalProtocol.pdf

Once the boundaries are clearly defined, the next step is to map the main actors and activities within the value chain and quantify the physical flows of the commodity across actors and activities. Drawing from common approaches and guidelines (Bellù, 2013; DFID, 2008; Collins *et al.*, 2016), the next two sections provide some guidance on mapping actors, activities and quantifying physical flows in the value chain.

2.1.3 Mapping actors and activities

Mapping the value chain is a central component of the EX-ACT VC assessment. It helps identify the various activities, actors in the value chain and the interdependencies among them. The mapping will provide the foundation upon which subsequent environmental and socio-economic assessments are performed.

EX-ACT VC tool simplifies the mapping exercise by providing the initial structure of activities necessary to bring a product from production to consumption. These activities in the tool are:

1. primary production
2. processing
3. packaging
4. storage (pre/post processing)
5. distribution or transportation.

Often, value chain assessments follow a linear sequence of activities and actors. However, the real world is highly complex, with some actors performing more than one activity. The tool accounts for this complexity by introducing a flexible approach that will allow users to map the actors to multiple activities. The tool is designed to identify up to nine categories of actors, of which up to three categories can be specified as performing primary production activities, and map each of the nine actors to the five activities listed above.

Distinguishing between actors depends on the level of detail the user requires and, on the needs, and objectives of the agrifood VC project or policy to be assessed. A simple way to distinguish an actor is to identify their main activity or occupation (Bellù, 2013; DFID, 2008). For example, aggregators are involved in collection of primary harvest, rice producers are the ones who produce rice. However, rice producers may display heterogeneous characteristics, which can allow further classification based on farm size (small, medium, large, etc.), production system (rain-fed, irrigated intensive, etc.) and many other specificities.

Once the actors have been classified, the actual number of actors within each category of actors is important to provide an overview of the scope and size of different actors within the value chain.

Additional resources that can help users perform this part of the analysis are listed in Annex 2.

2.1.4 Mapping and quantifying physical flows in the value chain

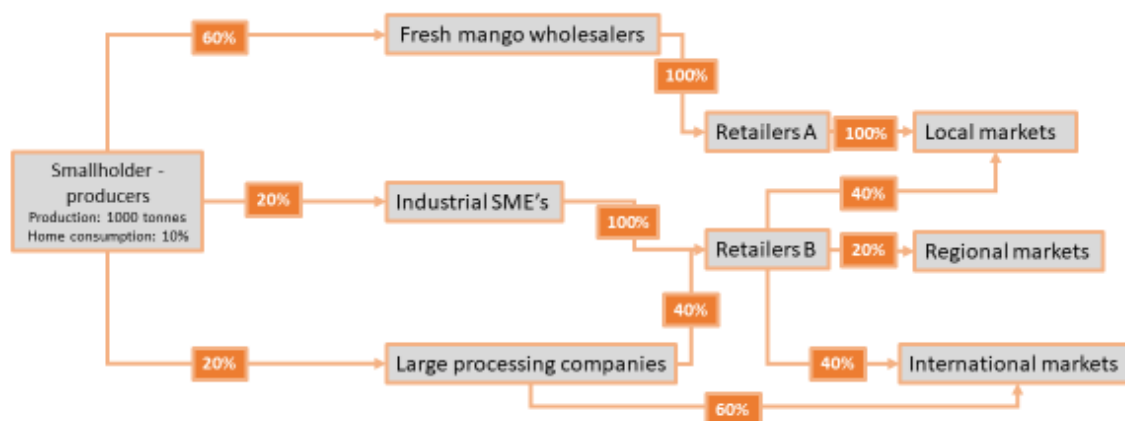
The actors in an agrifood value chain are linked together through many different flows. These flows can be both tangible (material/products and financial) and intangible (information). The EX-ACT VC tool provides a framework to map only the physical flows. In simple terms, mapping physical flows will allow the user to understand who is buying and who is selling; and quantifying physical flows will allow the user to understand how much is sold and how much is purchased by different actors. Physical flows include the transformation, storage, and transportation of products. A typical physical product flow begins with the raw materials supplied to processors and the processed product transferred to storage and distribution to the final consumer. The physical flows are quantified in terms of volume to provide an overview of the size of the different actors and channels within the value chain.

The user is first required to enter data on the total volume of raw material produced or harvested by each category of actors identified as performing primary production activities. The subsequent physical flows are then entered in the EX-ACT VC tool as a proportion of the total volume of raw material that flows through each actor and at each activity. The user is responsible for collecting data on the volume of products sold and purchased by each identified actor in the value chain.

Figure 5 gives an overview of the mapping of volumes of product flows through a value chain. In this example, there are several actors who are selling and purchasing mangoes. The value chain begins with smallholder producers harvesting 1 000 tonnes of mangoes of which 100 tonnes are consumed by the households. The remaining 900 tonnes of mangoes are sold to three different actors. Fresh mango wholesalers purchase 540 tonnes, industrial small and medium-sized enterprises (SMEs) and large processing companies purchase 180 tonnes each from the smallholder producers.

The user must convert data collected on volumes purchased by each actor as a proportion of the total volume sold by the previous actor in the value chain. In this example, therefore, the fresh mango wholesalers purchase 60 percent of the total mangoes sold by the smallholder producers. Similarly, industrial SMEs and large processing companies purchase 20 percent each of the total mangoes sold by the smallholder producers.

Figure 5. An example of mapping volumes and physical flows in the value chain



Source: Authors' own elaboration.

Collecting all data needed to quantify flows for a value chain analysis usually requires drawing information from different data sources. Annex 2 provides more information on this and guides the user in mapping and quantifying the physical flows.

2.2 Environmental assessment

The environmental assessment builds essentially on the functional analysis of the value chain described in Section 2.1, because it requires that users identify the building blocks of the value chain e.g. the actors and activities performed by each of the actors as well as quantification of the physical flows of the production among different actors and activities.

The EX-ACT VC tool calculates a set of indicators that represent the environmental performance of the value chain. Multiple measures are computed for some indicators. These indicators are listed in **Table 1** and described below.

Table 1. List of environmental indicators

Environmental indicators	GHG emissions (tCO ₂ -e) and carbon footprint (tCO ₂ -e/tonne of final product)
	Water usage (litres)
	Food loss (tonnes of product)
	Monetary value of GHGs estimated in the value chain

Source: Authors' own elaboration.

2.2.1 Indicator: GHG emissions

This indicator is intended to assess the potential of the value chain to contribute towards achieving climate mitigation goals by estimating GHG emissions from different types of activities across the value chain. GHG emissions are generated by activities in all stages of an agrifood value chain. The tool first distinguishes between “on-farm” and “off-farm” activities, and their related emissions as described in **Box 1**.

Box 1. On-farm vs off-farm GHG emissions

On-farm and off-farm GHG emissions are defined within EX-ACT VC as follows:

- **On-farm GHG emissions** are those strictly related to primary food/agriculture production. They include emissions originating from most of the activities arising from land use, primary production, up to harvesting, namely land use change, crop (annuals, perennials) and livestock management, use of inputs and infrastructure related to primary production.
- **Off-farm GHG emissions** are those originating from post-primary production activities e.g. related to processing, packaging, storage, and distribution up to the retailer.

Source: Authors' own elaboration.



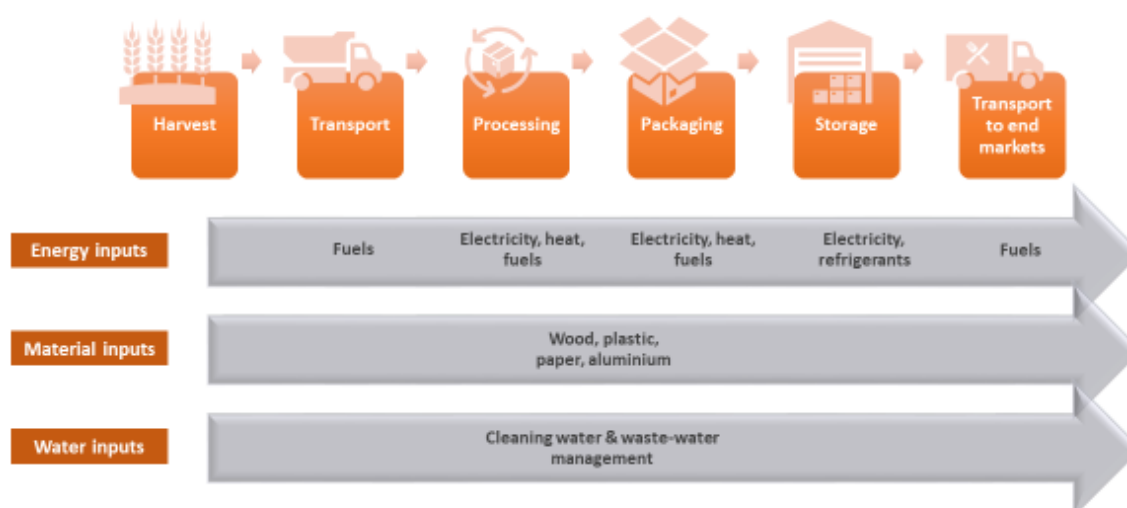
ATTENTION

When any post-harvest activities are performed on the farm, e.g. if some farmers (primary producers) begin any part of the product transformation within their farms, the related GHG emissions are not accounted as on-farm emissions, even though they occur on the farm; rather, they constitute off-farm emissions, as originating from post-harvest activities.

GHG emissions from on-farm activities are not calculated within the tool, however, the tool can account for the on-farm emissions when provided as an input by the user expressed in tonnes of carbon oxide equivalent (tCO₂-e). These on-farm emissions can be either externally calculated using on-farm GHG accounting tools such as EX-ACT (FAO, forthcoming) or derived from literature.

GHG emissions from off-farm activities are calculated within the tool. The EX-ACT VC tool calculates the total off-farm GHG emissions from energy (e.g. diesel, fuel, etc.), material use (packaging) and water inputs utilized across each activity and stage of the value chain in a current and planned scenario. The EX-ACT VC tool in its current version does not account for emissions originating from food losses across the value chain. **Figure 6** provides a visual overview of energy, water, and material inputs at different activities and stages of a typical value chain that lead to GHG emissions which are accounted in the EX-ACT VC tool.

Figure 6. Overview of emission sources across a typical value chain



Source: Authors' own elaboration.

The following two measures are calculated by the EX-ACT VC tool for the GHG emission indicator:

1. total amount of GHG emissions and net carbon balance in tCO₂-e per year;
2. carbon footprint in tCO₂-e/ tonne of product.

GHG emissions are generally calculated following the methodology established by the IPCC with using the following formula:

$$GHG\ emissions = Activity\ Data \times Emission\ Factor$$

In the above formula, activity data refers to a quantitative measure of a specific activity that results in GHG emissions or sequestration during a given period of time. Emission factors, expressed per unit of an individual activity, allow estimating GHG emissions from the activity. For example, processing a tonne of mangoes requires a certain amount of energy, reported in kilowatt hour (kWh) as activity data, which multiplied by a corresponding emission factor (GHG emissions per kWh) calculates the quantity of GHG emissions resulting from the usage of electricity to process the one tonne of mangoes.

The IPCC guidelines specify a "tier" to represent the reliability and methodological complexity of emission factors and activity data. Tier 1 are simple methods that provide default emission factors, Tier 2 are similar to Tier 1, but provide country specific emission factors, Tier 3 are the most complex approaches requiring specific data that provide more accurate emission factors.

EX-ACT VC tool embeds default Tier 1 emission factors from literature. However, the tool is flexible and allows the user to specify Tier 2 emission factors for activities if available.

A few examples of the type of activities and emission factors needed at each stage of the value chain is provided in **Table 2**.

Table 2. Examples of off-farm activity data and emission factors

Off-farm activity in agrifood VC	Source of emissions	Example of activity data	Example of emission factor
Processing (energy and wastewater)	Consists of carbon dioxide (CO ₂), methane (CH ₄) and nitrous oxide (N ₂ O) gases associated with direct liquid/gas fossil fuel or dry matter burned or energy consumed for food processing.	Amount of energy (kilowatt hour (kWh), fuel or gas (m ³), tonnes of dry matter (tdm) consumed, expressed per tonne of processed product.	Based on IPCC (2006) Volume 2, Energy. Energy emission factor (EF) expressed in tCO ₂ -e/m ³ . Based on International Finance Institutions (IFI, 2022) country specific emission factor of the energy grid of the selected country, in tCO ₂ -e/MWh (MegaWatt per hour).
	Consists of both, methane (CH ₄) – when treated or disposed of anaerobically, and nitrous oxide (N ₂ O) emissions.	Total amount of water used in the processing activity in m ³ per tonne of product.	Based on IPCC (2019) Volume 5, Waste. EF expressed in kg CH ₄ /kg Chemical Oxygen Demand (COD) for treatment/discharge pathway or system(s) used.
Storage (with refrigerant)	Consists of the energy use for the operation of the facility.	Amount of energy consumed in the facility during the time of the product is stored (kWh/day). The allocation of the emissions is based on the total amount of stored product and the total volume of storage facility.	Based on IFI (2022). Country specific emission factor of the energy grid of the selected country, express in tCO ₂ -e/MWh.
	Refrigerated storage can release potent GHG: hydro-fluorocarbons (HFCs) and chloro-fluorocarbons (CFCs) from leakage throughout the life operation of refrigerants or chillers.	The total refrigerant leakage over the year, expressed as kg per year.	Global Warming Potential (GWP) based on the fifth IPCC 2014 Assessment Report.
Packaging	Consists of the emissions of the energy on mass of packaging raw material from which the package is made.	The weight (kg) of material package per tonne of product.	The emissions factors for packaging are derived from Berneers-Lee and Hoolohan (2012), expressed in tCO ₂ -e per tonne of packaging.

Off-farm activity in agrifood VC	Source of emissions	Example of activity data	Example of emission factor
Transport	Consists of the fuel combusted to power the transport (tank-to-wheel) during a distance (km) and weight (tonnes).	Number of tonne/kilometres (weight and distance), in km and tonnes of product.	Emission intensity factor derived from the fuel and vehicle type, expressed in tCO ₂ -e/tkm based on Smart Freight Center (2019). Refrigerated transport consumes 20 percent additional energy than ambient distribution (Tassou <i>et al.</i> , 2009).

Source: Authors' own elaboration.

Calculation of total off-farm GHG emissions in EX-ACT VC tool

This section introduces and describes the technical equations used to calculate the GHG emissions from different activities at different stages of the value chain. Emissions calculated across all the activities and actors are aggregated to quantify total off-farm GHG emissions. In the following sections, the methodology used to calculate emissions from each of the activity is described.

Processing: the main activities in processing such as cooking, drying, shredding, grinding etc. involve utilization of heat, fuels, or electricity. GHG emissions from this activity are calculated following the guidelines published by GHG protocol (WRI, and WBCSD, 2013) using the equation below:

$$kg\ CO_2e\ emissions = \sum (Q_e\ (m^3\ or\ kWh) \times EF\ (kgCO_2e/m^3\ or\ kWh))$$

where:

- Q_e = quantity of energy, in m³ or kWh/year
- EF = emission factor corresponding to the fuel or energy used, in kgCO₂-e/m³ or kgCO₂-e/kWh.

Associated emission factors for the heat and energy derived from different stationary and mobile combustion fuels, are provided in **Table 3**. Annex 3 provides country level grid emission factors, in tCO₂-e/MWh.

Table 3. Default net calorific values, in TJ/Gg, emission factors for stationary and mobile combustion, in tCO₂-e/m³ and kg GHG/TJ, and fuel density, in kg/m³

Fuel and solid biofuels type	EF _{fuel}	Net calorific values	EF CO ₂	EF CH ₄	EF N ₂ O	Density
Stationary – motor gasoline	2.292	44.3	69 300	10	0.6	741
Stationary – gasoil /diesel oil	2.686	43.0	74 100	10	0.6	837
Stationary – waste oil/ lubricants	2.819	40.2	73 300	10	0.6	950
Stationary LPG	1.596	47.3	63 100	5	0.1	533
Stationary – natural gas	0.002	48.0	56 100	5	0.1	0.768
Mobile – motor gasoline	2.343	44.3	69 300	33	3.2	741
Mobile – gasoil /diesel oil	2.714	43.0	74 100	3.9	3.9	837
Mobile – natural gas	0.002	48.0	56 100	92	3	0.768
Mobile – LPG	1.645	47.3	63 100	62	0.2	533
Mobile – ethanol (cars)	0.045	27.0	1 508	18	N/A	788
Mobile – ethanol (trucks)	0.480	27.0	1 508	260	41	788
Off-road diesel	2.979	43.0	74 100	4.15	28.6	837
Off-road gasoline (2-stroke)	2.435	44.3	69 300	140	0.4	741
Off-road gasoline (4-stroke)	2.384	44.3	69 300	80	2	741
Wood	1.925 [0.178]	15.6	112 000	300	4	
Peat	1.138 [0.104]	9.8	106 000	300	1.4	
Charcoal	3.513 [0.209]	29.5	112 000	200	1	

Notes: Numbers in bracket are the default emission factor for solid biofuels excluding CO₂ emissions.

Source: Authors' elaboration based on IPCC. 2006. *IPCC Guidelines for National Greenhouse Gas Inventories*. Volume 2, Chapter 2. Geneva, Switzerland. www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

Packaging: GHG emissions from packaging reflect the embedded energy based on the material used and the mass of such material used for packaging. The following equation calculates the GHG emissions from packaging based on the type of material used and the weight of the material:

$$kg\ CO_2e\ emissions = W(kg/tonne) \times EF(kgCO_2e/kg)$$

where:

- W = weight of type of packaging, in kg/tonne of product
- EF = emission factor associated with the type of packaging, in kgCO₂-e/kg of packaging material.

Table 4. Emission factors for type of packaging

Type of packaging	Emission factors (tCO ₂ -e/tonne of packaging)
Wood	0.4
Paper	2.1
Aluminium	8.5
Plastic (mixed)	3.6

Source: Berneers-Lee, M. & Hoolohan, C. 2012. *The Greenhouse Gas Footprint of Booths*. Booths GHG report final, Small World Consulting Ltd. Lancaster, UK, Lancaster University.

Storage: storage consumes electricity. The energy requirement will be dependent on a variety of factors including whether the goods are stored in ambient, cold, or freezing temperatures. In cases of temperature-controlled storage, GHG emissions are also calculated from the leakage throughout the operational life of the refrigerants. Based on the GHG protocol (WRI, and WBCSD, 2013), the GHG emissions from storage are calculated using the following set of equations:

$$SEC = E_c (kWh/year) \times N (days)$$

$$kg CO_2e emissions = SEC(kWh) \times EF(kgCO_2e/kWh)$$

With refrigerant:

$$kg CO_2e emissions = (SEC (kWh) \times EF (kgCO_2e/kWh)) + (Q_r (kg) \times GWP (kgCO_2e/kg))$$

where:

- SEC = specific energy consumption, in kWh
- E_c = electricity consumption, in kWh/year
- N = number of days stored, days
- EF = emission factor corresponding to the electricity used, in kgCO₂-e/kWh
- Q_r = leakage, in kg
- GWP = global warming potential, in kgCO₂-e/kg.

Users must specify the type of refrigerant used and its GWP value in the EX-ACT VC tool. Default refrigerants and their respective GWP values are not embedded within the tool and users are responsible to specify them. Most commonly used refrigerants, their main applications and their GWP values are provided in Annex 4 to guide the users to perform an EX-ACT VC assessment (refer to Table A3, Annex 4).

Transportation: GHG emissions from transportation primarily come from burning fossil fuel for cars, trucks, ships, trains, and planes to travel from one-point to another. Based on the Smart Freight Centre's Global Logistics Emissions Council Frame (2019), the GHG emissions from transportation are calculated using the following equation:

$$kg CO_2e emissions = \sum_1^n (total tkm \times iEF (kgCO_2e/tkm))$$

where:

- tkm = tonnes per kilometre
- iEF = intensity factor, in kgCO₂/tkm
- n = transports involved.

Table 5. Emission factors for transportation, in tCO₂-e/tkm

Type of transport	Type of fuel	Intensity factor	Refrigerant
		TTW – tCO ₂ -e/tkm	TTW – kgCO ₂ -e/tkm
Animals	None	0.000	0.000
Aviation – air freight	Kerosene	0.00026	0.008560
Inland water (>1 000 tonnes)	Diesel	0.00002	0.008340
Inland water (1 000–2 000 tonnes)	Diesel	0.00002	0.008340
Inland water (container 110 metres)	Diesel	0.00002	0.008340
Inland water (container 135 metres)	Diesel	0.00002	0.008340
Rail (container)	Diesel	0.00002	0.008560
Rail (cereals)	Diesel	0.00002	0.008560
Rail (container)	Electric	0.00001	0.008560
Rail (cereals)	Electric	0.00001	0.008560
Van (>3.5 tonnes)	Diesel	0.000550	0.000660
Van (>3.5 tonnes)	Gasoline	0.000850	0.001020
Van (>3.5 tonnes)	Compressed Natural Gas (CNG)	0.000540	0.000648
Van (>3.5 tonnes)	Liquefied petroleum gas (LPG)	0.000590	0.000708
Light-duty-truck (3.5–7.5 tonnes)	Diesel	0.000300	0.000360
Light-duty-truck (3.5–7.5 tonnes)	CNG	0.000310	0.000372
Medium-duty-truck (7.5–12 tonnes)	Diesel	0.000190	0.000228
Medium-duty-truck (7.5–12 tonnes)	CNG	0.000190	0.000228
Medium-duty-truck (12–20 tonnes)	Diesel	0.000120	0.000144
Medium-duty-truck (12–20 tonnes)	CNG	0.000130	0.000156
Medium-duty-truck (12–20 tonnes)	Liquefied natural gas (LNG)	0.000130	0.000156
Medium-duty-truck (20–26 tonnes)	Diesel	0.000099	0.000119
Medium-duty-truck (20–26 tonnes)	CNG	0.000100	0.000120
Medium-duty-truck (20–26 tonnes)	LNG	0.000100	0.000120
Heavy-duty-truck (26–32 tonnes)	Diesel	0.000078	0.000094
Heavy-duty-truck container (26–32 tonnes)	Diesel	0.000069	0.000083
Heavy-duty-truck (up 34 tonnes)	Diesel	0.000074	0.000089
Heavy-duty-truck container (up 34 tonnes)	Diesel	0.000083	0.000100
Heavy-duty-truck (up to 40 tonne)	CNG	0.000066	0.111000
Heavy-duty-truck container (up to 40 tonnes)	CNG	0.000065	0.111000
Heavy-duty-truck (up to 40 tonnes)	LNG	0.000065	0.111000
Heavy-duty-truck container (up to 40 tonnes)	LNG	0.000064	0.111000
Heavy-duty-truck (up to 40 tonnes)	Diesel	0.000064	0.111000
Heavy-duty-truck container (up to 40 tonnes)	Diesel	0.000060	0.111000

Note: For refrigerated transportation: vans to heavy-duty-truck up 34 tonnes, it is assumed a 20 percent of intensity increased (Tassou *et al.*, 2009).

Source: Smart Freight Centre. 2019. Global Logistics Emissions Council Framework for Logistics Emissions Accounting and Reporting.

Wastewater management: activities in the processing stage of the value chain might require water as a material input to transform the commodity and thereby sometimes resulting in wastewater. Such wastewater is a source of both, methane (CH₄) – when treated or disposed of anaerobically (McIlvaine, 2015) – and nitrous oxide (N₂O) emissions. GHG emissions from wastewater management are calculated in the tool using IPCC methodology (IPCC, 2006, 2019c) as follows:

$$CH_4 \text{ emissions} = \sum_i [(TOW_i - S_i)EF_i - Ri]$$

where:

- CH₄ emissions = CH₄ emissions in kgCH₄/year
- TOW_i = total organically degradable material in wastewater from industry i, in kgCOD/year
- i = industrial sector
- S_i = organic component removed as sludge, in kgCOD/year
- EF_i = emission factor for industry i, in kgCH₄/kgCOD
- Ri = amount of CH₄ recovered, in kgCH₄/year.

$$N_2O \text{ emissions} = \left[\sum (T \cdot EF \cdot TN) \right] \times \frac{44}{28}$$

where:

- N₂O = N₂O emissions from industrial wastewater treatment plants in inventory year in kgN₂O/year
- T = degree of utilization of treatment/discharge pathway or system
- EF = emission factor for treatment/discharge pathway or system, in kgN₂O–N/kg N
- TN = total nitrogen in wastewater from industry, in kgN/year.

Table 6. Emission factors for wastewater

IPCC (2019) Chapter 6 and associated tables	Table 6.8	Table 6.8a	Table 6.10c
	CH ₄ correction factor MCF	kg N ₂ O–N/kg N EF	Nrem Default
Untreated (discharge to aquatic environments)	0.11	0.005	0
Untreated (discharge to aquatic environments other than reservoirs, lakes and estuaries)	0.035	0.005	0
Untreated (discharge to reservoirs, lakes and estuaries)	0.19	0.005	0
Centralised aerobic treatment plant	0	0.016	0.4
Anaerobic reactor	0.8	0	0.4
Anaerobic shallow lagoon, <2m depth	0.2	0	0.4
Anaerobic deep lagoon, >2m depth	0.8	0	0.4

Source: IPCC. 2019. *IPCC Guidelines for National Greenhouse Gas Inventories*. Volume 5. Cambridge, UK, Cambridge University Press and New York, USA. www.ipcc-nggip.iges.or.jp/public/2019rf/vol5.html

Table 7. Emission factors for wastewater management

IPCC (2019) Chapter 6 and associated tables	Table 6.9		Table 6.12
Industry type	Wastewater generation (m ³ /t)	COD (kg/m ³)	Total nitrogen kg/m ³
Alcohol refining	24	11	2.4
Beer and malt	6.3	2.9	0.055
Coffee	15	9	–
Pulp and paper combined	162	9	–
Starch production	9	10	0.9
Sugar refining	11	3.2	–
Vegetable oils	3.1	0.85	–
Vegetable, fruits and juices	20	5	–
Wine and vinegar	23	1.5	–
Dairy products	7	2.7	–
Fish processing	13	2.5	0.6
Meat and poultry	13	4.1	0.19

Sources: IPCC. 2006. *IPCC Guidelines for National Greenhouse Gas Inventories*. Volume 2, Chapter 2. Geneva, Switzerland. www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html; Basnet, R. 2014. *Sustainable utilization of coffee processing wastes through biogas technology*. Cited 3 February 2022. https://energypedia.info/wiki/Sustainable_Utilization_of_Coffee_Processing_Wastes_through_Biogas_Technology (for values in red).

New infrastructure: construction of new infrastructure such as buildings, warehouses and roads lead to GHG emissions from the use of material inputs, fuel, and energy inputs throughout the construction phase. GHG emissions from construction of new infrastructure is calculated in the tool as follows:

$$kg\ CO_2e\ emissions = Builtup\ area\ (m^2) \times EF(kgCO_2e/m^2)$$

where:

- Builtup area = area covered by the new infrastructure, in m²
- EF = emission factor associated with building new infrastructure, in kgCO₂-e/m².

Table 8. Emission factors for construction of buildings and roads, in tCO₂-e/m²

Type	Emission factor
Housing (concrete)	436
Agricultural buildings (concrete)	656
Agricultural buildings (metal)	220
Industrial buildings (concrete)	825
Industrial buildings (metal)	275
Garage (concrete)	656
Garage (metal)	220
Offices (concrete)	469
Offices (metal)	158
Other (concrete)	550
Other (metal)	220
Road (bitumen)	18
Road (asphalt)	73
Road (reinforced concrete)	86
Road rehabilitated (pavement)	9
Food sales (retail or wholesale)	515.9
Food service (restaurants)	517.4
Warehouse and storage	1 568.3
Education	440
Health care (metal)	440

Source: Authors' own elaboration based on ADEME. 2020. *Resource centre for greenhouse gas accounting*. Angers, France. Cited 26 June 2020. www.bilans-ges.ademe.fr; Breisinger, M. 2012. *Greenhouse Gas Assessment Emissions Methodology*. Technical Note IDB-TN-455. Washington, DC, Inter-American Development Bank (for values in red).

After estimating emissions from each of the activity, the EX-ACT VC tool calculates:

Total GHG emissions

Emissions across all the activities and actors are aggregated to quantify total GHG emissions in both current and planned scenarios as expressed below:

$$\text{Total GHG emissions} = \text{on farm emissions} + \text{off farm emissions}$$

where:

- on-farm emissions = emissions from primary production (calculated in EX-ACT and inputed in the EX-ACT VC);
- off-farm emissions = emissions from processing, storage, packaging, transport, wastewater management and new infrastructure.

Net carbon balance

The GHG emissions in current and planned scenario are compared using the following equation to estimate GHG emissions emitted or sequestered due to a specific project or policy implementation within a value chain:

Net carbon balance (Net(+/-) tCO₂e per year) =

$$\textit{Total on farm emissions + (-) reductions + (total emissions off farm planned - total emissions off farm current)}$$

Carbon footprint

The carbon footprint (CFP) of an agrifood value chain is the amount of GHG emissions originating from all the value chain activities expressed in tonnes of CO₂-e per tonne of final product. It is estimated using the below equation:

$$\textit{CFP = Total GHG emissions / total tonnes of final product}$$

2.2.2 Indicator: food loss

This indicator estimates the food losses along the value chain to assess the efficiency and functioning of the value chain. Food losses across the value chain impact environmental, economic, and social dimensions. Food loss is a reduction of food “quantity” – physical losses of food that were destined for human consumption – or food “quality” – decrease in food attributes that reduce its value in terms of intended use – resulting from decisions and actions by food suppliers in the chain up to the retailer’s door¹ (FAO, 2019a).


Food loss occurs at every stage of the value chain. The EX-ACT VC tool only calculates the food losses in terms of “quantity” reduced expressed in tonnes of the commodity. The computed food loss includes the commodity as a whole with its any non-edible parts.

EX-ACT VC tool follows the methodological approach in line with the FAO’s Global Food Loss Index (2018). It standardizes food losses at each activity of the value chain and aggregates them to obtain the overall production that does not reach the retail stage. The EX-ACT VC tool computes food loss across the value chain as follows:

1. It requires users to provide an average percentage of food lost at each actor and activity in the value chain.
2. The EX-ACT VC tool then compiles the amount lost at each stage by multiplying the average losses (in percent) of that stage to a reference quantity. At the primary production stage, this reference quantity is the total amount harvested, and for the subsequent stages the reference quantity is the amount remaining from the previous stage.
3. The tool computes the amount remaining at each stage by subtracting the amount lost from the amount remaining in the previous stage.

Figure 7 provides an example of aggregating food losses along the value chain.

¹ It excludes retailing, food service providers, and consumers. At this stage the food that does not get consumed is known as “food waste”.

Figure 7. Example of aggregating food losses along the value chain


	Total harvest	On-farm post-harvest	Transport	Processing	Packaging	Storage
Starting amount – (Total agricultural production/Raw material)	1 000 tonnes					
Average losses (%)		7.3%	1.5%	3.5%	0%	5.6%
Amount lost		73	13.9	31.9	0	49.3
Amount remaining		927	913	881	881	831

Source: Authors' own elaboration.

The tool computes the food loss for the current and planned scenarios and compares the change between the two scenarios.

2.2.3 Indicator: water usage

This indicator enables users to capture the water used during all processing activities in the entire value chain to assess the water use efficiency and sustainability of the value chain. EX-ACT VC tool calculates the total water usage in litres during the processing stage of the value chain and per tonne of final product and disaggregates the water usage across each actor involved in processing activities in the current and planned scenario and the change in amount of water used between the two.

The tool follows a simple water end-use approach and does not differentiate between the different water sources such as rainfall, surface/groundwater, or freshwater (Mekonnen and Hoekstra, 2011).

2.2.4 Indicator: monetary value of GHGs estimated in the value chain

This indicator represents the scale of expected economic costs or benefits resulting from GHG emissions or reductions across the value chain. This indicator uses the social cost of carbon (SCC) to quantify climate damages, representing the net economic cost of GHG emissions. In simple terms SCC “tries to add up all the quantifiable costs and benefits of emitting one additional tonne of CO₂, in monetary terms” (Carbon Brief, 2021). By assigning a monetary value to the emissions, the harmful externalities of climate change are converted into economic terms.

SCC links emissions from a value chain to climate change damages complementing traditional GHG calculations and allows to assess whether and to what extent the value chain project or policy contributes to climate change impact or climate change action. The EX-ACT VC tool quantifies the expected economic value per GHG emitted, reduced, or avoided across both current and planned value chain activities and helps evaluate whether the costs and benefits of a proposed agrifood VC project or policy to curb climate change are justified. It estimates the economic value of damages from the total GHG emissions in the value chain and from per tonne of the final product.

To estimate the net economic costs to climate change attributable to the value chain project or policy in a current and planned scenario, the total GHG emissions determined from the environmental assessment is multiplied by a selected SCC estimate. This is expressed as:

$$\text{Monetary value of GHG estimated in the value chain} = \text{total GHG emissions (tCO}_2\text{e} \times \text{social cost of carbon (USD)}$$

The EX-ACT VC also estimates the net economic value of mitigation actions (e.g. GHG emitted, reduced, or avoided) per tonne of the final product produced in the value chain.

$$\text{Monetary value of GHG estimated in the value chain} = \\ \text{carbon footprint (tCO}_2\text{e per tonne of product)} \times \text{social cost of carbon (USD)}$$

The default social cost of carbon (lower and upper bound) is taken from Nordhaus (2017).

The default lower bound for the SCC is USD 44.15 and upper bound for the SCC is USD 165.72 (as of 2021 dollars). These values are calculated by the DICE–2016R model, using the model's baseline assumptions, and using a 2.5 percent discount rate.

2.3 Socio-economic assessment

The socio-economic assessment builds on both the functional analysis of the value chain described in Section 2.1 and on the environmental assessments described in Section 2.2.

The EX-ACT VC tool calculates a set of indicators that represent socio-economic performance of the value chain. These are listed in **Table 9**.

Table 9. List of socio-economic indicators

Economic indicators	Gross production value
	Gross and net value added
	Net Income
	Average daily wage
Employment indicator	No. of jobs created along the entire VC
	No. of jobs created by category of actor/activity/sector
Gender and youth analysis	No. of women owning a business
	No. of women in managerial position
	No. of women employed (hired and as family workers)
	No. of jobs disaggregated by gender and age group

Source: Authors' own elaboration.

2.3.1 Economic indicators

Indicator: value-added

This indicator represents a set of economic productivity measures that reflects the contribution of the value chain to the economy. The EX-ACT VC tool calculates "value-added" across every stage of the value chain in a current and planned scenario. The tool defines value-added as an indicator of the agrifood VCs economic performance based on wealth created or accumulated along the different value chain activities and actors, net of the resources consumed by the activities and actors. The EX-ACT tool measures three types of value added (Bellù *et al.*, 2013):

1. Value-added by each actor and activity at each stage of the value chain;
2. Aggregate value-added by the value chain;
3. Distribution of value added among production factors (land, labour, capital, etc.) through their respective distributive variables (rent, wages, taxes and profits).

The following measures in monetary terms are computed as part of the value-added indicator:

1. Gross production value
2. Gross value added
3. Net value added
4. Net income
5. Average daily wage.

The methodological framework to calculate value-added measures throughout the value chain is based on macroeconomic framework provided by the System of National Accounts (SNA, 2008), and theory of firm, crop, and farm microeconomic budgets. An example of how value-added measures are calculated is reported in **Table 10**. This set of measures is calculated for each category of actors along the value chain, both at the aggregate level (e.g. entire category of actors) and at the individual level (e.g. for each actor in the category).

Table 10. Methodology to calculate different economic measures of value-added indicator

Equation	Economic measures of value added	Example	
C = A + B	Gross production value		USD 1 000
A	Sales revenue	USD 900	
B	Final own consumption	USD 100	
D	Intermediate inputs		USD 500
E = C - D	Gross value added		USD 500
F	Fixed capital consumption	USD 100	
G = E - F	Net value added		USD 400
H	Wages	USD 100	
I	Interests	USD 50	
J	Rents	USD 0	
K	Taxes	USD 25	
L	Subsidies	USD 20	
M = H + I + J + K - L	Production factors		USD 155
N = G - M	Net income		USD 245

Source: Authors' own elaboration.

Following the SNA guidelines, the tool first distinguishes between the production account and the income account in simple terms as follows:

- The production account determines the value added (VA) of the production process;
- The income account determines how this value added is distributed among the actors participating in the production process through the supply of production factors such as land, labour, capital etc.

The following section introduces and describes the steps to calculate the various items in **Table 10** within the tool.

Production account items

C: gross production value (GPV)

GPV is calculated for every category of actors within the value chain and represents an intermediary step in the calculation of value added. It is calculated by summing sales revenues and the value of own consumption, if any. The former is obtained by multiplying the price per unit of product sold (denominated as “selling price”) by the quantity of product sold.² The latter is estimated by multiplying the amount of product that was self-consumed by the selling price.

D: intermediate inputs (II)

Any goods entering the production process and totally consumed during a production period are recorded as intermediate inputs (only referred to as “inputs” in the tool). The cost of intermediate inputs is obtained by multiplying their purchase price e.g. their price when they enter the process of production, by the amount of the corresponding inputs used.³

E and G: gross and net value added (VA)

Value added measures the accumulation of wealth and the contribution of the production process to economic growth. In other words, the value added is the value that each actor, at each stage of the value chain, adds to the value of inputs during the accounting period of the food production process. Value added can be calculated by taking the GPV of each actor’s output and subtracting the value of intermediate inputs used to create the output. Gross value added (GVA) does not consider the cost of consuming or using fixed capital. Net value added (NVA) also subtracts fixed capital consumption from GPV. If fixed capital consumption is unknown, then gross value added will equal net value added.

F: fixed capital consumption

While some inputs (e.g. intermediate inputs) are entirely consumed during one single production period, others, such as vehicles, machinery, and equipment, can be used over several production periods. These inputs are defined as fixed assets, and the stock of fixed assets is defined as fixed capital. Although fixed assets produce services for several periods, their value normally declines over time, due to physical deterioration (wear and tear), obsolescence (e.g. loss of value due to technical progress) or expected accidental damage. The decline in value in one accounting period is defined as the consumption of fixed capital in that period (SNA, 2008). To correctly consider all the resources consumed to produce a given output, the consumption of fixed capital for the given production period also needs to be accounted in the production process. EX-ACT VC uses the one-hoss shay depreciation model, which assumes that the asset provides the same quantity of services in all the periods of its economic life, until it completely wears out. This implies also that the gains from the use of the asset, as well as the loss of its value (the related cost), are equal and can be calculated by taking the asset’s initial value divided by the number of periods of its economic life.

Income account items:

M: production factor incomes

The NVA constitutes the net wealth available to remunerate the factors of production involved in the production process. There are several types of income deriving from the distribution of the NVA. These are termed as production factor incomes and are as follows:

1. **Wages** include payments in cash, or in-kind contributions to hired employees and the remuneration of family labour. They determine labour costs, calculated by multiplying the average wage by the number of hired workers (over the time period considered) across different categories and actors.

² The product sold differs for every category of actors and corresponds to the output of each actor (e.g. the tomatoes for the producer, but the tomato paste for the processor).

³ Intermediate inputs, for instance, include fertilizers, pesticides, seeds, etc. and represent inputs originating from ‘outside’ the value chain. Inputs understood as the ‘primary commodity’ purchased from the previous actor in the value chain (e.g. whole tomatoes purchased by processors from producers to make tomato paste) do not belong to this category.

2. **Interests** include the financial charges on the purchase of fixed assets, and the charges generated in the short term to finance the working capital, for example the funds required to pay for input costs anticipated with respect to revenues (Bellù *et al.*,2013). Interests should not include the cost of financial services provided by banks, such as advice on funding opportunities and current account services (e.g. account keeping, check expenses, etc.) considered as services to be accounted for intermediate inputs. Interests belong to the category of "Other costs".
3. **Taxes** on production and imports accounted for the generation of the income account. **Subsidies** to production are recorded in this entry as negative. Taxes do not include social contributions and benefits paid to workers (comprised among the wages as components of the cost of hired labour), current taxes on income and wealth, or any other current transfer to the agent or referring to the household and not specifically to the production activity. Like interests, taxes belong to the category of "Other costs".

2.3.2 Social indicators

Indicator: employment

This indicator measures the employment opportunities generated along the value chain. Jobs are a key pathway, and labour is the most important asset to generate a steady income and enable a sustainable pathway out of poverty and towards shared prosperity. The EX-ACT VC tool calculates the number of jobs created along the value chain in both current and planned scenarios, and the number of jobs disaggregated for different actors, different activities and across different sectors as classified below.

The EX-ACT VC tool distinguishes between on-farm and off-farm jobs as well as between hired labour and family labour. **Box 2** explains the differences between these employment sectors in detail.

Box 2. Employment sectors within EX-ACT VC

The tool classifies the employment opportunities generated across the value chain into four "sectors", defined as follows:

- **On-farm jobs** aggregate all workforce engaged in primary production activities.
- **Off-farm jobs** include all workforce engaged in post-production (post-harvest) activities (e.g. processing, packaging, storage, transportation and distribution).
- **Hired labour** refers to workforce perceiving a wage remuneration. It corresponds to employees.
- **Family (non-remunerated) labour** refers to workforce not perceiving a wage remuneration, either because it perceives income from the operation, or because it is non-remunerated being at the family level (this can also be defined as "non-remunerated" labour).

The combination of these four employment types, in the context of an agrifood value chain, leads to the creation of four "employment sectors", defined as follows:

	Family labour	Hired labour
On-farm jobs	Farmers	Hired workers in farms (engaged in production)
Off-farm jobs	Family enterprises engaged in post-harvest activities	Hired workers in firms (engaged in post-harvest activities)

Source: Authors' own elaboration.

EX-ACT VC derives the number of jobs by dividing the total workdays required per unit by one “full-time equivalent” (FTE) position, expressed in number of days, as follows:

$$\text{No. of jobs} = \frac{\text{Total workdays required}}{\text{one FTE position}}$$

where:

- The number of workdays required per unit is measured according to the number of workers required per day to perform a task, e.g. 15 men/days for harvesting, (this includes both hired and family labour);
- One “full-time equivalent” position refers to the number of working days over a year, on average. By default, the tool assumes that a full-time equivalent position is equivalent to working on average 250 days a year. This value (250 days) may be changed by the user if more precise information is available.

The tool also calculates the number of jobs created across each category of actor and across each activity using the following equations:

$$\text{No. of jobs by category of actor} = \frac{\text{Total workdays required by category}}{\text{one FTE position}}$$

where:

Total workdays required by category of actor is the sum of workdays required for each activity performed by the category (e.g. summing workdays required for processing, packaging and storage for one category of actors):

$$\text{No. of jobs by activity} = \frac{\text{Total workdays required by activity}}{\text{one FTE position}}$$

where:

Total workdays required by activity is the sum of workdays required for specific activity (e.g. processing) by all the categories of actors performing that activity.

The EX-ACT VC tool then calculates employment across the four sectors identified in Box 2 using the following equations:

$$\text{On farm hired labour} = \frac{\text{Total workdays required for primary production}}{\text{one FTE position} \times \text{percent hired labour}}$$

$$\text{Off farm hired labour} = \frac{\text{Total workdays required for post production activities}}{\text{one FTE position} \times \text{percent hired labour}}$$

$$\text{On farm family labour} = \frac{\text{Total workdays required for primary production}}{\text{one FTE position} \times \text{percent hired labour}}$$

$$\text{Off farm family labour} = \frac{\text{Total workdays required for post production activities}}{\text{one FTE position} \times \text{percent hired labour}}$$

The user must provide all the data necessary in terms of total workdays required for each activity and the employment. The user must also collect and enter data on the proportion of family and hired labour for each activity.

The tool finally calculates the number of jobs created in the current and planned scenario, and reports the change between the two, identifying any increase or decrease in the employment opportunities along the value chain attributable to the project or policy implementation.

Indicator: women's representation

This indicator assesses the potential of the value chain to contribute to women's economic empowerment and advance gender equality. The EX-ACT VC tool focuses on three main aspects of women's participation in a value chain: ownership, management, and employment. See **Box 3** on how the tool distinguishes between an owner and a manager. The tool calculates in both the current and planned scenario the number of women owning a business, the number of women in managerial positions and the number of women employed, also differentiating between hired and family labour across each category of the actor and the entire value chain.

Box 3. "Owner" and "manager" definitions

According to the International Standard Classification of Occupation (ISCO-08) and other sources, owner and manager are classified and defined as follows:

- An **owner** is a physical person who owns the business and he/she may or may not work in the business. Profit and loss impact him/her directly. Ownership issues tend to be more strategic and might include dealing with the bank or finance, negotiating on suitable freehold or leasehold premises, maintaining relationships with other owners or investors in the business, deciding on future strategy and creating a compelling vision of the future.
- A **manager** is an employee of the business and he/she works for the owner in the business. The manager earns a salary and is not affected to the same extent as the power by fluctuating sales or profits. Management issues are the daily, weekly and monthly things that must be done to ensure the smooth running of the business.

Source: ILO. 2012. *International Standard Classification of Occupations. Structure, group definitions and correspondence tables*. Geneva, Switzerland. www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_172572.pdf

The EX-ACT VC tool calculates the number of jobs women hold through a simple multiplication of the total number of workers by the corresponding share of women across different actors and activities within the value chain as follows:

$$\begin{aligned} \text{No. of jobs by gender} = \\ \text{Total no. of hired workers} \times \text{percent of female (male) in age group} + \\ \text{Total no. of family workers} \times \text{percent of female (male) in age group} \end{aligned}$$

The user is responsible for collecting and enter the data on the share of females and males among both hired and family labour and across different actors within the value chain being analysed.

Indicator: youth participation

This indicator explores the potential of the value chain to create opportunities for young people. Youth participation is a key pathway towards social change, economic growth, and innovation. The EX-ACT VC disaggregates employment (distinguishing between hired and family [e.g. non-remunerated] labour) by age to estimate youth participation across the value chain in both a current and planned scenario. EX-ACT VC adopts the UN categorization of age groups (UN, 1982), which defines “youth” as those persons “between the ages of 15 and 24 years inclusive”.

The tool adopts the following categorization of age groups and calculates the number of hired and family labour disaggregated for each age group:

- **Children:** people under the age of 15.
- **Youth:** people aged 15 to 24 inclusive.
- **Non-youth labour force:** people over the age of 24. This is aggregated into a single age group for the sake of simplicity, as well as considering that the focus of this assessment is on the level of youth participation within the value chains under analysis.

The calculation involves a multiplication of the total number of workers (for both hired and family labour) by the percentage of the workforce in each of the age groups identified above, and then by the corresponding share of women within that age group as follows:

$$\begin{aligned} \text{No. of jobs by age group} = \\ \text{Total no. of hired workers} \times \text{percent hired workforce in one age group} + \\ \text{Total no. of family workers} \times \text{percent family workforce in one age group} \end{aligned}$$

$$\begin{aligned} \text{No. of jobs by gender and age group} = \\ \text{Total no. of hired workers} \times \text{percent hired workforce in one age group} \times \\ \text{percent of female (male) in age group} + \text{Total no. of family workers} \times \\ \text{percent family workforce in one age group} \times \text{percent of female (male) in age group} \end{aligned}$$

The above calculations are performed for each category of the actors and activities within the value chain, and then aggregated at the whole value chain level. The data required on the share of hired and family workforce belonging to each age group as well as share of females and males across each age group must be collected by the users and entered into the EX-ACT VC tool.

2.3.3 SDG tracker – Links to UN Sustainable Developmental Goals

The EX-ACT VC tool recognizes that activities throughout the value chain can have a direct impact on achieving the SDG targets. The EX-ACT VC tool measures how agrifood VC project or policy contributes to the objectives of SDGs by tracking a set of SDG indicators. The tool estimates the indicators at the value chain level for both the current and planned scenario and expresses the change between the two scenarios in percentage terms to reflect how agrifood VC project or policy allows progress towards achieving the corresponding SDG target.

Table 11 summarizes the specific SDG goals, targets and indicators that EX-ACT VC estimates.

Table 11. UN SDGs targets and indicator assessed within EX-ACT VC

Target		Indicator	
SDG 2 – Zero hunger			
2.3	By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, Indigenous Peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.	2.3.1	Volume of production per labour unit by classes of arming/pastoral/forestry enterprise size.
		2.3.2	Average income of small-scale food producers, by sex and indigenous status.
SDG 5 – Gender equality			
5.5	Ensure women’s full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.	5.5.2	Proportion of women in managerial positions.
SDG 6 – Clean water and sanitation			
6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.	6.4.1	Change in water-use efficiency over time at the processing level (MIMEC).
SDG 9 – Industry, innovation and infrastructure			
9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.	9.4.1	CO ₂ emission per unit of value added.
SDG 12 – Responsible consumption and production			
12.3	By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.	12.3.1	Adjusted global food loss index.

Source: UN. 2016. *Report of the Inter-Agency and Expert Group on Sustainable Development Goal Indicators*. Economic and Social Council (ECOSOC). Statistical Commission. Forty-seventh session. UN Doc. E/CN.3/2016/2/Rev.1, 19 February 2016. New York. USA. <https://digitallibrary.un.org/record/821651>

The following section introduces and describes the technical equations used within EX-ACT VC tool to calculate the indicators identified in **Table 11** for both the current and planned scenario.

Indicator 2.3.1: production per labour unit of small-scale food producers

$$I_{2.3.1} = \frac{\sum_{j=1}^n \left(\frac{V_j p_j}{L d_j} \right)}{n}$$

where:

- V_j is the total physical volume of agricultural product sold by the j^{th} category of small-scale food producers during the year assessed;

- p_j is the constant sale price received by the j^{th} category of small-scale food producer for the agricultural product during the year assessed;
- Ld_j is the total number of labour days utilized by j^{th} category of small-scale producers;
- n is the total number of categories of small-scale producers.

Note:

This indicator is calculated for small-scale food producers within the value-chain, based on the User's self-identification of the category of actor as "small-scale" (FAO, 2017).

Indicator 2.3.2: average income of small-scale food producers

$$I_{2.3.2} = \frac{\sum_{j=1}^n (V_j p_j - C_j)}{n}$$

where:

- V_j is the total physical volume of agricultural product sold by the j^{th} category of small-scale food producers during the year assessed;
- p_j is the constant sale price received by the j^{th} category of small-scale food producer for the agricultural product during the year assessed;
- C_j is the total production cost of agricultural product produced by the j^{th} category of small-scale food producers. Total production cost comprises all variable costs (e.g. payments in cash and kind of agricultural inputs as fertilizer, seeds, occasional labour, etc.) and fixed costs (e.g. hired labour, land rent and technical assistance costs);
- n is the total number of categories of small-scale producers.

Note:

This indicator is calculated for small-scale food producers within the value-chain, based on the User's self-identification of the category of actor as "small-scale" (FAO, 2017).

Indicator 5.5.2: proportion of women in managerial positions

$$I_{5.5.2} = P_W = \left(\frac{n_W}{n_t} \right) \times 100 \text{percent}$$

where:

- P_W = proportion of women in managerial positions (within Value Chain);
- N_w = total number of women employed in ISCO–88 category 1 (within Value Chain);
- N_t = total number of persons employed in ISCO–88 category 1 (within Value Chain).

Note:

This indicator is calculated using ISCO–88 methodology. Since users are not asked to provide statistics at the sub-major group level (two-digit level of ISCO), the major group 1 of ISCO–88 and ISCO–08 can be used as a proxy and the indicator would then refer only to total management (including junior management) (ILO, 2020).

Indicator 6.4.1: change in water-use efficiency over time (for mining, industry, manufacturing, electricity and constructions (MIMEC) sector only)

$$I_{6.4.1} = WUE = A_{we} \times P_A + M_{we} \times P_M + S_{we} \times P_S$$

where:

- WUE = water-use efficiency (USD/m³)
- A_{we} = irrigated agriculture water-use efficiency (USD/m³)
- M_{we} = MIMEC water-use efficiency (USD/m³)
- S_{we} = services water-use efficiency (USD/m³)

- P_A = proportion of water used by the agricultural sector over the total use
- P_M = proportion of water used by the MIMEC sector over the total use
- P_S = proportion of water used by the service sector over the total use.

Note:

Since EX-ACT VC currently does not account for water used by the agricultural or service sectors, the equations will not be expanded and are set to 0 and P_m is equal to 1. The resulting estimated WUE of the current scenario is compared to the estimated WUE for the planned scenario.

MIMEC water-use efficiency (including power production):

$$M_{we} = \frac{GVA_m}{V_m}$$

where:

- M_{we} = MIMEC water-use efficiency (USD/m³)
- GVA_m = gross value added by MIMEC (including energy) (USD)
- V_m = volume of water used by MIMEC (including energy) (m³).

V_m includes water from renewable freshwater resources, as well as over-abstraction of renewable groundwater or abstraction of fossil groundwater and use of desalinated water or direct use of (treated) wastewater. This definition refers to self-supplied industries not connected to the public water supply networks. If connected to such networks, water used for MIMEC sector may be included in the services water-use, unless disaggregated data are available. Water-use for this sector should include the losses for evaporation from artificial lakes used for hydropower production⁴. On the contrary, this sector does not include water used for powering the hydroelectric turbines, as such water is immediately returned to the riverbed (FAO, 2019c).

Indicator 9.4.1: CO₂ emission per unit of value added (manufacturing sector)

$$I_{9.4.1} = \frac{MCO_2}{MVA}$$

where:

- MCO_2 = total CO₂ emissions from manufacturing (in tonnes) activities within EX-ACT VC assessment
- MVA = total Value Added from manufacturing activities (in USD) within EX-ACT VC assessment.

Note:

CO₂ emissions resulting from energy used for transport by industry should not be included. The EX-ACT VC tool accounts only for the food and tobacco sector (ISIC Divisions 10 to 12).

Indicator 12.3.1: adjusted global food loss index

EX-ACT VC is in line with the approach developed by FAO to calculate food loss. It is a simplified process to standardize losses and aggregate losses along the supply chain to obtain the overall percentage of production that does not reach the retail stage.

The methodology to track this indicator is the same that we discuss in Section 2.2.2. The EX-ACT VC uses the commodity tracker module (see Section 3.2) as a reference of the quantity (tonnes) and the percentages of losses at different stages (e.g. transport, storage, etc.) and compares the food loss for the current and planned scenarios (FAO, 2019d; Fabi and English, 2018).

⁴ More information can be found in Evaporation from artificial lakes and reservoirs (FAO, 2015; Lehner *et al.*, 2011).

PART 3. Step-by-step instructions

This section provides a step-by-step overview of the tool, guiding the user through the structure of the tool, its different modules, the data requirements, and instructions for data entry to complete a value chain assessment using the tool. The tool is organized along four different modules for data entry. The tool has a Help tab which provides module-wise guidance and a Resources tab which provides links to common data resources that the user can access. Throughout the tool layout, the user will find question mark icons indicating that additional help is available. The user is encouraged to click on the icon which redirects to the HELP tab where extensive information and guidance is provided.

The tool follows a sequential structure based on the general methodology described in PART 2. It begins with mapping actors and activities of the value chain in the “Start” module, quantifying physical and transportation flows of the commodity in the “Commodity tracker” module, collecting data on activities that generate GHG emissions in the “Off-farm GHG assessment” module and finally collecting data on costs, revenues, employment, and other socio-economic variables in the “Socio-economic” assessment module. The user must follow this sequential order of data entry as each module is dependent on the previous one.

3.1 Start

Step 1 – description of project

Step 1 allows users to report key project information for their own personal records, specifically – username and date of analysis, project name, code, budget and status of the project, funding and implementing agencies (see **Figure 8**).

Figure 8. Description of project

Step 1 - Description of Project	
User Name	Test User
Date	14/01/2021
Project Name	Project Name
Project Code	NA
Project Budget (USD)	NA
Funding Agency	NA
Implementing Agency	NA
Project Status	Please select

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Step 2 – Description of value chain

Step 2 asks for key information about the value chain that will be analysed. Users must specify the general type of product at the origin of the value chain, the domestic or global scope of the value chain, its geographic location, and the corresponding currency (see **Figure 9**).

In this step, users can modify the global warming potential (GWP) on the basis of the IPCC’s Second (1995), Fourth (2007) or Fifth (2007) Assessment Reports (see **Figure 10**).

Table 12 provides detailed instructions on how to organize and enter information in Step 2.

Figure 9. Step 2 – description of value chain

Step 2 - Description of Value Chain			
Value Chain Commodity	Annual Crop		
Type of Value Chain	Domestic value chain		
Location of Value Chain:	Continent	Southern Asia	
	Country	Sri Lanka	
	Region / Municipality		
Exchange rate (USD / local currency)	1 USD =	199	LKR

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Figure 10. Selection of global warming potential

Global Warming Potential 100-year		
Fifth Assessment Report (AR5)		
5	CO2	1
	CH4	34
	N2O	298

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Table 12. Step 2 – instructions

1	Value chain commodity	Users select from the drop-down list. The tool allows selection from annual crop, perennial crop, flooded rice, milk, meat and fish. This will automatically change the units in the tool to correspond to the commodity selected, and some primary production activities within the socio-economic assessment.
2	Type of value chain	Users select from the drop-down list whether the value chain analysed remains within country's boundaries (domestic) or involves import-export activities (global). This will prompt a block of cells to pop up in Step 3 in case "global" is selected, aimed at describing the location of value chain actors.
3	Location (continent, country, region/municipality)	This refers to the geographical area where the project is taking place. Users select continent and country ⁵ from the drop-down list, while they may enter more specific geographic information in the corresponding cells of region/municipality.
4	Exchange rate	Users must enter the local currency exchange rate to USD (local currency will be automatically identified by selecting the country). The exchange rate is needed in order to complete the socioeconomic assessment. Users can refer to the "Resources" tab for data sources on exchange rate, if unknown.
5	Global warming potential	Users may select the Global Warming Potential according to IPCC's Second (1995), Fourth (2007) or Fifth (2007) Assessment Report.

Source: Authors' own elaboration.

⁵ The country list is based on the UN list, which is available at <https://unstats.un.org/unsd/methodology/m49>

Step 3 – mapping out the value chain

Step 3 allows users to map the different actors, and the activities they may engage in throughout the value chain. This is the most important step in the tool upon which subsequent modules will build on to complete the assessment. The user first identifies, lists, and describes the main categories of actors along the agrifood VC (see **Figure 11a**). The user then identifies one or more activities performed by each category of actor (see **Figure 11b**). Users also have to report the number of actors within each category of actor and map the flow of commodity from one category of actor to another by way of purchasing and selling. **Table 13** provides instructions for Step 3 compilation. **Box 4** provides some guidelines on categorization of actors and **Table 14** describes the activities considered within the tool.

Box 4. Step 3 – identifying and listing actors

- The categories of actors must be listed as per the sequential order of the commodity flow, beginning with the category(s) of actors involved in primary production.
- The first three categories of actors (A, B, C) in the tool are characterized as primary producers. This is to allow the users account for any heterogeneities associated with primary producers. Accordingly, the user should list in rows corresponding to actor A, B and C data related to primary producers only.
- If the users identify only one category of primary producers as actor A, they must list the next actors from categories D to I, leaving the rows corresponding to actor B and C empty.
- The actors from categories D to I do not perform any primary production activity.

Source: Authors' own elaboration.

Figure 11. Step 3 – mapping out the value chain

a. Identifying categories of actors and commodity flows

Step 3 - Mapping out the Value Chain									
Category of Actor	Please Name Category	Please Describe Category	Number of Actors within Category		Describe Commodity Sold	Purchases Commodity From:		Sells Commodity To:	
			Current	Planned		Current	Planned	Current	Planned
Example:	Small Scale Producers	Small-scale vegetable growers	20	30	Fresh Tomatoes			Local Coop	
Actor(s) A:	Tomato Farmers	Farmers cultivating Tomatoes	1000	1000	Tomatoes	N/A	N/A	Wholesalers & Processors	Wholesalers & Processors
Actor(s) B:									
Actor(s) C:									
Actor(s) D:	Wholesalers	Aggregators	50	50	Tomatoes	Tomato Farmers		Other Actor	Other Actor
Actor(s) E:	Processors	Processors producing Tomato Concentrate	10	10	Tomato Concentrate	Tomato Farmers	Tomato Farmers	Other Actor	Other Actor
Actor(s) F:									
Actor(s) G:									
Actor(s) H:									
Actor(s) I:									

b. Identifying activities performed by different actors

Please identify activities performed (either current or planned)								Is the commodity sold at retail level?
Primary Production	Storage (Pre-Processing)	Processing	Water Used (Processing)	Packaging	Storage / Display	Transportation: Pick Up	Transportation: Delivery	
Yes	Yes	No	Yes	No	No	N.A	Yes	
Yes	No	No	No	No	No	No	No	
Please select								
Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
No	Yes	Yes	Yes	Yes	Yes	Yes	No	No

Note: Screenshot of the EX-ACT VC tool.

Table 13. Step 3 – instructions

<p>1 Please name category</p>	<p>Users must enter a name of the category of actors identified, as best fits the analysis. If the cell remains blank, the tool will assume that a category of actor does not exist and turns the row grey. Refer to Box 4 for additional instructions on arranging data in this section.</p> <p>Additionally, users must enter categories in sequential order of the commodity flow. Categories from A to C are involved in primary production.</p>
<p>2 Please describe category</p>	<p>Users may provide additional description of the category of actors identified.</p>
<p>3 Number of actors within category</p>	<p>Users must specify the number of individual actors who make up the category identified in the agrifood VC. For example, if there are 100 farmers who fit the description of “small-scale producer”, then users would enter 100. The number of actors should be entered for both the current and planned scenario.</p>
<p>4 Describe commodity sold</p>	<p>Users can provide a description or name of the commodity sold to the next actor. For instance, this could be “tomatoes” for the producers, while “tomato concentrate” for the processors.</p>
<p>5 Purchases commodity from</p>	<p>Users select from a drop-down list a category of actor(s) whom the selected category purchases a commodity from. The actors appearing in the drop-down list are those reported by the user. The tool allows to select one category, or a combination of categories, up to three.</p> <p>Note:</p> <ul style="list-style-type: none"> • For categories A, B and C, no selection is allowed, as they produce the primary commodity (the default is N/A). • If no production is involved in the agrifood VC analysed, and/or one category of actor purchases the primary commodity from an actor outside the scope of the agrifood VC, the user should select “Other Actor” in correspondence of category D’s row. This will prompt Step 4.bis to pop up and request the user to enter the corresponding amount purchased.
<p>6 Sells commodity to</p>	<p>Users select from a drop-down list a category of actor(s) whom the selected category sells the commodity to. The actors appearing in the drop-down list are those reported by the user.</p> <p>Note:</p> <ul style="list-style-type: none"> • If the category of actor sells to an actor <i>outside</i> or <i>at the end</i> of the determined boundaries of the agrifood VC analysed, users may select “Other Actor”.
<p>7 Please identify activities performed</p>	<p>Users identify which activities each category of actor performs by selecting yes or no from the drop-down list. Description of each activity is provided in Table 14 to guide users. It is assumed that the same activities are performed in both current and planned scenarios.</p>
<p>8 Is the commodity at retail?</p>	<p>Users select Yes / No from the drop-down list. This is required for the calculation of the food loss along the agrifood VC, which only considers the amount of food lost in the chain up to the retailers.</p>
<p>9 Location of category of actor</p>	<p>In case of a Global Value Chain, the user can identify the country, local currency (LCU), and exchange rate to USD for the actors involved in the analysis. The “click here” icon directs the users to a link to retrieve exchange rates.</p>

Source: Authors’ own elaboration.

Table 14. Description of activities

Activity	Select YES in the current and/or the planned scenario if:
Primary production	The actor produces raw agricultural, livestock, fisheries or forestry products.
Storage (pre-processing)	The actor stores the agricultural, livestock or fisheries product prior to some type of processing or packaging activity.
Processing	The actor does some type of transformation of raw agricultural, livestock or fisheries products into food that can be used/consumed. The commodity can go through multiple types of processing by different actors.
Water used (processing)	The actor uses water during the processing activities.
Packaging	The actor uses packaging materials to re-organize and/or store the raw or processed agricultural, livestock, fisheries, or forestry product.
Storage / display	The actor stores or displays the agricultural, livestock or fisheries product after processing and before it is sold.
Transportation: pick up	The actor picks up the product from the actor selling it or pays for the product to be picked up.
Transportation: delivery	The actor delivers the product to the actor who is buying it from them or pays for the product to be delivered.

Source: Authors' own elaboration.

Step 4 – description of on-farm activities

Step 4 directs users to report data on the on-farm activities. If the user identifies at least one (the tool allows up to three) category of actor as involved in primary production activities, the tool will automatically prompt the user to enter data in a group of cells (see **Figure 12**). However, if the user does not identify any actor who is engaged in primary production activities, the cells in **Figure 12** will remain grey and Step 4.bis will appear (see **Figure 13**).

Inputs in this step are crucial to quantify the amount of commodity at the origin of the agrifood VC and to track its physical flow across actors and activities in subsequent sections. Inputs in this step are also important to account for on-farm GHG emissions in the overall emissions. Please see **Box 5** for further guidance on data required for this step. **Table 15** shows Step 4 compilation instructions.

Box 5. Step 4 – note on data requirements

Total amount harvested

- Users must enter data for the entire category of actors and on a yearly basis (e.g. total amount of product produced in a year from all the actors within the category).
- Depending on the type of commodity selected in Step 2 (e.g. annual crop, milk, etc.), the tool will adapt units of measure accordingly.

On-farm GHG emissions

- EX-ACT VC tool does not calculate on-farm GHG emissions but can account for them in the total GHG emissions when provided as an input in this section. On-farm GHG emissions can be calculated by using tools such as FAO's EX-ACT or can be derived from literature.

Source: Authors' own elaboration.



ATTENTION

Make sure "total emissions associated with production" and "total amount harvested / produced" are both reported on a yearly basis.

Figure 12. Step 4 – data on on-farm activities

STEP 4 - Description of On-Farm Activities				
		Tomato Farmers		
For the SDG Tracker, can this category of actor be defined as "small-scale"?		Yes		
		Current	Planned	
Value-Chain (Meso) Level Data	Total Amount Harvested	13300.0	13300.0	Tonnes
	Total Land used for Production	1000.0	1000.0	Ha
	Average Yield	13.3	13.3	Tonnes/Ha
	Total Emissions Associated with Production	500.0	500.0	tCO ₂ e / yr
Individual (Micro) Level Data	Total Amount Harvested	13.3	13.3	Tonnes
	Total Land used for Production	1.0	1.0	Ha

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Table 15. Step 4 – instructions

1	For the SDG tracker, can this category of actor be defined as "small-scale"?	Users must select yes or no from the drop-down list, to define if the corresponding category of actor is to be considered as a "small-scale" producer by the tool. If users are unsure about the definition of small-scale producers, they are encouraged to use the Help tab, or the Glossary provided in these guidelines.
2	Total amount harvested / produced	Users must enter the total amount of primary agriculture product harvested / produced per year by the entire category of actors, within the value chain (e.g. multiply total production by two if there are two production cycles within a year). Values must be entered for both current and planned scenarios.
3	Total land / livestock used for production	Users must enter the total amount of land (in hectares), livestock (in heads), fish (in catch / tonnes landed) directly used to produce the Total Amount Harvested/Produced. The value must be per year and for the category of actors as a whole.
4	Average yield	No action required. The tool will automatically calculate the average yield given the total production and total amount of land/animals used for production.
5	Total emissions associated with production	Users must enter the total amount of tCO ₂ -e produced per year associated with production specified above (total amount harvested / produced). The value must therefore be per year and for the entire category of actors.

Source: Authors' own elaboration.

If the user does not identify any actor performing primary production activities, and/or if a category of actors purchases the primary commodity from outside the scope of the agrifood VC analysed, Step 4.bis will appear (see **Figure 13**). The user must select “Other Actor” in “Purchasing commodity from” in Step 3 in rows corresponding to actor D to allow this Step 4.bis pop-up.

It requires the user to input the total amount purchased from the “Other Actor”, and the tool will calculate the corresponding amount purchased at the individual level (see **Table 16**).

Figure 13. Step 4.bis

Total Amount Purchased from Other Actor:		processor		
		Current	Planned	
1	Value Chain (Meso) Level Data	20.0	30.0	Tonnes
2	Individual (Micro) Level Data	10.0	15.0	Tonnes

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Table 16. Step 4.bis – instructions

1	Value chain level data	Users should enter the amount purchased from “Other Actor” by the entire category of actor (e.g. by all processors).
2	Individual level data	No action required. The tool automatically calculates the amount purchased from “Other Actor” by the average actor within category (e.g. by the average processor).

Source: Authors’ own elaboration.

3.2 Commodity tracker

Commodity tracker module in the tool fulfils two objectives. It provides a comprehensive overview of the physical flow of the commodity across different actors and activities in the value chain. It also provides a comprehensive overview of how the commodity travels throughout the chain. This module is organized in two parts – “Flow of commodity” and “Transportation details” – which are described in the sections below.

Flow of commodity

! ATTENTION

The tool allows to fill in only the required data, depending on the actors identified and activities selected in the “Start” module. Hence, users will notice that if an actor does not perform an activity, the cells associated with said activity will automatically be in grey. If an actor does not exist, their name will not appear.

In this step, the user must quantify the flow of commodity throughout the agrifood VC studied. The module reflects each category of actor identified and includes all the activities selected at the Step 2 – Mapping of the value chain in the Start module. The user is only required to insert percentages related to the volume of the commodity flows in the corresponding activity cells. The tool then calculates the volume of the corresponding amount in units related to the commodity.

Figure 14 presents how the “Flow of commodity” appears for one category of actor; the same “block” being replicated for the other categories of actors. **Table 17** describes how to report data for each of the components in **Figure 14**.

! ATTENTION

In the “Flow of commodity” section, data must be entered **in terms of percentage** within each category. This section displays the values aggregated for the entire category of actor. It also displays the values for the average actor within the category at the end.

Figure 14. Commodity tracker – flow of commodity

Flow of Commodity ?						
For the entire category of actors:		Absolute (tonnes)		Percentage		
		Current	Planned	Current	Planned	
Tomato Farmers	Amount harvested	13,300	13,300			
	Amount left unharvested	-	-	0%	0%	
	Amount lost during harvest	399	399	3%	3.0%	
	Amount consumed	-	-	0%	0%	
	Amount lost during transport (pick up)	-	-	0%	0%	
	Amount put in storage, before processing	12,901	12,901			
	Amount lost during storage, before processing	-	-	0%	0%	
	Amount to be processed	12,901	12,901			
	Transformation rate in processing			100%	100%	
	Amount of edible by-product from processing	-	-	0%	0%	
	Amount of edible by-product not used/consumed	-	-	0%	0%	
	Amount after processing	12,901	12,901			
	Amount packaged	12,901	12,901			
	Amount placed in storage	12,901	12,901			
	Amount lost during storage	-	-	0%	0%	
	Amount lost during transport (delivery)	-	-	0%	0.0%	
	Amount of Tomatoes sold to Wholesalers & Processors	12,901		100%		
	Amount of Tomatoes sold to Wholesalers & Processors (planned)		12,901		100%	
	Amount sold to Wholesalers & Processors - Individual Level		13	13		

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Table 17. Flow of commodity

Amount harvested	No action required. This row of cells appears only for categories (A, B, C) which correspond to primary producers. Production data entered in “Step 4 – description of on-farm activities” in “Start” module is reflected here.
Amount left unharvested and lost during harvest	This row of cells appears only for categories (A, B, C) which correspond to primary producers. Users may enter the corresponding percentages to allow the tool to calculate the volume in absolute terms.
Amount consumed	This row of cells appears only for categories (A, B, C) which correspond to primary producers. In case an actor self-consumes part of its production, the user should enter the percentage of the amount harvested which is self-consumed.
Amount purchased	No action required. It refers to the quantity of product purchased from the previous actor. Hence, this row of cells does not appear in primary producers’ categories (A, B, C), but from category D onwards.
Amount lost during transport (pick up)	It refers to the amount lost from one actor to another during pick-up transport. The default share is 0 percent, and users can modify it as needed.
Amount put in storage (before processing)	No action required. The tool assumes that 100 percent of product purchased is put in storage (after deducting the amount lost during transport (pick-up)).
Amount lost in storage (before processing)	It refers to the amount lost while the product is placed in storage before processing. The default share is 0 percent, and users can modify it as needed.
Amount to be processed	No action required. The tool calculates it deducting the amount lost in storage (pre-processing) from the amount put in storage (pre-processing).
Transformation rate in processing	It refers to the amount of a good that must be forgone to create or attain another good. The amount of good acquired for processing will be transformed according to the processing capacities in place and may not be fully efficient depending on the system in place. The default transformation rate is 100 percent and the user may modify it accordingly.
Amount after processing	No action required. The tool calculates it multiplying the amount to be processed by the transformation rate in processing.
Amount of edible by-product from processing	It is the amount of secondary product derived from the production process that is edible or consumed. By default, it is 0 percent and users can modify the percentage as needed.
Amount of edible by-product not used/consumed	It is the amount of secondary product derived from the production process that is edible yet not used or consumed and follows other destinations (e.g. landfill, discards, sewer, etc.). By default, it is 0 percent and users can modify the percentage as needed.
Amount packaged	No action required. It is the amount after processing that is being packaged. The tool assumes that 100 percent is packaged.
Amount placed in storage	No action required. It is the amount after processing that is placed in storage. The tool assumes that 100 percent is packaged.
Amount lost during storage	It is the percentage of the amount placed in storage that is lost. The default share is 0 percent, and users can modify it as needed.

Amount lost during transport (delivery)	It is the percentage of the amount after processing, and after deducting the amount lost during storage, that is lost during transport delivery. The default share is 0 percent, and users can modify it as needed.
Amount sold to [next actor] (current / planned)	It is the final amount that is being sold to the next actor (after deducting the amount lost in storage and during transport (delivery, if any)). The default share is 100 percent, and the user can modify it as needed.
Total amount of product sold to (next actor) from (the entire category of actors)	No action required. It is the aggregated amount of product sold to the next category of actor.

Source: Authors' own elaboration.

Transportation details

Next to the "Flow of commodity" section, users can input the transportation data available for current and planned scenarios. Based on the data gathered from "Step 3 – mapping out the value chain" in "Start" module, the rows with transport entry will be populated. This reflects which actor is responsible for the transport (see

Figure 15). Users must select from a drop-down list the type of fuel and transport used, and also choose the type of conditioning. Users then enter the distance as number of kilometres travelled and the total amount of fuel used (in litres). **Table 18** describes how users should fill in the corresponding cells in the tool.

! ATTENTION

In the "Transportation details" section, data must be entered **for the average actor** within each category.

Figure 15. Transportation details

Transportation Details										Tier 2
Type of fuel		Type of transport used		# of km		Type of conditioning		Total Fuel Used (Litres)		
Current	Planned	Current	Planned	Current	Planned	Current	Planned	Current	Planned	
Diesel	Diesel	Light-duty-truck (3.5 - 7.5t)	Light-duty-truck (3.5 - 7.5t)	20	20	Non-refrigerated	Non-refrigerated	120	120	
		Light-duty-truck (3.5 - 7.5t) Medium-duty-truck (7.5 - 12t) Medium-duty-truck (12 - 20t) Medium-duty-truck (20 - 26t) Heavy-duty-truck (26-32t) Heavy-duty-truck container (26-32t) Heavy-duty-truck (up 34t) Heavy-duty-truck container (up 34t)								

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Table 18. Transportation details

1	Type of fuel	Users select from a drop-down list the type of fuel used. The tool allows to choose between gasoline, diesel, compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (LPG), electric or kerosene. The options “Unknown” and “None” are also allowed.
2	Type of transport	Users select from a drop-down list the type of transport used. This requires the selection of the type of fuel first.
3	# km	Users are required to input the number of kilometres (km) travelled.
4	Type of conditioning	Users choose from a drop-down list whether the type of conditioning is refrigerated or non-refrigerated.
5	Total fuel used	Users are required to input the total amount of fuel used in the selected trip (litres of fuel).
6	Tier 2 data	User can also use the “Tier 2 Data” table to the right of the “Transportation details” section, to input more accurate data in relation to transportation. The user can report in the designated white cells the context-specific emission factor intensity in tCO ₂ -e/tkm. This can be specified for both the current and planned scenarios.

Source: Authors' own elaboration.

3.3 Off-farm GHG assessment module

The “Off-farm GHG Assessment” module gathers the activity data required to calculate GHG emissions originating from the off-farm stages of the value chain (e.g. excluding primary production). On-farm GHG emissions (if the agrifood VC assessment requires them) must be calculated elsewhere and should be already reported in “Step 4 – description of on-farm activities” in “Start” module.

The module is organized vertically by activities and horizontally by categories of actors. The tool collects information on the following off-farm activities – storage (pre-processing), processing, packaging, storage/display. Information on water use is also collected, as well as on new infrastructure, if any.

The tool allows to enter only relevant data, highlighting only those categories of actors based on activities performed as identified by the user in the “Start” module. Hence, the tool automatically turns the cells that do not require compilation into grey. Every “activity block” includes the activity data required. Data can be entered for both the current and planned scenarios.



ATTENTION

Data must be entered **for the average actor within each category** and **on an annual basis**.

Figure 16 shows how the activity block related to Storage (pre-processing) looks like, being structurally similar to the other activity blocks, while **Table 19** reports in detail the activity data required in this module.

Figure 16. Activity data required for the off-farm GHG assessment – storage and display (post-processing)

STORAGE & DISPLAY (Post-processing/packaging)							
	Tomato Farmers						
	<table border="1"> <tr> <th>Current</th> <th>Planned</th> </tr> <tr> <td style="text-align: center;">12.901</td> <td style="text-align: center;">17.751</td> </tr> </table>	Current	Planned	12.901	17.751		
Current	Planned						
12.901	17.751						
Amount stored/displayed (Tonnes)							
Days in Storage type A							
Total volume of storage facility (m3)							
Electricity Used (kWh / day)							
Storage type A	<table border="1"> <tr> <td>Please select conditioning</td> <td>Please select conditioning</td> </tr> </table>	Please select conditioning	Please select conditioning				
Please select conditioning	Please select conditioning						
	<table border="1"> <tr> <td>Please select conditioning</td> <td>Please select conditioning</td> </tr> <tr> <td>Non-refrigerated</td> <td></td> </tr> <tr> <td>Refrigerated</td> <td></td> </tr> </table>	Please select conditioning	Please select conditioning	Non-refrigerated		Refrigerated	
Please select conditioning	Please select conditioning						
Non-refrigerated							
Refrigerated							
Days in Storage type B							
Total volume of storage facility (m3)							
Electricity Used during Storage type B							
Storage type B	<table border="1"> <tr> <td>Please select conditioning</td> <td>Please select conditioning</td> </tr> </table>	Please select conditioning	Please select conditioning				
Please select conditioning	Please select conditioning						

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Table 19. Activity data required for the off-farm GHG assessment

	Activity data	Units
Storage (pre-processing)		
No action required	Amount stored	tonnes
User's task	Days in storage	Number of days
	Volume of storage facility	m ³
	Electricity used	kWh/day
	Type of storage (selected from a drop-down list)	Non-refrigerated Refrigerated
	Total leakage	kg/year
Processing		
No action required	Amount to be processed	tonnes
User's task	Electricity used	kWh per tonne
	Country of energy grid (selected from a drop-down list)	N/A
	Fuel use gaseous and petroleum (selected from a drop-down list)	m ³ /tonne of product
	Other solid biomass (selected from a drop-down list)	tonnes of dry matter (tdm)
	Other (please specify)	In case a power source not mentioned available above, the user can specify it with the EF

	Activity data	Units
Water use		
User's task	Share of production involved in the process	%
No action required	Total water used	m ³ /tonne
User's task	Type of treatment (selected from a dropdown list)	N/A
	Industry product (selected from a dropdown list)	N/A
Packaging		
No action required	Amount packaged	tonnes
User's task	Type of packaging (selected from a drop-down list)	N/A
	Weight of material used for packaging	kg/tonne
Storage and display		
No action required	Amount stored/displayed	tonnes
User's task	Days in storage	Number of days
	Total volume of storage facility	m ³
	Electricity used	kWh/day
	Type of conditioning (selected from a drop-down list)	N/A
	Total leakage	kg/year
New Infrastructure		
User's task	Building (selected from a drop-down list)	m ² of built-up area

Source: Authors' own elaboration.

3.4 Socio-economic assessment module



ATTENTION

The user must enter data into all previous modules ("Start", "Commodity tracker" and "Off-farm GHG assessment") **prior** to entering data in the "Socio-economic assessment" module.

The socio-economic module collates all the information required to conduct the socio-economic assessment to measure value created, employment generated and women and youth participation across different actors and activities along the value chain.

Similar to the "Off-farm GHG assessment" module, this module includes a horizontal layout for up to nine actors, while it displays costs, revenues, and employment data vertically. Data should be entered for both the current and the planned value chain scenarios. To simplify data entry, costs, prices, taxes and salaries must be specified **in local currency**. Note that in the case of global value chains, the currency must reflect the country of each category of actor.

Before entering data in the socio-economic module, users are required to select whether they want the final results to be shown in USD or in LCU (data entry is always in local currency) (Figure 17). In case of a domestic value chain, the corresponding exchange rate will automatically pop up below. In case of a

global value chain, a small table summarizing the local currency of each category of actors will pop up below to enter data accordingly.

Figure 17. Selection of currency for results and exchange rate

Exchange Rates	
Please Select Currency for the Results	
USD	Results currency
KES	Local currency (LCU)
0.009259259	Exchange Rate

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

The next sections provide step-by-step guidance for the compilation of the costs, revenues, and employment data. As regards to costs, they are broken down into the following four categories: input costs, labour costs, fixed capital costs and other costs.

Input costs

The user must enter input costs for each of the activities (primary production, storage, packaging processing, transportation) performed by each category of identified actor. With the exception of primary production, the tool automatically lists the total amount of inputs used per average actor within a category (on an annual basis) based on information retrieved from previous modules. If a particular input is not used by an actor, the corresponding cells will remain grey. Users only have to enter the cost per unit of input across different activities and actors.

Users are advised to always check the units and to use the **Resources** tab for relevant data sources on various input costs.

Figure 18 represents the Input costs section layout in the tool (taking an example of the primary production input costs section), while **Table 20** reports the data required to compile this section.

Figure 18. Primary production input costs section

PRIMARY PRODUCTION INPUT COSTS		
<u>Please select relevant inputs:</u>	Tomato Farmers	
	Current	Planned
Total Amount of Seeds Used (tonnes)	0.5	0.5
Cost (LKR/tonne)	50,000.0	50,000.0
Total Amount of Fertilizer Used (tonnes)	0.5	0.5
Cost (LKR/tonne)	35,000.0	35,000.0
Total Amount of Pesticides Used (tonnes)	0.1	0.1
Cost (LKR/tonne)	45,000.0	45,000.0
Total Amount of Electricity Used (kWh)		
Cost of Electricity (LKR/kWh)		
Total Amount of Fuel Used (litres)		
Cost of Fuel (LKR/Litre)		
Other Primary Production Costs (LKR)	0.0	0.0



Amounts are on an annual basis, for an average actor.

Costs are on a per unit basis.

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Table 20. Data required for the Input costs section

Data required		Unit
Primary commodity costs		
The tool calculates the total cost of product purchased from the previous actor in the value chain. This will be available from category of actor D onwards, as categories A, B and C are the primary producers. (!) Costs are on an annual basis for an average actor within category.		LCU
No action required	Amount purchased	tonnes
User's task	Purchase price	LCU/tonne
No action required	Total cost of product purchased	LCU
Primary production input costs		
Users select inputs from a drop-down list (specific to the value chain commodity analysed). If a specific input cannot be found in the drop-down list, users can enter it under "Other input costs".		
User's task	Total amount of [input] used	tonnes
	Total amount of electricity used	kWh
	Total amount of fuel used	litres
	[Input]'s unit cost	LCU/tonne
	Cost of electricity	LCU/kWh
	Cost of fuel	LCU/ litre
	Other primary production costs	LCU
Storage (pre-processing) input costs		
No action required	Total electricity used	kWh
	Total refrigerant use	kg
User's task	Cost of electricity	LCU/kWh
	Cost of refrigerant	LCU/kg
User's task	Other storage input costs	LCU (tot)
Processing input costs		
No action required	Total electricity used	kWh
	Total water used	m ³
	Total [fuel] used	litres
	Total [other] used	tonnes
User's task	Cost of electricity	LCU/kWh
	Cost of water	LCU/m ³
	Cost of fuel / other	LCU/litre
	Cost of "Other"	LCU/tonne
Packaging input costs		
No action required	Total amount of [packaging material] used	kg
User's task	Cost of [packaging material]	LCU/kg
Storage / display input costs		
No action required	Total electricity used	kWh
	Total refrigerant use	kg

Data required		Unit
User's task	Cost of electricity	LCU/kWh
	Cost of refrigerant	LCU/kg
User's task	Other storage / display input costs	LCU (tot)
Transportation input costs		
No action required	Total fuel used	litres
User's task	Cost of fuel	LCU/litre

Source: Authors' own elaboration.

Labour costs

Labour costs are associated with employed labour force perceiving a salary, as opposed to the “non-remunerated (family) labour”. Similar to input costs, labour costs are disaggregated by activities that an average actor may perform (e.g. primary production, processing, transportation, etc.). For each activity, the users can describe further specific sub-activities (e.g. weeding in primary production) and are required to provide the total workdays required on an annual basis for each of such identified sub-activities, average daily wage paid for all the listed activities and the percentage of non-remunerated (family) labour involved. The average daily wage should refer to the salary of employees and should not take into consideration any unpaid labour. **Figure 19** shows the section layout for processing labour costs – as an example “block”, while **Table 21** summarizes general data requirements.

Figure 19. Processing labour costs section

PROCESSING LABOUR COSTS			
	Wholesalers	Processors	
		Current	Planned
Total Work-Days Required			
Washing		300.0	300.0
Manager		300.0	300.0
Electrician		120.0	120.0
Please describe labour activity			
Please describe labour activity			
Please describe labour activity			
Average Daily Wage (LKR)		650.0	650.0
% of Non-Remunerated (family) Labour		0%	0%

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Table 21. Data required for the labour costs section

1	Total work days required	# days
2	Average daily wage	LCU
3	Percentage of non-remunerated (family) labour	%

Source: Authors' own elaboration.



Users are encouraged to enter more information about gender and youth employment in an ad hoc module, by clicking on the **Gender and youth** icon. There, users have the option to enter supplementary information about the labour force employed by the category of actor. Please see section “Gender and youth” for more detailed explanation.

Fixed capital costs

Users are required to enter costs associated with fixed capital assets for the average actor. Fixed capital costs section is divided into two parts: infrastructure and machinery/vehicles. **Figure 20** shows how they appear within the tool, while

Table 22 summarizes data requirements to compile the sections.

Users should identify and describe any existing fixed capital assets of the average actor within a category. The section on new buildings will automatically be populated based on data entered in the previous modules. Users should specify both the value of the fixed asset (purchase price, or insured value, in local currency) as well as the expected lifetime of the asset (in years). By default, the tool assumes 30 and 15 years of lifetime for buildings and machinery/vehicles, respectively. The user can modify these numbers as needed. For existing buildings and machinery/vehicles, information is entered once for both current and planned scenarios, while for new buildings and machinery/vehicles, data is recorded only in the planned scenario.

Users should only enter information about fixed capital assets of the actor if the asset is directly used for activities relating to the commodity of the value chain.

Figure 20. Fixed capital costs section (infrastructure and machinery and vehicles)

MACHINERY & VEHICLES				
	Wholesalers		Processors	
	Both Scenarios		Both Scenarios	
Existing Machinery & Vehicles				
Processing Machine	Value (LKR)		Value (LKR)	25,00,000
	Lifespan (yrs)	15	Lifespan (yrs)	20
Packing Machine	Value (LKR)		Value (LKR)	1500000
	Lifespan (yrs)	15	Lifespan (yrs)	10
Light Duty Truck	Value (LKR)	1500000	Value (LKR)	
	Lifespan (yrs)	15	Lifespan (yrs)	15
New Machinery & Vehicles				
Please describe	Planned Scenario Only		Planned Scenario Only	
	Value (LKR)		Value (LKR)	
	Lifespan (yrs)	15	Lifespan (yrs)	15
Please describe	Value (LKR)		Value (LKR)	
	Lifespan (yrs)	15	Lifespan (yrs)	15
Please describe	Value (LKR)		Value (LKR)	
	Lifespan (yrs)	15	Lifespan (yrs)	15
Please describe	Value (LKR)		Value (LKR)	
	Lifespan (yrs)	15	Lifespan (yrs)	15

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Table 22. Data required for the Fixed capital costs section

1	Value of fixed capital asset	LCU
2	Expected lifetime	# years

Source: Authors' own elaboration.

Other annual costs

In this section users are prompted to enter information about any other annual costs that the average actor within the category incurs.

Prior to entering information about other costs, user must first identify what percentage of the average actor's revenue is attributable to the commodity being assessed (see **Figure 21a**). For example, if 30 percent of an average producer's annual revenue is from producing tomatoes, then 30 percent of the producer's total other annual costs will be attributed to tomato production. While the assumed direct relationship is unlikely to hold, users are encouraged to consider using this approach, or otherwise modify the other costs added so that they are only attributed towards the production of the main commodity being assessed.

Users may then enter other annual costs for the average actor within each category (see **Figure 21b**). These include taxes paid in the year of the analysis; costs related to machinery maintenance/repair; costs related to cleaning agents; the annual cost for renting land, buildings, or equipment; the interest on loans, if any; costs related to marketing and promotion; and insurance costs. If there are other annual costs which are not mentioned in the list, users can report them under "Other (please describe)". **Table 23** provides instructions for data entry on other costs.

Figure 21. Other annual costs section

a. Share of income from the commodity sold

← OTHER COSTS									
What percentage of the average actor's total income is accounted for by the sale of the following commodity? Commodity Sold Percentage of Total Income Attributed to Commodity of VC	<table border="1"> <thead> <tr> <th colspan="2">Tomato Farmers</th> </tr> <tr> <th>Current</th> <th>Planned</th> </tr> </thead> <tbody> <tr> <td colspan="2">Tomatoes</td> </tr> <tr> <td>100%</td> <td>100%</td> </tr> </tbody> </table>	Tomato Farmers		Current	Planned	Tomatoes		100%	100%
Tomato Farmers									
Current	Planned								
Tomatoes									
100%	100%								

b. Disaggregation of other annual costs

OTHER ANNUAL COSTS	Wholesalers		Processors	
	Current	Planned	Current	Planned
	Taxes	1,550.0	1,550.0	15,000.0
Machinery Maintenance/Repair			50,000.0	50,000.0
Cleaning Agents (detergents, disinfectants, etc)				
Rent (Land)				
Rent (Buildings)	30,000.0	30,000.0	30,000.0	30,000.0
Rent (Equipment)				
Interest on Loans				
Marketing & Promotion				
Insurance				
Other (please describe)				
Other (please describe)				

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Table 23. Data required for the other annual costs section

1	Percentage of total income attributed to commodity of value chain	Users may enter the share of the actor's total income that is derived from selling the product (its final output) of the analysed value chain. Thus, not including the income derived from selling other commodities that may be produced.
2	Other annual costs	Users could include other annual costs related to the operation of the business, if they have a connection with the commodity of the assessed value chain.

Source: Authors' own elaboration.

Total costs

The tool aggregates all the input and labour costs, fixed costs, and other costs to calculate and display the total costs per actor. The cost per actor per tonne of product sold is also derived for each category.

The total costs will be estimated either in USD or in a local currency unit dependent on the country based on the selection made at the beginning of the module ("Please select currency for results") by the user. In case of a global value chain, the currency may differ throughout the categories of actors, according to their location. Users are suggested to review results in the total costs section to ensure consistency and accuracy of their data entries.

Total revenues and other economic indicators

In this section the user must enter the price at which every average actor sells the product to the next one in the value chain (e.g. a selling price) (see **Figure 22**). Users may also enter any annual subsidies or grants that are associated with the production of the commodity for the average actor, if applicable.

The tool then calculates several economic indicators for the average actor within each category. Depending on the selection made by the user at the beginning of the module ("Please select currency for results"), the economic indicators will be estimated **either in USD or in the country's currency**. If a global value chain is analysed, the currency may differ throughout the categories of actors, according to their location.

Figure 22. Prices and subsidies in total revenues section

	Tomato Farmers	
	<u>Current</u>	<u>Planned</u>
Amount sold (tonnes)	12.9	17.8
Selling Price (LCU / Tonne)	25,000.0	25,000.0
<u>Other annual revenue sources:</u>		
Direct subsidies/government payments		
Grants		

Note: Screenshot of the EX-ACT VC tool.


Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Table 24. Data required for the fixed capital costs section

1	Amount sold	No action required. The tool automatically retrieves the amount of product sold to the next actor (for the average actor).
2	Price of product sold	Users should enter the selling price that is the price at which the actor offers the product for sale to the next actor.
3	Other annual revenue sources	Users may enter additional sources of revenue; in case the actor receives subsidies or government payments in relation with the commodity of the analysed value chain.

Source: Authors' own elaboration.

Gender and youth

Users can utilize this module to explore women and youth participation in the value chain. The tool differentiates women participation as owners, managers, and employees. Hence, for each identified category of actors, users may specify the percentage of women owning a business, and the percentage of women in managerial positions. Further information can be found in the **HELP** tab, by clicking on the symbol .

Similarly, to account for youth participation, users may also distinguish the percentage of employees within each category of actors according to three different age groups: (i) under the age of 15; (ii) between the ages of 15 and 24; (iii) 24 years old and older. Of the percentage of employees within the three age categories, users can specify what percentage are female. **Figure 23** presents the module layout, while **Table 25** illustrates the data required to compile the module.

Figure 23. Gender and youth module

	Tomato Farmers	
	Current	Planned
Total Actors within Category	1,000	1,000
Percentage of women in ownership (%)	50%	50%
Total Managerial Position within Category		
...of which are held by women (%)		
Total Hired Labour within Category	84	84
Percentage of hired workforce <15 yrs		
... of which are women (%)		
Percentage of hired workforce 15-24 yrs		
... of which are women (%)		
Percentage of hired workforce >24 yrs		
... of which are women (%)		

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Table 25. Gender and youth module

Ownership		
1	Total actors within category	No action required. Alternatively formulated as the number of "operations"/businesses within each category.
	Percentage of women in ownership (%)	Report it as a share of total actors within category. Alternatively formulated as "the share of "operations" owned by women".
Management		
2	Total managerial positions within category (#)	Report it as the sum of all managerial positions within each category of actor.
	... of which are women (%)	Report the percentage of women in managerial positions (as a share of the total managerial positions within category).
Employment		
	Total hired labour within category	No action required. As the sum of all hired workforce of all actors within category.
3	Percentage of hired workforce <15 years, 15–24 years, >24 years	Report it as a share of the total hired workforce within category for each age group.
	... of which are women (%)	Users may report the percentage of female as a share of the total hired workforce within category for each age group.
	Total family (non-remunerated) labour within category	No action required. As the sum of all family (non-remunerated) workforce of all actors within category.
4	Percentage of family workforce <15 years, 15–24 years, >24 years	Report it as a share of the total family workforce within category for each age group.
	... of which are women (%)	Users may report the percentage of female as a share of the total family workforce within category for each age group.

Source: Authors' own elaboration.

PART 4. Interpretation of the results

This section discusses the different results generated by the EX-ACT VC tool which are organized under three modules – the first module summarizes estimated environmental indicators, the second presents the calculated socio-economic indicators, and the third module quantifies progress towards SDG targets. This section also explains how to interpret the results of different indicators and how they can be used in design or evaluation of a value chain project or policy.

4.1 Environmental results

The “Environmental results” module summarises the environmental indicators estimated by the EX-ACT VC tool, namely – GHG emissions, carbon footprint, water usage, and food loss.

GHG emissions

This section reports the total GHG emissions in tonnes of CO₂-e per year, for the entire value chain. It also reports GHG emissions estimated for each category of actor and for each activity across the value chain (see **Figure 24a**). The results are presented for both the current and planned scenario. The tool also reflects the change between the two scenarios which represents the net balance from all GHGs that were emitted, reduced, or avoided due to a value chain project or policy.

A coloured marker next to the value of the change visually displays the impact directionality of the project or policy. The impact of a project or policy on environment is positive if GHG emissions decrease and is represented by a green marker. The impact of a project or policy on environment is negative if GHG emissions increase and is represented by a red marker. The yellow marker represents no impact of the project or policy on GHG emissions.

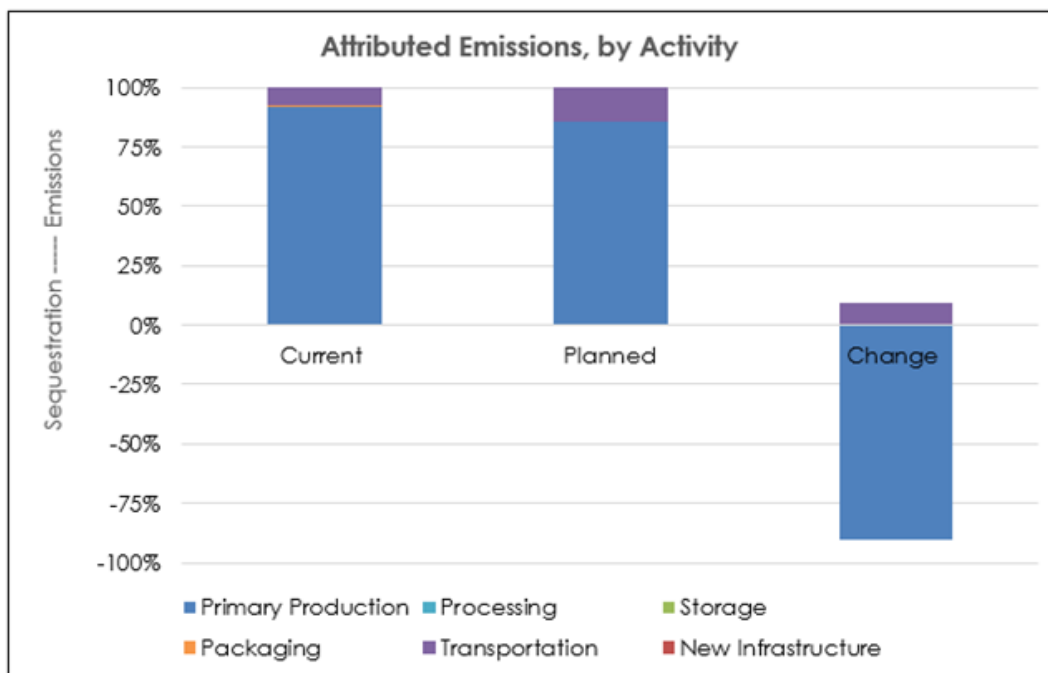
GHG emissions by actor and activity are also visually represented in bar graphs (see **Figure 24b**) to assist the user to intuitively understand the results and highlight actors and activities that most contribute to either GHG emissions or reductions. This can help the users identify potential entry points for subsequent interventions and investments to reduce GHG emissions in the assessed value chain.

However, it is important to revisit some limitations of the tool to estimate GHG emissions. It uses a simple cost-effective approach to quantify GHG emissions as a function of activity. Hence the accuracy of the estimation depends on both the emission factors and activity data. EX-ACT VC tool does not calculate the emissions from food loss, thereby compromising the completeness of the evaluation. The tool does not report any quantitative or qualitative uncertainty assessments associated with the use of default emission factors. As the tool only provides an annual assessment of the agrifood VC, it cannot capture the GHG impacts of any feedback loops and dynamic interactions that may arise over a time-period within the value chain.

Users are encouraged to use Tier 2 or Tier 3 emission factors and associated activity data when available to improve the accuracy of the GHG emissions indicator for project or policy evaluation.

Figure 24. GHG emissions results**a. GHG emissions, by actor, and by activity**

Greenhouse Gas Emissions (tonnes of CO ₂ -e)				
		Current	Planned	Change
Total GHG Emissions (tCO ₂ -e per year):		600	487	● -112
Total GHG Emissions, by category of actor:	Tomato Farmers	500	350	● -150
	Wholesalers	42	58	● 16
	Processors	58	80	● 16
Total GHG Emissions, by activity:	Primary Production	500	350	● -150
	Processing	41	56	● 15
	Storage	0	0	● 0
	Packaging	18	24	● 7
	Transportation	42	57	● 16
	New Infrastructure	-	0	● 0

b. Graphical representation of GHG emissions, by activity

Note: Screenshot of the EX-ACT VC tool.

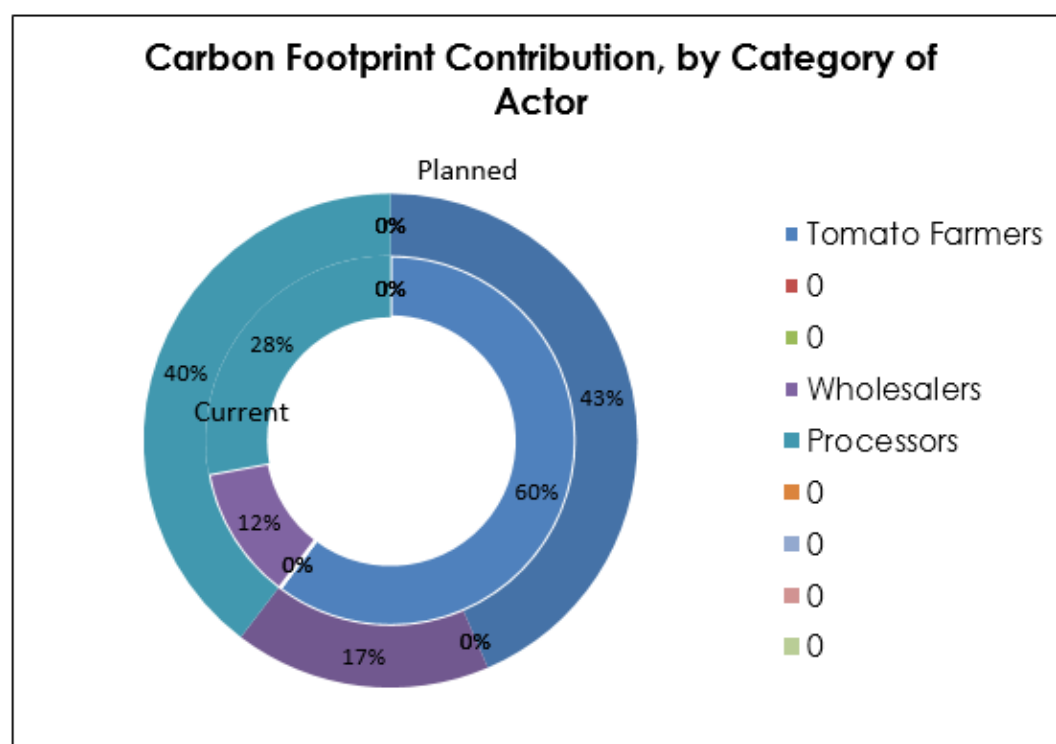
Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Carbon footprint

The carbon footprint (GHG emissions in tonnes of CO₂-e per year, **per tonne of product**) results are reported for the entire value chain first and then disaggregated by category of actor and by activity (see **Figure 25**). The estimated carbon footprint is reported for both the current and planned scenario and the change between the two scenarios. Similar to GHG emissions, the results are shown for both the current and planned scenario, and the change between the two is displayed. A coloured marker next to the value visually displays the sinks or reductions in green, the emissions in red, and no change in yellow. A graph also breaks down the attributed carbon footprint by actor and activity, assisting the user to read the results and highlight the changes.

Figure 25. Carbon footprint results**a. Carbon footprint results table**

Carbon Footprint (tonnes of CO ₂ -e per tonne of product) ¹				
		Current	Planned	Change
Overall Carbon Footprint, entire Value Chain:		0.186	0.110	● -0.076
Carbon Footprint, by category of actor:	Tomato Farmers	0.04	0.02	● -0.02
	Wholesalers			● 0.00
	Processors	0.01	0.01	● 0.00
			0.02	● 0.00
Carbon Footprint, by activity:	Primary Production	0.04	0.02	● -0.02
	Processing	0.00	0.00	● 0.00
	Storage	0.00	0.00	● 0.00
	Packaging	0.00	0.00	● 0.00
	Transportation	0.00	0.00	● 0.00

b. Carbon footprint results graph

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Water usage

This section reports the water usage (in litres) for all the actors engaged in any processing activities and also per tonne of final product both for the current and planned scenario. It also disaggregates water usage by category of actor (see **Figure 26**). The user can also compare the difference in water usage from the current and the planned scenario.

The impact of agrifood VC project or policy on environment is positive if the amount of water used in absolute terms and per quantity of final output decreases. This indicator can be particularly useful for

projects whose emphasis is on resource management. It is important to note here that the tool uses a simplified approach to calculate water use and does not distinguish between the types of water source (Mekonnen and Hoekstra, 2011). Users who are interested in differentiating water sources need to perform such exercise outside the scope of the EX-ACT VC tool.

Figure 26. Water usage results

Water Usage (in litres)				
		Current	Planned	Change
Total Water Used :		1612.625	2218.875	38%
Water Used, per tonne of final product :		0	0	0
By Category of Actor:	Tomato Farmers	0	0	0
	Wholesalers	0	0	0
	Processors	1612.625	2218.875	606.25

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Food loss results

This section displays the food loss (in tonnes) along the entire value chain and the food loss occurring at each category of actor identified (see **Figure 27**). Results are reported for both the current and planned scenario and also the comparative change between the two scenarios.

The impact of agrifood VC project or policy on the environment is positive if the food loss value decreases and the percentage of change between the two scenarios is negative.

Figure 27. Food loss results

Food Loss ^{1,2} (in tonnes)				
		Current	Planned	Change (%)
Total Food Lost:		3624	4987	27%
By Category of Actor:	Tomato Farmers	399	549	27%
	Wholesalers	0	0	0%
	Processors			27%
				0%

Notes: Screenshot of the EX-ACT VC tool. Food loss results take the following considerations: i) exclude any product that is consumed by the producers, including harvested product left in fields; ii) exclude any inedible by-product from processing.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

Monetary value of GHGs emitted in the value chain

The EX-ACT VC tool uses default lower and upper bound social cost of carbon (SCC) prices from Nordhaus (2017) and calculates the economic value of total GHG emissions from the value chain and the carbon footprint of the value chain end product. The values are reported for both the current and planned scenario and the change between the two (see **Figure 28**).

The impact of agrifood VC project or policy is positive if the economic value of emissions decreases, and the impact is negative if the economic value of emissions increases. This indicator is directly influenced by the total GHG emissions, and the carbon footprint derived in the environmental assessment.

The SCC is one useful tool to monetize the climate change damage avoided when agrifood VC projects or policies reduce GHG emissions. Scientists estimate the SCC using Integrated Assessment Models (IAMs) that represent our society, climate, and the way they interact. These models are inherently uncertain and incomplete, and the SCC estimates vary widely because of different assumptions these different models follow about future emissions, climate response, discount rates and damage functions (Pindyck, 2019).

The EX-ACT VC tool uses default global SCC estimates from Nordhaus (2017), but the users are encouraged to explore and enter a range of values based on several other global, regional, or country level SCC estimates where available when they wish to reflect fundamentally different future assumptions and to align the project or policies in that direction.

Despite the many uncertainties, caveats, and contention points surrounding the SCC, it still may offer an added lens through which costs associated with GHG emissions can be assessed, providing a better picture of a project or policy viability in monetary terms.

Figure 28. Monetary value of GHGs estimated in the value chain

*Lower and upper bounds may be changed							
Social cost of carbon USD (lower bound) per tCO ₂ -eq			\$44.15	Social cost of carbon USD (upper bound) per tCO ₂ -eq			\$165.72
	Lower Bound			Upper Bound			
	Current	Planned	Change	Current	Planned	Change	
Per Tonne (tCO ₂ -eq per tonne of final product)	\$8.2	\$4.8	-\$3.4	\$30.8	\$18.2	-\$12.6	
Total (tCO ₂ -eq per year)	\$26,484.5	\$21,519.7	-\$4,964.8	\$99,411.3	\$80,775.6	-\$18,635.7	

Note: Screenshot of the EX-ACT VC tool.

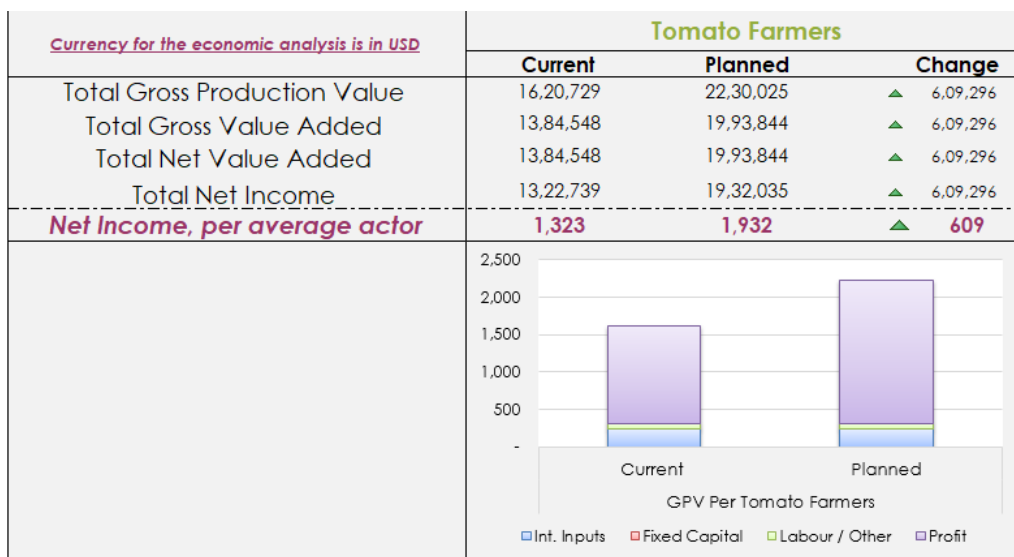
Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

4.2 Socio-economic results

The “Results – Socio-economic” module in the tool summarises estimated socio-economic indicators, under four sections: “Economic value of climate mitigation actions”, “Economic analysis”, “Employment” and “Gender and youth analysis”.

Economic analysis

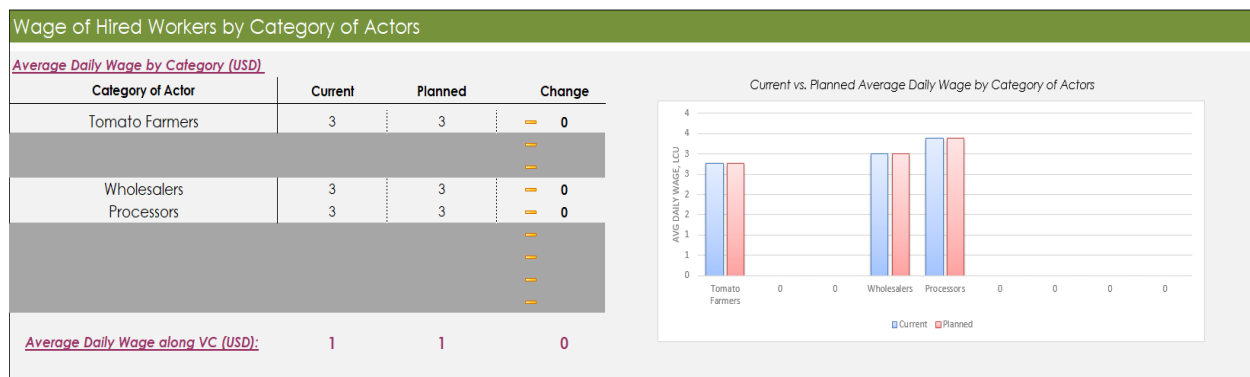
The results in the economic analysis are categorized in terms of value added and the distribution of such value-added wealth among different production factors. The total gross production value, gross value added, net value added, and total net income is reported for each of the category of actor identified. Net income per average actor in a category is also reported (see **Figure 29**). The results are estimated for both the current and planned scenario and also present the change between the two scenarios. The results are displayed either in USD or local currency units based on user selection in socio-economic assessment module. The tool also displays bar-graphs for a quick overview of the gross production volume of an individual actor and disaggregates the various costs and profits associated.

Figure 29. Economic indicators by category of actor

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

The tool calculates and presents the average daily wage of employed workers, for example hired labour perceiving a wage across different actors along the value chain for the current and planned scenario as well as the change between the two (see **Figure 30**). The wage reported is for the average actor. An associated graph provides a visual overview.

Figure 30. Wage of employed workers by category of actors

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

The impact of agrifood VC project or policy in terms of economic dimension is positive if each measure in **Figure 29** and **Figure 30** increases from the current scenario and the change between the current and planned scenario is positive. Users can identify potential trade-offs between value-added and how it is being distributed among the two major production factors namely capital (total net income) and labour (wages). The relative changes in capital and labour compensation provide users insights into any inequalities arising from the agrifood VC project or policy and can help users identify entry-points for interventions.

The accuracy and the completeness of the economic analysis depend on the user inputs.

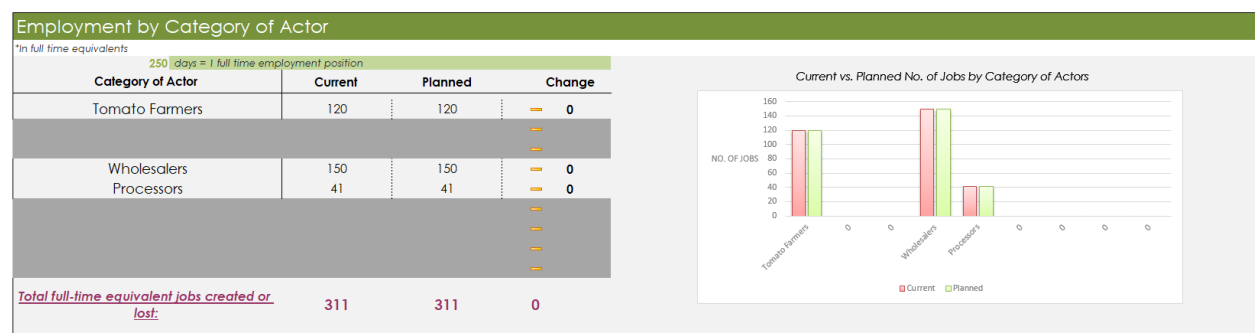
Employment along the value chain

Employment generated across the value chain is summarized for both current and planned scenarios as well as for the change between the two along three different classifications (see **Figure 31**):

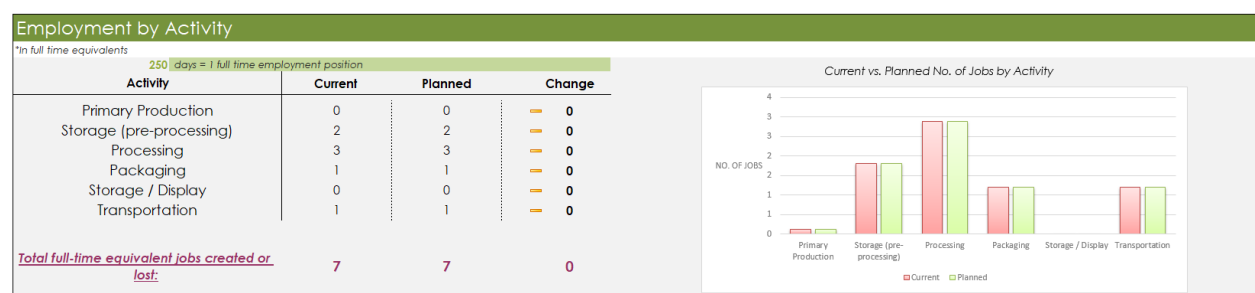
1. Category of actor (as identified by the user in the “Start” module).
2. Type of activity (e.g. primary production, storage [pre-processing, processing, packaging, storage/display and transportation]).
3. Employment sector (e.g. on-farm vs off-farm and family vs hired labour).

Figure 31. Employment results

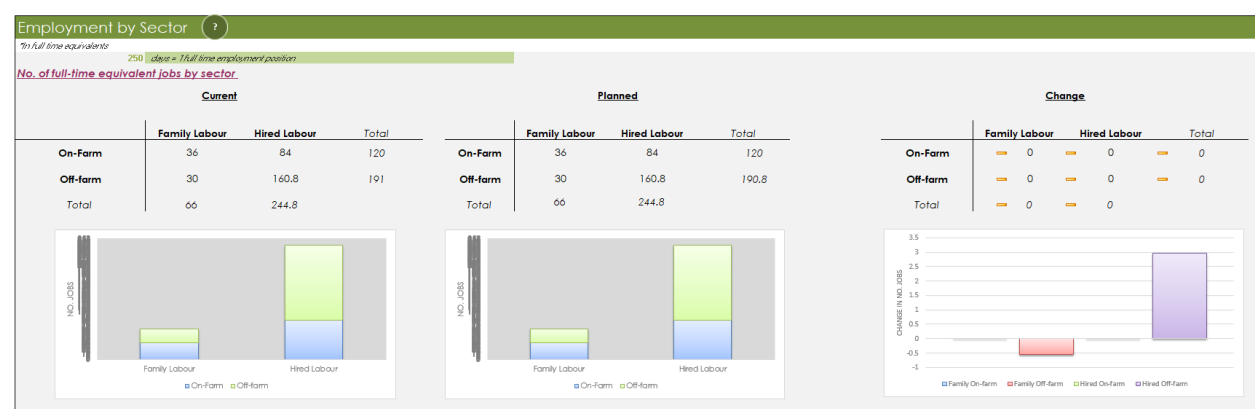
a. Employment by category of actors



b. Employment by activity



c. Employment by sector



Note: Screenshots of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

The impact of an agrifood VC project or policy on employment is positive if the number of jobs increase across each of the actor and activity along the value chain. The users have a holistic view that allows them to identify entry-points for job creation and redistribution of non-remunerated family labour.

The accuracy and completeness of the employment indicator depends on the user inputs.

Gender and youth analysis

Women and youth participation across the value chain is reported in this section. The results are organized across each category of actor and then aggregated to the whole value chain in the current and planned scenario (see **Figure 32**). The change between the two scenarios is also reported. Women's participation in the value chain is categorized under:

- Number of women in ownership (e.g. owning a business)
- Number of women in managerial positions
- Number of women employed as hired and family labour.

A graphical representation of the change is also provided (see **Figure 32**). The number of jobs disaggregated by age group and gender is reported for the current and planned scenarios in two respective graphs.

The accuracy and the completeness of the gender and youth analysis depends on the user inputs.

Figure 32. Gender and youth analysis – women's participation

Women Participation in the VC						
Category of Actor	Ownership <i>No. of women in ownership</i>			Management <i>No. of women in managerial positions</i>		
	Current	Planned	Change	Current	Planned	Change
Tomato Farmers	500	500	— 0.0	0	0	— 0.0
			—			—
Wholesalers	0	0	— 0.0	0	0	— 0.0
Processors	1	1	— 0.0	0	0	— 0.0
			—			—
			—			—
			—			—
Total:	501	501	— 0	0	0	— 0

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

4.3 SDGs tracker










The "Results – SDG" module summarises the results achieved in the five SDGs accounted by the tool, these are SDG 2 – Zero Hunger; SDG 5 – Gender Equality; SDG 6 – Clean Water and Sanitation; SDG 9 – Industry, Innovation and Infrastructure; and SDG 12 – Responsible Consumption and Production.

The tool adjusts the analysis to the scope of the value chain, automatically calculating an indicator related to the "sub-goals" that are tracked. By comparing the current and planned scenarios, it indicates whether or to which extent the (proposed) changes to the value chain would result in an achievement of the SDG target. The extent of the target's achievement is expressed as a percentage (see **Figure 33**).

For instance, the tool may report "The proposed changes to this value chain would result in a 50 percent achievement of the goal of doubling incomes of small-scale producers", if the income of small-scale producers were USD 1 000 and USD 1 500, in current and planned scenarios, respectively.

SDGs offer a shared impact language for users and aligning projects and policies with SDGs offers a tremendous opportunity to understand where and how much difference they make and communicate it to a broad range of audiences. The tool currently does not consider all the SDGs and tracks a set of only five SDGs with which the estimated indicators offer the highest synergies or trade-offs.

Figure 33. SDG tracker results

Connections to the UN Sustainable Development Goals				
Goal	Target	Indicator	Result	
 2.3	By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	2.3.1 Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size	The proposed changes to this VC would result in a 37.6 percent achievement of the goal of doubling productivity of small-scale producers.	
		2.3.2 Average income of small-scale food producers	The proposed changes to this VC would result in a 46.1 percent achievement of the goal of doubling incomes of small-scale producers.	
 5.5	Ensure women's full and effective participation and equal opportunities for leadership at all levels of decisionmaking in political, economic and public life	5.5.2 Proportion of women in managerial positions		
 6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 Change in water-use efficiency over time		
 9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	9.4.1 CO2 emission per unit of value added		
 12	By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	12.3.1 Global food loss index*	The proposed changes to this VC would result in food losses increasing by 37.59 percent.	

Note: Screenshot of the EX-ACT VC tool.

Source: FAO. 2022. *EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)*. Version 3. Rome. Cited 15 March 2022. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act-vc/en

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Agrifood value chain	Agrifood value chain links several people and activities to bring an agricultural commodity from production in the field to the consumer, through several stages such as processing, packaging, and distribution. Every stage of the value chain progressively creates added value that accumulates in the product until it reaches the final consumer.
Carbon balance	The carbon balance is the net balance from all greenhouse gases expressed in tonnes of carbon dioxide equivalent (tCO ₂ -e) that were emitted, avoided, or sequestered due to project implementation as compared to a business as usual scenario.
Carbon footprint	The carbon footprint of a product is the total amount of greenhouse gases emitted during production, processing, transporting, packaging, and storing the product, expressed in tonnes of carbon dioxide equivalent (tCO ₂ -e) per tonne of the product.
Category of actor	A category of actor in the value chain is defined as a type of individuals, households, farms, firms, etc., who share similar activities performed (e.g. farmers) and scale (e.g. small, medium and large).
Climate change mitigation	Climate change mitigation encompasses a set of actions and interventions to prevent, reduce or remove greenhouse gas emissions.
Domestic value chain	A domestic value chain is a production process that takes place within the boundaries of a given country. It requires producing the outputs within the country using only domestically sourced inputs.
Family labour	Family labour (or workers) are members of a family, who help each other to run an agricultural holding or other businesses and who are not formally considered as employees.
Food loss	Food loss is the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers. It refers to any food that is discarded, incinerated, or otherwise disposed of along the food supply chain from harvest/slaughter/catch up to, but excluding, the retail level, and does not re-enter in any other productive utilization, such as feed or seed. (FAO, 2019a).
Food waste	Food waste is the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers (FAO, 2019a).
Global value chain	Global value chains are the linked sets of value creating activities all the way from basic raw material sources for component suppliers through the ultimate end-use product delivered into the final customer's hands. All the activities involved in this process may involve foreign sourced inputs and internationally marketed outputs.
Greenhouse gases	Greenhouse gases or GHGs absorb and emit radiant energy within the thermal infrared range, causing the greenhouse effect, which results in increased temperatures on Earth. In the context of EX-ACT VC tool, GHGs are three of the six gases listed in the Kyoto Protocol: carbon dioxide (CO ₂), methane (CH ₄), nitrous oxide (N ₂ O).

Hired labour	Hired labour are workers who are employed in both the formal and informal economy by others (such as people, organizations or enterprises who are termed employers) and receive a salary/wage as compensation for work.
On-farm employment	Employment of workforce for tasks that deal with on-farm production activities (e.g. sowing and harvesting).
Off-farm employment	Employment of workforce in all agriculture-related activities that occur beyond the farm, that begin with post-harvest activities and end with retailing (e.g. primary or secondary processing, packaging, transportation and distribution).
Selling price	The selling price is the price at which the value chain actor (e.g. producer, wholesaler and retailer) offers the product for sale to the next actor in the value chain. It should exceed the purchase price by the actor's marketing margin, and – if any – transportation and market charges and incidental expenses.
Small-scale producer	For the purpose of this guidelines, following FAOs relative approach (FAO, 2017) small-scale producers can be defined using two criteria: physical size of the farm as expressed by land size in hectares and total livestock heads; economic size of the farm with total revenues measured in Purchasing power parity (PPP). Small-scale producers are those falling in the bottom 40 percent of the distribution of land size, total livestock heads or total revenues measured in PPP.
Social cost of carbon (SCC)	The social cost of carbon is the estimated monetary value for the damage caused by an incremental increase (by convention, one metric tonne) of CO ₂ emissions in a given year. Estimates of the SCC come from Integrated Assessment Models (IAMs) which aim to predict the effects of climate change under various future scenarios and assumptions and allow to estimate the monetary value of the climate change impacts.

Annex 1. Origins and development of EX-ACT VC

The first version of EX-ACT VC was released in 2016 and in 2020 it underwent a significant revision to increase its flexibility and comprehensiveness. The main objective of the tool remains the same: to assess environmental impacts of value chains, in terms of climate mitigation potential, including an analysis of the socio-economic performance in terms of value added, income and jobs generated throughout the chain.

A major structural change involved the removal of the calculation of the land-based GHG emissions at the farm level (production), which was performed through the partial inclusion of the FAO's Ex-Ante Carbon-balance Tool (EX-ACT).⁶ The underlying rationale was to increase the flexibility of the analysis and to foster the synergies of using both tools. Nevertheless, the revised version allows to account for the on-farm GHG emissions (e.g. from land use change or agriculture intensification, etc.), by retrieving results from separate analyses using EX-ACT or other on-farm GHG accounting tools. In this way, it is possible to account fully for land-based emission sources of the product, in addition to the emissions from off-farm stages of the value chain (e.g. from activities beyond production).

The revision involved an expansion of the scope of the socio-economic assessment aimed at including the imbalanced power relations and participation levels between men and women, and across different age groups, in particular youth, in the agrifood value chain. These imbalances, which can take different forms, such as the access to physical capital, services, and opportunities, the control of assets, and the ability and willingness to participate in decision-making process, can affect the efficiency and competitiveness of a value chain. For these reasons, a quantitative component aimed at analysing women and youth participation along stages of the value chain was added.

Similarly, to enhance the scope of the analysis, the revision also established a link to the Sustainable Development Goals (SDGs), introducing an "SDG tracker" to track progress – at the value chain level – towards selected SDG targets. While agrifood value chains are inherently linked to many SDGs, the tool, at this stage, tracks performance towards five SDGs, namely: Zero Hunger (SDG 2); Gender Equality (SDG 5); Clean Water and Sanitation (SDG 6); Industry Innovation and Infrastructure (SDG 9); and Responsible Production and Consumption (SDG 12).

Within the objective of providing a tool with an entirely quantitative approach, the qualitative resilience component was removed. In fact, resilience by itself entails another complex system where quantitative approaches are scarce.

On the methodological side, the tool's revision aimed at increasing its flexibility, by allowing the users to map unique agrifood VCs; enhancing its comprehensiveness, by allocating environmental and socio-economic results, both at the actor and activity level; and increasing transparency by directly showing the flow of commodity throughout the value chain.

All these modifications lead to the framework depicted in **Figure 1**.

⁶ The Ex-Ante Carbon-balance Tool (EX-ACT) is an appraisal system developed by FAO providing *ex ante* estimates of the impact of agriculture and forestry development projects, programmes and policies on the carbon balance. It is a land-based accounting system, estimating carbon stock changes (e.g. emissions or sinks of CO₂) as well as GHG emissions per unit of land, expressed in equivalent tonnes of CO₂ per hectare and year for the on-farm activities and the specific duration of a project.

Annex 2. Additional information on methodological guidelines

A.2.1 Identifying the value chain

As explained in Section 1.4 and 1.5, the EX-ACT VC tool currently allows the assessment of a single commodity or product. Therefore identifying a value chain to assess in EX-ACT VC tool will be straightforward for projects and policies dealing only with a single commodity or product. However, agrifood value chains are complex, with often a single commodity being transformed into multiple products. For projects and policies dealing with either multiple commodities or multiple products, it is necessary to identify and prioritize which commodity or product is to be analysed. The following resources can guide users in selecting value chains for EX-ACT VC assessments:

1. Guidelines for value chain selection by ILO (accessible at: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/instructionalmaterial/wcms_416392.pdf).
2. Making Value Chains Work Better for the Poor by the United Kingdom of Great Britain and Northern Ireland Department for International Development (DFID) (available at: www.fao.org/3/at357e/at357e.pdf).

A.2.2 Mapping number of actors

Table A1. Illustrative steps to map the number of actors

Actor	Calculating the number of actors
Farmers (producer)	<ul style="list-style-type: none"> • Estimate number of farmers based on hectares under each crop and yield (related to traded volumes). • Cross check with district authorities for official figures. • Sales of key inputs sold by input providers at bottleneck points (e.g. seed).
Aggregators	<ul style="list-style-type: none"> • Interviews with village leaders / community. • Number of aggregators under each trader/wholesaler. • Estimate the total volume of sales and the typical volume per transport unit (trucks, motorbikes, carts, boats, etc.). Then estimate the number of people required per transport unit, the time required to transport and the number of full-time equivalents this generates.
Processors	<ul style="list-style-type: none"> • Identify the number of processors in an area from official sources (e.g. registration certificates). • Identify the number of informal processors from key informant interviews such as government officials (involved in registration, tax collection, distribution of utilities, etc.), aggregators, processors, and wholesalers.
Wholesalers	<ul style="list-style-type: none"> • Identify the number of wholesalers in an area from official sources (e.g. registration certificates). • Identify the number of informal wholesalers from key informant interviews, such as government officials (involved in registration, tax collection, and distribution of utilities etc.) processors, wholesalers and retailers.
Retailers	<ul style="list-style-type: none"> • Based on the total traded volume of a product in a value chain and the average daily turnover of the sample retailers, the user can calculate how many retailers are involved.

Source: Authors' own elaboration

Annex 3. Country level grid emission factor

For electricity consumption, EX-ACT for VC proposes two sets of emission factors related to the energy grid following the Harmonized IFI Default Grid Factors (IFI, 2021). The default is the Operating Margin (OM) emission factor, representing electricity generation from existing power plants with the highest variable operating costs to dispatch the electricity across the system.

Users can also choose to adopt a Combined Margin (CM) emission factor, which additionally accounts for the annual emission intensities of new electricity generation projected over the next 8 years under the Stated Policy Scenario (STEPS) of the most recent IEA World Economic Outlook. As a result, CM emission factors thus take stock of projected changes in emissions of the electricity generation systems.

Table A2. Grid emission factors, in tCO₂-e/MWh

Country	EF OM	EF CM	Country	EF OM	EF CM	Country	EF OM	EF CM
Afghanistan	0.414	0.193	Gabon	0.946	0.533	Oman	0.479	0.320
Åland Islands	N/A	0.256	Gambia	0.753	0.591	Pakistan	0.592	0.386
Albania	N/A	0.226	Georgia	0.289	0.135	Palau	0.753	0.497
Algeria	0.528	0.397	Germany	0.650	0.313	Palestine	N/A	0.517
American Samoa	0.753	0.516	Ghana	0.495	0.276	Panama	0.477	0.230
Andorra	0.188	0.070	Gibraltar	0.779	0.369	Papua New Guinea	0.597	0.315
Angola	1.476	0.748	Greece	0.507	0.346	Paraguay	N/A	0.00001
Anguilla	0.753	0.472	Greenland	0.264	0.105	Peru	0.473	0.252
Antigua and Barbuda	0.753	0.489	Grenada	0.753	0.523	Philippines	0.672	0.525
Argentina	0.478	0.288	Guadeloupe	0.753	0.433	Pitcairn	N/A	0.451
Armenia	0.390	0.205	Guam	0.753	0.428	Poland	0.828	0.532
Aruba	0.753	0.441	Guatemala	0.753	0.427	Portugal	0.389	0.228
Australia	0.808	0.421	Guernsey	N/A	0.256	Puerto Rico	0.596	0.362
Austria	0.242	0.113	Guernsey, Bailiwick of (Sark)	N/A	0.256	Qatar	0.503	0.258
Azerbaijan	0.534	0.384	Guinea	0.753	0.460	Republic of Korea	0.555	0.330
Bahamas	0.753	0.441	Guinea-Bissau	0.753	0.577	Republic of Moldova	0.541	0.399
Bahrain	0.726	0.454	Guyana	0.847	0.616	Réunion	0.772	0.421
Bangladesh	0.528	0.412	Haiti	1.048	0.765	Romania	0.489	0.289
Barbados	0.749	0.484	Heard and McDonald Islands	N/A	0.541	Russian Federation	0.476	0.294
Belarus	0.400	0.292	Holy See	N/A	0.256	Rwanda	0.712	0.416
Belize	0.403	0.183	Honduras	0.662	0.359	Saint Barthélemy	N/A	0.461
Belgium	0.252	0.124	Hungary	0.296	0.191	Saint Helena	0.753	0.456

Country	EF OM	EF CM	Country	EF OM	EF CM	Country	EF OM	EF CM
Benin	0.745	0.576	Iceland	N/A	0.00003	Saint Kitts and Nevis	0.753	0.477
Bermuda	0.753	0.342	India	0.951	0.661	Saint Lucia	0.753	0.521
Bhutan	N/A	0.388	Indonesia	0.783	0.599	Saint Martin (French Part)	0.753	0.484
Bolivia (Plurinational State of)	0.604	0.393	Iran (Islamic Republic of)	0.592	0.421	Saint Pierre and Miquelon	0.753	0.415
Bonaire, Sint Eustatius and Saba	0.753	0.400	Iraq	1.080	0.788	Saint Vincent and the Grenadines	0.753	0.499
Bosnia and Herzegovina	1.197	0.739	Ireland	0.380	0.189	Samoa	0.753	0.434
Botswana	1.478	1.070	Isle of Man	0.436	0.204	San Marino	0.414	0.224
Bouvet Island	N/A	0.290	Israel	0.394	0.258	Sao Tome and Principe	0.753	0.565
Brazil	0.284	0.139	Italy	0.414	0.224	Saudi Arabia	0.592	0.374
British Indian Ocean Territory	N/A	0.418	Jamaica	0.711	0.498	Senegal	0.870	0.656
British Virgin Islands	N/A	0.420	Japan	0.471	0.286	Serbia	1.086	0.678
Brunei Darussalam	0.681	0.407	Jersey	N/A	0.256	Seychelles	0.753	0.479
Bulgaria	0.911	0.495	Jordan	0.529	0.382	Sierra Leone	0.489	0.246
Burkina Faso	0.753	0.420	Kazakhstan	0.797	0.532	Singapore	0.379	0.200
Burundi	0.414	0.197	Kenya	0.574	0.274	Sint Maarten (Dutch part)	0.753	0.463
Cabo Verde	0.753	0.505	Kiribati	0.753	0.530	Slovakia	0.332	0.164
Cambodia	1.046	0.588	Kuwait	0.675	0.400	Slovenia	0.620	0.285
Cameroon	0.659	0.354	Kyrgyzstan	0.217	0.098	Solomon Islands	0.753	0.563
Canada	0.372	0.156	Lao People's Democratic Republic	1.069	0.555	Somalia	0.753	0.582
Cayman Islands	0.753	0.373	Latvia	0.240	0.117	South Africa	1.070	0.747
Central African Republic	0.188	0.077	Lebanon	0.794	0.567	South Georgia and the South Sandwich Islands	N/A	0.290
Chad	0.753	0.581	Lesotho	N/A	0.652	South Sudan	0.890	0.704
Chile	0.657	0.371	Liberia	0.677	0.374	Spain	0.402	0.209
China	0.899	0.547	Libya	0.668	0.493	Sri Lanka	0.731	0.506

Country	EF OM	EF CM	Country	EF OM	EF CM	Country	EF OM	EF CM
China, Hong Kong Special Administrative Region	0.899	0.547	Liechtenstein	0.151	0.052	Sudan	0.736	0.398
China, Macao Special Administrative Region	N/A	0.512	Lithuania	0.211	0.102	Suriname	1.029	0.565
Christmas Island	N/A	0.451	Luxembourg	0.220	0.095	Svalbard and Jan Mayen Islands	N/A	0.256
Cocos (Keeling) Islands	N/A	0.451	Madagascar	0.876	0.567	Sweden	0.068	0.025
Colombia	0.410	0.208	Malawi	0.489	0.243	Switzerland	0.048	0.020
Comoros	0.753	0.589	Malaysia	0.551	0.436	Syrian Arab Republic	0.713	0.546
Congo	0.659	0.405	Maldives	0.753	0.524	Tajikistan	0.225	0.106
Cook Islands	0.753	0.422	Mali	1.076	0.623	Thailand	0.450	0.351
Costa Rica	0.108	0.039	Malta	0.520	0.295	Timor-Leste	0.753	0.589
Côte d'Ivoire	0.466	0.314	Marshall Islands	0.753	0.561	Togo	0.859	0.597
Croatia	0.294	0.168	Martinique	0.753	0.406	Tokelau	N/A	0.451
Cuba	0.559	0.391	Mauritania	0.753	0.513	Tonga	0.753	0.533
Curaçao	0.876	0.506	Mauritius	0.700	0.543	Trinidad and Tobago	0.559	0.370
Cyprus	0.751	0.438	Mayotte	N/A	0.512	Tunisia	0.468	0.348
Czechia	0.902	0.461	Mexico	0.531	0.360	Turkey	0.376	0.309
Democratic People's Republic of Korea	0.754	0.359	Micronesia (Federated States of)	0.753	0.557	Turkmenistan	0.927	0.676
Democratic Republic of the Congo	N/A	0.0004	Monaco	0.158	0.068	Turks and Caicos Islands	0.753	0.451
Denmark	0.362	0.155	Mongolia	1.366	1.002	Tuvalu	0.753	0.497
Djibouti	0.753	0.575	Montenegro	0.899	0.471	Uganda	0.279	0.116
Dominica	0.753	0.433	Montserrat	0.753	0.517	Ukraine	0.768	0.435
Dominican Republic	0.601	0.426	Morocco	0.729	0.547	United Arab Emirates	0.556	0.310
Ecuador	0.560	0.280	Mozambique	0.234	0.111	United Kingdom of Great Britain and Northern Ireland	0.380	0.187

Country	EF OM	EF CM	Country	EF OM	EF CM	Country	EF OM	EF CM
Egypt	0.554	0.406	Myanmar	0.719	0.407	United Republic of Tanzania	0.531	0.336
El Salvador	0.547	0.275	Namibia	0.355	0.319	United States Minor Outlying Islands	N/A	0.451
Equatorial Guinea	0.632	0.361	Nauru	0.753	0.521	United States of America	0.416	0.220
Eritrea	0.915	0.704	Nepal	N/A	0.00001	United States Virgin Islands	0.650	0.373
Estonia	1.057	0.625	Netherlands	0.326	0.203	Uruguay	0.174	0.065
Eswatini	N/A	0.652	New Caledonia	0.779	0.445	Uzbekistan	0.612	0.467
Ethiopia	N/A	0.00014	New Zealand	0.246	0.108	Vanuatu	0.753	0.504
Falkland Islands (Malvinas)	0.753	0.316	Nicaragua	0.675	0.372	Venezuela (Bolivarian Republic of)	0.711	0.368
Faroe Islands	0.753	0.320	Niger	0.772	0.718	Viet Nam	0.560	0.318
Fiji	0.640	0.334	Nigeria	0.526	0.358	Wallis and Futuna Islands	N/A	0.451
Finland	0.267	0.114	Niue	0.753	0.459	Western Sahara	N/A	0.432
France	0.158	0.068	Norfolk Island	N/A	0.451	Yemen	0.807	0.615
French Guyana	0.423	0.200	Northern Mariana Islands	0.753	0.416	Zambia	0.416	0.197
French Polynesia	0.753	0.412	North Macedonia	0.851	0.563	Zimbabwe	1.575	0.880
French Southern Territories	N/A	0.418	Norway	0.047	0.017			

Notes: Values in red correspond to regional averages and replace missing or zero values for Combined Margin EFs. N/A values correspond to missing or zero values for Operating Margin EFs, for which representative regional estimates could not be identified.

Source: Authors' own elaboration based on IFI (International Financial Institutions), 2021. *Methodological approach for the common fault grid emissions factors dataset*. Technical Working Group on Greenhouse Gas Accounting. IFI TWG-AHG-001. Version 3.0. December 2021. Cited 3 February 2022. <https://unfccc.int/climate-action/sectoral-engagement/ifi-harmonization-of-standards-for-ghg-accounting/ifi-twg-list-of-methodologies>

Annex 4. Refrigerants and GWP values

Table A3. Major hydrofluorocarbon (HFC) molecules, environmental properties and main applications

Designation	Complete name	Formula	CAS number	GWP (1)		Atmospheric lifetime (3)	Main applications
				F-gas regulation AR4 (2)	AR5 (3)		
HFC-23	Trifluoromethane	CHF ₃	75-46-7	14 800	12 400	222 years	- Very low temperature specialist refrigerant; - by product in production of HCFC-22 and aluminum smelting; - used as a feedstock.
HFC-32	Difluoromethane	CH ₂ F ₂	75-10-5	675	677	5.2 years	- Refrigerant for air-conditioning; - component of refrigerants for air-conditioning, commercial refrigeration and heat pumps.
HFC-125	Pentafluoroethane	CHF ₂ CF ₃	354-33-6	3 500	3 170	28.2 years	- Blend component for stationary air-conditioning, commercial refrigeration and heat pumps; - firefighting agent.
HFC-134a	1,1,1,2-tetrafluoroethane	CH ₂ FCF ₃	811-97-2	1 430	1 300	13.4 years	- Refrigerant for mobile air-conditioning applications (servicing only for cars); - blend component for stationary- air conditioning and commercial refrigeration; - propellant for pharmaceutical aerosols (MDIs); and for technical aerosols, to meet national safety standards from 2018; - blowing agent component for extruded polystyrene foams (XPS).
HFC-143a	1,1,1-trifluoroethane	CH ₃ CF ₃	420-46-2	4 470	4 800	47.1 years	Blend component for commercial refrigeration.
HFC-152a	1,1-difluoroethane	CH ₃ CHF ₂	75-37-6	124	138	1.5 years	- Propellant for specialized industrial aerosols; - blowing agent component for extruded polystyrene foams (XPS).
HFC-227ea	1,1,1,2,3,3,3-heptafluoropropane	CF ₃ CHFCF ₃	431-89-0	3 220	3 350	38.9 years	- Propellant for pharmaceutical aerosols (MDIs); - firefighting agent; - refrigerant for high-temperature environments.

Designation	Complete name	Formula	CAS number	GWP (1)		Atmospheric lifetime (3)	Main applications
				F-gas regulation AR4 (2)	AR5 (3)		
HFC-236fa	1,1,1,3,3,3-hexafluoropropane	CF ₃ CH ₂ CF ₃	290-39-1	9 810	8 060	242 years	- Firefighting agent; - refrigerant for high-temperature environments.
HFC-245fa	1,1,1,3,3-pentafluoropropane	CHF ₂ CH ₂ CF ₃	460-73-1	1 030	858	7.7 years	- Foam blowing agent for polyurethane (PUR) foams; - working fluid for organic rankine cycles (ORC).
HFC-365mfc	1,1,1,3,3-pentafluorobutane	CF ₃ CH ₂ CF ₂ CH ₃	406-58-6	794	804	8.7 years	- Foam blowing agent for polyurethane (PUR) and phenolic foams; - blend component for solvents; - working fluid for organic rankine cycle (ORC).
HFC-43-10mee	1,1,1,2,2,3,4,5,5,5-decafluoropentane	CF ₃ CHFCF ₂ CF ₃	138495-42	1 640	1 650	16.1 years	- Solvent for specialized applications.

Source: EFCTC (European Fluoro Carbons Technical Committee). n.d. *Fundamental properties of HFCS, HFOS, and HCFOs*. Cited 3 February 2022. www.fluorocarbons.org/hfcs-hfos-hcfos

Table A4. Major hydrofluoroolefins (HFO and HCFO) molecules, environmental properties, and main applications

Designation	Complete name	Formula	CAS number	F-Gas Regulation AR4 (2) unless stated	AR5 (3) unless stated	Atmospheric lifetime (3) unless stated	Ozone depleting substance (ODS)	Main applications
HFO-1234yf	2,3,3,3-tetrafluoroprop-1-ene	CF ₃ CF=CH ₂	754-12-1	4 (6)	<1	10.5 days	No	- Refrigerant for mobile air-conditioning, stationary air conditioning and refrigeration; - blend component for HFC-HFO blends.
HFO-1234ze(E)	Trans-1,3,3,3-tetrafluoroprop-1-ene	Trans-CF ₃ CH=CFH	29118-24-9	7 (6)	<1	16.4 days	No	- Refrigerant for chillers, refrigeration; - blend component for HFC-HFO blends; - aerosol propellant; - blowing agent for insulation foams.

Designation	Complete name	Formula	CAS number	F-Gas Regulation AR4 (2) unless stated	AR5 (3) unless stated	Atmospheric lifetime (3) unless stated	Ozone depleting substance (ODS)	Main applications
HFO-1336mzz(Z)	Cis-1,1,1,4,4,4-hexafluorobut-2-ene	Cis- CF ₃ CH=CHCF ₃	692-49-9	9	2 (7 &3)	22 days (8 &3)	No	· Refrigerant for low pressure chillers, residential and high temperate heat pumps, refrigeration and air-conditioning; - working fluid for organic rankine cycle (ORC); - fire extinguishant; - blowing agent for insulation foams.
HFO-1336mzz(E)	Trans-1,1,1,4,4,4-hexafluorobut-2-ene	Trans- CF ₃ CH=CHCF ₃	66711-86-2		7 (7)	67 days (7)	No	- Refrigerant for medium temperature applications heat pumps and refrigeration systems; - working fluid for organic rankine cycle (ORC).
HCFO-1233zd(E)	Trans 1-Chloro-3,3,3-trifluoroprop-1-ene	Trans- CHCl=CHCF ₃	102687-65-0	4.5	1	26 days	No, a VLS (5)	- Refrigerant for chiller applications, high temperature heat pumps; - working fluid for organic rankine cycle (ORC); - blowing agent for Insulation foams.
HCFO-1224yd(Z)	2,3,3,3 tetrafluoro-1-chloroprop-1-ene	CF ₃ -CF=CHCl	111512-60-8	na	< 1 (4)	21 days (4)	No, a VLS (5)	- Refrigerant for centrifugal chillers, high temperature heat pumps; - working fluid for organic rankine cycle (ORC); - blowing agent for polyurethane foams.

Source: EFCTC (European Fluoro Carbons Technical Committee). n.d. *Fundamental properties of HFCS, HFOS, and HCFOs*. Cited 3 February 2022. www.fluorocarbons.org/hfcs-hfos-hcfos

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