Food and Agriculture Organization
of the United Nations

Ex-Ante Carbon-balance Tool for Value Chain (EX-ACT VC)

GUIDELINES

EX-ANTE CARBON-BALANCE TOOL EX-ACT

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Acknowledgments

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Acronyms

AFOLU	Agriculture, Forestry and Other Land Uses
CC	Climate Change
CFP	Carbon footprint
CSA	Climate Smart Agriculture
EX-ACT	EX-Ante Carbon-balance Tool
EX-ACT VC	EX-Ante Carbon-balance Tool for Value Chain
FAO	Food and Agriculture Organization of the United Nations
FUI	Fuel Use Intensity
GDP	Gross Domestic Product
GHG	Greenhouse fas
GI	Gross Income
GPV	Gross Production Value
Ha	Hectare
HH	Household
IPCC	Intergovernmental Panel on Climate Change
LED	Low Emissions Development
PV	Production Value
Q	Quantity produced
SO	Strategic Objective
tCO_2-e	Tonne of CO_2 equivalent
UNFCCC	United Nations Framework Convention on Climate Change
VA	Value Added
VC	Value Chain

Executive summary

This manual explains how to use the EX-Ante Carbon-balance Tool for Value Chain (EX-ACT VC) and how to address a multi-impact appraisal in terms of socio-economic and environmental performance of value chains. These guidelines justify the development of the tool, and introduce its goals for value chain analysis and the step-by-step approach of its modules.

Specifically, *Chapter 1* discusses the importance of incorporating climate change mitigation and resilience into agricultural production systems. *Chapter 2* explains the development of the FAO EX-ACT Value Chain tool, along with its logic and methodology, while *Chapter 3* provides a concise overview of its structure. *Chapters 4 to 12* guide users through the process of entering data into the tool. *Chapter 13* focuses on the results of value chain analyses conducted using EX-ACT VC. To aid understanding of the whole process of inputs and outputs, an example value chain for coffee production is evaluated.

1. Introduction

a) Background

Currently food production responds to basic needs and to numerous social, cultural and aesthetic needs and demands (Notarnicola *et al.*, 2017). The demand to feed 7.5 billion people and address dietary changes over the past decades has driven the intensification of food production, while environmental threats such desertification, drought, soil degradation and loss of biodiversity have added to the list of challenges that humanity has to face. Through its impacts on agriculture[1], livelihoods, infrastructures and market access, climate change (CC) threatens every aspect of food security, placing millions of people at risk of hunger and poverty, especially in tropical regions of the globe (FAO, 2016). The world's population is expected to rise to almost 10 billion by 2050, particular in regions already facing widespread undernourishment and vulnerability to CC. As such, global food demand will need to increase by 60 percent above 2006 levels whilst facing increasing pressures from CC (FAO, 2013; FAO, 2016; FAO, 2017).

The targets of achieving zero hunger, eradicating poverty, promoting sustainable development, tackling CC and increasing the climate adaptation and resilience of the most vulnerable members of the population found their roots in the 2030 agenda on sustainable development and the Paris Agreement on CC. However, if all these challenges are to be addressed the entire food and agriculture sector must be transformed, and its associated food value chains with it.

Despite global economic growth and poverty reduction in recent decades, around 2.1 billion people are still living in poverty, and 700 million in extreme poverty (FAO, 2017). This world poverty is primarily a rural phenomenon; 75 percent of the world's poor live in rural areas and 80 percent of their income is derived from the agricultural sector (IFAD, 2011). The agriculture and food sectors constitute a large, if not the largest, part of the economy in most developing countries (FAO, 2014). Paradoxically however, growth in the agriculture sector is, on average, at least twice as effective at reducing poverty when compared with growth in non-agricultural sectors. For instance, growth of gross domestic product (GDP) originating in agriculture is four times more effective at reducing poverty than if the increase came from any other sector (World Bank, 2008).

Unfortunately, poorer members of the population living in less-favourable regions, who depend on agriculture for their livelihood, are also the most vulnerable to CC. Advances in climate mitigation, climate resilience and climate adaptation provide important pathways out of poverty. If climate effects impact agricultural production (e.g. through a decrease in productivity or variability of yields) they will also impact rural infrastructure, market access and the different facets of their food value chains (FAO, 2013).

Many activities in the process of food production generate greenhouse gas (GHG) emissions. With fertilizer manufacture, agriculture processing, transport, retail, household food management and waste disposal, food systems contribute between 19-29 percent of all anthropogenic GHG emissions. This equates to 9 800 – 16 900 million tonnes of carbon dioxide equivalent per year (tCO_2-e yr^{-1}) at the 2008 levels (Vermeulen *et al.*, 2012). In the near future, energy prices will increase and a global price of carbon will emerge. Thus sustainably managed agricultural value chains could provide an opportunity for countries to contribute to the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) by supporting Low Emissions Development (LED).

For nations targeting sustainable economic emancipation it is vital to establish a low-carbon economy that leads to higher economic growth. Low-carbon economies, characterized by energy efficiency, minimised pollution, reduced carbon emissions and high energy performance, have been idealised as a step on the path to global advancement (Ganda and Ngwake, 2013). The distributive nature of food value chains presents both a challenge and an opportunity to make meaningful progress in de-carbonizing our global economy.

In September 2015, the 193 Member States of the United Nations adopted a new program for sustainable development, entitled "Transforming Our World: the 2030 Agenda for Sustainable Development". The program contains 17 objectives[2] and 169 targets and focuses on the three core components of sustainable development – economic growth, social inclusion and protection of the environment. It recognises that *"eradicating poverty in all*

[1] Agriculture here include crop, agroforestry, livestock and fisheries
[2] Full list: https://sustainabledevelopment.un.org/partnerships/unsummit2015

its forms and dimensions, combating inequality within and among countries, preserving the planet, creating sustained, inclusive and sustainable economic growth and fostering social inclusion are linked to each other and are interdependent". Among the different sustainable development goals, goal #2 *"End hunger, achieve food security and improved nutrition and promote sustainable agriculture"* and goal #12 *"Ensure sustainable consumption and production patterns"* are at the heart of the development of the EX-ACT value chain tool (EX-ACT VC).

b) Agriculture and the climate dimension

Agriculture, forestry and other land use systems are responsible for up to 25 percent of anthropogenic GHG emissions (Smith *et al*., 2014). In fact, agriculture alone has become the second largest emitter of GHGs after the energy sector, accounting for around 10-12 percent of global anthropogenic GHG emissions between 2000-2010, mainly in the form of CH_4 and N_2O (Smith *et al*., 2014). From production to consumption, the agro-food sector contributes 19-29 percent of global anthropogenic GHG emissions (Vermeulen *et al.*, 2012).

Nonetheless, agriculture does provide numerous environmental services including biodiversity preservation, basin conservation and biological carbon sequestration (in biomass and soils). The agricultural sector could account for up to twenty percent of the GHG mitigation potential, especially in developing countries (Smith *et al.*, 2014). As stated in the Paris Agreement on CC, the price of energy is expected to increase in the coming years and a global price of carbon is set to emerge. Thus managing agricultural chains sustainably could provide numerous opportunities for member states to meet their emission targets.

Climate change will impact developing countries most severely, at every level (population, production, rural infrastructure, etc.). Therefore developing growth opportunities for agriculture and forestry, whilst creating new sources of income, will improve the resilience of communities and production systems, and reduce rural poverty (FAO, 2013).

Numerous options exist for sustainable food production. These include conservation agriculture, climate-smart agriculture (CSA), improved waste management and changes in dietary behaviour (FAO, 2011). Additionally, 26 to 40 percent of global agricultural production is lost before harvest. Therefore, reducing food loss is another key target for achieving more productive and sustainable agricultural systems. Improving food production, changing consumption patterns and reducing food waste and loss are at the core of sustainable development strategies from both an environmental and a socio-economic perspective, and at both a local and international scale (Notarnicola *et al*., 2015). Hence, policy objectives for achieving food safety, reducing rural poverty and developing sustainable and conservative agro-ecosystems are becoming increasingly important in decision makers' debates. These adaptation policies will be targeted at improving practices at every stage along the agricultural chain, thus contributing towards CC attenuation. For instance, shifting from typical western diets to more environmentally sustainable dietary patterns could reduce GHG emissions and agricultural land use by up to 70 percent and water use by up to 50 percent (Aleksandrowicz *et al*., 2016)

Environmental assessments have existed for decades and numerous methodologies have been developed, yet their application to the food and agricultural sector has only recently been considered (Lescot, 2012). It is vital for countries aiming for a sustainable future to develop low carbon economies. Food value chains present significant opportunities to make progress in the de-carbonisation of the global economy (Ganda and Ngwake, 2013). The environmental assessment of agricultural and food production is now a strategic issue worldwide at both a national and international scale. A value chain analysis is a valuable starting point to begin understanding all socio-economic elements (such as markets and the involvement of different actors) and environmental challenges (such as reducing GHG emissions and lowering the extent of food waste and loss) that are encountered along the value chain from initial production to final consumption (Rota and Sperandini, 2010; FAO, 2011, FAO, 2014). The distributive nature of food value chains presents both a challenge and an opportunity to make meaningful progress in de-carbonizing the global economy through methods of environmental assessment, such as Carbon Footprint (CFP) and Life Cycle Assessment.

As seen above, population growth, resource constraints and social and market pressures have direct implications for supply chains, in terms of access to healthy dietary styles and to food in sufficient quantities. In light of this, a tool for developing sustainable food value chains and climate resilience analysis is essential. Such a tool should take into account the consecutive and interlinked life cycle stages of a product, from the extraction of natural resources to the final disposal. To do so, it must cover a whole range of performance indicators such as social performance (employment), economic performance (income growth and value added), environmental (adoption of agro-ecological practices) and GHG performance and climate resilience. Such a tool would be interlinked with many of the FAO Strategic Objectives (SO) (in particular SOs #2, #3, #4 and #5), thus striving for the end of hunger and poverty worldwide by dealing with the different dimensions that affect value chain performance. Therefore, multi-benefit appraisal related to value chain analysis can simultaneously address the many challenges faced by rural populations, breaking the vicious cycle of underperformance and poverty.

c) What is a sustainable food value chain

Development of the value chain concept

The concept of a "value chain" has been derived from several related concepts in the literature. From the notion of *filière* to that of "product chain" in the 1950s, the concept has been reframed over the years to address the constantly changing conditions and incorporate them into definitions. For instance, the concept of a "supply chain" is primarily concerned with optimising the product and service flow along the chain (i.e. logistics). In 1985, Porter (cited in FAO, 2014) introduced the concept of a "value chain", identifying the value addition in competitive markets as the core element of the production-to-consumption chain of activities.

Thus, derived from this development, a value chain is defined as:

"The full range of activities that is required to bring a product or service from conception, through the different phases of production, to the delivery to final customers, and to the final disposal after use" (Kaplinsky and Morris, 2000).

In the context of food production, these activities include farm production, food transformation, trade and delivery of food commodities to final market. Thus, value chain analysis allows one to identify the value added at each stage of the chain.

Value chains play a key role in improving linkages between farmers and buyers by ensuring that the farmers tailor their production to the demands of consumers (Anonymous, 2012; Rota and Sperandini, 2010). This way, actors can become more actively engaged in adding value to products by improving quality, packaging and presentation at every stage of the chain.

In light of the FAO SOs, the sustainable food value chain concept has been recently upgraded from the afore-mentioned notions to now target the three pillars of sustainable development. This guide has adapted the "sustainable food value chain" concept to include climate-related actions that affect value chain performance, i.e. climate resilience, adaptation and mitigation. In particular, there are many benefits to linking the "value chain" approach with climate resilience, considering that CC affects both food production and the food industry.

Sustainable food value chain and climate smart agriculture

A sustainable food value chain applies the sustainability aspects of the value chain concept to the specific processes of food production, processing and distribution. The guiding principles set out by FAO in 2014, define sustainable food value chains as:

"The full range of farms and firms and their successive coordinated value-adding activities that produce particular raw agricultural materials and transform them into particular food products that are sold to final consumers and disposed of after use, in a manner that is profitable throughout, has broad-based benefits for society, and does not permanently deplete natural resources" (FAO, 2014).

Unlike the related concepts of "filière", "commodity chain" and "supply chain", the sustainable food value chain concept stresses the importance of three elements:

(i) A "value chain" is a broadly defined concept and may be applied to any of a country's product subsectors (e.g. beef, maize or salmon).

(ii) Value chains are dynamic, market-driven systems governed and regulated through vertical coordination.

(iii) Sustainability and the value added are explicit, multidimensional performance measures assessed at an aggregate level (FAO, 2014).

CSA is a win-win strategy, providing the necessary means to cope with long-term climatic changes, risks and shocks.

This guide also addresses climate-change related strategies of **mitigation**, **adaptation** and **resilience of the value chain**, and stresses the importance of CSA, agro-ecological and socio-economic practices in the analysis of food value chains.

The CSA concept was launched by FAO in 2010 and concerns a type of agriculture that targets food security and development goals through sustainable practices (FAO, 2013). CSA has three main objectives: (i) to increase **food security** while boosting productivity and income generation; (ii) to enhance the resilience of agricultural systems and rural populations to CC; and (iii) to reduce GHG emissions in agriculture (**mitigation**). Thus, CSA is neither a new agricultural model nor a new set of practices, but rather a framework for developing more productive and sustainable food value chains. This framework involves (i) CC mitigation and adaptation options through ecosystem management in order to (ii) preserve existing carbon stocks and decrease existing carbon sources and (iii) improving smallholder livelihoods to reduce their vulnerability to CC.

Achieving food security and agricultural development goals, while simultaneously coping with CC and GHG emissions, requires significant changes to agricultural production systems. These transformations could allow food producers to contribute significantly to the rural development of their population, whilst increasing access to local and national markets (i.e. improving productive and resilience and reducing the variability of production). Many agricultural strategies may be considered, such as conservation agriculture, improved irrigation and water management, adapted crop and farming practices, and risk management of crop and income loss (FAO, 2013).

To improve productivity and resilience, the agricultural sector requires a transformation of the way land, water, soil nutrients and genetic resources are managed. Switching to CSA will require changes in governance at both the national and international levels, particularly with respect to legislation and finances. This transformation would improve the access of producers to the market and develop sustainable practices at every stage along the value chain. Sectors and stakeholders alike must all cooperate and coordinate their interests if this transition is to occur. It is here that multi-appraisal tools become essential facilitate decision making and the adoption of CSA practices (FAO, 2013).

d) Mapping a food value chain

Value chains are highly complex analytical techniques, taking into account a huge diversity of products, production practices and actors involved. Defining the limits of the analysis is, therefore, essential to ensure analytical clarity and prevent misunderstanding.

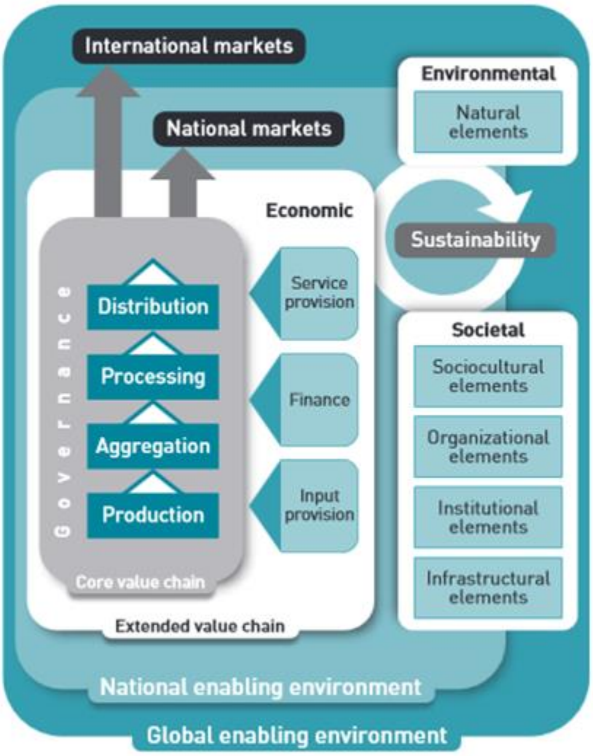
A value chain begins at the product cultivated (i.e. rice, banana, cotton, cattle, etc.) and can be sub-divided into smaller value chains according to the practices undertaken, the type of processing and the final product. For instance, the value chain for rice in Madagascar can be divided into two pathways: (i) rainfed rice and (ii) irrigated rice. The bovine value chain can be split into a value chain for meat and a value chain for milk. To clearly define a particular value chain, the different operations at work in the entire food production process must be considered. Value chains are typically named after the cultivated product (e.g. cocoa value chain, rice value chain, dairy value chain, etc.), however it is more appropriate to delimit the chain by starting from the primary agricultural production, identifying the main inputs and services present at each stage along the chain (Duruflé, Fabre and Yung, 1988), and to follow the product downstream through the marketing channels and stages of transformation up to the final market realisation (Bockel and Tallec, 2005).

However, the upstream approach can present challenges when assessing the degree to which agro-furniture providers (i.e. fertilizers, pesticides, agricultural machineries, feed) participate in the value chain and whether they should be included in the value chain analysis. Therefore, for simplicity, EX-ACT VC only considers agents between which the product actually transits, within the value chain boundaries. Likewise, given the multiplicity of production styles, delimiting unique value chains for each stage of a product's transition would lead to difficulties in defining the sub- chains and segments. Products on a given production line may be destined for different uses and, vice-versa, several different types of production may be used to create a final product, for example in the dairy value chain (raw milk, pasteurized milk, butter, cheese, etc) and fishery value chain (canned fish, smoked fish, fresh fish, etc.). Until the identification of the final consumer, or until the exportation, the value chain is restricted to the market stage.

To that end, the sustainable food value chain framework acts as guidance for structuring the analysis of the food chain performance. This framework involves the value chain actors, i.e. those who produce a good or a service, who add value to the product, sell it, transfer it to the next level or export it. In this framework, shown in Figure 1, four core functions of the value chain are identified : (i) production (agriculture, livestock, fishing), (ii) aggregation, (iii) processing and (iv) distribution (wholesale and retail) at local, national and international levels (FAO, 2014).

This framework offers several capabilities; to identify the criteria that can serve as growth engines, to assess the poverty reduction potential of an activity and to facilitate the adoption of agricultural strategies with appropriate policy measures.

Figure 1 : The sustainable food value chain framework



*The E*X-ACT Value Chain tool (EX-ACT VC), developed in 2016 and targeting developing countries, is a multi-agent based tool appraising input supply, production, transport and processing, using numerous indicators. Designed for multi-impactappraisal, the tool provides performance assessments for value chains in the following areas: (i) climate mitigation (GHG emissions, carbon footprint, economic return of climate mitigation), (ii) climate resilience (iii) socio-economic performances (value added, income and employment generated) and other environmental factors (such as water use and energy use). These can be applied for either the current chain situation, or for assessing an upgraded scenario. EX-ACT VC covers value chains for crops, livestock, fisheries and aquaculture.

2. The FAO EX-ACT Value Chain Tool

a) Objectives

Initiatives that focus on a value chain approach for policy making, with a mix of environment and income distribution-oriented objectives have been increasing in less industrialised countries. The different objectives of these projects often converge towards common goals, namely increasing the profitability of the value chain for smallholder farmers, raising farmers' income and creating new jobs in processing activities.

Regarding environmental performance, there is an increasing demand to understand the carbon footprint (CFP) and GHG emissions of a particular product and its associated activities along the value chain. The aim is to reduce the impact of climate variability on yields and reduce the chemical inputs and energy usage per hectare. These minimise the negative environmental effects of the value chain by using CFP labelling to certify and give credit to sustainable management efforts.

EX-ACT VC helps design value chains that are efficient and sustainable, as explained in more detail above. The methodology provides both a quantified socio-economic appraisal, at both the micro- and at the meso-levels (i.e. by agent, by stage and by sector) and an environmental carbon-balance appraisal (climate mitigation, adaptation and resilience).

To elaborate, within EX-ACT VC:

- The **impacts in terms of climate mitigation** are assessed through quantitative indicators, derived directly from the EX-ACT tool. These indicators are used to analyse the mitigation impacts of both the current value chain and of an upgrade project scenario in terms of tonnes of CO_2-equivalent (tCO_2-e). The CFP is calculated for the whole value chain and each of the different analytical stages, thus comprehensively evaluating the environmental performance of the chain. The equivalent economic return is also determined, as this may be important when considering, for example, access to environmental services.
- **Value chain resilience** is estimated using quantitative and qualitative indicators, measuring the reduction in the vulnerability to CC of people, livelihoods, ecosystems and value chains (Ifejika Speranza, 2010).
- The **socio-economic performance** of the value chain is evaluated in terms of value added, income and jobs generated throughout the chain.

Considered together, these indicators allow the user to estimate the benefits of initiatives that address the challenges faced by rural populations. Simultaneously the user may identify options for poverty reduction, productivity increases, rural employment promotion, a reduction in GHG emissions and the resilience of agro-food systems.

Therefore, the EX-ACT VC tool is of great interest to local and national initiatives in developing countries, in order to:

- pre-assess the impacts that can be engendered in a given time framework at the value chain level (ex-ante appraisal);
- monitor countries' progress towards achieving select targets at different points in time and at different scales of the chain;
- to evaluate the extent to which stated objectives have been achieved (ex-post assessment).

Therefore, common methodologies and improved practices are essential if we are to enhance the sustainability, resilience and competitiveness of value chains in developing countries.

<u>EX-ACT in short</u>

EX-ACT is an appraisal tool developed by FAO that provides ex-ante estimates of the carbon balance generated by projects, programmes and policies for agricultural and forestry development. The carbon balance is defined as the net balance of all GHG emissions, expressed in tCO_2-e, emitted or sequestered following the realisation of a project. The carbon balance is estimated with respect to a reference scenario – the situation that would occur should the project not take place. EX-ACT is based on the allocation of land, according to which it is possible to evaluate the carbon stocks and their evolutions per unit of surface (in hectare), or on raw production (livestock and fisheries) and its evolution per unit of production (tonnes). The tool takes into account emissions of CH_4, N_2O and CO_2, expressed in tCO_2-e per hectare or tonne per year. It therefore helps project designers to estimate the carbon impact of their project and to set priorities among project activities according to the economic and environmental benefits targeted.

b) EX-ACT VC Boundaries

Following the EX-ACT approach (Bernoux *et al.*, 2016), EX-ACT VC analyses the environmental and socio-economic performance of value chains from producers to retailers, comparing two scenarios: the **current situation** of the value chain and an **upgraded scenario** induced by a project (applicable to different stages of the chain). The comparison is based on the analysis of agricultural[3] production and land use changes, as well as of the processing, packaging and transportation phases of the agricultural product.

The **current situation** of the value chain refers to the production, processing and transportation dynamics characterising the value chain under analysis.

The **upgraded scenario** denotes the development path of the value chain. This aims to improve the socio-economic performance of the chain, whilst taking into account the environmental performance in terms of climate mitigation, adaptation and resilience. The upgraded scenario covers three different aspects: (i) "product upgrading", which refers to the innovation, diversification and improvement of the final product, (ii) "process upgrading"; the improvement of production and distribution technology and logistics), and (iii) "functional upgrading"; the shifting of value chain functions from one operator to the next.

To build a value chain strategy, a sequence of steps, described in the following figure, is needed:

Upgrading necessitates activities that can be defined as "*improving business linkages, associations and partnerships, strengthening service supply and demand, introducing standards, improving policies and business environments, and enhancing productive capacity which in turn increases the volume sold*".

Therefore, the multi-impact appraisal provided by EX-ACT VC compares both scenarios, where the 'current situation' is used as the baseline scenario. Improvement of the value chain can occur at any stage.

EX-ACT VC has been adapted and designed to analyse value chains in developing countries. It is well-suited to analysing simple value chains or a segment of more complex value chains (regional or area specific sub-value chains). Complex value chains can first be divided into segments before analysis. This provides a separate impact appraisal for each segment. These may then be aggregated together to form the final results. For instance, the rice value chain in Madagascar can be divided into the rainfed rice chain and the irrigated rice chain, thus simplifying the analysis.

[3] Including livestock, fisheries and aquaculture

c) Methodology

The performance of sustainable food value chains are determined by many different factors, all of which are tackled simultaneously in the analytical framework of the tool. Value chains present both challenges and opportunities to make progress in the de-carbonisation of the food industry while increasing the resilience of local populations directly dependent on the food sector. Adaptation and mitigation are two strategies that can have a real impact on food value chain performance, defending against CC and reducing the vulnerability of the population to risks, shocks and long-term climate variability. This environmental performance of the value chain is complemented by the socio-economic performance. Socio-economic performance is primarily determined by wealth accumulation, the number and nature of direct and indirect jobs, and extent to which food supplies meet food demands in both rural and urban areas. All these factors must be considered when quantifying and analysing the performance of sustainable food value chains.

The EX-ACT VC methodology stands out as the first analytical framework to simultaneously consider the socio-economic performance of value chains and the factors relating to climate mitigation, adaptation and resilience. It recognises the need for simple indicators, easy to collect and to aggregate, in order to develop a measurable and precise tracking system of food value chain impacts.

Methodological background for climate mitigation analysis

Climate mitigation involves reducing both the frequency and magnitude of environmental changes, considered at the whole value chain level. It aims to reduce GHG emissions and increase carbon sequestration by improving practices at each stage of food production (e.g. improving agricultural practices and reducing waste and loss).

- Climate mitigation in agricultural production is calculated using the EX-ACT version 7 framework. Emission factors and default values come from the IPCC (2006), which developed a methodological guidance to estimate CO_2-e emissions for the different crop production phases. It has been supplemented with other existing methodologies, such as embodied GHG emissions for farm operations, inputs transportation, and irrigation system implementation extrapolated from Lal (2004). For additional details concerning the computation of GHG emissions, please refer to the EX-ACT Technical Guidelines (Bernoux *et al.*, 2016).
- Emissions from the **fishery sector** are mainly due to fuel consumption[4] during the capture phase, refrigerant leakage and post-production operations (such as ice production). The straightforward approach to estimate CO_2 emissions from the catch involves multiplying the quantity of fish caught by an emission factor, the values for which are provided by Parker and Tyedmers (2014). The CO_2 emission factor is associated with the harvest phase and uses the standardized metric Fuel Use Intensity (FUI), which is defined as the quantity of fuel used to produce 1 metric tonne (t) of landed fish. In EX-ACT VC, CO_2 emissions from fishing operations are thus indirectly estimated using FUI data provided by Parker and Tyedmers (2014). Our FUI data are averaged according to the fish category and the gear type used. When no information is available for the fish category and/or gear type, the data are placed in the "not specified" category, using the weighted average at the species category and/or the gear type. See Annex 1 and Parker and Tyedmers (2014) for the full data-set.

[4] Direct GHG emissions due to fuel combustion on board.

Similarly, emissions from on-board refrigerant leakages are estimated from the quantity of fish production associated with these activities multiplied by an emission factor provided by Winther *et al.* (2009) and Irribaren *et al.* (2011).

- GHG emissions from aquaculture: N_2O emissions during aquaculture use in coastal ponds and GHG emissions from energy and agricultural inputs.

N_2O emissions are only considered for aquaculture systems when "in use" (i.e. stocked). N_2O is emitted as a by-product of the ammonia excreted by fish; the ammonia is metabolized by microorganisms into nitrates through nitrification, and from nitrates to N_2 gas through denitrification. It is possible to quantify its emission from fish production data. The emission factor (EF) is estimated based on the N content of fish, excretion of N into the water column and the conversion of N to N_2O, following the methodological guidlines of the IPCC (2014).

- At the processing and transportation level:
    - GHG emissions are mainly associated with **energy use**, such as fuel consumption and electricity, and the type of conditioning. Therefore, the standard approach to estimating CO_2 emissions involves multiplying the quantity of input per tonne of production by an ad-hoc emissions factor defined in the scientific literature. For **energy use** at the processing level, the emission factor is the same as those used in EX-CT (in the Energy and Investments modules). Energy-related emissions can be found in Volume 1 (Energy) of the IPCC (2006), in the "Bilan Carbone" used by French AFD and from the International Energy Agency. Default values associated with the installations of irrigation systems are from Lal (2004).
    - Regarding **packaging**, (annex 2), the values provided in Berneers-Lee and Hoolohan (2012) are used. For simplicity, only the most common forms of packaging are taken into account. A Tier 2 option allows users to enter other packaging types not covered, and their related emission factors.
    - Regarding **refrigeration**, both at the processing and at the transportation levels, data are extrapolated from Luske (2010) on banana production. Given the context-dependency and specificities of the different types of food production, users can enter more suitable emission factors as a Tier 2 option.
    - **Regarding methane emissions from wastewater management,** estimations of these emissions from industrial wastewater streams are based on the guidance and methodology of IPCC (2006), Volume 5, Chapter 6. Methane emissions depend on the concentration of degradable organic matter in the wastewater, the volume of wastewater and the propensity of the industrial sector to treat its wastewater in anaerobic conditions. The IPCC (2006) identified five major industrial wastewater sources with high methane potential emissions: pulp and paper manufacture, meat and poultry processing (slaughterhouse), alcohol, beer and starch production, organic chemicals production, and other food and drink processing (such as dairy and coffee). Methane emissions will thus depend on the maximum methane-production capacity, a methane correction factor and an emission factor for each treatment/discharge pathway or system. Equations and detailed default parameters retained for EX-ACT VC methane emissions from wastewater are given in Annex 3.

Regarding transportation, EX-ACT VC uses the emission factors set out in Weber and Mathews (2008). These are expressed in tonnes of CO_2-e per tonne per km (tCO_2-e/t/km), according to the following categories: *truck, air, rail, inland water and international water container.* These default values are based on a global scale and have a high degree of uncertainty. As a result, using these values in the analysis might result in an over or under-estimation of carbon emissions.

Results may be put in context of climate mitigation by using a CFP indicator (in tCO_2-e per tonne of product), providing a quantitative appraisal of the environmental performance of the whole value chain for the different stages of food production. A reduction in the CFP reflects an improvement in the environmental performance of the value chain, denoting a reduction in GHG emissions and/or an increase in soil carbon sequestration. A lower

CFP can serve as an incentive for the food sector to reduce carbon emissions, minimise the environmental impact of the value chain and make food production more efficient.

These indicators allow the user to analyse the mitigation impacts of the with-project scenario and the tCO_2-equivalent economic return which may be important when considering, for example, access to environmental services. To assess an equivalent value of the impact of mitigation per year and per ha, users can enter the carbon price (US$) in the "VC Results Module". The main question addressed is: "*How much money does one gain or lose by upgrading the value chain?*"

CC mitigation performance is assessed using the following quantitative indicators, derived directly from the EX-ACT tool:

- tonnes of carbon dioxide equivalent (tCO_2-e) reduced or avoided (including increased removals) over 20 years;
- mitigation impact in tCO_2-e per year;
- mitigation impact in tCO_2-e per year per ha;
- project cost (US$) per tonne of CO_2–e reduced;
- equivalent value of the impact of mitigation per year (US$10 per tCO_2-e);
- equivalent value of the impact of mitigation per year per ha (US$10 per tCO_2-e); i.e. the carbon footprint.

Figure 2 and Figure 3 display how these mitigation impact indicators appear in the EX-ACT VC results module.

Figure 2 : Climate mitigation appraisal of a value chain in the EX-ACT VC results module

Climate Mitigation dimension of the Value Chain	Current	Upgrading	Balance
GHG impact (tCO_2-e per year)	-50,926	-302,475	
GHG impact (tCO_2-e per year per hectare)	-1	-3	-3
Carbon footprint of production (tCO_2-e per tonne of product)	-3	-11	-8
Annual tCO_2-e [emitted (+) / reduced or avoided (-)]		-251,549	
Annual tCO_2-e from renewable energy		0	
Equivalent project cost per tonne of CO_{2-e} reduced or avoided (in US$ per tCO_2-e)		0	
Equivalent value of mitigation impact per year (US$ 30/tCO_2-e)		7,546,471	
Equivalent value of mitigation impact per year per ha (US$ 30/tCO_2-e per year per ha)		84	

Figure 3: Carbon footprint at the different stages of the value chain, as displayed in the EX-ACT VC module

Carbon footprint at the different levels of the Value Chain	tCO_2-e per tonne of product		Balance
	Current	Upgrading	
PRODUCTION	-3.18	-10.92	-7.73
PROCESSING	0.08	0.08	0.00
TRANSPORT	0.09	0.09	0.00
RETAIL	0.00	0.00	0.00
TOTAL	-3.02	-10.75	-7.73

Methodological background for climate adaptation analysis

The EX-ACT VC appraisal of climate adaptation assesses the incremental resilience generated by upgrading the value chain. Existing methods combine global quantitative indicators, such as the number of beneficiaries, the improvement in value chain resilience capacity and improved resilience to climate shocks. It also uses a set of qualitative indicators to estimate the potential of an upgraded scenario to develop resilience.

Resilience cannot be assessed using one indicator alone as it depends on the social, ecological and political conditions of the chain and their dynamics geographically and temporally. The buffer capacity factor captures farmers' endowments and access to capital, while self-organisation and continuous learning refer to more process-like and practice-like indicators which capture the ability of farmers to build resilience. The aim of such resilience appraisal is (i) to verify if, and to what extent, a project might increase the climate resilience of the value chain and (ii) to identify the factors associated with resilience, in order to better adapt food production to the environmental constraints.

Quantitative resilience indicators

The EX-ACT VC quantitative resilience appraisal derives a set of quantitative indicators for resilience, either in terms of areas or in terms of households benefiting from increased resilience:

- increase in hectares of land managed through practices resilient to CC;
- hectares with increased coverage of trees and vegetation (reducing landslides and erosion, and improving flood resistance);
- hectares with a greater soil carbon content (providing resilience to drought and reducing erosion);
- number of households benefiting from all the above mentioned improved practices and states.

These qualitative resilience indicators are automatically computed from the tool based on "if conditions", and appear in EX-ACT VC as shown in Figure 4.

Figure 4: Quantitative appraisal of value chain resilience, as displayed in the EX-ACT VC results module

Climate Resilience dimension (s)	Upgrading	
Hectares of land managed under climate-resilient practices	74,000	ha
Hectares with improved tree and vegetal coverage (land slide, flood resilience)	74,000	ha
Number of hectares with increased soil carbon (drought and erosion resilience)	74,000	ha
Number of HH having become more climate resilient	140,000	HH

Qualitative resilience appraisal:

A more thorough assessment of climate adaptation is based on a multi-criteria analysis of different dimensions of resilience extrapolated from FAO methodical study work (Ifejika Speranza, 2010). The three resilience dimensions are:

(i) buffer capacity, based on three levels of analysis: area, household and production levels;

(ii) resilience and self-organisation of households;

(iii) market resilience and adaptation capacity.

These three dimensions are based on a series of indicators derived from the project profile and analysed by experts, project designers or project beneficiaries.

EX-ACT VC subsequently analyses resilience on the basis of five resilience factors:

- buffer capacity of the project area to natural shocks;
- the absorption capacity of production systems to climatic shocks;
- the absorption capacity of households to climatic shocks, with respect to food security;
- the resilience and self-organising ability of households;
- market resilience and adaptation capacity of the value chain.

A resilience index, derived from these factors, provides an initial estimate of the resilience of a value chain under an upgraded scenario, which can be classified as "very high", "high", "medium", "low" or "very low". To estimate the impact of the project each of these resilience factors is measured through a set of specific qualitative criteria assessed by value chain experts, project designers or project beneficiaries, on a scale from zero to four. A score of zero means that the project does not bring any benefit in terms of resilience. A score of four denotes a significant resilience impact. In order to include all types of agricultural sectors, weighting can be assigned to each of these criteria depending on the type of sector. For example, a rice value chain will not receive the same weight of plant coverage as a cocoa value chain within an agro-forestry system.

By way of example, to assess the buffer capacity of watersheds, landscapes and project areas to natural shocks, consider the following seven questions:

(i) *"To what extent does upgrading the value chain improve land cover (i.e. agroforestry, cover crops, etc.)?"*

(ii) *"To what extent does upgrading the value chain reduce soil erosion?"*;

(iii) *"To what extent does upgrading the value chain improve soil conditions (i.e. soil moisture, soil structure, etc.)? "*;

(iv) *"To what extent does upgrading the value chain improve the efficient use of water?"*;

(v) *"To what extent does upgrading the value chain save water?"*;

(vi) *"To what extent is the value chain area protected from climate shocks?"*;

(vii) *"To what extent are the value chain infrastructure and building investments climate-proof?"*

Results are aggregated in the "VC Results" module, as shown in Figure 5.

Figure 5: Qualitative appraisal of value chain resilience in the VC results module

Resilience index of the value chain upgrading	Upgrading		
Buffer capacity of watershed and landscape and project area	low	Buffer capac	1.0
Buffer capacity of crop –livestock production	medium	buffer capaci	2.3
Buffer capacity of households in relation to food security	medium	Buffer capac	2.6
Self-organisation of households	medium	Self-organisa	2.6
Learning capacity of households	high	Learning cap	2.6
Global climate resilience generated by Value chain	**medium**		

Socio-economic methodological background

The four main indicators that are used to appraise the socio-economic performance of the value chain are value added, gross production value, gross revenue and volume of employment generated, in relation to the concept of "pro-poor growth". Growth is argued to be pro-poor if the value chain makes use of the assets that poor people own, if it favours the sectors where poor people work and if it occurs in areas where poor people live. This concept must take into account both relative and absolute conditions of the poor to ensure rapid growth and an equitable wealth distribution (Bockel and Chand, 2004).

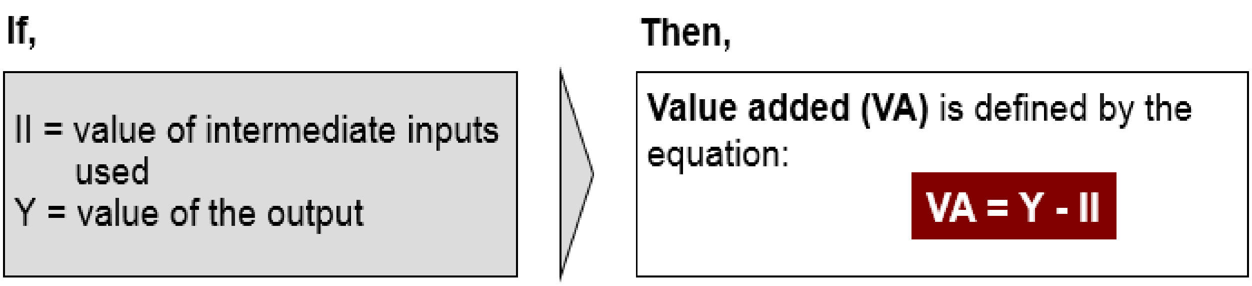
(i) Value added (VA)

Value added measures the accumulation of wealth and the contribution of the production process to economic growth. It is one of the key concepts identified by Porter (1985) and FAO (2014).

It is defined as the difference between the gross production value (incorporating the value of all factors that contribute to production) and the wealth consumed in the production process (Bockel and Tallec, 2005). In other words, the value added is the value that each agent, at each stage of the value chain, adds to the value of inputs during the accounting period of the food production process. It is calculated as the difference between the intermediate inputs used (II) and the value of the output in the post-production phase (Y), as shown in Figure 6 and Equation A.

Equation A: $\mathbf{VA} = \mathbf{Y} - \mathbf{II}$

Figure 6 : The concept of value added



VA can be calculated for each intermediate agri-food product and at every stage of the value chain (i.e. storage, conditioning, transport, processing, etc.). It can also increase or decrease over space and time (FAO, 2014). This allows analysis of the redistribution of wealth generated at each level of the chain.

VA generated during the production process, from producers to retailers, plays a major role in the performance of food value chains. Indeed, the value created at every stage of the chain may influence the three main pillars of sustainable development (economic, social and environmental sustainability) and directly impact poverty and hunger.

VA has five major components: (i) the salaries of workers, (ii) tax revenues to the government, (iii) returns to assets (profits), (iv) a better food supply to consumers (consumers surplus) and (v) impacts on the environment (FAO, 2014). Redistribution is thus measured amongst the different economic agents: households (returns to labour), financial institutions (interest charges), government (taxes) and non-financial enterprises (gross income).

In conclusion, the impact of upgrading a value chain may be analysed at the socio-economic level by assessing the increase or decrease of the VA at every stage of the production process. An increase in the VA implies an increase in the ability of its components to better target poverty reduction and food security.

(ii) Gross production value (GPV)

The gross production value (GPV) is determined for every stage of the value chain and represents an intermediary step in the calculation of the value added. It is calculated by multiplying the production value (PV) in US$ with the net quantity produced (Q) or the area covered (ha) (Equation B). It takes into account the amount of production lost during the different phases of the food production process.

Equation B: $$\mathbf{GPV} = \mathbf{PV \times Q}$$

This makes it possible to assess any increase in the value of production induced by upgrading the value chain, at each stage. An increase in the GPV can be explained by an increase in the value added. It is therefore possible to appraise value chain impacts in terms of poverty reduction, particularly by using the indicators -defined below – gross income and volume of employment generated.

(iii) Gross income (GI)

As explained previously, an increase in the value added has an impact on the wealth distribution among the different economic agents. Gross income (GI) denotes the distribution of wealth at both the meso- and the micro-economic levels. EX-ACT VC measures this redistribution through the revenues of each operator and for each stage of the production process (i.e. processing, transport and harvesting).

The gross income or gross profit is defined as the difference between the value added (VA) at each stage of the value chain and the sum of labour costs, interest charges and taxes (Equation C). In other words, the GI represents the economic return, once all labour costs, interest charges and taxes have been deducted. Thus GI refers to the economic gain or loss of the agent, once all production costs are subtracted.

Equation C: $$\mathbf{GI = VA - Labour\ costs - Taxes\ and\ Interests}$$

The comparison between the current situation and the upgraded scenario allows the user to assess the extent to which the upgraded scenario augments the income of beneficiaries. In conclusion, the gross production value, the value added and the gross income are linked in the manner shown in Table 1.

Table 1: Summary of the economic indicators used in EX-ACT VC

Gross production value
- Intermediate production factors
= Value added
- Labour costs, interests, taxes
= Gross income
Total jobs generated **= Number of additional man-days divided by 250 days**

(iv) Volume of employment generated

Despite being indirectly associated, the value added is deeply connected to the volume of employment generated.

In the agricultural sector, the volume of employment generated is an important "pro-poor" growth engine. Agriculture is an extremely important source of employment and income in rural areas of developing countries. It thus presents several opportunities to facilitate economic growth and reduce poverty (World Bank, 2008). The key challenge is to shape an environment that enables poor people, particularly those working in small and medium-sized farm enterprises, to respond to the opportunities created by emerging markets.

Furthermore, economic growth in the agricultural sector triggers a multiplier effect for the rest of the economy. There is growing evidence that, for every job created in the agricultural sector, two to three jobs are created in the non-agricultural sectors (Mellor, 2002).

When analysing the volume of employment generated along the value chain, EX-ACT VC uses several different approaches. The following two steps are used to calculate an equivalent volume of employment. The number of man-days per unit is measured according to the number of people required per day to perform a task at each stage of the value chain. An equivalent return to employment is then calculated, using the assumption that employees work on average 250 days a year (although this can be changed as a Tier 2option). Eventually, it is possible to estimate the equivalent volume of employment generated at the value chain level, and to identify the increase or decrease in equivalent employment compared to the upgraded scenario. EX-ACT automatically assigns the unit of measurement according to the number of people and number of means of transport required at each stage of the value chain. The different stages of the value chain are shown in Figure 6.

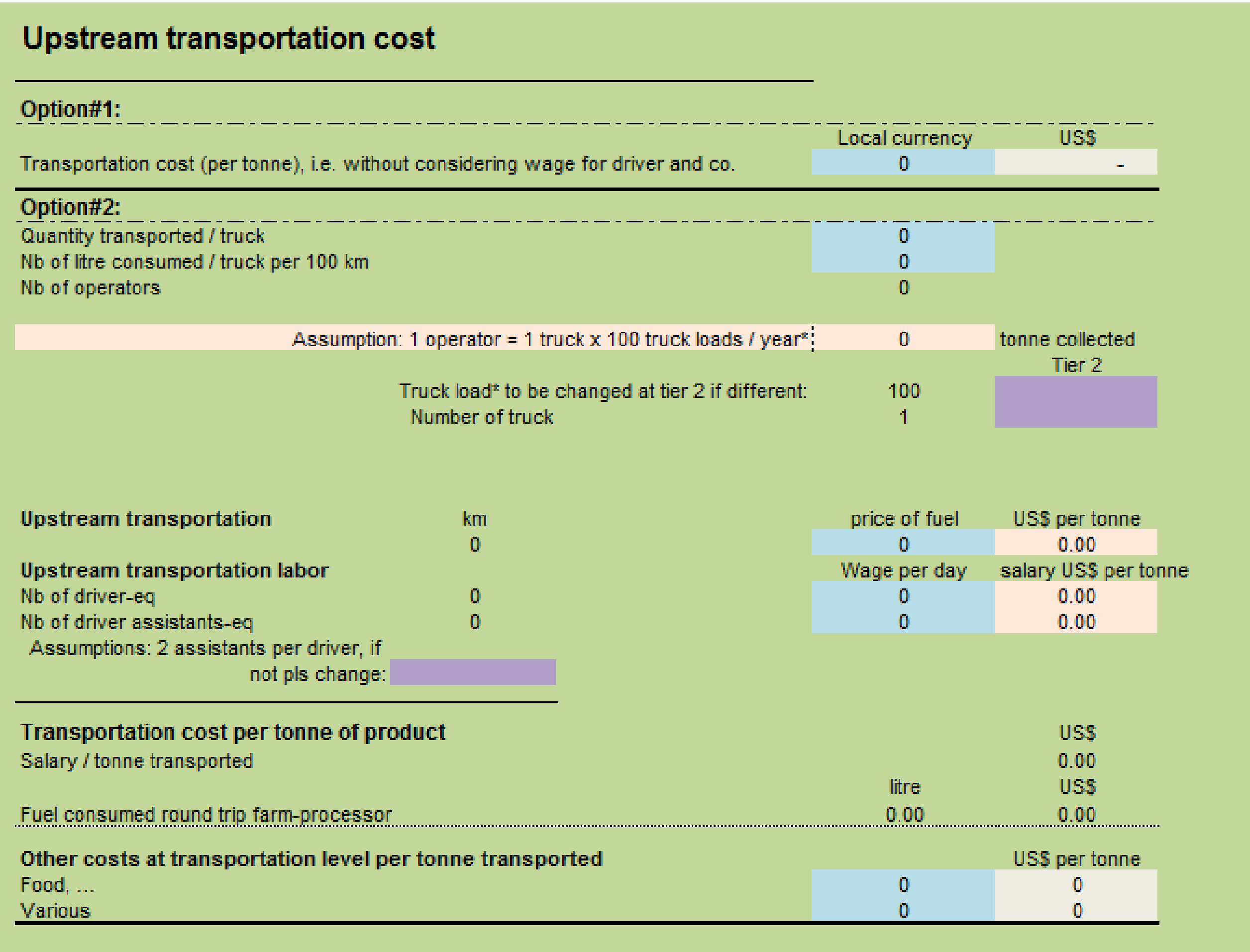
Figure 7: Schematic representation of the different actors taken into account in an EX-ACT VC analysis

- **Production**

At this level, EX-ACT VC takes into account the labour force that is required to perform each task, specific to the type of production. This is expressed either in man-days per hectare in the case of agricultural production, or in man-days per household in the case of livestock, fisheries and aquaculture. Thus the calculation of the volume of equivalent employment created in each scenario consists of the total amount of labour force that is needed for the production process over a default period of 250 days.

- **Upstream transportation**

EX-ACT VC uses the cost of transportation per tonne of product, or specified in-field information (numbers of drivers, assistants and associated salaries per man-day, quantity of product transported by truck, and fuel/diesel consumption per truck per 100 km). The user can manually modify default values and assumptions (e.g. the tool assumes that one operator corresponds to 1 truck conducting 100 journeys/truck loads per year) in the Tier 2 section, as shown in Figure 7. The volume of equivalent employment created for each scenario is determined by the total amount of labour force required for transporting the goods over a period of 250 days (the default value). Salaries are converted into US$.



Upstream transportation cost

Option#1:			
		Local currency	US$
Transportation cost (per tonne), i.e. without considering wage for driver and co.		0	-
Option#2:			
Quantity transported / truck		0	
Nb of litre consumed / truck per 100 km		0	
Nb of operators		0	
Assumption: 1 operator = 1 truck x 100 truck loads / year*		0	tonne collected
			Tier 2
Truck load* to be changed at tier 2 if different:		100	
Number of truck		1	
Upstream transportation	km	price of fuel	US$ per tonne
	0	0	0.00
Upstream transportation labor		Wage per day	salary US$ per tonne
Nb of driver-eq	0	0	0.00
Nb of driver assistants-eq	0	0	0.00
Assumptions: 2 assistants per driver, if not pls change:			
Transportation cost per tonne of product			US$
Salary / tonne transported			0.00
		litre	US$
Fuel consumed round trip farm-processor		0.00	0.00
Other costs at transportation level per tonne transported			US$ per tonne
Food, ...		0	0
Various		0	0

Figure 8 : Detail of the socio-economic analysis at the upstream transportation level

- **Processing**

At the processing level, EX-ACT VC distinguishes between full-time workers (managers and operators) and seasonal workers. The user specifies the number of man-days necessary to manipulate a tonne of production, then volume of equivalent employment generated at this stage is given as the sum of man-days for each category divided by 250 days (the default value).

- **Downstream transportation**

Regarding employment dynamics at the upstream transportation level, EX-ACT VC only takes into account transportation by truck in the country of production. Analysis of employment generation in train, ship and aeroplane transportation is extremely complex, due to the fact that several types of production are transported simultaneously. Furthermore, it is not relevant to focus on transportation occurring outside the country as EX-ACT VC is designed for analyses in developing and producing countries only and not in importing countries.

- **Wholesale production & retailers**

At this level, EX-ACT VC only takes into account the number of employees.

The following table (table 2) summarises the methodology and unit of measurement adopted for each stage of the value chain.

Table 2: Analysis of the volume of employment at the different stages of the value chain

Value chain stage	Unit	Methodology
Agricultural production	Number of man-days	Each step of agricultural production is differentiated: from soil preparation to harvest
Upstream transportation	- Number of truck drivers equivalent + Number of truck assistants - Cost of transport	- We assume 1 collector = 1 truck x number of truckloads / year, estimating the quantity transported by truck (n depends on the distance travelled) - If no data from the above point
Processing	Number of man-days/tonne of production	The type of workers are differentiated: Full time practical workers and managers/Seasonal employees/Family workers
Downstream transportation	Number of truck drivers equivalent + Number of truck assistants	Same calculation as in the case of upstream transportation
Wholesaler	Number of man-days/tonne + Number of truck drivers and assistants	Only the number of employees / tonne of production is taken into account Truck drivers: Same calculation as in the case of upstream transportation
Retailers	Number of man-days	Only the number of employees / tonne of production is taken into account

Following these calculations, the "Economic Analysis" module, described in Chapter 10, allows the user to calculate the costs of every intermediate input at each stage of the value chain. This is an important step in the computation of the above-mentioned indicators. The results are then grouped in the "VC Results" module for each stage of the value chain, as shown in Figure 9.

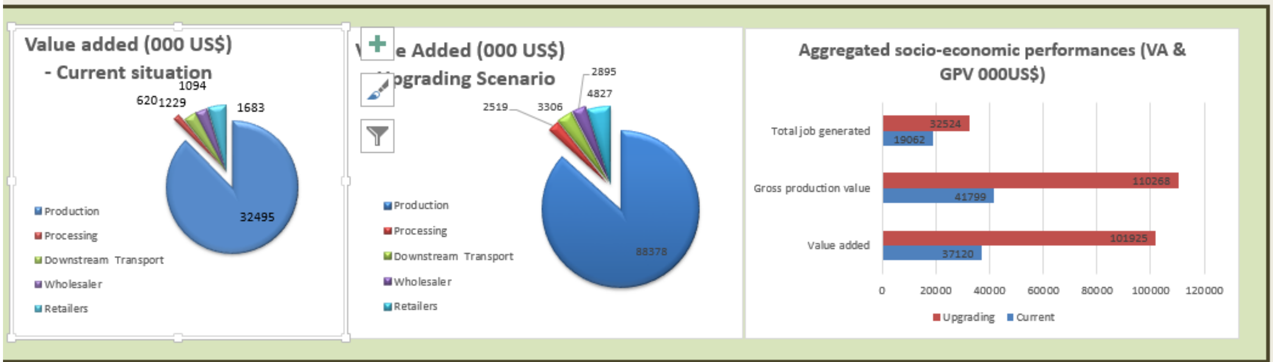
Figure 9: Detailed socio-economic results – the production and processing levels as displayed in the EX-ACT VC results module

	Socio-economic performances of the value chain		Current	Upgrading	Balance	
	Production level					
		Nb of HH	0	0		
		Nb of employement-eq	0	0	0	jobs
#DIV/0!	Gross production Value (GPV)		0	0	0	000 US$
#DIV/0!	Value Added (VA)		0	0	0	000 US$
#DIV/0!	Gross Income (GI)		0	0	0	000 US$
#DIV/0!	VA / tonne of product		0	0	0	US$
#DIV/0!	VA / ha		0	0	0	US$
#DIV/0!	Gross income / HH		0	0	0	US$
	Processing and upstream transportation level					
		Nb of operator-eq	0	0		
		Nb of employement-eq	0	0	0	Jobs
#DIV/0!	Gross processed production value (GPPV)		0	0	0	000 US$
#DIV/0!	Value added		0	0	0	000 US$
#DIV/0!	Gross income		0	0	0	000 US$
#DIV/0!	VA / tonne of product		0	0	0	US$
#DIV/0!	Gross income / operator		0	0	0	US$

In order to better visualise the different factors that contribute to wealth creation and poverty reduction, EX-ACT VC provides aggregated results according to the socio-economic outcomes discussed previously. In order to better identify the stage of the value chain that generates the most value, EX-ACT VC also provides detailed visual depictions of the value added at each stage. These are shown in Figure 10.

Figure 10 : Aggregated results and detailed value added

Aggregated Socio-economic performances	Current	Upgrading	Balance	
Value added	37120	101925	64804	000 US$
Gross production value	41799	110268	68469	000 US$
Total job generated	19062	32524	13462	Jobs created



3. Structure of EX-ACT VC

EX-ACT VC consists of eight interconnected Microsoft Excel sheets, referred to as modules, which users fill in according to their project and available data. Data screening, collection and insertion in EX-ACT VC depends of the value chain type, so it is not necessary to complete all the modules in the tool.

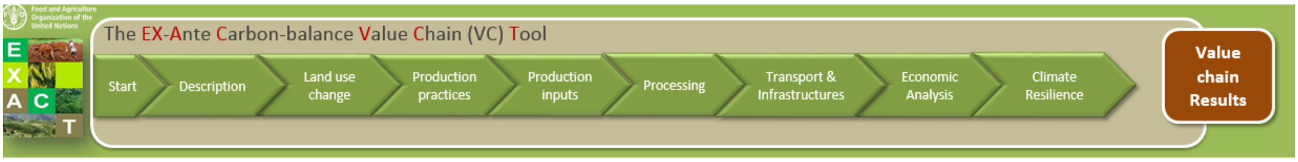
Users can specify geographical and agro-ecological conditions at the production level, as well as data on agricultural management practices and inputs at the processing and transportation levels. They may also provide economic figures such as input costs, salaries and number of agents for each stage of the value chain.

When performing an analysis with EX-ACT VC the user should compare information from the current value chain to projections for the upgraded scenario. This should occur at every step of the value chain as their impacts will differ accordingly. For example, increased yield from replacing old coffee trees with new coffee trees will increase coffee production and have a higher energy consumption at the processing level, generating more work at downstream transportation and production levels, towards retailers and exportation. As another example, change in water management in rice production will result in a decrease in CH_4 emissions and improve climate resilience in the project area.

This proposed methodology is the first analytical framework to use mitigation, adaptation, resilience and socio-economic indicators to appraise the performance of a value chain. It recognises the need for simple indicators that are easy to collect and aggregate, in order to create a measurable and concrete tracking system and accurately assess every type of food value chain.

The eight different modules that make up EX-ACT VC are organized into eight Microsoft Excel spreadsheets (see Figure 11, green arrows) and described below (in Table 5). Each of the different component and its sections are described in the next chapters.

Figure 11: The EX-ACT VC navigation bar



The navigation bar shown in Figure 10 contains eight modules: Description / Land use change / Production practices / Production inputs / Processing / Transport / Economic analysis / Climate resilience. The modules “Description”, “Land Use Change”, “Production Practices” and “Production Inputs” are constructed on the EX-ACT interface. EX-ACT VC adds to these with downstream analysis components, i.e. the modules “Processing”, “Transport”, “Economic Analysis” and “Climate Resilience”. These modules are capable of analysing a wide variety of crops (cereals, fruits, agroforestry systems and pulses), livestock (both mono- and poly-gastric animals), fisheries and aquaculture production.

A brief description of these eight modules is provided in Table 5.

Table 3: Description of the eight modules that comprise the EX-ACT VC tool

	Module	Description
1	General description	Description of the production zone and/or the upgrade project, including: type of value chain and/or project, climate, soil, type of vegetation, additional information (e.g. number of households, mean annual temperature, project budget, local currency and exchange rate in US$)
2	Land use change	Deforestation, non-forest land use change, new irrigated area
3	Production practices	Annual and perennial crop, flooded rice system, grassland and livestock, fisheries and aquaculture, production loss
4	Production inputs	Fertilizer and pesticides, energy consumption, livestock and aquaculture feeds
5	Processing	Energy consumption, production loss
6	Transport	Type of transport, associated loss and distance between phases of the value chain, conditioning during transport, infrastructure built as part of the upgrading scenario
7	Economic analysis	Price and input cost, labor in local currency
8	Climate resilience	Qualitative evaluation of value chain resilience
	Value Chain results	Climate mitigation dimension, climate resilience, socio-economic performance

Thus these eight modules comprehensively cover the current situation of the food value chain as well as a wide range of potential project activities, such as developing agricultural production, changes in land uses, boosting rural development, reducing production loss at multiple different levels, food security projects, and so on.

All results – the potential for mitigation, CFP, economic outcomes and climate resilience – are registered in a single module named “Value Chain Results”. This module, as it appears in the tool, is shown in Figure 12.

Figure 12: Value chain results - a case study of a Haitian coffee value chain

Project:	Relance filiere café 2018-2028		Upgrading	Current
country	Haiti	Production (tonne)	16560	38976
region	Please specify name	Yield (t ha^{-1} yr^{-1})	0.23	0.45
Budget (US$)	46000000	Hectares		90000
Year	2018	Households		140000

Climate Mitigation dimension of the Value Chain	Current	Upgrading	Balance
GHG impact (tCO_2-e per year)	-46,592	-294,022	
GHG impact (tCO_2-e per year per hectare)	-0.5	-3.3	-2.7
Carbon footprint of production (tCO_2-e per tonne of product)	-3.0	-10.7	-7.7
Annual tCO_2-e [emitted (+) / reduced or avoided (-)]		-247,430	
Annual tCO_2-e from renewable energy		0	
Equivalent project cost per tonne of CO_{2-e} reduced or avoided (in US$ per tCO_2-e)		186	
Equivalent value of mitigation impact per year (US$ 30/tCO_2-e)		7,422,910	
Equivalent value of mitigation impact per year per ha (US$ 30/tCO_2-e per year per ha)		82	

Carbon footprint at the different levels of the Value Chain	CO_2-e per tonne of produc		Balance
	Current	Upgrading	
PRODUCTION	-3.03	-10.75	-7.72
PROCESSING	0.04	0.04	0.00
TRANSPORT	0.21	0.21	0.00
TOTAL	-2.78	-10.50	-7.72

Each EX-ACT VC module is sub-divided into different sections using boxes. All sub-modules components are clearly delimited by an outside frame. A specific colour code is used throughout the tool to guide users, as shown in Figure 13.

Figure 13: Colors used and their meanings

Color code	Meaning
	Request an action from users: provide number (hectare, head number..) or select from drop-down list
	Help option, send to the "help" excel sheet
	Description information to be filled up by users
	Default value proposed which can be changed if necessary
	Yield and default crop related to the proposed project

EX-ACT VC allows analysis of a simple value chain, or a section of more complex value chains (for instance, regional or area-specific sub-value chains). For analysing more complex value chains, users should segment it into sub-value chains and follow the instructions below.

The following chapters will provide user information on how to fill in each of the different modules. To aid understanding, figures from here onwards display an example analysis of a value chain for coffee in Haiti.

4. Description module

The "Description" module is compulsory and must be completed first before proceeding with the tool. If incorrectly, or incompletely, filled, users will not be able to proceed with the other EX-ACT VC modules, as they will lack the necessary input information. This information concerns the agro-ecological conditions of the region, which fixes the default values and coefficients used for estimating GHG emissions generated by land use changes, agricultural practices and use of different energy sources.

Users must fill in the following information to the module. Figure 14 shows this process as it appears in the tool.

(i) General information on the value chain

1 **Name of the value chain**: Users insert the name of the analysed value chain.

2 **Location**: Users select the continental region of the study area under analysis from the drop-downmenu. This fixes a set of default values for emission calculations.

The eleven continental regions are: *Africa / Asia (continental) / Asia (Sub-continental India) / Asia (Insular) / Middle East / Western Europe / Eastern Europe / Oceania / North America / Central America/ South America*

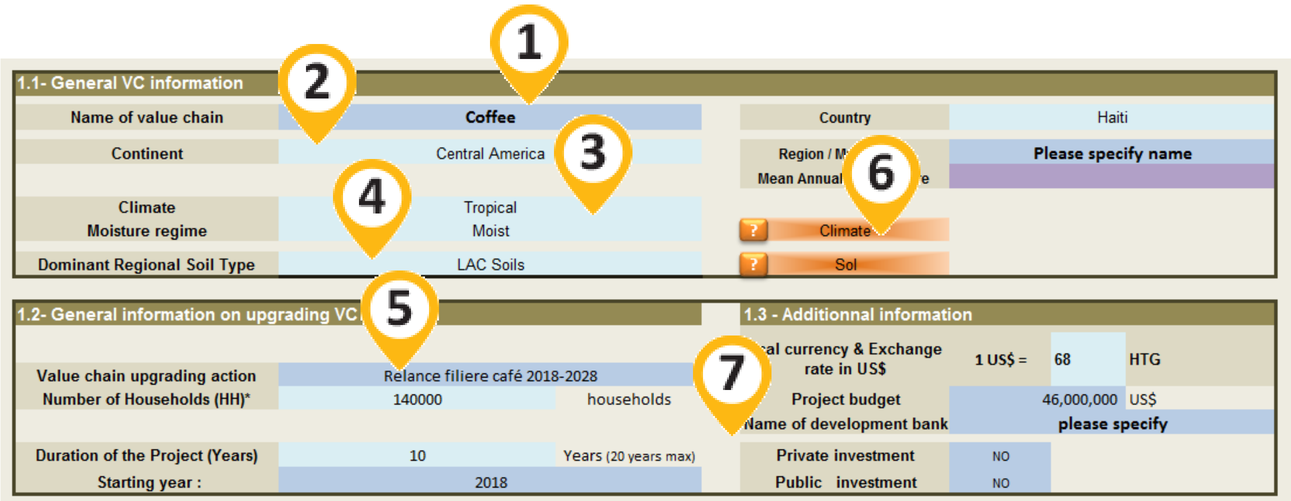
Users can complement this information by specifying the country, region, department and municipality of the study area under analysis.

The coffee value chain in this analysis takes place in Haiti within a Tropical Moist climate where LAC soils represent the dominant regional soil type.

3 **Agro-ecological conditions**: climate strongly influences GHG emissions and carbon sequestration in agriculture (including livestock). A careful choice of correct climate type is therefore key. The default options are: *Boreal / Cool Temperate / Warm Temperate / Tropical / Tropical Montane*. The default options for the **moisture regime** are: *Dry / Wet / Moist*.

4 The **Dominant soil type** is the variable that fixes the carbon stocks in the different biomass and soil compartments. Users should indicate the dominant soil type using the simplified IPCC classification. IPCC lists six soil categories: *High Activity Clay soils (HAC) / Low Activity Clay soils (LAC) / Sandy soils / Sodic soils / Volcanic soil / Wetlands soils.*

Figure 14 : Description module



5 **Type of analysis**: the user specifies the type of analysis, related either to the current situation or to the upgraded scenario.

6 **Help**: clicking on the orange boxes redirects users to a section that provides guidance on the type of soil and climate associated with the agro-climatic area where the project tales place, with helpful world maps.

(ii) General information on the upgrade project

7 Here the user provides key information necessary for the economic analysis, namely the number of beneficiaries and the duration of the project. The remaining information (the start year of the upgrade scenario, the project budget, the name of the development bank and whether the project involves public and/or private investments) are facultative.

In this example, the analysis focuses on the value chain for coffee in Haiti. The project seeks to make improvements at the production and processing levels. The project begins in 2018 and covers a 10-year period.

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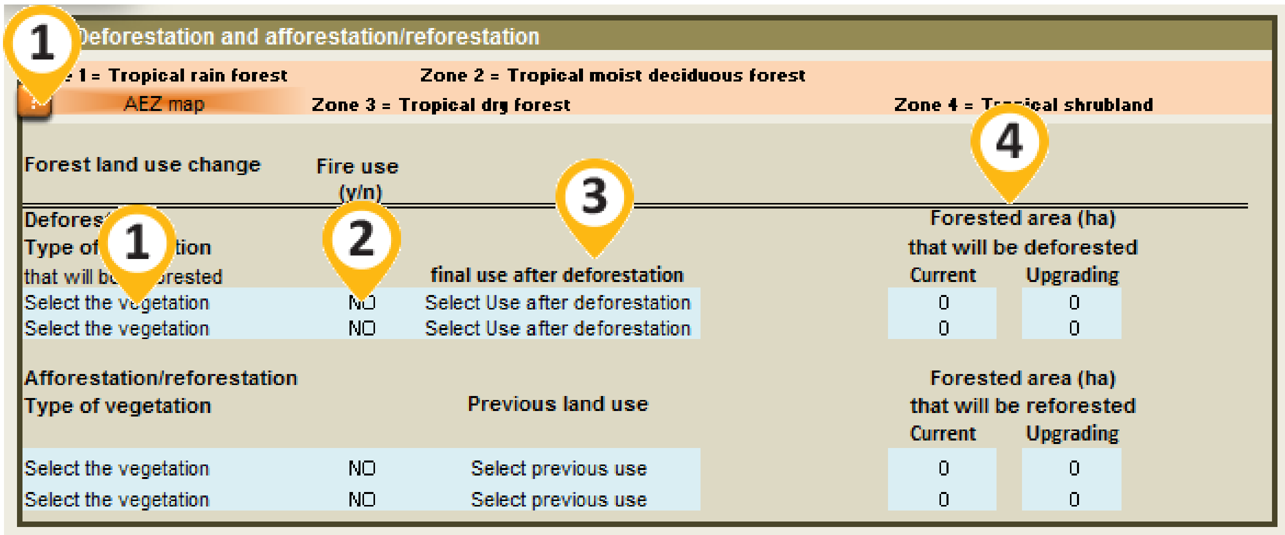
5. Land use change module

This module is only concerned with land use changes caused by an upgrade project. It takes into account (i) changes in forest area (deforestation/reforestation), (ii) non-forest land use changes and (iii) newly irrigated area.

a) Forest land use changes

This section concerns deforestation and/or reforestation activities. The user specifies the number of hectares of deforested area either induced or reduced, as well as number of hectares of reforested or agroforestry-converted area, as a consequence of the upgrade program. Figure 15 displays this section.

Figure 15 : Forest land use change section



1 **Type of vegetation**: Depending on the type of climate, the user must specify the type of vegetation, choosing from the following four categories: *Forest zone 1 = Tropical rain forest; Forest zone 2 = Tropical deciduous forest; Forest zone 3 = Tropical dry forest and Forest zone 4 = Tropical shrubland.* A help button inform users about the type of vegetation associated to the continent, climate and moisture informed in the description module. This help button is linked to a global ecological zones map.

Furthermore, users must choose the agro-ecological characteristics of the forest areas affected by the project. EX-ACT VC distinguishes between (i) natural forests and (ii) plantations, which require different management strategies and imply different biomasses and growth rates of trees.

2 **Fire use:** slash-and-burn practises on forestland are a major cause of GHG emissions. This is why it is important to specify whether or not fire is used during land use conversion, as the resulting emission levels will vary significantly.

3 **Final/previous land use**: users select the final state of the land after deforestation from a drop-down menu. This will determine default carbon stocks in the biomass and in the soil the year following the conversion. In the case of reforestation activities, the previous land use should be specified. The options in both cases are: *Annual Crop / Perennial or Tree Crop / Flooded Rice / Set Aside / Grassland / Degraded / Other*.

4 **Surface area:** users specify the surface area affected by the changes made by the upgrade project, and the surface area under the current scenario, in terms of deforestation (induced or reduced) and reforestation or conversion to agro-forestry.

b) Non-forest land use changes

This section concerns all land use changes that are not related to forestland as displayed in Figure 16.

Figure 16 : Non-forest land use change section – Land use change module

2.2 - Non forest Land use change for an upgrading project scenario

Fill with your description	Initial land use	Final land use	Fire Use (y/n)	Area transformed (ha) Current	Upgrading
new coffee plantations	Degraded Land	Perennial/Tree Crop	NO	0	10000
Description#2	Select Initial Land Use	Select Final Land Use	NO	0	0
Description#3	Select Initial Land Use	Select Final Land Use	NO	0	0

1 **Description**: users fill in a description of the system in which land use changes brought about by the project occur.

2 **Initial and final land use:** users select the initial land use prior to project changes, and the final land use, from a drop-down menu. The available options are: *Annual Crop / Perennial or Tree Crop / Flooded Rice / Set Aside / Grassland / Degraded / Other*.

3 **Fire use**: slash-and-burn practises on non-forestland are a major cause of GHG emissions. It is therefore important to specify whether or not fire is used during land use conversion, as the resulting GHG emissions will vary drastically.

4 **Area transformed**: the user should specify the area affected by land use changes in the current and/or the upgrade scenario.

In this coffee value chain, 10 000 ha of degraded land will be converted into new coffee plantations

c) Irrigation systems

This section does not require much information, only the surface area covered by irrigations systems in both scenarios and the associated water consumption, shown in Figure 17.

Figure 17 : Irrigation system – Land use change module

2.3. Irrigation and water management

	Area affected (ha) Current	Upgrading VC	Type of irrigation systems
New irrigated areas installed	0	0	Please select
			*IRRS = Irrigation Runoff Return System
	Current	Upgrading VC	
Water consumption (m^3/yr)	0	0	
Water efficiency at production level (m^3/yr)	0		

1 **Installation of new irrigated areas:** users should specify the surface area (ha) fed by irrigated systems for both the current value chain and the upgraded value chain.

2 **Type of irrigation system**: from a drop-down menu, users select the type of irrigation system involved in the project. The available options are: *Surface without IRRS / Surface with IRRS / Solid set sprinkle / Hand moved sprinkle / Solid roll sprinkle / Centre-pivot sprinkle / Travel sprinkle / Trickle*

3 **Water consumption**: users should indicate water consumption for both the current and the upgraded scenarios. Any reduction in water consumption following the implementation of the project is an indicator of the efficacy of the irrigation system.

6. Production practices module

This module gathers together agricultural practices according to the type of agricultural system: (i) annual systems, (ii) perennial systems, (iii) flooded rice and (iv) grassland and livestock. Users should complete this module according to the practices used for the relevant production process. Any land use changes specified in the previous module are automatically reverted to the current use under the denomination “annual systems from other land use changes”. This is valid for perennial, rice and grassland systems. For systems that remain the same (i.e. perennial systems remaining perennial systems and annual systems remaining annual systems, rice systems remaining rice systems and grassland remaining grassland), users should specify the ad hoc information.

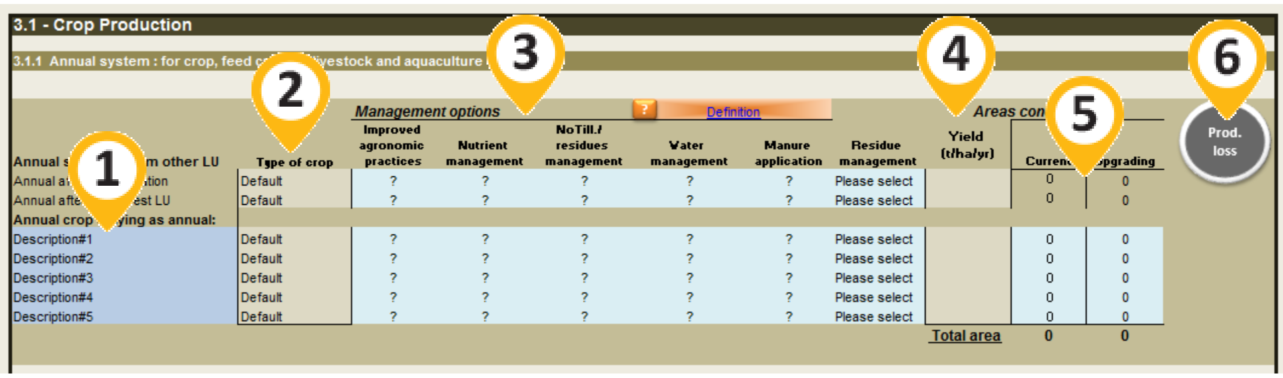
a) Annual systems

As mentioned above, this section considers two types of annual systems: (i) annual systems generated from a land use change (either from deforestation or initial non-forest lands) and (ii) annual systems that remain annual systems. In the case of the former, the corresponding surfaces are automatically retrieved from the “Land Use Change” module and transferred in this section, as seen in Figure 18. Users need only detail the potential management techniques for biomass and/or soil applied the year following land use conversion. For “annual systems remaining annual systems”, within the framework of an improved project scenario or the current situation of the value chain, users must specify what changes are made, in terms of agricultural management practices.

Agricultural practices are important determinants of the quantity of carbon sequestered in soil. For instance, annual crops are generally characterised by more intensive forms of land preparation. The improvement of agricultural practices is, therefore, integral to the improvement of agro-food value chains. EX-ACT VC recognises several improved management practices:

- **Improved agronomic practices** encompass all practices that could lead to increased yields, thus generating higher quantities of biomass residue. Examples of such practices, reported in Smith *et al.* (2007), include the use of improved crop varieties, the extension of crop rotation systems and the association of crops with pulses.
- **Improved nutrient management** includes the application of fertilizers, the greater efficiency of manure and bio solids (i.e. adjusting application rate and improving timing and location) and minimising potential losses (i.e. using fertilizers with slow release rates or nitrification inhibitors).
- **Improved tillage and residue management** refers to the adoption of lower intensity tillage practices, ranging from minimum tillage to no tillage. It also includes mulching of crop residues, represents a key element of conservation agriculture.
- **Enhanced water management** consists of enhanced irrigation measures that lead to an increase in productivity and thus augment residue quantities.

Figure 18 : Annual systems section – Production practices module



In this section, users must specify the following elements in order to estimate the impact of the improved agricultural practises:

1. **Description**: to avoid mistakes and maintain a clear idea of the annual crops impacted by the project, users are advised to provide a description of the systems (e.g. 'traditional cassava' in the first line and 'improved cassava' on the second).
2. **Type of crop**: users select the type of annual crop from a drop-down menu. The options are: *Grain / Beans and pulse / Root crops / Tubers / Barley / Maize / Oats / Potato / Soybean / Wheat*. This sets a default value for the selected crop residues, biomass and nitrogen inputs. If no selection is made a default value is used.
3. **Management options**: users must specify which type of management practice is used in the system under consideration. The agricultural practices concern both (i) management options and (ii) residue management. Currently there is no evidence to suggest that these practices may have additive effects for climate change mitigation, so EX-ACT VC uses only the practice with the most favourable mitigation potential.

   - **Management options** include: *Improved agronomic practices*, *Nutrient management*, *No till/residue management*, *Water management* and *Manure management*. The drop-down menu informs the user on whether the particular management option is realised for each type of crop. A question mark stands as the default entry, corresponding to "NO".
   - **Residues management**: users must define which residue management type is used in the practice under analysis (i.e. *Burned*, *Exported* or *Retained*).

4. **Yield**: users must enter the average yield for each crop practice analysed, in tonnes per hectare per year. This will be integrated into the Economic analysis module.
5. **Area concerned**: for each system described, users must specify the surface area of both the current situation and the upgraded value chain scenario. The specified area needs to be balanced among the different practices in both scenarios to result in even total area.
6. **Production loss:** this option directs the user to the section concerning percentage loss at the production level.

b) Perennial systems

As explained in the previous section, each line corresponds to a type of production used for perennial crops (with the exception of the first two lines that are automatically filled using the information entered in the "Land Use Change" module – i.e. deforestation, reforestation/afforestation, non-forest land use changes, irrigation and water management). The second sub-section concerns perennial crops that remain perennial within the scope of the upgrade project or the current value chain scenario. For this, the user must take into account a management system that might affect the growth rate of the biomass and/or residue management. This section, as it appears in EX-ACT VC, is shown in Figure 19.

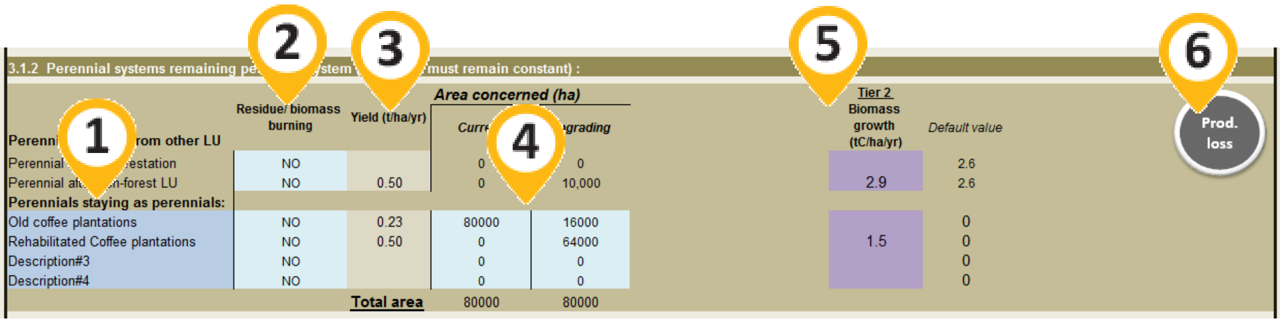
1. **Description**: users set down a description of the perennial systems to avoid any misunderstanding in data entry.
2. **Residues management**: users define which type of residue management is used in the practice under analysis (i.e. *Burned, Exported* or *Retained*).
3. **Yield**: users enter the average yield, in tonnes per hectare per year. This will be integrated into the economic analysis.
4. **Area concerned**: the user must specify the area affected by each practice, for both the current situation and the upgraded value chain scenario.

Tier 2: A Tier 2 option is available in this section. If the value for biomass growth of agroforestry systems is different from the default value, users should enter their data, in tonnes of carbon per hectare per year (tC/ha/yr), in the Tier 2 section.

Production loss: this option directs the user to the section concerning loss at the production level, expressed in percentage of production.

In this coffee VC, 64 000 ha of old plantations will be rehabilitated, while 16 000 ha remain unchanged, which increases the yield from 0,225 to 0.5 t/ha/yr from the current VC to the upgraded one. Biomass growth is also changed in Tier 2

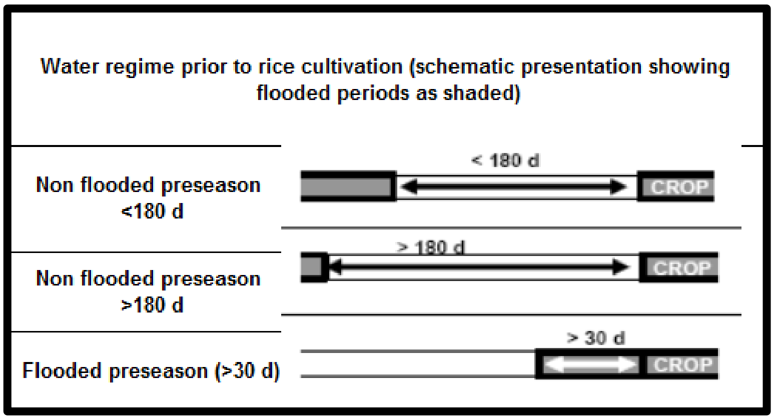
Figure 19 : Perennial systems – Production practices module



c) Flooded rice systems that remain as flooded rice systems

Flooded rice systems, either under irrigation or rainfed, have certain special implications for CH_4 emissions. As such, while all other annual crops are dealt with in the sections described above, flooded rice systems are addressed separately in this sub-module. Rice systems, before cropping, can be separated into three systems; those with a non-flooded pre-season of less than 180 days, those with a non-flooded pre-season of more than 180 days, and those with a flooded pre-season of at least 30 days or longer. These systems are explained visually in Figure 20. Rice systems are then differentiated into three water regimes during the cropping season:

Figure 20: Water regime prior to rice cultivation - schematic presentation showing flooded periods as shaded.



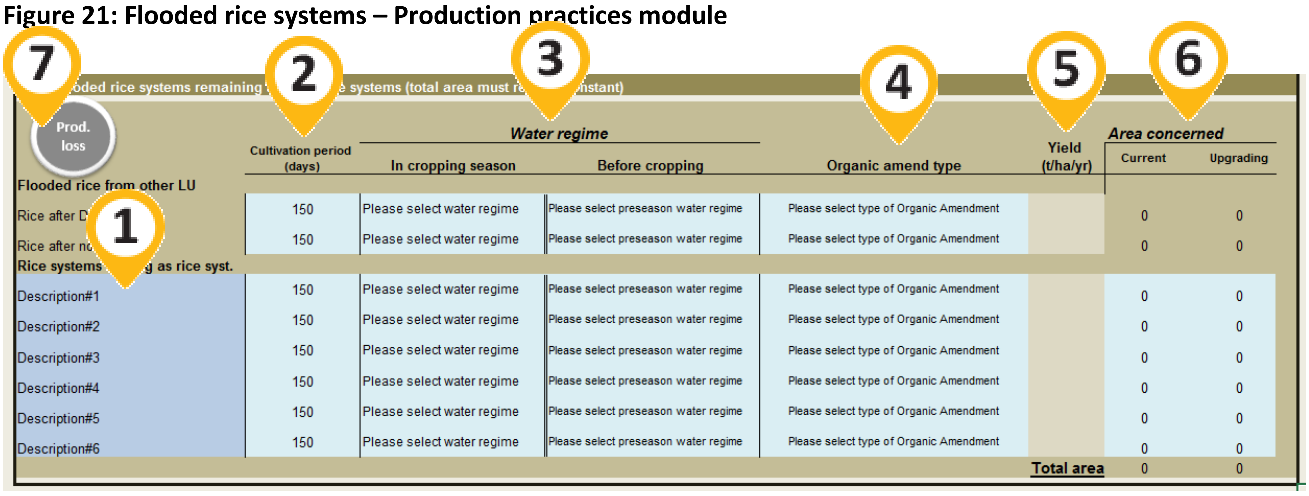
(i) **Irrigated – Continuously flooded:** fields that contain standing water throughout the entire growing season and are only dried out for harvest (end-season drainage).

(ii) **Irrigated – Intermittently flooded**: fields that are subject to at least one aeration period of more than three days during the cropping period. No distinction is made between single and multiple aerations.

(iii) **Rainfed, deep water**: fields that are flooded for a significant period of time, and for which water availability depends solely on precipitation. This water regime includes the following sub-cases: (i) regular rain (the water level rises up to 50 cm during the cropping season), (ii) drought (periods of drought occur during the cropping season), and (iii) deep water rice (floodwater rises to more than 50 cm for a significant period of time during the cropping season).

To fill in the flooded rice sub-module, the user needs to provide the following information (also shown in Figure 21).

Figure 21: Flooded rice systems – Production practices module



	Cultivation period (days)	Water regime: In cropping season	Water regime: Before cropping	Organic amend type	Yield (t/ha/yr)	Area concerned: Current	Area concerned: Upgrading
Flooded rice from other LU							
Rice after D	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment		0	0
Rice after nc	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment		0	0
Rice systems ... g as rice syst.							
Description#1	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment		0	0
Description#2	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment		0	0
Description#3	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment		0	0
Description#4	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment		0	0
Description#5	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment		0	0
Description#6	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment		0	0
					Total area	0	0

1. **Type of system**: users must specify the cropping system to avoid mistakes in data entry.

2. **Cultivation period**: users specify the length of the cultivation period.

3. **Water regime**: users must define whether the rice field is continuously or intermittently flooded during the ***cropping season*** or whether it is managed as a rainfed and deepwater system, as described above. Furthermore, users must specify the water regime used during the ***pre-cropping season***. From a drop-down menu, users select whether the preseason is flooded or non-flooded. If the preseason is non-flooded users should specify whether this occurs for longer or shorter than 180 days.

4. **Organic amendment**: this step concerns the way in which crop residues are managed and utilised. The different options are: *Straw burnt / Straw exported / Straw incorporated shortly or long before cultivation / Compost / Farm yard manure / Green manure*.

5. **Yield:** users must enter the average yield, in tonnes per hectare per year, for each rice crop practice. This information will later be used in the economic analysis.

6. **Surface area concerned:** finally, users specify the surface area involved for both the current and upgraded scenarios. Surfaces obtained from land use changes are automatically derived from the "Land Use Change" module.

7. **Production loss:** this option directs the user to the section detailing percentage loss at the production level.

7. Grassland and livestock management

This section concerns pastures (grasslands), livestock and diary production

a) Grassland management

Grasslands are an important stock of soil carbon and may become a source for emissions through degradation or periodic burning. Like the crop production module, the grassland sub-module is divided into an upper section for grassland subject to land use change and a lower sectionfor areas permanently grassland (see Figure 22).

To complete the grassland section users need to specify:

1 Naming the specific pasture system: users denominate the grassland area.

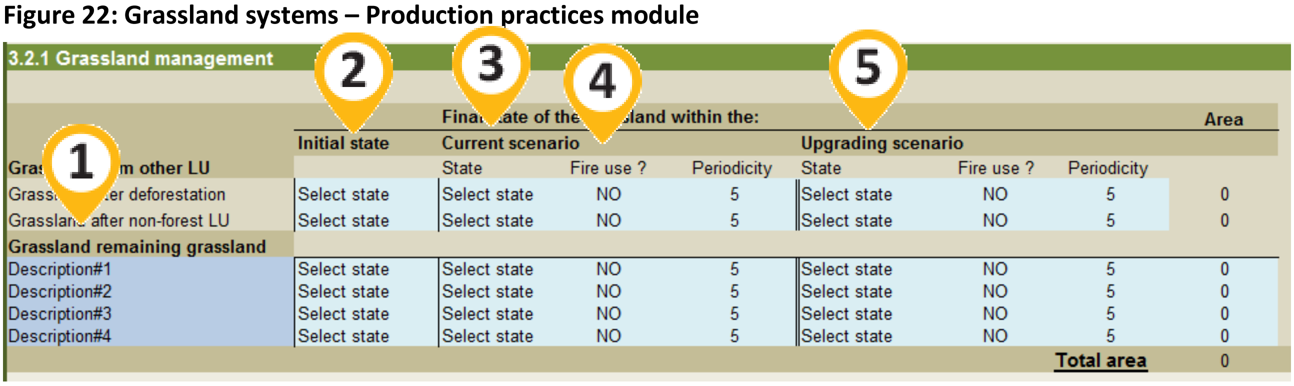
2 Initial state of degradation*:* In this step users specify the initial state of degradation of the grassland area for both the current and upgraded scenarios, by selecting from the drop-down menu. The options are: Non-degraded / moderately degraded / severely degraded / improved without inputs / improved with inputs. Each state of degradation refers to a respective stock of soil carbon per hectare, dependent on the agro-ecological zone identified in the description module.

3 Final state of degradation: Users specify the final state of degradation for both the current and upgraded scenarios, selecting from the same options as previously.

4 Fire use: In this step users specify whether, and how frequently, grassland is burned. In the example in Figure 21, fire is used every five years on the area used for cattle grazing under both the baseline scenario and the project scenario.

5 Surface size of grassland: Users specify the size of the grassland area for grassland remaining grassland, while grassland's area coming from land use change is automatically specified from data entered in the previous module (land use change)

Figure 22: Grassland systems – Production practices module


3.2.1 Grassland management

		Fina... ate of the ...land within the:						
	Initial state	Current scenario			Upgrading scenario			Area
Gras... m other LU		State	Fire use ?	Periodicity	State	Fire use ?	Periodicity	
Grass... er deforestation	Select state	Select state	NO	5	Select state	NO	5	0
Grasslan... after non-forest LU	Select state	Select state	NO	5	Select state	NO	5	0
Grassland remaining grassland								
Description#1	Select state	Select state	NO	5	Select state	NO	5	0
Description#2	Select state	Select state	NO	5	Select state	NO	5	0
Description#3	Select state	Select state	NO	5	Select state	NO	5	0
Description#4	Select state	Select state	NO	5	Select state	NO	5	0
							Total area	0

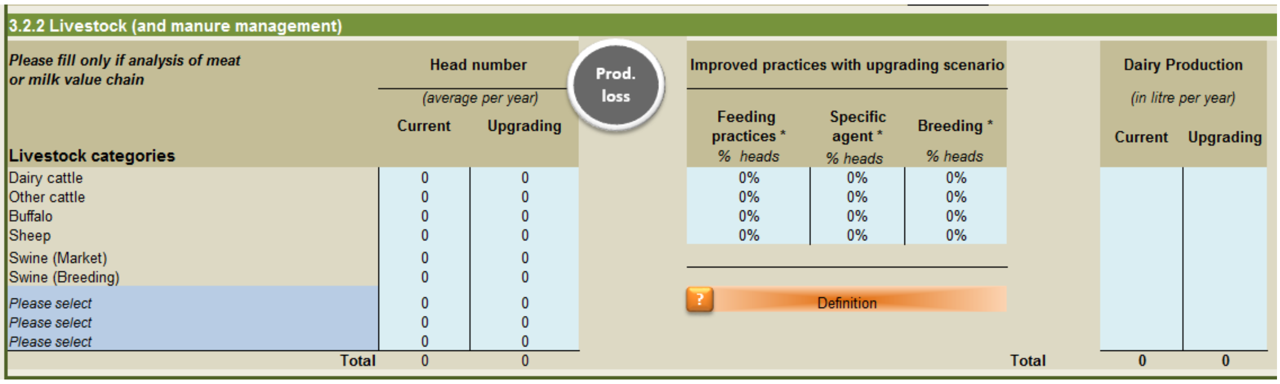
b) Livestock management

The livestock section was developed based on IPCC (2006). For specific technical mitigation options not covered in IPCC (2006), information was taken from the Fourth Assessment Report from Working Group III of the IPCC and Smith *et al.* (2007).

The GHGs covered by the livestock sub-module (Figure 23) are (i) CH_4 emissions from enteric fermentation, (ii) CH_4 emissions from manure management, (iii) N_2O emissions from manure management, and (iv) additional technical mitigation options for CH_4 emissions from livestock (see Figure 22). In the description module, users can specify the mean annual temperature (MAT, in ^{O}C) of the value chain region. If no value is provided EX-ACT-VC uses default values according to the climate indicated in the Description Module: -5°C for "Boreal", 5°C for "Cool Temperate", 14°C for "Warm Temperate", 22°C for "Tropical Montane" and 24°C for "Tropical". MAT will affect the CH_4 and N_2O emissions from manure management.

This section also allows users to include dairy production, in litres per year. Data entered here are automatically used for the socio-economic analysis (Economic analysis module).

Figure 23: Livestock management – Production practices module



3.2.2 Livestock (and manure management)

Please fill only if analysis of meat or milk value chain Livestock categories	Head number (average per year) Current	Upgrading	Prod. loss	Improved practices with upgrading scenario: Feeding practices * % heads	Specific agent * % heads	Breeding * % heads		Dairy Production (in litre per year) Current	Upgrading
Dairy cattle	0	0		0%	0%	0%			
Other cattle	0	0		0%	0%	0%			
Buffalo	0	0		0%	0%	0%			
Sheep	0	0		0%	0%	0%			
Swine (Market)	0	0							
Swine (Breeding)	0	0							
Please select	0	0		Definition					
Please select	0	0							
Please select	0	0							
Total	0	0					Total	0	0

To complete the livestock sub-module users need to specify:

1 Choosing the adequate animal categories*:* users may choose from the proffered animal types or choose from further types in the drop-down menu (*goats / camels / horses / mules / poultry / deer / alpacas*).

2 Livestock numbers: In the second step users specify livestock numbers for both the current and upgraded scenarios.

3 Technical mitigation options: here users specify what percentage of livestock herds are subject to (i) improved feeding practices, (ii) application of specific agents or (iii) improved breeding practices.

4 Dairy production: here users can detail the annual dairy production for both the current and upgraded scenarios.

5 Production loss: this option directs the user to the section detailing percentage loss (milk) or mortality (livestock) at the production level

c) Fishery and aquaculture section

Management activities in the fisheries – catch at sea

The GHG emissions from fisheries (Figure 24) accounted for in EX-ACT VC are derived from: (i) fuel use of wild-capture fisheries during the harvest phase (ii) on-board leakage from the refrigerants, excluded in the artisanal fishery (iii) ice produced ashore and brought on board during the harvest phase.

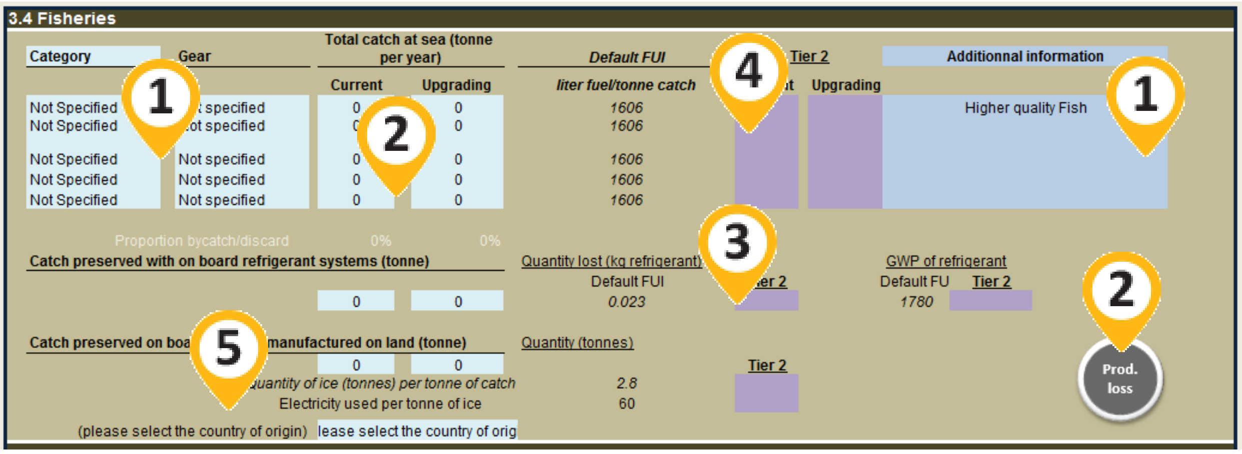
When analysing a fishery value chain, the following information is required:

1 Fish category and associated gear: users select one of the following options from the drop-down menu: *Crustaceans / Finfish / Flatfish / Large Pelagics / Molluscs / Salmonids / Small Pelagics / Not Specified.* Users can input information on the fish catch in the "additional information" section. Gear-type options are: *bottom trawls / gillnets /hooks & lines / pelagic trawls / pots & traps / surrounding nets / dredges / not specified*. Users can also denominate the fish category within the additional information column.

2 Total Catch per year (in tonnes per year): in this step users specify the catch for the current scenario and the upgraded scenario. Users can specify the production lost on board.

3 On-board leakage from refrigeration systems: users specify the quantity of the catch preserved in on-board refrigeration systems for both the current value chain and for the upgraded scenario. The default emission factor for the quantity of refrigerant, i.e. 0.023 kg per tonne of fish preserved can be changed at tier 2, as well as the global warming potential of the refrigerant used, by default 1780.

Figure 24: Fisheries management – Production practices module



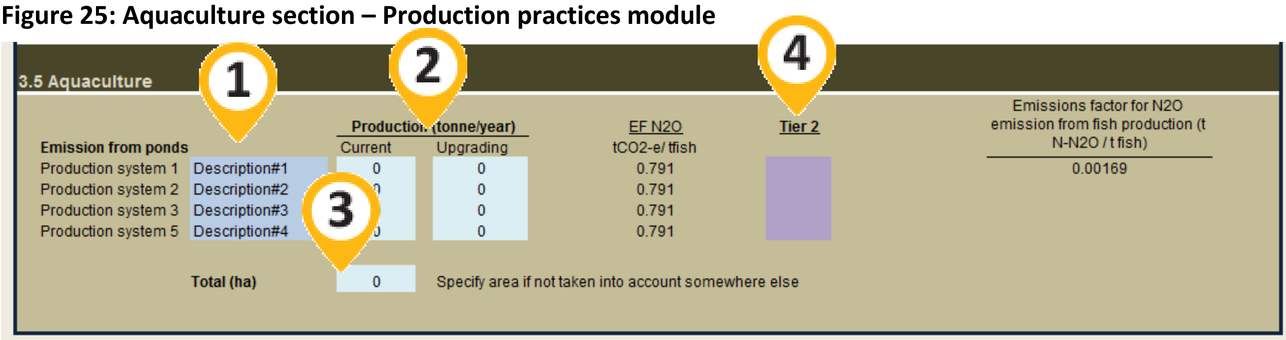
Fuel Use Intensity (FUI): FUI is the fuel consumed, in litres, per tonne of fish caught at sea. Users may specify the FUI of both the current and upgraded scenario. The default value is 1606 litres per tonne. Any management activities (such as improved gears or boat maintenance to avoid fouling) will affect the fuel consumption, and thus affect the GHG emissions and carbon footprint of the production process.

Emissions from production of ice produced ashore: Users specify the quantity of the catch (in tonnes) that is preserved on board using ice produced ashore. The default ratio (ice:fish) is 2.8 tonnes of ice per tonne of fish preserved (however this can be changed using a Tier 2 approach). Users must also specify the country of electricity production. Electricity consumption to provide 1 tonne of ice may be specified. The default value is set at 60 kWh per tonne of ice.

d) Aquaculture

This section concerns fish farming and the assessment of N_2O emissions due to nitrogen excretion from fish metabolism (Figure 25). Use of feed in fish farming systems should be specified in the "Production inputs" module.

Figure 25: Aquaculture section – Production practices module



To complete the aquaculture sub-module, users need to specify:

<u>For the fish production:</u>

Users fill up the description of the production

Annual fish production (in tonnes per year): in this step, users specify annual fish production for both the current and upgraded scenarios.

Total surface area (ha): area occupied by feed-fed fish farming systems of the upgraded scenario should be specified <u>if</u> the surface of the pond is not already accounted for in other EX-ACT VC modules (for instance, the area of a pond created due to conversion from rice paddies to shrimp ponds would already be accounted for in the EX-ACT calculations, so inputting this data in the aquaculture module would lead to double the true total surface area of the project in the final carbon balance.

4 **The emission factor for N_2O emissions:** The emission factor for N_2O emissions from fish production (tN-N_2O/tfish) should be specified. The default value is 0.791.

e) Production loss and water management

The final section of the module concerns the percentage of wasted production and mortality rate of livestock and aquaculture at the farm level, shown in Figure 26. Users must enter the percentage loss for both scenarios. This section assessed whether a reduction in production loss due to improved management practices is the source of a climate mitigation impact. Water consumption can also be specified for both the current situation and upgraded scenario. This information is used to evaluate water efficiency at the production level (m^3/yr), as a direct consequence of improved practices.

In this coffee VC, 8% of the production is lost in the current situation, while the upgraded VC will decrease it to 4%

Figure 26 : Production loss and water management at the farm level

3.3. Production loss and water management at the farm level		
	Current	Upgrading
Percentage of wasted production or mortality rate	8%	4%
	Current	Upgrading
Water consumption (m^3/yr)	0	0
Water efficiency at production level (m^3/yr)	0	

8. Production inputs module

Inputs are highly important to the environmental and socio-economic performance of the production process. The module consists of three sections: (i) energy consumption, (ii) agricultural inputs and (iii) infrastructure.

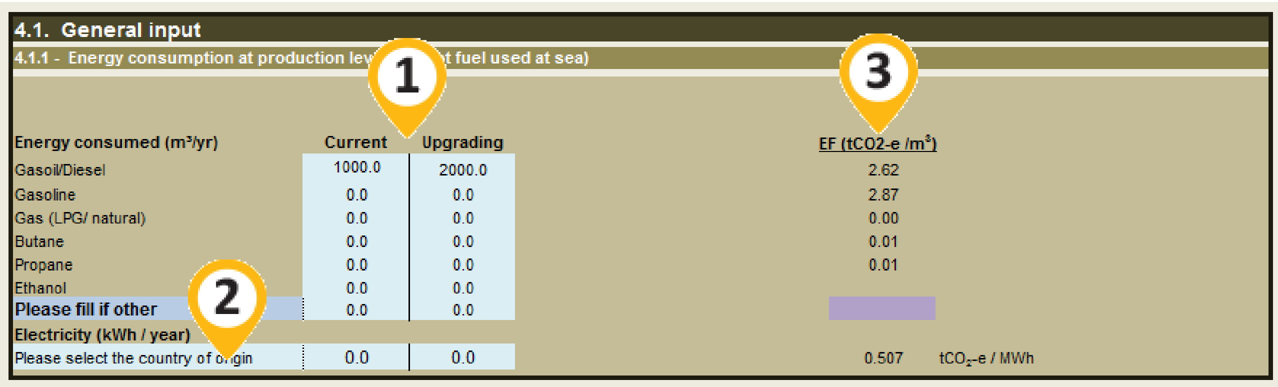
Data entered to this module contribute to the estimation of GHG emissions at the production level and to the analysis of the socio-economic performance. Indeed, entered data are automatically used in the Economic analysis module. Users should specify the type and quantity of inputs used, and the associated costs in local currency per unit (e.g. litre, kg, etc.). These sections can be completed for both the current situation and upgraded scenario.

a) Energy consumption

At the production level, energy consumption refers to the electricity, gas and fuel used at the farm scale during the different production phases (e.g. for mechanisation, irrigation and other energy-dependant infrastructures). This applies to all sectors; crops, livestock, aquaculture and land-based fishing activities (fuel used at sea is already accounted for in the previous module – FUI).

The section appears in EX-ACT VC as shown in Figure 27. Users must specify:

Figure 27: Energy consumption at the production level – Production inputs module


4.1. General input

4.1.1 - Energy consumption at production lev... t fuel used at sea)

Energy consumed (m^3/yr)	Current	Upgrading	EF (tCO_2-e /m^3)
Gasoil/Diesel	1000.0	2000.0	2.62
Gasoline	0.0	0.0	2.87
Gas (LPG/ natural)	0.0	0.0	0.00
Butane	0.0	0.0	0.01
Propane	0.0	0.0	0.01
Ethanol	0.0	0.0	
Please fill if other	0.0	0.0	
Electricity (kWh / year)			
Please select the country of origin	0.0	0.0	0.507 tCO_2-e / MWh

Quantity of fossil energy consumed: users must specify the annual quantity of energy consumed at the production level, for both scenarios, expressed in m^3 per year (for all energy types except electricity). If renewable energy is used within the upgraded scenario, it is assumed that the consumption of fossil fuels ceases and is substituted by the renewable energy. In the column "Upgrading", the quantity of fossil fuel is therefore reduced to 0 m^3 per year.

Electricity: users must specify the quantity of electricity consumed in Kwh per year, as well as the country in which the electricity is generated. This is particularly important for cases in which the project is implemented at country boundaries, so that transported electricity could be produced in a different country from where the project is implemented. The country of origin determines the GHG emission factor.

Emission factors: Users may find that the type of energy consumed in their situation does not appear in the predefined list. Therefore, as a Tier 2 option, users may define the type of energy used and to assign a context-dependent emission factor.

b) Agricultural Inputs

This section concerns all inputs directly involved in agricultural production, primarily fertilisers and pesticides, as seen in Figure 28 and Figure 29.

Figure 28 : Fertilizer consumption at the production level – Production inputs module

4.2. Crop-based input

4.2.1 - Fertilizer consumption at production level :

Please fill this part both for crop or feed crop (livestock)

List of specific fertilizers	Specify NPK parts (%) N	P	K	Amount introduced and corresponding areas – Current Qty (Kg/ha/yr)	Current Area (ha)	Upgrading Qty (kg/ha/yr)	Upgrading Area (ha)
Lime				0	0	0	0
Urea	47%			15	7500	45	15000
Other N-fertilizer	40%			0	0	0	0
N fertilizer in irrigated rice	38%			0	0	0	0
Sewage	5%			0	0	0	0
Compost	4%	1.5%	1.2%	300	37500	500	45000
Phosphorus synthetic fertilizer (P2O5)		10%		15	2500	30	5000
Potassium synthetic fertilizer (K2O)			10%	0	0	0	0
Please enter your specific NPK synthetic fertilizer (N other than urea and not for irrigated rice)							
TSP	0%	45%	0%	10	5000	20	10000
Description#2	0%	0%	0%	0	0	0	0
Description#3	0%	0%	0%	0	0	0	0
Description#4	0%	0%	0%	0	0	0	0
Description#5	0%	0%	0%	0	0	0	0

1. **List of specific fertilizers:** users may choose from the predefined list of fertilizers, or add their own crop-specific fertilizers in the description section.

2. **NPK content (%):** the composition of nitrogen (N), Phosphate (P) and Potassium (K) can vary significantly between fertilizers, consequently influencing GHG emissions. Therefore users may specify the percentage share of each element in each fertilizer.

3. **Amount introduced and the corresponding area**: In the 'Qty' column the user must specify the average quantity of each fertilizer used in kg per hectare per year for each of the above-mentioned types of production, for both scenarios. In the 'Area' column the corresponding area of fertilizer spread should be entered, in hectares.

In the upgrade scenario, an increase of organic amendment (green manure) is observed, while use of chemical fertilizers is decreasing

Figure 29: Pesticide consumption at the production level

4.2.1 - Pesticides consumption at production level :

Type of pesticides	Amount introduced and corresponding areas – Current Qty (kg/ha/yr)	Current Area (ha)	Upgrading Qty (kg/ha/yr)	Upgrading Area (ha)
Herbicides (kg of active ingredient per year)	0	0	0	0
Insecticides (kg of active ingredient per year)	2	15000	5	30000
Fungicides (kg of active ingredient per year)	0	0	0	0

In the same way, users should specify the average quantity of pesticides (herbicides, insecticides, fungicides) used, in kg of active ingredients per hectare per year, and the corresponding area for both scenarios.

c) Inputs for feeding practices

This section deals with feed used for livestock and aquaculture. At present EX-ACT VC does not provide any CFP data for feed. Users may provide only the quantity of feed used per tonne of livestock or aquaculture production.

Here, users should provide a description of the feed or production system, the quantity of feed used in both scenarios and the feed's CFP, see Figure 30.

Figure 30: Feeding practices inputs for livestock and aquaculture value chains

4.3. Feeding practices input for Livestock & Aquaculture value chain

	Feed consumption (tonne/yr)		CFP feed	
Emission from feed	Current	upgrading	tCO2-e per feed	Tier 2
Production system 1			0	
Production system 2			0	
Production system 3			0	
Production system 4			0	
Production system 5			0	

9. Processing module

This module is divided into three sub-sections: (i) energy consumption for processing, storing and conditioning on land, (ii) other inputs and consumables and (iii) production loss and processing rate at the processing and storage levels.

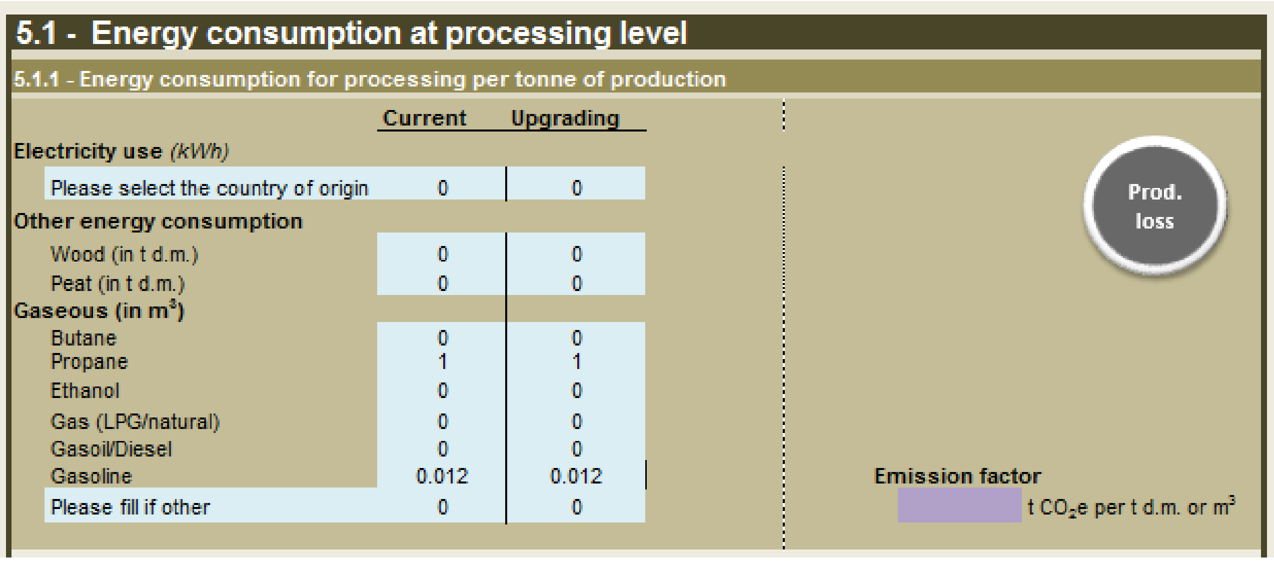
However, before entering data on processing, packaging and storage activities, users must specify the percentage of food production that is self-processed and/or self-consumed by the local population.

a) Energy consumption

Energy consumption is divided into two subsections: (i) energy consumption for processing per tonne of product, shown in Figure 31, and (ii) energy consumption for storage per tonne, shown in Figure 32.

Processing: Users must specify electricity, wood, fuel and gas consumption in units per tonne of product. Additional energy forms not listed above may be specified, with associated emissions factors in tCO_2-e per tonne of dry matter or tCO_2-e per m^3.

Figure 31: Energy consumption at the processing level – Processing module



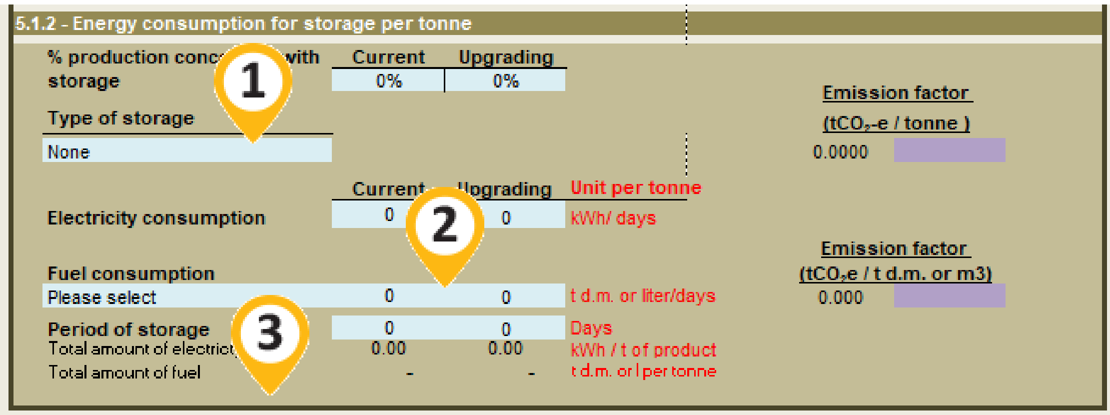
1 **Storage**: users must specify **the type of storage** used for the production, and the percentage of production going through storage. Data should be entered in units per tonne of product going through processing and/or storage.

A drop-down menu lists the following types of storage: *Refrigeration* (involving specific gases at the origin of GHG emission and energy consumption) / *Ventilation / None / Other*. An emission factor is given for each type of storage selected. This may be modified with a Tier 2 option if needed.

2 **Electricity and fuel consumption:** the user must specify the electricity and fuel consumption per day. For the latter, the user must also specify the type of fuel (from the options of *Wood / Peat / Butane / Propane / Ethanol / GAS (LPG-Natural) / Gasoil-Diesel / Gasoline / Other*) and the corresponding emission factor.

3 **Period of storage**: the duration of storage is an important factor for accurately determining the energy consumed during production. Duration will differ according to the type of food product involved.

Figure 32: Energy consumption at the storage level – Processing module



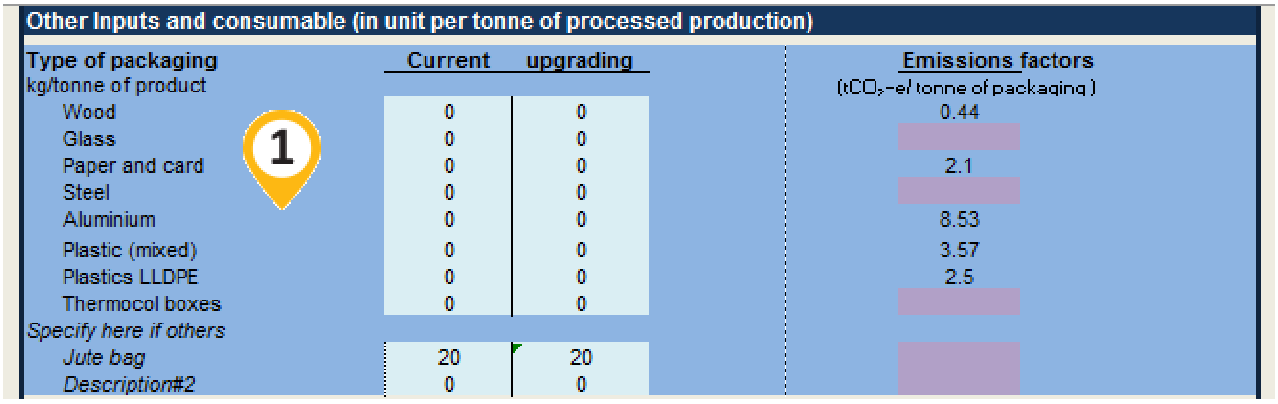
b) Other inputs and consumables

Processing involves a number of other inputs and consumables.

Type of packaging for transportation and conditioning: data on the weight of packaging per tonne of production is necessary. Each type of packaging has a specific emission factor, though other types of packaging, with their corresponding emission factor in tCO_2-e per tonne of packaging, may be entered.

For transporting coffee, jute bags are used; approximately 20 bags per tonne of coffee.

Figure 33 : Other consumable at the processing level – Processing module



c) Production loss and processing rate

In this section, production loss during processing, packaging and storage, and the processing rate, are dealt with (Figure 34).

Processing rate is defined as the quantity transformed during processing phase with one tonne of raw production. For instance, the processing rate for producing rice from paddy is between 60 and 69 percent. Therefore, 1 tonne of paddy produces between 600 kg and 690 kg of rice. By upgrading the value chain, it is possible to increase this rate to enhance the efficiency of the processing phase and thus increase the amount of food available.

Figure 34 : Other consumables at the processing level - Processing module

5.3 - Production loss and processing rate at processing and storage level

	Current	Upgrading	
Total loss on PPS* level	3%	2%	*PPS = Processing, Packaging, Storage
Processing rate (if any transfo)	100%	100%	(example 60-69% for paddy transformed in rice)

d) Production of wastewater and methane emission

Wastewater originates from a variety of domestic, commercial and industrial sources. It may be treated on site (uncollected), sent to a decentralized plant (collected) or disposed untreated nearby or via an outfall. Wastewater can be a source of methane when treated or disposed of anaerobically so is an important factor to take into account when calculating GHG emissions from food processing. EX-ACT VC estimates methane emissions from wastewater not collected in domestic sewer systems, i.e on-site industrial wastewater treatment. Detailed equations and default parameters and emission factors are provided in Annex I.

As stated in IPCC (2006, Chapter 6, p. 6.7):

"**Wastewater as well as its sludge components can produce CH_4 if it degrades anaerobically. The extent of CH_4 production depends primarily on the quantity of degradable organic material in the wastewater, the temperature, and the type of treatment system. With increases in temperature, the rate of CH_4 production increases. This is especially important in uncontrolled systems and in warm climates. Below 15°C, significant CH_4 production is unlikely because methanogens are not active and the lagoon will serve principally as a sedimentation tank. However, when the temperature rises above 15°C, CH_4 production is likely to resume**".

Thus methane emissions are a function of the amount of organic waste generated.

In this section (Figure 35), users must specify the following elements:

1. The **industry product** under analysis in the value chain. The available options are: *Alcohol refining / Beer and malt / Coffee / Dairy products / Fish processing / Meat and poultry / Pulp and paper combined / Starch production / Sugar refining / Vegetable oils / Vegetables, fruits and juice / Wine and vinegar*.

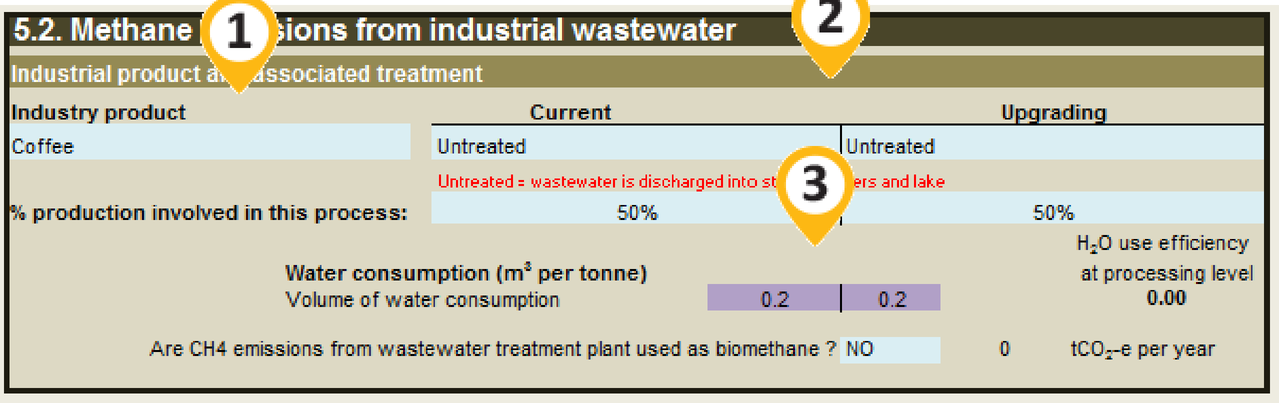
2. The **type of wastewater treatment** should be specified from a drop down menu for the current and upgraded scenario. The options are: *Untreated / Well managed aerobic treatment plant / Not well managed aerobic treatment plant / Anaerobic digester for sludge / Anaerobic reactor / Anaerobic shallow lagoon / Anaerobic deep lagoon*. Definitions for each of these options are provided in Annex I

3. The **percentage of the production** involved in this process.

The **water consumption** for both scenarios.

Users may also specify whether CH_4 emissions from anaerobic processes are used as biomethane. If so, these emissions will be counted as renewable energy in the climate mitigation section of the EX-ACT VC results.

Figure 35: Methane emission from industrial wastewater



For methane emissions from treated systems, EX-ACT VC assumes a methane leakage of 10 percent and that the remaining 90 percent will be used as renewable energy.

10. Transport and infrastructure module

a) Transport

The transport module covers the transportation of production from farm to retailers and the associated GHG emission from fuel and energy consumption (conditioning) therein. The module as it appears in EX-ACT VC is shown in Figure 36. It takes into account the type of transport, any potential conditioning, the distance in km between two actors of the chain, and the percentage production loss between these two steps.

1. Starting from the farm users must specify the next actor along the value chain, and so on, potentially down to the retailers. A drop-down menu offers the following options: *Farm / Processing/storage / Wholesaler / Harbour initial / Harbour final / Airport initial / Airport final / Retailers / Collectors.*

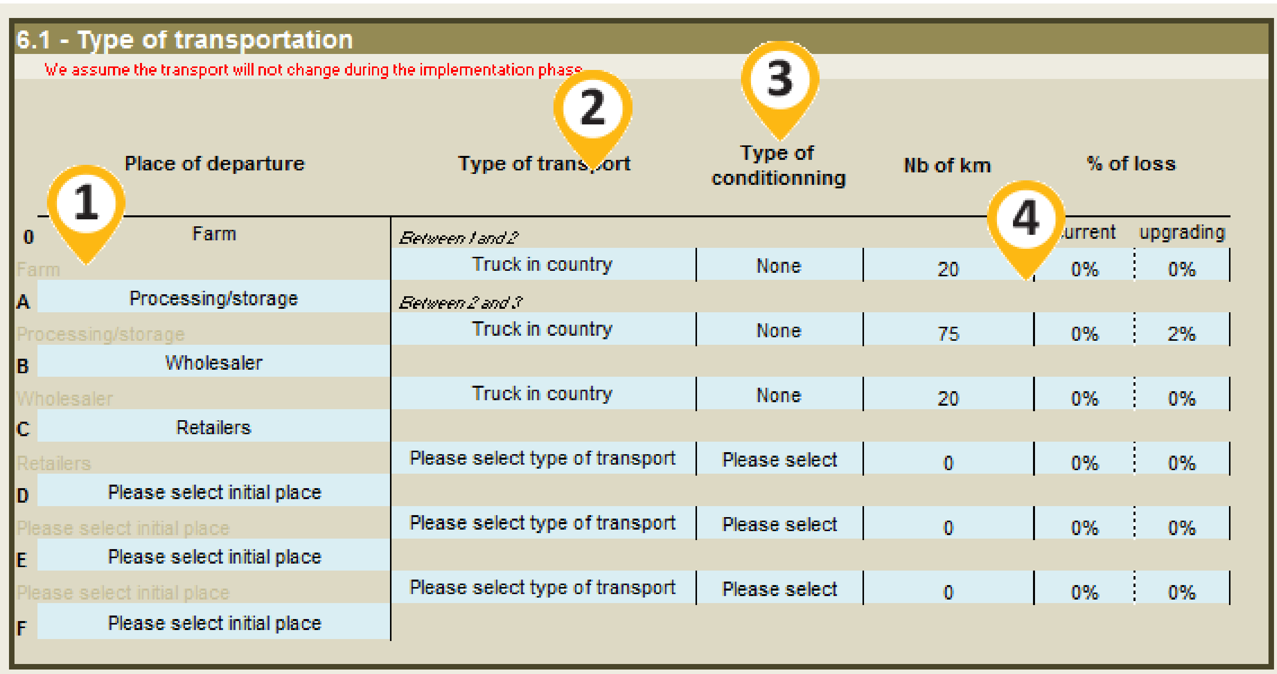
2. Users must specify the **type of transport** from the drop-down menu: *Truck in country / Truck out country / Rail / Air /Inland water / International water container*. Users can also specify, from the drop-down menu, whether a **type of conditioning** is associated with the type of transport used. Possible conditioning options are: *Refrigeration / Ventilation / None / Other*.

In Haiti, only trucks are used to transport coffee for local consumption, from farm to retailers. The distances travelled, as shown in the figure, represent an average estimation. There is no conditioning taken into account.

3. When a conditioning system is selected it is automatically assigned an emissions factor, in tCO_2-e per tonne of product. This can be changed under a Tier 2 option.

4. Users then specify the distance between two actors (in km), as well as the percentage of production lost, for both scenarios.

Figure 36: Production transport at different steps of the value chain - Transport and infrastructures module


6.1 - Type of transportation

We assume the transport will not change during the implementation phase

	Place of departure		Type of transport	Type of conditionning	Nb of km	% of loss current	% of loss upgrading
0	Farm	*Between 1 and 2*	Truck in country	None	20	0%	0%
A	Processing/storage	*Between 2 and 3*	Truck in country	None	75	0%	2%
B	Wholesaler		Truck in country	None	20	0%	0%
C	Retailers		Please select type of transport	Please select	0	0%	0%
D	Please select initial place		Please select type of transport	Please select	0	0%	0%
E	Please select initial place		Please select type of transport	Please select	0	0%	0%
F	Please select initial place						

b) Building and infrastructures

The final section of the module concerns building and infrastructure activities. Users first select the type of building or road envisioned by the project, and then specify the surface area in m^2 used for the construction.

Users can choose from the following list: *Housing (concrete) / Agricultural buildings (concrete) / Agricultural buildings (metal) / Industrial buildings (concrete) / Industrial buildings (metal) / Garage (concrete) / Garage (metal) / Offices (concrete) / Offices (metal) / Road for medium traffic (concrete) / Road for medium traffic (asphalt) / Road for intense traffic (concrete) / Road for intense traffic (asphalt).*

11. Socio-economic analysis

This module has been designed to allow users to enter quantified data on input prices, labour, salaries and other costs for both the current situation and the upgraded scenario.

This module is divided into three sections: (i) agricultural production, (ii) processing activities and upstream transportation and (iii) all downstream stages following processing, i.e. the transport and sale of the product to wholesalers and retailers.

To simplify data entry, prices, costs, taxes and salaries are specified in local currency. Costs at each stage of the value chain are given in US$ (exchange rates are specified in the description module). Costs are calculated by multiplying the quantity of inputs, yields or areas specified in the previous modules with prices in local currency. These computation dynamics are based on the assumption that input prices do not change between the two scenarios. Users must also provide data on the selling price at each stage (farmgate, after processing, wholesaler and retailers) and the salary (in local currency per man-day) of each agent, for both scenarios. Additional information, such as taxes, renting equipment, maintenance, number of operator and transport capacity per truck, must be specified in this module to provide a precise and comprehensive analysis.

For each stage of the value chain, and for both scenarios, the module provides the cost of production per hectare, per household and annually, the gross production value, the added value as defined in Chapter 2, labor costs, taxes and gross income. Value added is defined as value added per hectare and value added per tonne of production. Gross income is defined as gross income per actor (households, processing units, wholesalers and retailers).

Information on labor is provided at each step of the value chain in terms of cost and man-days. This allows the total days of labor in man-days, and the total employment created, to be estimated, assuming 250 days of work per year (this assumption can be refined at Tier 2). At each step of the socio-economic analysis, balances of employment generated, incremental value added and gross income per beneficiary are generated. A positive balance implies creation of jobs, value added and gross income from improvement of the value chain, respectively.

Figure 37 shows the concluding section of the socio-economic analysis at the production level for both scenarios.

Figure 37 : Socio-economic analysis - Farmgate level

Current situation		Agregate Value chain at farm/HH level	Upgraded value chain	
	Unit	Coffee Value chain		Unit
80,000	ha	Area covered for crop	90000	ha
16,560	tonne	Annual total food production	38,976	tonne
36,432	000 US$	Gross production Value	85,747	000 US$
32,495	000 US$	Value Added (VA)	79,085	000 US$
10,412	000 US$	Labor costs	20,614	000 US$
-	US$	Tax and Bank interest	0	US$
22,083	000 US$	Gross Income (GI)	58,471	000 US$
1,962	US$	Value Added / tonne of product	2,029	US$
406	US$	Value added / ha	879	US$
158	US$	Gross income / HH	418	US$
4720000	MD	Total days of labour in man days	8010000	MD
18880	Units	Total employments equivalent	32040	Units
		BALANCE:		
		Additional employments generated	13,160	
		Incremental value added	46,591	000 US$
		Incremental Gross Income of beneficiaries	36,389	000 US$

The other sections (i.e. upstream transportation and processing, and downstream transportation to wholesalers and retailers) follow the same structure. The only factors that change are the type of labour and the type of costs and inputs. Some additional data can also be added. Please refer directly to the tool to better understand how this framework.

12. Climate resilience module

As explained in the Methodology section of Chapter 2, EX-ACT VC's approach to value chain resilience appraisal is a qualitative multi-criteria analysis. Thus, this module poses 36 questions corresponding to 36 qualitative criteria.

These questions are grouped into five sections covering each qualitative factor appropriate for measuring value chain resilience.

This appraisal concerns only the impact of the upgraded scenario, in terms of household, ecosystem and market resilience. It does not concern the current situation of the value chain.

An evaluation of each question is conducted by experts, and given a score from zero to four. Four refers to a highly impactful factor on the resilience potential of the value chain. Zero denotes a negligible impact. Each question is assigned a weighting, according to the value chain under analysis and the type of project concerned. For instance, a project concerning agroforestry would not consider crop failure to be important, whilst a project concerning monocrop banana upgrading would.

Figure 38 shows a small part of the module as an example, concerning the buffer capacity of watershed, landscape and project area.

Figure 38 : Qualitative value chain resilience appraisal

	Buffer capacity of watershed, landscape and project area	Expert group assessment (0-4)	Indicator weighting (0-3)	
1	To what extent does upgrading the value chain improve land cover? (e.g. agroforestry, cover crops	4	*3*	
2	To what extent does upgrading the value chain reduce soil erosion?	4	*3*	
3	To what extent does upgrading the value chain improve soil conditions (e.g. soil moisture, soil	4	*3*	
4	To what extent does upgrading the value chain improve efficient use of water?	4	*2*	
5	To what extent does upgrading the value chain save water?	4	*2*	
6	To what extent the value chain area upgraded is protected from climate shocks ?	4	*3*	
7	To what extend the value chain infrastructure - building investments are climate-proof ?	3	*2*	
8	To what extend the upgrading value chain reduce negative impact on natural resources (land,	4	*3*	
9	To what extend the upgrading value chain reduce waste water effluent?	3	*2*	
	Sub-Result	88	high	*46*

13. EX-ACT VC results

a) Value chain results module

The completed analysis of the value chain, both for the current state and the upgraded scenario, is summarised in a single page of a Microsoft Excel sheet, using the set of agro-ecological, energy-related and socio-economic data provided in previous modules.

Three dimensions are addressed: (i) climate mitigation, (ii) climate resilience and (iii) socio economic performance. A comparison of the two scenarios (i.e. current situation and upgraded situation) is conducted, providing an assessment of the improvements brought about by the project. This methodology is based on the idea of tackling the environmental and socio-economic performances of the value chain, which are closely associated, simultaneously. Thus, this final module provides users with a comprehensive overview of the value chain performance. These results, as they appear in EX-ACT VC, are displayed in Figure 38, Figure 39 and Figure 40.

b) Analysis of results

This section provides an overview of the EX-ACT VC appraisal results and how to analyse these results.

Context

A pre-analysis of a Haitian green coffee value chain was performed with EX-ACT VC. The analysis used **data collected from interviews** with local experts during an EX-ACT training workshop organized as part of an investment project in Haiti. The project aims to enhance the resilience and climate change mitigation potential of the agroforestry systems consisting predominantly of coffee and cacao plantations. Among the expected outputs are: increased resilience of smallholder farmers to climate change and food security, decreased soil erosion and enhanced climate change mitigation of the Haitian AFOLU and energy sectors.

Analysis

This analysis focuses on a coffee value chain in Haiti, in a tropical moist climate, where LAC soils represent the most common soil type in the region. We assume that implementation of the project will begin in 2018 and run for a 10-year duration period.

The CFP analysis encompasses all elements of on-farm coffee production for local retailers (excluding GHG emissions associated with the transportation of fertilizers and pesticides).

Land use changes and production practices

Conventional coffee production in Haiti currently involves 80 000 hectares of coffee plantations with an average yield of 0.225 tonnes of coffee per hectare per year. The project aims to double this yield to 0.5 tonnes per year. It aims to achieve this by developing coffee agroforestry systems on an additional 10 000 ha and improve agronomic practices in all areas (for instance, compost and urea inputs are almost doubled in the upgraded scenario, while the use of insecticides increases significantly).

For new plantations, coffee biomass growth with the upgrade project is 2.9 tC per hectare per year, according to the scientific literature on coffee agroforestry (Umulisa 2017, personal communication), and was entered using a Tier 2 approach. The default value from the IPCC (2006) is 2.6 $tCha^{-1}yr^{-1}$. For mixtures of old and new coffee plantations we assumed an intermediate biomass growth of 1.5 tC per hectare per year.

Processing

Once coffee cherries have been harvested, the beans must be extracted using either wet or dry methods. The wet method is more expensive than the dry, but the coffee produced is of better quality. However, the process does generate significant quantities of wastewater and CH_4 emissions.

We assume that 15 percent of the production is self-processed and consumed locally, without involving local processing facilities. Therefore only 85 percent of production goes through processing, with half going through wet processing. Regarding energy consumption, this stage typically uses 12 liters of gasoline per tonne of production. Only jute bags are used to pack the products before transporting them to the wholesaler, amounting to about 20 kg/t of green coffee.

Readers should consult the figures presented earlier in this guide for data inputs in the different modules.

Analysis of EX-ACT VC results

Climate mitigation

The improvement of the Haitian coffee agroforestry system (promoting afforestation and renewed polyculture) results in a climate mitigation potential of about -294 000 tCO_2-e per year. This is a ten-fold increase on the -46 600 tCO_2-e per year in the current scenario. This amounts to about -10.7 tCO_2-e per hectare per year in the improved scenario (Figure 39).

Looking at overall GHG emissions and carbon sequestration at the production level, the CFP of Haitian coffee is -10.75 tCO_2-e per tonne of coffee. This is a result of increased bio-sequestration from an increase in vegetation cover and the new plantations introduced by the project. Conversely, the processing and transportation phases are emitters of GHGs, amounting to 0.04 tCO_2-e and 0.21 tCO_2-e per tonne of green coffee respectively. However this coffee value chain maintains a strong impact in terms of climate change mitigation.

Socio-economic performance of the value chain

The revival and reformation of the Haitian coffee sector resulted in a two-fold increase in production from 16 560 to 38 976 tonnes per year. This generates value added at every stage of the chain, whilst augmenting gross production value and the gross income of farmers and operators. For instance, the value added per hectare at the production level increases from US$406 to US$879 between the two scenarios (+ US$473 per hectare), which is mainly driven by the increased production (Figure 40).However the value added per tonne does not significantly change; the increase in production compensates for the increase in inputs. The boost in production also leads to a 62 percent increase in income for farmers.

Additionally the volume of employment generated increases in the upgraded scenario due to the higher demand for labor at every stage of the chain (although predominantly at the production level). In total about 13 414 jobs are created at every stage of the coffee value chain, of which 13 160 are at the production level (Figure 41).

Climate resilience

Climate resilience is also significantly improved by the project (Figure 39). This resilience derives from: a superior buffer capacity of the project area (reduced soil erosion, improved agronomic practices, improved soil conditions, etc.), an enhanced buffer capacity of the production systems (improved resistance to pests and diseases, on-farm diversity promoted with agroforestry) and an improved buffer capacity of the households in relation to food security (an increase in income and agricultural production).

Figure 39: Climate dimension of the analysed value chain (mitigation, carbon footprint and resilience) – Haitian Coffee Value Chain

			Upgrading	Current
Project:	Relance filiere café 2018-2028			
country	Haiti	Production (tonne)	16560	38976
region	Please specify name	Yield (t ha^{-1} yr^{-1})	0.23	0.45
Budget (US$)	46000000	Hectares		90000
Year	2018	Households		140000

Climate Mitigation dimension of the Value Chain	Current	Upgrading	Balance
GHG impact (tCO_2-e per year)	-46,592	-294,022	
GHG impact (tCO_2-e per year per hectare)	-0.5	-3.3	-2.7
Carbon footprint of production (tCO_2-e per tonne of product)	-3.0	-10.7	-7.7
Annual tCO_2-e [emitted (+) / reduced or avoided (-)]		-247,430	
Annual tCO_2-e from renewable energy		0	
Equivalent project cost per tonne of $CO_{2\text{-}e}$ reduced or avoided (in US$ per tCO_2-e)		186	
Equivalent value of mitigation impact per year (US$ 30/tCO_2-e)		7,422,910	
Equivalent value of mitigation impact per year per ha (US$ 30/tCO_2-e per year per ha)		82	

Carbon footprint at the different levels of the Value Chain	tCO_2-e per tonne of product		Balance
	Current	Upgrading	
PRODUCTION	-3.03	-10.75	-7.72
PROCESSING	0.04	0.04	0.00
TRANSPORT	0.21	0.21	0.00
TOTAL	-2.78	-10.50	-7.72

Climate Resilience dimension (s)	Upgrading	
Hectares of land managed under climate-resilient practices	74,000	ha
Hectares with improved tree and vegetal coverage (land slide, flood resilience)	74,000	ha
Number of hectares with increased soil carbon (drought and erosion resilience)	74,000	ha
Number of HH having become more climate resilient	140,000	HH

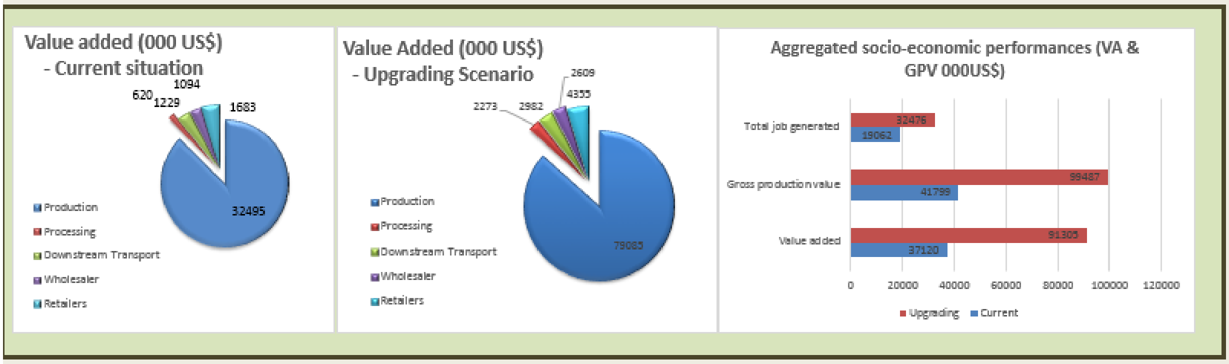
Resilience index of the value chain upgrading	Upgrading		
Buffer capacity of watershed and landscape and project area	high	Buffer capac	3.9
Buffer capacity of crop –livestock production	high	buffer capaci	3.2
Buffer capacity of households in relation to food security	medium	Buffer capac	2.6
Self-organisation of households	medium	Self-organis:	2.6
Learning capacity of households	high	Learning car	2.6
Global climate resilience generated by Value chain	**high**		

Figure 40: Socio-economic results for each level of the analysed value chain – Haitian Coffee Value Chain

	Socio-economic performances of the value chain	Current	Upgrading	Balance	
	Production level				
	Nb of HH	0	140000		
	Nb of employement-eq	18880	32040	13160	jobs
58%	Gross production Value (GPV)	36432	85747	49315	000 US$
59%	Value Added (VA)	32495	79085	46591	000 US$
62%	Gross Income (GI)	22083	58471	36389	000 US$
3%	VA / tonne of product	1962	2029	67	US$
54%	VA / ha	406	879	473	US$
62%	Gross income / HH	158	418	260	US$
	Processing and upstream transportation level				
	Nb of operator-eq	93	110		
	Nb of employement-eq	111	265	154	Jobs
67%	Gross processed production value (GPPV)	1221	3683	2463	000 US$
73%	Value added	620	2273	1652	000 US$
81%	Gross income	277	1457	1180	000 US$
34%	VA / tonne of product	46	70	24	US$
77%	Gross income / operator	2980	13190	10210	US$
	Downstream transportation level				
	Nb of operator eq	9	22		
	Nb of employement-eq	18	43	25	jobs
59%	Gross production value	1249	3032	1782	000US$
59%	Value added	1229	2982	1753	000 US$
59%	Gross income	1204	2933	1729	000 US$
1%	VA / operator	68187	68894	707	US$
1%	Gross income / operator	66808	67757	949	US$
	Wholesaler				
	Nb of operator eq	10	18		
	Nb of employement-eq	26	64	38	jobs
57%	Gross production value	1133	2654	1520	000 US$
58%	Value added	1094	2609	1515	000 US$
60%	Gross income	977	2438	1461	000 US$
25%	VA / operator	109372	144951	35579	US$
28%	Gross income / operator	97702	135427	37725	US$
	Retailers				
	Nb of operator	325	636		
	Nb of employement-eq	26	64	38	Jobs
60%	Gross production value	1764	4371	2607	000 US$
61%	Value added	1683	4355	2672	000 US$
61%	Gross income	1659	4237	2578	000 US$
24%	VA / retailers	5184	6843	1659	US$
23%	Gross income / operator	5111	6657	1547	US$

Figure 41: Aggregated socio-economic performances of the Haitian Coffee Value Chain

Aggregated Socio-economic performances	Current	Upgrading	Balance	
Value added	37120	91305	54184	000 US$
Gross production value	41799	99487	57688	000 US$
Total job generated	19062	32476	13414	Jobs created



14. Conclusion

In the world today there is a trend towards the greening and de-carbonization of local, national and international economies. This creates a greater demand for multi-performance tools capable of raising awareness and helping policy makers, investors and actors strive for more sustainable food value chains. Tools such as EX-ACT VC help confront the socio-economic and environmental trends that limit food value chain performances.

EX-ACT VC is an innovative tool that combines all these elements together. It is capable of conducting an ex-ante (during the monitoring phase) or ex-post analysis of the sustainability of a food value chain. This makes it possible to assess whether international goals have been met, to assess progress and to estimate a priori the impact over a given time period. It is an efficient tool, analysing simple food value chains with little, easy-to-collect data. Derived from the EX-ACT tool, which has already been applied to several agricultural development projects around the world, the methodology of EX-ACT VC meets the international demand for quick, easy, multi-performance tools.

Using this tool will facilitate decision making for the strategic orientation of value chain operators. The indicators used to analyse environmental and socio-economic performances are complementary and paint a picture of both the current value chain performance and any possible improvements that could be made. EX-ACT VC is therefore suitable for a wide range of actors, including both those directly involved in value chain activities and those only involved in the decision making process.

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15. Annex

Annex 1: Average Fuel Use Intensity (litre per tonne of fish caught) according to fish category and gear type, adapted from Parker and Tyedmers (2014)

Category	Bottom trawls	Gillnets	Hook & Lines	Pelagic trawls	Pots & Traps	Surrounding nets	Dredges	Not specified
Crustaceans	3399	630	1031	857	3290			**3314**
Finfish	733	643	847	608		384	445	**669**
Flatfish	2640	537	570	1086		380		**2228**
Large pelagics	824	695	1698	627		308		**1274**
Molluscs	2058	2162		1097	513		502	**770**
Salmonids		886	835			291		**616**
Small pelagics	339	602	323	169		71		**121**
Not specified	2638	675	1183	477	3016	172	500	**1606**

Annex 2: Emission factors adapted for value chain analysis

<table>
<tr><td rowspan="6">Processing</td><td>Type of packaging</td><td>Emission factors
(tCO$_2$-e/tonne of packaging)</td><td>References</td></tr>
<tr><td>Wood</td><td>0.4</td><td rowspan="4">Berneers-Lee and Hoolohan (2012)</td></tr>
<tr><td>Paper</td><td>2.1</td></tr>
<tr><td>Aluminium</td><td>8.5</td></tr>
<tr><td>Plastic (mixed)</td><td>3.6</td></tr>
<tr><td>Conditioning (refrigeration)</td><td>0.00834
(tCO_2- e/ tonne of product)</td><td>Lukse (2009)</td></tr>
<tr><td rowspan="7">Transport</td><td>Type of transport</td><td>Emission factor
(tCO_2e par tonne-km)</td><td>References</td></tr>
<tr><td>Truck</td><td>0.0018</td><td rowspan="5">Weber & Mathews (2008)</td></tr>
<tr><td>Air</td><td>0.0068</td></tr>
<tr><td>Train</td><td>0.0018</td></tr>
<tr><td>Inland water</td><td>0.0021</td></tr>
<tr><td>International ship</td><td>0.0014</td></tr>
<tr><td>Conditioning (refrigeration)</td><td>0.00122
(tCO_2- e/ tonne of product)</td><td>Lukse (2009)</td></tr>
</table>

Annex 3 : Methane emissions from wastewater treatment

1. Total CH_4 emissions from industrial wastewater are calculated using the following equation:

$$CH4\ emissions = \sum_{i}[(TOWi - Si)EFi - Ri]$$

Where:

CH_4 emissions = CH_4 emissions in kg CH_4 / yr
TOWi = total organically degradable material in wastewater from industry I, in kg COD / yr
i = industrial sector
Si = organic component removed as sludge, in kg COD / yr
EFi = emission factor for industry I, in kg CH_4 / kg COD
Ri = amount of CH_4 recovered, in kg CH_4 / yr

Default parameters retained in EX-ACT VC

Industry type	Table 6.9 IPCC (2006)	
	Wastewater generation (m^3/tonne)	COD (kg/m^3)
Alcohol refining	24	11
Beer and malt	6.3	2.9
Coffee*	15	9
Dairy products	7	2.7
Fish processing	13	2.5
Meat and poultry	13	4.1
Pulp and paper combined	162	9
Starch production	9	10
Sugar refining	11	3.2
Vegetable oils	3.1	0.85
Vegetable, fruits and juices	20	5
Wine and vinegar	23	1.5

*Source:
https://energypedia.info/wiki/Sustainable_Utilization_of_Coffee_Processing_Wastes_through_Biogas_Technology

2. The CH_4 emission factor for industrial wastewater is calculated using the equation:

$$EFj = B0 * MCFj$$

Where:
EFj = emission factor for each treatment/discharge pathway or system, in kg CH_4 / kg COD
J = each treatment/discharge pathway or system
B0 = maximum CH_4 producing capacity, in kg CH_4 / kg COD
MCFj = methane correction factor (the fraction of waste treated anaerobically)

Default MCF values for industrial wastewater

Type of treatment and discharge pathway or system	Comments	MCF	Range
Untreated			
Sea, river and lake discharge	Rivers with high organic loadings may turn anaerobic, however these are not considered here	0.1	0-0.2
Treated			
Aerobic treatment plant	Must be well managed. Some CH_4 can be emitted from settling basins and other pockets	0	0-0.1
Aerobic treatment plant	Not well managed. Overloaded	0.3	0.2-0.4
Anaerobic reactor	CH_4 recovery is not considered here	0.8	0.8-1.0
Anaerobic shallow lagoon	Depths less than 2 metres	0.2	0-0.3
Anaerobic deep lagoon	Depths more than 2 metres	0.8	0.8-1.0

EX-ANTE CARBON-BALANCE TOOL [EX-ACT]

The EX-Ante Carbon-balance Tool (EX-ACT) is an appraisal system developed by FAO providing estimates of the impact of agriculture and forestry development projects, programmes and policies on the carbon-balance. The tool helps project designers estimate and prioritize project activities with high benefits in terms of economic and climate change mitigation, and it helps decision-makers to decide on the right course to mitigate climate change in agriculture and forestry and to enhance environmental services.

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