



Food and Agriculture  
Organization of the  
United Nations

# Measuring carbon and water footprints in pineapple value chains

A training guide



# **Measuring carbon and water footprints in pineapple value chains**

**A training guide**

## Required citation:

FAO. 2024. *Measuring carbon and water footprints in pineapple value chains – A training guide*. Rome.

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

© FAO, 2024



Some rights reserved. This work is made available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; <https://creativecommons.org/licenses/by-nc-sa/3.0/igo/legalcode>).

Under the terms of this licence, this work may be copied, redistributed and adapted for non-commercial purposes, provided that the work is appropriately cited. In any use of this work, there should be no suggestion that FAO endorses any specific organization, products or services. The use of the FAO logo is not permitted. If the work is adapted, then it must be licensed under the same or equivalent Creative Commons licence. If a translation of this work is created, it must include the following disclaimer along with the required citation: "This translation was not created by the Food and Agriculture Organization of the United Nations (FAO). FAO is not responsible for the content or accuracy of this translation. The original English edition shall be the authoritative edition."

Disputes arising under the licence that cannot be settled amicably will be resolved by mediation and arbitration as described in Article 8 of the licence except as otherwise provided herein. The applicable mediation rules will be the mediation rules of the World Intellectual Property Organization <http://www.wipo.int/amc/en/mediation/rules> and any arbitration will be conducted in accordance with the Arbitration Rules of the United Nations Commission on International Trade Law (UNCITRAL).

Third-party materials. Users wishing to reuse material from this work that is attributed to a third party, such as tables, figures or images, are responsible for determining whether permission is needed for that reuse and for obtaining permission from the copyright holder. The risk of claims resulting from infringement of any third-party-owned component in the work rests solely with the user.

Sales, rights and licensing. FAO information products are available on the FAO website ([www.fao.org/publications](http://www.fao.org/publications)) and can be purchased through [publications-sales@fao.org](mailto:publications-sales@fao.org). Requests for commercial use should be submitted via: [www.fao.org/contact-us/licence-request](http://www.fao.org/contact-us/licence-request). Queries regarding rights and licensing should be submitted to: [copyright@fao.org](mailto:copyright@fao.org).

Cover photo: © iStock

# Contents

<b>Acknowledgements</b>	iv
<b>1. Introduction</b>	<b>1</b>
<b>2. Objective</b>	<b>1</b>
<b>3. Target users</b>	<b>2</b>
<b>4. Documentation and tools</b>	<b>2</b>
Training guide	2
Technical guide	3
Introductory videos	3
Slide deck	4
<b>5. Related FAO resources</b>	<b>5</b>
<b>6. Developing a training plan</b>	<b>6</b>
<b>Annex 1. Measuring carbon and water footprints in pineapple value chains (introductory slide deck)</b>	<b>7</b>
<b>Annex 2. Learning about carbon footprint measurements in pineapple value chains (practical training slide deck)</b>	<b>23</b>
<b>Annex 3. Learning about water footprint measurements in pineapple value chains (practical training slide deck)</b>	<b>36</b>

# Acknowledgements

This guide was produced by the Markets and Trade Division of the Food and Agriculture Organization of the United Nations (FAO) and is a product of the project “Building responsible global value chains for the sustainable production and trade of tropical fruits” (the Responsible Fruits Project). The project helps companies, producer and farmer organizations, trade associations, processors, packers, exporters and importers in the pineapple sector to become more sustainable and resilient to shocks.

This guide was prepared by Michael Riggs and María Hernández Lagana, both from the Responsible Fruits Project team. The content in Annexes 2 and 3 was produced by Verónica Vargas Madrigal, Miguel Ángel Vallejo Solís and Ana Lorena Vallejo Chaverri at Gestarse S.A. under the direction of FAO. The document benefited from the overall guidance and support of Pascal Liu, Senior Economist and Team Leader, Responsible Global Value Chains team, Markets and Trade Division.

Thanks to Laura del Castillo Buelga, Aymeline Main De Boissiere, Debora Piscitelli and Alejandro Schoor Gallardo for their support in reviewing and preparing this guide for publication. Thanks to Jonathan Hallo for creating the layout and design of this document.

The development of this guide was possible thanks to support from the Government of Germany.

# 1. Introduction

The FAO technical guide, [Measuring carbon and water footprints in pineapple value chains](#), was developed to support resilient and sustainable businesses. It aims to develop the capacity of users and empower them to make their own carbon and water footprint calculations independently. The guide has two main objectives:

1. introduce companies in pineapple value chains to a methodology to estimate the carbon footprint of their operations, including production, packing, processing and transportation to port; and
2. introduce companies in pineapple values chain to a methodology to estimate the footprint of their direct water use, from production to transportation to the port.

There is growing demand for this type of information, and thus a growing need for new or enhanced capacities to develop, analyse and plan based on this type of information. The body of work described below builds on FAO's experience in supporting climate change mitigation, including measuring carbon and water footprints in [banana supply chains](#) and other tropical fruit value chains. FAO may update this training guide from time to time based on experience, or as technology or knowledge evolves. Feedback and suggestions to improve these learning materials are welcome from any user at any time by writing to [responsible-fruits@fao.org](mailto:responsible-fruits@fao.org).

## 2. Objective

**This training guide** is a companion to the technical guide and other materials prepared by the Responsible Fruits Project.

The objective of the training guide is to support trainers and other users to identify the different materials and tools available to develop capacities to quantify greenhouse gas emissions and water use and pollution. By measuring carbon and water footprints, producers and companies in pineapple value chains will have information to become more efficient, reduce costs, enhance the resilience of their operations, contribute to the mitigation of climate change and better manage water resources.

## 3. Target users

This guide is a resource to orient trainers and others involved in capacity development to the materials that are currently available.

Given the technical complexity of calculating carbon and water footprints, these materials are primarily for technical trainers, environmental engineers and other professionals who are responsible for developing capacities for the quantification of carbon footprints and/or water footprints in pineapple growers' associations and pineapple producing and packing companies. Ideally, **users should have some knowledge of emissions inventories, carbon neutrality and water management. Otherwise, trainers could work in teams** with one learning expert and one expert in the technical matters related to measuring carbon and/or water footprints.

Learners and users without advanced technical knowledge may still benefit by referring to the introductory videos, selected content from the technical guide and training material from the Annexes. These resources are described further in the next section.

## 4. Documentation and tools

There are several resources available to support understanding and measuring carbon and water footprints in pineapple value chains.

### Training guide

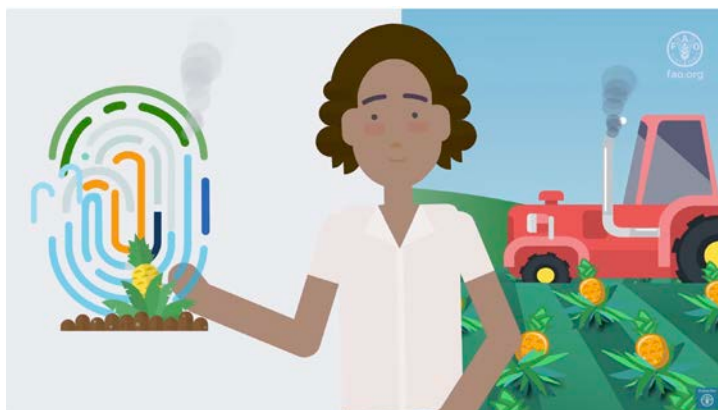
This training guide is a companion to the technical guide and provides a starter kit for trainers and others who are developing capacities for better carbon and water footprint measurement. The guide includes links to documentation and tools available to achieve that goal. It is available in English, French and Spanish.

## Technical guide



The technical guide, **Measuring carbon and water footprints in pineapple value chains**, provides detailed information on these processes at the stages of pineapple production, packing, processing and transportation to the port. The guide includes extensive step-by-step calculations and formulae as well as many additional resources for better understanding key issues and references to find information that is needed for accurate calculations. The technical guide is available in English, French and Spanish.

## Introductory videos



Two videos are available to introduce the concepts of carbon footprints and water footprints, and how measuring these can be valuable to pineapple producers, packers and exporters.

These videos can be used alone or as part of a learning programme.

“Measuring carbon footprints in pineapple value chains”, a video of 5 minutes and 26 seconds, can be found at <https://youtu.be/APdrly9YyVs>. It is available in English and Spanish.

“Measuring water footprints in pineapple value chains”, a video of 4 minutes and 44 seconds, can be found at <https://youtu.be/F1xH69V0q2s>. It is available in English and Spanish.

### Slide decks



There are three slide decks available for trainers, facilitators and others to customize and use.

The first slide deck (**Annex 1**) introduces carbon and water footprint measurement. This includes the context in which these measurements are important for the tropical fruit sector and how these measurements can benefit value chain actors; basic concepts related to the two

measurements; a high-level introduction to the FAO tool and how it works; information on other useful tools for measuring carbon; and examples of how the measurement results can be used to reduce GHG emissions and water impacts in tropical fruit value chains. This slide deck can be adapted for use with any audience, from beginners to more advanced participants. While the examples are specific to pineapple production, it is broadly relevant to the tropical fruit sector and the examples could be substituted depending on the audience.

The other two slide decks include focused technical guidance to prepare participants from the pineapple sector to conduct these measurements, one for carbon footprints (**Annex 2**) and one for water footprints (**Annex 3**). Each of these two slide decks provides an overview of the relevant content in the technical guide, including technical concepts, data preparation, reference factors and calculations. These slide decks were designed to be used in a capacity development event with technical experts on hand and participants who have or will have a direct role in making our using these measurements. The content in these slides has been developed by the expert team at Gestarse S.A. in Costa Rica, the same team that developed the FAO methodology in the technical guide.

You will find all these slides in the Annexes of this training guide. To obtain an editable version of the slide decks, write to [responsible-fruits@fao.org](mailto:responsible-fruits@fao.org). The slide decks are available in English, French and Spanish.

## 5. Related FAO resources

The [Responsible Fruits Project's website](#) has many useful resources, in particular the section on how businesses and other actors in the tropical fruit sector can [take action on climate change](#).

The World Banana Forum has developed a guide and online tool, and conducts capacity development on [reducing carbon and water footprints in banana plantations](#).

Measuring carbon and water footprints is closely related to the Responsible Fruits Project's work on climate change adaptation and reducing loss and waste in pineapple value chains:

- [Adapting to climate change in the tropical fruit industry: a technical guide for pineapple producers and exporters](#)
- [Reducing food loss and valorizing fruits and residues to boost pineapple industry sustainability and profitability](#)

And in other value chains:

- [Adapting to climate change in the tropical fruit industry: a technical guide for avocado producers and exporters](#)
- [Reducing food loss and valorizing fruits and residues to boost avocado industry sustainability and profitability](#)

## 6. Developing a training plan

The slide decks on carbon footprints and water footprints are structured documents that will support facilitators and trainers who are guiding participants to:

- understand the concepts of carbon or water footprint measurement, and ultimately to independently make their own calculations;
- identify and prepare the data needed to make these calculations; and
- evaluating options to reduce either footprint and to improve the efficiency of their business operations.

The slide decks can and should be adapted to fit the context in which the capacity development exercise is carried out. Learning outcomes are more impactful if the slides and content are contextualized to an organization, business(es) or target audience.

Things to consider when customizing the learning content:

- Identify and focus on parts of the measurements for which data are known to exist.
- Create example scenarios and data sets for practical exercises when it is not possible to use real data due to low availability or confidentiality concerns.
- Fine-tune the content relative to the scale of the participants' or businesses' operations (e.g. small, medium or large).

# Annex 1.

## Measuring carbon and water footprints in pineapple value chains

(introductory slide deck)

Please contact the Responsible Fruits Project team at [responsible-fruits@fao.org](mailto:responsible-fruits@fao.org) to access an editable version of the slide deck.





## Content

1. Challenges and opportunities in the pineapple sector
2. What carbon and water footprint measurements are and why these are important
3. Measuring carbon and water footprints in the pineapple sector
4. Reducing greenhouse gas (GHG) emissions and water impacts in pineapple value chains



## 1. Current challenges in the pineapple sector



## Current challenges in the pineapple sector



Cultivation is **climatically vulnerable** in tropical regions.



**Fast growing international demand** for pineapple.



**Rising requirements from export markets** to report on environmental impacts and GHG emissions.



Important source of **economic growth, livelihoods, food and nutrition security** for producing countries.

## Current challenges in the tropical fruit sector

Council of the EU | Press release | 24 May 2024 10:20

**Corporate sustainability due diligence: Council gives its final approval**

13 August 2024

Two in three (66%) UK shoppers prefer to buy products that have a more positive environmental impact, but are unsure how to identify them

**COP26: Supermarkets promise to halve environmental impact by 2030**

6 November 2021

Share ◀ Save ▶



Food and Agriculture Organization of the United Nations

## 2. What are carbon and water footprint measurements and why are these important?



Food and Agriculture Organization of the United Nations

### What is carbon footprint measurement?

Refers to the total amount of greenhouse gases (GHG) that are generated by human activity.



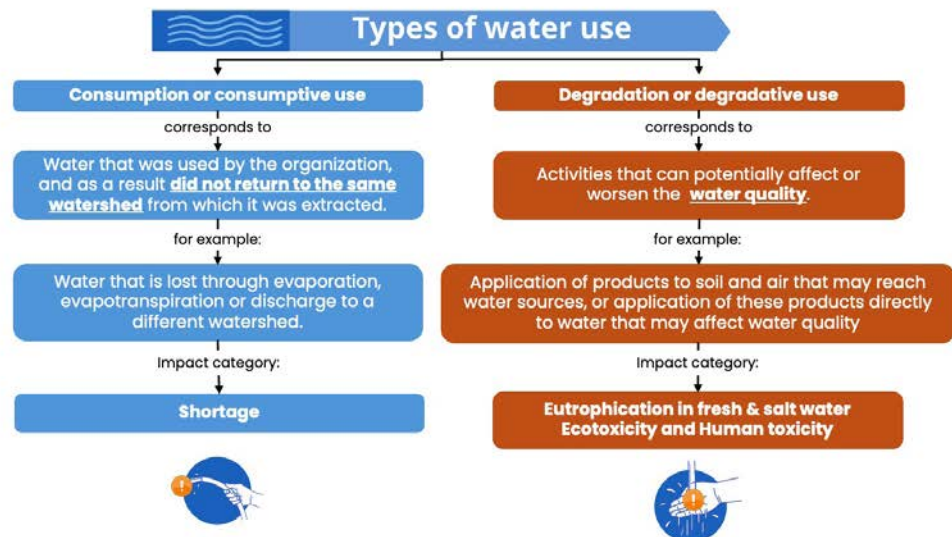
Potential to warm the planet once released into the atmosphere at a specific time.



Human-driven climate change

## What is water footprint measurement?

It measures the potential environmental impacts related to water.



## Why is it important to calculate these footprints?

-  **Meet the demands from international markets** and consumers
-  Opportunity to **enhance input management** and reduce operational costs
-  **Reducing environmental impact** of operations and increasing compliance with environmental requirements (1.5 °C target)
-  **Enhanced brand image and reputation** (product differentiation and business opportunities)
-  Robust information for **decision-making**

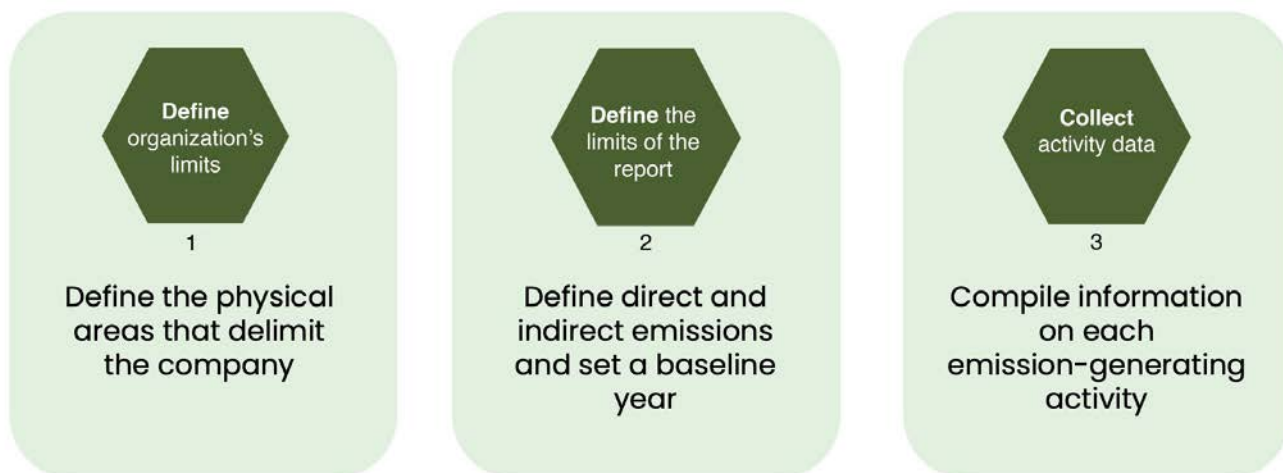


**What other benefits do you see in measuring the carbon and water footprints?**

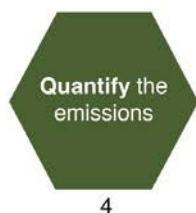
**What does a verifiable carbon footprint study look like?**



## What does a verifiable carbon footprint study look like? (continued)



## What does a verifiable carbon footprint study look like? (continued)



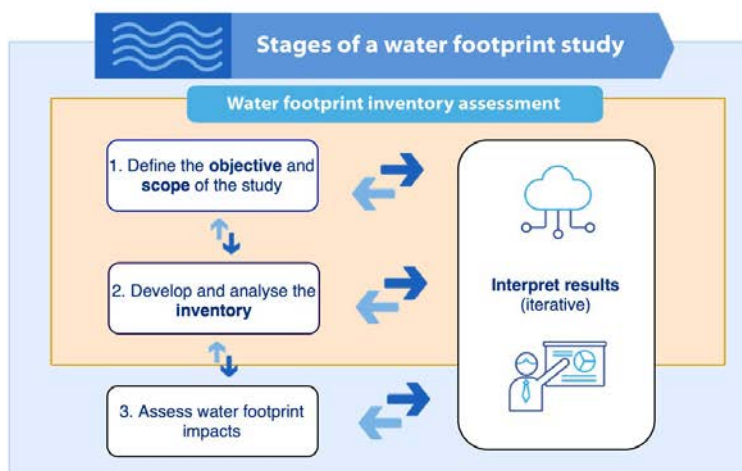
Source	Sub-source (examples)	GHG
Electricity consumption	Electricity consumption from the power grid	CO <sub>2</sub> e
Use of lubricating oils	Use of engine lubricants in vehicles, tractors, or trucks Use of mixed lubricants in weed whackers	CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O
Use of fire extinguishers	Use of CO <sub>2</sub> fire extinguishers Use of clean agent fire extinguishers Use of halon fire extinguishers	CO <sub>2</sub> , HFC, halons
Gas consumption for welding and oxyfuel (acetylene, propane)	Use of acetylene for welding Use of propane for oxyacetylene cutting	CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O
Refrigerant gas leaks	Leaks of refrigerant gas from air conditioners Leaks of refrigerant gas from refrigerators Leaks of refrigerant gas from cold storage rooms	HFC, HCFC
Fossil fuel consumption (mobile and stationary sources)	Diesel consumption in field tractors Gasoline consumption in vehicles Diesel consumption in emergency power generator	CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O
Use of nitrogen fertilizers	Use of granular fertilizers Use of fertigation	N <sub>2</sub> O

## What does a verifiable carbon footprint study look like? (continued)



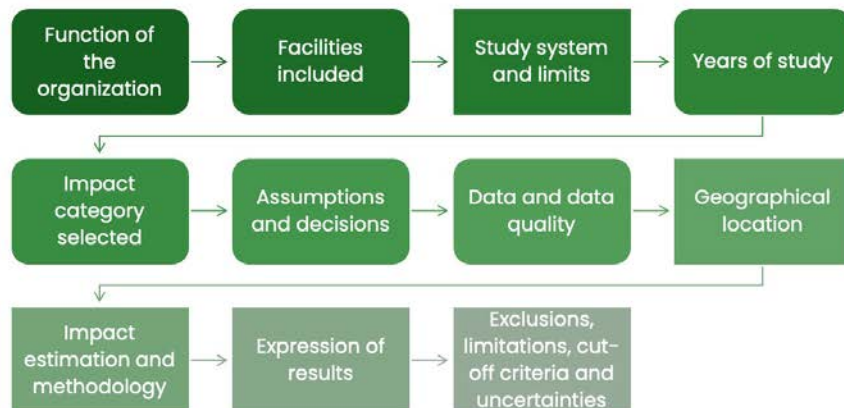
Category	Emission source	CO <sub>2</sub> (t CO <sub>2</sub> e)	CH <sub>4</sub> (t CO <sub>2</sub> e)	N <sub>2</sub> O (t CO <sub>2</sub> e)	HFCs (t CO <sub>2</sub> e)	HCFCs (t CO <sub>2</sub> e)	Other Gases (t CO <sub>2</sub> e)	Total (t CO <sub>2</sub> e)
Direct	Source 1							
	Source 2							
Indirect by imported energy	Source 3							
Indirect by transport	Source 4							
	Source 5							
Indirect by products used by the company	Source 6							
	Source 7							
Indirect by use of company products	Source 8							
	Source 9							
Indirect from other sources	Source 10							
	Source 11							
Total emissions t CO <sub>2</sub> e								

## What does a verifiable water footprint study look like?



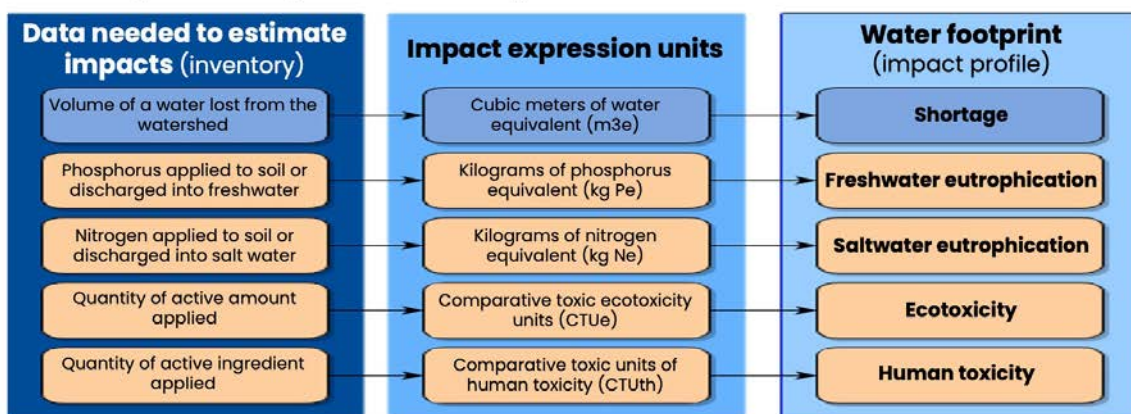
## What does a verifiable water footprint study look like? (continued)

### Step 1. Define the objective and scope of the study



## What does a verifiable water footprint study look like? (continued)

### Step 2. Develop and analyze the inventory





## What does a verifiable water footprint study look like? (continued)

### Step 3. Assess water footprint impacts

#### Methodologies:

- AWARE**  → **Shortage**
- ReCiPe**  → **Freshwater eutrophication**  
→ **Saltwater eutrophication**
- USEtox**  → **Ecotoxicity**  
→ **Human toxicity**



Water footprint profile			
Impact	Field	Packing house	Total
Shortage (m <sup>3</sup> e)			
Freshwater eutrophication (kg Pe)			
Saltwater eutrophication (kg Ne)			
Ecotoxicity (CTUe)			
Human toxicity (CTUh)			



The '**severity**' of the impacts are context specific as it depends on the water availability, types of soils and climatic characteristics of the area

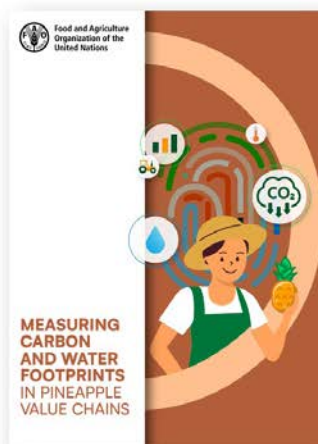
© Noun Project



## 3. Measuring carbon and water footprints in the pineapple sector



# Measuring the carbon and water footprint in the pineapple sector



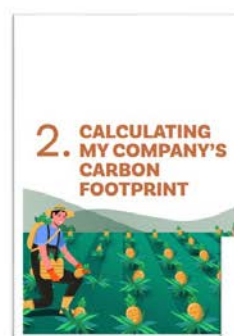
- Guide developed by the FAO Responsible Fruits Project

### Why?

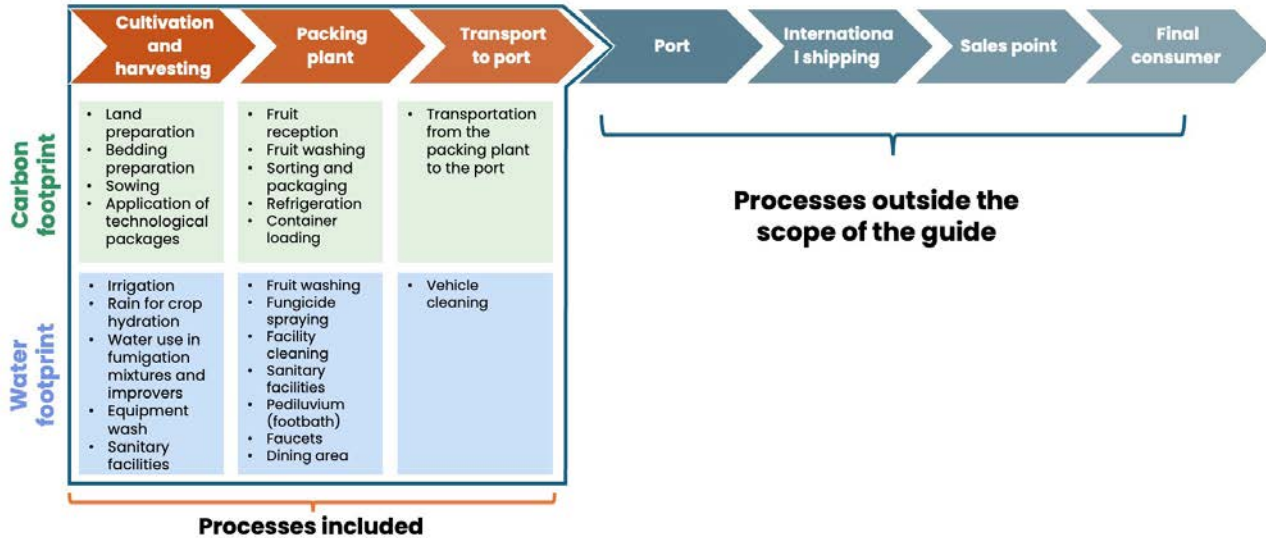
- Respond to the **need for measurement** of footprints (prioritized by the industry) and **market demand**
- Provide a **quantitative framework** for measuring carbon and water footprints
- **Enable users** to measure footprints autonomously
- Support the **reduction of environmental impacts** of pineapple production and trade
- **Optimization of processes, efficiency and cost savings**
- Contribute to **risk mitigation and prevention** (aligned with responsible business conduct)

## Development of the guide

- Building on the experience of measuring carbon and water footprints in banana value chains (World Banana Forum) and adapting this to the pineapple industry.
- Based on internationally recognized methodologies (ISO 14064 for carbon and ISO 14046 for water).
- Validation with six export-oriented pineapple producing and packing companies and cooperatives in Costa Rica.



## Scope of carbon and water footprint measurement:



## Contents: Carbon footprint measurement guide

### Carbon footprint of the company:

- 1 Carbon footprint calculation overview
- 2 Scope of an emissions inventory
- 3 Identification of emission sources
- 4 Consolidation of carbon footprint results
- 5 Emissions reduction opportunity (measures)
- 6 Inventory uncertainty



### Example: guidance to identify and calculate GHG emissions

#### 2.6.1 Electricity consumption

Category	Indirect from imported energy						
	Type of GHG to be evaluated						
Source	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	HFC	HCFC	CO <sub>2</sub> e	Others
Electricity						✓	

#### 2.6.1.A Calculation method

**Equation 2.6.1a**  
*Electricity emissions (t CO<sub>2</sub>e): AD × EFE × CF*

**Where:**  
**tCO<sub>2</sub>e:** emissions from electricity in tonnes of carbon dioxide equivalent.  
**AD:** activity data (kWh or MWh).  
**EF<sub>e</sub>:** electricity emission factor (kg CO<sub>2</sub> e/kWh or MWh).  
**CF:** unit conversion factor (e.g. conversion from kg to tonnes).

## Contents: Water footprint measurement guide

Water footprint of the company:

- 1 Overview of water footprint calculation
- 2 Scope of the water footprint
- 3 Water balance identification and product usage
- 4 Assessing water footprint impacts
- 5 Water footprint report
- 6 Water footprint reduction measures





**Example: guidance to identify and calculate the impacts on water**

**3.5.2.1.A2 Calculation method for saltwater eutrophication**

The value of the impact indicator is estimated with the ReCiPe methodology, which assumes that the main factor causing eutrophication in saltwater is nitrogen. The results are given in units of kilograms of nitrogen equivalent (kg Ne), as shown in the following equation (Goedkoop *et al.*, 2013).

$$\text{Equation 3.5.2.1b}$$
$$WF_{\text{eutrof-S}} = m_{Nt} \times CF$$

**Where:**  
**WF<sub>eutrof-S</sub>**: value of impact on saltwater eutrophication (kg Ne).  
**m<sub>Nt</sub>**: amount of total nitrogen used or discharged in soil or water (kg total N).  
**CF**: characterization factor given by ReCiPe (kg Ne/kg total N).



**How do you think this tool can be used in your company?**





Food and Agriculture Organization  
of the United Nations

## 5. Reducing GHG emissions and water impacts in pineapple value chains



Food and Agriculture Organization  
of the United Nations

## Recommendations to reduce the carbon footprint



**Inputs:** Optimized use of agrochemicals, use of integrated pest and nutrition management.



**Solid waste and wastewater disposal:** Lower organic matter load in wastewater, water reuse & circulation, water consumption optimization, separation & recycling.



**Energy:** Clean and well-functioning energy systems



**Stubble management and tillage:** tillage practices with lower emissions, reincorporation of organic matter in the soil.



**Fuels:** Efficient vehicles, optimization of routes, fuel-saving devices



**Refrigerant gases and fire extinguishers:** Maintenance, monitoring and replacement



## Recommendations to reduce the water footprint

### Shortage



Water treatment, recirculation and reuse



Efficient irrigation technologies



Rainwater harvesting



Reforestation and forest protection

### Degradation (quality)



Rational use of agrochemicals (integrated pest management, nutrient management)



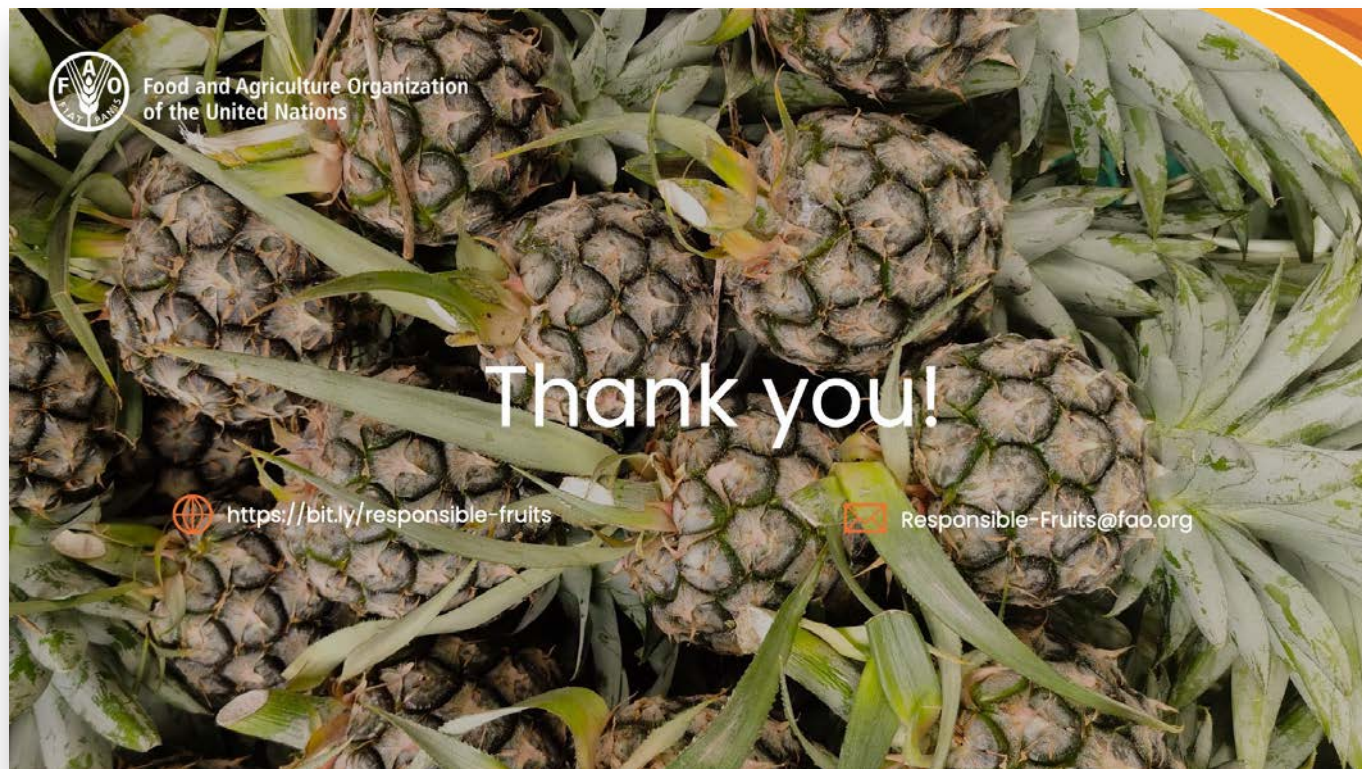
Integrated solid waste management



Integrated liquid waste management



Soil and biodiversity protection



## Annex 2.

# Learning about carbon footprint measurements in pineapple value chains

(practical training slide deck)

Please contact the Responsible Fruits Project team at [responsible-fruits@fao.org](mailto:responsible-fruits@fao.org) to access an editable version of the slide deck.



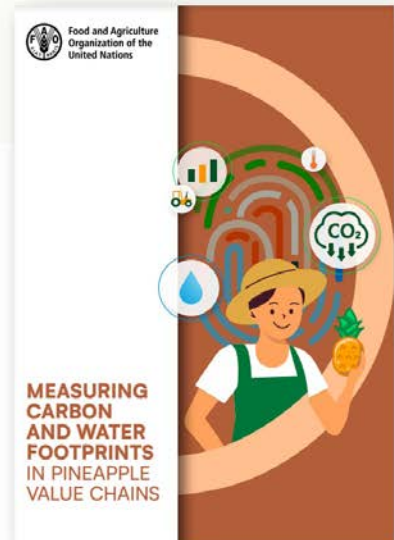


### Objective:

- ✓ To introduce the pineapple sector companies to the use of the carbon footprint measurement guide for pineapple value chains.

### Reference:

- ✓ This guide used references such as the international voluntary standard **ISO 14064** "Greenhouse gases—part 1: specification with guidance, at the organization level, for the quantification and reporting of greenhouse gas emissions and removals", the *GHG Protocol guidelines*, and the *Intergovernmental panel on Climate Change (IPCC) Guidelines*.



©FAO

### Who is the target audience of this guide:

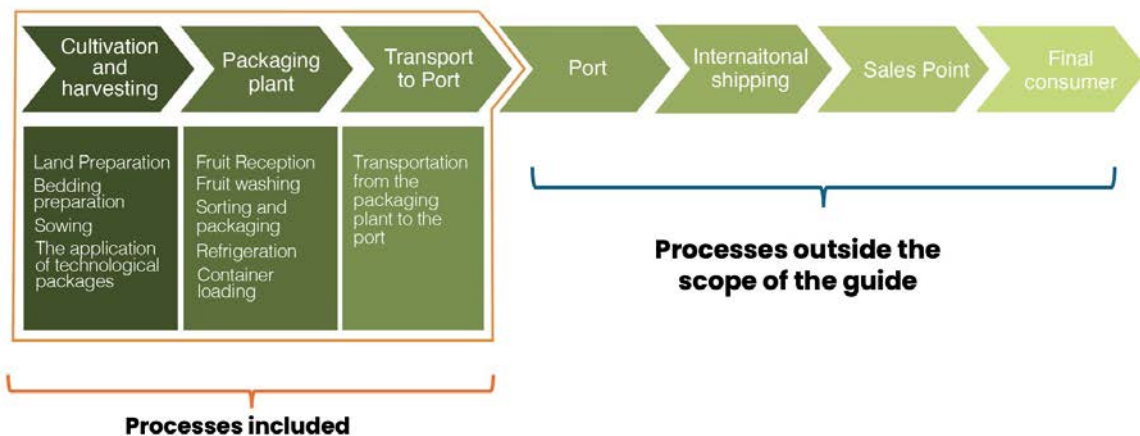
- ✓ Due to the high degree of technical difficulty, the guide is aimed at:
  - technical personnel;
  - environmental engineers;
  - personnel responsible for preparing the quantification of the carbon footprint within companies; or
  - professionals in related areas.



## Contents of this course: How is a carbon footprint calculated?

- 1 Carbon footprint calculation overview
- 2 Scope of an emissions inventory
- 3 Identification of emission sources
- 4 Consolidation of carbon footprint results
- 5 Emissions reduction opportunity (measures)
- 6 Inventory uncertainty

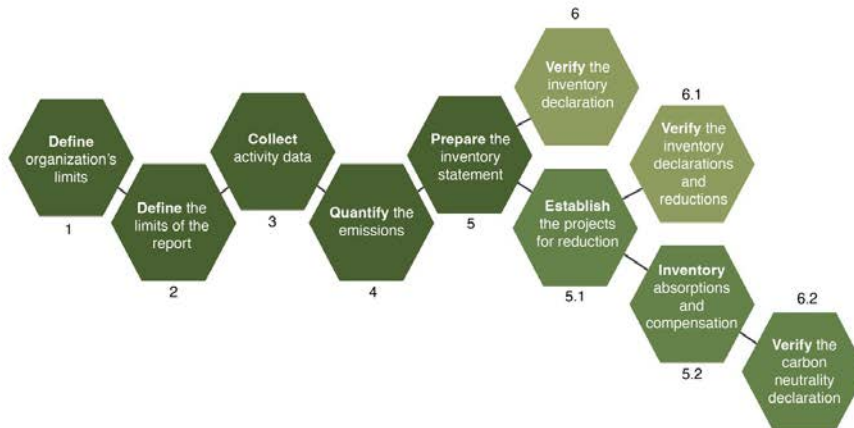
Processes considered within the scope of the carbon footprint measurement guide:



# Measuring carbon and water footprints in pineapple value chains

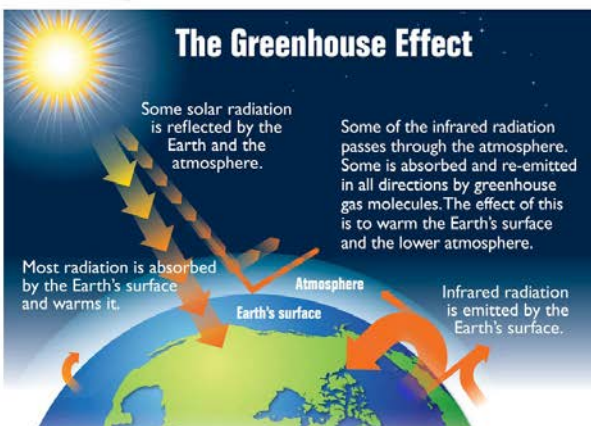


Recommended steps towards carbon footprint quantification and reporting:

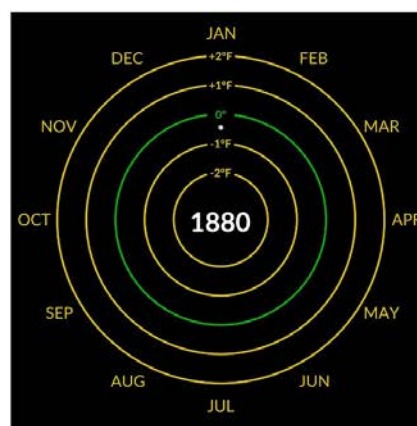


## Basic concepts

**Natural process:**



**Climate change:**



## Basic concepts

### Greenhouse gas (GHG):



Gaseous components in the atmosphere, both naturally occurring and human-made, that can absorb and emit radiation.

### GHG emission source:



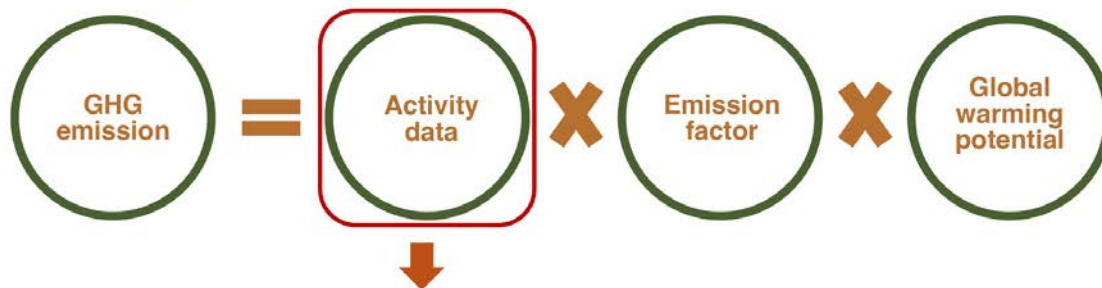
Any activity or process that releases GHG emissions into the atmosphere (INTECO, 2019).

### GHG emission:



It refers to the total amount of one or more GHGs that have been released into the atmosphere at a specific time.

## Basic concepts



Specific quantitative measure of the activity (source) generating the emissions; which will allow accounting of the impact on emissions.

**For example:** kWh, liters of fuel , kg of refrigerant gas, kg of nitrogen fertilizer applied to the soil, among others...

### Basic concepts



The factor of emission relates the activity data to the emission of a specific GHG. There are differentiated emission factors that determine emissions by type of GHG. **For example:**

Emission source/type	GHG	Emission factor	Units	Reference
Electricity consumption (imported)	CO <sub>2</sub>	0.0400	kg CO <sub>2</sub> e/kWh	(IMN, 2022)
Use of lubricating oil (four-stroke engine)	CO <sub>2</sub>	0.5184	kg CO <sub>2</sub> /l	(IMN, 2022)

### Basic concepts



It is a value that describes the greenhouse impact of a given GHG, in relation to CO<sub>2</sub>, enabling the reporting of all emission in terms of CO<sub>2</sub>. **For example:**

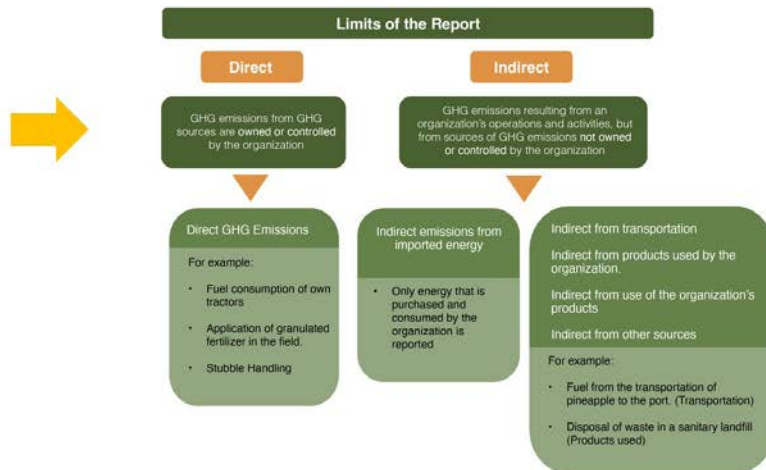
Gas	IPCC second report	IPCC fourth report	IPCC fifth report	IPCC sixth report
	Global warming potential (horizon: 100 years)			
Carbon dioxide (CO <sub>2</sub> )	1	1	1	1
Methane (CH <sub>4</sub> )	21	25	28	27.9

## Basic concepts

### Organizational boundaries:



These refer to the company areas that define its boundaries, including physical facilities, cultivation, processing, packing and shipping areas, along with the chosen consolidation approach for inventory quantification.



## Identification of emission sources

Emission sources must be identified within the limits established by category.

Using a checklist and conducting facility walk-throughs to identify emission sources is considered good practice.

**For example:**

Source	Sub-source (examples)	GHG	Category
Electricity consumption	Electricity consumption from the power grid	<input checked="" type="checkbox"/>	Indirect from electricity
Use of lubricating oils	Use of engine lubricants in vehicles, tractors, or trucks	<input type="checkbox"/>	Indirect emissions from products used
	Use of blending lubricant in weedwacker	<input checked="" type="checkbox"/>	
Use of fire extinguishers	Use of CO <sub>2</sub> fire extinguishers	<input type="checkbox"/>	Direct
	Use of clean agent fire extinguishers	<input checked="" type="checkbox"/>	
	Use of halon fire extinguishers	<input type="checkbox"/>	
Gas consumption for welding and oxyfuel (acetylene, propane)	Use of acetylene for welding	<input checked="" type="checkbox"/>	Direct
	Use of propane for oxyacetylene cutting	<input type="checkbox"/>	
Refrigerant gas leaks	Leaks of refrigerant gas from air conditioners	<input checked="" type="checkbox"/>	Direct
	Leaks of refrigerant gas from refrigerators	<input type="checkbox"/>	
	Leaks of refrigerant gas from cold storage rooms	<input type="checkbox"/>	
Fossil fuel consumption (mobile and stationary sources)	Diesel consumption in field tractors	<input type="checkbox"/>	Indirect emissions from products used
	Gasoline consumption in vehicles	<input checked="" type="checkbox"/>	
	Diesel consumption in emergency power plant	<input type="checkbox"/>	
Use of nitrogen fertilizers	Use of granular fertilizers	<input checked="" type="checkbox"/>	Direct
	Use of fertigation	<input checked="" type="checkbox"/>	



## Main emissions sources (continued)

The guide offers orientation for identifying GHGs. Each GHG must be quantified for its respective emission source, using the appropriate calculation methodology.

### For example:

#### 2.6.1 Electricity consumption

Category	Indirect from imported energy						
	Type of GHG to be evaluated						
Source	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	HFC	HCFC	CO <sub>2</sub> e	Others
Electricity						✓	

Emissions from imported electricity correspond to those associated with the production of electricity consumed by the company. When a company purchases, acquires and consumes electricity from an electrical grid, it has associated indirect GHG emissions that must be accounted for.

For the purposes of this guide, the emission source indicated is considered only when the company consumes electricity produced by a third party. In Costa Rica, for example, third-party providers include the Costa Rican Institute of Electricity, Cooperative of Rural Electrification of San Carlos and National Power and

#### 2.6.1.A Calculation method

**Equation 2.6.1a**  
*Electricity emissions (t CO<sub>2</sub>e): AD × EFE × CF*

**Where:**

**tCO<sub>2</sub>e:** emissions from electricity in tonnes of carbon dioxide equivalent.

**AD:** activity data (kWh or MWh).

**EF<sub>e</sub>:** electricity emission factor (kg CO<sub>2</sub> e/kWh or MWh).

**CF:** unit conversion factor (e.g. conversion from kg to tonnes).

**Emission factor:** The emission factor for electricity consumption is usually expressed as kg CO<sub>2</sub> e/kWh or kg CO<sub>2</sub> e/MWh. For the calculation of emissions from this source, average emission factors of the local, regional or national grid can be used, depending on the information available and the characteristics of generation, sale and distribution of energy in each country. The emission factor used must correspond to the emissions of the year being reported or to be calculated, if available, otherwise, of the most recent year.

Below is an example of an emissions calculation for the electricity consumption, indirect category for imported energy.

#### 2.6.1.B Collection of information

**Activity data:** The origin of the activity data depends on the characteristics of each company.



## Main emissions sources (continued)

The guide provides practical examples for calculating GHG emissions by source to guide the user in applying the methodology.

### For example:

#### Example: calculation of electricity emissions

**Step 1.** At a farm located in San Carlos, Costa Rica, 15 000 kWh of electricity were consumed during the year 2021 from the service provider's power grid. To calculate the associated emissions from electricity consumption, first identify the appropriate emission factor (EF) for this specific source, year and country.

FE <sub>e</sub>	Reference
0.0400 $\frac{\text{kg CO}_2\text{e}}{\text{kWh}}$	Specific value for Costa Rica for the year 2021

**Step 2.** Multiply the total amount of kWh consumed by the respective emission factor to obtain the CO<sub>2</sub>

equivalent emissions (kg CO<sub>2</sub> e) and convert to tonnes with the CF. Emission factors for this source are usually given in CO<sub>2</sub> e, so it is not necessary to use the global warming potential (GWP).

#### Equation 2.6.1a

$$\text{Electricity emissions (t CO}_2\text{e)} = 15\,000 \text{ kWh} \times 0.0400 \text{ kgCO}_2\text{e/kWh} \times \frac{1}{1000 \text{ kg}} = 0.6 \text{ t CO}_2\text{e}$$



## Main emissions sources (continued)

The guide **considers three carbon change scenarios based on land usage.**

Land use and management directly influence various ecosystem processes that affect GHG fluxes, potentially leading to either GHG emissions or their removal.



Initial land use	Final land use
Cropland	Forest land
Forest land	Cropland
Forest land	Forest land



## Consolidation of carbon footprint results

After evaluating all emission sources identified by the company, the results are consolidated by source category and GHG type.

**The results are expressed in tons of carbon dioxide equivalent (CO<sub>2</sub>e).**

This process will help the company analyse emissions during the evaluation period, facilitate future comparisons, and assess performance improvements.

**For example:**



Category	Emission source	CO <sub>2</sub> (t CO <sub>2</sub> e)	CH <sub>4</sub> (t CO <sub>2</sub> e)	N <sub>2</sub> O (t CO <sub>2</sub> e)	HFCs (t CO <sub>2</sub> e)	HCFCs (t CO <sub>2</sub> e)	Other Gases (t CO <sub>2</sub> e)	Total (t CO <sub>2</sub> e)
Direct	Source 1							
	Source 2							
Indirect by imported energy	Source 3							
	Source 4							
Indirect by transport	Source 5							
	Source 6							
Indirect by products used by the company	Source 7							
	Source 8							
Indirect by use of company products	Source 9							
	Source 10							
Indirect from other sources	Source 11							
	Total emissions t CO <sub>2</sub> e							

## Consolidation of carbon footprint results (continued)

The emissions inventory results are typically presented in a report intended for all stakeholders.

This document must meet minimum content requirements in accordance with the INTE-ISO 14064-1 standard.



### Minimum content in relation to the report findings

- Description of the company;
- person or entity responsible for the report;
- reporting period;
- documentation of the company's boundaries;
- documentation of reporting boundaries, including criteria established to define significant emissions;
- direct emissions quantified separately by type of GHG in t CO<sub>2</sub>e;
- description of how biogenic emissions and removals are considered in the inventory, quantified separately in t CO<sub>2</sub>e;
- whether direct removals are quantified in t CO<sub>2</sub>e;
- explanation of the exclusion of any significant sources or sinks from the quantification;
- indirect emissions quantified separately by category in t CO<sub>2</sub>e;
- the selected historical base year and the year of the GHG inventory;
- explanation of any changes to the base year or other historical GHG data, or categorization and any recalculation of the base year or other historical GHG inventory, and documentation of any limitations to comparability resulting from such recalculation;
- reference or description of quantification approaches, including the rationale for their selection;
- explanation of any changes to previously used quantification approaches;
- reference to or documentation of the GHG emission or removal factors used;
- description of the impact of uncertainties on the accuracy of GHG emissions and removals data by category;
- description and results of the uncertainty assessment;
- a statement that the GHG report has been prepared in accordance with the standard;
- disclosure describing whether the GHG inventory, report or statement has been verified, including the type of verification and the level of assurance achieved; and
- the GWP values used in the calculation, as well as their source.

## Reduction of emissions

The reduction of GHG emissions is **fundamental** of the management of an emission inventory.

... it allows reducing the GHG emissions through the implementation of actions planned by the company.

Determining the carbon footprint makes it possible to:

- identify potential opportunities to **reduce emissions**, and
- contribute to **mitigating** the effects of **climate change**.

Once the emission sources have been identified and the company's GHG emissions have been accounted for, reduction strategies must be established to manage these sources and reduce GHG emissions.

## Reduction of emissions (continued)

Examples of emission reduction options:

Emission source	Reduction alternatives	Emission source	Reduction alternatives
Electricity	<ul style="list-style-type: none"> <li>On-site power generation from renewable sources, e.g. solar panels</li> <li>Replacement of artificial lighting with natural lighting</li> <li>Replacement of fluorescent or sodium lighting with LED lighting</li> <li>Improvements or renovation of electrical installation</li> </ul>	Fertilizer use	<ul style="list-style-type: none"> <li>Reincorporation of organic matter into the soil and use of organic amendments</li> <li>Utilization of fertilizers with less volatilized nitrogen sources</li> <li>Utilization of fertilizers with volatilization inhibitors</li> </ul>
	Use of fuels		<ul style="list-style-type: none"> <li>Replacement of obsolete or old equipment with more efficient equipment, for example, air conditioners, refrigerators, computers, printers, etc.</li> </ul>
<ul style="list-style-type: none"> <li>Substitution of combustion vehicles for other technologies, such as electric or hybrid</li> <li>Replacement of old or obsolete vehicles with more efficient vehicles</li> <li>Utilization of fuel-saving devices</li> <li>Route optimization</li> <li>Application of efficient driving techniques or habits</li> <li>Replacement of combustion engines with electric motors</li> <li>Equipment and vehicle preventive management programmes</li> </ul>			

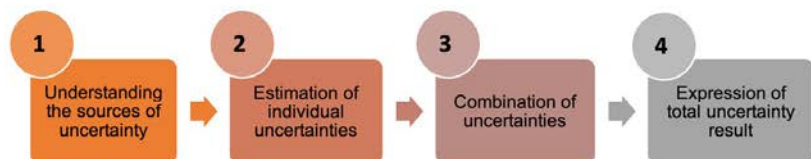
## Inventory uncertainty

**Uncertainty** analysis is an important element of an inventory of emissions and removals.

It is used as a mean to prioritize efforts to reduce uncertainty in future inventories and to guide decisions on the application of methodologies.

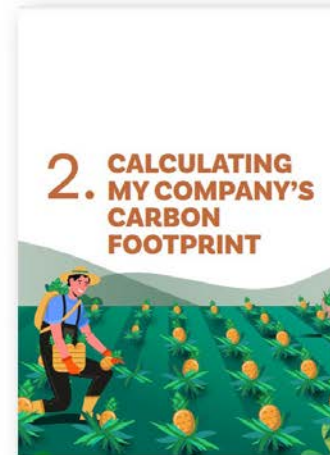
The guide provides a general guidance on uncertainty analysis.

### General steps for uncertainty assessment



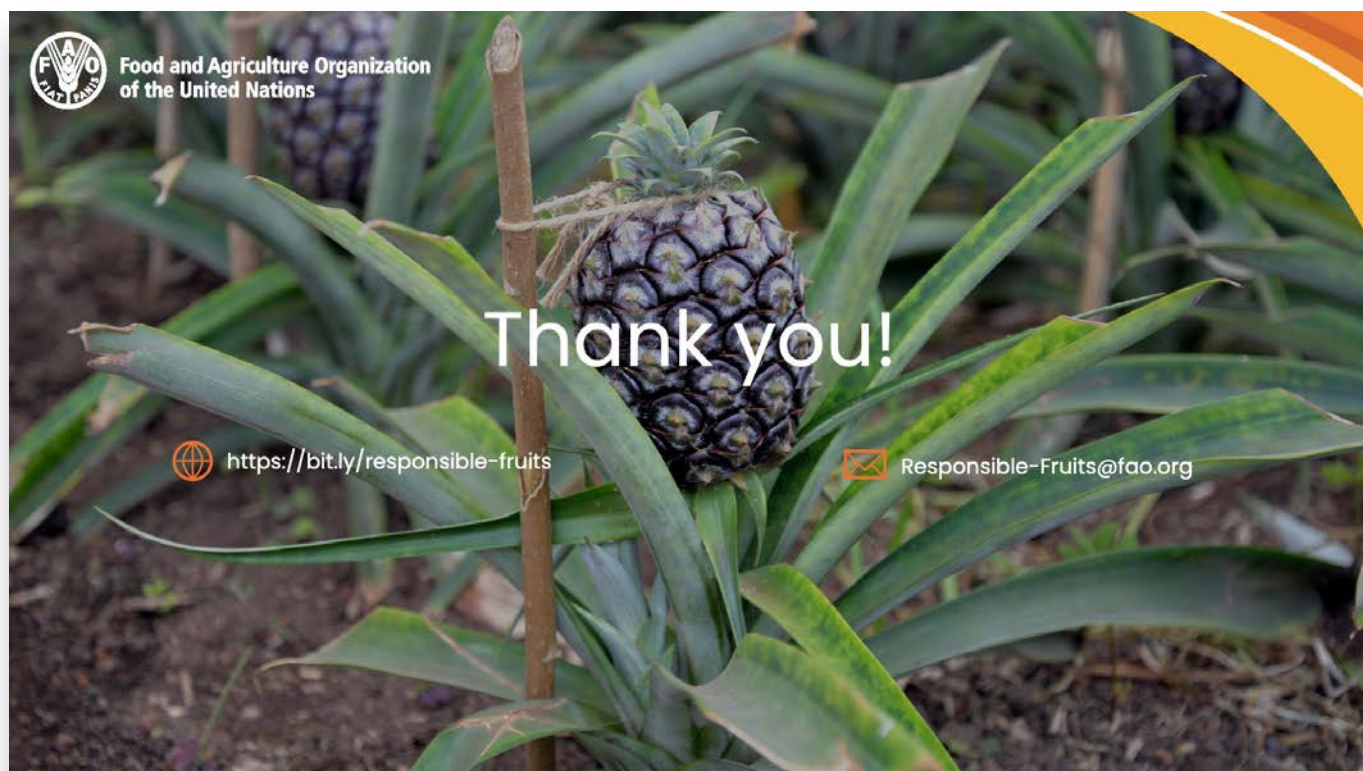
## Why to use the carbon footprint measurement guide in pineapple companies?

- ✓ Provides detailed guidance for the elaboration of the carbon footprint in the sector.
- ✓ Contains case examples for the application of the calculation methodologies for each emission source.
- ✓ Addresses relevant emission sources for the sector.
- ✓ **It is the first carbon footprint measurement guide available to the pineapple value chain.**



## Some limitations

- It does not include evaluation criteria for the determination of significant indirect sources. Instead, it allows each company to define its own criteria.
- This guide is applicable to elaborate the carbon footprint at the company level, it **is not applicable to develop a carbon footprint for a product.**



## Annex 3.

# Learning about water footprint measurements in pineapple value chains

(practical training slide deck)

Please contact the Responsible Fruits Project team at [responsible-fruits@fao.org](mailto:responsible-fruits@fao.org) to access an editable version of the slide deck.



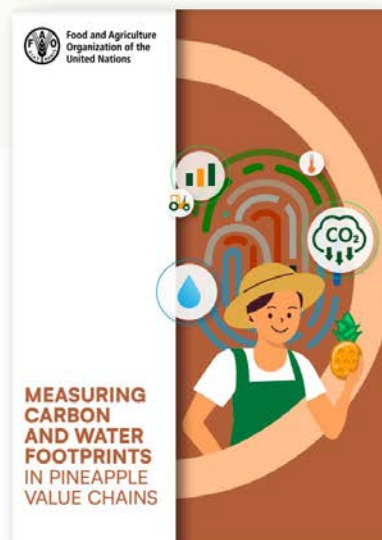
## A training guide



### Objectives:

- ✓ To introduce companies in the pineapple value chain to a method for **measuring water footprints** based on the FAO technical guide “Measuring carbon and water footprints in pineapple value chains”.
- ✓ To build the capacity of individuals and organizations to make their own water footprint calculations independently.

➔ The technical guide is available at:  
<https://doi.org/10.4060/cdl688en>



### Acknowledgements:

The slide content was prepared by Gestarse for FAO.

This work has been made possible by support from the Government of Germany.



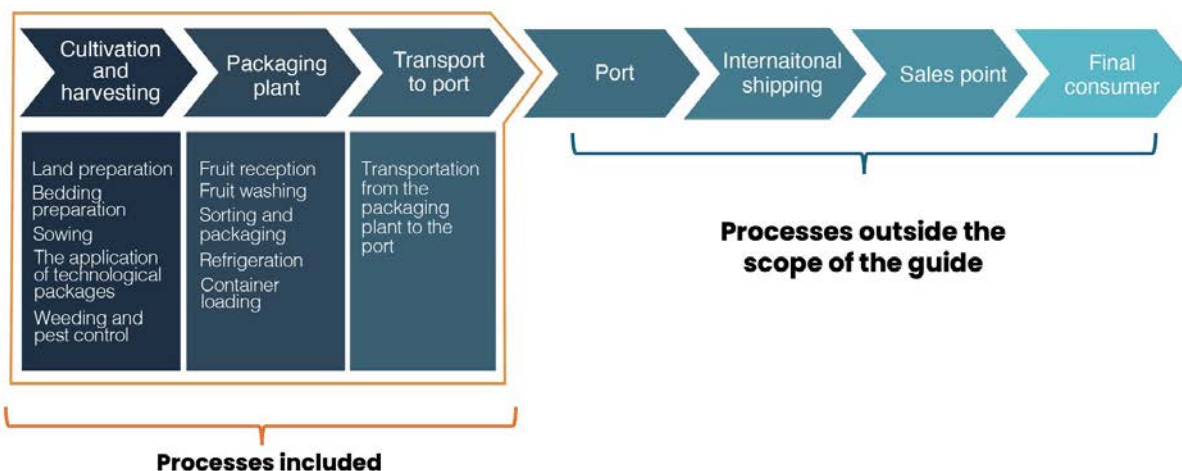


## Contents of this course: How is a water footprint calculated?

- 1 General water footprint calculation
- 2 Scope of the water footprint
- 3 Identification of water balance and use of products
- 4 Assessment of water footprint impact
- 5 Water footprint report
- 6 Water footprint reduction measures

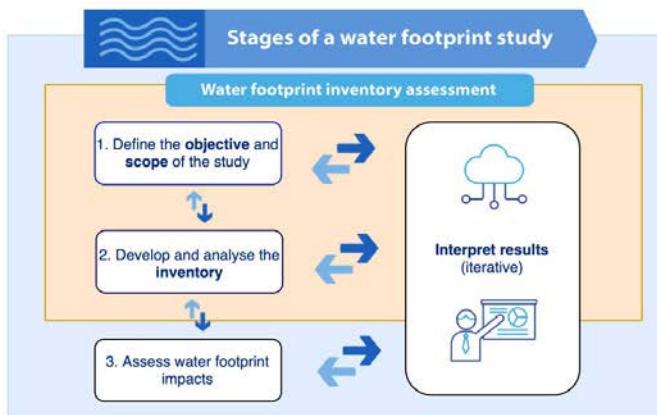
## General water footprint calculation

Processes considered within the scope of the water footprint measurement guide:



## General water footprint calculation (continued)

Recommended steps for the water footprint study:



Source: Adapted from **ISO (International Organization for Standardization)** . 2014. International standard ISO 14046:2014(E): Environmental management – Water footprint – Principles, requirements and guidelines.

## General water footprint calculation (continued)

### Basic concepts

#### Water footprint:



Metric(s) that quantifies the potential environmental impacts related to water.

#### Direct water usage:



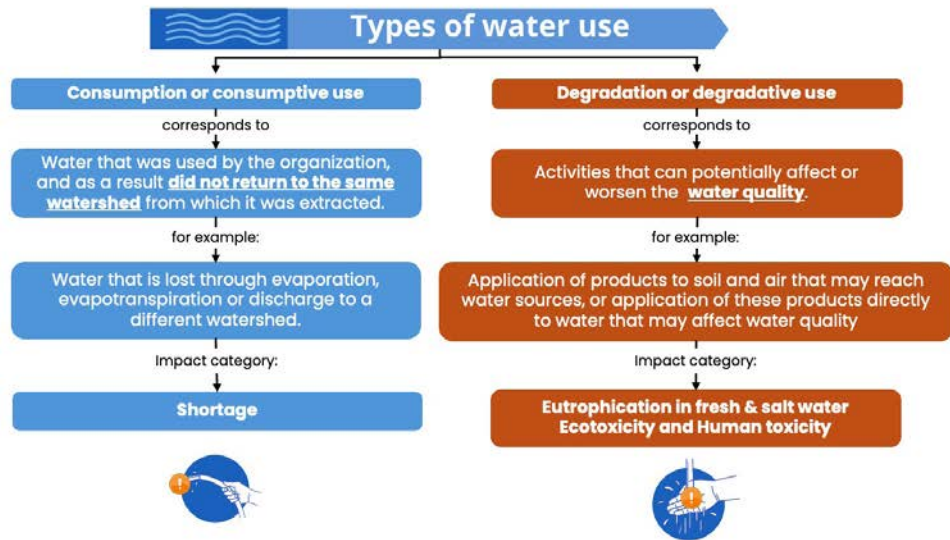
Usage that take place during day-to-day operations within the company's facilities

#### Water use related to human activities:



Any form of withdrawal or release of water, or its use within the same watershed, that affects water quantity or quality.

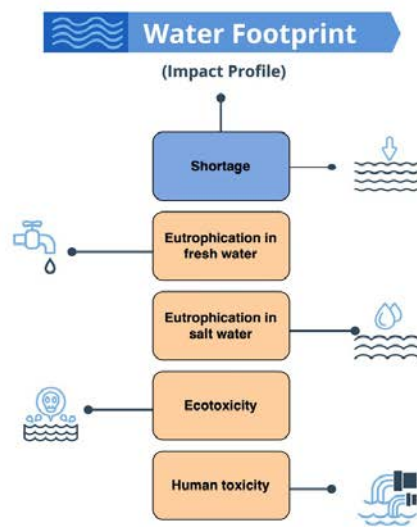
**Basic concepts**



**Basic concepts**

**Impact category:**

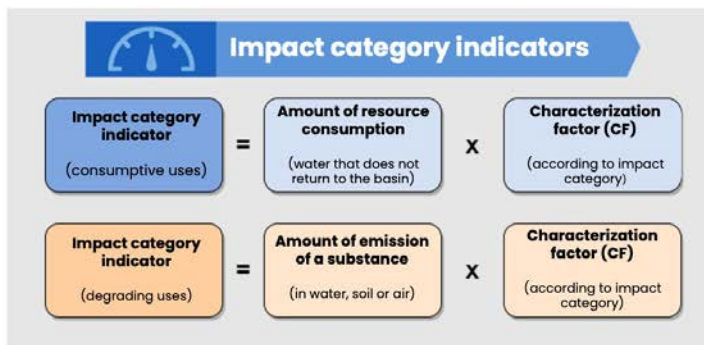
This classification is given to an aspect that represents an environmental importance related to the usage of water in the productive activities of the sector.



### Basic concepts

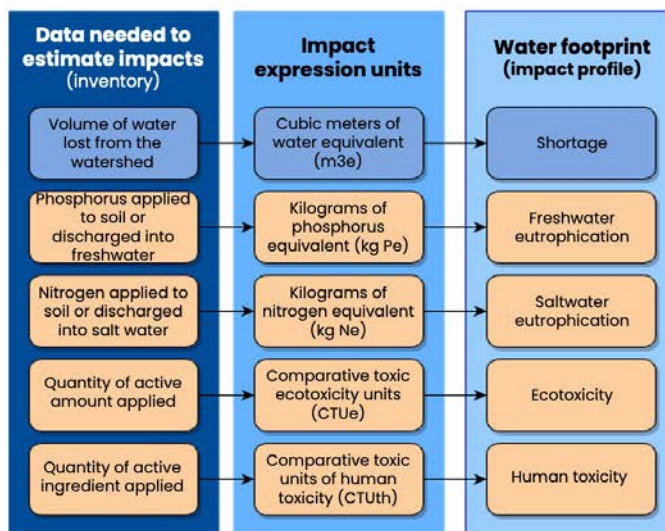
#### Impact category indicator:

This indicator corresponds to the numerical value of each impacted estimate. This is achieved by multiplying the water consumption or quantity of a substance emitted, as appropriate, with a value known as the characterization factor (CF).

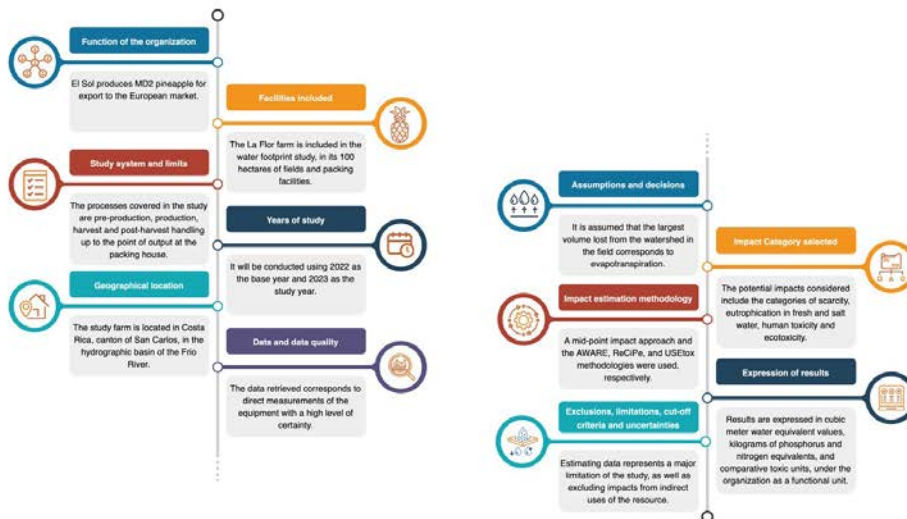


### Basic concepts

The information collected should correspond to the **year of study** defined within the scope. The data required will be associated with the impacts to be estimated.

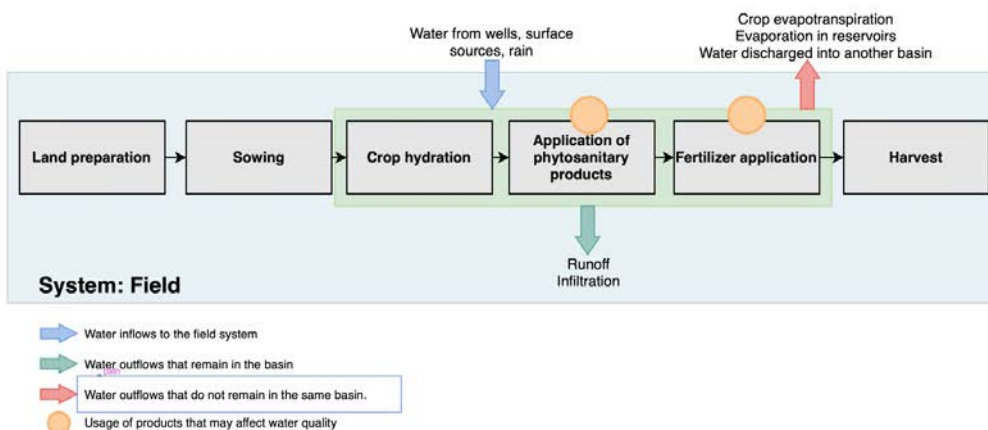


## Scope of the water footprint



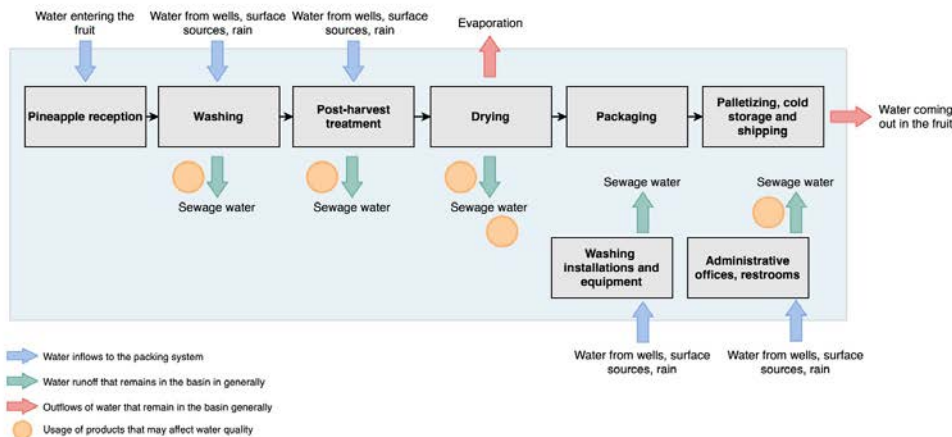
## Identification of water balance and use of products

Identification of water balance and use of products at the **field stage**



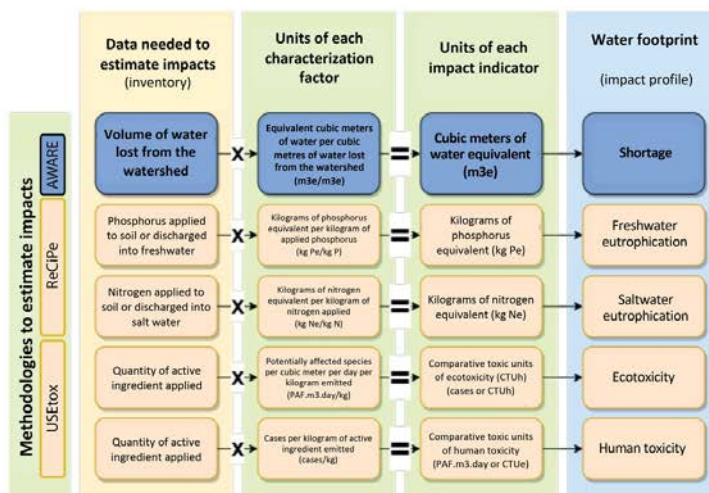
## Identification of water balance and use of products

Identification of water balance and use of products at the **packing stage**



## Assessment of water footprint impact

After collecting the information for the water footprint inventory, we will proceed to estimate the potential water footprint impacts.



**Note:** Blue shows the indicator related to consumptive use and orange shows those associated with degradative uses. AWARE=Available Water Remaining.



## Assessment of water footprint impact (continued)

The water footprint measurement guide provides guidance for assessing potential impacts and the corresponding calculation methodologies.

**For example:**

### 3.5.1. Impacts due to consumptive uses of water or water consumption

#### 3.5.1.1. Scarcity

A potential scarcity impact is generated when a volume of water does not return to the same basin from which it was extracted due to the company's activity. As such, other potential users would no longer be able to consume it to meet their needs (UNEP, 2012). Water is lost in the following way (Vallejo, 2015; Vallejo *et al.*, 2018):

- **field system:** crop evapotranspiration, evaporation, or discharges to a different watershed; and
- **packing house system:** evaporation, discharge to a different basin, or water incorporated into the fruit.

The summary worksheet for water scarcity can be consulted in [Annex 3](#). The calculation method is described below.

#### 3.5.1.1.A Calculation method

For the estimation of the impact indicator, the AWARE methodology ("Available WATER REmaining") is used. The estimation is done by multiplying the total volume lost from the basin by a CF according to the geographic location, as shown in the following equation. The result will be given in terms of equivalent cubic meters of water (m<sup>3</sup>e) (WULCA, 2017; Vallejo *et al.*, 2018).

$$\text{Equation 3.5.1.1a}$$

$$WF_{\text{scarcity}} (\text{m}^3\text{e}) = BVT \times CF_{\text{regional}}$$



## Assessment of water footprint impact (continued)

An example calculation is provided for each impact, to guide the user in the application of the methodology.

#### Example: water scarcity footprint

**Step 1.** On a 15-hectare pineapple farm (latitude 10°35'31.50 "N and longitude 84°29'23.67 "W), a total water volume (BV) was lost by evapotranspiration from the watershed during the study year as described below.

Month	Evapotranspiration of pineapple (m <sup>3</sup> )	Month	Evapotranspiration of pineapple (m <sup>3</sup> )
January	5 250	July	10 200
February	5 025	August	9 720
March	6 060	September	8 355
April	5 985	October	7 185
May	6 000	November	5 655
June	9 585	December	5 130
<b>Total</b>		<b>84 150</b>	

**Step 2.** To identify the monthly scarcity characterization factor, find the geographic location according to the Google Earth application and use the indicated coordinates.

Month	CF (m <sup>3</sup> e/m <sup>3</sup> )	Month	CF (m <sup>3</sup> e/m <sup>3</sup> )
January	0.3	July	0.2
February	0.7	August	0.2
March	1.0	September	0.2
April	1.1	October	0.2
May	0.6	November	0.2
June	0.3	December	0.2

## Water footprint report

Once the potential water footprint impacts have been assessed, it is recommended to consolidate the results into a water footprint profile.

**For example:**

Water footprint profile			
Impact	Field	Packing house	Total
Shortage (m <sup>3</sup> e)			
Freshwater eutrophication (kg Pe)			
Saltwater eutrophication (kg Ne)			
Ecotoxicity (CTUe)			
Human toxicity (CTUh)			

## Water footprint report (continued)

The results of the water footprint inventory are generally presented in a report, which is recommended to contain at least the following points:

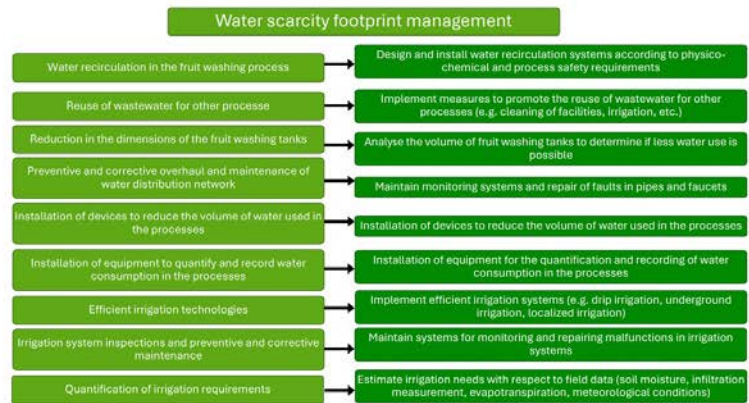
Water footprint report	
1.	Home Page
2.	Contact
3.	Introduction
4.	General information <ul style="list-style-type: none"> <li>o Farm</li> <li>o Processes</li> <li>o Direct water uses</li> <li>o Date of report</li> </ul>
5.	Objective
6.	Scope
7.	Water footprint inventory analysis <ul style="list-style-type: none"> <li>o Water balance</li> <li>o Consumption Data Inventory</li> <li>o Degradation data inventory</li> </ul>
8.	Assessment of water footprint impacts <ul style="list-style-type: none"> <li>o Impact indicators by category</li> <li>o Discussion of results and prioritization of actions</li> <li>o Uncertainty analysis</li> <li>o Limitations of the study</li> </ul>
9.	Conclusions and recommendations
10.	References
11.	Annexes <ul style="list-style-type: none"> <li>o Evidence</li> <li>o Photographs</li> <li>o Calculations</li> </ul>



## Water footprint reduction measures

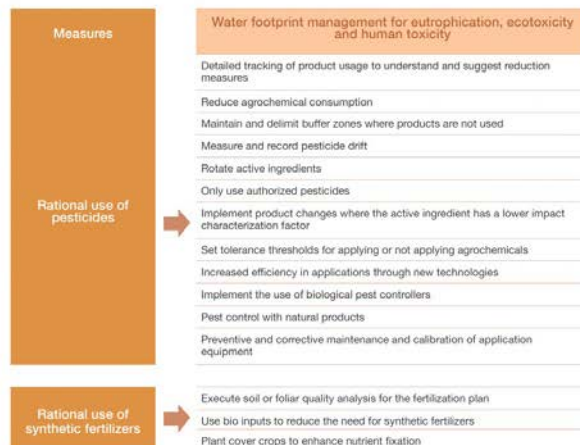
The water footprint indicator, having a life cycle analysis approach, is expressed by a **set of potential impacts on different aspects associated with water resources.**

When thinking about options for reducing the footprint, the company must visualize all the good and best practices available within the sector to make a more efficient use of water and reduce the use of substances or activities that affect water quality.



## Water footprint reduction measures (continued)

**Examples** of water footprint reduction measures due to human toxicity, ecotoxicity and eutrophication.



## Advantages of using the water footprint measurement guide in the pineapple value chain

- ✓ Provides a **detailed guidance** for the development of the water footprint in the sector.
- ✓ It contains **case examples for the application of the calculation methodologies** for each potential water footprint impact.
- ✓ It is the **first water footprint measurement guide** oriented to the pineapple value chain.



Thank you!

# BUILDING RESPONSIBLE GLOBAL VALUE CHAINS FOR SUSTAINABLE TROPICAL FRUITS

## GET IN TOUCH

Responsible Fruits Project

[Responsible-Fruits@fao.org](mailto:Responsible-Fruits@fao.org)

<https://bit.ly/responsible-fruits>

Markets and Trade Division  
Economic and Social Development Stream

[www.fao.org/markets-and-trade](http://www.fao.org/markets-and-trade)

**Food and Agriculture Organization  
of the United Nations**

Rome, Italy

Supported by:



Federal Ministry  
of Food  
and Agriculture