Cradle-to-grave greenhouse gas emissions assessment of Azura herbs and flowers with a view to carbon offsetting in accordance with PAS 2060

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Report prepared for Azura based on LCA done by PWC on 2020 (cradle to grave)

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EXECUTIVE SUMMARY

The objective of the present study is to update of a previous GhG assessment study carried out in 2020 of the herbs and flowers produced by Azura in Agadir (Morocco) with a life cycle approach. All (4) Azura herbs and flowers farms/greenhouses were considered in this study. The period covered by the study is July 2020 - June 2021. Azura produces 14 different types of herbs (99.96% of total sales) and 7 types of flowers (0.04% of total sales). The main types of herbs produced are chives, mint, basil and coriander (representing 81% of the total sales). To assess the environmental impacts, the ISO standards 14040 and 14044 were followed.

This report underwent a critical review by an independent LCA expert.

Data collection and assumption used. This study is based on the 2020-2021 herbs and flowers production grown in Agadir. Data were collected from Azura with various sources (spent data from purchase ledger, meters measurements, ERP tools, etc.) and generic data were used to represent production of materials from first and second rank suppliers. Data collected from Azura was combined with bibliographical sources to represent the production of material and energy supply. Estimations had to be made for some products that did not exactly match an existing module. In the end, over the entire data set provided, 99% of material purchased were included in the study. Plant health products were modelled using data from Azura and a 2010 study on Azura tomatoes life cycle.

Scope of the study. This study focuses on the impact of Azura herbs and flowers in terms of greenhouse gas emissions (method IPCC 2013) with a full life cycle assessment approach from resource extraction ('cradle') to the use phase and disposal phase ('grave'). All steps were considered: farming and conditioning in Agadir, distribution and storage in Europe to Azura's retailers (distribution centres and retail stores), storage at consumers level and waste management (packaging end of life). Even if the maintenance of the warehouses was included (plastic covers, metal structure, wooden poles), the initial construction of warehouses was not included in this LCA study along with R&D, administration, kitchens, machines and equipment, services, and the maintenance of vehicles.

Focus on Basilic. A specific focus was made to differentiate basilic (6% of the total herbs production and 2% of the total cultivation surface) from other herbs and flowers and to assess its specific carbon impact. Indeed, its farming process requires the use of heat (propane) in the warehouse, which significantly changes the final carbon impact.

Average results. The farms are the most impactful step of the production and distribution process, due to the production and transport of fertilisers and agricultural spreading. In this regard, Azura environmental initiatives include the creation of a zero-pesticide residue product line in order to reduce the impact of plant health products in the life cycle. The use of propane to produce basil emits 31 kg CO_2 eq. per kg of basil sold, which represents 81% of the total greenhouse gas emissions.

Within the farming stage (representing 79% of the total impact for herbs & plants (h&f) and 95% for basil) greenhouse gas emissions are distributed between the various processes on the farms including fertiliser production and transport (h&f: 19% of the farms emissions | basil: 4%), infrastructure maintenance (h&f: 5% | basil: 1%), electricity production (h&f: 16% | basil: 4%), fertiliser and pesticide spreading (h&f: 13% | basil: 1%), and plastic mulching (h&f: 2% |basil: 0.5%).

Table 1 - Life cycle assessment results for Azura herbs and plants sold in Europe (functional unit: "Delivering 1 kg of herbs to European consumers in a yearly average.")

Indicator	Azura average (per 1kg of herbs (other than basil))	Azura average (per 1kg of basil)
Greenhouse effect – kg CO_2 eq.	10.57	38.37

SECTION I – General introduction

1.1. Context of the LCA study

The Franco-Moroccan Azura group, which produces different kinds of tomatoes, aromatic herbs, edible flowers and clams to be sold around the world, is committed to respect the environment, to implement a social approach, to ensure food safety and to constantly improve the quality of the products and services provided to its customers.

To that extent, Azura is seeking to understand how suppliers of the European retailers make a difference in terms of social and environmental impacts.

As such, Azura decided in 2018 to launch a pilot project to understand the environmental and social impacts of its products, using a methodology that is robust, transparent, reflective of unique contexts. In order to assess the impacts of its products, an LCA study was first conducted in 2019 on the environmental impacts of its tomatoes (cradle-to-grave life-cycle assessment) using data provided by Azura. A first GhG assessment was conducted in 2020 on Azura herbs and flowers, this study is an update of the 2020 study.

This LCA study is critically reviewed.

1.2. Objectives of the LCA study

The study aims to quantify the GhG emissions of herbs and flowers cultivated in Morocco by Azura and sold in Europe. In order to learn more about the environmental impacts of these products, the report relies on an LCA study, according to ISO 14040 and 14044 standards, and to PAS 2050.

The scope of the study is as follows (cradle-to-grave):

- Infrastructure: maintenance of herbs and flowers greenhouses in Agadir,
- Farming: herbs and flowers farms,
- Packing station: sorting and packaging of herbs and flowers,
- Distribution: transport from packing station to Azura's distribution centre in Perpignan, and from Perpignan to retailers' distribution centres in Europe[1],
- Customers:
    - Distribution Centres: Storage in the retailers' distribution centres,
    - Retail Stores: Transport from the retailers' distribution centres to retail stores or directly to professional customers (bars, hotels and restaurants), and storage in the stores or the customers.
- Consumers: Storage and consumption at the consumers' place,
- Waste: End of life of the product (packaging and organic waste).

Boundary conditions: initial building of infrastructure, R&D, administration, kitchens, machines and equipment, services, and maintenance of vehicles were not included. Indeed, based on our experience, these steps are negligible compared to operational steps.

The purpose of this LCA study is for Azura to measure the total emissions resulting from the sale and consumption of its products ("gate to grave") and compare it with the emissions resulting from the products production and distribution ("gate to gate"). Azura wishes then to offset the emissions its carbon footprint according to PAS 2050 standards and to communicate this compensation to its main stakeholders (clients, suppliers, non-governmental organizations and public authorities). In this respect, an effort has been made to ensure that the figures and data presented are reliable and verifiable.

Azura wants to obtain an LCA according to ISO 14040 standards and to make it public, including therefore a critical review. This LCA study presents only potential impacts and does not predict impacts on category endpoints, exceeding thresholds, safety margins or risks.

A peer review by an external LCA expert was also performed as explained in §2.6.

[1] These are the countries representing the selling shares of Azura herbs and flowers in Europe (data from 2019/2020): France, Germany, Italy, The Netherlands, Spain and Switzerland.

1.3. Organization of this report

This report is organized as follows:

- Sections II and III describe the products considered, the systems studied, the nature and sources of data collected, and the assumptions used in the calculation;
- Sections IV and V present the results of the study, their interpretation and the conclusions of the report;
- Sections VI sets out the external critical review of this LCA;
- Section VII lists the references that are used in this report.

The appendices supplement the body of the report:

- Appendix A presents the life cycle analysis methods
- Appendix B specifies the sources of secondary information to model the herb and flowers;
- Appendix C presents the inventories of the life cycle analyses calculated during this study;

Note: in this document 2.2E-05 means 2.2×10^{-5}.

SECTION II - Definition of the scope of the LCA study

2.1. Methodology used

This report has been prepared in conformance with the methodological requirements of the following standards: ISO 14040, ISO 14044 and PAS 2050:2011.

2.2. Functional unit and products studied

2.2.1. Functional unit

The function of herbs and flowers is to be sold, bought and eaten in Europe, its main market. Thus, the functional unit is as follows:

"Delivering 1 kg of herbs and/or flowers to European retailers[2] in a yearly average."

2.2.2. Description of the studied product

Products studied in this LCA:

- Herbs and flowers produced in unheated greenhouses in Agadir (Morocco). All types of herbs (14 types) and flowers (7 types) produced by Azura were considered in this LCA study. The total volume of herbs and flowers (basil excluded) sold is composed as follows:
  - 51% chives (of total sales),
  - 16% mint,
  - 7% coriander,
  - 4% sage,
  - 3% dill,
  - 3% rosemary,
  - 3% parsley,
  - 7% other herbs (thyme, oregano, savory, marjoram, lovage and melissa),
  - <1% flowers (borage, nasturtium, daisy, snapdragon, pansy, marigold and tagetes).
- Basil produced in heated greenhouses in Agadir (Morocco). Basil accounts for 6% of the total herbs production.

2.3. Boundaries of studied system

The aim of the following paragraphs is to present, for the considered product, the system used to describe its life cycle.

For the reasons explained in paragraph §1.2, some activities are excluded from the system boundaries:

- Infrastructure (initial building),
- R&D,
- administration,
- kitchens,
- machines and equipment (except sorting machines),
- services,
- maintenance of vehicles,
- transportation of workers on the field.

[2] Countries supplied by Azura include France, Germany, Italy, The Netherlands, Spain and Switzerland.

2.3.1. Life cycle of herbs and flowers

The studied system relates to the life cycle of herbs, from production of seed and growth in the farms, to product packing and distribution to European clients and purchase and consumption by final consumers.

Figure 2 summarizes the principal stages taken into account for the assessment of herbs & flowers LCA. Moroccan electricity grid has been considered for the supply of electricity to the Azura production site (see 3.2.5).

Herbs produced by Azura are chives, mint, basil, coriander, sage, dill, rosemary, parsley, thyme, oregano, savory, marjoram, lovage, and melissa.

Flowers produced by Azura are borage, nasturtium, daisy (yellow, red and blue), snapdragon, pansy (blue, cornuta, large, yellow, red and purple), marigold and tagetes.

The herbs and flowers life cycle includes 6 main steps that are :

Farms

All (4) Azura herbs and flowers farms/greenhouses were considered in this study: all 4 were in Agadir in 2020-2021. One of these four greenhouses is partially heated (2% of its surface) to grow basil. The rest of the greenhouses are unheated. Herbs and flowers stems are either farmed from imported seeds (75% of total herbs and flowers) or from direct seeding (25%). All the herbs and flowers that are chopped in the farms are beforehand ordered by retailers. Fertilisers and plant health products are used on the herbs and flowers. Herbs and flowers are grown using plastic mulch. The equipment is also regularly disinfected. All those operations are assessed in this study.

The maintenance of farms is assessed in this LCA study and include materials for the structure of the farm greenhouses (wood, steel, etc.) as well as the equipment and farm infrastructure changed on a regular basis (plastic films, nets, gutter, etc.).

After harvest, herbs and flowers are transported to their dedicated sorting station (adjacent area of the farms). In this centralized sorting station, all herbs and flowers are sorted and stored in a cool place and before being packaged (see “Packaging” step). The storage step is included in the farm sub-system.

In this step, the production and transport of raw materials (fertilisers, plant health products, equipment, etc.) from the suppliers to the farms are also assessed.

Packaging

This step includes sorting and packaging of the herbs and plants. Data from the packing facility located in near the farms was used for water and energy and data from packaging component purchases department were used. All the sorting is done manually by the workers and all the packaged herbs and flowers are pre-ordered by customers and sent to them (no packaging waste). The herbs that are chopped but not packed in punnet are used for agriculture purposes.

Flowers are directly packed in 5 grams punnet. Herbs, however, are packed in 2.39 kg-package by Azura, before being repacked by Azura’s retailers in various models of punnet and trays. Details of packaging materials are synthetized in Figure 1 and detailed in 3.2.2.

Distribution

This step includes transport in refrigerated lorries form Morocco to Azura’s Perpignan warehouse, short storage of the products (5 hours) and distribution from Perpignan to the European retailers considered in this study. During transportation and storage in Perpignan, there are no product losses, as Azura pays a particular attention in sending the exact quantity of products ordered by its retailers. Lorries are on purpose less loaded than usual (e.g. for tomatoes) to keep the retailers’ rejection rate as low as possible.

Retailers Distribution Centers

This step includes the storage of the products, the repacking of the herbs by the retailers, and the waste management of the old packaging and the products rejected. According to Azura, the retailers' rejection rate is very low in comparison with its competitors: 0.8% for the herbs and 0% for the flowers. For every rejection, the retailer receives a voucher and is responsible for managing the end-of-life of the product.

Retailers Stores and Professional Clients

Azura products are bought by two types of clients: mass retail (60% of the herbs, 0% of the flowers) and professional customers such as restaurants, bars and hotels (40% of the herbs, 100% of the flowers).

For mass retail clients, the steps included in our study are the distribution in refrigerated lorries of the herbs and flowers from the distribution platforms to the retailers' stores, where they are stored at chilled temperature and put on the shelves at chilled temperature (before being bought by the final consumers): this step includes transport, use of energy (gas and electricity), water and refrigerant, and waste management (for both packaging and organic waste.

For professional clients, the same steps are assessed, and we add the end-of-life of the products (packaging and food waste).

During transportation and storage, there are some limited product losses 2.5% at customer level (retail stores), and 5% at professional client's level (food wastage). The waste generated (organic and plastic) is considered either composted (herbs and flowers), recycled, incinerated or landfilled, each country having its own waste management specificities.

Final Consumers (Mass Retail only)

This step is the storage of the herbs by final consumers and the products' end-of-life. It includes the use of electricity, refrigerant, and the waste management of the product (packaging and food waste).

During storage and consumption, there are some limited product losses estimated at 5% (food wastage). The waste generated (organic and plastic) is considered either composted (herbs), recycled, incinerated or landfilled, each country having its own waste management specificities.

Figure 1 – Different packaging processes between herbs and flowers

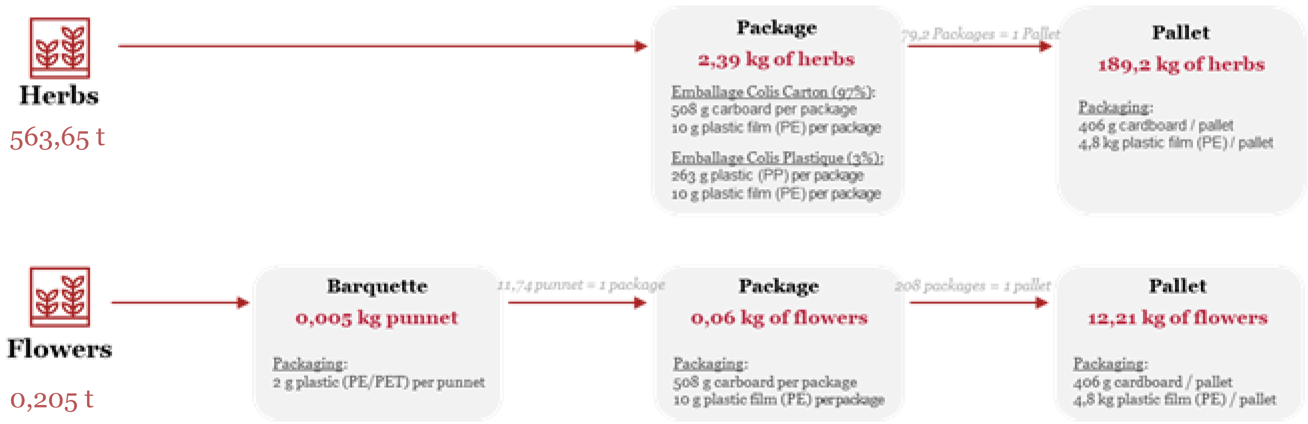
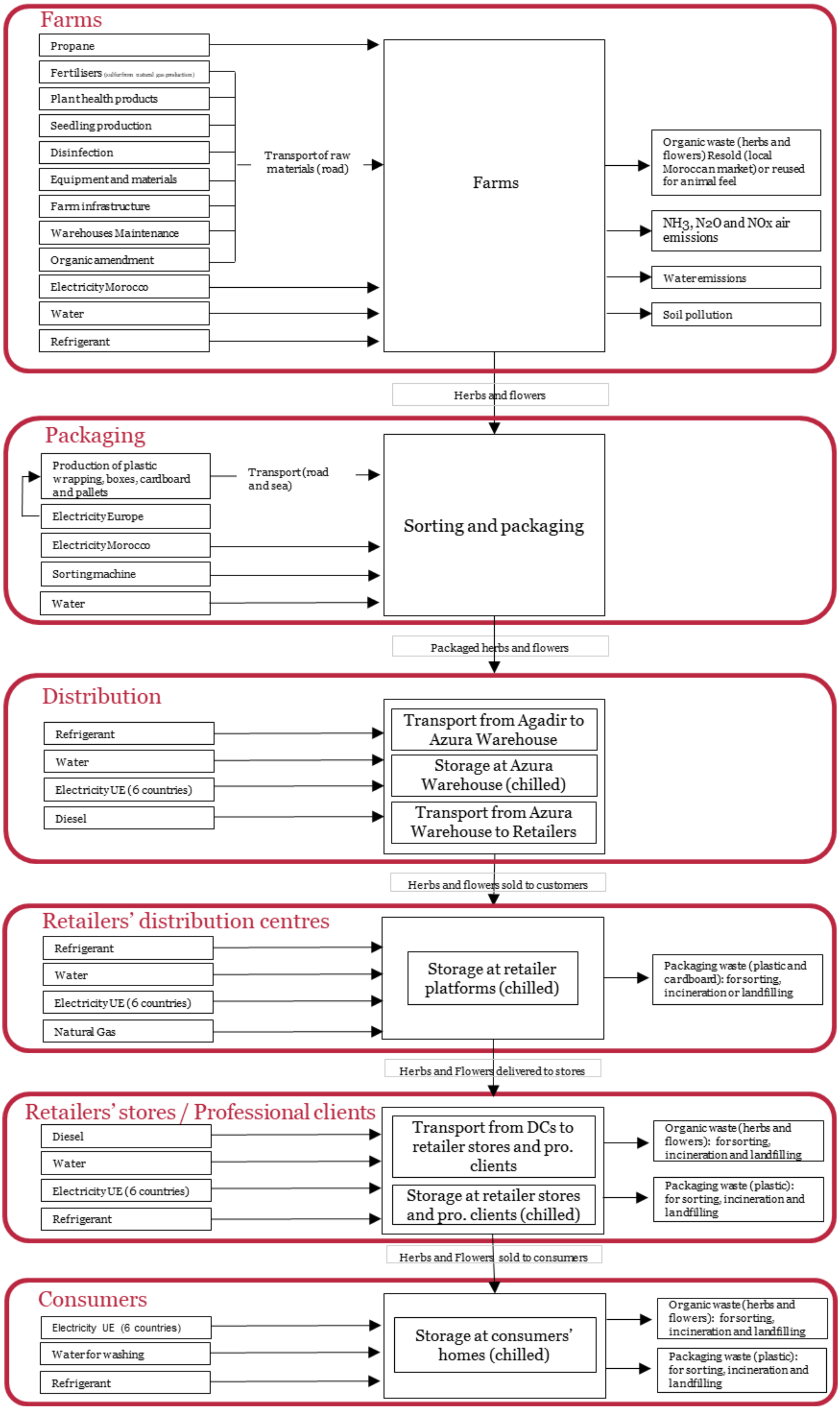


Figure 2 –Life cycle system of herbs and flowers



2.3.2. Delimitations of system boundaries

2.3.2.1. Delimitation rules

To precisely delineate the systems, i.e. to decide if the production or fate of a product or material must be taken into account, a systematic rule has been used in this project:

1. For the production and transport of a consumable:
    - if the data is available to PwC, provided by the client or via LCA databases, the production of the said consumable are systematically taken into account, even if the quantity consumed is low;
    - otherwise, the inclusion threshold is set at 5 %. This means that the sum of the inputs whose production is not included in the system represents less than 5% of the total mass of the system inputs.

    Proportion of consumables whose production is excluded from the systems is given in Appendix B.

2. For the fate of a co-product:
    - if the data is available, it is taken into account;
    - otherwise, the end of life of the product is not taken into consideration.

2.3.2.2. List of excluded life cycle stages

As explained in paragraph 1.2 and shown on Figure 2 initial infrastructure building, R&D, administration, kitchens, machines and equipment, services and maintenance of vehicles have been excluded.

The maintenance of the greenhouses has been accounted for in this study as well as agricultural infrastructures on the farms. However, the emissions related to the initial construction of the infrastructures are excluded as they are amortised over time and are negligible (no heavy work).

In accordance with ISO 14040, certain categories of operation may be excluded from the systems on condition that this is clearly stated. The following paragraph specifies the secondary stages which have not been taken into account within the context of this project.

Indeed, stabilized operation of each of these systems is assumed, i.e. the impact on the environment linked to construction and demolition of the buildings and equipment is absorbed over the whole of their period of use. As experience has shown that these impacts on the environment are negligible compared with those linked to operation, this hypothesis is justified within the context of this project.

2.3.3. Allocation rules

According to ISO 14044, inputs and outputs shall be allocated to the different products according to clearly stated procedures. The study shall identify the processes shared with other product systems and deal with them according to the stepwise procedure presented below.

Step 1: wherever possible, allocation should be avoided by

1. Dividing the unit process into several sub-processes
2. Expanding the product system to include the additional functions related to the co-products.

Step 2: where allocation cannot be avoided, the inputs and outputs of the system should be partitioned between its different products in a way that reflect the underlying physical relationships between them.

Step 3: where physical relationship alone cannot be established or used, other relationships between them should be used.

As the data provided was for all herbs and flowers produced (product types, markets), a **mass allocation** has been applied to get the impacts of 1 kg of herbs and flowers. For water impact, a **surface allocation** has been applied. Raw materials consumed by Azura for other products than herbs and flowers were excluded from the study system boundaries thanks to Azura accountancy department.

Moreover, we distinguished in our study the basil from the other herbs and plants. The main difference of inputs are: energy (propane), water consumption, surface, and country of distribution (distance and waste management are different).

Environmental impacts linked to the incineration of waste with energy recovery are not taken into account but allocated to the production of energy and not the treatment of the waste, in order to follow the requirement of

PAS2050 (section 8.2.2).

2.4. Greenhouse effect impact indicator studied

The impact method used defines the way each input or output flow is responsible for an impact. Each flow is affected to a coefficient for each method. Thus, the choice of these methods has an impact on the results. For this study, we only focus on one main impact indicator:

Table 2 – Environmental impact indicators

Impact indicator	Field	Method
Greenhouse effect This indicator takes into account emissions of fossil CO_2 and N_2O (these emissions coming, for example, from the combustion of fuel and natural gas) and CH_4 emissions (coming for example from the fermentation of discarded paper). On the other hand, the indicator does not take into account biomass CO_2 emissions resulting, for example, from the combustion of paper in an incinerator. Greenhouse effect is expressed in g CO_2 eq.	AIR	IPCC[3], 2013

Land use change and its contribution to climate change was not taken into account in our study, as Azura's farms are located on historically agricultural land (farmed more than 20 years).

2.5. Requirements relative to precision, completeness and representativeness of data used

This study aims to analyse the environmental assessment of the life cycle of herbs and flowers distributed throughout Europe. In conformance with ISO 14040, requirements relative to the quality of data cover the following criteria:

Table 3 – Data quality

Criteria	Herbs and flowers life cycle
Source	Azura data
Time coverage	Data corresponding to the culture of herbs and flowers over July 2019 – June 2020
Geography	The herbs and flowers farms are located in Morocco. The transport distances are from farms to European clients (main ones are France 40%, Switzerland 28%, Germany 19%, France 25%, the Netherlands 9%, Italy 3% and Spain 1%, weighted average between countries delivered). The electricity model adopted for the farming and transport correspond to the Moroccan electricity mix (IEA 2016), whereas the electricity model adopted for the distribution and storage correspond to the electricity mix of the European countries concerned. In case of raw materials produced in European countries, an average European electricity mix was used. Seedling models are representative of the worls (Ecoinvent, RoW) as the suppliers are located worldwide (China, Tanzania, Denmark, Egypt, France, Spain and Poland). The natural gas models are representative of countries outside Europe (Ecoinvent, RoW) as well as the tap water model and recycled PET model. Organic amendment models are representative of global average (Ecoinvent, GLO). The cardboard model is representative of Europe.[4]
Technology	Data reflect mean current technology

[3] IPCC: International Panel on Climate Change
[4] Only most significative inputs are detailed here.

Precision	++++ Farming: Primary data have been collected from Azura and used for modelling. It is precisely representative of Azura situation. ++/+++ Distribution (Customers and Consumers): Data were mainly obtained from literature and completed by Azura's operational team.

2.6. Critical review

This updated study has been carried out by Azura based on the first study carried out by PwC. On completion of this study, Hélène Lelièvre (enviroconseil) carried out an independent critical review of the report, with 2 rounds of review.

The LCA expert reviewed also the LCA model for this study with a sampling procedure.

The critical review of this life cycle analysis corresponds – in accordance with ISO 14 040 – to an external expert review and follows the recommendation of the ISO/TS 14 071.

The external review took place from November to January 2023. The comments made by the reviewer and Azura responses given, are presented in section VI of the report.

SECTION III – Calculation of inventory: collection of data and assumptions description

This section presents the data sources specific to the study and the hypotheses adopted to calculate the LCA carbon assessment. Only data and hypotheses relative to the primary stages such as farming, greenhouse construction and transport are detailed. Bibliographical data sources used to model secondary stages of the systems are listed in Appendix B.

3.1. Method of collecting information

To gather relevant information on the production and distribution processes and identify available data sources, the following method was followed:

3.1.1. Data collection

Information was collected from Azura through a combination of interviews with persons in charge of accountancy, operations and logistics, and of further data transmission. A questionnaire was sent to Azura requesting information on the following elements:

- Distance and type of transport of raw minerals,
- Quantity of seeds sown in the plant nursery,
- Quantity and type of construction materials for the greenhouses,
- Quantity and type of chemicals used for disinfection of the greenhouses,
- Quantity and type of fertilizers spread on the fields,
- Quantity and type of plant health products spread to protect the crops,
- Quantity and type of materials used to package the herbs and flowers,
- Quantity and type of energy consumed in the process,
- Quantity, type and management of waste.

Site data were provided by Azura based on various sources (spent data from purchase ledger, meters measurements, ERP tools, etc.). Data is representative of annual maintenance for the materials used on the farms and plant nursery.

3.2. Life cycle

The data used to model the life cycle is shown in Figure 2. Most datapoints were obtained from the accountancy department; energy consumption, water consumption, transport from farms and quantities produced, were collected from Azura production sites and the reporting of the technical department.

The appendix B gives also the cut-off analysis of the calculated inventory (less than 1 % of inputs are not integrated in the study).

Herbs and flowers life cycle can be broken down in five steps. The assumptions taken for each of those steps are detailed below.

3.2.1. Farms

3.2.1.1. General information

All (4) Azura herbs and flowers farms/greenhouses were considered in this study. Herbs and flowers studied in this LCA report are cultivated Agadir where the greenhouses surface is around 479,523 m^2. The water consumed during farming is 619.694 m^3 per year representing 1,099 l per kg of herbs and flowers and 1.3 m^3/m^2.yr. The average yield is 1,18 kg of herbs and flowers per m^2. year. Associated electricity consumption is 1,636,570.00kWh. In terms of refrigerant, 119 kg of R22 and 156 kg of R404 were also consumed in the farming step for storage purposes.

If we distinguish basil from other herbs and flowers, we find the following annual consumption for 1 kg of herbs produced:

Table 4 – Detail of energy consumption by type of product

	Basil	Other Herbs and Flowers
Water consumption (l/kg)	328	1,153
Average Yield[5] (kg/m^2. year)	4.30	1.12
Propane (for heating purpose) (kg/kg)	6	0
Electricity (kwh/kg)	1.17	3.0
Refrigerant R22 (g/kg)	0.23	0.21
Refrigerant R404 (g/kg)	0.30	0.27

The sorting step also generates 580 ktons of organic waste per year which are reused for agriculture purposes. Sorting is done directly in the greenhouses and only selected products (which will be send to Europe) are stored in a cool place.

3.2.1.2. Behaviour of fertilizers on the fields

The use of nitrogen fertilizers (mineral, organic) contribute to global warming via the emission of N_2O, which has a stronger greenhouse effect than CO_2.
Direct emissions of N_2O can be calculated as follows:

N-N_2O direct = 1% x (N synthetic fertilizers + N organic fertilizers)
[Min-Max: 0,3%-3%][6]

Indirect emissions from atmospheric deposition of N volatilized from managed soils are calculated as follows:

N-NH_3+N-NOx = 10% x (N synthetic fertilizers) [Min-Max: 3%-30%]
+ 20% x (N organic fertilizers) [Min-Max: 5%-50%][7]

We assumed that of this total, 50% is N-NH_3 and 50% is N-NOx.

N-N_2O indirect = 1% x (N-NH_3+N-NOx from N synthetic fertilizers + organic fertilizers) [Min-Max: 0,2%-5%][8]

In some cases, indirect emissions from nitrogen leaching/runoff from managed soils occur in regions where rain washes the soil regularly. In our case, no run-off occurs as drip-irrigation is used and as the farms are located in dryland regions, so no leachate of N occurs and hence no N_2O indirect emissions from N leaching/runoff is to be expected.

[5] This yield only takes into account the total amount of final and distributed products (and not the quantity of herbs that is produced)
[6] IPCC 2006 Guidelines for National Greenhouse Gas Inventories, chapter 11: N2O Emissions from managed soils and CO2 emissions from lime and urea application; table 11.1 for Tier 1 emissions
[7] IPCC 2006 Guidelines for National Greenhouse Gas Inventories, chapter 11: N2O Emissions from managed soils and CO2 emissions from lime and urea application; table 11.3 for Tier 1 emissions.
[8] IPCC 2006 Guidelines for National Greenhouse Gas Inventories, chapter 11: N2O Emissions from managed soils and CO2 emissions from lime and urea application; table 11.3 for Tier 1 emissions.

Table 5 – Detail of nitrogen application by Azura

Indicator	Nitrogen used in one year (kg)	Azura average (per 1kg of herbs)
Nitrogen application	30,882 kg	54.8 g

3.2.1.3. Behaviour of plant health products on the fields

Among the 27 different pesticides reported by Azura, 12 were used for the study (Agree, Limocide, Kabon, Ortiva, , Thiovitjet, heliocopper, Decis, Proclaim, Tracer, Vertim, Nemagold and Lantana) as they represent 95% of all pesticide mass spread on the herbs and flowers. To assess the impacts of those pesticides, a global dichloropropene model was used (Ecoinvent, RoW). Suppliers of these pesticides are all located in Morocco, therefore, the distance considered for the transport of pesticides is 517 km corresponding to the distance between Agadir and Casablanca, the economic capital of the country.

3.2.2. Packaging

During this step, herbs and flowers are sorted and packaged. As last year, 2,038,000 litres of water and 249,360 kWh are used for crate washer and disinfection every year. In addition, 156 kg of refrigerant (R404) and 119 kg of R22 are necessary to operate the packaging station for a year. Herbs and flowers follow different packaging processes, as summarised in the following table:

Table 6 – Detail of packaging materials used by Azura

Packaging materials	For 1kg of herbs	For 1kg of flowers
Cardboard – Packaging (kg)	0.22	8.75
Plastic – Film PE (kg)	0.03	2.68
Wood - Pallet (kg)	0.10	1.64

3.2.3. Distribution

Distances have been evaluated based on Azura data (delivery cities) and Google Maps (road distance).

Distance between Agadir and Perpignan is set to 2190 km and the hypotheses chosen for the transportation of herbs and flowers to the European market are detailed below:

Table 7 – Hypotheses for transport of basil through Europe

Country	Reference city	Distance from Perpignan (km)	Sales volume per city
Switzerland	Bern	755	56%
France	Nantes	788	28%
France	Nice	475	9%
France	Perpignan	0	4%
France	Annemasse	601	4%
	Weighted average distance	**708**	**100%**

Table 8 – Hypotheses for transport of herbs and flowers (basil excluded) through Europe

Country	Reference city	Distance from Perpignan (km)	Sales volume per city
Switzerland	Bern	755	26%
France	Paris - Rungis	674	24%
Germany	Bornheim	1 174	20%
The Netherlands	Rotterdam	1 286	10%
France	Nantes	788	7.3%
France	Nice	475	4.9%
Italy	Bologna	948	2.9%
France	Lyon	452	2.4%
Spain	Barcelona	193	1.0%
France	Annemasse	601	0.93%
France	Perpignan	0	0.27%
	Weighted average distance	**850**	**100%**

Shares of herbs and flowers distributed to different countries did not change between last year and this year. Also, no loss is considered for the distribution step. This data was provided by Azura based on operating data from the Perpignan warehouse.

3.2.4. Transport models

3.2.4.1. Transport phases considered

In the system considered for the LCA study, the transport phases considered are as follows:

- transport of raw materials to the farms,
- transport of building materials for the maintenance of greenhouses,
- transport of fertilizers to the farms,
- transport of disinfection agents to the farms,
- transport of plant health products to the farms,
- transport of equipment to the farms,
- transport of herbs and flowers packaged from the packhouse to European retailers' distribution centres (refrigerated lorries),
- transport of herbs and flowers packaged from the European retailers' distribution centres to retailers' stores and professional clients (refrigerated lorries).

According to PAS 2050, GHG emissions related to the "transport of consumers to and from the point of retail purchase" are excluded from the system boundary of the product life cycle.

3.2.4.2. Standard consumption of a lorry

The standard consumption of a lorry with a 24-t payload is generally estimated to be 38 litres of diesel per 100 km when fully loaded.

To calculate actual consumption, it is assumed that part (2/3) is fixed and part (1/3) depends on the weight transported by the truck.
In this LCA study, the following formula has been used:

$$Actual\ consumption\ (L) = km \times \frac{38}{100} \times \left(\frac{2}{3} + \frac{1}{3} \times \frac{actual\ load}{payload} + empty\ return\ rate \times \frac{2}{3}\right)$$

According to Azura information, the empty return rate is assumed to be equal to 0%. In addition, the actual load is assumed to be 90% the payload for all materials and products that are not herbs or flowers (see below). Actual load takes into account herbs and flowers as well as pellets and packaging.

3.2.4.3. Focus on Azura's refrigerated lorries

Based on Azura information, we took the following hypothesis for refrigerated lorries: a consumption of 40 litres of diesel per 100 km for an actual load of 30%[9] (source: Azura). Some steps included refrigerated transport which are modelled using either an Ecoinvent 3.6 model or if enough data were available, a more detailed model. As such, refrigerant gases content and leakages are taken into account in our model.

Emission factors have been calculated based on the EMEP/EEA air pollutant emission inventory guidebook 2009, updated in 2012 for heavy duty vehicles, based on Copert 4, Emisia model, assuming a typical European fleet and activity data for 2005.

3.2.5. Electricity production models

Azura's retailers and consumers are located in several European countries (cf. Table 7 & 8). Consequently, we modelled an electricity production model representative of the situation in 6 different countries (only 2 for basil), as illustrated in Table 9 (IEA 2018). These various electricity mixes were namely used to simulate electrical consumption of the distribution centres (fridges, lightning), retail stores (fridges, lightning) and consumers (fridges).

Table 9– Electricity mix by country (%)

Sources of energy	Weighted average (basil)	Weighted average (other)	DE	FR	IT	NL	ES	SW
Nuclear	53.0	43.01	14.19	76.95	0.00	3.70	20.4	34.1
Coal and peat	0.94	14.16	43.86	2.14	16.04	38.65	18.7	0.00
Natural gas	2.08	9.18	9.74	3.48	39.17	42.28	18.7	0.98
Hydro	37.6	20.88	3.85	10.45	16.60	0.08	11.2	58.9
Wind	1.74	5.01	12.24	3.74	5.25	6.86	17.6	0.16
Import	28.9	18.3	5.72	1.75	17.97	27.95	5.32	50.3
Solar	1.52	2.53	5.99	1.28	8.11	1.02	2.94	1.7
Fuel Oil	0.21	0.70	0.96	0.38	4.73	1.30	6.14	0.07
Other non-thermal	0.03	0.10	0.28	0.06	0.21	0.14	0.08	0.00
Tide	0.04	0.04	0.00	0.09	0.00	0.00	0.00	0.00
Share of sales Basil				*44%*				*56%*
Share of sales other Herbs & flowers			*20%*	*40%*	*3%*	*10%*	*1%*	*26%*

The data used for the distribution between electrical production types and yields are taken from statistics representative for most of the year 2016, prepared by the International Energy Agency (IEA). The data used to model each option are as follows:

- For energy breakdown and transport losses for the year 2013: International Energy Agency, Web site : http://www.iea.org/statistics/

[9] According to Azura, the average load of a 24-t lorry is 7,279 kg of herbs and flowers, ie an actual load rate of 30%.

- For efficiencies for the year 2013: International Energy Agency; Energy Efficiency Indicators for Public Electricity Production from Fossil Fuels
- For CO_2, CH_4, N_2O pollutants: « 2006 IPCC Guidelines for National Greenhouse Gas Inventories » Volume 2 Energy Chp2 Stationary combustion. tier 1 default emission factors
- For other Emission factors: « EMEP/EEA emission inventory guidebook 2009, updated June 2010 », Energy Industries, Combustion in energy and transformation industries tier 1 factors
- For nuclear energy, specific adaptation of the model for total production, burn-up rate, NCV, numbers of reactors according:"ELECNUC LES CENTRALES NUCLÉAIRES DANS LE MONDE", édition 2011, CEA and "Annexe au courrier COR ARV SHS DIR 09-046"
- For wind power electricity: Life Cycle Assessment of Electricity Production from a V112 Turbine Wind Plant, PE NWE for Vestas, February 2011
- For hydropower electricity: ETH 1996 French technological mix in 2011, source: « Syndicat des Energies Renouvelables »
- Power plants Yields were adapted to each OECD, by default a global value is applied according to « Energy Efficiency Indicators for Public Electricity Production from Fossil Fuels », 2008, IEA. In the case of Morocco, the following yields were taken, corresponding to Turkish data: 35% for coal, 54.6% for natural gas, 35.3% for fuel oil. For 28-Europe average yields were used: 36.9% for coal, 45.4% for natural gas and 34.3% for fuel oil. For France, the following yields were taken: 39.1% for coal, 47.6% for natural gas and 30.6% for fuel oil
- For production of coal, lignite, heavy fuel oil, natural gas, process gas: Laboratorium für Energiesysteme ETH, Zurich, 1996 2)

Influence of the electricity model on the results. Among the indicators adopted, the choice of electricity model influences mainly the emission of greenhouse effect gases, atmospheric acidification and photochemical oxidation. For example, the European electricity model contributes 2.5 times less to these indicators than the Moroccan model.

3.2.6. Retailers – Distribution centres

This step includes the chilled storage of the herbs and flowers in the centres. The hypotheses chosen for one punnet and for the storage conditions are detailed in tables 11, 12 and 13.

- **Table 10**: As Azura's retailers are responsible for the final packaging of the herbs, and as every retailer has its own packaging standard, we used the 25g as default punnet for the volume of 1 herbs punnet. This default punnet was chosen based on Azura knowledge of its retailers. Concerning the 5g flowers punnet, the data was directly provided by Azura, as the company is responsible for the final packaging.
- **Table 11:** For Distribution Centres, default data were used to model the various Retailers' centres as detailed data were not available (each retailer having its various types of distribution centres). Data come from a Quantis' report, named "Organisation Environmental Footprint Sector Rules (OEFSR): Retail". Based on these, we calculated the energy and water consumptions and the refrigerant usage per punnet. To do so, an allocation was made based on the storage capacity of one Distribution Centre compared to the volume needed by 1 herbs punnet.

For this step, and to measure Azura's footprint, we considered the volume of sales by country (Source: Azura) and deducted the number of punnets associated.

Table 10 – Description of Azura products

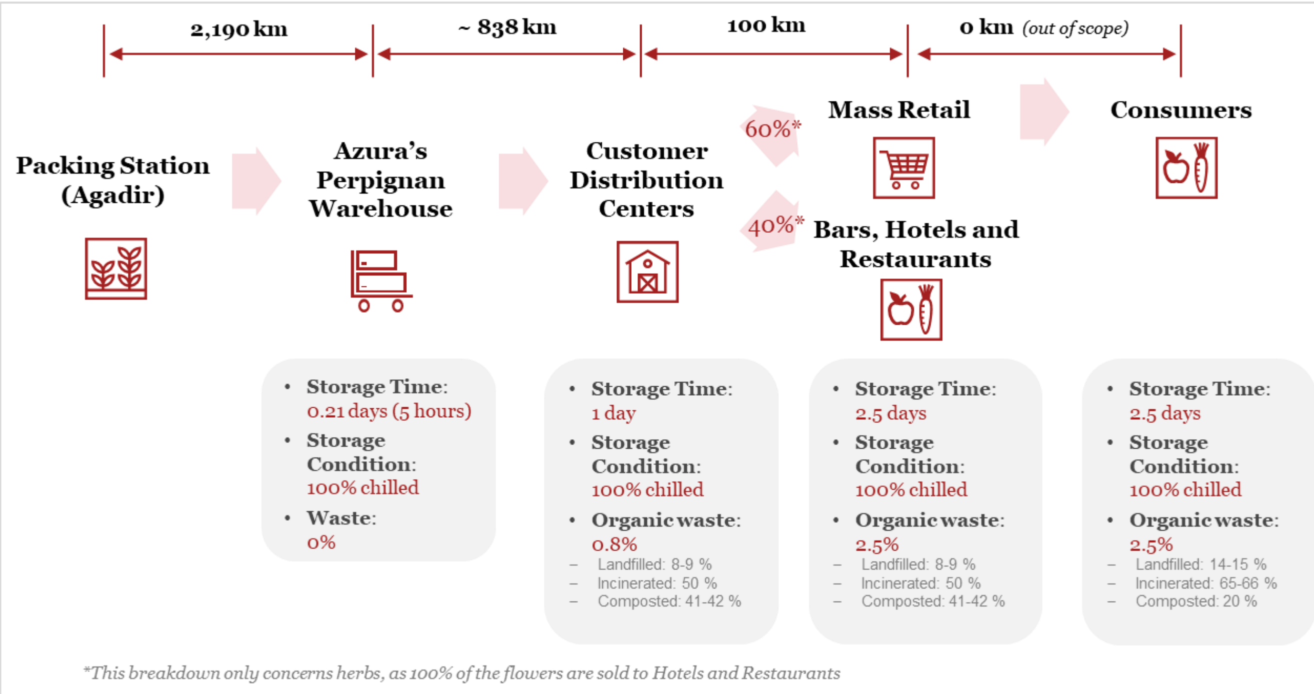
Information	For 1 herb punnet	For 1 flower punnet	Sources
Capacity (product)	25 g	5 g	*Azura*
Plastic (tray and flowpack)	10 g	2 g	*Azura*
Volume	490 cm^3 (20 x 7 x 3.5)	949 cm^3 [10]	*Azura*
Share of sales	99.9 %	*0.1 %*	*Azura*
Plastic components	PE (flowpack) and PET (tray)	PE (flowpack) and PET (tray)	*Azura*

[10] This volume was calculated based on the two types of flower punnet packaged by Azura: the 423 cm^3 (13 x 13 x 2.5), which accounts for 8.5% of the sales, and the 998 cm^3 model (19 x 15 x 3.5) which accounts for 91.5% of the sales. Both contain 5g of flowers (Source: Azura).

Table 11 – Hypotheses of storage for the Retailers' Distribution Centres (DCs)

Information (default data)	For 1 distribution centre	Sources
Volume of 1 herbs punnet (25g)	490 cm^3	*Calculation*
Volume of 1 flower punnet (5g)	949 cm^3	*Calculation*
Total surface of the DC / Chilled surface of the DC	30,000 m^2 / 6,000 m^2	*Quantis, OEFSR Retail*
Energy consumption - Electricity	70 kWh/m^2·year	*Quantis, OEFSR Retail*
Energy consumption – Natural gas	360 MJ/ m^2·year	*Quantis, OEFSR Retail*
Refrigerant gases content (R404A)	0.29 kg/m^2	*Quantis, OEFSR Retail*
Refrigerant gases annual leakage (R404A)	10%	*Quantis, OEFSR Retail*
Fridge – lifetime	15 years	*Quantis, OEFSR Retail*
Water consumption	365 m^3 per year	*Quantis, OEFSR Retail*
Storage capacity (chilled storage)	624,000 m^3·weeks/year[11]	*Quantis, OEFSR Retail*
Storage time	1 day	*Azura*
Space-time allocation – Storage volume (chilled storage)	3 times the product volume*stored 1 day	*Quantis, OEFSR Retail*
Herbs and flowers waste (% of stored product)	0.8% of herbs and 0% of flowers	*Azura*

Figure 3 - Distribution circuit and storage conditions of herbs and flowers (cradle-to-grave)



3.2.7. Retailers – Stores & Professional Clients – Bars, Hotels and Restaurants

This step includes the transport from retailers' distribution centres to their stores (60% of the herbs) or to their Professional Clients (40% of the herbs, 100% of the flowers), and the chilled storage of the products in the stores.

The average distance between DCs and stores have been evaluated to be 100 km (Bahoken F., Blanquart C., Gaubert E., 2014).

Similarly, with the Distribution Centres (see 3.2.6), for this step the emissions of each punnet were calculated using the volume to allocate the total emissions of the Retail Store (i.e. the volume of 1 herbs or flowers punnet

[11] According to the OEFSR, an average distribution centre can store 12000m^3 of chilled product. Storage for 52 weeks, i.e., 624000 m^3·weeks/year

compared to the volume of an average Retail Store). The hypotheses chosen for the storage conditions are detailed in the table 12, and data also come from the Quantis' report, named "Organisation Environmental Footprint Sector Rules (OEFSR): Retail".

In terms of waste, a 2.5% loss is considered at the retail stores level (based on Azura experience). Based on Eurostat figures by countries, on the OEFSR study and on Azura data, we estimated the waste management of the Azura products as following:

A. Basil

- Packaging Waste:
  - Plastic Waste (among which 80% of PET and 20% of PE): 16% recycled, 14% landfilled, and 70% incinerated with energy recovery;
  - Organic waste (paper and cardboard): 90% recycled, 0% landfilled, and 10% incinerated with energy recovery.
- Organic Waste (basil): 50% recycled/composted, 8% landfilled and 42% incinerated with energy recovery.

B. Other herbs and flowers

- Packaging Waste:
  - Plastic Waste (among which 80% of PET and 20% of PE): 16% recycled, 16% landfilled, and 68% incinerated with energy recovery;
  - Organic waste (paper and cardboard): 90% recycled, 1% landfilled, and 9% incinerated with energy recovery.
- Organic Waste (basil): 50% recycled/composted, 9% landfilled and 41% incinerated with energy recovery.

Please refer to 3.2.9. for further information on waste management.

Table 12– Hypotheses of storage for the Retail Stores

Information (default data)	For 1 retail store	Sources
Volume of 1 herbs punnet (25g)	490 cm³	*Calculation*
Volume of 1 flower punnet (5g)	949 cm³	*Calculation*
Total surface of 1 store	2,000 m²	*Quantis, OEFSR Retail*
Total surface dedicated to fridges in 1 store	60 m²	*Quantis, OEFSR Retail*
Electricity consumption - 1 Store	400 kWh/m²·year	*Quantis, OEFSR Retail*
Electricity consumption – Additional consumption (fridges, chilled area)	1900 kWh/m²·year	*Quantis, OEFSR Retail*
Refrigerant gases content (R404A)	0.29 kg/m²	*Quantis, OEFSR Retail*
Refrigerant gases annual leakage (R404A)	10%	*Quantis, OEFSR Retail*
Fridge – lifetime	15 years	*Quantis, OEFSR Retail*
Water consumption	3,650 m³ per year	*Quantis, OEFSR Retail*
Storage capacity – 1 Store	104,000 m³·weeks/year	*Quantis, OEFSR Retail*
Storage time	2.5 days	*Azura*
Space-time allocation – Storage volume (chilled products)	3 times the product volume*2.5 days	*Quantis, OEFSR Retail*
Herbs and flowers waste (% of stored product)	2.5%	*Azura*

3.2.8. Consumers

According to PAS 2050, GHG emissions related to the "transport of consumers to and from the point of retail purchase" are excluded from the system boundary of the product life cycle. Thus, this final step only includes the chilled storage of the herbs by consumers (no flowers are sold for mass retail).

In terms of waste, a 2.5% loss is considered at consumers stage (based on Azura experience). Please refer to 3.2.9. for further information on waste management.

Please note, that we included the emissions related to the production and distribution of water needed to wash and/or cook the herbs.

Table 13– Hypotheses of storage for consumers

Type of information	Figures	Sources
Volume of 1 herbs punnet (25g)	490 cm^3	*Calculation*
Fridge consumption	0.0037 kWh/L-day	*Quantis, OEFSR Retail*
Water	0,05 litre/punnet	*PWC assumption*
Refrigerant gases content (R134A)	100 g / fridge	*Quantis, OEFSR Retail*
Refrigerant gases annual leakage (R134A)	1%	*Quantis, OEFSR Retail*
Share of consumers using fridge to store herbs and flowers	100%	*Default assumption as no statistics were available*
Storage time	2.5 days	*University of California*[12]
Space-time allocation – Storage volume (chilled storage)	3	*Quantis, OEFSR Retail*
Herbs waste (% of stored product)	2.5%	*Azura*

3.2.9. End-of-life: Waste management for retailers and consumers

Concerning the waste management at retailers and consumers steps, the hypotheses taken are summarised in table 14, 15 and 16 (2018 Data, Eurostat).

For the waste management by country, the original Eurostat figures were providing the figures related to the waste management of all municipal waste. Considering that Azura packaging waste is less recycled than other plastic waste such as plastic bottles, the average rate of 16% of recycled waste was assumed, based on a report delivered by Plastics Recyclers Europe (Eunomia, 2020). This average rate relates to the estimation of the PRE of the sorting for recycling rate for PET trays in 2018. We took this study, as PET is the main plastic component for Azura punnets.

For organic waste (2.5% of wasted herbs), the share of recycling (compost and anaerobic digestion) in the EU-28 reaches 17% (“2018 Municipal waste”, Eurostat).

[12] In the absence or study on the topic, we took the same hypothesis as the tomatoes LCA study: based on Tracy L. Parnell et al., consumers can store tomatoes up to 5 days. We took the hypothesis of an average storage time of 2.5 days (“Tomatoes: Safe Methods to Store, Preserve, and Enjoy”, University of California, division of agriculture and natural resources, 2004). This hypothesis was agreed by Azura.

Table 14 – Hypotheses of packaging waste management by country and type of packaging

Basil	Domestic Waste			Plastic Packaging Waste			Paper & Board Packaging Waste			
Source	Eurostat			Eurostat & PRE[13]- Adjusted data			Eurostat - Adjusted data			Azura
Countries	Share of recycling	Share of landfill	Share of incineration	Share of recycling	Share of landfill	Share of incineration	Share of recycling	Share of landfill	Share of incineration	**Sales**
Switzerland	52%	0%	48%	16%	0%	84%	83%	0%	17%	*56%*
France	42%	22%	36%	16%	32%	52%	98%	1%	1%	*44%*
Weighted Average	48%	10%	42%	16%	14%	70%	90%	0%	10%	

Other Herbs	Domestic Waste			Plastic Packaging Waste			Paper & Board Packaging Waste			
Source	Eurostat			Eurostat & PRE[14]- Adjusted data			Eurostat - Adjusted data			Azura
Countries	Share of recycling	Share of landfill	Share of incineration	Share of recycling	Share of landfill	Share of incineration	Share of recycling	Share of landfill	Share of incineration	**Sales**
France	42%	22%	36%	16%	32%	52%	98%	1%	1%	*40%*
Switzerland	52%	0%	48%	16%	0%	84%	83%	0%	17%	*26%*
Germany	66%	1%	33%	16%	2%	82%	88%	0%	12%	*20%*
Netherlands	53%	1%	46%	16%	2%	82%	87%	1%	12%	*10%*
Italy	51%	28%	21%	16%	48%	36%	80%	12%	8%	*3%*
Spain	36%	51%	13%	16%	67%	17%	69%	26%	6%	*1%*
Weighted Average	51%	10%	39%	16%	16%	68%	90%	1%	9%	

Please note that we excluded the production and the end of life of the fridges (customers and consumers), as these machineries are used and amortised by many different products.

Table 15 – Hypotheses of organic waste by country and place of waste generation

Basil	Customer (retailer) - Organic Waste			Consumer – Organic Waste			
Source	Eurostat & OEFSR - Adjusted data			Eurostat - Adjusted data			Azura
Countries	Share of recycling	Share of landfill	Share of incineration	Share of recycling	Share of landfill	Share of incineration	**Sales**
Switzerland	50%	0%	50%	22%	0%	78%	56%
France	50%	19%	31%	19%	31%	50%	44%
Weighted Average	50%	8%	42%	20%	14%	66%	

Other herbs	**Customer (retailer) - Organic Waste**			**Consumer – Organic Waste**			
Source	Eurostat & OEFSR - Adjusted data			Eurostat - Adjusted data			Azura
Countries	Share of recycling	Share of landfill	Share of incineration	Share of recycling	Share of landfill	Share of incineration	**Sales**
France	50%	19%	31%	19%	31%	50%	40%
Switzerland	50%	0%	50%	22%	0%	78%	26%
Germany	50%	1%	49%	18%	2%	80%	20%
The Netherlands	50%	1%	49%	29%	2%	70%	10%
Italy	50%	29%	21%	21%	45%	34%	3%
Spain	50%	40%	10%	18%	66%	17%	1%
Weighted Average	50%	9%	41%	20%	15%	65%	

Table 16 – Hypotheses for waste transport

Type of information	Figures	Sources
Waste truck average consumption	80 L/100 km	PwC Wisard tool
Distance covered by the waste truck	30 km	PwC Wisard tool
Waste truck capacity	5 metric tons	PwC Wisard tool
Waste truck occupancy rate	50%	PwC Wisard tool

[13] Plastics Recyclers Europe
[14] Plastics Recyclers Europe

3.3. Comparison between 2020 and 2021 data

LCA modelling did not change between 2020 and 2021, only the main primary data from Azura for farming and packaging was updated. Assumptions for distribution stages (from DC to consumers) did not change either, only the volume supplied was updated. Evolution between 2020 and 2021 is shown in tables 17, 18, and 19:

Table 17 - Comparison between 2020-2021 Basil

		Basil 2020	Basil 2021	Evolution
Farming	**Production (kg)**	34200	37,179	7.8%
	Water consumption (l/kg)	329	328	-0,3%
	Average Yield[15] (kg/m². year)	3.9	4.30	10,3%
	Propane (for heating purpose) (kg/kg)	5.7	6	5,3%
	Electricity (kwh/kg)	0.73	1.17	60,3%
	Refrigerant R22 (g/kg)	0.13	0.23	76,9%
	Refrigerant R404 (g/kg)	0.35	0.30	-14,3%
	Nitrogen application (kg)	29,534	30,882	4,6%
Packaging	**Cardboard – Packaging (kg/kg of herbs)**	0.21	0.22	4,8%

Table 18 - Comparison between 2020-2021 herbs & flowers

		Other Herbs and Flowers 2020	Other Herbs and Flowers 2021	Evolution
Farming	**Production (kg)**	532,182	526,679	-1%
	Water consumption (l/kg)	1,312	1,153	-12,1%
	Average Yield[16] (kg/m². year)	1.1	1.12	1,8%
	Propane (for heating purpose) (kg/kg)	0	0	0,0%
	Electricity (kwh/kg)	2.0	3.0	50,0%
	Refrigerant R22 (g/kg)	0.14	0.21	50,0%
	Refrigerant R404 (g/kg)	0.39	0.27	-31%

[15] This yield only takes into account the total amount of final and distributed products (and not the quantity of herbs that is produced)
[16] This yield only takes into account the total amount of final and distributed products (and not the quantity of herbs that is produced)

	Nitrogen application (kg)	29,534	30,882	5%
Packaging	**Cardboard – Packaging (kg)**	8.73	8.75	0%
	Plastic – Film PE (kg/kg Herbs and flowers)	1.58	2.68	70%

Table 19 - Comparison between 2020-2021 Basil , herbs & flowers

		Basil, herbs & flowers 2020	Basil, herbs & flowers 2021	Evolution
Farming	**Diesel**	17.53	33,017.5	N/A
Packaging	**Refrigerant R404a (kg)**	65	65.4	0,6%
	Diesel (l)	21,158.88	975	N/A
	Electricity (kWh)	249,360	249,360	0%
	Water (l)	2,038,000	2,038,000	0%

In 2020 LCA, Diesel consumption between farming stage and packaging stage was wrong and has been rectified in 2021 study. In packaging step, same assumption as last year were considered for water and electricity consumption of H&F since those can't be separated from tomatoes consumption as there is a common water/electricity counter for tomatoes, herbs and flowers.

3.4. Modelling of systems and inventory calculation tool

To model the systems and calculate the LCA inventories and environmental impacts, we used the TEAM™ software, version 5.4. TEAM™ is PwC's tool for analysing product life cycles. TEAM™ allows the user to build up and manage large databases and model any system representing the different industrial operations relative to the products, processes and activities of a company. Impacts of production of all inputs (ex. 1 kg of carboard or 1 kWh of electricity) are modelled thanks to databases (Ecoinvent 3.6 or PwC database).

SECTION IV – Results

Preamble: unless otherwise stated, all the results shown and the following graphs relate to the functional unit adopted (cf. paragraph 2.2.1), namely, "delivering 1 kg of herbs and flowers to Europe in a yearly average".

4.1. Limits of the LCA study

Before presenting the results, the limits of the study are summarized below. We collected data from Azura for the culture of herbs and flowers and used generic data to represent production of the materials provided by first and second rank suppliers (combustibles, electricity, etc.). This data does not necessarily match the data which could have been collected from Azura suppliers.

The maintenance of greenhouses was modelled according to the data provided by Azura, but the construction of warehouses was not taken into account in this LCA study.

Water consumption has been studied however; the water indicator does not take into account the water scarcity in the region to evaluate the impact of water consumption. Moreover, the fate of disinfection products was not accounted for in this study.

4.2. Results

In this section, we present the GhG results of the LCA of herbs and flowers produced in Agadir. Percentages are displayed based on actual values; absolute figures are displayed with limited round numbers.

Table 20 – GHG Assessment of herbs and flowers (company average)

	Basil		**Other Herb and Flowers**	
	g CO2 eq.	% of Azura	g CO2 eq.	% of Azura
Azura	**38372**	**100%**	10571	**100%**
Farms	36400	**95%**	8366	**79%**
Packing	259	**0,7%**	259	**2%**
Distribution Agadir - Perpignan	412	**1,1%**	412	**4%**
Distribution Perpignan - Retailers	144	**0,4%**	148	**1%**
Retailers - Distribution Centres	916	**2,4%**	923	**9%**
Retailers - Stores and Professional Clients	146	**0,4%**	291	**3%**
Consumers	94	**0,2%**	170	**2%**

4.2.1. Greenhouse effect - Basil

The production and distribution of 1 kg of basil emits 38.37 kg CO_2 equivalent. As shown in Figure 4, the vast majority of these emissions arises from the consumption of propane, used to heat the greenhouses (85% of the total emission). The other 15% comes mainly from farming activities: within this farming activities, the main contributors for greenhouse gas emissions is the production and transportation of fertilizers (4%), and N_2O emissions on the fields due to the spread of N fertilizers (ammonium, calcium and potassium nitrates) (1%). Electricity production in Morocco (1.17 kWh/kg produced) and water supply (328 l/kg produced) also contribute to greenhouse gas emissions (4%). Finally, packaging, distribution and storage of basil punnets only accounts for 5% of the total emissions.

If we bring it back to a punnet dimension, we find 0.96 kg CO_2 equivalent per punnet of 25 g purchased.

Figure 4 –Main sources of greenhouse gas emissions and focus on the farming stage (basil)

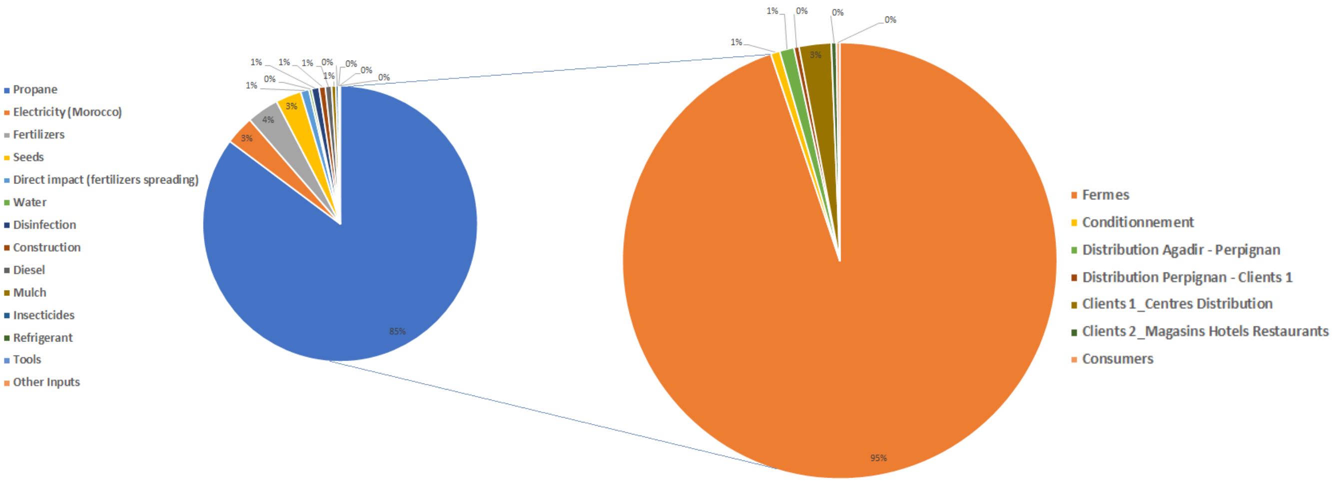
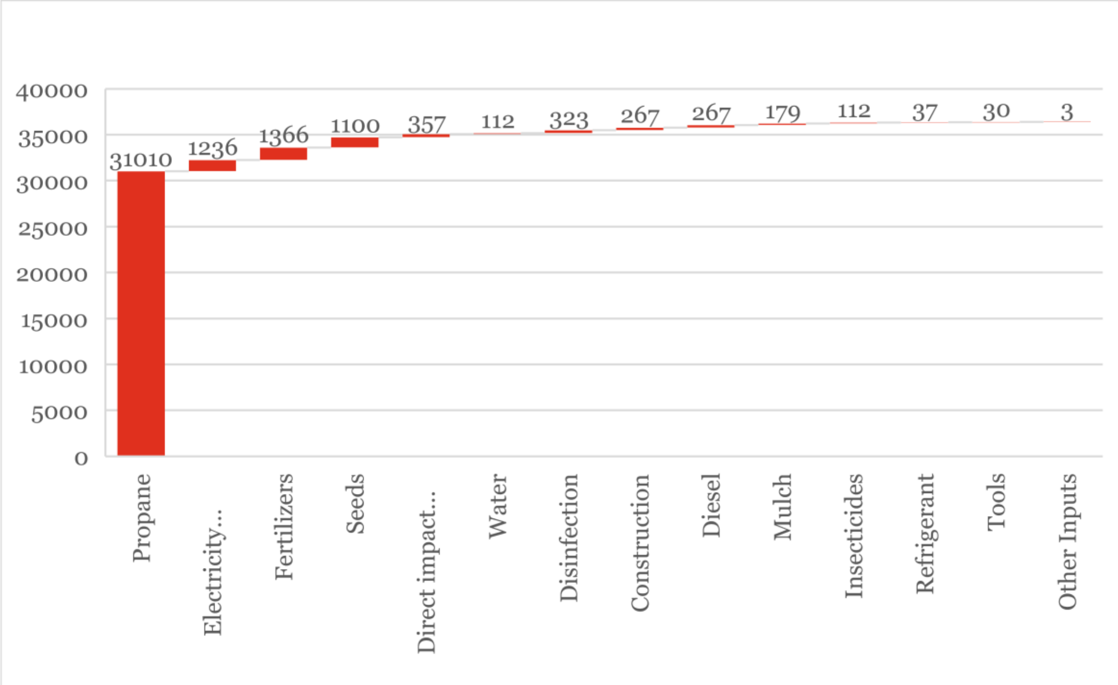


Figure 5 – Focus on the farming stage: main emissions sources (basil)



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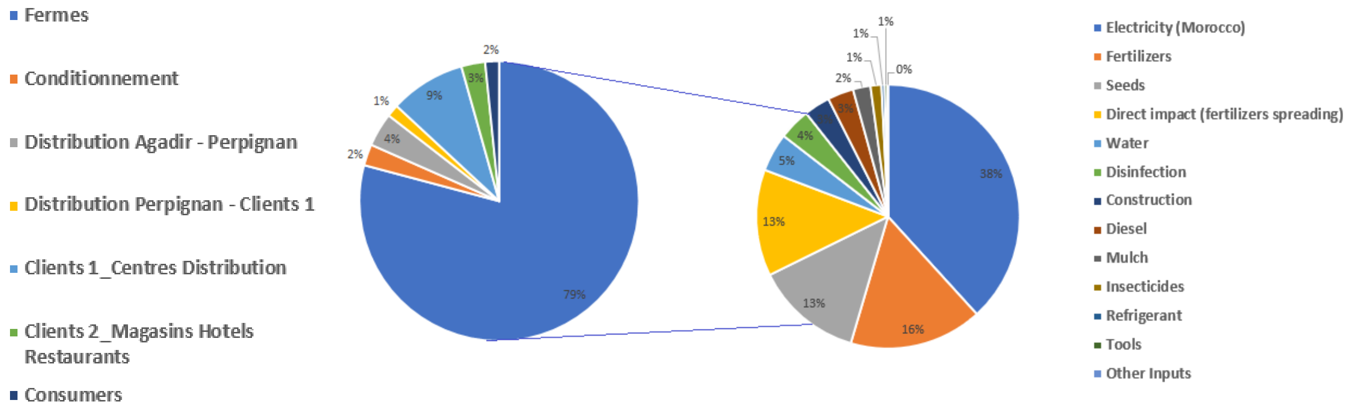
4.2.2. Greenhouse effect – Other herbs and flowers

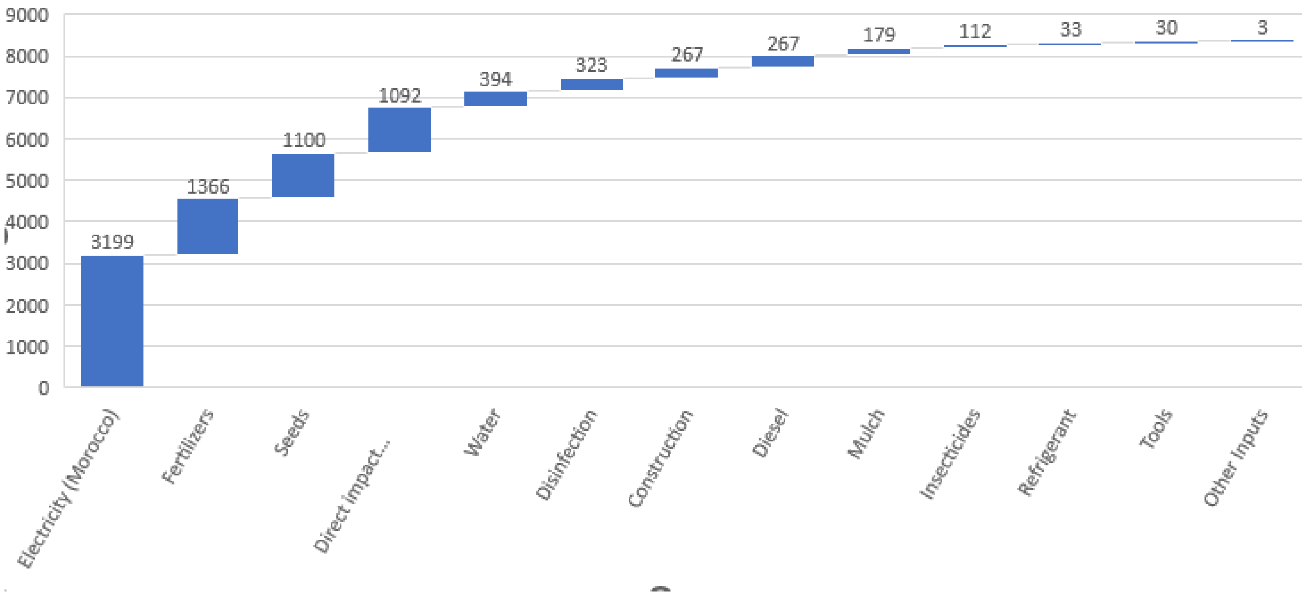
The production and distribution of 1 kg of herbs and flowers (basil excluded) emits 10.57 kg CO_2 equivalent. As shown in Figure 6 most of these emissions arises from farming activities (79%): within this farming activities, the main contributors for greenhouse gas emissions is the electricity production in Morocco (3.0 kWh/kg produced) which accounts for 38% of the total carbon assessment, the production and transportation of fertilizers (16%), and N_2O emissions on the fields due to the spread of N fertilizers (ammonium, calcium and potassium nitrates) (13%). Water supply (1,153.44/kg produced) also contributes to greenhouse gas emissions (5%).

Finally, packaging, distribution and storage of basil punnets accounts for 21% of the total emissions.

If we bring it back to a punnet dimension, we find 0.26 kg CO_2 equivalent per punnet of 25 g purchased.

Figure 6 –Main sources of greenhouse gas emissions and focus on the farming stage (other herbs and flowers)





4.2.3. Detailed Results

Table 21 – Detailed description of greenhouse gas emissions results for Azura herbs and flowers sold in Europe

	Basil			Other Herbs and Flowers		
	g CO2 eq.	% of the step	% of Azura	g CO2 eq.	% of the step	% of Azura
Azura	**38.372**	**100%**	**100%**	**10.572**	**100%**	**100%**
Farms	36.400	**100%**	**95%**	8.366	100%	**79%**
Propane	31.010	85%	81%	-	0%	0%
Electricity (Morocco)	1.236	3%	3%	3.199	38%	30%
Fertilizers	1.366	4%	4%	1.366	16%	13%
Seeds	1.100	3%	3%	1.100	13%	10%
Direct impact (fertilizers spreading)	357	1%	1%	1.092	13%	10%
Water	112	0%	0%	394	5%	4%
Disinfection	323	1%	1%	323	4%	3%
Construction	267	1%	1%	267	3%	3%
Diesel	267	1%	1%	267	3%	3%
Mulch	179	0%	0%	179	2%	2%
Insecticides	112	0%	0%	112	1%	1%
Refrigerant	37	0,1%	0,1%	33	0%	0,3%
Tools	30	0,1%	0,1%	30	0%	0,3%
Other Inputs	3	0,01%	0,01%	3	0%	0,03%
Packing	259	**100%**	**0,7%**	259	100%	**2%**
Direct impact	115	45%	0,3%	115	45%	1%
Miscellaneous packages	75	29%	0,2%	75	29%	1%
Labels	59	23%	0,2%	59	23%	1%
Diesel	8	3%	0,0%	8	3%	0%
Water	1	0%	0,0%	1	0%	0%
Cardboard	1	0%	0,0%	1	0%	0%

Punnets	0	0%	0,0%	0	0%	0%
Distribution Agadir - Perpignan	412	**100%**	**1,1%**	412	100%	**4%**
Road transport	412	99,90%	1,07%	412	100%	3,90%
Storage Perpignan	0	0,10%	0,00%	0	0%	0,00%
Distribution Perpignan - Retailers	144	**100%**	**0,4%**	149	100%	**1%**
Road transport	141	97,5%	0,4%	145	97%	1,4%
Direct impact	4	2,5%	0,0%	4	2%	0,0%
Refrigerant	0	0,0%	0,0%	0	0%	0,0%
Retailers - Distribution Centres	916	**100%**	**2,4%**	924	100%	**9%**
Repacking of herbs by Retailers (PET)	870	95%	2%	870	94%	8%
Refrigerated Transport	18	2%	0%	18	2%	0%
Plastic waste (landfill)	13	1%	0%	15	2%	0%
Direct impact	10	1%	0%	10	1%	0%
Organic waste (landfill)	-	0%	0%	5	0%	0%
Road transport	3	0%	0%	3	0%	0%
Natural gas	2	0%	0%	2	0%	0%
Electricity	0	0%	0%	1	0%	0%
Refrigerant	0	0%	0%	0	0%	0%
Retailers - Stores and Professional Clients	146	**100%**	**0,4%**	291	100%	**3%**
Electricity	26	18%	0%	164	56%	2%
Direct impact Retailers	60	41%	0%	60	20%	1%
Plastic waste (landfill)	49	34%	0%	56	19%	1%
Refrigerant	4	3%	0%	4	1%	0%
Organic waste (landfill)	4	3%	0%	4	2%	0%
Road transport	2	2%	0%	2	1%	0%
Consumers	94	**100%**	**0,2%**	170	100%	**2%**
Plastic waste (landfill)	70	74%	0%	80	0	1%
Electricity	12	13%	0%	79	0	1%
Organic waste (landfill)	4	5%	0%	4	0	0%
Road transport	3	3%	0%	3	0	0%
Refrigerant	2	2%	0%	2	0	0%
Direct impact Consumer	2	2%	0%	2	0	0%
Water	1	1%	0%	1	0	0%

Section V - Conclusions

The objective of the present study is to update of a previous GhG assessment study carried out in 2020 of the herbs and flowers produced by Azura in Agadir (Morocco), with a life cycle approach, from farms in Morocco to final consumers in Europe, with a life cycle approach. Due to its specific farming condition (heated farms), Basil was excluded from the other herbs and flowers, and two studies were conducted: one for the basil (heated greenhouse) and one for the other herbs and flowers (unheated greenhouses). All (4) Azura herbs and flowers farms/greenhouses were considered in this study. The period covered by the study is July 2020 – June 2021. Azura produces 14 different types of herbs and 7 different types of flowers. To assess the environmental impacts, the ISO standards 14040 and 14044 were followed.

This study underwent a critical review by an independent LCA expert.

Data collection and assumption used. This study is based on the 2020-2021 herbs and flowers production grown in Agadir. Data were collected from Azura with various sources (spent data from purchase ledger, meters measurements, ERP tools, etc.) and generic data were used to represent production of materials from first and second rank suppliers.

Data collected from Azura was combined with bibliographical sources to represent the production of material and energy supply. Estimations had to be made for some products that did not exactly match an existing module.

Scope of the study. All production steps were considered from farming, packaging to distribution and storage in Europe by both retailers and consumers, including construction materials for the farms. The initial construction of warehouses was not included in this LCA study along with R&D, administration, kitchens, machines and equipment (except sorting machines), services, and the maintenance of vehicles.

Average results for basil. The farms are the most impactful step of the production and distribution process, due to the use of propane: with 6 kg of propane per kg of basil produced, the use of propane is responsible for 81% of the total emissions. Apart from this, within the farming stage (representing 95% of the total impact) greenhouse gas emissions are distributed between the various processes on the farms including fertiliser production and transport (4% of the total impact), fertilizers spreading (1%), electricity production and water supply (4%).

Average results for other herbs and flowers. For the other herbs and flowers, the farms are also the most impactful step, representing 79% of the total emissions. The Moroccan electricity is the first source of emissions within this farming step (30% of the total emissions), which can be explained by the important volume of electricity consumed to produce 1 kg of herbs and flowers (3 kWh/kg) and the highly carbonated Moroccan energy mix. Fertilizers and pesticides spreading are together responsible for 11% of the total carbon emissions.

Within the retailers and consumers stage (14.5% of the total emissions), greenhouse gas emissions are mainly coming from the repacking of herbs by retailers (10 g of plastic for 25 g of herbs), which represents 8% of the total emissions. Waste management accounts for 2% of the total emissions.

Section VI – Critical review

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Critical review report of Azura greenhouse gases emissions assessment on Azura Moroccan herbs

Author: Hélène Lelièvre, independent LCA consultant, Enviroconseil, France
Date: 24th January 2023

1. Goal and scope of the critical review

This independent external review was carried out from November 2022 to January 2023. The cradle-to-grave GhG (Greenhouse Gases) assessment study on Azura Moroccan herbs (actually 99.9% of herbs and 0.1% of flowers) was carried out by Azura between August and December 2022. It is the update of a previous GhG assessment study carried out in 2020 by PwC with the update of the Azura primary data used in the model (period 2020/2021 instead of 2019/2020). A first critical review was performed in 2020 on the first version of the study by the same reviewer. The comments done at that time are available in the corresponding 2020 critical review report.

The goal of this study is to assess the greenhouse gases emissions associated to the whole life cycle of the Azura Moroccan herbs and flowers in view of a CO2 compensation according to PAS 2060 standard.

The external review was performed in a 3 steps process, on the following documents, transmitted by Azura:

- "Cradle-to-grave greenhouse gas emissions assessment of Azura herbs and flowers with a view to carbon offsetting in accordance with PAS 2050", version of 11 November 2022 (for the first round of comments),
- "Cradle-to-grave greenhouse gas emissions assessment of Azura herbs and flowers with a view to carbon offsetting in accordance with PAS 2050", version of 19 December 2022 (for the second round of comments)
- "Cradle-to-grave greenhouse gas emissions assessment of Azura herbs and flowers with a view to carbon offsetting in accordance with PAS 2050", final version of the report of 28 December 2022 (final check).

In addition, the LCA modelling in the TEAM™ LCA software and the Excel file compiling all inputs gathered by Azura based on its ERP were reviewed by sampling during several Webex.

The critical review goal was to assess the compliance of the LCA study focused on GhG emissions with ISO 14 040 and ISO 14 044 standards. More precisely, ISO 14044 standard (section 6.1) specifies that:
"The critical review process shall ensure that:

- the methods used to carry out the LCA are consistent with this International standard;
- the methods used to carry out the LCA are scientifically and technically valid;
- the data used are appropriate and reasonable in relation to the goal of the study;
- the interpretations reflect the limitations identified and the goal of the study;
- the study report is transparent and consistent."

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2. Main findings and conclusions

Most of the reviewer comments were taken into account by the practitioner and the content of the report was improved by better detailing the input data and assumptions. A correction was done on the LCA model on waste. It was asked to add a dedicated section detailing the changes between the 2 studies (2022 compared to 2020) for a better understanding of the results changes.

Some remarks on the datasets used in the model and on the version of the GhG assessment method could not be integrated due to the time constraints and technical issues with the LCA software.

For the future update of the study, the following recommendations can be emitted:

- For the input data, to avoid effects due to stocks in Azura operations, calculate the consumptions of raw materials as the purchased quantities over the period corrected by the stock at the beginning and the end of the studied period. This will allow to compare the environmental performance over years without the stocks effect.
- To ease the update process in the future with updated primary data from Azura, change the LCA model dealing with distribution, consumer use and end of life of packaging to use directly literature ratios on these steps instead of recalculated absolute values with the literature ratios and distributed tonnages. This will lighten the update work each year and decrease potential errors.
- Use updated Ecoinvent datasets (cut off series, at least version 3.8) in the whole system, in particular for energy production and combustion, electricity models, plastic production and waste treatment instead of datasets from PwC internal database.
- Use the updated 2019 version of 2006 IPCC Guidelines for National Greenhouse Gas Inventories for the modelling of the agricultural steps.
- Use the updated 2021 IPCC method for the GhG assessment instead of the 2013 version of the method.
- Distinguish the methane emissions from biogenic source and fossil sources in the LCA software by having 2 different flows of methane emissions.
- Regionalize the water flows to be able to calculate a water scarcity indicator based on the AWARE consensual method on this topic (see https://wulca-waterlca.org).
- Use the updated 2021 IPCC method for the GhG assessment instead of the 2013 version of the method.
- Use the PEF (Product Environmental Footprint) LCA method for the environmental indicators.

This LCA study focused on GHG emissions is compliant with ISO 14040 and ISO 14044 requirements. In case compliance with PAS 2050 and PAS 2060 is requested, additional requirements are to be met, for instance, necessity to define reduction action plan in PAS 2060 or review in detail of all input data and calculations.

The annex displays the detailed reviewer's comments and Azura practitioner's answers.

Section VII – References

0. ISO 14040:2006 « Environmental management — Life cycle assessment — Principles and framework » ISO 14044:2006 « Environmental management — Life cycle assessment — Requirements and guidelines ».

1. Zampori, L. and Pant, R., Suggestions for updating the Product Environmental Footprint (PEF) method, EUR 29682 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-00654-1, doi:10.2760/424613, JRC115959.

2. Quantis, Organisation Environmental Footprint Sector Rules (OEFSR) Retail, Version 1.0 of April 20, 2018.

3. Françoise Bahoken, Corinne Blanquart, Emilie Gaubert. Typologie spatiale du commerce de la grande distribution et de ses relations d'approvisionnement. ASRDLF - 51ème colloque de l'Association de Science Régionale de Langue Française, Jul 2014, France. 16p. ffhal-01052910f.

4. Tracy L. Parnell et al. Tomatoes: Safe Methods to Store, Preserve, and Enjoy. University of California, division of agriculture and natural resources, 2004.

5. PAS 2050: 2011, Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. British Standard Institution, 2011 London.

6. PAS 2050-1:2012, Assessment of life cycle greenhouse gas emissions from horticultural products. British Standard Institution, 2012 London.

7. Eunomia, PET Market in Europe, State of Play. Production, Collection and Recycling Data, 2020. Plastics Recyclers Europe, Petcore Europe, EFBW.

8. World Bank, Waste in Russia: garbage or valuable resource? Scenarios for developing the municipal solid waste management sector. 2014. IFC Advisory Services in Europe and Central Asia, Resource Efficiency Program.
   Link: http://documents1.worldbank.org/curated/pt/702251549554831489/pdf/Waste-in-Russia-Garbage-or-Valuable-Resource.pdf

Appendix A. - General methods for life cycle analysis

The evaluation of industrial systems is not a recent discipline. The first attempts to evaluate the environmental impacts of a product procedure were made in the mid-70s and were centred uniquely on energy aspects[17].

The term "Life Cycle Analysis" or "Assessment" was introduced during workshops organized by the SETAC (Society of Environmental Toxicology and Chemistry). According to standards defined by practitioners, taken up by the SETAC and formalized in national or international standards (AFNOR X 30-300 and ISO 14040 respectively), the environmental assessment of a product is carried out in four phases[18]:

***Definition of objectives and field of research**,* (first definition of the system boundaries, functional unit, data to be collected, etc.),

Analysis of the inventory, phase of the inventory listing the flows of materials and energy (impact factors) for a defined system,

***Evaluation of impact**,* phase interpreting and analysing the impacts on the environment, carried out on the basis of figures in the inventory and synthetic indicators, carefully chosen and representative of specific impacts,

Interpretation, phase analysing the procedure, including identification of strengths and weaknesses in the procedure and any analysis of specific scenarios.

The life cycle inventory consists of noting the energy and material flows – or *impact factors* on the environment – within the boundaries of the *system studied*. These flows are related to a unit called the *functional unit*.

The object of this paragraph is to present the various phases of the inventory, from definition of the functional unit through collection of data on site, via definition of the system and choice of allocation rules and rules for taking into account recycling of products at the end of their life.

A.1. The functional unit

The flows listed in the inventories are not calculated on physical product quantity, but on the basis of an equivalent service rendered.

For example, during evaluation of the respective advantages of different types of packaging, 1 kg of glass would not be compared with 1 kg of plastic material, but a comparison would be made between a litre of liquid packaged in either X g of non-returnable glass, Y g of returnable glass (Y being a function of the number of re-uses of the bottles) or Z g of plastic material.

Choice of this unit must be conditioned by the fact that aim of a product's inventory is to evaluate the impacts of that product on the environment, **fulfilling a given function**. The functional unit must therefore be a **unit of use** and not simply a unit of manufacture (tonnage or volume for example).

This unit, called the "functional unit" in accordance with European LCA inventory terminology, is the basis for calculating the flows assessed.

A.2. Delimitation of the system

The objective of the LCA inventory is to recognize, understand and interpret all the impacts on the environment

[17] Handbook of industrial energy analysis. Boustead I. & Hancock G.F. - Ellis Horwood (1979)
[18] ISO/14040 . International Standardisation Organisation, (1997), Environmental management – Life cycle analysis – Principles and framework.

of a given system which, according to the problem envisaged, can be:

- all the life cycle stages of a given product,
- the stages of a given process, for a given product,
- a production site for a given product.

The flows listed within the boundaries of the system must be directly interpretable in terms of environmental impact. Thus, consumption of gasoil is not directly interpretable, however this consumption corresponds to a particular quantity of crude oil extracted, transported, refined then burnt, with each of these stages having impacts on the environment.

Interpretable flows are those directly drawn from or discarded into the environment and are called **elementary flows**. They can be:

- input into the system: raw materials and certain forms of energy (wind, solar, hydraulic…),
- output from the system: liquid or gaseous waste, final solids and certain energy flows (heat, ionizing radiation, etc.).

These are the opposite of the following **non elementary flows**:

- input into the system: extracted materials, intermediate products, steam, electricity, …,
- output from the system: packaging waste, energy produced, ….

Thus, the system must include the stages enabling these elementary flows to be reached, such as development of intermediate products and the production of consumed energy.

Generally speaking, such a system includes the following stages (as well as transport) that are treated as sub-systems:

- extraction of raw materials and production of the component's parts of the finished product,
- assembly / formulation of the finished product,
- distribution,
- use,
- end of life processing of the product.

More generally, the LCA broadens the system to include the production procedures for each input flow, up to their constituent raw materials.

Output flows from the system must similarly be monitored up to final waste in the natural environment or dumping.

The procedure for broadening the system described above is simple in principle: all the stages enabling ascent to or descent from the elementary flows are taken into account in the system.

However, it cannot be conducted exhaustively for the following reason:

inclusion of all the stages contributing to the life cycle of a product entails study of the whole of the industrial world: construction of capital goods (factories, lorries, ships, etc.…), roads and port infrastructures necessary for transport, etc.…

Thus, the procedures included in the system concerning the development of intermediate products consumed and the discarding of output flows up until their transformation into final waste must be clearly stated.

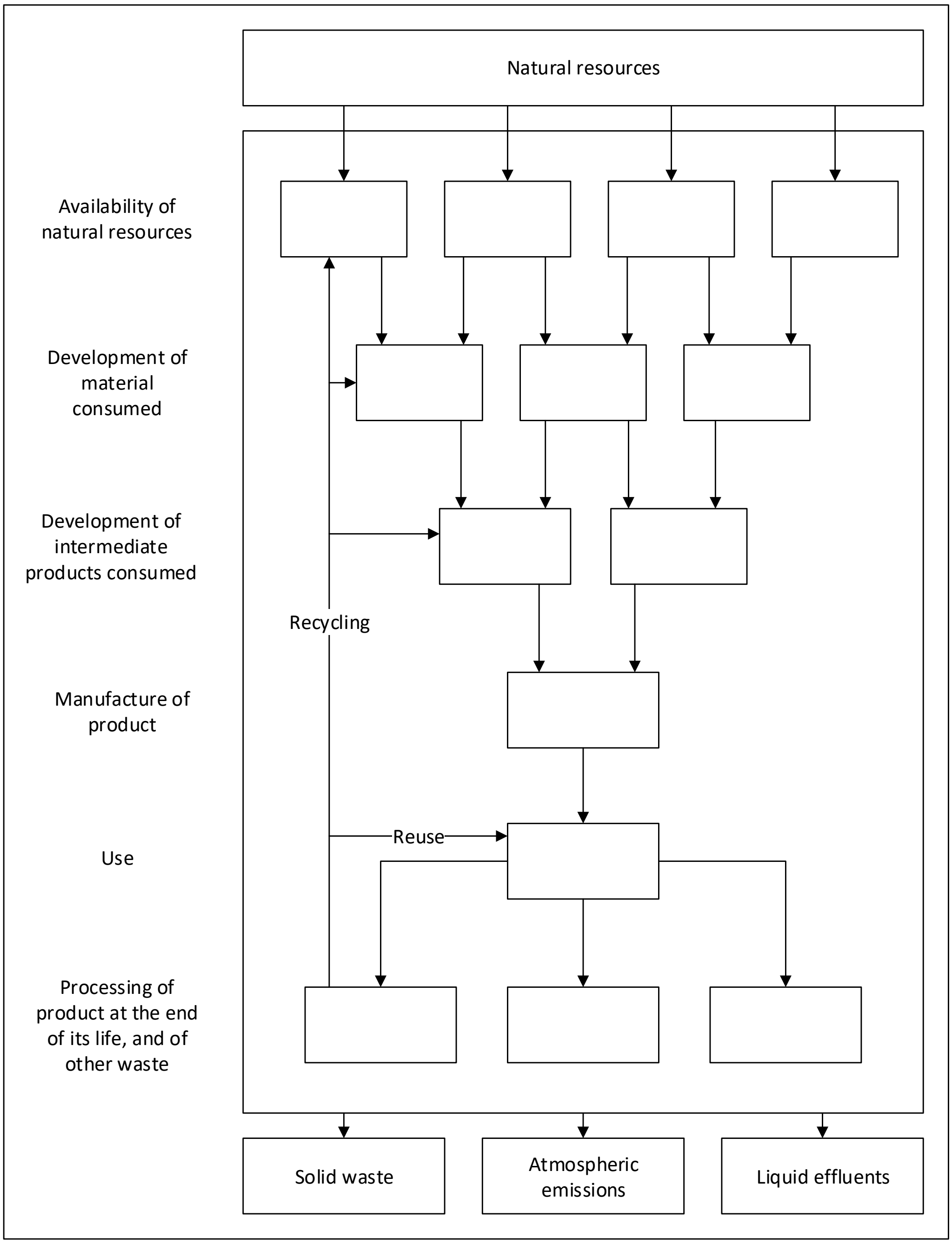
The choice of boundaries for the system studied – by nature conventional and dependent on the objectives of the LCA inventory – must be based on criteria which are:

- quantitative: for example, percentage of mass or energy content in relation to the mass of the product studied,
- qualitative: for example, toxicity (inclusion of a procedure said to be polluting even if it makes only a minor contribution to the total product).

Integrated into the elementary flows are:

- materials with a non-energy use, consumed on site and for which the extraction or production is not taken into account; these are materials used in small quantities,
- liquid effluent and atmospheric emissions,
- some solid waste products, in the absence of data concerning their discharge procedures.

Figure 8 – Methodology: Delimitation of the system



Note on capital goods: the following example offers a schematic representation of the (generally negligible) incidence of capital goods on the life cycle of a product (limited to an energy evaluation). The example of steel manufacture has been used to evaluate the cost in energy terms of fabricating a refinery. A refinery processing 6 million tonnes of raw product per annum over 15 years requires around 20 000 tonnes of steel for its construction. The preparation of a tonne of steel requires approximately the energy equivalent of one TOE. The steel working then requires energy of 0.0002 TOE/ tonne of refined oil, or 0.02%, which is negligible compared to the energy consumed in extracting, transporting and refining the oil (around 10% of the energy delivered).

A.3. Data collected

For each stage identified within the system, the following flows (known as impact factors as they are a source of environmental impact) should be listed:

- **energy consumption**, differentiated by origin: electrical energy from the grid, energy from fossil fuels, etc.,
- **consumption of raw materials,** renewable or not (water, ores, etc.),
- **liquid effluent:** suspended matter, chemical (and biological) demand for oxygen, hydrocarbons, nitrates, sulphates, phenols, heavy metals, etc.,
- **atmospheric emissions:** CO, CO_2, NO_x, N_2O, SO_x, CH_4, dust, volatile organic compounds, hydrocarbons, metals, etc.,
- **solid waste**, classified by type (paper, plastic, metal, glass, etc.) or destination (dumping, incineration, recycling, energy recovery, etc.).

This collection of data concerns all the industrial stages included in the system as well as the transport stages, availability of energy (electrical and thermal energy) and consumption of packaging and exterior packaging.

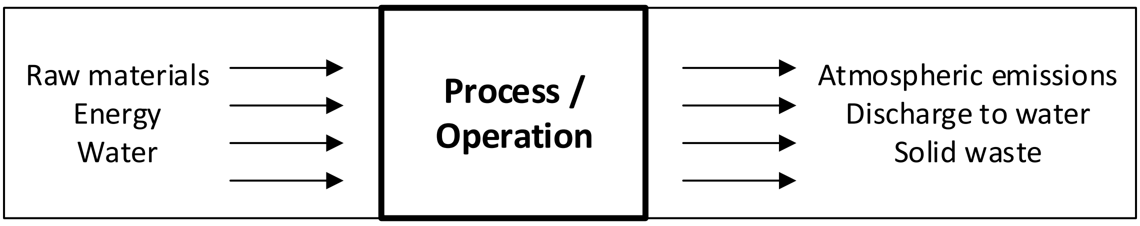
Figure 23 shows the data that must be collected at each life cycle stage.

This quantitative data is, first and foremost, that measured by the industrial sites involved in the procedure.

As a last resort, data from other manufacturers producing similar products may be used. This data is then generally of bibliographical origin.

In accordance with the principle of transparency applied to the preparation of LCA inventories, this type of choice is always explained.

Figure 9 – Methodology: data recorded for each module



Bibliographical data may be presented in three forms:

- **"Raw" LCA inventory:** only the final results of the inventory are accessible,
- **documented LCA inventory:** all the information sources are referenced and explained,
- **broken down bibliographical data:** data is distributed between several sources (i.e. each source deals with only one aspect of data). The LCA inventory calculated via this route corresponds definitively to a model which is internal to the company PwC and which can be refined over time.

Data obtained in the latter two cases can be adapted to the analysis of particular procedures.

However, taking into account the relatively recent character of the notion of environmental assessment, the last case is the most frequent. Furthermore, data available in scientific literature often only allows an inventory of material and energy consumption to be drawn up. The origin and nature of the data must be made clear to enable the LCA inventory to be completed once the data is available or measurements have been taken.

To summarize, bibliographical data makes up for the lack of information collected directly from the industrial sites involved. Its use is compulsory for processes where observation on industrial sites is difficult (extraction of gas, oil, production of electricity for example). It offers a significant time-saving and has the advantage of allowing the system studied to be extended to stages which could not have been included without it. However, it is preferable to substitute this for data measured on the industrial sites applicable to the system, wherever this is possible.

A.4. Choice of allocation rules

The industrial systems studied are often multi-product (or multi-function). It is thus necessary to be able to allocate to each of the co-products, the impacts incumbent on them, with the aid of allocation rules.

For example, an oil refinery is responsible for bitumen, grease, oil, heavy fuels, gasoil, kerosene and light cuts (naphtha and liquefied petroleum gas: particularly propane and butane).

Generally speaking, a number of processes are responsible for generating the co-products of the chemical industry, since it is rare that a chemical reaction gives rise to the synthesis of only one product. Usually two or even three products are obtained, which may be co-products, or by-products from which energy is likely to be recovered, or even waste with no value.

Where there are co-products, or if some of the by-products of the product studied are subject to energy recovery, the impacts on the environment of the process from which they result must be distributed between the various products.

It is essential that allocation rules are determined in the case of procedures with multiple input flows such as incineration.

Various allocation rules can be used which distribute the process impact factors prorata according to the particular case, to:

- the mass of the products (**mass allocation**),
- the volume of the products (**volume allocation**),
- the number of moles in the products (**molar allocation**),
- the low calorific value of the products (**energy allocation**).

Several rules relating to different impact factors may be used if the physical nature of the phenomena so requires.

Note: the absence of precise data also means that distribution keys must be used without the processes in question generating co-products. This is the case for a factory which manufactures unrelated products in distinct workshops, and which only communicates information relative to the factory as a whole.

A.5. Choice of rules for taking recycling into account

In the life cycle of products within a procedure, numerous recycling loops may exist:

- recycling of manufacturing rejects and scrap,
- incorporation of recycled materials into product manufacture,
- recycling of products at the end of their life, etc.

Cases where a product is recycled within its own life cycle (known as **closed loop** recycling) are directly taken into account in the LCA inventory prepared, via the functional unit.

Thus, a green glass bottle recycled at a rate of 50% post-consumption, will consume an amount of raw materials two times lower than a non-recycled green glass bottle (disregarding the recycling output).

In contrast there is **open loop** recycling – the most frequent – where the initial product is recycled into another procedure, known as a secondary.

In the latter case, different methods exist for allocating the flows associated with the recycling stages and the material savings made between the procedure used for the initial product and that used for the secondary product. Here again there is a choice of rules for allocating and taking into account co-products. Open loop recycling can be considered either as waste processing from the point of view of the initial product, or as a stage in obtaining raw materials from the point of view of the secondary product.

The effects of the recycling operation entail:

- collection of products for recycling,
- the actual recycling process,
- the savings in raw materials in the secondary product procedure,
- adaptation of the processes or products to the use of recycled material,
- waste removal savings in the primary product procedure,
- the differences introduced into the waste removal procedure for the secondary product

Choices, on which the final results depend, must then be made between:

- allocation of all the impacts of recycling to the initial product,
- allocation of all the impacts of recycling to the secondary product,
- distribution of all or some of the impacts of recycling between the initial and secondary products.

Theoretically, the analysis of multi-function systems should rule out these choices.

These rules for delimiting the boundaries of the system are the subject of a publication, acknowledged by the profession, in the documentation from SETAC's Leyden workshop (December 1991 "*System boundaries*" workshop, presented by PwC), and are detailed in the international standard ISO 14040.

Appendix B. - Secondary data used

Table 22 – Bibliographic sources of secondary data

Industrial processes	Use or process	Data sources
Wood Logs (Maritime Pine)	Maintenance	Ecoinvent
EU Hot Dip Galvanized Steel	Maintenance	LCI data for steel products-Report produced for PwCWorldsteel contactClare BroadbentBrussels, May 2013
Aluminium	Material and equipment	International Aluminium Institute, 2013
Synthetic Rubber	Material and equipment	Synthetic rubber production - LCI - RoW – AD, Ecoinvent, 1995
Soap	Material and equipment	Soap production – LCI – RoW – AD, Ecoinvent, 1992
Cellulose	Material and equipment	Cellulose fibre production, inclusive blowing in - LCI - RoW – AD, Ecoinvent 1995
Seeds	Material and equipment	Mint seedling production, for planting - LCI - RoW – AD, 2009
Ammonium nitrate	Fertilizer	Ammonium nitrate production, Europe, Ecoinvent, 1999
Calcium nitrate	Fertilizer	Calcium nitrate production, RoW, Ecoinvent, 2010
Phosphoric acid	Fertilizer	Phosphoric acid production, dihydrate process, Morocco, Ecoinvent, 2012
Iron sulphate	Fertilizer	ISIC rev.4 ecoinvent
Magnesium sulphate	Fertilizer	Magnesium sulphate production, RoW, Ecoinvent, 2000
Potassium sulphate	Fertilizer	Potassium sulphate production, RoW, Ecoinvent, 1999
Potassium nitrate	Fertilizer	Potassium nitrate production, RoW, Ecoinvent, 1999
Sulphuric acid	Fertilizer	Sulphuric acid production, RoW, Ecoinvent, 2001
Lime	Fertilizer	Lime production, milled, packed, RoW, Ecoinvent, 2000
Ammonium chloride	Disinfection	Ammonium chloride production, global, Ecoinvent 2012
Sodium Hypochlorite	Disinfection	sodium hypochlorite production, product in 15% solution state - LCI - RoW - AD,Ecoinvent
Soap and detergent	Disinfection	cleaning consumables, without water, in 13.6% solution state - LCI - GLO - AD, Ecoinvent,
Dichloropropene	Pesticide	Dichloropropene to generic market for pesticide, Global, Ecoinvent, 2012
Cardboard	Conditioning	FEFCO 2012
Kraftliner	Conditioning	Kraftliner (FEFCO; 2012): Production
Refrigerant R134a	Conditioning	Refrigerant R134a production – LCI – RER – AD, Ecoinvent, 2011
Chlorodifluoromethane	Conditioning	Chlorodifluoromethane, RoW, Ecoinvent, 1999

PET	Plastics	Polyethylene terephthalate production, granulate, bottle grade, recycled, RoW, Ecoinvent, 2014 Polyethylene terephthalate, Bottle grade, 2005, Plastics Europe
LDPE	Plastics	Plastics Europe 2005 Film, Ecobilan module 1999
HDPE	Plastics	Plastics Europe 2005
Electricity France	Utilities	IEA 2016
Electricity Morocco	Utilities	Electricity mix, Morocco, 2016, IEA 2019
Electricity Switzerland, Spain, Netherlands, Germany, Italy	Utilities	IEA 2015
Electricity Europe	Utilities	IEA 2013
Electricity Belgium	Utilities	IEA 2011
Natural gas	Utilities	Natural gas production, RoW, Ecoinvent, 1989
LPG	Combustible	Petroleum refinery operation LPG, RoW, Ecoinvent, 2005
Propane combustion	Farms	Propane, burned in building machine, Global, Ecoinvent 2013
Organic waste landfilling	Waste	PwC Wisard tool
Organic waste incineration	Waste	PwC Wisard tool, composition of waste: INSA 1996
PET incineration	Waste	PwC Wisard tool, composition of waste: INSA 1996
PE incineration	Waste	PwC Wisard tool, composition of waste: INSA 1996
Water	Farm, Conditioning and distribution	Tap water production, underground water without treatment, RoW, Ecoinvent, 2012
Wooden pallets	Distribution	EUR-flat Pallet production, Europe, Ecoinvent, 2000
Refrigerated lorry	Distribution	Market for transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO3, R134a refrigerant, cooling, Global, Ecoinvent, 2010
Diesel	Distribution	Diesel Oil, Production / Engine Combustion, Ecoinvent, 1996. Laboratorium fur Energiesysteme
Refrigerant	Distribution and storage	Refrigerant R134a production, Europe, Ecoinvent, 1999
Lorry transport	Transport	Production of diesel and combustion in a Heavy-Duty Vehicle, assuming a typical EU-15 fleet and activity data for 2005
Sea transport	Transport	Transport, freight, sea, transoceanic ship, Global, Ecoinvent, 1992

Appendix C. - Life cycle analysis inventories

The inventories show the results for one year of consumption for all herbs and flowers produced and distributed by Azura (563.8t of herbs and 0.205 t of flowers), within the boundaries detailed in Section II.

Table 23 – Inputs inventories for all herbs and flowers sold

Inputs	Unit	Data from Azura 2020-2021	
		Basil	Other Herbs and Flowers
Farming			
Desinfection			
Bleach	liters	5.497,00	
DD 92	liters	7.994,00	
Virocid	liters	275,85	
Konflic	liters	135,91	
Fertilizers			
Sulphuric acid	liters	12,28	
Lime nitrate	liters	127.863,00	
Potassium nitrate	liters	91.521,25	
Potassium sulphate	liters	119.000,00	
Magnesium sulphate	liters	30.615,00	
Ammonium nitrate	liters	22,50	
Phosphoric acid	liters	29.492,00	
Farm infrastructures			
Mulching	kg	43.027,20	
Wires and cables	kg	5.532,80	
Agricultural nets	kg	5.302,24	
Roofing films	kg	54.140,37	
Wooden posts	kg	13.237,00	
Cement CEM I	kg	150,00	
Electricity	kWh	43.443,54	1.593.126,00

Energy			
Diesel	liters	33.017,50	
Propane	kg	240.005,00	0
Water	liters	12.200.746,95	607.493.253,01
Refrigerant			
R22	kg	9	110
R404a	kg	11	145
Surface			
Occupational annual crop greenhouse	m².year	8.640,00	470.883
Packing house			
Packaging			
rPET Trays	kg	279,83	
Couvercle PSE	kg	30,00	
Paper remains	kg	1,00	
Cardboard	kg	117,60	
PP Box	kg	3.913,24	
PP Pallets	kg	562,35	
Virgin Wood rental pallets	kg	43,20	
Recycled Wood pallets	kg	24,05	
PE bag, attachment, strapping	kg	64,17	
Paper bag, attachment, strapping	kg	206,00	
PP bag, attachment, strapping	kg	1.236,00	
PP film	kg	11.271,39	
Electricity	kWh	249.360,00	
Diesel	liters	975,00	
Water	liters	2.038.000,00	
Refrigerant R404a	kg	65.4	
Perpignan Warehouse			
Electricity	kWh	662	
Water	liters	115	
Refrigerant R404A (content)	kg	2,75	

Retailer – Distribution Centers		
Electricity	kWh	3,164
Natural Gas	MJ	16,271
Water	liters	550
Refrigerant R404A (content)	kg	13
Professional Clients - Bars, Hotels and Restaurants (40% of herbs, 100% of flowers)		
Electricity	kWh	122,724
Refrigerant R134A (content)	kg	43,27
Retail – Stores (100% of herbs)		
Electricity	kWh	256,716
Water	liters	233
Refrigerant R404A (content)	kg	78
Consumers		
Electricity	kWh	182,471
Refrigerant R134A (content)	kg	64,34

Appendix D. - Detailed comments and answers of the practitioner of the 2 rounds of review

External review, LCA Model review, completed on the 21st November 2022 by Hélène Lelièvre, Enviroconseil, Independent LCA consultant
Document reviewed: Cradle-to-grave assessment of Azura tomatoes with a view to carbon offsetting in accordance with PAS 2060 -Complementary Study to the LCA study issued in April 2020- 30 July 2020

N°	line number	paragraph, figure, table	type (editorial, general, technical)	review comment	review recommandation	practitioner response
1		LCA model	T	same remarks as for tomatoes for upstream modules, water flows and GhG IPCC indicator		For future studies
2		LCA model	T	The quantity of PET film has been significantly reduced (279 kg in 2020/21 of 932 kg in 2019/2020). The explanation given is that there were some stocks at the conditioning unit.	For future studies, take into account the stock level at the beginning and end of the period so to account this. Otherwise there will be biais between years not corresponding to reality and it will	OK

					be difficult to compare years	
3		LCA model	T	A important quantity pf PP film used at the nursery stage has been accounted for in the conditioning stage	In the future, add a nursery stage and take into account this flow at this stage	OK
4		LCA model	T	The qty of loss at the retail level (organic waste and packaging waste) is not accounted for. Only the qty of loss at the restaurants level is accounted for.	Take into account these quantities and correct the quantities of sold herbs	OK
5		LCA model			Recommandation for future: review the model so to use ratios instead of absolute values for the downstream model (distribution centers, retail and consumers). This will lighten the update work each year as this part is not likely to change. Now,	OK

						all data have to be updated as they are expressed as absolute values for the total sold knowing the absolutes values are calculated in Excel with the volumes of the year but are based on the same ratios of impact.	

External review, first round, completed on the 21st November 2022 by Hélène Lelièvre, Enviroconseil, Independent LCA consultant

LCA report dated 11th November 2022

N°	line number	paragraph, figure, table	type (editorial, general, technical)	review comment	review recommandation	practitioner response
1			G	same remarks as for tomatoes (title, allocation…)		ok
2			G		Add a new section in the report describing the changes compared to the 2020 LCA study (addition of some processes, changes in data, changes in upstream modules etc.)	ok 3.3. Comparison between 2020 and 2021 data
3		2.3.3 Allocation procedures for co-products	T	There is an allocation rule for the emissions of refrigerants at the farm between herbs and basil but this is not described	Describe the fact that an allocation rule based on the cultivated surfaces of the herbs and basil is used for the	ok, not refrigerants but water

					emission of refrigerants at the farm level	
4		SECTION III – Calculation of inventory: collection of data and assumptions description	T	Add a section listing the specificities for basil at the farm stage (ie all flows that have a different value for basil compared to herbs: electricity, land use, propane…)		Already there: (3.2.1. Farms 3.2.1.1. General information Table 4)
5		2.3.2.2 List of excluded life cycle stages	T		Add in the excluded steps the nursery step and justify it	The nursery is not excluded. The step does not apply for herbs and flowers .
6		3.2.8 Consumers	D	The assumption taken for the washing of the herbs at the consumers is not described	Add the assumption used (0,05 litre used per punnet) and justify this low value (example: on the pack, it is said not to wash herbs)	Study pwc
7		2.3.3 Allocation procedures for co-products	T	The allocation section should be renamed as it covers more than coproducts allocation	rename it as "Allocation rules"	ok

8		2.3.3 Allocation procedures for co-products	T		Add the fact that the envronmental impacts linked to the incineration of waste with energy recovery are not taken into account but allocated to the production of energy and not the treatment of the waste, in order to follow the requirement of PAS2050 (section 8.2.2)	ok
9		2.3.1.Life cycle tomatoes		"The tomato life cycle includes 7 main steps that are plant nursery, farms, packaging and distribution"	replace by "6 main stages"	ok
10		2.4.2. Environmental life cycle impact indicators	T	IPCC 2013 is old. There is an update with IPCC 2021	Use the updated indicator	IPCC 2013 IS THE LATEST ON TEAM
11		2.4.2. Environmental life cycle impact indicators	G	The water scarcity indicator is now usually assessed in LCA studies	For future study, include the water scarcity indicator (AWARE method). This will imply to review the whole LCA model and	ok

					regionalize the water flows. This involves also to regionalize the tap water process and waste water treatment to consider the country where the water flow takes place.	

External review, round 2, completed on the 19th December 2022 by Hélène Lelièvre, Enviroconseil, Independent LCA consultant

LCA report dated 13th December 2022

N°	line number	paragraph, figure, table	type (editorial, general, technical)	review comment	review reco	practitioner response
1		cover page	G		Change author of report (Azura instead of PwC)	ok
2		exe summary	G		Add a sentence saying this is an update of a previous GhG assessment study carried out in 2020 (before data collection section)	ok
3		exe summary	G	"The use of propane to produce basil emits 31 kg CO_2 eq. per kg of basil sold, which represents 85% of the total greenhouse gas emissions." Table 18 shows 81% for the contribution of propane	Correct 85% to 81%	ok

4		whole report	G		change the bottom of the page heading (ghg assessment instead of environmental impacts assessment) and update the date on the right bottom	ok
5		1.1. Context of the LCA study	G	"This study aims at enlarging the scope of its analysis by measuring the impact of its aromatic herbs and edible flowers "	replace by "a first GhG assessment was conducted in 2020 on Azura herbs and flowers, this study is un update of the 2020 study"	ok
6		1.2. Objectives of the LCA study	G	"The study aims to quantify the environmental impacts of herbs and flowers "	Replace "environmental impacts" by GhG emissions	ok
7		1.3. Organization of this report	E	"Appendix B specifies the sources of secondary information to model the tomatoes;"	Replace tomatoes by herbs and flowers	ok
8		2.3.3. Allocation rules	T	The comment on adding the sentence for the allocation of emissions from incineration with energy recovery was not		ok

				added (see comment 1 of first round of comments)		
9		2.3.3. Allocation rules	T	Remark 3 of the first round of comments has not been added		Already updated : "As the data provided was for all herbs and flowers produced (product types, markets), a mass allocation has been applied to get the impacts of 1 kg of herbs and flowers. For water impact, a surface allocation has been applied. " The surface allocation is only applied to water not refrigerant. For refrigerants, a mass allocation was applied.
10		2.6. Critical review	G	"This study has been carried out on behalf of Azura"	Replace by : "This updated study has been carried out by Azura based on the first study carried out by PwC"	ok
11		2.6. Critical review	G	"On completion of this study, Hélène Lelièvre (enviroconseil) carried out an independent critical review of the report." This sentence is no more adapted	Replace by : "Hélène Lelièvre (enviroconseil) carried out an independent critical review of the report, with 2 rounds of review"	ok
12		2.6. Critical review	G	"The external review took place in November 2021. "	Replace by "November and December 2022"	ok

13		2.6. Critical review	G	"The comments made by the representatives and the responses given by PwC, are presented in section VI of the report."	Replace by "the comments made by Azura are presented in…"	ok
14		3.2.2 Packaging	D	Why only refrigerants consumptions are updated ? Why not water and electricity consumption ?	Say explicitely what was not updated	We couldn't separate tomatos comsumption from H&F since there is a common water/electricity counter for tomatoes, herbs and flowers. Same assumption as last year were considered.
15		3.2.3 Distribution	D	"Distances have been evaluated based on Azura data (delivery cities) and Google Maps (road distance). " Nothing is said on the first transportation step between Agadir and Perpignan	Add a sentence saying the distance of transport that was considred for this first step	Distance between Agadir and Perpignan is set to 2190 km
16		3.2.3 Distribution	G	Table 7 and 8: the shares of each country is exactely the same as for the 2020 study: is it really the case ?	If not updated, say it explicitely or say if the shares are the same between 19/20 and 20/21	yes, same as last year "Shares of herbs and flowers distributed to different countries did not change between last year and this year. "
17		3.2.3 Distribution	E	"The hypotheses chosen for one punnet and for the storage conditions are detailed in tables 11, 12 and 13. "	Replace by "table 10 and table 11"	it's 3.2.6. Retailers – Distribution centres and it's correect : tables 11, 12 and 13 Hypotheses of storage (From DC to consumer) table 10 & 11 : Description of Azura products
18		3.2.8 Consumers	D	Table 13	add a source for the water consumption (PwC judgement)	ok

19		3,3. Comparison between 2020 and 2021 data	D	It is not transparent enough whas was updated and what was not	List explicitely which steps are using updated 2020/2021 data (farming and only refrigerants consumptions for packaging and packaging consumption). List the stages where no update was done (sorting/packging step, distribution step…). Say also that the LCA modeling did not change (only the main primary data from Azura)	ok
20		3,3. Comparison between 2020 and 2021 data	E	Tables have no number	Add a legend to the 2 tables	ok
21				First column heading of herbs is 2021 instead of 2020	Correct	ok
22		3,3. Comparison between 2020 and 2021 data	D		Add a column "change" showing the % of evolution between the 2 periods in both tables	ok

23		3,3. Comparison between 2020 and 2021 data	G		Add some comments below the tables on the evolution of the data between the 2 periods	ok
24		4.2 Results	G	Table 17 – Environmental impacts of herbs and flowers (company average)	Replace "environmental impacts" by GhG emissions	ok
25		4.2 Results	E	Table 17 – Environmental impacts of herbs and flowers (company average)	Remove the numbers after the comma for the values for other herbs than basil (to have the same format as basil)	ok
26		4.2.1 Greenhouse effect - Basil	E	Figure 4 –Main sources of greenhouse gas emissions and focus on the farming stage (basil). The legend is too small on the figure	Have the legend bigger	ok
27		4.2.2. Greenhouse effect – Other herbs and flowers	E	"the most of these emissions "	Remove "the"	ok
28		4.2.2. Greenhouse effect – Other herbs and flowers	E	Figure 7 – Focus on the farming stage: main emissions sources (other herbs and flowers). The legend is too small on the figure	Have the legend bigger	ok

29		4.2.3. Detailed Results		Table 18 – Detailed description of greenhouse gas emissions results for Azura herbs and flowers sold in Europe	same remark on values format as for table 17 for other herbs	ok	
30		page 29	E		Remove blank page	ok	
31		section V - Conclusions	G	"period covered by the study is July 2019 – June 2020. "	Replace July 2019 -June 2020 by July 2021-June 2021	ok	
32		section V - Conclusions	G	"Data collection and assumption used. This study is based on the 2019 herbs and flowers production grown in Agadir"	Replace by "2020-2021 period"	ok	
33		section V - Conclusions	T	"including construction materials for the farms and the plant nursery. "	Remove "nursery" as there is no nursery staep for herbs	ok	
34		section V - Conclusions	G	Average results for basil - "pesticide spreading"	Replace by "fertilisers speading"	ok	
35		section V - Conclusions	G	Average results for other herbs and flowers - "The Moroccan electricity is the first source of emissions within this farming step (38% of the total emissions)"	Correct to 30% as shown by table 18	ok	

36		section V - Conclusions	G	Average results for other herbs and flowers - " Fertilizers and pesticides spreading are together responsible for 31% of the total carbon emissions"	Correct the value with the right column of table 18 (% on the total and not on the farming step)	ok : 11%
37		Appendix A. - Life cycle analysis inventories	G	Table presents absolute values and not values for 1 ton	Present the ratio per ton or change the title	Data from Azura 2020-2021
38		Appendix A. - Life cycle analysis inventories		The farming step and packing step are missing (in last study, this was presented in the other report)	Add these steps with the values	This was presented on the tomatoes report only. Done