Interreg
Balkan-Mediterranean
BalkanRoad

Towards farms with zero carbon-, waste- and water-footprint. Roadmap for sustainable management strategies for Balkan agricultural sector

PROJECT DELIVERABLE

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1 Extended Summary

This report is the Deliverable 3.4.3 of the BalkanROAD project towards farms with zero carbon-, waste- and water-footprint. It compiles the three individual pilot areas Life Cycle Analyses reports and includes the LCA of all stages of the selected products' life (from cradle to grave) for each of them, their environmental impacts assessment and alternative practices/processes proposal that can improve them according to project's priorities. The LCA technique used for this deliverable preparation follows ISO 14040: 2006 and ISO 14044: 2006 guidelines and requirements and is performed in the proposed by the standards four phases.

The selected Functional Units according to which the analysis is carried out for the three pilot areas are one 0.75 L bottle of wine, one 275 mL jar of pepper paste in own sauce and a 1.0 L of apple juice. Furthermore the description of the three pilot areas is also included in the report, where the location, the main characteristics and the products of each one is presented.

The common system boundaries for all three individual cases covers an expanding "cradle to grave" approach including farm supplies, farm, processing and distribution as transportation to Thessaloniki port as a common reference and the analysed systems of each pilot are presented. Primary data collection was carried out by site visits and questionnaire use and secondary data were retrieved by well-known LCA databases. For Life Cycle Impact Analysis, five mid-point environmental impact categories were selected, which characterize the burdens of the agriculture production i.e. energy consumption, water consumption and emissions to air, water and soil. The categories are Acidification Potential, Eutrophication Potential, Ozone Depletion Potential, Global warming potential (100 years), Photochemical Ozone Depletion Potential and Cumulative Energy Demand.

The report also presents the analytical Life Cycle Inventory of the three pilot areas as resulted by the data collected. This includes analysis of all the inputs and outputs of the system as well as their quantification. The data quality is assessed according to ecoinvent methodology. Afterwards the Life Cycle Impacts Analysis is carried out for the five impact categories specified for each pilot area Functional Unit and according to the results interpretation conclusions as well as the suggestions are formulated.

2 Introduction

Agriculture is responsible for several environmental impacts as greenhouse gas emissions, water consumption and contamination and deforestation and the size of these impacts may depend on the applied agricultural approaches and practices [1]. The sector is also vulnerable to the climate change [2]. In this framework, the knowledge as well the assessment of these impacts throughout the life of an agriculture product enables the more effective choice and the improvement of the cultivation as well as the production methods in order to achieve their mitigation, guiding to environmental effective and sustainable agriculture and agri-food production.

This report summarizes the Life Cycle Analyses of three pilot sites in the framework of BalcanROAD project and presents the agriculture and agri-food production system of all stages of the products' life cradle i.e. field to market i.e Thessaloniki port at each of them, the Life Cycle Inventory and chosen Life Cycle Impacts Assessment for all three pilot sites. The results of this report are available for further analyses in order alternative practices/processes that can improve production from cultivation to processing according to project's priorities. The report will enable BalcanROAD project partners to decide further action and planning in order to achieve the project targets.

The three pilot areas under analyses are the following:

- KYR YIANNI S.A, Ktima Kyr-Yianni vineyard and winery at Yiannakochori, Naoussa, Greece
- EKO-GRUP, pepper cultivation field at Palikura and pepper paste processing unit at Kavadarci, FYROM
- BULGARPLOD KYUSTENDIL – Georgi Razsipiyski, apples plantation and juice production unit at Granitca, Bulgaria

3 Material and Methods

Life Cycle Analysis (LCA) is a technique to address the environmental aspects and potential environmental impacts throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal [3]. It is increasingly used for the improvement of the environmental performance of goods and services, including products belonging to the agri-food sector [4]. Therefore, it has also been included in BalcanROAD project WP as a useful tool for project priorities implementation.

Further to the BalcanROAD LCA Guidelines the technique helps to identify hot spots where the most significant impacts occur, giving the user the opportunity to develop strategies for improving the product's environmental performance. The use of LCA in environmental management and sustainability has gain considerable attention by researchers and related practitioners in recent years as seen in the steadily increasing number of published research on several case studies [5].

In respect to agriculture, LCA is a tool that can better place the 'food miles' concept into perspective, and enables farmers and agricultural enterprises to respond to demands and awareness from consumer and environmental groups about the carbon and water footprints of agricultural products. Both environmental demands and awareness influence the way in which legislative bodies such as governments will guide the future development of agricultural and industrial food production systems [5].

3.1 LCA Methodology

The LCA methodology is based on ISO 14040 : 2006 [3] and ISO 14044: 2006 [6] international standards. According to [3] there are four phases in an LCA study:

a) the goal and scope definition phase,

b) the inventory analysis phase,

c) the impact assessment phase, and

d) the interpretation phase.

The goal and scope definition phase shall specify the functional unit, studied system boundary and level of detail of the LCA. The life cycle inventory analysis phase (LCI phase) involves the collection of the necessary input/output data with regard to the studied system in order to meet the goals of the defined study. The life cycle impact assessment phase (LCIA) is the third phase of the LCA. The purpose of the life cycle impact assessment phase (LCIA) is to provide information for a product system's LCI results by assessing the impacts in order to understand their environmental significance. On the Life cycle interpretation phase the results of the inventory and impact assessment phase are summarized and discussed and the conclusions, recommendations in accordance with the goal and scope definition [3]. A schematic overview of a typical LCA is presented in Figure 1 [5].

3.2 Functional Units

The Functional Unit (FU) shall reflect the marketable product, including expected packaging of the final product. In order to ensure input and output data are normalised in a mathematically consistent way, functional units or/and reference flows shall be clearly defined and measurable [6, 5]. According to BalkanROAD LCA Guidelines [5] for example, the typical functional unit for a "cradle to grave" LCA of the wine production is a 0.75 mL bottle of wine. It is important to note that only the product suitable for sale on the market should be taken into account.

Based on the production characteristics and the related published literature [5], the functional units, presented in Table 1, have been selected for the three pilot areas under study. They have been chosen in order to represent the marketable agricultural products for each pilot.

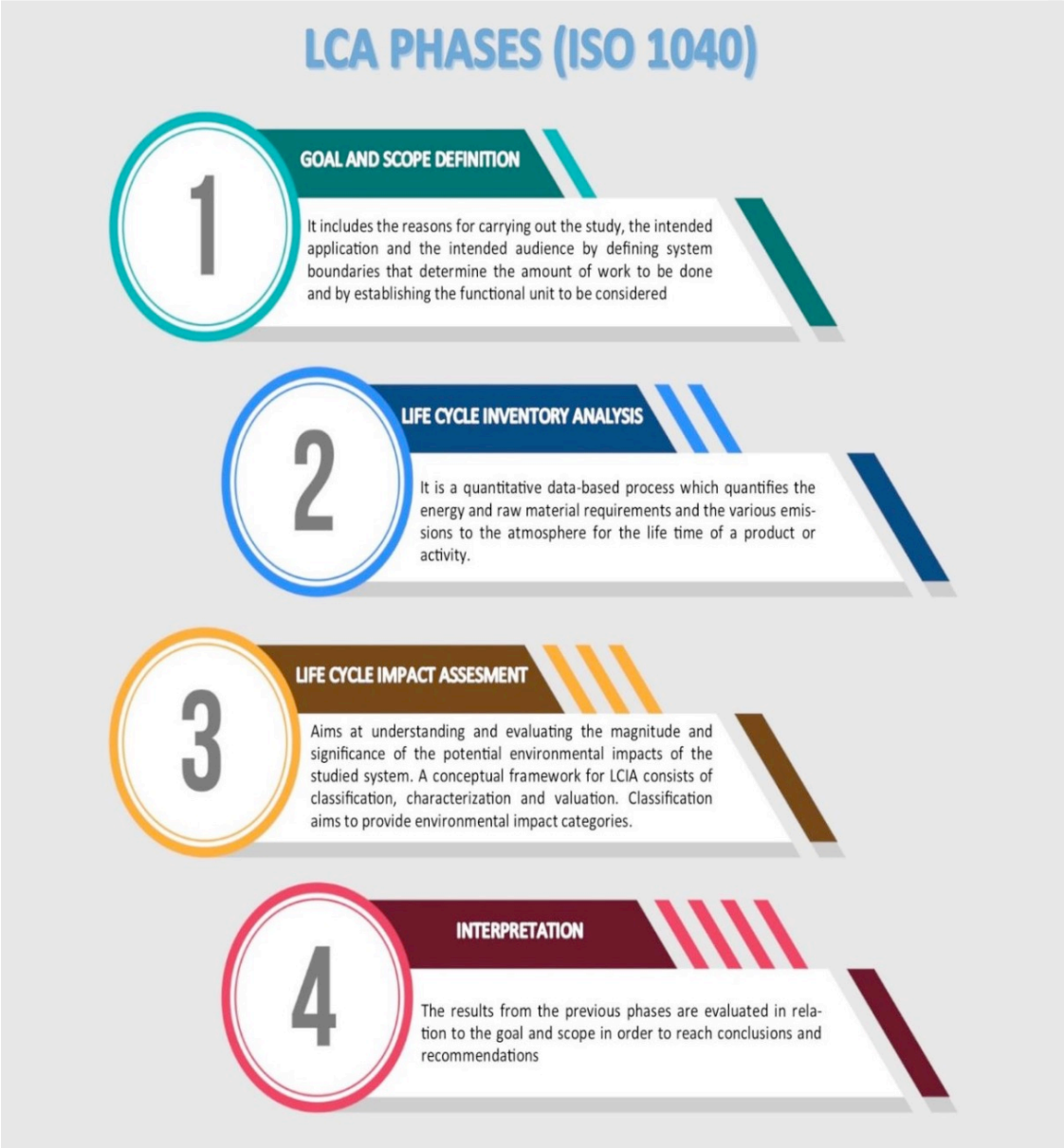

Figure 1. LCA steps in standardized methodology according to ISO 1040 standard [5]

Table 1. Functional Units for "cradle to grave" LCA studies conducted in the three pilot areas of the BalcanROAD project

Pilot area (District)	Agricultural production	Functional Unit	Unit
Greece (Naousa)	Wine/Vineyard	One bottle of wine	0.75 L
FYROM (Kavadarci)	Pepper Paste /Pepper	One jar of pepper "in own sauce"	275 mL
Bulgaria (Kustendil District)	Apple Juice /Apples	One bottle of juice (3)	1.0 L

Figure 2 presents photos of the three Functional Units.

One 0.75 L bottle of wine	One 275 mL jar of pepper	One 1 L bottle of juice

Figure 2. Functional Units (FU) photos

3.3 Study Areas description

The geographical positions of the three BalkanROAD pilot areas under study are presented on the map in Figure 3.

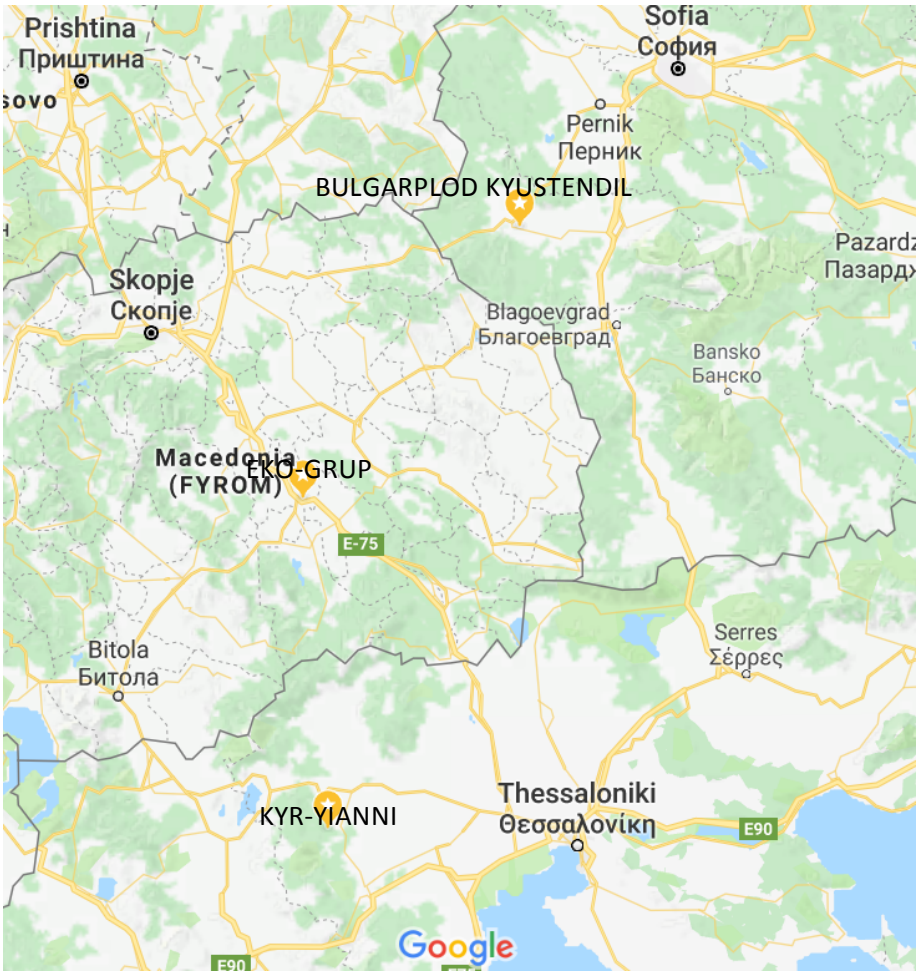

Figure 3. The three BalkanROAD pilot areas

The three BalkanROAD pilot areas, as taken into account for the LCA and described in [5] and the individual LCA reports [7, 8, 9], are presented in the following paragraphs.

3.3.1 Greece

According to the Greek Pilot Area LCA report [7] , "Ktima Kir Yianni" has been selected to join the BalcanROAD project activities. It is located near the city of Naousa which is located about 22 km north of Veroia i.e. the capital city of the Imathia regional unit in the Central Macedonia and 90 km east of Thessaloniki. It lies on the eastern foothills of Vermio Mountains, one of the biggest mountain ranges in Greece, and west to the plain of Kambania. Within the study area, Chamites (or Chanaktsi), at an elevation of 2062 m, is the highest point (Figure 4).

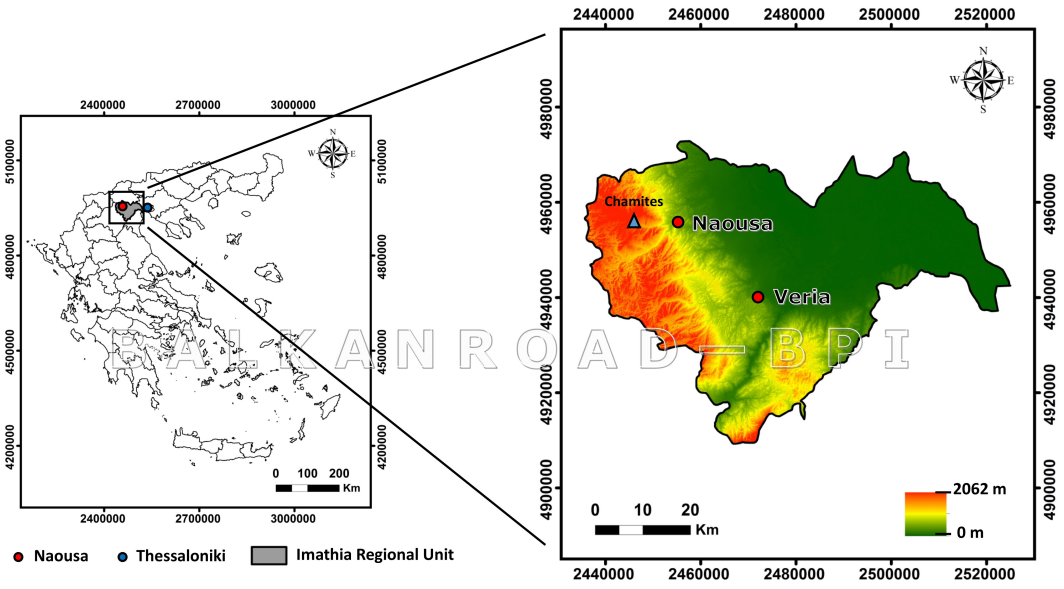

Figure 4. Location and altitude map of the Greek study area

Today, Naousa is one of the most prominent wine producing regions of Greece, with approximately 500 ha of cultivated - Protected Designation of Origin (PDO) - wine growing land spreading over an altitude rising from 80 to over 350 meters and about 20 wineries located in the wider area. Apart from vines, it is also surrounded by orchards, producing peaches, apples, cherries and other fruits.

The Greek wine producing pilot site "Ktima Kir-Yianni" is located about 3 km north of Naousa and covers a total surface of 58 hectares, which lies at an altitude of 280 to 330 meters i.e. the highest point of the Naousa PDO zone (Figure 5). Ktima Kir-Yianni is planted with Xinomavro (50%), Syrah (15%), Merlot (20%) and Cabernet Sauvignon (10%), while the rest of the area is covered with various experimental varieties, all trained in vertical shoot positioning (Figure 6). The mountainous mass of Vermion protects the vines from the cold winds coming from the north in the winter, and sends down a beneficial cool breeze during the summer, which is usually hot and dry.

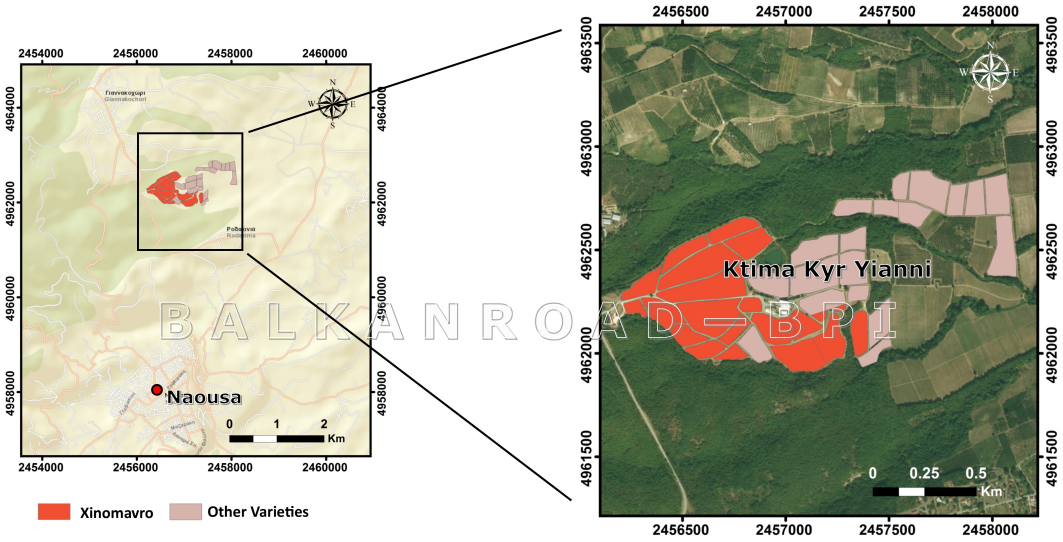

Figure 5. Location and wine-variety map of the Greek wine producing pilot site "Ktima Kir-Yianni" near Naousa

Figure 6. Vertical shoot positioning of the vineyards in the pilot site "Ktima Kir-Yianni"

3.3.2 FYROM

MOPF has selected one of the EKO-GRUP OCP company vegetable production plots to implement BalcanROAD project activities. EKO-GRUP manages most if its own vegetable in several locations within the Tikvesh region. The selected plot for BalcanROAD activities is located in Palikura village (about 10 km near Kavadarci). On this location EKO-GRUP OCP (Figure 7) company grows peppers (Kapia variety) in 0,5 ha in plastic tunnels (dimensions 5,1 x 33m) which are subject of the BalcanROAD activities , but also tomato, eggplant and garlic.

Crop rotation involves mostly chickpeas and kidney beans, but oats and barley are also used for weed control.

Figure 7. EKO-GRUP pilot farm in Palikura village, FYROM

All harvested products are transported to the EKO-GRUP OCP processing facility, located in Kavadarci and finalized in to a variety of jarred or bottled products. EKO-GRUP OCP processes about 70 different products made mostly from raw materials grown in own operations or in cooperation with local growers.

The main categories of products include:

- Pepper products
- Tomato products
- Eggplant products
- Chickpeas and kidney bean products
- Fruit products
- Leafy greens products

EKO-GRUP OCP sells products on both the domestic and export markets in the region, EU but also overseas markets like Canada, Australia and New Zealand.

Photos of EKO-GRUP pilot farm are presented in Figure 8.

Figure 8. EKO-GRUP pilot farm photos

3.3.3 Bulgaria

The "BULGARPLOD KYUSTENDIL – Georgi Razsipiyski" is a company specialized in the processing of fresh fruits and vegetables. It has been selected one of the BULGARPLOD KYUSTENDIL company production plots to implement BalcanROAD project activities, located in Kustendil District (Figure 9), between the villages of Piperkov thchiflik, Granitca and Bagrenci. The total land of the pilot farm occupied with orchards is 27,7606 ha as follows: Apples - 25,1829 ha, Plums - 2,2280 ha and Cherries - 0,2497 ha.

Figure 9. BULGARPLOD KYUSTENDIL pilot farm in Kyustendil District, Bulgaria

The company's factory is located in village Granitsa, district Kyustendil, whereas it successfully develops and imposes on the market its brand "BAGRA" with the offering of high quality products, appropriated for a wide circle of consumers. The company has at its

disposal several production bases as well as a multitude of product range. The bases are designed and constructed depending on the contemporary requirements, whereas they have at their disposal new production and warehouse premises and furthermore the latter are equipped with European machines and facilities, fully corresponding to the requirements about quality and safety of the food.

- Industrial unit for the production of direct fruit juices:
- Apple juice
- Apple juice with slightly sour taste
- Juice from apples, pears and quinces
- Juice from apples and Morello cherries
- Juice from apples and grapes
- Juice from apples and raspberries
- Juice from apples and bilberries

The offered variety of juices are prepared in different parceling and packages - boxes “Bag-in-box” with volumetric capacity of 3 l and glass bottles with contents of 1 l and 0.250 l.

The technology of the direct juices from fruits is cold pressed juice, without added sugar, sweeteners, water, preservatives, concentrates, flavors. The advantage of «Bag-in-box» package is the method for storing and pouring without oxygen access from outside, preserving the juice from loss of taste qualities and oxidation.

- Industrial unit for dry fruits and vegetables:
- Dried black cherry
- Dry apricot
- Dry plum
- Dry apple
- Dry aronia
- Dried fruit mix /cherry, blue plum, blue plum and aronia/
- Dried fruit mix /cherry and apricot/
- Dried vegetables - Tomatoes, Peppers
- Fruit chips - Apples, Pears, Mix /apple and pear/

Figure 10. BULGARPLOD KYUSTENDIL pilot farm photos

The offered variety of dried fruits and vegetables are offered in different parceling – bag with capacity of 0,100 kg. / 0,200 kg.

Photos of BULGARPLOD KYUSTENDIL pilot farm are presented in Figure 10.

3.4 System Description

In the frame of BalcanROAD and according to the LCA Guidelines [5], the "cradle-to-grave" approach will be used (where possible), considering all production processes involved from raw materials extraction (i.e. the cradle) to the point where the final product is made available to the market (i.e. the gate after processing) (Figure 11).

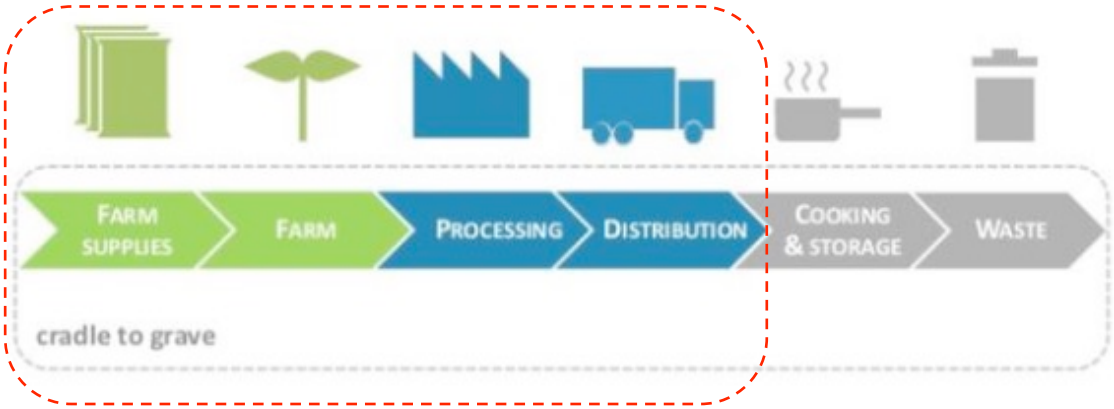

Figure 11. System boundaries adopted in the BalcanROAD project (red circle) [5]

However, aiming to establish a reliable comparison basis of the marketable products under study, an expanding "cradle-to-grave" approach will be adopted in the BalcanROAD project, including the stage of distribution. In this context, the port of Thessaloniki is used as the final destination of the LCA study, common for all the marketable products and Functional Units [5].

Since the LCA concerns the cultivations under study and in turn, the products delivered to market, ingredients of the marketable agri-food products that are not produced in the pilot farms e.g. salt, oil in pepper paste is assumed that are not included in the applied LCA.

3.4.1 Software

The three pilot areas LCA's were carried out by using the open source and free software openLCA, which was developed by GreenDelta [10]. Many free and commercial LCA databases and LCIA methods can be imported in the software, so it gives the ability to design a life cycle system by connecting all LCI elements and to quantify the LCIA according to the method used.

3.5 Data Collection

According to the BalkanROAD LCA Guidelines [5] and the individual pilot areas LCA reports [7, 8, 9], data collection was conducted through in-situ/field campaigns and voluntary survey of growers, agronomists etc. operating in each pilot area. This approach aims to increase the

credibility of LCA and to draft conclusions relying on the local agricultural and economic conditions. So primary site-specific data was obtained with the use of a questionnaire for each pilot farm. Where possible, based on the primary data derived, direct field emissions from farming activities in every environmental medium (water, soil and air) ware estimated. To complete the life cycle inventory, data associated with the operations performed in the background system (agro-chemicals production, fertilizers production, machinery production and transportation) were drawn from literature and other available LCI databases i.e. Ecoinvent v3.3 and Agribalyse v1.2 and v1.3. Data included common farm management and normal mode of field-work processes for agricultural production (both cultivation and processing/post-harvest), by considering data extrapolated from the past 5 years (2013-2017), except the Palikura pilot area where last 3 years data were used.

3.6 Impact categories

Further to the goal and the scope of BalkanROAD LCA, five mid-point environmental impact categories, were calculated for pilot farms Life Cycle Impact Assessment. The four of them are defined according to the CML 2001 (April 2013 and January 2015 version) impact assessment method of the Centre of Environmental Science of Leiden University [11]. The fifth is the impact category of the cumulative energy demand as an energy flow indicator can be calculated according to [12]. The environmental impact categories for BalkanROAD are presented in Table 2.

Table 2. Environmental impact categories for BalkanROAD LCIA

Impact Category	**Acronym**	**Unit**
Acidification potential	AP	kg SO_2-eq· FU^{-1}
Eutrophication potential	EP	kg PO_4-eq· FU^{-1}
Global warming potential (100 years)	GWP	kg CO_2-eq· FU^{-1}
Ozone depletion potential	ODP	kg CFC-11-eq· FU^{-1}
Photochemical ozone creation potential	POCP	kg C_2H_4-eq· FU^{-1}
Cumulative energy demand	CED	MJ-eq·FU^{-1}

Above impact categories are linked to the main environmental burdens of agriculture production including emissions to soil, air and water, as well as energy related environmental impacts. Literature extracted impact categories calculations for similar to the pilot areas Functional Units, activities or products are presented in Table 3 for reference purposes.

Table 3. BalkanROAD similar activities LCIA (literature extracted)

Product [Reference]	AP kg SO_2-eq· FU^{-1}	EP kg PO4-eq· FU^{-1}	GWP kg CO_2-eq· FU^{-1}	ODP kg CFC-11-eq· FU^{-1}	POCP kg C_2H_4-eq· FU^{-1}	CED GJ-eq·FU^{-1}
0.75-L bottle of organic red wine **[4]**	0.013	0.006	1.704	1.43E-7	5.3E-4	
One bottle of Red High Quality wine **[13]**			1.58E+00	3.91E-08		
One tonne of fresh apples **[14]**	0.95	0.44	89			1.21
Apples production ha-1 (means) **[15]**	25.4		2600			37.6
Greenhouse peppers (Mean of a group of foods/kg produce) **[16]**			1.02			
Pepper (FU 1000 kg) **[17]**	6.9	3.4	915.5	4.0E-04	0.3	18
Apples production 1 ton (conventional) **[18]**			6.12E+02	8.54E-05		
Apples production 1 ton (organic) **[18]**			5.88E+02	8.46E-05		

4 Life Cycle Inventory

LCI analyses is an inventory of the input/output data with regard to the system being studied [3]. A presentation of common system inputs, processes and outputs for the three pilot areas is presented in Figure 12. Adjustments for each pilot study area are applied but the general inventory is included in the flow chart.

4.1 Systems modelling

The Greek pilot area LCA flow diagram for the wine production as modelled in the OpenLCA v 1.7.0 software, concerning main phases is given in Figure 13 [7]. The openLCA FYROM pilot area flow diagram for the peppers in own sauce production is presented in Figure 14 [8] and the openLCA Bulgaria pilot area flow diagram for the apple juice production is presented in Figure 15 [9].

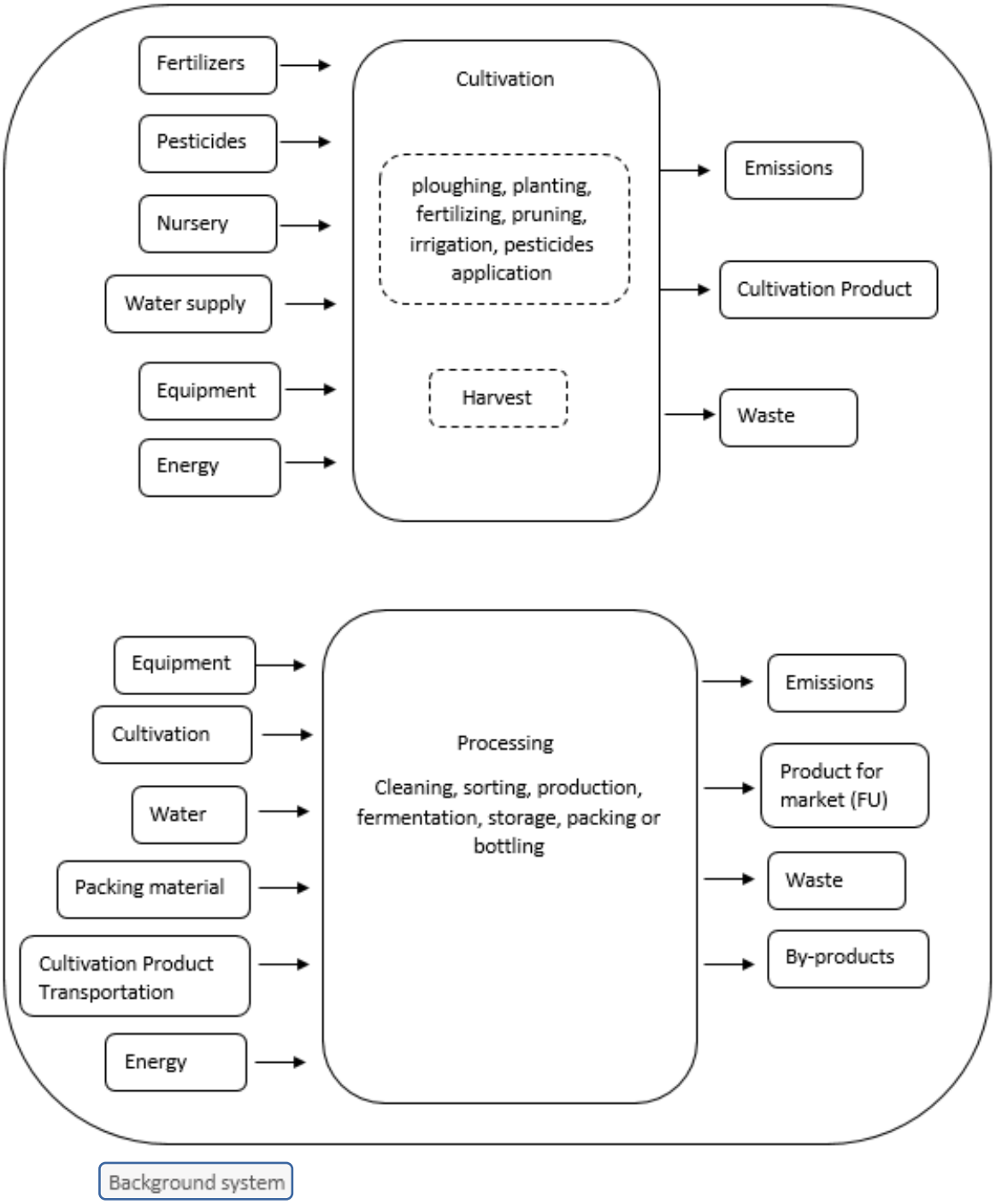

Figure 12. Presentation of system inputs, processes and outputs

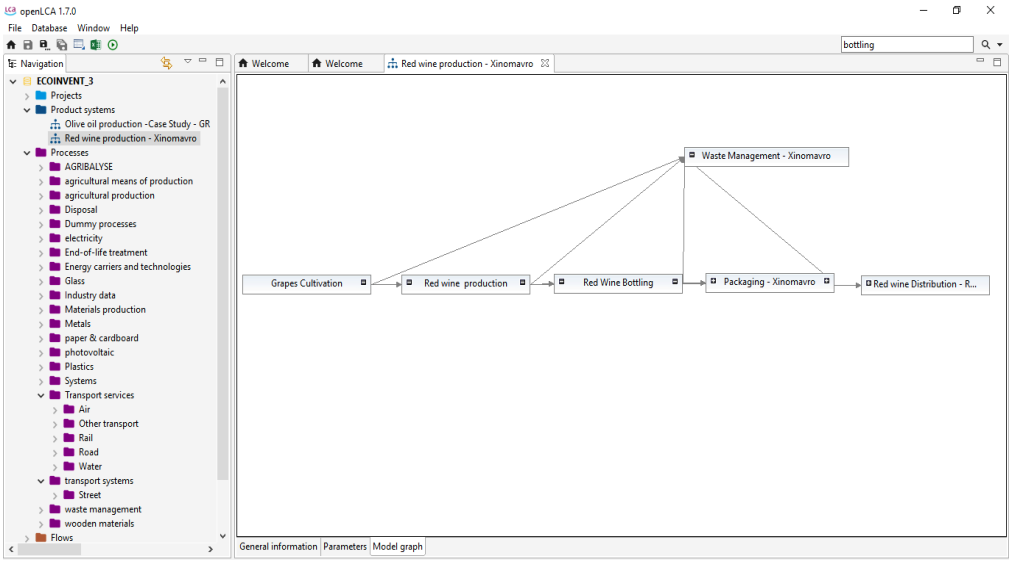

Figure 13. Life cycle modelling of the main phases considered for the environmental impact assessment of wine production under study [7]

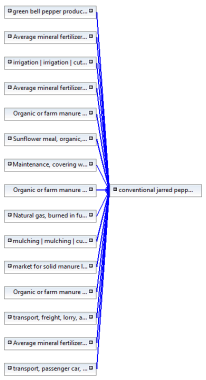

Figure 14. Life cycle modelling of the main phases considered for the environmental impact assessment of own sauce production production under study [8]

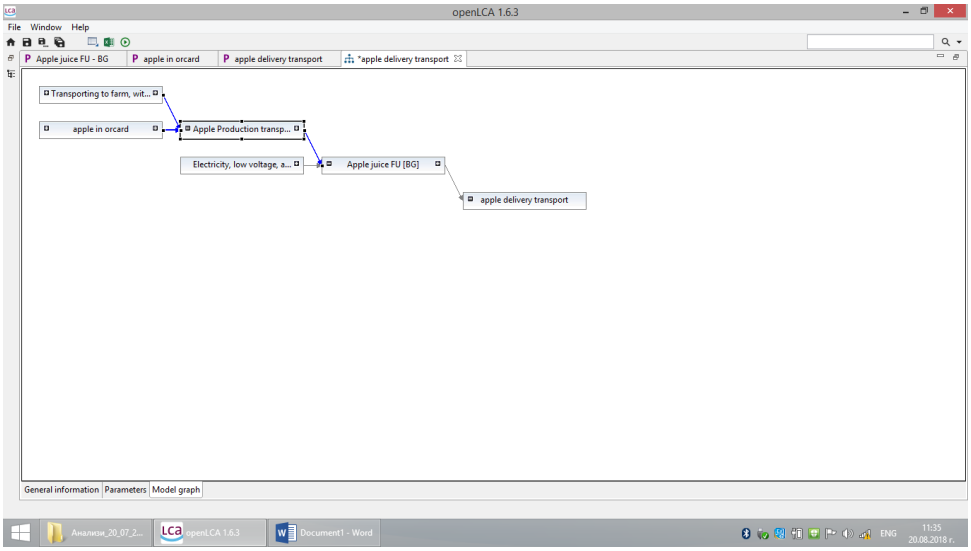

Figure 15. Life cycle modelling of the main phases considered for the environmental impact assessment of apple juice production under study [9].

4.2 Life Cycle Inventory

The primary data for the Life Cycle Inventory for each pilot area are included in the completed questionnaires. Other data regarding orchard and processing as well as background system data for inventory are available through secondary data sources as relevant scientific literature and databases i.e. Ecoinvent and Agribalyse. Table 4 include the basic elements of the Life Cycle Inventory of the three pilot areas.

Table 4. BalkanROAD LCI basic elements

Input / Output	**Pilot Area**		
	Greece (grapes/wine)	**FYROM*** (peppers/pepper paste)	**Bulgaria** (apples/apple juice)
Orchard production (average last 5 years)	8090 kg/ha	48000 kg/ha	1690 kg/ha
Fertilizers	YARA BELLA (P) 200 kg/ha/year Patenkali (K) 200/ha/3 years	KAN (potassium Ammonium Nitrate) 300 kg/ha/year NPK 10-30-20 500 kg/ha/year	$NH_4NO_3^-$ 120 kg/ha/year P_2O_5 80 kg/ha/year K_2O 200 kg/ha/year
Organic Fertilizers	--	30 manure ton/ha / 3 years 0,7% N P2O5 0,22% K20 0,8%	--
Pesticides	63.75 L / ha / year	21 kg / ha / year	5 L / ha / year
Irrigation water	0 -1000 m^3/ha/year	30 m^3/ha/year	1400 m^3/ha/year
Orchard diesel demand	7000 L/year	300 L/year	15000 L/year
Orchard electricity demand	0	0	200000 KWh/year
Orchard lubricants demand	250 L/year	4 L/year	50 L/year
Waste by orchard	2800 – 3000 kg/ha pruning 7.5 kg/ha plastic containers (recycling)	15 kg of pesticides packaging/years 333 kg / ha / year of plastic tunnel film 1500 kg crop residues/year 400 kg / ha / year of black plastic mulching film	4800 kg/ha pruning 12 kg/ha plastic containers (recycling)
Working hours (cultivation)	372 /ha / year	786 / ha / year	1135 / ha / year

Input / Output	Pilot Area		
	Greece (grapes/wine)	**FYROM*** (peppers/pepper paste)	**Bulgaria** (apples/apple juice)
Processing water consumption	0.2 m^3 / ton of processed grape	4.5 m^3 / ton of processed peppers	n/a
Processing electricity demand	84000 kWh / year	190 kwh per month	40000 kWh/year
Processing gas demand	--	60 L/tone (LPG)	n/a (Natural Gas)
Processing lubricants demand	10 L/year	20 L/year	8000 kg/year
Packaging material	1 glass bottle, paper label / FU	1 glass jar, lid and paper label / FU	1 glass bottle and PVC label / FU
Waste by processing	20% Grape marc	Organic waste 35 tons/year Plastic 300 kg / year Paper 100 kg / year	90% Apple jelly Apple skins 1000 kg / ha / year
Waste water by processing	0.2 m^3 / ton of processed grape	300 m^3 / year	n/a
Transportation distance (orchard to factory)	50 – 500 m	10 km	4 km
By-products	20% Grape marc	none	Apple flower
Equipment (orchard & product preparation)	Cars Agriculture tractors Irrigation Pumps Power and hand tools Conveyor Lifts Pallet trucks Freezing chambers Bottling machine Labelling machine Wine pumps	Agriculture tractors Irrigation Pump Freezing chambers Unloader Conveyor Roasting ovens Peeling machine Cutting machine Cooking machine Filling machine Labelling machine LOT printer Water pumps Lifts Pallet trucks Power and hand tools Pasteurization machine	Cars Agriculture tractors Irrigation Pumps Power and hand tools Lifts Freezing chamber Pressing machine Pasteurization machine Mimmer machine Bottling and packing machine Water pumps
FU production	0.6 L wine / kg grapes	1.5 jars / kg pepper	0.6 L juice / kg apples

*Reference to last 3 years

4.3 Data Quality

According to [7, 8, 9] primary data for the three pilot areas LCA studies was collected through in-situ surveys conducted in the pilot areas and secondary data were drawn from well-established LCI databases i.e. Ecoinvent v3.3 and Agribalyse. Assessment of the quality of the data for the LCI for the three pilot areas has been prepared according to the ecoinvent guidelines [19]. The assessment results are presented in Table 5.

Table 5. BalkanROAD LCI quality assessment

Assessment Indicator	Indicator Score (Table 10.4, [19])	
	Primary data	Secondary data
Reliability	3	3
Completeness	1	5
Temporal correlation	1	5
Geographical correlation	1	4
Further technological correlation	1	4

Although primary data acquired by survey are of high quality, secondary data mainly concerning the background systems could be improved. The main burden is that Balkan Countries accurate data are not included in the available databases. So referring this report and the LCA's prepared an issue should be discussed is the data quality and measures to improve them, especially for secondary data.

5 Life Cycle Impact Analyses

The Life Cycle Impact categories for the three pilot areas have be calculated by using openLCA software. For the Greek pilot area the CML 2001 (April 2013 version) was used and for the other two pilot areas CML (baseline) [v4.4, January 2015] European reference inventories. Cumulative energy demand (CED) impact category calculation was based on the method proposed by Frischknecht et al. [12].

The impacts of each category as calculated for the three pilot areas are presented in Table 6.

Table 6. BalkanROAD LCIA for the three pilot [7, 8, 9]

PILOT SITE (FU)	AP kg SO_2-eq· FU^{-1}	EP kg PO4-eq· FU^{-1}	GWP kg CO_2-eq· FU^{-1}	ODP kg CFC-11-eq· FU^{-1}	POCP kg C_2H_4-eq· FU^{-1}	CED MJ-eq·FU^{-1}
KYR-YIANNI (One 0.75 L bottle of wine)	1.98E-02	5.62E-03	1.10E+00	2.21E-07	4.48E-04	2.13E+01

PILOT SITE (FU)	AP kg SO_2-eq· FU^{-1}	EP kg PO4-eq· FU^{-1}	GWP kg CO_2-eq· FU^{-1}	ODP kg CFC-11-eq· FU^{-1}	POCP kg C_2H_4-eq· FU^{-1}	CED MJ-eq·FU^{-1}
BULGARPLOD KYUSTENDIL (One 1 L bottle of juice)	1.41E+01	3.49E+00	2.02E+03	0.00E+00	1.26E-01	2.27E+06
EKO-GRUP (One 275 mL jar of pepper paste in own sauce)	3.50E+02	1.37E+02	7.46E+04	3.63E-03	2.27E+06	7.13E+05

6 Conclusions and discussion

Although LCA and LCIA is widely used in studies to asses Life Cycle environmental impact of several agriculture and agri-food products including the BalkanROAD pilot farms products [4, 10, 11, 12, 13, 14], the available literature does not cover neither the total range of impact categories was selected to be assessed nor all the products under study. Besides wine in a 0.75 L glass bottle, which Life Cycle has been analysed for several production areas and varieties, pepper paste and apple juice products have not been any LCA study topic. Furthermore the available information for the five mid-point environmental impact categories i.e. AP, EP, GWP, ODP, POCP and CED size do not cover the range selected for the pilot orchards and products. Literature extracted LCIA is able to help to some conclusions, but such an interpretation is not able to provide all the needed information for further use towards farms with zero carbon-, waste- and water-footprint.

The interpretation of the LCI and LCIA of the three BalkanROAD pilot farms features the differences of agriculture as well as processing practices followed in each one. Taking into consideration that three different crops and agri-food products are studied, the differences of inputs, outputs size between the pilot areas feature issues could be discussed but impact categories size cannot be compared. A common observation is that the five selected environmental impact categories have value for all the pilot areas (except ODP for the Bulgarian pilot) so there are significant. Therefore selected measures could be implemented and mitigate them.

According to [11] for AP impact category, the major acidifying pollutants are SO_2, NO_x and NH_x. For EP, excessively high environmental levels of macronutrients such as nitrogen (N) and phosphorus (P) are important. For ODP, emissions of CFC and Halon is a major factor as toluene, trans–2-Butene, trans–2-Hexene and trans–2-Pentene among others is for POCP. GWP100 is depended on emissions of greenhouse gases to the air throughout the full process. Finally, all life cycle energy need and energy intensive factors affect each product CED. Measures to decrease either use or emission of these elements could contribute to impact categories size.

In order, farms with zero carbon-, waste- and water-footprint target to be achieved good agriculture as well as production practices should be obvious throughout the orchard to product life of all the three products. Depending on the crop and product processing, issues to consider in order mitigating the environmental impacts of the three pilot areas activities are the following.

- Chemical fertilizers and pesticides use as well as plastic film waste should be minimized and products with low life cycle environmental impact should be preferred.
- Packaging materials use should also be minimized and raw material with low life cycle environmental impact should be preferred.
- Renewable energy should be preferred in all product processing phases.
- Equipment with low Life Cycle Environmental Impact should be used. Equipment used in all phases, should also be well maintained.
- Fruits or vegetables and final product cooling equipment should be controlled and well maintained.
- Low environmental impact transportation means should be preferred.
- Transportation distance should be minimized where possible.
- Waste reducing, reusing and recycling should be adopted in all life cycle of the pilot products.

Although zero impacts size is a demanding task, above suggestions particularization and implementation in each one of the three pilot areas could lead to alternative processes that may improve production from cultivation to processing and have a considerable effect to the impact categories size.

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