Perú

Analysis, measurement, and interpretation

of the environmental footprint of the alpaca value chain based on a Life Cycle Analysis (LCA)

USE AND END-OF-LIFE REPORT

PERÚ Ministerio de Comercio Exterior y Turismo

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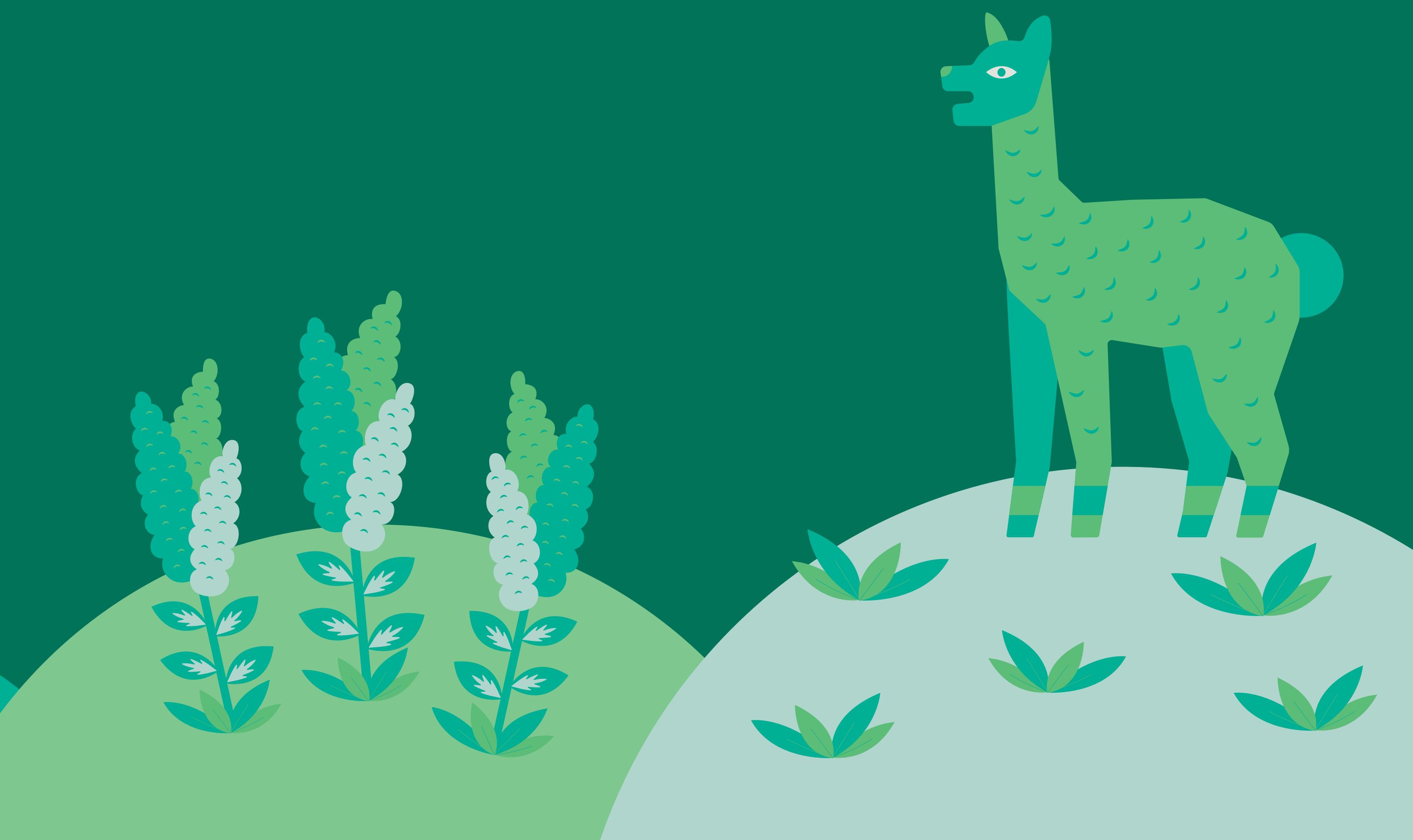


Environmental footprint of alpaca fiber in its complete value chain using the Life Cycle Analysis tool

This report summarizes the study of the Life Cycle Analysis (LCA) of alpaca fiber throughout its value chain to find its environmental footprint. The study was conducted following the LCA methodology, according to the ISO 14040 and 14044 standards.

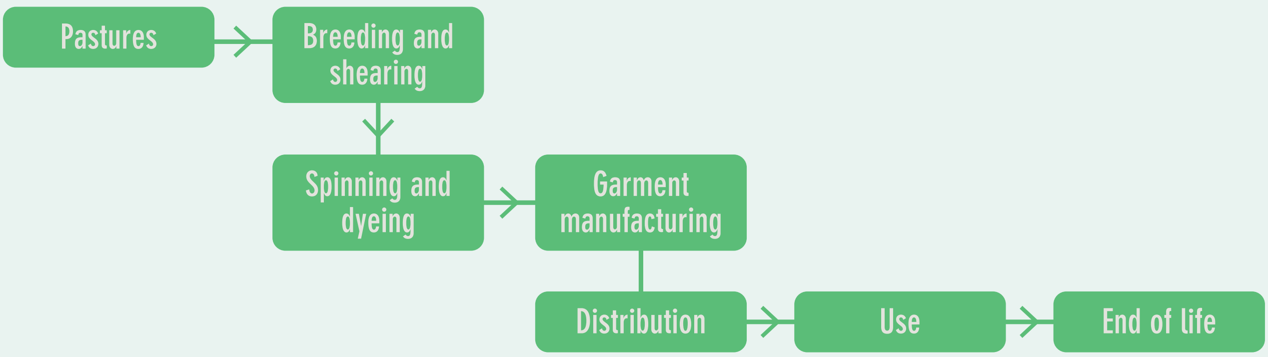
1. GOAL

Identify, analyze, and calculate the environmental impacts of the alpaca fiber at each stage of the life cycle, as well as the drivers of these impacts. Results, conclusions, and recommendations of this study will aid in decision-making that contributes to the sustainability and competitiveness of the business sector.

2. SCOPE

The product evaluated in this study is a garment made with alpaca fiber weighing 400g. Based on the LCA, the scope of the study included pastures, breeding, shearing, spinning, dyeing, manufacturing, distribution, use and the end of life of the garment, as shown in Figure 1.

FIGURE 1. SCOPE OF THE ALPACA SWEATER PRODUCTION SYSTEM



The environmental impacts of the life cycle of the alpaca fiber garment must be referenced to a functional unit (FU). The FU is based on providing a reference from which all the input and output data of the production system are mathematically normalized (Aranda et al., 2006). The function of the system is defined as the use of the garment made from alpaca fiber. Therefore, the FU selected for the system of this study is defined as one use of a sweater weighing 400g made exclusively with alpaca fiber.

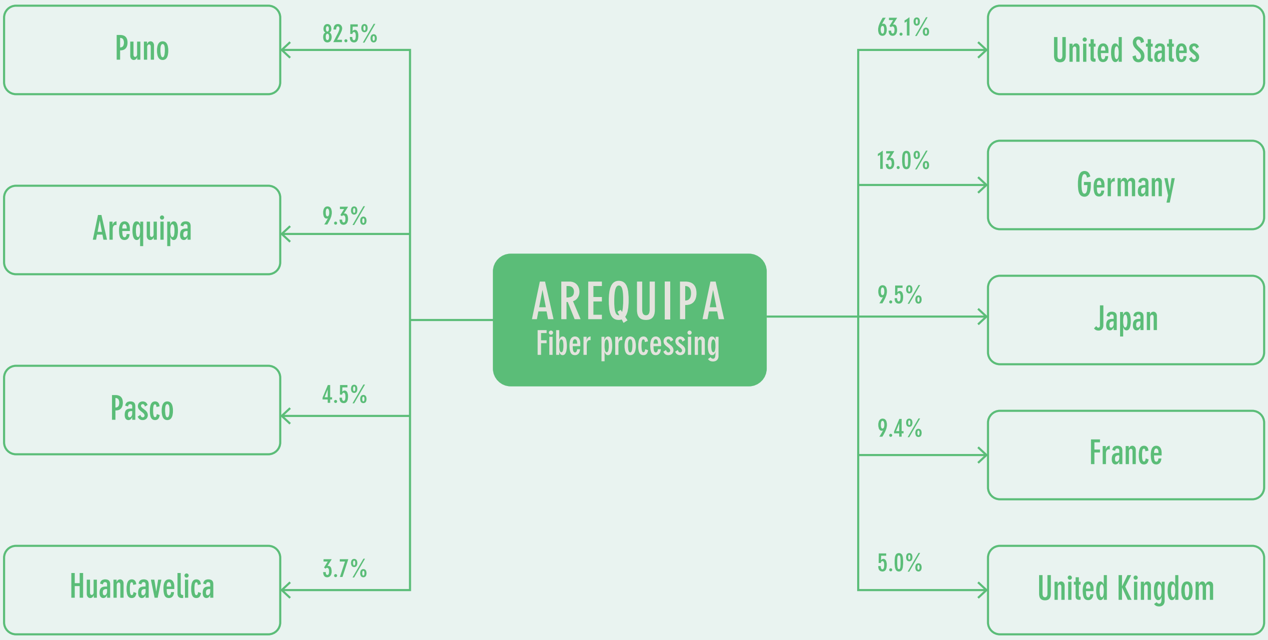
3. INVENTORY

Inventory is the identification and quantification of all inputs (resources, materials, or energy) and outputs (waste, effluents, or emissions) at each stage of the life cycle of the product. These amounts should be referenced to the FU.

Information from primary sources, in the form of questionnaires and interviews with those responsible for the different processes throughout the life cycle of alpaca fiber, were mainly used during data collection. The production systems of each of these companies and organizations were modeled and then combined according to their participation in production. In this sense, the alpaca fiber of the regions Puno, Arequipa, Pasco, and Huancavelica have participation rates of 82.5%, 9.3%, 4.5% and 3.7% with respect to the total volume of alpaca fiber that serves as raw material for the spinning mill companies (MIDAGRI, 2020).

There are two companies that are involved in the spinning and dyeing stages of fiber processing in Peru. Due to a lack of provided information, we assumed an impact allocation of 50% of total spinning production to each company and used only one company's data for dyeing. For the manufacturing stage, each company was assigned an impact allocation value according to its annual production volume (Kero, 4.15%; Incalpaca 94.05%, Brisan, 1.79%) (see Figure 2). In addition to showing the combination of fiber flows from different regions, Figure 2 also shows how the garment distribution has been considered in the exportation to different countries.

FIGURE 2. FIBER AND GARMENT FLOWS FROM DIFFERENT REGIONS TO DIFFERENT EXPORT DESTINATIONS

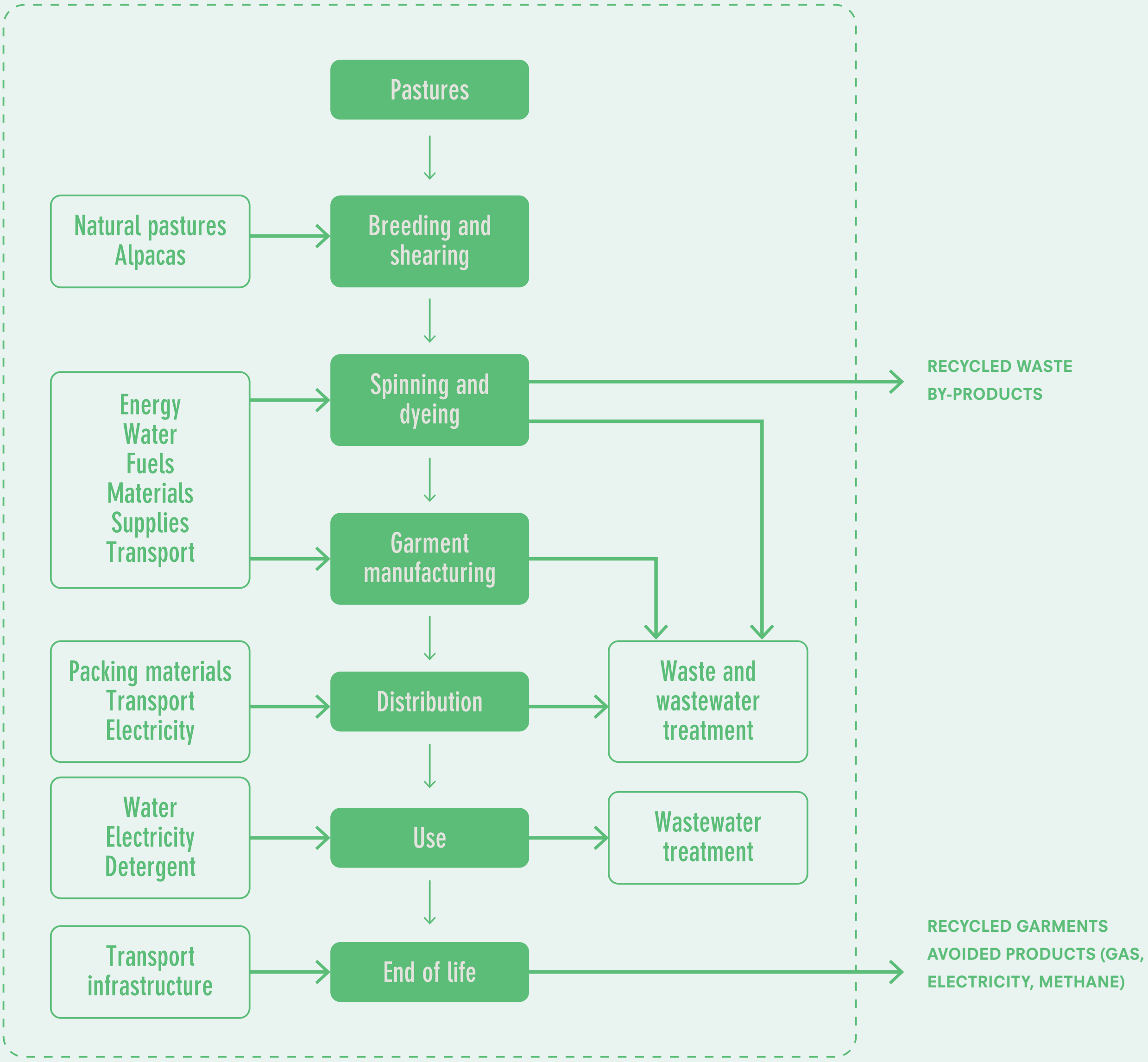


Secondary data were obtained from the literature for the production system under study and from the Ecoinvent v3.3® database (Werner et al., 2016). For the materials and components used in production processes and their transport, the impacts were modeled using the Ecoinvent® database v.9.1.1.1. Faculty.

The questionnaires carried out in the natural pastures, breeding, and shearing stages were validated by officials of the General Directorate of Agrarian Development. Questionnaires from the spinning, dyeing, and clothing stages were validated by professionals from the companies involved.

The limits of the system are from cradle to grave, involving the main activities to obtain the alpaca fiber, its processing in the factory, distribution, use and final disposal of the garment. Also, the inventory analysis includes all the inputs and outputs of the processes related to the stages of obtaining the fiber (natural pastures, breeding, and shearing), as well as the subsequent processes related to factory production (spinning, dyeing, and garment manufacturing) up to the distribution, use and final disposal, as shown in Figure 3.

FIGURE 3. STUDY SYSTEM INPUTS AND OUTPUTS



In this study, 109 uses were considered (includes 2 different users) during the entire life cycle of the garment and that it is washed after every 5.2 uses, which leads to a total of 21 washes during its useful life (Wiedemann et al., 2020).

4. ENVIRONMENTAL IMPACT ASSESSMENT

For the environmental footprint, environmental impacts were calculated in four categories: global warming, eutrophication, water consumption and abiotic depletion (fossil fuels). Table 1 shows the categories and their corresponding environmental assessment methodologies.

TABLE 1. ENVIRONMENTAL IMPACT CATEGORIES AND METHODOLOGIES

METHODOLOGY	IMPACT CATEGORY	REFERENCE UNIT
IPCC - 2013	Global warming	kg CO_2-eq
CML - 2013	Eutrophication	kg PO_4-eq
ReCiPe 2016	Water consumption	m^3
CML- 2013	Abiotic depletion (fossil fuels)	MJ

The emissions from the stage associated with natural pastures, breeding and shearing (including enteric fermentation, decomposition of excreta, and phosphorus content in soils, among others) were modeled using global formulas and secondary sources such as publications from the Ministry of Agriculture and undergraduate theses. In addition, factors, and methods of evaluation of emissions from agricultural systems were considered, for example, the leaching factors for pastures of Nemecek and Schnetzer (2011).

The environmental impact allocation of the alpaca system was assigned 50% for obtaining alpaca fiber and 50% for the alpaca meat, according to an interview with Daniel Aristegui, Manager of the International Alpaca Association (IAA).

Table 2 shows that the impact associated with 1 kg of alpaca fleece is lower in Pasco with 45 kg CO2- eq/kg of fleece than in other regions. In Huancavelica, the region with the highest impact, 2.4 times more CO2-eq emissions are generated per kg of fleece than in Pasco.

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TABLE 2. ENVIRONMENTAL IMPACT FOR 1 KG OF ALPACA FLEECE ACCORDING TO REGION

	AREQUIPA	PASCO	PUNO	HUANCAVELICA
Global warming (kg CO2 – eq)	82.4	45.0	62.6	109.0

While the sources of greenhouse gas emissions are the same in the four-alpaca fiber-producing regions, the impacts per kg of fleece vary considerably from region to region. The main reason for these differences is the average percentage of the alpaca herd shorn, which in 2019 reached 84% in Pasco, while in Huancavelica only accounted for 34%. A low percentage of animals shorn translates into high environmental impacts per unit of fleece because all alpacas emit, for example, methane, including those that are not shorn. It should be mentioned that the primary data used in this study is from one year and that factors such as fiber prices and context also influence the decisions of alpaca producers and, therefore, also determine the percentage of animals shorn annually in each herd. For this reason, the management of alpaca units could be better reflected by using data from several years.

TABLE 3. ENVIRONMENTAL IMPACTS FOR ONE USE OF AN ALPACA SWEATER (0.4 KG)

LIFE CYCLE STAGES	GLOBAL WARMING (kg CO_2-eq)	EUTROPHICATION (kg PO_4-eq)	WATER CONSUMPTION (m^3)	ABIOTIC DEPLETION - FOSSIL FUELS (MJ)
Pastures, breeding, and shearing	0.314	4.50E-04	6.37E-07	0.003
Spinning and dyeing	0.028	5.09E-05	9.93E-04	1.091
Garment manufacturing	0.017	5.44E-05	9.35E-04	0.639
Distribution	0.065	7.49E-05	2.19E-04	0.869
Use	0.017	6.95E-05	1.88E-04	0.197
End of life	0.008	-2.97E-06	-3.93E-06	-0.007
Total	**0.449**	**0.0007**	**0.002**	**2.792**

The potential impacts for global warming amounts to 0.449 kg CO2-eq per use, where 70% of the impact corresponds to the pasture, breeding and shearing stage, 9.02% to the fiber processing stage (spinning, dyeing, and manufacturing), 14.45% at the distribution stage, 3.87% at use and 1.80% at the end-of-life stage. Analyzing the pasture, breeding and shearing stage in greater detail, the process that most contributes to the impact is enteric fermentation and the resulting methane (85% of the impact in this stage).

The second stage with the greatest contribution to the global warming environmental impact is the distribution stage. This stage contains the product's packaging material, export by air and sea to the destination countries, road distribution to the sales center, retail (energy consumption at the sales center) and transport from the retail center to the user. Retail and road distribution represent 54%, and exports by air and sea 46% of the impact in this category. A change of means of transportation in each of these two stages (from airplane to cargo ship or from truck to train) could reduce the impacts at this stage.

The eutrophication potential amounts to 0.0007 kg PO4-eq use, where 65% of the impact corresponds to the pasture, breeding and shearing stage, 15% to the fiber processing stage, 10.75% to the distribution stage, 9.96% to use and -0.43% to the end-of-life stage. The sources of nitrogen and phosphorus in the alpaca rearing stage are alpaca feces and the same phosphorus from the soil that, through the process of soil erosion, can reach bodies of water. In the fiber processing, distribution and use stages, the eutrophication potential is mainly linked to the consumption of electricity and fossil fuels and the generation of wastewater. Finally, it is striking that the potential for eutrophication at the end-of-life stage is negative. At this stage it is considered that a part of the garment ends its life in a solid waste incineration plant with energy recovery, and this recovered energy replaces energy from the national grid. Therefore, environmental impacts assigned to this replaced electricity are avoided and this is accounted for as a negative impact on the garment. For the same reason, the impacts of water consumption and depletion of abiotic resources are also slightly negative at the end-of-life stage.

The water consumption for one use of the alpaca garment is 0.0023 m3. 83% of consumption occurs in the processing stage (spinning, dyeing, and manufacturing), 9.40% in the distribution stage, 8.05% in the use stage, 0.03% in the pasture, breeding and shearing stage corresponding to the transfer from fleece to spinning mills and -0.17% at the end-of-life stage. The use of water in the pasture, breeding and shearing stage has probably been underestimated due to not considering irrigation water because of lack of information. In the processing stage, water consumption is mainly due to the use of electricity in companies. The direct consumption of water in the processes carried out in the spinning, dyeing and manufacturing plants was not accounted for because the companies only keep records of volumes of water used, but not volumes of wastewater. Therefore, it was considered that the same volume of water that enters the plant also leaves it in the form of wastewater. The water consumption in the use stage is 0.0002 m3 / use of the garment, a volume that seems very small. But here it should also be considered that the garment is not washed first after each use but after each 5.2 uses and that the washing water is not considered consumed because it becomes wastewater which is returned to the environment after treatment. The use of water in this stage is mainly due to the consumption of electricity.

The abiotic resource depletion impact category assesses the decline in the availability of fossil energy resources. This indicator amounts to 2.79 MJ per use. 62% of the impact corresponds to the stage of processing and making garments, 31% to the distribution stage, 7.07% to the use stage, 0.11% to the meadow, breeding and shearing stage corresponding to the transfer of the fleece to the spinning mills and finally -0.27% to the end-of-life stage. The use of electricity and natural gas for heat generation in the garment processing and manufacturing stage are the main factors responsible for the depletion of abiotic resources at this stage. In the distribution stage, it is the fuel consumption that determines this indicator and in the use stage, the electricity consumption (for machine washing and dry cleaning).

5. CONCLUSIONS

- In the impact categories global warming and eutrophication, most of the impacts are generated in the pastures, breeding and shearing stage (70% of the impact in the global warming category and 65% of the impact in the eutrophication category correspond to this stage).
- Enteric fermentation is the source of 85% of greenhouse gases (in CO2-eq) that are emitted in the pasture, breeding and shearing stage.
- There is a large variation in CO2-eq emissions per kg fleece in regions that produce it (between 45 and 109 kg CO2-eq/kg fleece). These variations are mainly due to the differences in the percentage of alpacas shorn in the herds of each region.
- The sources of eutrophication in the pasture, breeding and shearing stages are nitrogen in alpaca feces and phosphorus from the soil that, through the process of soil erosion, can reach bodies of water.
- Regarding water consumption, the fiber processing stage (spinning, dyeing, and manufacturing) predominates with 83% of the total consumption. Water consumption in this stage occurs indirectly through the consumption of electricity and natural gas.
- In the depletion of abiotic resources impact category - fossil fuels, the processing stages (spinning, dyeing, and manufacturing) predominate with 62% of the impact and the distribution stage, with 31% of the impact. The use of electricity, natural gas and fossil fuels are the main factors responsible for the depletion of abiotic resources in these stages.
- The impacts in the use and end-of-life phases are generally small and even negative in the end-of-life phase, due to the energy recovered in the incineration of the waste.
- The sensitivity analysis shows that the Global Warming and Eutrophication indicators are highly influenced by the factors for assigning environmental loads to fiber and alpaca meat products in the pastures, breeding and shearing stage.
- The potential for reducing impacts related to the Global Warming category that can be achieved with an increase in the percentage of sheared alpacas is high (28% reduction approx.).

6. RECOMMENDATIONS

For the identification and formulation of impact reduction strategies, the following are recommended:

- Evaluate the causes of low alpaca shearing rates in some regions and develop measures to increase them.
- Develop strategies to improve the efficiency of alpaca systems to increase fleece yield per animal and per herd.
- Review the technology and/or methodology used to heat the water in the dyeing stage.
- Attach environmental information in addition to the garment care instructions demonstrating the environmental benefits of washing at low temperatures or by hand. In addition, it can be indicated that the alpaca fiber garments do not need to be washed after each use. Finally, it is also suggested to inform users that alpaca fiber is a material that can be recycled and, in this way, encourage the recycling of the product after its useful life, achieving a greater number of uses and improving its environmental performance.

- Rethink the export strategies of the final products considering a change of means of transport from plane to cargo ship.

For future studies of the Environmental Footprint of Alpaca fiber, the following are recommended:

- Carry out studies on carbon sequestration in wetlands to be able to consider these data in future LCA studies.
- Collect detailed information on the irrigation of the pastures to be able to include the water consumption in these areas and in the breeding and shearing stage in future studies.
- Perform soil analysis to estimate the amount of phosphorus and soil erosion (t soil/ha) in the study area, to obtain eutrophication estimates that are more adjusted to the reality of the areas study.
- Deepen the studies of alpaca manure in its chemical transformation at the soil-air interface.
- Design studies on protein metabolism in alpacas to obtain data for the calculation of the allocation factors.
- Incorporate the AWARE methodology to estimate impacts on water resources.
- Perform analysis of wastewater from spinning and dyeing plants and incorporate the operations of water treatment plants in future LCA studies.
- Carry out studies on the use and final disposal of garments made of alpaca fiber.
- The results of this study open the possibility of individual studies for decision-making in environmental performance and future certifications.
- Complement the environmental footprint study with socioeconomic studies for the design of strategies and policies that contribute to sustainability throughout the value chain of alpaca fiber garments.

8. REFERENCES

Aranda Uson, A. (2006). Life cycle analysis as a business management tool. Madrid: Confederal Foundation.

European Commission (2017), PEFCR Guidance Document. Guide for the development of 13 Product Environmental Footprint Category Rules (PEFCR), version 6.3.

Condori Mamani, KE (2017). Determination of total endogenous nitrogen: metabolic fecal, urinary, and dermal in three-year-old female alpacas (Vicugna pacos).

Ecoinvent LCI data base (2021) Ecoinvent Center, Basel

International Standard Organization (ISO), 2006. ISO 14040 - Environmental Management - Life Cycle Assessment - Principles and Framework.

Nemecek, T., & Schnetzer, J. (2011). Methods of assessment of direct field emissions for LCIs of agricultural production systems. Agroscope Reckenholz-Tänikon Research Station ART.

Intergovernmental Panel for Climate Change - IPCC. (2006). IPCC Guidelines for National Inventories of Greenhouse Gases (GHG)

Quispe Chacon, NF (2017). Emission of enteric methane in alpacas when grazing in Andean grasslands.

Sabino Rojas, E., Felipe-Obando, O., & Lavado-Casimiro, W. (2017). Atlas of soil erosion by hydrological regions of Peru.

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