LIFE CYCLE ASSESSMENT OF THREE OVS JEANS MODELS

Rev. n.0 - 14/07/2021

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Acronyms

CO: Cotton

EA: Spandex

ETP: Effluent Treatment Plant

GLO: Global

IT: Italy

LCA: Life Cycle Assessment

PEF: Environmental Product Footprint

PEFCR: Product Environmental Footprint Category Rules

PL: Polyester

RER: Europe

RoW: Rest of the World

Company information

OVS S.p.A. is the leading company in the Italian women's, men's and kids' apparel market, with a market share of 8.4%. Under OVS and UPIM brands it counts over 1,800 stores in Italy and overseas. OVS was floated on the Italian Stock Exchange in March 2015 and with net sales of 1,018.5 million euros.

The Group operates with a business model typical of vertically-integrated retailer including the following activities: product development entrusted to a team of product managers, designers and merchandisers who – by relying on a structure that is highly specialized in sourcing and has a major presence in key geographical areas – designs, develops and creates the merchandise mix through external suppliers. This process takes place under the artistic guidance of fashion coordinators and under the organizational leadership of product directors.

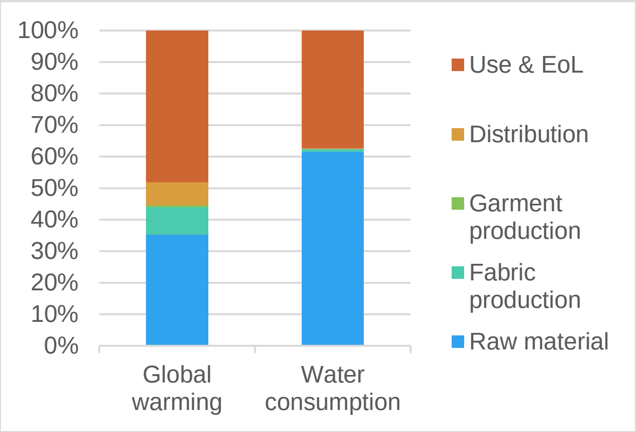
Figura 1: OVS headquarter

Executive summary

In this study, three models of jeans considered as representative products for women, men and kids were analyzed.
Hereafter are presented the characteristics of these garments and the results of impact categories Global warming (kg CO_2 eq) and water consumption (m^3).

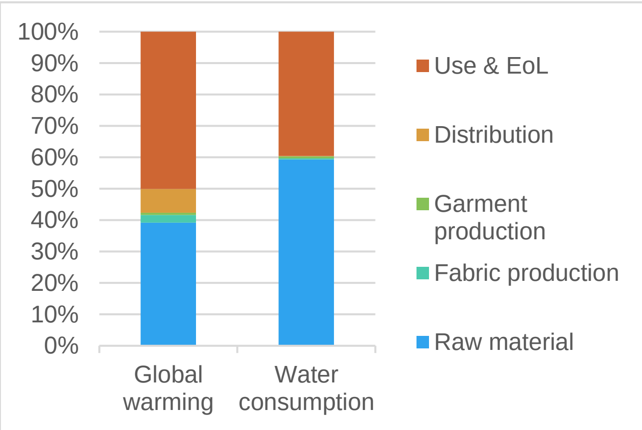
Style	211TRODORTOY-217
Category	OVS Man
Unit Net weight (g)	600
Composition	99% CO 1% EA

Impact Category	Unit	Total
Global warming	kg CO_2 eq	6,31
Water consumption	m^3	0,99



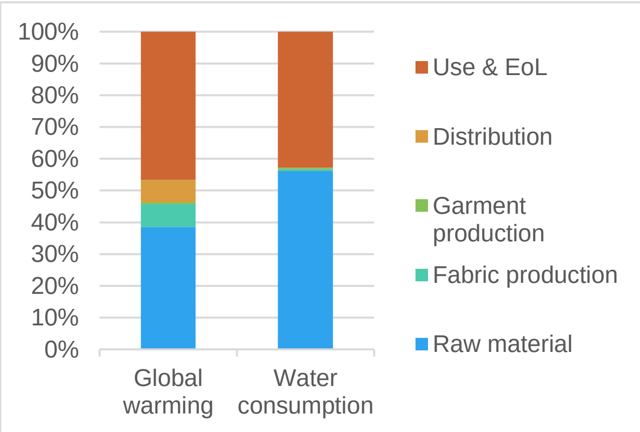
Style	202TROCAROL-66
Category	OVS Woman
Unit Net weight (g)	427
Composition	89% CO 8% PL 3% EA

Impact Category	Unit	Total
Global warming	kg CO_2 eq	4,31
Water consumption	m^3	0,66



Style	202TRO009-226
Category	OVS Kids
Unit Net weight (g)	313
Composition	77%CO 22% PL 1% EA

Impact Category	Unit	Total
Global warming	kg CO_2 eq	3,40
Water consumption	m^3	0,45



1 Products Description

The products under study are three models of jeans marketed by OVS for men, women and children respectively. The following tables present these products with their main characteristics.

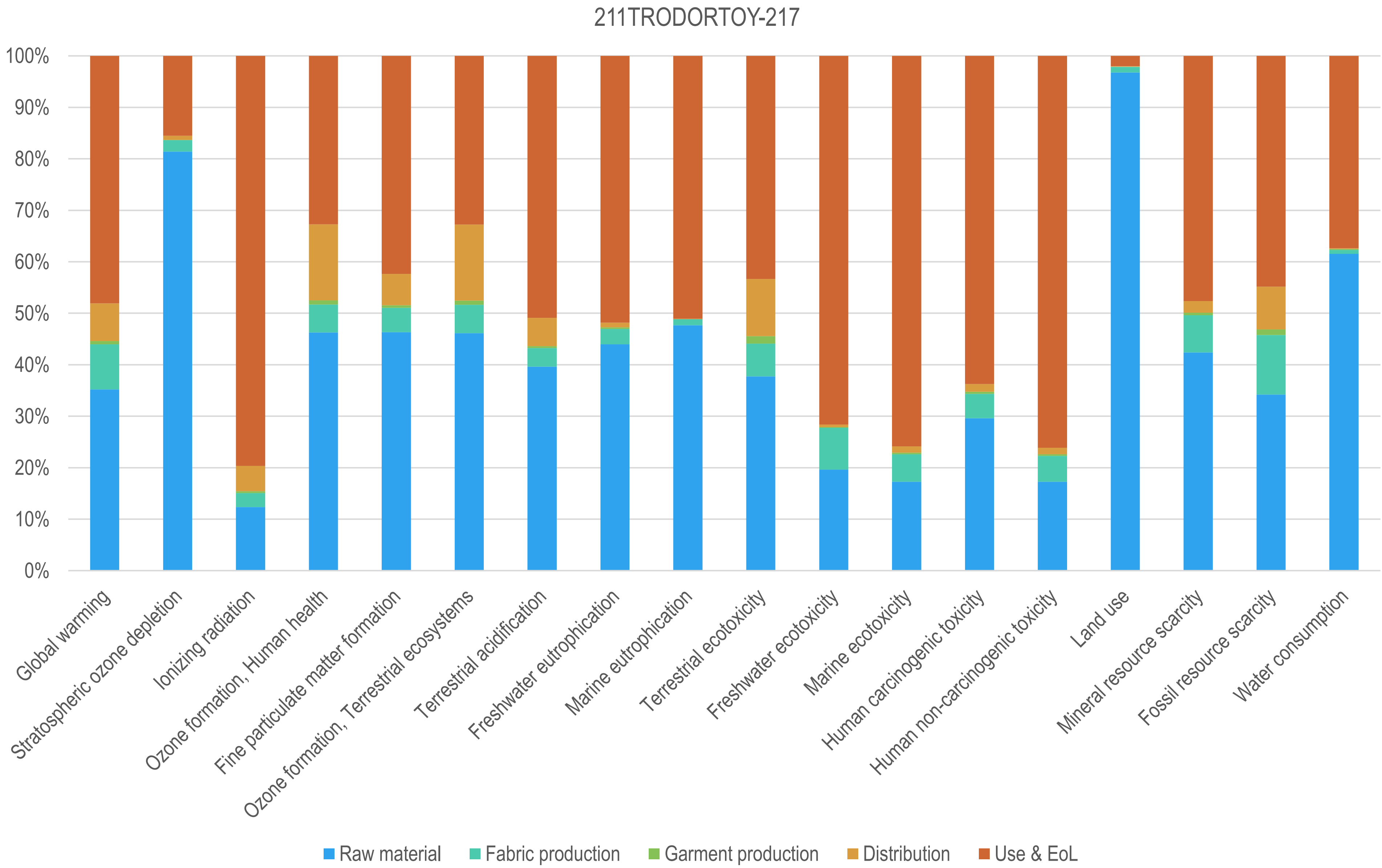
Table 1: Products description

	
Style	211TRODORTOY-217
Category	OVS Man
Material	Rigid denim
Unit Net weight (g)	600
Composition	99% CO 1% EA
	
Style	202TROCAROL-66
Category	OVS Woman
Material	Denim stretch
Unit Net weight (g)	427
Composition	89% CO 8% PL 3% EA
	
Style	202TRO009-226
Category	OVS Kids
Material	Jog denim
Unit Net weight (g)	313
Composition	77%CO 22% PL 1% EA

2 Products environmental performance

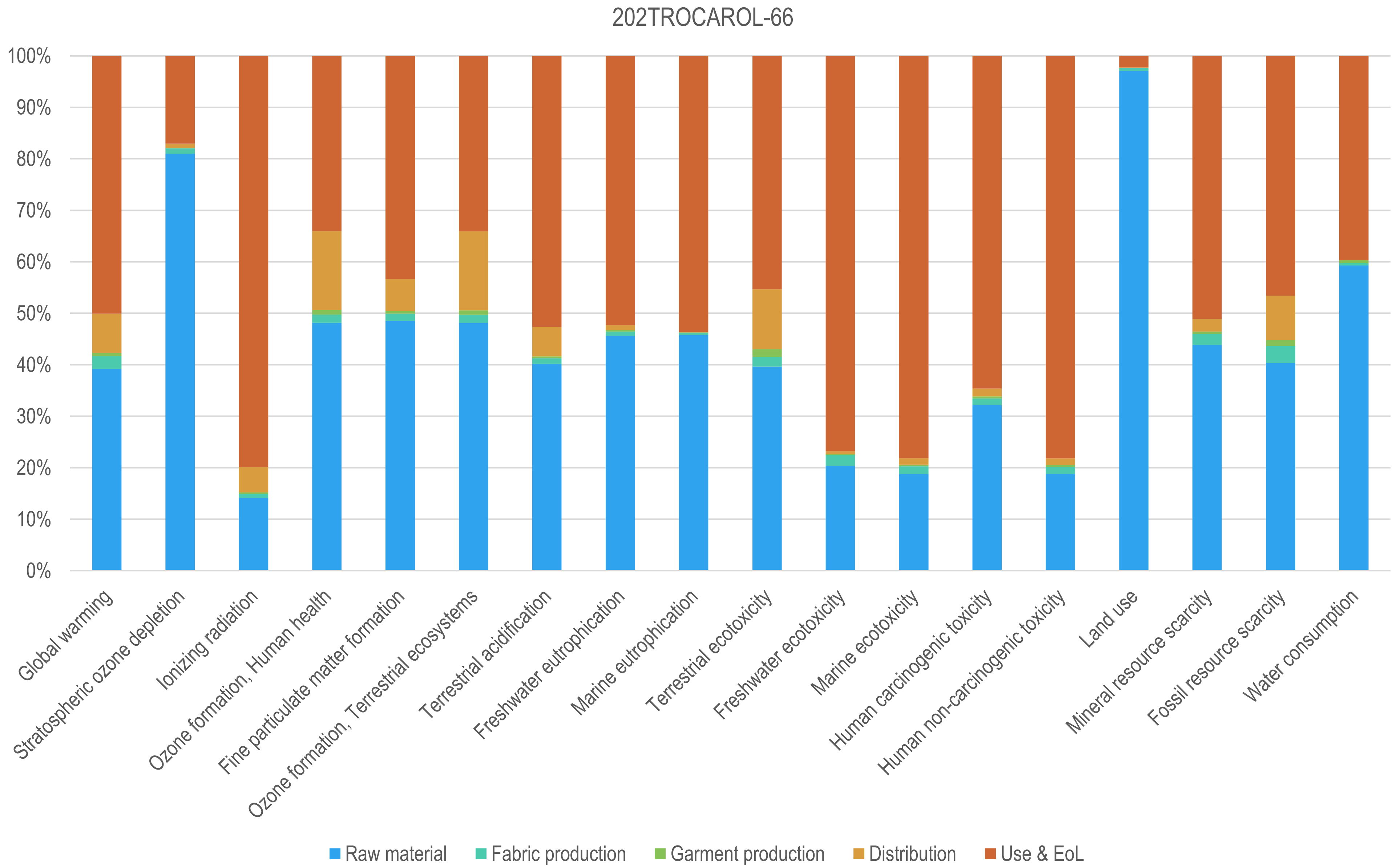
2.1 Style: 211TRODORTOY-217

Impact Category	Unit	Total	Raw material	Fabric production	Garment production	Distribution	Use & EoL
Global warming	kg CO2 eq	6,31E+00	2,22E+00	5,54E-01	3,95E-02	4,61E-01	3,03E+00
Stratospheric ozone depletion	kg CFC11 eq	2,77E-05	2,25E-05	6,10E-07	1,60E-08	2,16E-07	4,30E-06
Ionizing radiation	kBq Co-60 eq	8,79E-01	1,08E-01	2,40E-02	2,98E-03	4,35E-02	7,00E-01
Ozone formation, Human health	kg NOx eq	1,96E-02	9,07E-03	1,06E-03	1,59E-04	2,90E-03	6,41E-03
Fine particulate matter formation	kg PM2.5 eq	1,35E-02	6,24E-03	6,39E-04	6,43E-05	8,23E-04	5,71E-03
Ozone formation, Terrestrial ecosystems	kg NOx eq	1,99E-02	9,18E-03	1,09E-03	1,65E-04	2,93E-03	6,52E-03
Terrestrial acidification	kg SO2 eq	4,35E-02	1,73E-02	1,58E-03	1,59E-04	2,38E-03	2,22E-02
Freshwater eutrophication	kg P eq	2,67E-03	1,17E-03	7,96E-05	7,78E-06	2,48E-05	1,38E-03
Marine eutrophication	kg N eq	3,11E-03	1,48E-03	3,58E-05	7,67E-07	2,07E-06	1,59E-03
Terrestrial ecotoxicity	kg 1,4-DCB	1,78E+01	6,70E+00	1,14E+00	2,56E-01	1,97E+00	7,69E+00
Freshwater ecotoxicity	kg 1,4-DCB	5,85E-01	1,15E-01	4,76E-02	8,34E-04	2,98E-03	4,19E-01
Marine ecotoxicity	kg 1,4-DCB	2,96E+03	5,12E+02	1,57E+02	9,39E+00	3,60E+01	2,25E+03
Human carcinogenic toxicity	kg 1,4-DCB	2,18E+01	6,46E+00	1,04E+00	9,34E-02	3,24E-01	1,39E+01
Human non-carcinogenic toxicity	kg 1,4-DCB	2,38E+03	4,10E+02	1,19E+02	7,79E+00	2,98E+01	1,81E+03
Land use	m2a crop eq	5,19E+00	5,03E+00	5,70E-02	8,90E-04	5,75E-03	1,04E-01
Mineral resource scarcity	kg Cu eq	1,67E-02	7,08E-03	1,21E-03	8,04E-05	3,78E-04	7,96E-03
Fossil resource scarcity	kg oil eq	1,90E+00	6,51E-01	2,20E-01	2,02E-02	1,58E-01	8,53E-01
Water consumption	m3	9,86E-01	6,07E-01	7,53E-03	1,90E-03	1,01E-03	3,69E-01


211TRODORTOY-217
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Global warming
Stratospheric ozone depletion
Ionizing radiation
Ozone formation, Human health
Fine particulate matter formation
Ozone formation, Terrestrial ecosystems
Terrestrial acidification
Freshwater eutrophication
Marine eutrophication
Terrestrial ecotoxicity
Freshwater ecotoxicity
Marine ecotoxicity
Human carcinogenic toxicity
Human non-carcinogenic toxicity
Land use
Mineral resource scarcity
Fossil resource scarcity
Water consumption
Raw material
Fabric production
Garment production
Distribution
Use & EoL

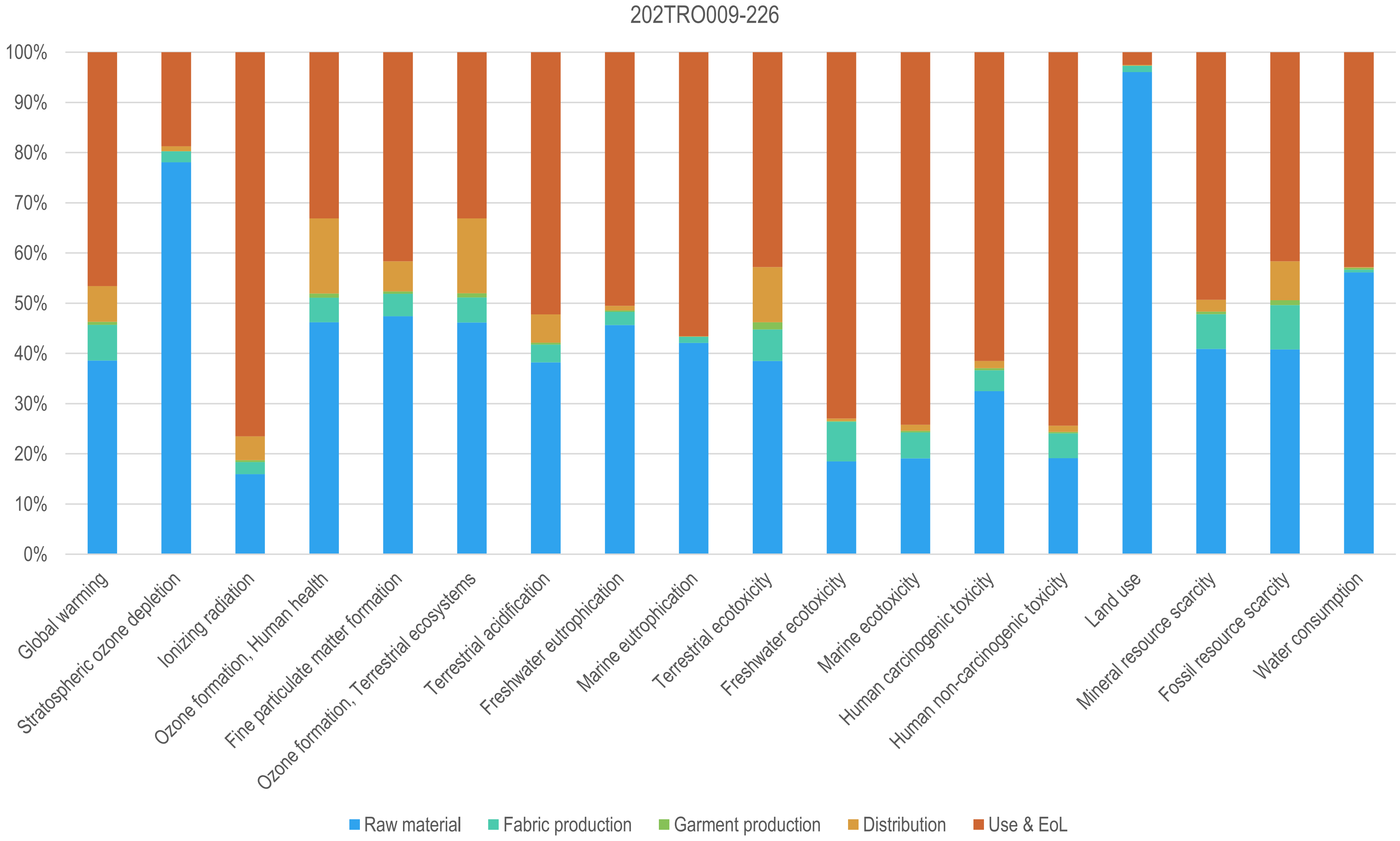
2.2 Style: 202TROCAROL-66

Impact Category	Unit	Total	Raw material	Fabric production	Garment production	Distribution	Use & EoL
Global warming	kg CO2 eq	4,31E+00	1,69E+00	1,09E-01	2,77E-02	3,28E-01	2,16E+00
Stratospheric ozone depletion	kg CFC11 eq	1,79E-05	1,45E-05	1,83E-07	1,06E-08	1,54E-07	3,06E-06
Ionizing radiation	kBq Co-60 eq	6,24E-01	8,76E-02	4,95E-03	2,08E-03	3,10E-02	4,98E-01
Ozone formation, Human health	kg NOx eq	1,34E-02	6,45E-03	2,14E-04	1,12E-04	2,06E-03	4,56E-03
Fine particulate matter formation	kg PM2.5 eq	9,37E-03	4,55E-03	1,31E-04	4,49E-05	5,86E-04	4,06E-03
Ozone formation, Terrestrial ecosystems	kg NOx eq	1,36E-02	6,55E-03	2,21E-04	1,16E-04	2,09E-03	4,64E-03
Terrestrial acidification	kg SO2 eq	2,99E-02	1,20E-02	3,30E-04	1,11E-04	1,70E-03	1,58E-02
Freshwater eutrophication	kg P eq	1,88E-03	8,57E-04	1,67E-05	5,38E-06	1,77E-05	9,84E-04
Marine eutrophication	kg N eq	2,10E-03	9,64E-04	9,66E-06	5,30E-07	1,47E-06	1,13E-03
Terrestrial ecotoxicity	kg 1,4-DCB	1,21E+01	4,78E+00	2,27E-01	1,82E-01	1,41E+00	5,48E+00
Freshwater ecotoxicity	kg 1,4-DCB	3,88E-01	7,87E-02	8,63E-03	5,82E-04	2,12E-03	2,98E-01
Marine ecotoxicity	kg 1,4-DCB	2,04E+03	3,83E+02	3,07E+01	6,61E+00	2,56E+01	1,60E+03
Human carcinogenic toxicity	kg 1,4-DCB	1,53E+01	4,92E+00	2,02E-01	6,57E-02	2,31E-01	9,91E+00
Human non-carcinogenic toxicity	kg 1,4-DCB	1,65E+03	3,08E+02	2,35E+01	5,49E+00	2,12E+01	1,29E+03
Land use	m2a crop eq	3,32E+00	3,22E+00	1,85E-02	6,30E-04	4,09E-03	7,39E-02
Mineral resource scarcity	kg Cu eq	1,11E-02	4,85E-03	2,36E-04	5,74E-05	2,69E-04	5,66E-03
Fossil resource scarcity	kg oil eq	1,30E+00	5,26E-01	4,30E-02	1,42E-02	1,12E-01	6,07E-01
Water consumption	m3	6,62E-01	3,93E-01	3,18E-03	3,45E-03	7,16E-04	2,62E-01


202TROCAROL-66
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Global warming
Stratospheric ozone depletion
Ionizing radiation
Ozone formation, Human health
Fine particulate matter formation
Ozone formation, Terrestrial ecosystems
Terrestrial acidification
Freshwater eutrophication
Marine eutrophication
Terrestrial ecotoxicity
Freshwater ecotoxicity
Marine ecotoxicity
Human carcinogenic toxicity
Human non-carcinogenic toxicity
Land use
Mineral resource scarcity
Fossil resource scarcity
Water consumption
Raw material
Fabric production
Garment production
Distribution
Use & EoL

2.3 Style: 202TRO009-226

Impact Category	Unit	Total	Raw material	Fabric production	Garment production	Distribution	Use & EoL
Global warming	kg CO2 eq	3,40E+00	1,31E+00	2,41E-01	2,07E-02	2,41E-01	1,58E+00
Stratospheric ozone depletion	kg CFC11 eq	1,20E-05	9,33E-06	2,59E-07	8,05E-09	1,13E-07	2,24E-06
Ionizing radiation	kBq Co-60 eq	4,77E-01	7,62E-02	1,15E-02	1,58E-03	2,27E-02	3,65E-01
Ozone formation, Human health	kg NOx eq	1,01E-02	4,66E-03	4,95E-04	8,30E-05	1,51E-03	3,34E-03
Fine particulate matter formation	kg PM2.5 eq	7,15E-03	3,39E-03	3,18E-04	3,40E-05	4,29E-04	2,98E-03
Ozone formation, Terrestrial ecosystems	kg NOx eq	1,03E-02	4,74E-03	5,13E-04	8,63E-05	1,53E-03	3,40E-03
Terrestrial acidification	kg SO2 eq	2,21E-02	8,46E-03	7,87E-04	8,32E-05	1,24E-03	1,16E-02
Freshwater eutrophication	kg P eq	1,43E-03	6,51E-04	3,75E-05	4,16E-06	1,29E-05	7,21E-04
Marine eutrophication	kg N eq	1,46E-03	6,16E-04	1,78E-05	4,03E-07	1,08E-06	8,28E-04
Terrestrial ecotoxicity	kg 1,4-DCB	9,38E+00	3,61E+00	5,90E-01	1,34E-01	1,03E+00	4,01E+00
Freshwater ecotoxicity	kg 1,4-DCB	3,00E-01	5,53E-02	2,37E-02	4,36E-04	1,56E-03	2,18E-01
Marine ecotoxicity	kg 1,4-DCB	1,58E+03	3,01E+02	8,21E+01	4,92E+00	1,88E+01	1,17E+03
Human carcinogenic toxicity	kg 1,4-DCB	1,18E+01	3,84E+00	4,93E-01	4,93E-02	1,69E-01	7,26E+00
Human non-carcinogenic toxicity	kg 1,4-DCB	1,27E+03	2,42E+02	6,26E+01	4,09E+00	1,55E+01	9,44E+02
Land use	m2a crop eq	2,14E+00	2,05E+00	2,65E-02	4,67E-04	3,00E-03	5,42E-02
Mineral resource scarcity	kg Cu eq	8,42E-03	3,44E-03	5,82E-04	4,20E-05	1,97E-04	4,15E-03
Fossil resource scarcity	kg oil eq	1,07E+00	4,36E-01	9,44E-02	1,05E-02	8,25E-02	4,45E-01
Water consumption	m3	4,49E-01	2,52E-01	2,56E-03	1,70E-03	5,25E-04	1,92E-01


202TRO009-226
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
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Global warming
Stratospheric ozone depletion
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Ozone formation, Human health
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Human carcinogenic toxicity
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Land use
Mineral resource scarcity
Fossil resource scarcity
Water consumption
Raw material
Fabric production
Garment production
Distribution
Use & EoL

3 LCA Information

3.1 Objective of the study

The objective of this study is to assess the potential environmental impacts, from a life cycle perspective, associated with the products listed in the table above.

The results presented in this report refer univocally to the company's production methods and in this sense, they have not been calculated to be compared with those of other companies, as differences in methodological choices, assumptions, data quality and choice of databases may produce results that are not comparable.

The data collected for conducting this study refer to the 2019 business year.

3.2 Functional unit and reference flow

The functional unit of the study is 1 pair of jeans.
The reference flow is not definable as the possible applications in the downstream phase and thus the functions of the garment are extremely variable.

3.3 System boundaries

The boundaries of the system include all aspects related to the production, transport, installation, use and end of life of the products analyzed according to a "from cradle to grave" application.
The life cycle is divided into the following phases:

- UPSTREAM PROCESSES:
  - Production of raw materials;
  - Transportation of raw materials;
- CORE PROCESSES:
  - Production and transport of the materials used in production processes;
  - End-of-life and management of manufacturing waste flows;
  - Power generation and use in production processes;
- DOWNSTREAM PROCESSES:
  - Transport from the country of production to Italy;
  - Use phase;
  - End of product life.

Details of the manufacturing processes are provided, along with the data used for modeling, in the following sections of this document.

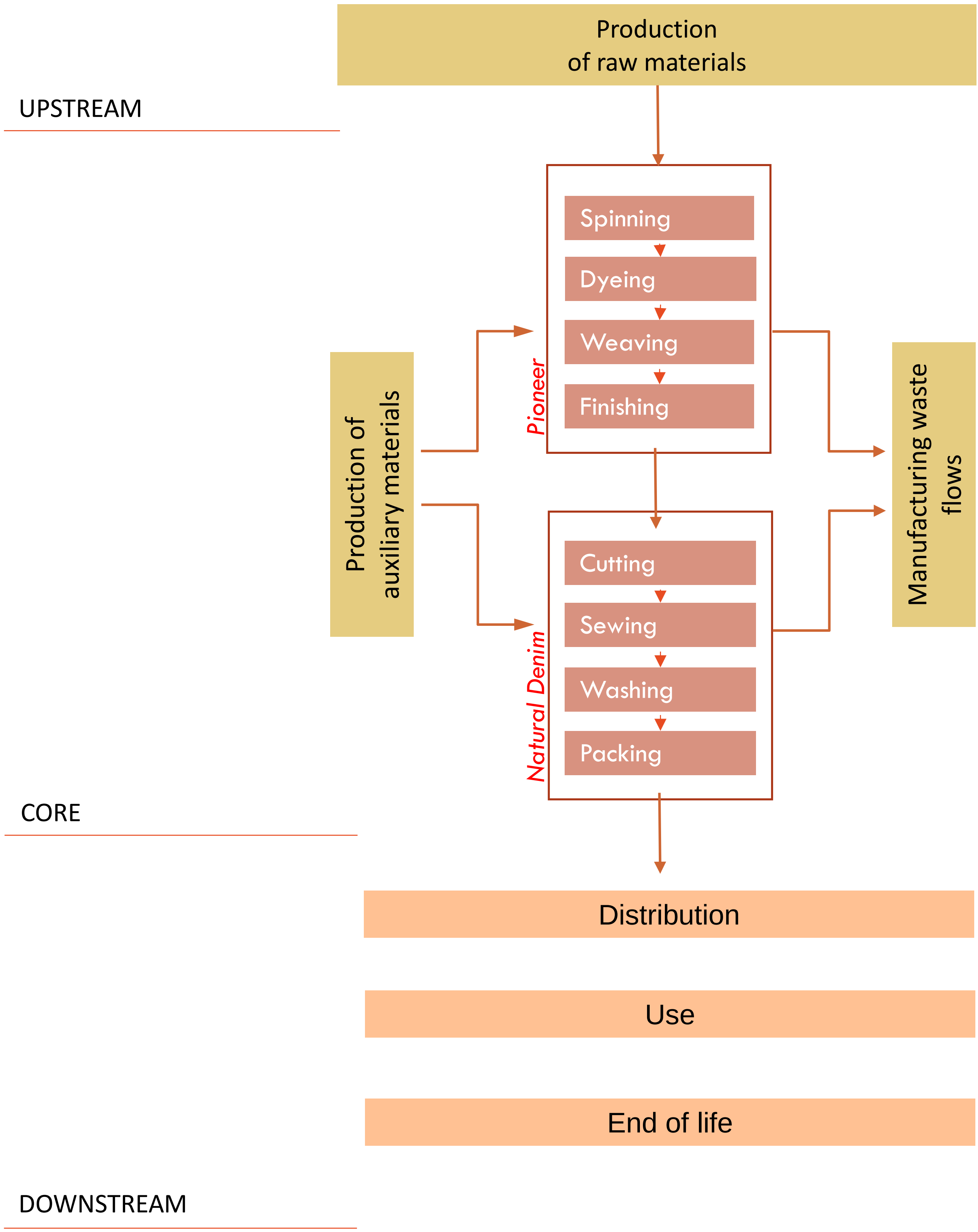

Figure 2: System boundaries

3.4 Assumptions and limitations

Primary data were referenced where available to conduct this study. Where access to this type of data was not possible, datasets from the Ecoinvent v3.5 database were referenced.
The following were excluded from this study: the construction, maintenance and decommissioning of infrastructure, understood as machinery and buildings, and the occupation of industrial land (if this information was not already present in the dataset used).

3.4.1 Allocation principles and process

The need to allocate the flows in and out of a product system between the system itself and other external systems can arise in two cases:

1. In the case of simultaneous products, i.e., in the case of production of products and co-products (co-product allocation);
2. In the case of subsequent products, or in the case of materials that enter a recycling process (end of life allocation/allocation procedure of reuse, recycling, recovery).

In this study the allocation procedure was adopted to divide the impacts associated with plant consumption such as: consumption of methane, electricity, water withdrawals and discharges, management and disposal of waste generated. Moreover, all the consumption of auxiliary materials involved in the production were allocated according to a physical principle (mass), considering the total amount produced in each single plant.
The following table presents the allocation percentages used in the modeling of production activities.

Table 2: Allocation percentage

Plant	Plant Total production volume	Single style production		
		211TRODORTOY-217	202TROCAROL-66	202TRO009-226
		99% CO 1% EA	89% CO 8% PL 3% EA	77%CO 22% PL 1% EA
Pioneer	100%	37,04%	9,88%	20,06%
Natural denim	100%	0,18%	0,10%	0,10%

3.4.2 Impact categories

The methodology chosen to assess the potential environmental impacts of the product in this study is the ReCiPe 2016 Egalitarian method that includes 18 impact categories:

4 Life Cycle Inventory

Inventory analysis comprises the collection of the data and the procedures of calculation that concur to quantify the elements in input and output relative to the considered products.
Below are the elements that were considered in the inventory analysis with reference to the ISO 14040 series Standards.

4.1 Data Collection Process

The information gathering phase was conducted by preparing a sheet that collected input and output data, in terms of mass, energy consumption and emissions in the various environmental sectors for the products analyzed.
The data collection sheet was verified and checked by mass balances and reporting any inconsistencies that were clarified and resolved.

4.2 Raw materials

The following is a description of the datasets and values used to model raw materials. Specifically, in this study, all materials that make up the product are classified as raw materials.

4.2.1 Cotton

The data collected, specified in the following table summarizes the origin and quantities of cotton purchased by the various producers during the year of activity.

Table 3: Origin and quantities of cotton purchased

Supplier	Quantity purchased [kg]
Pratima Self help Coopertative (i)	559.560
Radha madhav Herbals Agrp Pvt. Ltd.	7.359.564
SP Agro Pvt ltd.	782.074,8
Pratima Self help Coopertative (ii)	467.058
Kishan Self help Cooperative (ii)	566.556
Spaa Straw Board Industries	668.724
Pratima organic Grower Group	945.756
Kishan Self help Cooperative (i)	741.156
Maa Arnapurna Jaibik Krushak Sangha	66.484,8
Maa Bastren Jaibik Krushak Sangha	67.117,2
Maa Bindhen Mauli Jaibik Krushak Sangha	64.734
MaaDharitri Jaibik Krushak Sangha	80.929,2
Maa Gramadebati Jaibik Krushak Sangha	73.171,2
Maa Maheswari Jaibik Krushak Sangha	61.766,4
TOTAL	12.504.651,6

The cotton purchased comes from Better Cotton Initiative (BCI) crops located in India. In the calculation model has been used the database Cotton fibre {INDIA}| cotton production | Cut-off, U reporting the electricity and water consumption related to the Indian geographical context through the databases Electricity, low voltage {IN}| market group for electricity, low voltage | Cut-off, U and Irrigation {IN}| market for | Cut-off, U attributing a water consumption of 1 m^3 per hectare of cultivation.

In addition, transportation to the ginning stage, which occurs in Orissa, India, was modeled with Transport, freight, lorry 16-32 metric ton, euro3 {RoW}| market for transport, freight, lorry 16-32 metric ton, EURO3 | Cut-off, U database and weighted average distance of 2.228,25 km.
Finally, the transport of cotton from Orissa to Hobigonj (location where Pioneer is based) was modeled with Transport, freight, lorry 16-32 metric ton, euro3 {RoW}| market for transport, freight, lorry 16-32 metric ton, EURO3 | Cut-off, U database and distance 986 km.

4.2.2 Polyester

Since no information regarding the origin of the polyester used in the manufacturing process was collected, the database Polyethylene terephthalate, granulate, amorphous [GLO]| market for |Cut-off, U, and Spinning, bast fibre {GLO}| market for | Cut-off, U were used. A market dataset collects all activities with the same reference product in a certain geographical region. Furthermore, it includes average transports of that product within the geography, as well as inputs of the product itself to cover losses in trade and transport.

4.2.3 Spandex

Similar to polyester, spandex was modeled using the “market” database Polyurethane, flexible foam {RoW}| market for polyurethane, flexible foam | Cut-off, U, and Spinning, bast fibre {GLO}| market for | Cut-off, U.

4.3 Fabric production process (Pioneer plant)

4.3.1 Auxiliary materials for spinning process

The materials needed in the spinning process are shown in the following table.

Table 4: Auxiliary materials for spinning process

Equipment	Supplier	Quantity purchased [pcs]
Bobbin	Pegasus,China	4.000.000
Paper cone	Badsha Textiles Ltd.Self Products	25.000.000

The bobbin was modeled in the aluminum model with Aluminium, cast alloy {GLO}| market for | Cut-off, U database Sheet rolling, aluminium {RoW}| processing | Cut-off, U and Deep drawing, steel, 650 kN press, automode {CINA} as machining process. Transportation from China the Bangladesh by sea was modeled with Transport, freight, sea, transoceanic ship {GLO}| market for | Cut-off, U and distance of 5983 km.
The paper cone wes modeled with database Carton board box production service, with gravure printing and the transportation by land with database Transport, freight, lorry 16-32 metric ton, euro3 {RoW}| market for transport, freight, lorry 16-32 metric ton, EURO3 | Cut-off, U and distance covered of 136 km.
Should be noted that the quantities entered into the analysis model were allocated at the amount needed to process one pair of jeans.

4.3.2 Auxiliary materials for dyeing process

The materials shown in the following table are the chemicals used in the dyeing.

Table 5: Auxiliary materials for dyeing process

Chemical	Supplier	Quantity purchased [kg]	Made in
Caustic Soda Flakes	ASM CHEMICAL INDUSTRIES LTD	588.950	Bangladesh
Belfasin GT	PULCRA KIMYA SANAYI TIC A.Ş	61.080	Turkey
Dystar Indigo Vat 40%	DYSTAR SINGAPORE PTE LTD	367.200	Germany
Denim Blue 30%	BLUCONNECTION PTE LTD	279.560	Singapore
Diresul Black RDT D BD Liq	ARCHROMA SINGAPORE PTE LTD	273.500	Indoneshia
Sodium Hydrosulfite E	BASF HONG KONG LTD	192.000	Germany
Sulfotex Black SN-155	APLICACIÓN Y SUMINISTROS TEXTILES, S.A	165.750	Spain
Denisol Indigo 30%	ARCHROMA SINGAPORE PTE LTD	102.864	Pakistan
Diresul Brown RDT GS Liq	ARCHROMA SINGAPORE PTE LTD	91.770	Spain
Acetic Acid	JLP CORPORATION	28.170	Korea
Perifil 210 D	TEXTILE CHEMIE DR PETRY GMBH	24.000	Germany
Sulfotex Grey JG Liq	APLICACIÓN Y SUMINISTROS TEXTILES, S.A	22.120	Spain
Pure Denisol Indigo 30% Liq	ARCHROMA SINGAPORE PTE LTD	19.720	Pakistan
Mercerol QWXL	ARCHROMA SINGAPORE PTE LTD	18.000	Indoneshia
Reducing Agent DP	ARCHROMA SINGAPORE PTE LTD	18.000	Indoneshia
Reductor SVF Polvo P	APLICACIÓN Y SUMINISTROS TEXTILES, S.A	16.000	Spain
Kieralon EHC Liq	ARCHROMA SINGAPORE PTE LTD	12.000	Indoneshia
Leonil EHC Liq	ARCHROMA SINGAPORE PTE LTD	11.880	Indoneshia
Sulfotex Blue Black 3B Liq	APLICACIÓN Y SUMINISTROS TEXTILES, S.A	10.080	Spain
Breviol DNV	PULCRA KIMYA SANAYI TIC A.Ş	9.060	Turkey
Primasol NF	ARCHROMA SINGAPORE PTE LTD	6.000	Indoneshia
Dekol 1097 sp Th	ARCHROMA SINGAPORE PTE LTD	6.000	Indoneshia
Asutol LB	APLICACIÓN Y SUMINISTROS TEXTILES, S.A	3.120	Spain
Securon BAT3	PULCRA KIMYA SANAYI TIC A.Ş	3.000	Turkey

While, the following table defines which substances are used for the realization of the three models under study.

Table 6: Auxiliary materials for dyeing process of selected styles

Chemical	Single style production		
	211TRODORTOY-217	202TROCAROL-66	202TRO009-226
	99% CO 1% EA	89% CO 8% PL 3% EA	77%CO 22% PL 1% EA
Caustic Soda Flakes	Yes	Yes	Yes
Belfasin GT	Yes	Yes	Yes
Dystar Indigo Vat 40%	Yes	Yes	Yes
Denim Blue 30%	No	No	No
Diresul Black RDT D BD Liq	No	No	No
Sodium Hydrosulfite E	Yes	Yes	Yes
Sulfotex Black SN-155	No	Yes	No
Denisol Indigo 30%	No	No	No
Diresul Brown RDT GS Liq	No	No	No
Acetic Acid	Yes	Yes	Yes
Perifil 210 D	No	No	No

Chemical	Single style production		
	211TRODORTOY-217	202TROCAROL-66	202TRO009-226
	99% CO 1% EA	89% CO 8% PL 3% EA	77%CO 22% PL 1% EA
Sulfotex Grey JG Liq	No	No	No
Pure Denisol Indigo 30% Liq	No	No	No
Mercerol QWXL	Yes	Yes	Yes
Reducing Agent DP	No	Yes	No
Reductor SVF Polvo P	No	Yes	No
Kieralon EHC Liq	No	No	No
Leonil EHC Liq	Yes	Yes	Yes
Sulfotex Blue Black 3B Liq	No	No	No
Breviol DNV	No	No	No
Primasol NF	Yes	Yes	Yes
Dekol 1097 sp Th	No	No	No
Asutol LB	Yes	Yes	Yes
Securon BAT3	No	No	No

Chemicals were modeled as follows:

- Caustic Soda Flakes: Sodium hydroxide, without water, in 50% solution state
- Dystar Indigo Vat 40%: Market for sodium hydrogen sulfite GLO
- Diresul Black RDT D BD Liq: Anionic resin {Turchia}
- Sodium Hydrosulfite E: Market for sodium hydrogen sulfite GLO
- Belfasin GT: Sodium hydroxide, without water, in 50% solution state e market for fatty acid GLO

While the remainder was modeled as generic organic chemicals through database Textile production, knit cotton, batch dyed GLO.

Transport was modeled using database Transport, freight, sea, transoceanic ship {GLO}| market for | Cut-off, U and Transport, freight, lorry 16-32 metric ton, euro3 {RoW}| market for transport, freight, lorry 16-32 metric ton, EURO3 | Cut-off, U by assigning the distances shown in the table depending on the origin.

Table 7: Distance from supplier of auxiliary materials for dyeing process

Made in	Distance [km]
Bangladesh	138,00
Turkey	10.141,00
Germany	17.166,00
Singapore	3.624,00
Indoneshia	4.204,00
Germany	17.166,00
Spain	13.851,00
Pakistan	5.694,00
Spain	13.851,00
Korea	10.123,00
Germany	17.166,00
Spain	13.851,00
Pakistan	5.694,00

Indoneshia	4.204,00
Indoneshia	4.204,00
Spain	13.851,00
Indoneshia	4.204,00
Indoneshia	4.204,00
Spain	13.851,00
Turkey	10.141,00
Indoneshia	4.204,00
Indoneshia	4.204,00
Spain	13.851,00
Turkey	10.141,00

4.3.3 *Auxiliary materials for finishing process*

The materials shown in the following table are the chemical elements used in the finishing process.

Table 8: Auxiliary materials for finishing process

Chemical	**Supplier**	**Quantity purchased [kg]**	**Made in**
Caustic Soda Flakes	ASM CHEMICAL INDUSTRIES LTD	100.000,00	Bangladesh
Acetic Acid	JLP CORPORATION	18.090,00	Korea
Asucryl E HL	APLICACIÓN Y SUMINISTROS TEXTILES, S.A	2.200,00	Spain
Asufix MF- R	APLICACIÓN Y SUMINISTROS TEXTILES, S.A	5.125,00	Spain
Asutol ABK	APLICACIÓN Y SUMINISTROS TEXTILES, S.A	22.800,00	Spain
Base Asumin TR	APLICACIÓN Y SUMINISTROS TEXTILES, S.A	23.760,00	Spain
Estabilizador FE	APLICACIÓN Y SUMINISTROS TEXTILES, S.A	5.040,00	Spain
Hydrogen Peroxside	TASNIM CHEMICAL COMPLEX LTD	13.020,00	Bangladesh
Perrustol IPS New	RUDOLF SINGAPORE PTE LTD	22.200,00	Germany
Rucowet RMB	RUDOLF SINGAPORE PTE LTD	4.550,00	Germany
Rucogen WBL	RUDOLF SINGAPORE PTE LTD	42.000,00	Germany
Rucolase HCH	RUDOLF SINGAPORE PTE LTD	26.875,00	Germany

Table 9: Auxiliary materials for finishing process of selected styles

Chemical	**Single style production**		
	211TRODORTOY-217	**202TROCAROL-66**	**202TRO009-226**
	99% CO 1% EA	**89% CO 8% PL 3% EA**	**77%CO 22% PL 1% EA**
Caustic Soda Flakes	No	No	Yes
Acetic Acid	Yes	No	Yes
Asucryl E HL	No	No	No
Asufix MF- R	No	No	No
Asutol ABK	No	No	Yes
Base Asumin TR	Yes	No	Yes
Estabilizador FE	No	No	No
Hydrogen Peroxside	No	No	No
Perrustol IPS New	No	No	No
Rucowet RMB	No	No	Yes

Chemical	Single style production		
	211TRODORTOY-217	202TROCAROL-66	202TRO009-226
	99% CO 1% EA	89% CO 8% PL 3% EA	77%CO 22% PL 1% EA
Rucogen WBL	No	No	No
Rucolase HCH	No	No	No

Chemicals were modeled as follows:

- Caustic Soda Flakes: Sodium hydrogen sulfite
- Acetic Acid: Acetic acid, without water, in 98% solution state {KOREA}
- Asutol ABK: non-ionic surfactant production, fatty acid derivate
- Hydrogen Peroxside: hydrogen peroxide production, product in 50% solution state RER
- Perrustol IPS New: Polyester-complexed starch biopolymer {GERMANY}| production
- Rucolase HCH: Enzymes {RoW}| enzymes production | Cut-off, U

While the remainder was modeled as generic organic chemicals through database textile production, knit cotton, batch dyed GLO.

4.3.4 Production plant data

The data collected related to the production plant concerns electricity use and process water management.
The production site is energetically self-sufficient thanks to the cogeneration system and the photovoltaic plant that produced 1.069.440,00 kWh in the reference year.
Production process required 62.270,10 tons of steam generate by the combustion of 4.981.608,00 m^3 of methane. This combustion process was modeled using database Heat, district or industrial, natural gas {BG}| heat and power co-generation, natural gas, conventional power plant, 100MW electrical | Cut-off, U.
The management of process water is carried out by means of an Effluent Treatment Plant (ETP). The global difference between water intake and output of the production plant is equal to 3.831 m^3.

4.4 Garment production process (Natural Denim plant)

For the cutting, sewing and packaging process phases, the following production waste data was collected.

Table 10: Cutting, sewing and packaging waste production

Process	Waste type	Quantity [kg]
Cutting Process	Cutting Fabrics (Jhut)	1.144.100
Sewing Process	Empty Cone	20.800
Packaging Process	Waste Carton	111.100

The end-of-life management of previous production waste has been modeled through the following databases.

- Cutting Fabrics (Jhut): Waste textile, soiled {RoW}| market for waste textile, soiled | Cut-off, U
- Empty Cone: Waste paperboard {RoW}| market for waste paperboard | Cut-off, U
- Waste Carton: Waste paperboard {RoW}| market for waste paperboard | Cut-off, U

4.4.1 Auxiliary materials for washing process

The following table shows the chemical elements used for the washing phase. This process and the quantities indicated refer to the treatment for 48 kg of denim to obtain the color light blue.
Always in the same table are indicated the data banks used in the calculation model.

Table 11: Washing process recipe for light blue denim color

Chemical	Quantity [gr]	Database
Anti-Slipping Ap	400	Activated silica {GLO}| market for | Cut-off, U
Ross Acid N Liq	200	Acetic acid, without water, in 98% solution state {GLO}| market for | Cut-off, U
GP.5501 NF	400	Vinyl acetate {GLO}| market for | Cut-off, U
Enzyme DM	400	Chemical, organic [GLO]| production | Cut-off, U
BG ABS	600	Acrylonitrile-butadiene-styrene copolymer {GLO}| market for | Cut-off, U
GP.5501 NF	800	Vinyl acetate {GLO}| market for | Cut-off, U
Soda Ash	600	Sodium bicarbonate {GLO}| market for sodium bicarbonate | Cut-off, U
Bleach Protector (B.P)	200	Sodium hypochlorite, without water, in 15% solution state {RoW}| market for sodium hypochlorite, without water, in 15% solution state | Cut-off, U
Bleach K.C.I	15.000	Sodium hypochlorite, without water, in 15% solution state {RoW}| market for sodium hypochlorite, without water, in 15% solution state | Cut-off, U
BASF Meta	1000	Chemical, organic [GLO]| production | Cut-off, U
Rossa Acid N Liq	300	Acetic acid, without water, in 98% solution state {GLO}| market for | Cut-off, U
BASF SE	1000	Chemical, organic [GLO]| production | Cut-off, U
GB ABS	300	Acrylonitrile-butadiene-styrene copolymer {GLO}| market for | Cut-off, U
Rossa Acid N Liq	300	Acetic acid, without water, in 98% solution state {GLO}| market for | Cut-off, U
M.D. Brown GTL	300	Cyanuric chloride {GLO}| market for | Cut-off, U
Yellow PG	150	Cyanuric chloride {GLO}| market for | Cut-off, U
Global Salt	2000	Chemical, organic [GLO]| production | Cut-off, U
Ross Acid N Liq	200	Acetic acid, without water, in 98% solution state {GLO}| market for | Cut-off, U
GP 5501 NF	500	Vinyl acetate {GLO}| market for | Cut-off, U

The following table shows the amount of water needed to wash one pair of the three-denim analyzed.

Table 12: Washing process water use

Water use [l]	Single style production		
	211TRODORTOY-217	202TROCAROL-66	202TRO009-226
	99% CO 1% EA	89% CO 8% PL 3% EA	77%CO 22% PL 1% EA
	26	62,7	27,7

4.4.2 Production plant data

In the reporting year, the plant absorbed 9.429.721,00 kwh of energy from the grid, while the photovoltaic system generated 4.501,00 kWh of energy.
The energy absorption from the power grid was modeled with dataset Electricity, low voltage {BD}| market for electricity, low voltage | Cut-off, U.
The ETP system available to the production site recorded a water release of 95% of the water input.
The direct emissions reported in the following table were recorded and modeled.

Table 13: Direct air emission

Direct air emission	Quantity [kg/year]
Substance 1 (PM2.5)	19,14
Substance (PM10)	23,67
SO2	21,53
Nox	51,01

4.5 Downstream

4.5.1 Distribution

The distribution phase was modeled considering the Italy-Bangladesh distance of 11.275 km and transport was allocated in the percentages of 86%, 4% and 10% for sea, air and road transport, respectively.
The databases used for the three means of transport are:

- Truck: Transport, freight, lorry 16-32 metric ton, euro3 {RER}| market for transport, freight, lorry 16-32 metric ton, EURO3 | Cut-off, U
- Ship: Transport, freight, sea, transoceanic ship {GLO}| market for | Cut-off, U
- Airplane: Transport, freight, aircraft {RoW}| intercontinental | Cut-off, U

4.5.2 Use

A garment life of 80 washing cycles was assumed.
At each washing cycle was attributed a water consumption of 11 kg and an electricity withdrawal of 0.5 MJ.
The databases for water withdrawal and discharge are respectively Tap water {Europe without Switzerland}| market for | Cut-off, U and Wastewater, from residence {RoW}| market for wastewater, from residence | Cut-off, U. While electricity consumption was modeled with Electricity, low voltage {IT}| market for | Cut-off, U.

4.5.3 Garment End of Life

For the end of life of the garment, a scenario consisting of 19.4% recycling, 56.3% landfilling and 24.3% incineration was considered.
This scenario was modeled using the following databases Municipal Solid Waste {IT}| municipal solid waste market | Cut-off, U and Municipal Solid Waste {IT}| treatment, incineration | Cut-off, U, for landfilling and incineration, respectively.