Sustainability Consulting

Report

Life cycle assessment (LCA) of five types of bamboo products

Prepared for Holse & Wibroe

by
Mr. Chao Wang
Ms. Dandan Li

Ecovane Environmental

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EXECUTIVE SUMMARY

Holse & Wibroe A/S is a Danish company founded in 2004.

The entire business is based upon bamboo. Bamboo products were supplied for both outdoor and indoor use. Hereunder bamboo floorings, bamboo panels, bamboo veneer, bamboo decking, bamboo cladding and bamboo beams. The head office is located near Copenhagen, Denmark.

Through continuous innovation, H&W has by far produced five categories of bamboo products available for indoor applications, namely semi-finished bamboo panels, traditional bamboo flooring, strand woven bamboo flooring, bamboo wood composite flooring, and bamboo industrial parquet. These five products are all included in the LCA study within this report.

Life cycle assessment (LCA) is defined by ISO as the “compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle” (ISO 14040). In other words, LCA identifies the materials, energy, emissions and waste flows of a product, process or service over its entire life cycle in order to determine its environmental impacts.

This life cycle stages within this report includes raw materials extraction and processing (A1), transport to the manufacturing (A2), manufacturing (A3), and transport of product (A4), end of life (C) and benefit beyond boundary (D).

For certain aspects of bamboo flooring studied, the following assumptions were made:

1) For missing background data, substitution of missing data using similar background data approach was taken to shorten the gap.
2) Transport assumptions were made where it was not possible to obtain the specific data, for instance from distribution center to outlet and from outlet to consumer. When this occurred, it was clearly stated in the report.
3) Electricity consumption data was not obtained for certain processes so assumptions were made for these. When this occurred, it was clearly stated in the report.
4) In line with the requirement from EN 15804, the lifecycle stage in this report include cradle to gate with option of considering end of life treatment and benefit beyond boundary.
5) Biogenic carbon dioxide storage and uptake from the air was included in the modeling, and emission of CO_2 was considered in the end-of-life stage, to follow a so-called carbon-neutral approach for calculation of the global warming potentials of the product.

Modification of the global background database was done in case of necessary by replacing all the energy data, especially electricity production data, with Chinese energy data, and the study used the modified background data to get better indication of the potential environmental impact results by using more localized dataset of energy supply.

The LCA results show that the stage of raw material stage A1 contribute to the main environment impact with different shares for each environment impacts categories.

Besides stage contribution, from the study, three findings are worth highlighted below:

(1) In the raw material stage A1, the glue content account for a large share of the environment impacts. It is advised to take some measures toward green resin.
(2) In the manufacturing stage A3, some processes are energy intensive. Measures should be taken to lower the level of energy consumption.
(3) In addition, transport has a considerable environmental impact, how to reduce the environment burden through optimization of transportation is a key issue for bamboo products.

Critical Review Statement

This LCA has been critically reviewed to the ISO 14040:2006, ISO 14044:2006 standards as well as EN 15804 and PCR 2019:14 of construction product from IVL, Sweden. According to the verification report, the report achieved a good level of representativeness and transparency and is compliant with the requirements of LCA, PCR and EN 15804 standard.

Disclaimer

The results presented in this study are based on a few realistic models of typical bamboo product life cycles. As with any model, different assumptions will lead to different outcomes. It is important to understand the working of the model, the scope and the limitations before applying these results to support decisions or other applications.

Acknowledgments

The author wants to send acknowledgement to the following organizations for their support during the LCA study and report:

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Ecovane Environmental Co. Ltd

1. Introduction

1.1 Company introduction

Holse & Wibroe A/S is a Danish company founded in 2004.

The entire business is based upon bamboo. Bamboo products were supplied for both outdoor and indoor use. Hereunder bamboo floorings, bamboo panels, bamboo veneer, bamboo decking, bamboo cladding and bamboo beams. The head office is located near Copenhagen, Denmark.

Holse & Wibroe is founded upon the values of honesty, trust, long term partnership and the ability to supply environmental and sustainable bamboo products of high quality, for both residential and commercial use.

Together with the long-term partners, Holse & Wibroe strive to develop new bamboo products of high quality, and move the borders for bamboo used in the building industry.

1.2 Product description

This report serves as the background report for the Environmental Product Declarations (EPD) for the bamboo floorings. Within this report, five series of products are analyzed: traditional bamboo, strand woven bamboo, bamboo wood composite, semi-finished bamboo, and industrial parquet.

For traditional bamboo flooring, there are two types of products which are Holse & Wibroe BambooPlank™, and Holse & Wbroe Bamboo Heeringbone parquet. Because of the similar products, the average result was declared in this report.

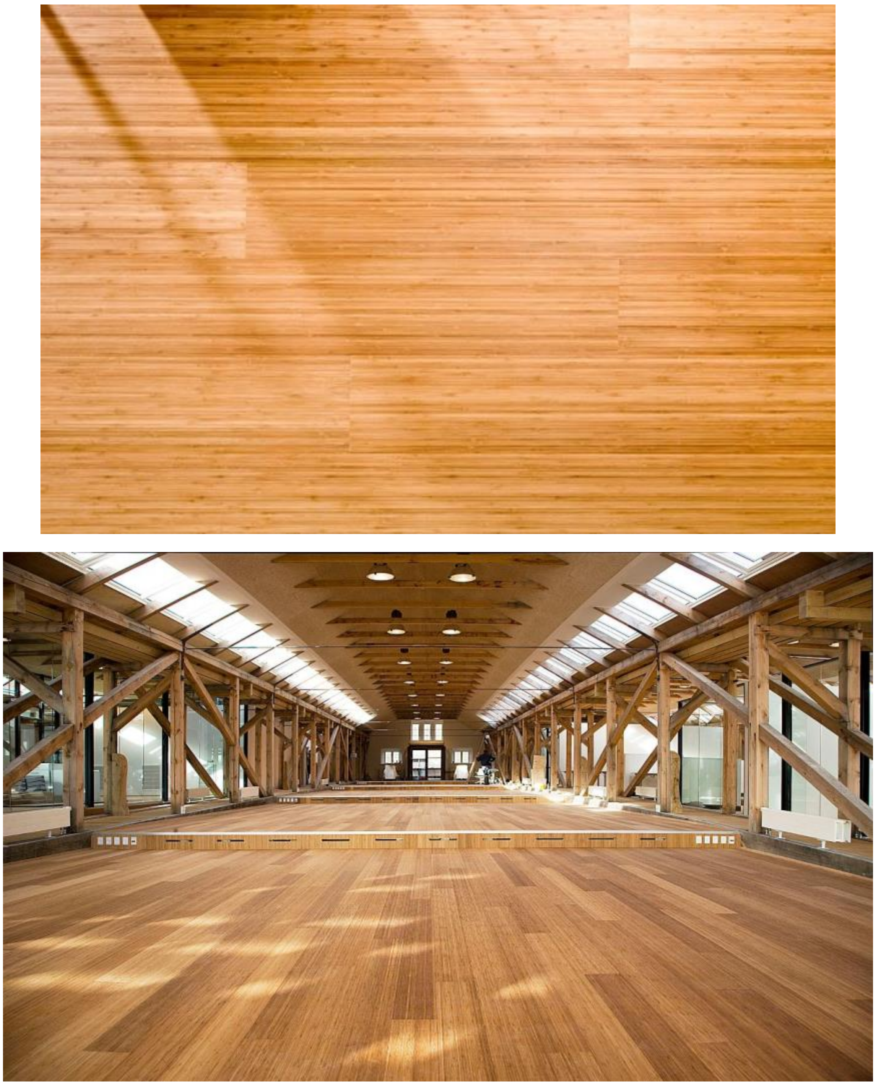


Figure 1 traditional bamboo

Holse & Wibroe BambooPlank™ are solid floorings made from special selected bamboo strips. All strips are sorted by hand and then glued together. The look is strict Scandinavian with straight lines appearing, but with a warm glow. Floorings are delivered with tongue & grove. Made from bamboo specie "Phyllostachus Pubescens", origin China. Available with FSC certificate upon request.

Holse & Wibroe Bamboo Heeringbone parquet are solid floorings made from special selected bamboo strips. All strips are sorted by hand and then glued together. The look is classic with a modern twist, due to the strict lines of the bamboo strips. Floorings are delivered with tongue & grove. Made from bamboo specie "Phyllostachus Pubescens", origin China. Available with FSC certificate upon request.

For strand woven bamboo flooring, there are two types of products which are Holse & Wibroe Bamboo Extreme™ floorings and Holse & Wibroe Bamboo Extreme™ Industrial parquet. Because of the similar products, the average result was declared in this report.

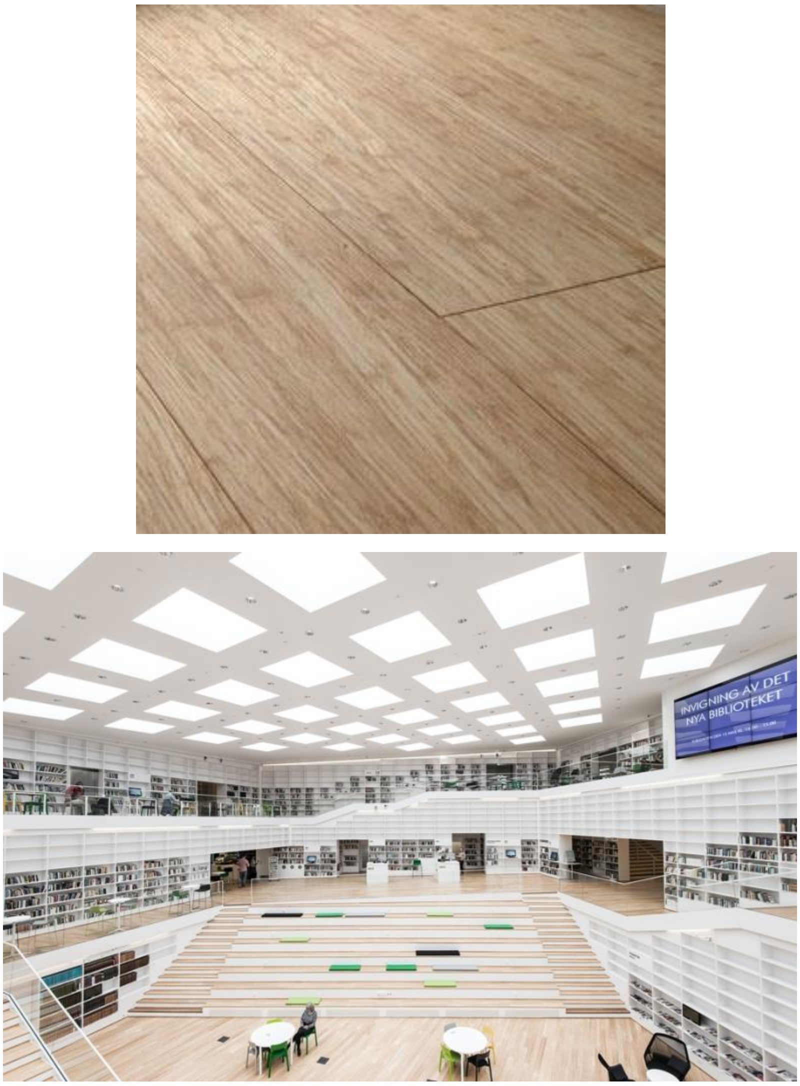


Figure 2 strand woven bamboo

Holse & Wibroe Bamboo Extreme™ floorings are made from bamboo fibers that are crushed, put in resin and then pressed under extreme high pressure. Creating an extremely dense and solid material, much harder than any hardwood. The look is similar with known hardwoods. Floorings are delivered with tongue & grove or click-assembly. Produced from bamboo specie "Phyllostachus Pubescens", origin China. The material consists of 96% pure bamboo. Available with FSC certificate upon request.

Holse & Wibroe Bamboo Extreme™ Industrial parquet are floorings made from the solid and dense Bamboo Extreme™ material. The lose bamboo strips are cut into length and bundled in a block with adhesive tape. The looks are infinity with notes and shades as knowns hardwoods. The strips are made from 96% pure bamboo. Produced from bamboo specie "Phyllostachus Pubescens", origin China. Available with FSC certificate upon request.

For bamboo wood composite flooring, there are two types of products which are Holse & Wibroe Bamboo Laminated Plank™ and Holse & Wibroe Bamboo Extreme™ Laminated plank. Because of the similar products, the average result was declared in this report.

Figure 3 bamboo wood composite

Holse & Wibroe Bamboo Laminated Plank™ are laminated floorings with a top layer of special sorted bamboo strips, applied on top of a wooden multiply core. The look is strict Scandinavian with straight lines appearing, but with a warm glow. The multiply core creates an extreme stability. Made with click-assembly and produced from bamboo specie "Phyllostachus Pubescens", origin China. Available with FSC certificate upon request.

Holse & Wibroe Bamboo Extreme™ Laminated plank are laminated floorings with a top layer of Bamboo Extreme™, applied on top of a wooden multiply core. The multiply core creates extreme stability combined with the extreme durable top layer. The look is similar with known hardwoods. Made with tongue & grove and produced from bamboo specie "Phyllostachus Pubescens", origin China. Available with FSC certificate upon request.

For semi-finished bamboo panels, there are two types of products which are Holse & Wibroe Bamboo panel and Holse & Wibroe Extreme™ panel, the main difference between these two products is the top layer. Because of the production volumes, the representative result of Holse & Wibroe Bamboo panel was declared in this report.

Figure 4 semi-finished bamboo

Holse & Wibroe Bamboo panels are made from sorted bamboo strips which are glued together. The top & bottom-layer-strips or Bamboo extreme™-material are in full length. The core (=> 20 mm thickness) is made with horizonal cross layer for maximum stability. Bamboo Panels can be used as decoration, walls, stairs, tabletops, furniture or similar. Produced from bamboo specie "Phyllostachus Pubescens", origin China. Available with FSC certificate upon request.

For bamboo industrial parquet, there is only one product which is Holse & Wibroe Bamboo Industrial parquet.

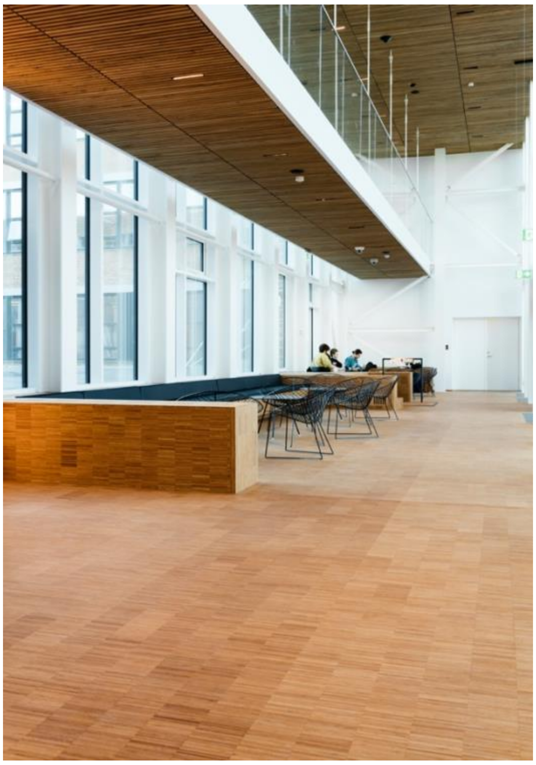
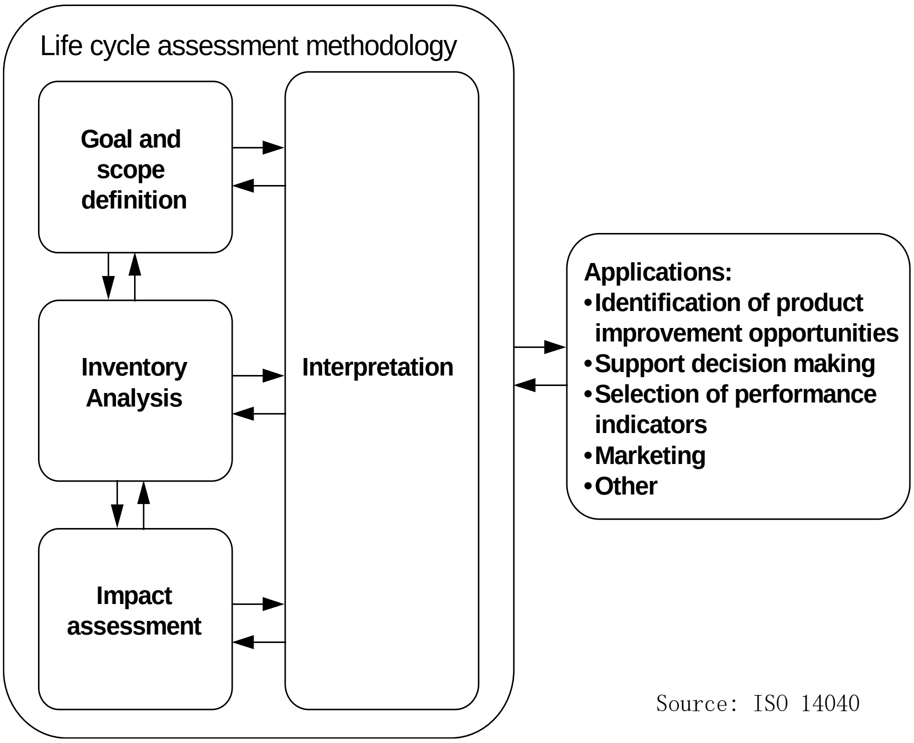


Figure 5 industrial parquet

Holse & Wibroe Bamboo Industrial parquet are floorings made from 100% pure bamboo. The lose bamboo strips are cut into length and bundled in a block with adhesive tape. The look is sharp with straight lines and a warm glow, yet creating an infinity look. Produced from bamboo specie "Phyllostachus Pubescens", origin China. Available with FSC certificate upon request.

2. Introducing life cycle assessment

Life cycle assessment (LCA) is an internationally standardized analytical method for measuring and comparing the environmental impacts of producing, using and disposing of a product. LCA consists of several interrelated stages: definition of goal and scope, inventory analysis, impact assessment and interpretation of results, as shown in Figure 1.



Source: ISO 14040

Figure 6 Life cycle assessment

Life cycle assessment (LCA) is defined by ISO as the "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (ISO 14040). In other words, LCA identifies the materials, energy, emissions and waste flows of a product, process or service over its entire life cycle for its environmental impacts to be determined.

LCA is an internationally standardized analytical framework for identifying and quantifying the impact of resource use and emissions (e.g. greenhouse gases) from the “cradle” to the “grave” of a system. The general impacts to be considered include resource depletion, human health, and ecological consequences. For example:

- Emissions of greenhouse gases affecting human health and causing loss of ecosystem services through the effects of global warming and climate change;
- Depletion or pollution of scarce freshwater resources necessary for human consumption, food production systems and to sustain eco-systems;
- Use of finite resources such as fossil fuels that are limiting the available pool for future generations, etc.

The study followed the ISO 14040 and ISO 14044 guidelines, it:

- Identified the goal and scope of products and life cycle to be reviewed;
- Identified the energy, water and materials used, pollution emitted and waste generated through the life cycle, by life cycle stages;
- Assessed the potential resource use, human and ecological impacts of those uses and emissions, acknowledging the uncertainties and assumptions used;
- Compared those impacts for the selected bamboo products;
- Highlighted any significant results and implications.

The study has also followed the requirement of EN 15804 and PCR 2019:14 Construction products v1.2.5.

To complete compliance, the study should be critically reviewed before public disclosure.

A full LCA of a product can be a time- and cost-consuming exercise. This has proved a great obstacle to the uptake of LCA in industry. As a response, the concept of the streamlined LCA has evolved. The streamlining primarily involves using generic industry data instead of collecting system specific data.

This study followed a complete LCA approach rather than streamlined version, other than using generic data, the team collected as many specific data as possible in order to get more accurate LCA results.

Companies undertake LCAs for a variety of reasons. Companies often strive to improve the environmental performance of their products due to environmental legislation and pressures along the supply chain. Another reason is the increasing number of environmentally conscious customers who are demanding better performing products and seeking products that combine the benefits of high performance and low cost with good environmental performance.

The life cycle principle is also the main foundation for many information tools. For example, the life cycle principle lies behind the criteria for environmental labels such as the EU Product Environmental Footprint Scheme (PEF), environmental product declaration (EPD), Eco-labels such as the German Blue Angel and the Nordic Swan. It also forms the basis of analyzing product carbon foot printing and water foot printing.

While LCA is a valuable tool, it should be emphasized that it is one of many factors that need to be considered by companies during decision-making, among others, costs, consumer acceptance, production feasibility and so on. And it should be noted that the estimated impact results are only relative statements which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risks.

3. Goal of study

With over years of history of bamboo products production, H&W is always thinking of new ways to use bamboo. H&W concentrates on developing high quality products, following customer needs and providing outstanding value-added service.

As part of H&W's continuous innovation activities and fulfillment of social responsibility, H&W intends to report the environmental aspects of the products with transparency by means of Environmental Product Declaration (EPD). The goal of this LCA study is to generate the LCA results for a portfolio of five categories of H&W products (traditional bamboo flooring, strand woven bamboo flooring, bamboo wood composite flooring, semi-finished panels, bamboo industrial parquet) for EPD application, and also identify the hotspot of the products' environmental impact, based on which H&W may seek ways in the future to continuously improve its environmental footprint through better recycling system or improvement in e.g. manufacturing processes and so on.

The LCA study is intended to be used for application of product environmental declaration (EPD). The main purpose of EPDs is for business-to-business communication about the environmentally relevant information of the products.

4. Scope of study

4.1 Declared unit

The declared unit is the product category unit to be referred to when determining environmental impacts. In order to assess the environmental impacts of different products, it is important that the declared units of these products are equivalent so that the results may be interpreted clearly.

In this report, the declared unit is the 1kg of bamboo flooring.

4.2 Product systems and system boundaries

4.2.1 Product systems studied

Up to now, H&W has five products： semi-finished bamboo panels, traditional bamboo flooring, strand woven bamboo flooring, bamboo wood composite flooring, and bamboo industrial parquet. These five kinds of products are all included in this report. The information is shown in Table 1.

Table 1 Information of products

Name	Density	Thickness
Semi-finished bamboo panels	650 kg/m^3	10/12/15/20/30/40mm
Traditional bamboo flooring	700 kg/m^3	15/19mm
Strand woven bamboo flooring	1100 kg/m^3	10/14mm
Bamboo wood composite flooring	600 kg/m^3	14/22mm
Bamboo industrial parquet	680 kg/m^3	10/15mm

4.2.2 System boundaries

The study of H&W bamboo flooring products includes all life cycle stages and processes. All energy and material inputs have been traced back to the extraction of resources. Emissions from the whole system have been quantified.

Figure 5 illustrates the system boundary for the study of five products. This report includes A1 raw materials, A2 transport of raw material, A3 manufacturing, A4 transport of product, C end of life and D reuse and recycle. A5 installation and B are not declared.

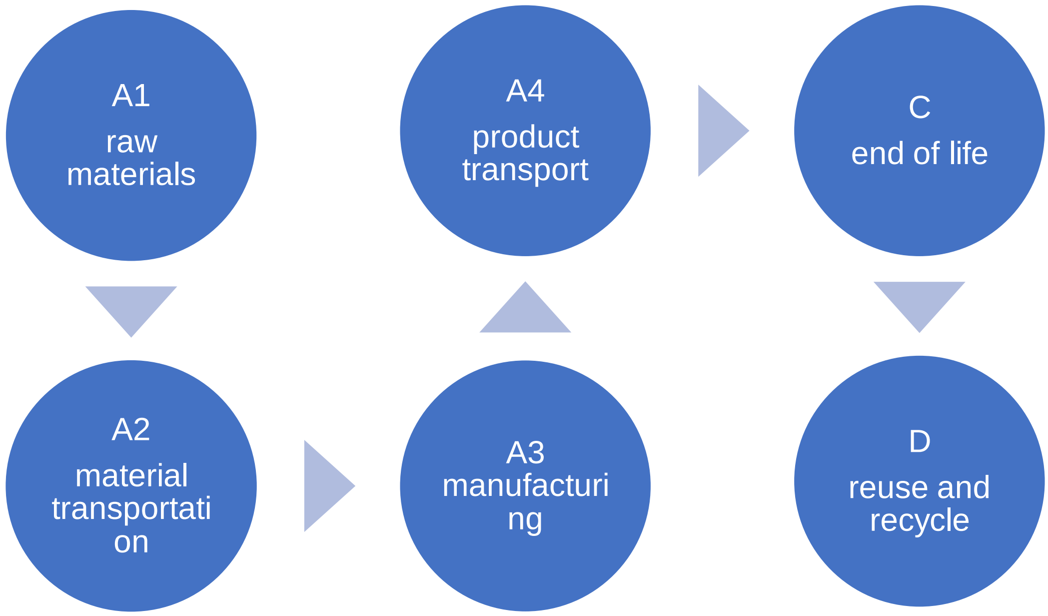


Figure 7 System boundaries

Within this report, the scenarios included are currently in use and are representative for one of the most likely scenario alternatives, more detailed description of each included life cycle stage is shown below.

Table 2 Life cycle stages

<table>
<tr><td rowspan="17">Included modules in the life cycle assessment</td><td rowspan="3">Product Stage</td><td>X</td><td>A1 Raw material supply</td></tr>
<tr><td>X</td><td>A2 Transport to the manufacturer</td></tr>
<tr><td>X</td><td>A3 Manufacturing</td></tr>
<tr><td rowspan="9">Construction process stage</td><td>X</td><td>A4 Transport to the site</td></tr>
<tr><td>MND</td><td>A5 Assembly/Install</td></tr>
<tr><td>MND</td><td>B1 Use</td></tr>
<tr><td>MND</td><td>B2 Maintenance</td></tr>
<tr><td>MND</td><td>B3 Repair</td></tr>
<tr><td>MND</td><td>B4 Replacement</td></tr>
<tr><td>MND</td><td>B5 Refurbishment</td></tr>
<tr><td>MND</td><td>B6 Operational energy use</td></tr>
<tr><td>MND</td><td>B7 Operational water use</td></tr>
<tr><td rowspan="4">End of Life Stage</td><td>X</td><td>C1 Deconstruction</td></tr>
<tr><td>X</td><td>C2 Transport to waste processing</td></tr>
<tr><td>X</td><td>C3 Waste processing for reuse, recovery and/or recycling</td></tr>
<tr><td>X</td><td>C4 Disposal;</td></tr>
<tr><td>Benefits and loads beyond the product system boundary</td><td>X</td><td>D Reuse, recovery and/or recycling potentials,</td></tr>
<tr><td colspan="4">Note: X=Declared Module, MND=Module not Declared in this LCA study</td></tr>
</table>

Raw material

The production of the raw materials, such as original bamboo, melamine formaldehyde resin, phenolic resin and auxiliary packaging materials were included in the study. All packaging materials used for flooring packaging were included in the raw material modeling (A1 stage). Packaging materials includes corrugated board, packaging film, pallet, and packaging belt.

Transport of raw materials

The transport of the raw materials to the flooring manufacturer has been included. Where it was not possible to define specific distances, justified estimates and web-based map service was used to the best of our knowledge. For all transportation vehicles, if not specified, 10-tonne-truck scenario was used for LCA modelling for simplification purpose.

Transport of packaging materials

The transport of the packaging materials to the flooring manufacturing site has been included. Where it was not possible to define specific distances, justified estimates were used.

Manufacturing

The manufacturing process of the five kinds of products was included. The process of traditional bamboo flooring, strand woven bamboo flooring, bamboo wood composite flooring, semi-final bamboo panels, and bamboo industrial parquet are different from each other, see Section 5 for more explanation for manufacturing stage.

Transport of bamboo products to regional market

The transport of the bamboo product from the manufacturing site to Denmark was included. Where it was not possible to define specific distances, justified estimates were used.

Consumer

Environment impacts associated with the transport of the product from market to the consumers were considered minor and not included.

Environmental impact associated with the energy and material used for cleaning and maintenance of the bamboo product was considered minor and not included.

Deconstruction

Demounting and demolition were assumed manually, no industrial process was considered.

Transport to waste management

Waste collection of used bamboo product from consumer households to waste management facilities was included and estimated to be 100km in average.

Waste processing for reuse, recovery and/or recycling

The waste process of the five kinds of products was included. The process was assumed only the wood chipping machine was used then only electricity was consumed. The scenario was assumed for 100% incineration and energy recovery. See section 5 for more explanation for waste processing stage.

Disposal

As waste scenario after the demolition stage, incineration for energy recovery was assumed as scenario following default values.

Benefits and loads beyond the system boundary

The avoided products as a result from the energy recovery of bamboo flooring from incineration is considered as benefit beyond the system boundary, is calculated in the stage D Reuse and recycle.

4.2.3 Excluded processes

The following are the secondary processes that have been excluded from the system and have not formed part of the study:

- Handling operations such as during usage at the consumer household
- Transport from retailer / outlet to consumer household
- Capital equipment
- General infrastructure

4.3 Key assumptions and limitations

For certain aspects of bamboo flooring studied, the following key assumptions were made as follows:

- For missing background data, substitution of missing data using similar background data approach was taken to shorten the gap.
- Transport assumptions were made where it was not possible to obtain the specific data, for instance from distribution center to outlet and from outlet to consumer. When this occurred, it was clearly stated in the report;
- Electricity consumption data was not obtained for certain processes so assumptions were made for these. When this occurred, it was clearly stated in the report;
- A modification of the global background database was done by replacing all the energy data, especially electricity production data, by Chinese energy data, and the study used the modified background data to get better indication of the potential environmental impact results by using more localized dataset of energy supply.
- And it is also assumed that there is no difference among five kinds of H&W products during end of life stage treatment.

4.4 Allocation

Allocation refers to partitioning of input or output flows of a process or a product system between the product systems under study and one or more other product systems. In the production of bamboo flooring, special production is used because all the inputs and outputs are clearly corresponding to the products, there is no production of by products that need to be used to allocate the situation.

4.5 Cut-off-criteria

The following procedure was followed for the exclusion of inputs and outputs:

- All inputs and outputs to a (unit) process will be included in the calculation for which data is available. Data gaps may be filled by conservative assumptions with average or generic data. Any assumptions for such choices will be documented;
- According to PCR, life cycle inventory data shall according to EN 15804 include a minimum of 95% of total inflows (mass and energy) per module. In addition, if less than 100% of the inflows are accounted for, proxy data or extrapolation should be used to achieve 100% completeness. The neglected flow is demonstrated in Table 3.

Table 3 cut off flows

Flow name	Process stage	Mass %	Criteria to cut off
Bona Lacquer	A1	0.0002	<1%
UV coat	A1	0.0003	<1%

4.6 Electricity power mix

In this LCA study, different electricity mix is used based on grid mixes of China. The electricity inventory is based on 2018 for Chinese electricity generation (China Energy Statistics Yearbook 2019). The energy structure is depicted in Figure 3. The production of five kinds of bamboo products takes place in Anji, Zhejiang province. Eastern China grid electricity mix is used. Figure 48 demonstrates the GWP factors of different voltage levels in different electricity grids. The GWP is calculated by GWP 2013 100a method in SimaPro 9.4.0.1. The emission of the electricity used for manufacturing stage is 0.85kg/CO_2 eq.

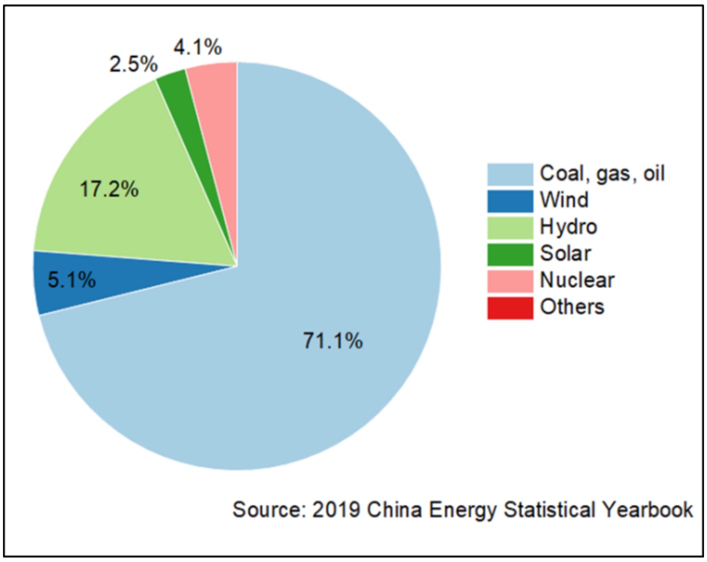


Figure 8 China's electricity production mix-2018

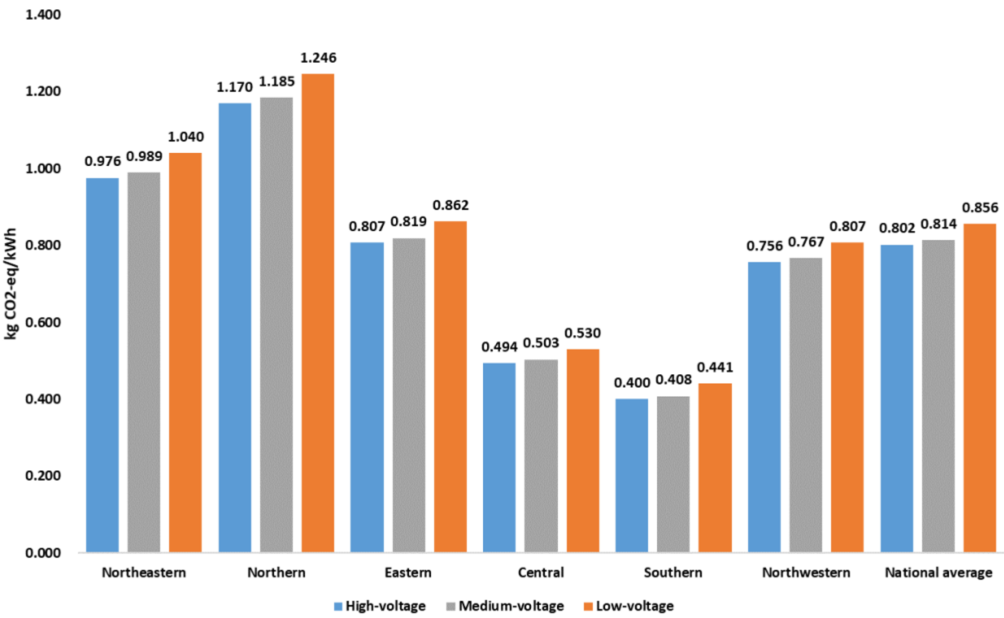


Figure 9 GWP factors in different grid

4.7 Initial data quality requirements

Steps were taken to ensure that the life cycle inventory data were reliable and representative. The type of data that was used is clearly stated in the Inventory Analysis, be it measured or calculated from primary sources or whether data are from the life cycle inventory databases. In this streamlined study, generic data for certain processes were sourced from these databases (Ecoinvent 3.8) in SimaPro 9.4.0.1.

SimaPro is the world's most widely used LCA software and the data in it comes predominantly from Ecoinvent, the world's most complete and widely used set of data on industrial processes, material production, packaging production, transport and so on.

The data quality requirements for this study were as follows:

- Existing LCI data were, at most, 10 years old. Newly collected LCI data were current or up to 3 years old;
- The LCI data related to the geographical locations where the processes occurred;
- The technology represented the average technologies at the time of data collection.

5. Life Cycle Inventory (LCI) Analysis

5.1 System description

The system boundary has been described in section 4.2. Same system boundary is considered for five kinds of products. The main differences are raw materials and manufacturing stage. The transportation of raw materials and products mainly depends on the raw material production site and market. Transportation will be described in 5.4. In this part, the manufacturing stage will be shown.

5.1.1 Traditional bamboo flooring, strand woven bamboo flooring, and bamboo wood composite flooring

The following scheme represents same steps of the manufacturing of traditional bamboo flooring, strand woven bamboo flooring, and bamboo wood composite flooring considered in this study.

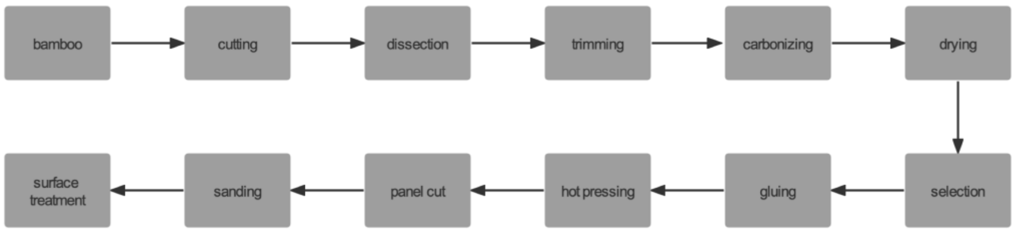


Figure 10 Manufacturing process of the traditional bamboo flooring

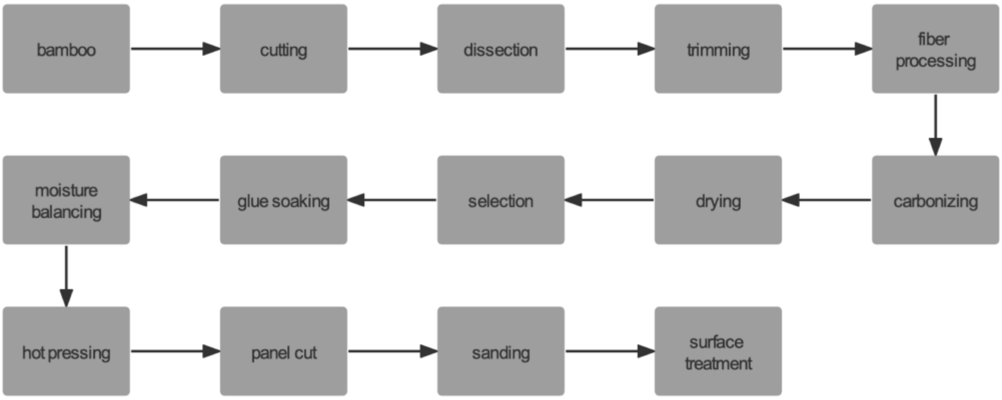


Figure 11 Manufacturing process of the strand woven bamboo flooring

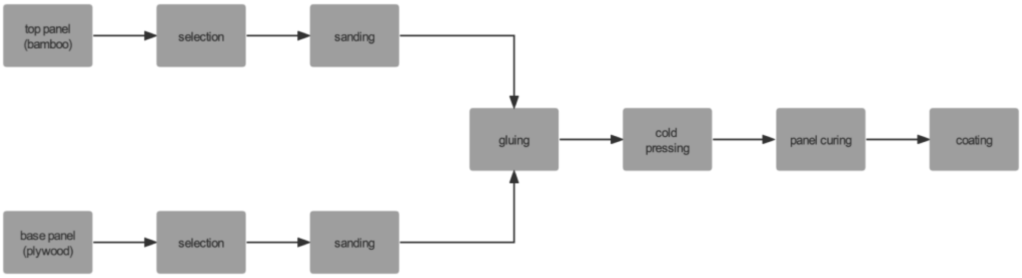


Figure 12 Manufacturing process of the bamboo wood composite flooring

5.1.2 semi-finished bamboo panels

The following scheme represents manufacturing steps of semi-finished bamboo panels considered in this study.

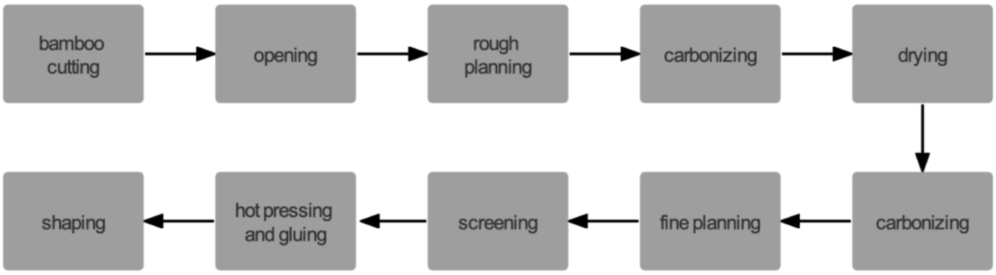


Figure 13 Manufacturing process of semi-finished bamboo panels

5.1.3 bamboo industrial parquet

The following scheme represents manufacturing steps of bamboo industrial parquet considered in this study.

Figure 14 manufacturing process of bamboo industrial parquet

5.2 Raw material acquisition

The materials required for five products include raw material and packaging materials for transportation. The raw materials include bamboo pole, plywood, melamine formaldehyde resin, and phenolic resin. The packaging materials include corrugated board, flat pallet, and packing film. The main material bamboo pole is mainly from the bamboo plant not far from the manufacturing plant. The bamboo pole for traditional bamboo flooring, strand woven bamboo flooring, and bamboo wood composite flooring is from Fujian province. The bamboo pole for semi-finished bamboo panels is from Jiangxi province. The bamboo pole for bamboo industrial parquet is from Zhejiang province.

The details of raw materials for five kinds of products are shown in table 4.

Table 4 Raw materials and packaging of products

Materials		Units	Traditional Bamboo flooring	Strand woven bamboo flooring	Bamboo wood composite flooring	Semi-finished Bamboo panels	Bamboo industrial parquet
Raw materials	bamboo pole	kg/kg	1.1457	1.0368	0.4792	1.3399	1.0500
	plywood	kg/kg	-	-	0.6350	-	-
	melamine formaldehyde resin	kg/kg	-	-	-	0.0323	-
	phenolic resin	kg/kg	0.0857	0.1200	0.1188	-	-

Packing materials	Corrugated board	kg/kg	0.0400	0.0255	0.0475	-	0.03
	Pallet	kg/kg	0.0120	0.0027	0.0144	0.0288	0.0192
	Packing film	kg/kg	0.0004	0.0003	0.0005	0.0007	0.0001

5.3 Manufacturing

The manufacturing process of five kinds of bamboo flooring mainly includes drying, profiling, and polishing, press and etc., which involves raw materials, energy, and emissions. The inputs and outputs for manufacturing of different kinds of bamboo flooring are different.

Since the raw materials are already considered in “raw material acquisition” step above, the model will mainly deal with energy consumption and emissions. The life cycle inventory data including input and output data of energy, water and emissions is calculated using weighted average method. Since the energy consumption and emission data was collected during the 2021, and in each factory, HW’s products were manufactured only part of the whole production, the accurate inventory data should be allocated by production using weighted average method.

The life cycle inventory data of manufacturing was calculated and submitted by Qichen in Traditional bamboo flooring, Strand woven bamboo flooring, Bamboo wood composite flooring, by Aixi in Semi-finished bamboo panels, and by Hengfeng in industrial parquet.

Table 5 Inputs for manufacturing

Name	Electricity: kWh/kg	Water: kg/kg
Traditional bamboo flooring	0.3314	0.8704
Strand woven bamboo flooring	0.2773	0.5539
Bamboo wood composite flooring	0.3667	1.0344

Semi-finished bamboo panels	0.3784	2.8917
Bamboo industrial parquet	0.005	-

Table 6 Outputs of manufacturing

Name	Particulates: kg/kg	Bamboo Scrap Waste Recycling: kg/kg
Traditional bamboo flooring	0.1857	0.0457
Strand woven bamboo flooring	0.1128	0.0440
Bamboo wood composite flooring	0.2207	0.0123
Semi-finished bamboo panels	0.3238	0.0484
Bamboo industrial parquet	-	0.0500

5.4 Transportation

5.4.1 Raw material transportation

The transportation mainly takes place on the upstream of raw material supply and downstream of product delivery. According to the production site in Anji, Zhejiang province, the raw materials besides bamboo are sourced from other places in Zhejiang province, and delivered by lorry. As it was not possible to define specific distances, justified estimates and web map service were used to the best of our knowledge. For all transportation vehicles, if not specified, 10-tonne-truck scenario was used for LCA modelling for simplification purpose.

Products are transported to foreign market, and the mode of transportation involves land transportation and sea transportation.

The information related to raw materials transportation including distance, vehicle is shown in the table below.

Table 7 Transportation of raw material

Name	Original bamboo		Eucalyptus		Melamine formaldehyde		Phenolic	
	Distance: km	source	Distance: km	source	Distance: km	source	Distance: km	source
Traditional Bamboo flooring	500	Fujian	-	-	-	-	40	Zhe jiang
Strand woven bamboo flooring	500	Fujian	-	-	-	-	40	Zhe jiang
Bamboo wood composite flooring	500	Fujian	200	Zhe jiang	-	-	40	Zhe jiang
Semi-finished bamboo panels	100	Jiang xi	-	-	780	Zhe jiang	-	-
Bamboo industrial parquet	100	Zhe jiang	-	-	-	-	-	-

5.4.2 Product transportation

According to H&W, five kinds of bamboo products are consumed in Denmark. Transportation distance for product delivery was estimated with reference to external resources. The transportation distance and mode are given in table below.

Table 8 Transportation distance and mode of five kinds of products

Name	Land distance: km	Sea distance: km
Traditional bamboo flooring	227	23474
Strand woven bamboo flooring	227	23474
Bamboo wood composite flooring	227	23474
Semi-finished bamboo panels	245	23474
Bamboo industrial parquet	265	23474

5.5 End of life and Benefits and loads beyond the product system boundary

Demounting and demolition of assumed was conducted manually, so there is no energy and material input involved. The transport distance from installation site to final waste processing site was assumed to be 100 km. The wood chipping energy use was assumed 0.0125kwh/kg and the 100% incineration were assumed in the waste processing stage. The energy recovery of the waste bamboo chips was assumed at the stage D. For energy recovery, production of heat and electricity with wood chips in a state-of-the-art co-generation plant in Denmark was assumed. Heat is considered as the main product and electricity is a by-product. According to the electric efficiency 0.15 and thermal efficiency 0.45, and the heat value of bamboo 19.8MJ/kg, then the energy recovery could be calculated.

These data are all adapted from the Ecoinvent 3.8 database.

Table 9 End of life scenario assumption

Waste transportation distance: km	Wood chipping energy use: kwh/kg	Incineration waste wood: kg/kg	Energy recovery	
			Electricity: MJ/kg	Heat: MJ/kg
100	0.125	1	2.82	8.46

5.6 Discussion of biogenic carbon

According to PCR specification, when a product contains biomass carbon that is stored in product for more than one year, this biomass carbon can be accounted in the assessment of GHG emission of the product. The weighted average of this carbon is treated as negative GHG emission.

Due to the relatively long service life of the bamboo flooring, the effect of carbon stock was considered in the carbon footprint assessment of bamboo flooring. The biomass carbon stock was determined by multiplying the dry weight of the bamboo product by the carbon content of bamboo. The effect of carbon stock for bamboo flooring was calculated with formula:

$$C=M*0.88*T$$

Where,

C is the effect of carbon stock for bamboo flooring (kg CO2 eq),

M is carbon stock in 1 m^3 of bamboo flooring (kg CO2 eq) which derived from the amount of dry weight of bamboo flooring, carbon density and transfer ratio of carbon to CO2 (44/12),

T is the dry weight for a specific bamboo flooring except glue content,

0.88* T is a weighted factor for carbon stock. 0.88 is the moisture content of the bamboo.

The weight of $1m^3$ bamboo flooring is 589 to 1100kg, the carbon ration is considered 50%. The lifespan of bamboo flooring is assumed to be 20 years.

For example, the biogenic carbon of traditional bamboo flooring is (700-60) * 0.88 * 0.5 * 44 / 12 = 1032.53

The biogenic carbon of five kinds of bamboo flooring are shown in table.

Table 10 biogenic carbon of five products

Name	Density: kg/m^3	Glue: kg/m^3	Carbon ratio	Biogenic CO_2: kg CO_2/m^3	Biogenic CO_2: Kg CO_2/kg	Biogenic carbon: Kg C/kg
Traditional bamboo flooring	700	60	0.5	1032.53	1.4750	0.4023
Strand woven bamboo flooring	1100	132	0.5	1561.71	1.4197	0.3872
Bamboo wood composite flooring	600	70	0.5	855.07	1.4251	0.3887
Semi-finished bamboo panels	650	21	0.5	1014.79	1.5612	0.4258
Bamboo industrial parquet	680	0	0.5	1097.07	1.6133	0.4400

Considering all five products are made of biogenic materials, the LCA result of GWP-biogenic should be revised based on the table 16.

In order to balance the biogenic CO2, in A1 stage, the biogenic CO2 should be negative because of the CO2 uptake. Meanwhile, in C3 stage, the biogenic CO2 should be positive because of the CO2 release.

Thus, the biogenic mass balance is manually added and calculated.

6. Environment Impact Assessment

Environment impact assessment provides indicators and a basis for analyzing the potential contributions of the resource extractions, usage of material, and waste disposal/emissions in an inventory to several potential impacts. To compare life cycle inventory results, “EN15804:A2” impact category methods were used.

6.1 Environmental impact assessments (EN15804:2012+A2:2019)

The EN 15804 standard covers Environmental Product Declarations (EPDs) of Construction Products. The 2019 A2 revision of this standard has aligned their methodology with the EF 3.0 method, except for their approach on biogenic carbon. According to the EN 15804, biogenic carbon emissions cause the same amount of Climate Change as fossil carbon, but can be neutralized by removing this carbon from the atmosphere again.

Table 11 Impact categories of environmental impacts

Impact Category	Indicator	Unit	Model
Climate change - total	Global Warming Potential total (GWP-total)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Climate change - fossil	Global Warming Potential fossil fuels (GWP-fossil)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Climate change - biogenic	Global Warming Potential biogenic (GWP-biogenic)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Climate change – land use and land use change	Global Warming Potential land use and land use change (GWP-luluc)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Ozone Depletion	Depletion potential of the stratospheric ozone layer (ODP)	kg CFC11eq.	Steady-state ODPs, WMO 2014
Acidification	Acidification potential, Accumulated Exceedance (AP)	mol H^+ eq.	Accumulated Exceedance, Seppala et al. 2006, Posch et al., 2008
Eutrophication aquatic fresh water	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater)	kg PO_4 eq.	EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe
Eutrophication aquatic marine	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-marine)	kg N eq.	EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe
Eutrophication terrestrial	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	mol N eq.	Accumulated Exceedance, Seppala et al. 2006, Posch et al.
Photochemical ozone formation	Formation potential of tropospheric ozone (POCP)	kg NMVOC eq.	LOTOS-EUROS, Van Zelm et al., 2008, as applied in ReCiPe
Depletion of abiotic resources – minerals and metals	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	kg Sb eq.	CML 2002, Guinee et al., 2002, and van Oers et al. 2002.

Depletion of abiotic resources – fossil fuels	Abiotic depletion potential for fossil resources (ADP-fossil)	MJ, net calorific value	CML 2002, Guinee et al., 2002, and van Oers et al. 2002.
Water use	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	m^3 world eq. deprived	Available Water Remaining (AWARE) Boulay et al., 2016

6.2 LCA results

This section shows the LCA results of five kinds of bamboo flooring.

6.3 Contribution of life cycle stages

6.3.1 Traditional bamboo flooring

To produce traditional bamboo flooring, the main contributor for environment impacts is A1 raw materials. Each environment impact has a different characteristic of life cycle stage contribution. When considering the stage of C and D, the impact of global warming potential - total and global warming potential - biogenic are positive because the biogenic carbon was add back to the stage C3.

(1) Global Warming Potential - total (GWP - total)

In the impact category of Global Warming Potential - total, to produce traditional bamboo flooring product, A1 is negative because the biogenic carbon was deleted in this stage. When considering the stage of C and D, climate change in this stage is positive because the biogenic carbon was added back, and the total climate change is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle aggravates the environmental impacts of the production process (A1-A3).

(2) Global Warming Potential - fossil (GWP - fossil)

In the impact category of Global Warming Potential - fossil, to produce traditional bamboo flooring product, A1 dominates the contribution with 61.84% of impact which is the most. When considering the stage of C and D, climate change in this stage is negative, while the total climate change is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(3) Global Warming Potential - biogenic (GWP - biogenic)

In the impact category of Global Warming Potential - biogenic, to produce traditional bamboo flooring product, A1 is negative because of the biogenic carbon. When considering the stage of C and D, climate change in this stage is positive, while the total climate change is negative. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(4) Global Warming Potential – land use and land use change (GWP - luluc)

In the impact category of Global Warming Potential - land us and land use change, to produce traditional bamboo flooring product, A1 dominates the contribution with 97.05% of impact which is the most. When considering the stage of C and D, climate change in this stage is negative, while the total climate change is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(5) Depletion potential of the stratospheric ozone layer (ODP)

In the impact category of depletion potential of the stratospheric ozone layer, to produce traditional bamboo flooring product, A1 dominates the contribution with 37.83% of impact, the stage A2 contributes to 57.72%. When considering the stage C and D, ozone depletion in this stage is negative, while the total ozone depletion is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(6) Acidification potential, accumulated exceedance (AP)

In the impact category of acidification potential, to produce traditional bamboo flooring product, A1 dominates the contribution with 65.86% of impact which is the most. When considering the stage C and D, acidification in this stage is negative, while the total acidification is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(7) Eutrophication potential - fresh water (EP - freshwater)

In the impact category of eutrophication potential - fresh water, to produce traditional bamboo flooring product, A1 dominates the contribution with 83.17% of impact which is the most. When considering the stage C and D, eutrophication aquatic fresh water in this stage is negative, while the total eutrophication aquatic fresh water is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(8) Eutrophication potential - marine (EP - marine)

In the impact category of eutrophication potential - marine, to produce traditional bamboo flooring product, A1 dominates the contribution with 62.41% of impact which is the most. When considering the stage C and D, eutrophication aquatic marine in this stage is negative, while the total eutrophication aquatic marine is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(9) Eutrophication potential - terrestrial (EP - terrestrial)

In the impact category of eutrophication potential - terrestrial, to produce traditional bamboo flooring product, A1 dominates the contribution with

61.81% of impact which is the most. When considering the stage C and D, eutrophication terrestrial in this stage is negative, while the total eutrophication terrestrial is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(10) Photochemical Ozone Creation Potential (POCP)

In the impact category of photochemical ozone creation potential, to produce traditional bamboo flooring product, A1 dominates the contribution with 66.11% of impact which is the most. When considering the stage C and D, photochemical ozone formation in this stage is negative, while the total photochemical ozone formation is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(11) Abiotic depletion potential - non-fossil resources (ADPE)

In the impact category of abiotic depletion potential - non-fossil resources, to produce traditional bamboo flooring product, A1 dominates the contribution with 97.13% of impact which is the most. When considering the stage C and D, depletion of abiotic resources – minerals and metals in this stage is negative, while the total depletion of abiotic resources – minerals and metals is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(12) Abiotic depletion potential - fossil resources (ADPF)

In the impact category of abiotic depletion potential - fossil resources, to produce traditional bamboo flooring product, A1 dominates the contribution with 68.97% of impact which is the most. When considering the stage C and D, depletion of abiotic resources – fossil fuels in this stage is negative, while the total depletion of abiotic resources – fossil fuels is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(13) Water (user) deprivation potential (WDP)

In the impact category of water (user) deprivation potential, to produce traditional bamboo flooring product, A1 dominates the contribution with 82.23% of impact which is the most. When considering the stage C and D, water use in this stage is negative, while the total water use is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(14) Global warming potential (GWP-GHG)

In the impact category of global warming potential, to produce traditional bamboo flooring product, A1 dominates the contribution with 61.93% of impact, the stage A3 contributes to 24.68%. When considering the stage C and D, global warming potential in this stage is negative, while the total global warming potential is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

Table 12 Environmental impacts of traditional bamboo flooring

Impact category	Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
Climate change	kg CO2 eq	-5.57E-01	1.79E-01	3.28E-01	-4.96E-02	2.60E-01	0.00E+00	1.72E-02	1.50E+00	0.00E+00	-6.91E-02
Ozone depletion	kg CFC11 eq	2.74E-08	3.89E-08	3.00E-09	6.93E-08	5.23E-08	0.00E+00	3.74E-09	1.10E-09	0.00E+00	-1.79E-08
Ionising radiation	kBq U-235 eq	2.84E-02	1.22E-02	2.28E-02	6.34E-02	1.54E-02	0.00E+00	1.17E-03	1.15E-03	0.00E+00	-6.64E-03
Photochemical ozone formation	kg NMVOC eq	3.49E-03	9.57E-04	6.63E-04	5.11E-03	5.29E-03	0.00E+00	9.20E-05	2.01E-04	0.00E+00	-1.97E-03
Particulate matter	disease inc.	6.82E-08	1.57E-08	2.10E-09	8.60E-08	1.03E-08	0.00E+00	1.51E-09	1.74E-09	0.00E+00	-3.31E-08
Human toxicity, non-cancer	CTUh	2.64E-08	2.22E-09	1.31E-09	2.99E-08	1.60E-09	0.00E+00	2.13E-10	2.03E-09	0.00E+00	-9.69E-09

Human toxicity, cancer	CTUh	2.35E-09	6.78E-11	2.28E-11	2.44E-09	1.48E-10	0.00E+00	6.52E-12	4.30E-11	0.00E+00	-2.80E-10
Acidification	mol H+ eq	5.38E-03	9.08E-04	1.56E-03	7.84E-03	7.38E-03	0.00E+00	8.73E-05	1.68E-04	0.00E+00	-2.40E-03
Eutrophication, freshwater	kg P eq	2.80E-04	1.35E-05	3.69E-05	3.30E-04	1.02E-05	0.00E+00	1.29E-06	9.02E-06	0.00E+00	-1.70E-05
Eutrophication, marine	kg N eq	1.00E-03	3.07E-04	2.32E-04	1.54E-03	1.83E-03	0.00E+00	2.96E-05	8.47E-05	0.00E+00	-6.95E-04
Eutrophication, terrestrial	mol N eq	1.06E-02	3.36E-03	2.46E-03	1.65E-02	2.04E-02	0.00E+00	3.23E-04	8.18E-04	0.00E+00	-1.16E-02
Ecotoxicity, freshwater	CTUe	4.63E+01	2.28E+00	2.41E+00	5.10E+01	2.23E+00	0.00E+00	2.20E-01	3.01E-01	0.00E+00	-2.40E+01
Land use	Pt	2.87E+01	1.80E+00	5.58E-01	3.10E+01	7.73E-01	0.00E+00	1.73E-01	1.02E-01	0.00E+00	-4.99E+01
Water use	m3 depriv.	2.89E-01	9.18E-03	4.96E-02	3.48E-01	6.87E-03	0.00E+00	8.83E-04	-1.00E-02	0.00E+00	-8.53E-03

Resource use, fossils	MJ	1.30E+01	2.66E+00	2.83E+00	1.85E+01	3.41E+00	0.00E+00	2.55E-01	1.75E-01	0.00E+00	-7.25E-01
Resource use, minerals and metals	kg Sb eq	2.78E-05	6.15E-07	8.93E-08	2.85E-05	4.37E-07	0.00E+00	5.91E-08	5.05E-08	0.00E+00	-2.16E-07
Climate change - Fossil	kg CO2 eq	9.15E-01	1.79E-01	3.30E-01	1.42E+00	2.60E-01	0.00E+00	1.72E-02	1.80E-02	0.00E+00	-6.09E-02
Climate change - Biogenic	kg CO2 eq	-1.48E+00	1.06E-04	-2.39E-03	-1.48E+00	2.98E-06	0.00E+00	1.02E-05	1.48E+00	0.00E+00	-7.56E-03
Climate change - Land use and LU change	kg CO2 eq	3.02E-03	7.43E-05	4.99E-06	3.10E-03	1.77E-04	0.00E+00	7.15E-06	1.19E-05	0.00E+00	-6.40E-04
Human toxicity, non-cancer - organics	CTUh	1.14E-09	8.81E-11	8.76E-11	1.32E-09	4.45E-11	0.00E+00	8.48E-12	3.86E-12	0.00E+00	-5.41E-11

Human toxicity, non-cancer - inorganics	CTUh	2.66E-09	4.80E-10	1.22E-10	3.26E-09	5.01E-10	0.00E+00	4.62E-11	1.25E-10	0.00E+00	-3.01E-09
Human toxicity, non-cancer - metals	CTUh	2.28E-08	1.65E-09	1.18E-09	2.56E-08	1.06E-09	0.00E+00	1.59E-10	1.90E-09	0.00E+00	-6.62E-09
Human toxicity, cancer - organics	CTUh	1.51E-09	3.16E-11	4.46E-12	1.54E-09	4.03E-11	0.00E+00	3.04E-12	1.18E-11	0.00E+00	-1.68E-10
Human toxicity, cancer - inorganics	CTUh	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Human toxicity, cancer - metals	CTUh	8.44E-10	3.62E-11	1.83E-11	8.99E-10	1.08E-10	0.00E+00	3.48E-12	3.12E-11	0.00E+00	-1.12E-10
Ecotoxicity, freshwater - organics	CTUe	3.69E+00	1.53E-01	2.58E-03	3.85E+00	2.10E-01	0.00E+00	1.47E-02	2.13E-03	0.00E+00	-4.42E-02

Ecotoxicity, freshwater - inorganics	CTUe	3.88E+00	5.90E-01	3.35E-01	4.81E+00	6.06E-01	0.00E+00	5.67E-02	9.50E-02	0.00E+00	-1.88E-01
Ecotoxicity, freshwater - metals	CTUe	3.88E+01	1.54E+00	2.07E+00	4.24E+01	1.41E+00	0.00E+00	1.48E-01	2.04E-01	0.00E+00	-2.38E+01
GWP-GHG	kg CO2 eq	9.18E-01	1.79E-01	3.30E-01	1.43E+00	2.60E-01	0.00E+00	1.72E-02	1.81E-02	0.00E+00	-6.15E-02

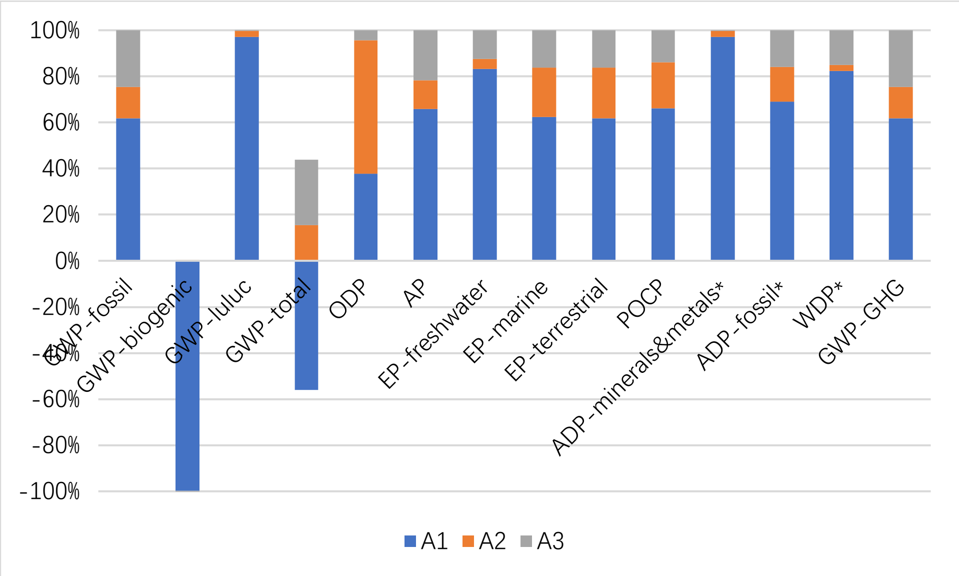


Figure 15 Life cycle contributions of traditional bamboo flooring production

6.3.2 Strand woven bamboo flooring

For the product of strand woven bamboo flooring, the main contributor for environment impacts is A1 raw materials. Each environment impact has a different characteristic of life cycle stage contribution. When considering the stage of C and D, the impact of global warming potential - total and global warming potential - biogenic are positive because the biogenic carbon was add back to the stage C3.

(1) Global Warming Potential - total (GWP - total)

In the impact category of Global Warming Potential - total, to produce strand woven bamboo flooring product, A1 is negative because the biogenic carbon was deleted in this stage. When considering the stage of C and D, climate change in this stage is positive because the biogenic carbon was added back, and the total climate change is positive as well. The environmental benefit of bamboo flooring waste-based reuse and recycle aggravates the environmental impacts of the production process (A1-A3).

(2) Global Warming Potential - fossil (GWP - fossil)

In the impact category of Global Warming Potential - fossil, to produce strand woven bamboo flooring product, A1 dominates the contribution with 66.89% of impact which is the most. When considering the stage of C and D, climate change in this stage is negative, while the total climate change is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(3) Global Warming Potential - biogenic (GWP - biogenic)

In the impact category of Global Warming Potential - biogenic, to produce strand woven bamboo flooring product, A1 is negative because of the biogenic carbon. When considering the stage of C and D, climate change in this stage is positive, while the total climate change is negative. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(4) Global Warming Potential – land use and land use change (GWP - luluc)

In the impact category of Global Warming Potential - land us and land use change, to produce strand woven bamboo flooring product, A1 dominates the contribution with 96.98% of impact which is the most. When considering the stage of C and D, climate change in this stage is negative, while the total climate change is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(5) Depletion potential of the stratospheric ozone layer (ODP)

In the impact category of depletion potential of the stratospheric ozone layer, to produce strand woven bamboo flooring product, A1 dominates the contribution with 40.80% of impact, the stage A2 contributes to 55.68%. When considering the stage C and D, ozone depletion in this stage is negative, while the total ozone depletion is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(6) Acidification potential, accumulated exceedance (AP)

In the impact category of acidification potential, to produce strand woven bamboo flooring product, A1 dominates the contribution with 69.83% of impact which is the most. When considering the stage C and D, acidification in this stage is negative, while the total acidification is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(7) Eutrophication potential - fresh water (EP - freshwater)

In the impact category of eutrophication potential - fresh water, to produce strand woven bamboo flooring product, A1 dominates the contribution with 85.81% of impact which is the most. When considering the stage C and D, eutrophication aquatic fresh water in this stage is negative, while the total eutrophication aquatic fresh water is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(8) Eutrophication potential - marine (EP - marine)

In the impact category of eutrophication potential - marine, to produce strand woven bamboo flooring product, A1 dominates the contribution with 65.09% of impact which is the most. When considering the stage C and D, eutrophication aquatic marine in this stage is negative, while the total eutrophication aquatic marine is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(9) Eutrophication potential - terrestrial (EP - terrestrial)

In the impact category of eutrophication potential - terrestrial, to produce strand woven bamboo flooring product, A1 dominates the contribution with 64.85% of impact which is the most. When considering the stage C and D, eutrophication terrestrial in this stage is negative, while the total eutrophication terrestrial is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(10) Photochemical Ozone Creation Potential (POCP)

In the impact category of photochemical ozone creation potential, to produce strand woven bamboo flooring product, A1 dominates the contribution with 70.19% of impact which is the most. When considering the stage C and D, photochemical ozone formation in this stage is negative, while the total photochemical ozone formation is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(11) Abiotic depletion potential - non-fossil resources (ADPE)

In the impact category of abiotic depletion potential - non-fossil resources, to produce strand woven bamboo flooring product, A1 dominates the contribution with 97.25% of impact which is the most. When considering the stage C and D, depletion of abiotic resources – minerals and metals in this stage is negative, while the total depletion of abiotic resources – minerals and metals is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(12) Abiotic depletion potential - fossil resources (ADPF)

In the impact category of abiotic depletion potential - fossil resources, to produce strand woven bamboo flooring product, A1 dominates the contribution with 74.67% of impact which is the most. When considering the stage C and D, depletion of abiotic resources – fossil fuels in this stage is negative, while the total depletion of abiotic resources – fossil fuels is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(13) Water (user) deprivation potential (WDP)

In the impact category of water (user) deprivation potential, to produce strand woven bamboo flooring product, A1 dominates the contribution with 88.44% of impact which is the most. When considering the stage C and D, water use in this stage is negative, while the total water use is positive The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(14) Global warming potential (GWP-GHG)

In the impact category of global warming potential, to produce strand woven bamboo flooring product, A1 dominates the contribution with 66.93% of impact, the stage A3 contributes to 20.06%. When considering the stage C and D, global warming potential in this stage is negative, while the total global warming potential is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

Table 13 Environmental impacts of strand woven bamboo flooring

Impact category	Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
Climate change	kg CO2 eq	-4.43E-01	1.79E-01	2.74E-01	1.02E-02	2.60E-01	0.00E+00	1.72E-02	1.44E+00	0.00E+00	-6.91E-02
Ozone depletion	kg CFC11 eq	2.97E-08	3.89E-08	2.46E-09	7.10E-08	5.23E-08	0.00E+00	3.74E-09	1.10E-09	0.00E+00	-1.79E-08
Ionising radiation	kBq U-235 eq	3.16E-02	1.22E-02	1.91E-02	6.29E-02	1.54E-02	0.00E+00	1.17E-03	1.15E-03	0.00E+00	-6.64E-03
Photochemical ozone formation	kg NMVOC eq	3.76E-03	9.57E-04	5.55E-04	5.27E-03	5.29E-03	0.00E+00	9.20E-05	2.01E-04	0.00E+00	-1.97E-03
Particulate matter	disease inc.	6.72E-08	1.57E-08	1.75E-09	8.47E-08	1.03E-08	0.00E+00	1.51E-09	1.74E-09	0.00E+00	-3.31E-08
Human toxicity, non-cancer	CTUh	2.53E-08	2.22E-09	1.09E-09	2.86E-08	1.60E-09	0.00E+00	2.13E-10	2.03E-09	0.00E+00	-9.69E-09

Human toxicity, cancer	CTUh	2.75E-09	6.78E-11	1.90E-11	2.83E-09	1.48E-10	0.00E+00	6.52E-12	4.30E-11	0.00E+00	-2.80E-10
Acidification	mol H+ eq	5.48E-03	9.08E-04	1.30E-03	7.69E-03	7.38E-03	0.00E+00	8.73E-05	1.68E-04	0.00E+00	-2.40E-03
Eutrophication, freshwater	kg P eq	2.87E-04	1.35E-05	3.08E-05	3.31E-04	1.02E-05	0.00E+00	1.29E-06	9.02E-06	0.00E+00	-1.70E-05
Eutrophication, marine	kg N eq	9.98E-04	3.07E-04	1.94E-04	1.50E-03	1.83E-03	0.00E+00	2.96E-05	8.47E-05	0.00E+00	-6.95E-04
Eutrophication, terrestrial	mol N eq	1.07E-02	3.36E-03	2.06E-03	1.61E-02	2.04E-02	0.00E+00	3.23E-04	8.18E-04	0.00E+00	-1.16E-02
Ecotoxicity, freshwater	CTUe	4.55E+01	2.28E+00	1.74E+00	4.95E+01	2.23E+00	0.00E+00	2.20E-01	3.01E-01	0.00E+00	-2.40E+01
Land use	Pt	2.51E+01	1.80E+00	4.66E-01	2.74E+01	7.73E-01	0.00E+00	1.73E-01	1.02E-01	0.00E+00	-4.99E+01
Water use	m3 depriv.	3.39E-01	9.18E-03	3.37E-02	3.81E-01	6.87E-03	0.00E+00	8.83E-04	-1.00E-02	0.00E+00	-8.53E-03

Resource use, fossils	MJ	1.53E+01	2.66E+00	2.36E+00	2.03E+01	3.41E+00	0.00E+00	2.55E-01	1.75E-01	0.00E+00	-7.25E-01
Resource use, minerals and metals	kg Sb eq	2.66E-05	6.15E-07	7.01E-08	2.73E-05	4.37E-07	0.00E+00	5.91E-08	5.05E-08	0.00E+00	-2.16E-07
Climate change - Fossil	kg CO2 eq	9.74E-01	1.79E-01	2.76E-01	1.43E+00	2.60E-01	0.00E+00	1.72E-02	1.80E-02	0.00E+00	-6.09E-02
Climate change - Biogenic	kg CO2 eq	-1.42E+00	1.06E-04	-2.01E-03	-1.42E+00	2.98E-06	0.00E+00	1.02E-05	1.42E+00	0.00E+00	-7.56E-03
Climate change - Land use and LU change	kg CO2 eq	2.77E-03	7.43E-05	4.06E-06	2.85E-03	1.77E-04	0.00E+00	7.15E-06	1.19E-05	0.00E+00	-6.40E-04
Human toxicity, non-cancer - organics	CTUh	1.20E-09	8.81E-11	7.31E-11	1.36E-09	4.45E-11	0.00E+00	8.48E-12	3.86E-12	0.00E+00	-5.41E-11

Human toxicity, non-cancer - inorganics	CTUh	2.68E-09	4.80E-10	1.00E-10	3.26E-09	5.01E-10	0.00E+00	4.62E-11	1.25E-10	0.00E+00	-3.01E-09
Human toxicity, non-cancer - metals	CTUh	2.17E-08	1.65E-09	9.81E-10	2.43E-08	1.06E-09	0.00E+00	1.59E-10	1.90E-09	0.00E+00	-6.62E-09
Human toxicity, cancer - organics	CTUh	1.94E-09	3.16E-11	3.71E-12	1.97E-09	4.03E-11	0.00E+00	3.04E-12	1.18E-11	0.00E+00	-1.68E-10
Human toxicity, cancer - inorganics	CTUh	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Human toxicity, cancer - metals	CTUh	8.11E-10	3.62E-11	1.53E-11	8.62E-10	1.08E-10	0.00E+00	3.48E-12	3.12E-11	0.00E+00	-1.12E-10
Ecotoxicity, freshwater - organics	CTUe	5.09E+00	1.53E-01	2.14E-03	5.24E+00	2.10E-01	0.00E+00	1.47E-02	2.13E-03	0.00E+00	-4.42E-02

Ecotoxicity, freshwater - inorganics	CTUe	3.68E+00	5.90E-01	2.74E-01	4.54E+00	6.06E-01	0.00E+00	5.67E-02	9.50E-02	0.00E+00	-1.88E-01
Ecotoxicity, freshwater - metals	CTUe	3.67E+01	1.54E+00	1.46E+00	3.97E+01	1.41E+00	0.00E+00	1.48E-01	2.04E-01	0.00E+00	-2.38E+01
GWP-GHG	kg CO2 eq	9.76E-01	1.79E-01	2.76E-01	1.43E+00	2.60E-01	0.00E+00	1.72E-02	1.81E-02	0.00E+00	-6.15E-02

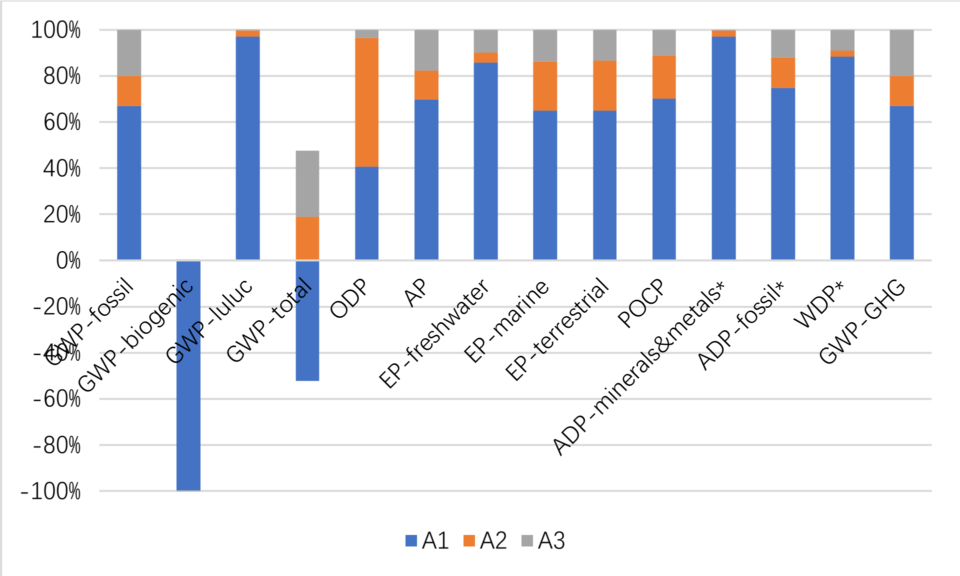


Figure 16 Life cycle contributions of strand woven bamboo flooring production

6.3.3 Bamboo wood composite flooring

For the product of bamboo wood composite flooring, the main contributor for environment impacts is A1 raw materials. Each environment impact has a different characteristic of life cycle stage contribution. When considering the stage of C and D, the impact of global warming potential - total and global warming potential - biogenic are positive because the biogenic carbon was add back to the stage C3.

(1) Global Warming Potential - total (GWP - total)

In the impact category of Global Warming Potential - total, to produce bamboo wood composite flooring product, A1 is negative because the biogenic carbon was deleted in this stage. When considering the stage of C and D, climate change in this stage is positive because the biogenic carbon was added back, and the total climate change is positive as well. The environmental benefit of bamboo flooring waste-based reuse and recycle aggravates the environmental impacts of the production process (A1-A3).

(2) Global Warming Potential - fossil (GWP - fossil)

In the impact category of Global Warming Potential - fossil, to produce bamboo wood composite flooring product, A1 dominates the contribution with 71.18% of impact which is the most. When considering the stage of C and D, climate change in this stage is negative, while the total climate change is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(3) Global Warming Potential - biogenic (GWP - biogenic)

In the impact category of Global Warming Potential - biogenic, to produce bamboo wood composite flooring product, A1 is negative because of the biogenic carbon. When considering the stage of C and D, climate change in this stage is positive, while the total climate change is negative. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(4) Global Warming Potential – land use and land use change (GWP - luluc)

In the impact category of Global Warming Potential - land us and land use change, to produce bamboo wood composite flooring product, A1 dominates the contribution with 97.42% of impact which is the most. When considering the stage of C and D, climate change in this stage is negative, while the total climate change is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(5) Depletion potential of the stratospheric ozone layer (ODP)

In the impact category of depletion potential of the stratospheric ozone layer, to produce bamboo wood composite flooring product, A1 dominates the contribution with 59.66% of impact which is the most. When considering the stage C and D, ozone depletion in this stage is negative, while the total ozone depletion is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(6) Acidification potential, accumulated exceedance (AP)

In the impact category of acidification potential, to produce bamboo wood composite flooring product, A1 dominates the contribution with 76.95% of impact which is the most. When considering the stage C and D, acidification in this stage is negative, while the total acidification is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(7) Eutrophication potential - fresh water (EP - freshwater)

In the impact category of eutrophication potential - fresh water, to produce bamboo wood composite flooring product, A1 dominates the contribution with 88.71% of impact which is the most. When considering the stage C and D, eutrophication aquatic fresh water in this stage is negative, while the total eutrophication aquatic fresh water is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(8) Eutrophication potential - marine (EP - marine)

In the impact category of eutrophication potential - marine, to produce bamboo wood composite flooring product, A1 dominates the contribution with 79.83% of impact which is the most. When considering the stage C and D, eutrophication aquatic marine in this stage is negative, while the total eutrophication aquatic marine is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(9) Eutrophication potential - terrestrial (EP - terrestrial)

In the impact category of eutrophication potential - terrestrial, to produce bamboo wood composite flooring product, A1 dominates the contribution with 79.83% of impact which is the most. When considering the stage C and D, eutrophication terrestrial in this stage is negative, while the total eutrophication terrestrial is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(10) Photochemical Ozone Creation Potential (POCP)

In the impact category of photochemical ozone creation potential, to produce bamboo wood composite flooring product, A1 dominates the contribution with 81.38% of impact which is the most. When considering the stage C and D, photochemical ozone formation in this stage is negative, while the total photochemical ozone formation is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(11) Abiotic depletion potential - non-fossil resources (ADPE)

In the impact category of abiotic depletion potential - non-fossil resources, to produce bamboo wood composite flooring product, A1 dominates the contribution with 94.73% of impact which is the most. When considering the stage C and D, depletion of abiotic resources – minerals and metals in this stage is negative, while the total depletion of abiotic resources – minerals and metals is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(12) Abiotic depletion potential - fossil resources (ADPF)

In the impact category of abiotic depletion potential - fossil resources, to produce bamboo wood composite flooring product, A1 dominates the contribution with 78.72% of impact which is the most. When considering the stage C and D, depletion of abiotic resources – fossil fuels in this stage is negative, while the total depletion of abiotic resources – fossil fuels is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(13) Water (user) deprivation potential (WDP)

In the impact category of water (user) deprivation potential, to produce bamboo wood composite flooring product, A1 dominates the contribution with 94.77% of impact which is the most. When considering the stage C and D, water use in this stage is negative, while the total water use is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(14) Global warming potential (GWP-GHG)

In the impact category of global warming potential, to produce bamboo wood composite flooring product, A1 dominates the contribution with 71.18% of impact, the stage A3 contributes to 18.22%. When considering the stage C and D, global warming potential in this stage is negative, while the total global warming potential is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

Table 14 Environmental impacts of bamboo wood composite flooring

Impact category	Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
Climate change	kg CO2 eq	1.13E-01	2.13E-01	3.63E-01	6.90E-01	2.60E-01	0.00E+00	1.72E-02	1.44E+00	0.00E+00	-6.91E-02
Ozone depletion	kg CFC11 eq	7.57E-08	4.63E-08	3.33E-09	1.25E-07	5.23E-08	0.00E+00	3.74E-09	1.10E-09	0.00E+00	-1.79E-08
Ionising radiation	kBq U-235 eq	7.95E-02	1.45E-02	2.53E-02	1.19E-01	1.54E-02	0.00E+00	1.17E-03	1.15E-03	0.00E+00	-6.64E-03
Photochemical ozone formation	kg NMVOC eq	8.59E-03	1.14E-03	7.34E-04	1.05E-02	5.29E-03	0.00E+00	9.20E-05	2.01E-04	0.00E+00	-1.97E-03
Particulate matter	disease inc.	1.67E-07	1.87E-08	2.32E-09	1.88E-07	1.03E-08	0.00E+00	1.51E-09	1.74E-09	0.00E+00	-3.31E-08
Human toxicity, non-cancer	CTUh	2.79E-08	2.64E-09	1.45E-09	3.20E-08	1.60E-09	0.00E+00	2.13E-10	2.03E-09	0.00E+00	-9.69E-09

Human toxicity, cancer	CTUh	7.23E-09	8.08E-11	2.53E-11	7.34E-09	1.48E-10	0.00E+00	6.52E-12	4.30E-11	0.00E+00	-2.80E-10
Acidification	mol H+ eq	1.01E-02	1.08E-03	1.72E-03	1.29E-02	7.38E-03	0.00E+00	8.73E-05	1.68E-04	0.00E+00	-2.40E-03
Eutrophication, freshwater	kg P eq	4.83E-04	1.60E-05	4.09E-05	5.40E-04	1.02E-05	0.00E+00	1.29E-06	9.02E-06	0.00E+00	-1.70E-05
Eutrophication, marine	kg N eq	2.59E-03	3.67E-04	2.57E-04	3.22E-03	1.83E-03	0.00E+00	2.96E-05	8.47E-05	0.00E+00	-6.95E-04
Eutrophication, terrestrial	mol N eq	2.82E-02	4.01E-03	2.72E-03	3.49E-02	2.04E-02	0.00E+00	3.23E-04	8.18E-04	0.00E+00	-1.16E-02
Ecotoxicity, freshwater	CTUe	6.10E+01	2.72E+00	2.78E+00	6.65E+01	2.23E+00	0.00E+00	2.20E-01	3.01E-01	0.00E+00	-2.40E+01
Land use	Pt	1.48E+02	2.15E+00	6.17E-01	1.51E+02	7.73E-01	0.00E+00	1.73E-01	1.02E-01	0.00E+00	-4.99E+01
Water use	m3 depriv.	1.27E+00	1.09E-02	5.81E-02	1.34E+00	6.87E-03	0.00E+00	8.83E-04	-1.00E-02	0.00E+00	-8.53E-03

Resource use, fossils	MJ	2.42E+01	3.17E+00	3.13E+00	3.05E+01	3.41E+00	0.00E+00	2.55E-01	1.75E-01	0.00E+00	-7.25E-01
Resource use, minerals and metals	kg Sb eq	1.98E-05	7.33E-07	1.01E-07	2.06E-05	4.37E-07	0.00E+00	5.91E-08	5.05E-08	0.00E+00	-2.16E-07
Climate change - Fossil	kg CO2 eq	1.53E+00	2.13E-01	3.66E-01	2.11E+00	2.60E-01	0.00E+00	1.72E-02	1.80E-02	0.00E+00	-6.09E-02
Climate change - Biogenic	kg CO2 eq	-1.43E+00	1.27E-04	-2.63E-03	-1.43E+00	2.98E-06	0.00E+00	1.02E-05	1.43E+00	0.00E+00	-7.56E-03
Climate change - Land use and LU change	kg CO2 eq	4.03E-03	8.86E-05	5.56E-06	4.13E-03	1.77E-04	0.00E+00	7.15E-06	1.19E-05	0.00E+00	-6.40E-04
Human toxicity, non-cancer - organics	CTUh	1.18E-09	1.05E-10	9.70E-11	1.39E-09	4.45E-11	0.00E+00	8.48E-12	3.86E-12	0.00E+00	-5.41E-11

Human toxicity, non-cancer - inorganics	CTUh	6.75E-09	5.73E-10	1.36E-10	7.45E-09	5.01E-10	0.00E+00	4.62E-11	1.25E-10	0.00E+00	-3.01E-09
Human toxicity, non-cancer - metals	CTUh	2.28E-08	1.97E-09	1.30E-09	2.61E-08	1.06E-09	0.00E+00	1.59E-10	1.90E-09	0.00E+00	-6.62E-09
Human toxicity, cancer - organics	CTUh	6.50E-09	3.77E-11	4.94E-12	6.54E-09	4.03E-11	0.00E+00	3.04E-12	1.18E-11	0.00E+00	-1.68E-10
Human toxicity, cancer - inorganics	CTUh	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Human toxicity, cancer - metals	CTUh	7.37E-10	4.31E-11	2.03E-11	8.00E-10	1.08E-10	0.00E+00	3.48E-12	3.12E-11	0.00E+00	-1.12E-10
Ecotoxicity, freshwater - organics	CTUe	5.23E+00	1.82E-01	2.86E-03	5.42E+00	2.10E-01	0.00E+00	1.47E-02	2.13E-03	0.00E+00	-4.42E-02

Ecotoxicity, freshwater - inorganics	CTUe	3.85E+00	7.03E-01	3.73E-01	4.93E+00	6.06E-01	0.00E+00	5.67E-02	9.50E-02	0.00E+00	-1.88E-01
Ecotoxicity, freshwater - metals	CTUe	5.19E+01	1.84E+00	2.41E+00	5.61E+01	1.41E+00	0.00E+00	1.48E-01	2.04E-01	0.00E+00	-2.38E+01
GWP-GHG	kg CO2 eq	1.54E+00	2.13E-01	3.66E-01	2.12E+00	2.60E-01	0.00E+00	1.72E-02	1.81E-02	0.00E+00	-6.15E-02

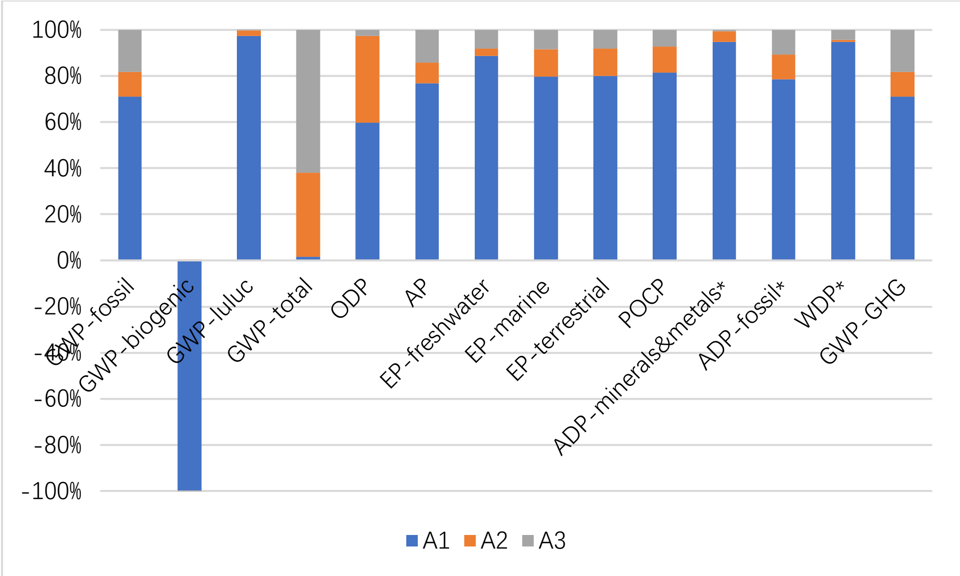


Figure 17 Life cycle contributions of bamboo wood composite flooring production

6.3.4 Semi-finished bamboo panels

For the product of semi-finished bamboo panels, the main contributor for environment impacts is A1 raw materials. Each environment impact has a different characteristic of life cycle stage contribution. When considering the stage of C and D, the impact of global warming potential - total and global warming potential - biogenic are positive because the biogenic carbon was added back to the stage C3.

(1) Global Warming Potential - total (GWP - total)

In the impact category of Global Warming Potential - total, to produce semi-finished bamboo panels product, A1 is negative because the biogenic carbon was deleted in this stage. When considering the stage of C and D, climate change in this stage is positive because the biogenic carbon was added back, and the total climate change is positive as well. The environmental benefit of bamboo flooring waste-based reuse and recycle aggravates the environmental impacts of the production process (A1-A3).

(2) Global Warming Potential - fossil (GWP - fossil)

In the impact category of Global Warming Potential - fossil, to produce semi-finished bamboo panels product, A1 dominates the contribution with 54.64% of impact which is the most. When considering the stage of C and D, climate change in this stage is negative, while the total climate change is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(3) Global Warming Potential - biogenic (GWP - biogenic)

In the impact category of Global Warming Potential - biogenic, to produce semi-finished bamboo panels product, A1 is negative because of the biogenic carbon. When considering the stage of C and D, climate change in this stage is positive, while the total climate change is negative. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(4) Global Warming Potential – land use and land use change (GWP - luluc)

In the impact category of Global Warming Potential - land us and land use change, to produce semi-finished bamboo panels product, A1 dominates the contribution with 96.42% of impact which is the most. When considering the stage of C and D, climate change in this stage is negative, while the total climate change is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(5) Depletion potential of the stratospheric ozone layer (ODP)

In the impact category of depletion potential of the stratospheric ozone layer, to produce semi-finished bamboo panels product, A1 dominates the contribution with 36.33% of impact, the stage A2 contributes to 58.30%.

When considering the stage C and D, ozone depletion in this stage is negative, while the total ozone depletion is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(6) Acidification potential, accumulated exceedance (AP)

In the impact category of acidification potential, to produce semi-finished bamboo panels product, A1 dominates the contribution with 62.25% of impact which is the most. When considering the stage C and D, acidification in this stage is negative, while the total acidification is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(7) Eutrophication potential - fresh water (EP - freshwater)

In the impact category of eutrophication potential - fresh water, to produce semi-finished bamboo panels product, A1 dominates the contribution with 79.09% of impact which is the most. When considering the stage C and D, eutrophication aquatic fresh water in this stage is negative, while the total eutrophication aquatic fresh water is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(8) Eutrophication potential - marine (EP - marine)

In the impact category of eutrophication potential - marine, to produce semi-finished bamboo panels product, A1 dominates the contribution with 55.72% of impact which is the most. When considering the stage C and D, eutrophication aquatic marine in this stage is negative, while the total eutrophication aquatic marine is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(9) Eutrophication potential - terrestrial (EP - terrestrial)

In the impact category of eutrophication potential - terrestrial, to produce semi-finished bamboo panels product, A1 dominates the contribution with 59.13% of impact which is the most. When considering the stage C and D, eutrophication terrestrial in this stage is negative, while the total eutrophication terrestrial is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(10) Photochemical Ozone Creation Potential (POCP)

In the impact category of photochemical ozone creation potential, to produce semi-finished bamboo panels product, A1 dominates the contribution with 57.45% of impact which is the most. When considering the stage C and D, photochemical ozone formation in this stage is negative, while the total photochemical ozone formation is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(11) Abiotic depletion potential - non-fossil resources (ADPE)

In the impact category of abiotic depletion potential - non-fossil resources, to produce semi-finished bamboo panels product, A1 dominates the contribution with 96.72% of impact which is the most. When considering the stage C and D, depletion of abiotic resources – minerals and metals in this stage is negative, while the total depletion of abiotic resources – minerals and metals is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(12) Abiotic depletion potential - fossil resources (ADPF)

In the impact category of abiotic depletion potential - fossil resources, to produce semi-finished bamboo panels product, A1 dominates the contribution with 55.26% of impact which is the most. When considering the stage C and D, depletion of abiotic resources – fossil fuels in this stage is negative, while the total depletion of abiotic resources – fossil fuels is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(13) Water (user) deprivation potential (WDP)

In the impact category of water (user) deprivation potential, to produce semi-finished bamboo panels product, A1 dominates the contribution with 71.11% of impact which is the most. When considering the stage C and D, water use in this stage is negative, while total water use is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(14) Global warming potential (GWP-GHG)

In the impact category of global warming potential, to produce semi-finished bamboo panels product, A1 dominates the contribution with 54.75% of impact, the stage A3 contributes to 29.91%. When considering the stage C and D, global warming potential in this stage is negative, while the total global warming potential is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

Table 15 Environmental impacts of semi-finished bamboo panels

Impact category	Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
Climate change	kg CO2 eq	-7.13E-01	1.95E-01	3.76E-01	-1.43E-01	2.63E-01	0.00E+00	1.72E-02	1.58E+00	0.00E+00	-6.91E-02
Ozone depletion	kg CFC11 eq	2.96E-08	4.22E-08	3.89E-09	7.57E-08	5.30E-08	0.00E+00	3.74E-09	1.10E-09	0.00E+00	-1.79E-08
Ionising radiation	kBq U-235 eq	2.21E-02	1.33E-02	2.62E-02	6.15E-02	1.56E-02	0.00E+00	1.17E-03	1.15E-03	0.00E+00	-6.64E-03
Photochemical ozone formation	kg NMVOC eq	3.01E-03	1.04E-03	7.60E-04	4.81E-03	5.31E-03	0.00E+00	9.20E-05	2.01E-04	0.00E+00	-1.97E-03
Particulate matter	disease inc.	7.45E-08	1.71E-08	2.45E-09	9.40E-08	1.06E-08	0.00E+00	1.51E-09	1.74E-09	0.00E+00	-3.31E-08
Human toxicity, non-cancer	CTUh	2.87E-08	2.41E-09	1.55E-09	3.26E-08	1.64E-09	0.00E+00	2.13E-10	2.03E-09	0.00E+00	-9.69E-09

Human toxicity, cancer	CTUh	2.30E-09	7.36E-11	2.73E-11	2.40E-09	1.49E-10	0.00E+00	6.52E-12	4.30E-11	0.00E+00	-2.80E-10
Acidification	mol H+ eq	5.64E-03	9.87E-04	1.79E-03	8.42E-03	7.39E-03	0.00E+00	8.73E-05	1.68E-04	0.00E+00	-2.40E-03
Eutrophication, freshwater	kg P eq	2.69E-04	1.46E-05	4.25E-05	3.26E-04	1.04E-05	0.00E+00	1.29E-06	9.02E-06	0.00E+00	-1.70E-05
Eutrophication, marine	kg N eq	9.37E-04	3.34E-04	2.66E-04	1.54E-03	1.84E-03	0.00E+00	2.96E-05	8.47E-05	0.00E+00	-6.95E-04
Eutrophication, terrestrial	mol N eq	1.14E-02	3.65E-03	2.82E-03	1.79E-02	2.04E-02	0.00E+00	3.23E-04	8.18E-04	0.00E+00	-1.16E-02
Ecotoxicity, freshwater	CTUe	4.74E+01	2.48E+00	5.82E+00	5.57E+01	2.27E+00	0.00E+00	2.20E-01	3.01E-01	0.00E+00	-2.40E+01
Land use	Pt	3.22E+01	1.96E+00	6.41E-01	3.48E+01	8.04E-01	0.00E+00	1.73E-01	1.02E-01	0.00E+00	-4.99E+01
Water use	m3 depriv.	4.02E-01	9.97E-03	1.42E-01	5.54E-01	7.03E-03	0.00E+00	8.83E-04	-1.00E-02	0.00E+00	-8.53E-03

Resource use, fossils	MJ	8.97E+00	2.89E+00	3.24E+00	1.51E+01	3.45E+00	0.00E+00	2.55E-01	1.75E-01	0.00E+00	-7.25E-01
Resource use, minerals and metals	kg Sb eq	3.11E-05	6.68E-07	1.53E-07	3.19E-05	4.47E-07	0.00E+00	5.91E-08	5.05E-08	0.00E+00	-2.16E-07
Climate change - Fossil	kg CO2 eq	8.45E-01	1.94E-01	3.78E-01	1.42E+00	2.63E-01	0.00E+00	1.72E-02	1.80E-02	0.00E+00	-6.09E-02
Climate change - Biogenic	kg CO2 eq	-1.56E+00	1.15E-04	-2.56E-03	-1.56E+00	4.82E-06	0.00E+00	1.02E-05	1.56E+00	0.00E+00	-7.56E-03
Climate change - Land use and LU change	kg CO2 eq	3.07E-03	8.07E-05	6.95E-06	3.16E-03	1.79E-04	0.00E+00	7.15E-06	1.19E-05	0.00E+00	-6.40E-04
Human toxicity, non-cancer - organics	CTUh	1.01E-09	9.58E-11	1.01E-10	1.21E-09	4.60E-11	0.00E+00	8.48E-12	3.86E-12	0.00E+00	-5.41E-11

Human toxicity, non-cancer - inorganics	CTUh	2.59E-09	5.22E-10	1.62E-10	3.28E-09	5.09E-10	0.00E+00	4.62E-11	1.25E-10	0.00E+00	-3.01E-09
Human toxicity, non-cancer - metals	CTUh	2.53E-08	1.80E-09	1.38E-09	2.84E-08	1.09E-09	0.00E+00	1.59E-10	1.90E-09	0.00E+00	-6.62E-09
Human toxicity, cancer - organics	CTUh	1.39E-09	3.43E-11	5.30E-12	1.43E-09	4.09E-11	0.00E+00	3.04E-12	1.18E-11	0.00E+00	-1.68E-10
Human toxicity, cancer - inorganics	CTUh	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Human toxicity, cancer - metals	CTUh	9.12E-10	3.93E-11	2.20E-11	9.73E-10	1.08E-10	0.00E+00	3.48E-12	3.12E-11	0.00E+00	-1.12E-10
Ecotoxicity, freshwater - organics	CTUe	1.07E-01	1.66E-01	3.09E-03	2.76E-01	2.12E-01	0.00E+00	1.47E-02	2.13E-03	0.00E+00	-4.42E-02

Ecotoxicity, freshwater - inorganics	CTUe	4.35E+00	6.41E-01	4.70E-01	5.46E+00	6.17E-01	0.00E+00	5.67E-02	9.50E-02	0.00E+00	-1.88E-01
Ecotoxicity, freshwater - metals	CTUe	4.29E+01	1.67E+00	5.34E+00	4.99E+01	1.44E+00	0.00E+00	1.48E-01	2.04E-01	0.00E+00	-2.38E+01
GWP-GHG	kg CO2 eq	8.48E-01	1.94E-01	3.78E-01	1.42E+00	2.63E-01	0.00E+00	1.72E-02	1.81E-02	0.00E+00	-6.15E-02

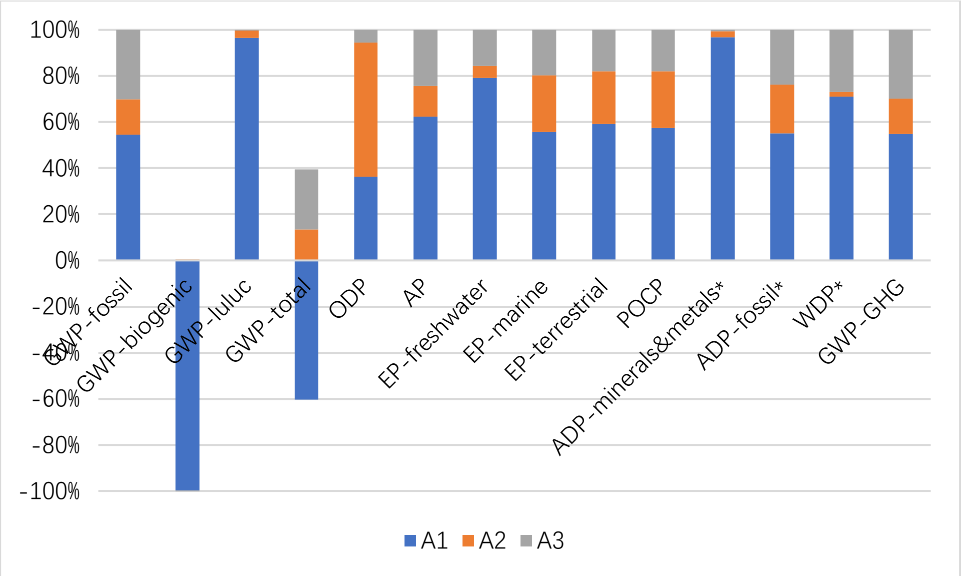


Figure 18 Life cycle contributions of semi-finished bamboo panels production

6.3.5 bamboo industrial parquet

For the product of bamboo industrial parquet, the main contributor for environment impacts is A1 raw materials. Each environment impact has a different characteristic of life cycle stage contribution. When considering the stage of C and D, the impact of global warming potential - total and global warming potential - biogenic are positive because the biogenic carbon was added back to the stage C3.

(1) Global Warming Potential - total (GWP - total)

In the impact category of Global Warming Potential - total, to produce bamboo industrial parquet product, A1 is negative because the biogenic carbon was deleted in this stage. When considering the stage of C and D, climate change in this stage is positive because the biogenic carbon was added back, and the total climate change is positive as well. The environmental benefit of bamboo flooring waste-based reuse and recycle aggravates the environmental impacts of the production process (A1-A3).

(2) Global Warming Potential - fossil (GWP - fossil)

In the impact category of Global Warming Potential - fossil, to produce bamboo industrial parquet product, A1 dominates the contribution with 95.21% of impact which is the most. When considering the stage of C and D, climate change in this stage is negative, while the total climate change is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(3) Global Warming Potential - biogenic (GWP - biogenic)

In the impact category of Global Warming Potential - biogenic, to produce bamboo industrial parquet product, A1 is negative because of the biogenic carbon. When considering the stage of C and D, climate change in this stage is positive, while the total climate change is negative. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(4) Global Warming Potential – land use and land use change (GWP - luluc)

In the impact category of Global Warming Potential - land us and land use change, to produce bamboo industrial parquet product, A1 dominates the contribution with 99.63% of impact which is the most. When considering the stage of C and D, climate change in this stage is negative, while the total climate change is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(5) Depletion potential of the stratospheric ozone layer (ODP)

In the impact category of depletion potential of the stratospheric ozone layer, to produce bamboo industrial parquet product, A1 dominates the contribution with 74.04% of impact which is the most. When considering the stage C and D, ozone depletion in this stage is negative, while the total ozone depletion is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(6) Acidification potential, accumulated exceedance (AP)

In the impact category of acidification potential, to produce bamboo industrial parquet product, A1 dominates the contribution with 96.38% of impact which is the most. When considering the stage C and D, acidification in this stage is negative, while the total acidification is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(7) Eutrophication potential - fresh water (EP - freshwater)

In the impact category of eutrophication potential - fresh water, to produce bamboo industrial parquet product, A1 dominates the contribution with 98.80% of impact which is the most. When considering the stage C and D, eutrophication aquatic fresh water in this stage is negative, while the total eutrophication aquatic fresh water is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(8) Eutrophication potential - marine (EP - marine)

In the impact category of eutrophication potential - marine, to produce bamboo industrial parquet product, A1 dominates the contribution with 94.20% of impact which is the most. When considering the stage C and D, eutrophication aquatic marine in this stage is negative, while the total eutrophication aquatic marine is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(9) Eutrophication potential - terrestrial (EP - terrestrial)

In the impact category of eutrophication potential - terrestrial, to produce bamboo industrial parquet product, A1 dominates the contribution with 94.13% of impact which is the most. When considering the stage C and D, eutrophication terrestrial in this stage is negative, while the total eutrophication terrestrial is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(10) Photochemical Ozone Creation Potential (POCP)

In the impact category of photochemical ozone creation potential, to produce bamboo industrial parquet product, A1 dominates the contribution with 93.90% of impact which is the most. When considering the stage C and D, photochemical ozone formation in this stage is negative, while the total photochemical ozone formation is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(11) Abiotic depletion potential - non-fossil resources (ADPE)

In the impact category of abiotic depletion potential - non-fossil resources, to produce bamboo industrial parquet product, A1 dominates the contribution with 99.66% of impact which is the most. When considering the stage C and D, depletion of abiotic resources – minerals and metals in this stage is negative, while the total depletion of abiotic resources – minerals and metals is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(12) Abiotic depletion potential - fossil resources (ADPF)

In the impact category of abiotic depletion potential - fossil resources, to produce bamboo industrial parquet product, A1 dominates the contribution with 93.11% of impact which is the most. When considering the stage C and

D, depletion of abiotic resources – fossil fuels in this stage is negative, while the total depletion of abiotic resources – fossil fuels is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(13) Water (user) deprivation potential (WDP)

In the impact category of water (user) deprivation potential, to produce bamboo industrial parquet product, A1 dominates the contribution with 98.86% of impact which is the most. When considering the stage C and D, water use in this stage is negative, while the total water use is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

(14) Global warming potential (GWP-GHG)

In the impact category of global warming potential, to produce bamboo industrial parquet product, A1 dominates the contribution with 95.23% of impact, the stage A2 contributes to 3.90%. When considering the stage C and D, global warming potential in this stage is negative, while the total global warming potential is positive. The environmental benefit of bamboo flooring waste-based reuse and recycle cannot compensates the environmental impacts of the production process (A1-A3).

Table 16 Environmental impacts of industrial parquet

Impact category	Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
Climate change	kg CO2 eq	-1.07E+00	2.24E-02	4.94E-03	-1.05E+00	2.67E-01	0.00E+00	1.72E-02	1.63E+00	0.00E+00	-6.91E-02
Ozone depletion	kg CFC11 eq	1.40E-08	4.86E-09	4.20E-11	1.89E-08	5.37E-08	0.00E+00	3.74E-09	1.10E-09	0.00E+00	-1.79E-08
Ionising radiation	kBq U-235 eq	1.40E-02	1.52E-03	3.44E-04	1.59E-02	1.59E-02	0.00E+00	1.17E-03	1.15E-03	0.00E+00	-6.64E-03
Photochemical ozone formation	kg NMVOC eq	2.00E-03	1.20E-04	9.99E-06	2.13E-03	5.33E-03	0.00E+00	9.20E-05	2.01E-04	0.00E+00	-1.97E-03
Particulate matter	disease inc.	5.01E-08	1.96E-09	3.12E-11	5.21E-08	1.09E-08	0.00E+00	1.51E-09	1.74E-09	0.00E+00	-3.31E-08
Human toxicity, non-cancer	CTUh	2.12E-08	2.77E-10	1.93E-11	2.15E-08	1.68E-09	0.00E+00	2.13E-10	2.03E-09	0.00E+00	-9.69E-09

Human toxicity, cancer	CTUh	9.89E-10	8.47E-12	3.35E-13	9.97E-10	1.50E-10	0.00E+00	6.52E-12	4.30E-11	0.00E+00	-2.80E-10
Acidification	mol H+ eq	3.66E-03	1.14E-04	2.34E-05	3.79E-03	7.41E-03	0.00E+00	8.73E-05	1.68E-04	0.00E+00	-2.40E-03
Eutrophication, freshwater	kg P eq	1.84E-04	1.68E-06	5.54E-07	1.86E-04	1.07E-05	0.00E+00	1.29E-06	9.02E-06	0.00E+00	-1.70E-05
Eutrophication, marine	kg N eq	6.80E-04	3.84E-05	3.50E-06	7.22E-04	1.85E-03	0.00E+00	2.96E-05	8.47E-05	0.00E+00	-6.95E-04
Eutrophication, terrestrial	mol N eq	7.33E-03	4.20E-04	3.70E-05	7.79E-03	2.05E-02	0.00E+00	3.23E-04	8.18E-04	0.00E+00	-1.16E-02
Ecotoxicity, freshwater	CTUe	3.48E+01	2.85E-01	1.53E-02	3.51E+01	2.31E+00	0.00E+00	2.20E-01	3.01E-01	0.00E+00	-2.40E+01
Land use	Pt	2.70E+01	2.25E-01	8.39E-03	2.73E+01	8.39E-01	0.00E+00	1.73E-01	1.02E-01	0.00E+00	-4.99E+01
Water use	m3 depriv.	1.14E-01	1.15E-03	1.59E-04	1.15E-01	7.21E-03	0.00E+00	8.83E-04	-1.00E-02	0.00E+00	-8.53E-03

Resource use, fossils	MJ	5.06E+00	3.32E-01	4.26E-02	5.43E+00	3.50E+00	0.00E+00	2.55E-01	1.75E-01	0.00E+00	-7.25E-01
Resource use, minerals and metals	kg Sb eq	2.26E-05	7.68E-08	9.96E-10	2.27E-05	4.59E-07	0.00E+00	5.91E-08	5.05E-08	0.00E+00	-2.16E-07
Climate change - Fossil	kg CO2 eq	5.44E-01	2.24E-02	4.98E-03	5.72E-01	2.67E-01	0.00E+00	1.72E-02	1.80E-02	0.00E+00	-6.09E-02
Climate change - Biogenic	kg CO2 eq	-1.61E+00	1.33E-05	-3.71E-05	-1.62E+00	6.86E-06	0.00E+00	1.02E-05	1.61E+00	0.00E+00	-7.56E-03
Climate change - Land use and LU change	kg CO2 eq	2.53E-03	9.29E-06	6.65E-08	2.54E-03	1.80E-04	0.00E+00	7.15E-06	1.19E-05	0.00E+00	-6.40E-04
Human toxicity, non-cancer - organics	CTUh	7.29E-10	1.10E-11	1.31E-12	7.42E-10	4.77E-11	0.00E+00	8.48E-12	3.86E-12	0.00E+00	-5.41E-11

Human toxicity, non-cancer - inorganics	CTUh	1.86E-09	6.00E-11	1.71E-12	1.92E-09	5.18E-10	0.00E+00	4.62E-11	1.25E-10	0.00E+00	-3.01E-09
Human toxicity, non-cancer - metals	CTUh	1.87E-08	2.07E-10	1.75E-11	1.89E-08	1.12E-09	0.00E+00	1.59E-10	1.90E-09	0.00E+00	-6.62E-09
Human toxicity, cancer - organics	CTUh	3.12E-10	3.95E-12	6.58E-14	3.16E-10	4.15E-11	0.00E+00	3.04E-12	1.18E-11	0.00E+00	-1.68E-10
Human toxicity, cancer - inorganics	CTUh	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Human toxicity, cancer - metals	CTUh	6.76E-10	4.52E-12	2.70E-13	6.81E-10	1.09E-10	0.00E+00	3.48E-12	3.12E-11	0.00E+00	-1.12E-10
Ecotoxicity, freshwater - organics	CTUe	1.14E-01	1.91E-02	3.78E-05	1.33E-01	2.15E-01	0.00E+00	1.47E-02	2.13E-03	0.00E+00	-4.42E-02

Ecotoxicity, freshwater - inorganics	CTUe	3.15E+00	7.37E-02	4.61E-03	3.23E+00	6.28E-01	0.00E+00	5.67E-02	9.50E-02	0.00E+00	-1.88E-01
Ecotoxicity, freshwater - metals	CTUe	3.15E+01	1.93E-01	1.07E-02	3.17E+01	1.47E+00	0.00E+00	1.48E-01	2.04E-01	0.00E+00	-2.38E+01
GWP-GHG	kg CO2 eq	5.47E-01	2.24E-02	4.98E-03	5.74E-01	2.67E-01	0.00E+00	1.72E-02	1.81E-02	0.00E+00	-6.15E-02

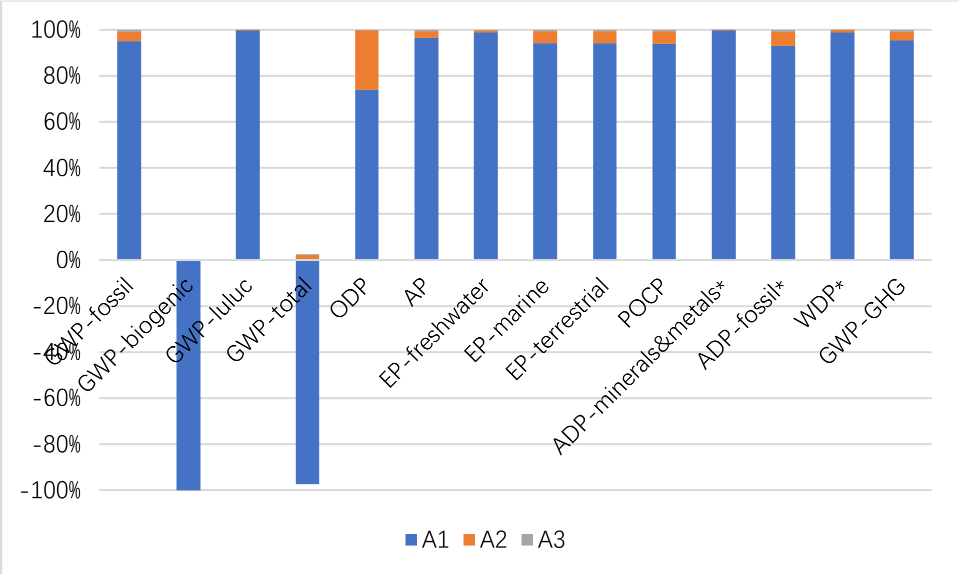


Figure 19 Life cycle contributions of industrial parquet production

6.4 Comparison analysis of bamboo products

6.4.1 Comparison of environmental impact (A1-A3)

The environment impacts of five kinds of product are shown in figure. For environment impacts of climate change-total, the bamboo wood composite flooring product is the biggest one and the industrial parquet is the smallest one. The reason of why the climate change of bamboo wood composite is particularly higher than the others is that the plywood use in A1, which significantly increase the climate change (fossil) of bamboo wood composite in A1. On the opposite, the climate change of industrial parquet is negative because of the only bamboo culm use in A1.

In conclusion, the bamboo wood composite flooring product has the heaviest environment burden, followed by strand woven bamboo flooring product. The main reason is the lowest density of the flooring product.

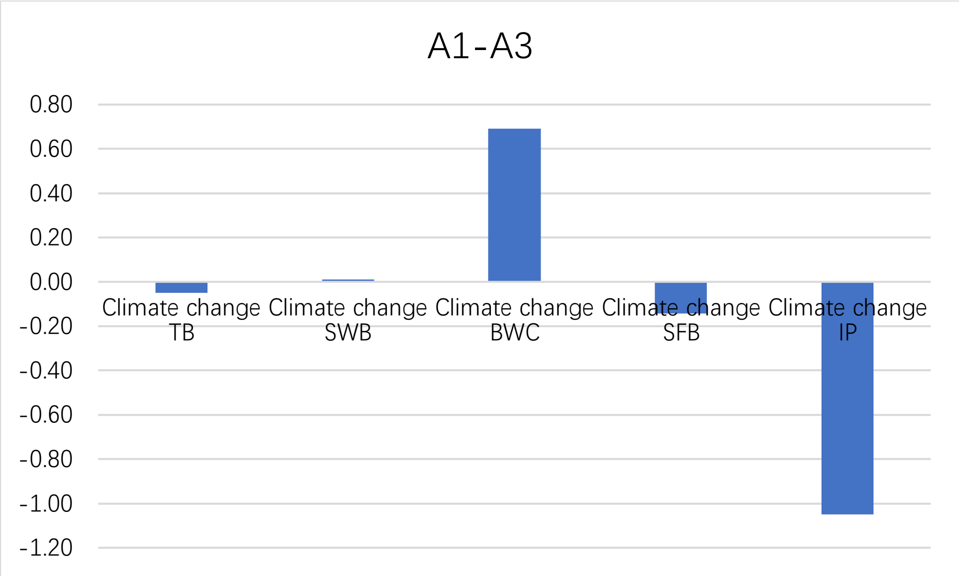


Figure 20 Life cycle environment impacts of A1-A3

6.4.2 Comparison of environmental impact (C, D)

When stage of C end of life and D reuse and recycle was considered, the biggest environment impact is the industrial parquet.

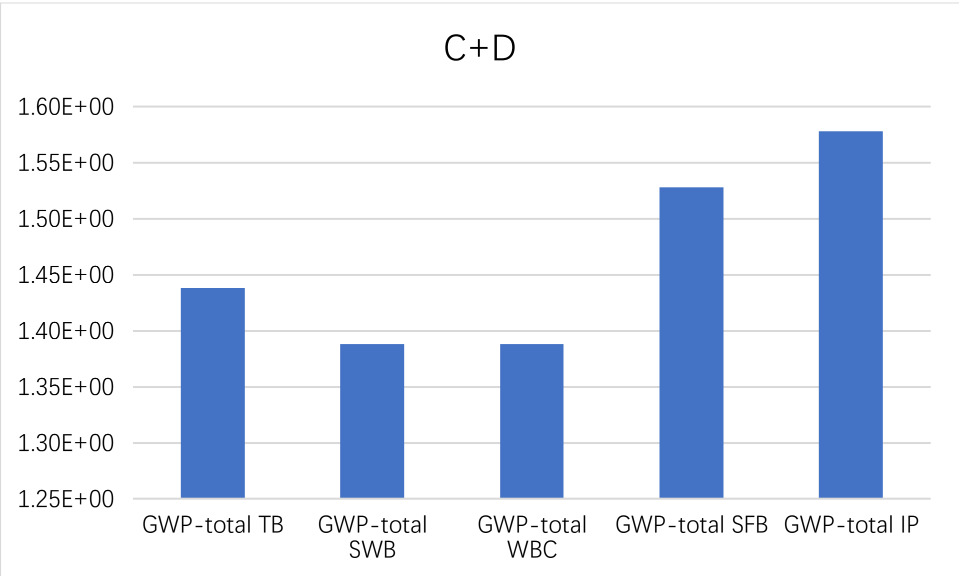


Figure 21 Life cycle environment impacts of C and D

7. Environmental parameters

The following environmental parameters data are applied on the LCI. They describe the use of renewable and non-renewable material resources, renewable and non-renewable primary energy and water. The description of parameters will be shown in appendix.

Table 17 Resource use categories of traditional bamboo flooring

Impact category	Unit	A1	A2	A3	A1-A3	A4
PENRE	MJ	1.56E+01	2.62E+00	3.94E+00	2.22E+01	3.31E+00
PERE	MJ	2.01E+01	3.07E-02	2.03E-01	2.03E+01	2.60E-02
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.56E+01	2.62E+00	3.94E+00	2.22E+01	3.31E+00
PERT	MJ	2.01E+01	3.07E-02	2.03E-01	2.03E+01	2.60E-02
FW	m3	6.54E-01	3.75E-02	1.06E-02	7.03E-01	4.44E-02
SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NHWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MRF	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 18 Resource use categories of strand woven bamboo flooring

Impact category	Unit	A1	A2	A3	A-A3	A4
PENRE	MJ	1.78E+01	2.62E+00	3.30E+00	2.37E+01	3.31E+00
PERE	MJ	1.81E+01	3.07E-02	1.70E-01	1.83E+01	2.60E-02
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.78E+01	2.62E+00	3.30E+00	2.37E+01	3.31E+00
PERT	MJ	1.81E+01	3.07E-02	1.70E-01	1.83E+01	2.60E-02
FW	m3	6.94E-01	3.75E-02	8.63E-03	7.40E-01	4.44E-02
SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NHWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MRF	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 19 Resource use categories of bamboo wood composite flooring

Impact category	Unit	A1	A2	A3	A-A3	A4
PENRE	MJ	2.76E+01	3.13E+00	4.36E+00	3.51E+01	3.31E+00
PERE	MJ	3.77E+01	3.66E-02	2.25E-01	3.80E+01	2.60E-02
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	2.76E+01	3.13E+00	4.36E+00	3.51E+01	3.31E+00
PERT	MJ	3.77E+01	3.66E-02	2.25E-01	3.80E+01	2.60E-02
FW	m3	1.52E+00	4.47E-02	1.18E-02	1.57E+00	4.44E-02
SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NHWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MRF	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 20 Resource use categories of semi-finished bamboo panels

Impact category	Unit	A1	A2	A3	A-A3	A4
PENRE	MJ	1.23E+01	2.85E+00	4.51E+00	1.97E+01	3.36E+00

PERE	MJ	2.31E+01	3.34E-02	2.33E-01	2.33E+01	2.65E-02
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.23E+01	2.85E+00	4.51E+00	1.97E+01	3.36E+00
PERT	MJ	2.31E+01	3.34E-02	2.33E-01	2.33E+01	2.65E-02
FW	m3	5.69E-01	4.07E-02	1.45E-02	6.24E-01	4.50E-02
SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NHWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MRF	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 21 Resource use categories of industrial parquet

Impact category	Unit	A1	A2	A3	A-A3	A4
PENRE	MJ	7.26E+00	3.28E-01	5.94E-02	7.65E+00	3.41E+00
PERE	MJ	1.84E+01	3.84E-03	3.06E-03	1.84E+01	2.71E-02
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

PENRT	MJ	7.26E+00	3.28E-01	5.94E-02	7.65E+00	3.41E+00
PERT	MJ	1.84E+01	3.84E-03	3.06E-03	1.84E+01	2.71E-02
FW	m3	3.94E-01	4.68E-03	1.43E-04	3.99E-01	4.57E-02
SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NHWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MRF	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 22 Resource use categories of C and D

Impact category	Unit	C1	C2	C3	C4	D
PENRE	MJ	0.00E+00	2.52E-01	1.86E-01	0.00E+00	-6.56E-01
PERE	MJ	0.00E+00	2.95E-03	4.42E-02	0.00E+00	-1.18E+01
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	0.00E+00	2.52E-01	1.86E-01	0.00E+00	-6.56E-01
PERT	MJ	0.00E+00	2.95E-03	4.42E-02	0.00E+00	-1.18E+01
FW	m3	0.00E+00	3.60E-03	9.08E-03	0.00E+00	-3.57E-02

SM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NHWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RWD	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MRF	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

8. Conclusions

The LCA results show that the stage of raw materials A1 contribute the main environment burden. It contributes different share for different environment impacts. For all five kinds of product, the A1 raw materials stage accounts for the largest share of impact. And the total impact is positive for all five products except the GWP-total, and the GWP-biogenic.

It is advised to pay more attention to three points:

(1) In the raw material stage A1, the glue content accounts for a large share of the environment impacts. It is advised to take some measures toward green resin.

(2) In the manufacturing stage A3, because there is no clear energy use in each step, the manufacturing process should be measured individually in the next researches.

(3) In addition, transport has a considerable environmental impact, how to reduce the environment burden through optimization of transportation is a key issue for bamboo products.

9. Appendix

9.1 Life cycle impact description based on EN 15804+A2

The following environment impacts were included in the study:

Table 23 core environmental indicators, units and models

Impact Category	Indicator	Unit	Model
Climate change - total	Global Warming Potential total (GWP-total)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Climate change - fossil	Global Warming Potential fossil fuels (GWP-fossil)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Climate change - biogenic	Global Warming Potential biogenic (GWP-biogenic)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Climate change – land use and land use change	Global Warming Potential land use and land use change (GWP-luluc)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Ozone Depletion	Depletion potential of the stratospheric ozone layer (ODP)	kg CFC11eq.	Steady-state ODPs, WMO 2014
Acidification	Acidification potential, Accumulated Exceedance (AP)	mol H^+ eq.	Accumulated Exceedance, Seppala et al. 2006, Posch et al., 2008
Eutrophication aquatic fresh water	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater)	kg PO_4 eq.	EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe
Eutrophication aquatic marine	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-marine)	kg N eq.	EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe
Eutrophication terrestrial	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	mol N eq.	Accumulated Exceedance, Seppala et al. 2006, Posch et al.
Photochemical ozone formation	Formation potential of tropospheric ozone (POCP)	kg NMVOC eq.	LOTOS-EUROS, Van Zelm et al., 2008, as applied in ReCiPe

Depletion of abiotic resources – minerals and metals	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	kg Sb eq.	CML 2002, Guinee et al., 2002, and van Oers et al. 2002.
Depletion of abiotic resources – fossil fuels	Abiotic depletion potential for fossil resources (ADP-fossil)	MJ, net calorific value	CML 2002, Guinee et al., 2002, and van Oers et al. 2002.
Water use	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	m^3 world eq. deprived	Available Water Remaining (AWARE) Boulay et al., 2016

9.2 Environmental parameters

PENRT = Total use of non-renewable primary energy resources;

PENRM = Use of non-renewable primary energy resources used as raw materials;

PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials;

PERT = Total use of renewable primary energy resources;

PERM = Use of renewable primary energy resources used as raw materials;

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials;

SM =Use of secondary material;

RSF = Use of renewable secondary fuels;

NRSF = Use of non-renewable secondary fuels;

FW = Use of net fresh water

HWD = Hazardous waste disposed;

NHWD = Non-hazardous waste disposed;

RWD = Radioactive waste disposed;

CRU =Components for re-use;

MFR = Materials for recycling;

MER = Materials for energy recovery;

EEE = Exported electrical energy;

EET =Exported thermal energy.

ANNEX 1: Overview of life cycle inventory date info

Table 24 life cycle inventory data

Process	Input / Output	Quality	LCI in Simapro
Traditional bamboo flooring	Bamboo pole {CN}| bamboo pole production | Cut-off, U	1.1457 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Phenolic resin {RoW}| production | Cut-off, U	0.0857 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	EUR-flat pallet {RoW}| production | Cut-off, U	0.0005 p/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Packaging film, low density polyethylene {RoW}| production | Cut-off, U	0.0004 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Corrugated board box {RoW}| production | Cut-off, U	0.04 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.5 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.04 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.1 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit

	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.2 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.2 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, medium voltage {CN_2018_Huadong} | market group for | Cut off, U	0.3314 kWh/kg	EI3_CN_2020
	Water, deionised {RoW}| market for water, deionised | Cut-off, U	0.8704 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.227 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, sea, container ship {GLO}| market for transport, freight, sea, container ship | Cut-off, U	23.474 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.1 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, medium voltage {DK}| market for | Cut-off, U	0.0125 kwh/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Waste wood, untreated {CH}| treatment of, municipal incineration | Alloc Def, U	0.95 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit

	Electricity, high voltage {DK}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | Cut-off, U	2.82 MJ/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Heat, district or industrial, other than natural gas {DK}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | Cut-off, U	8.46 MJ/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
Strand woven bamboo flooring	Bamboo pole {CN}| bamboo pole production | Cut-off, U	1.0368 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Phenolic resin {RoW}| production | Cut-off, U	0.12 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	EUR-flat pallet {RoW}| production | Cut-off, U	0.0003 p/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Packaging film, low density polyethylene {RoW}| production | Cut-off, U	0.0003 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Corrugated board box {RoW}| production | Cut-off, U	0.0255 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.5 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.04 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit

	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.1 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.2 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.2 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, medium voltage {CN_2018_Huadong} | market group for | Cut off, U	0.2773 kWh/kg	EI3_CN_2020
	Water, deionised {RoW}| market for water, deionised | Cut-off, U	0.5539 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.227 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, sea, container ship {GLO}| market for transport, freight, sea, container ship | Cut-off, U	23.474 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.1 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit

	Electricity, medium voltage {DK}| market for | Cut-off, U	0.0125 kwh/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Waste wood, untreated {CH}| treatment of, municipal incineration | Alloc Def, U	0.95 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, high voltage {DK}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | Cut-off, U	2.82 MJ/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Heat, district or industrial, other than natural gas {DK}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | Cut-off, U	8.46 MJ/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
Bamboo wood composite flooring	Bamboo pole {CN}| bamboo pole production | Cut-off, U	0.4792 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Plywood {RoW}| plywood production | Cut-off, U	0.6350 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Phenolic resin {RoW}| production | Cut-off, U	0.1188 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	EUR-flat pallet {RoW}| production | Cut-off, U	0.0006 p/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Packaging film, low density polyethylene {RoW}| production | Cut-off, U	0.0005 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Corrugated board box {RoW}| production | Cut-off, U	0.0475 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit

	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.5 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.2 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.004 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.1 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.2 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.2 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, medium voltage {CN_2018_Huadong} | market group for | Cut off, U	0.3667 kWh/kg	EI3_CN_2020
	Water, deionised {RoW}| market for water, deionised | Cut-off, U	1.0344 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit

	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.227 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, sea, container ship {GLO}| transport, freight, sea, container ship | Cut-off, U	23.474 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.1 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, medium voltage {DK}| market for | Cut-off, U	0.0125 kwh/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Waste wood, untreated {CH}| treatment of, municipal incineration | Alloc Def, U	0.95 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, high voltage {DK}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | Cut-off, U	2.82 MJ/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Heat, district or industrial, other than natural gas {DK}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | Cut-off, U	8.46 MJ/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
Semi-finished bamboo panels	Bamboo pole {CN}| bamboo pole production | Cut-off, U	1.3399 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Melamine formaldehyde resin {RoW}| production | Cut-off, U	0.0323 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit

	EUR-flat pallet {RoW}| production | Cut-off, U	0.0007 p/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Packaging film, low density polyethylene {RoW}| production | Cut-off, U	0.0012 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.1 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.78 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.05 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.2 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, medium voltage {CN_2018_Huadong} | market group for | Cut off, U	0.3784 kWh/kg	EI3_CN_2020
	Water, deionised {RoW}| market for water, deionised | Cut-off, U	2.8917 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.245 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit

	Transport, freight, sea, container ship {GLO}| transport, freight, sea, container ship | Cut-off, U	23.474 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.1 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, medium voltage {DK}| market for | Cut-off, U	0.0125 kwh/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Waste wood, untreated {CH}| treatment of, municipal incineration | Alloc Def, U	0.95 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, high voltage {DK}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | Cut-off, U	2.82 MJ/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Heat, district or industrial, other than natural gas {DK}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | Cut-off, U	8.46 MJ/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
Industrial parquet	Bamboo pole {CN}| bamboo pole production | Cut-off, U	1.05 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	EUR-flat pallet {RoW}| production | Cut-off, U	0.0008 p/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Packaging film, low density polyethylene {RoW}| production | Cut-off, U	0.0001 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit

	Corrugated board box {RoW}| production | Cut-off, U	0.03 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.1 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.01 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.01 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.01 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, medium voltage {CN_2018_Huadong} | market group for | Cut off, U	0.005 kWh/kg	EI3_CN_2020
	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.265 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Transport, freight, sea, container ship {GLO}| transport, freight, sea, container ship | Cut-off, U	23.474 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit

	Transport, freight, lorry 16-32 metric ton, EURO4 {RoW}| transport, freight, lorry 16-32 metric ton, EURO4 | Cut-off, U	0.1 tkm/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, medium voltage {DK}| market for | Cut-off, U	0.0125 kwh/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Waste wood, untreated {CH}| treatment of, municipal incineration | Alloc Def, U	0.95 kg/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Electricity, high voltage {DK}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | Cut-off, U	2.82 MJ/kg	Ecoinvent 3 – allocation, cut-off by classification, unit
	Heat, district or industrial, other than natural gas {DK}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | Cut-off, U	8.46 MJ/kg	Ecoinvent 3 – allocation, cut-off by classification, unit