LIFE CYCLE ASSESSMENT (LCA) OF GARDEN ON THE WALL® PRESERVED WALL GARDENS

Public version

For Type III environmental declarations visit:
https://transparencycatalog.com/company/garden-on-the-wall

Status	Public
Client	Garden on the Wall®
Date	January 2026
Authors	Jui-Lung Li, Sustainable Minds Kim Hammer, Sustainable Minds

EXECUTIVE SUMMARY

Garden on the Wall® is committed to sustainability as the foundation of everything they create. They believe that bringing nature into a built environment should never come at the expense of environmental health, occupant well-being, or future generations. Since their founding, they have committed to redefining industry standards through radical transparency, circular economy principles, and uncompromising material health practices. They encourage customers, suppliers, and other stakeholders to join them with this continuing and evolving environmental and business responsibility. As part of its commitment to assessing and minimizing the environmental impact of its products and operations, Garden on the Wall® commissioned Sustainable Minds to conduct a life cycle assessment (LCA) to evaluate the potential environmental impacts of preserved wall gardens.

The functional unit of preserved wall gardens was determined to be 0.093 m² (1 square foot) of constructed area using the product, including all layers required to achieve the expected performance with a 75-year reference service life (RSL). The LCA was conducted conforming to the relevant product category rules (PCR) and applicable ISO standards using a cradle-to-grave approach. The scope includes life cycle stages from raw material supply (A1-A3), distribution to end users (A4), product installation (A5), use (B1-B7), and end-of-life disposal (C1-C4).

A high-level summary of the findings from this study is presented in the table below, which shows impacts per functional unit. The table includes results for global warming, ozone depletion, acidification, eutrophication, smog formation potential, and the SM single figure scores across the various life cycle modules. For other impact categories and a detailed breakdown by life cycle stage, refer to the tables in the full report. The negative global warming potential (GWP) values in the production stage (A1-A3) are attributed to the biogenic carbon uptake from natural sources by using plant-based materials, representing a removal of carbon from nature. When these bio-based materials return to nature at the end of life, they are converted to biogenic carbon emissions.

Overall, the study found that the environmental performance of the product is primarily driven by the use phase. The impacts within this phase are largely influenced by product replacements. The product needs to be replaced 1.5 times to meet the prescribed estimated service life (ESL) of 75 years. The cumulative impact of manufacturing, distributing, and disposing of the product throughout the service period makes product replacement the major impact contributor.

Impact category	**Unit**	**Production**	**Construction / Installation**	**Use**	**End of life**	**Total**
		A1-A3	**A4-A5**	**B1-B7**	**C1-C4**	
Global warming (IPCC, 2013)	kg CO_2 eq	-1.35E-01	1.45E-01	1.73E+00	1.15E+00	**2.89E+00**
		-4.1%	4.4%	52.5%	34.7%	**N/A**
Ozone depletion	kg CFC-11 eq	7.47E-09	1.75E-09	1.59E-08	1.36E-09	**2.64E-08**
		28.23%	6.62%	60.00%	5.12%	**100%**
Acidification	kg SO_2 eq	5.31E-03	4.87E-04	9.18E-03	3.14E-04	**1.53E-02**
		34.75%	3.19%	60.00%	2.05%	**100%**
Eutrophication	kg N eq	2.89E-03	5.08E-05	4.45E-03	2.26E-05	**7.41E-03**
		39.00%	0.69%	60.00%	0.30%	**100%**
Smog	kg O_3 eq	8.86E-02	1.08E-02	1.62E-01	8.33E-03	**2.69E-01**
		32.88%	4.01%	60.00%	3.09%	**100%**
SM single figure score	mPts	8.19E-02	9.17E-03	1.52E-01	1.01E-02	**2.53E-01**
	%	32.37%	3.62%	60.00%	4.01%	**100%**

CONTENTS

1. BACKGROUND

1.1. Opportunity

Garden on the Wall® is a leading turnkey provider of preserved wall garden installation solutions for interior environments. Using all-natural preserved moss and foliage, Garden on the Wall® crafts biophilic design features that retain a “fresh cut” aesthetic without needing water, sunlight, or soil. As a pioneer in preserved garden, moss wall, and planter insert applications within the U.S. commercial interior design space, Garden on the Wall® emphasizes longevity, low-maintenance performance, and environmental transparency. Their installations are engineered to last up to 75 years, ensuring exceptional durability and lower lifecycle costs compared to traditional living green walls.

Garden on the Wall® aims to provide robust environmental disclosures and life cycle insights for their products. In fulfilling their commitment to sustainability, it is important for Garden on the Wall® to conduct life cycle assessments (LCAs). These life cycle assessments will evaluate the environmental impacts of products across all stages of their life cycle, from raw material extraction to end-of-life disposal, following a cradle-to-grave approach. The goal of conducting this life cycle assessment is to understand the scope of environmental impacts from the products and to recognize ways to improve the process and reduce overall impacts. Garden on the Wall® intends to provide information that the market needs to be able to accurately assess the environmental impacts of their products and solutions.

Garden on the Wall® commissioned Sustainable Minds to help develop the LCA for its preserved wall gardens and is looking forward to being informed on how to reduce the environmental impacts for its products from raw material acquisition to end-of-life disposal.

Garden on the Wall® is interested in having LCA data available for its preserved wall gardens to be able to obtain a Sustainable Minds Transparency Report [EPD]™ (TR), which is an ISO 14025 Type III [1] environmental declaration that can be used for communication with and amongst other companies, architects, and consumers, and that can also be utilized in whole building LCA tools in conjunction with the LCA background report and life cycle inventory (LCI). This study aims to conform to the requirements of ISO 14040/14044 [2], ISO 21930:2017 [3], and UL’s PCR Part A [4] and Part B for Non-Metal Ceiling and Interior Wall Panel EPD Requirements [5].

1.2. Life cycle assessment (LCA)

LCA is performed to comprehensively explore, quantify, and interpret the potential environmental impacts associated with a product or service throughout its entire life cycle. A product’s life cycle consists of various stages, starting from raw material acquisition and manufacturing to product use and maintenance, plus final product disposal. Depending on the inclusion and exclusion of life cycle stages, an LCA could be cradle to gate (from raw material acquisition to the manufactured product ready to be shipped), cradle to gate with options (which also optionally includes other modules such as shipment and installation), and cradle to grave (which includes all other stages including the use phase and disposal once the useful life is over).

Any LCA conducted with the intention of publishing EPDs needs to comply with the internationally accepted ISO 14040 and ISO 14044 standards. ISO 14040 provides principles and frameworks for conducting an LCA, while ISO 14044 specifies requirements and provides guidelines for an LCA. ISO 14040 sets out a four-phase methodology framework for completing a LCA, as depicted in Figure 1.

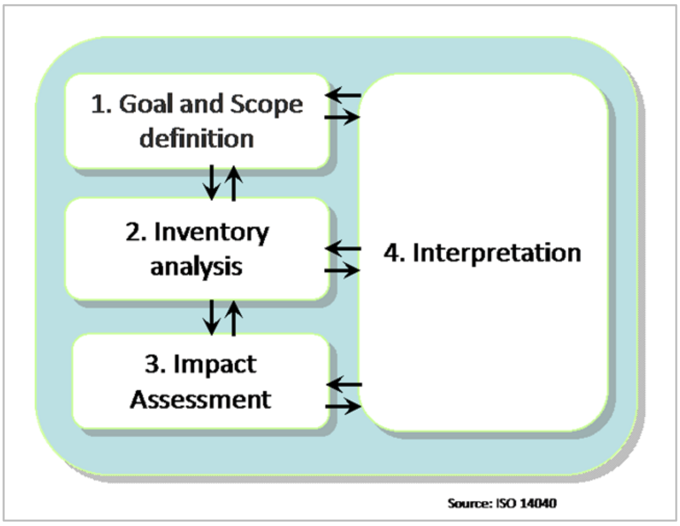

Figure 1. Phases of an LCA

- **Goal and scope definition:** Goals refer to establishing the purpose of the LCA, and they define the environmental aspects to be studied and the intended audience. Scope outlines the system boundaries, the functional unit of analysis, and the life cycle stages to be included. System boundaries set up inclusions and exclusions in an LCA. PCRs usually specify whether the boundary must be cradle-to-gate, cradle-to-installation, or cradle-to-grave.

- **Life cycle inventory analysis:** In this step, a detailed inventory of all the environmental inputs and outputs associated with each stage of the product's life cycle is compiled. Primary data about materials, energy, and emissions assessing the upstream supply chain, company's manufacturing operations, and downstream processes (after product leaves the factory gate) are collected via LCI data collection templates or tools. Annual data is suggested in most cases to be representative of the manufacturing operations. In the case of multi outputs, resources can be allocated to the product of interest via mass or volume, or as relevant. The inventory is then scaled to meet the functional unit of the LCA.

- **Life cycle impact assessment:** The compiled LCI is then modeled using an LCA software like SimaPro, GaBi, openLCA, or others using suitable background data sets available on their databases. Each is assigned to categories according to different impact methodologies, and the software provides final impact values for those different environmental impact categories. Several LCIA methodologies exist in the market including ReCiPe, TRACI, CML, and ILCD, which differ in terms of their approaches, characterization factors, evaluated impact categories, and modeling assumptions. Practitioners can choose a combination of LCIA methodologies to provide a holistic view of the environmental performance of a product.

- **Interpretation of results:** In this step, the LCIA results are analyzed and presented via an LCA report. This stage helps draw conclusions about the environmental performance of the product, identify any environmental hotspots, make recommendations, and assess the significance of the findings. Sensitivity analysis, scenario studies, and uncertainty assessment are often included as a part of the interpretation to ensure the reliability and robustness of the results. LCA, if well interpreted and evaluated, presents a number of opportunities for the manufacturer in developing sustainability goals and initiatives.

This LCA study follows an attributional approach and uses a cradle-to-grave system boundary. This report incorporates LCA terminology. To assist the readers in understanding LCA, special attention has been given to list definitions of important terms used at the end of this report.

A critical review of the LCA and an independent verification of the TR are required for ISO 14025 Type III environmental declarations. Both are included in this project.

1.3. Team

This LCA report is the outcome of the efforts of the project team led by Can Ozturk and Jessica Puli on behalf of Garden on the Wall®, with support during the data collection, reporting, and interpretation phases. Sustainable Minds led the development of the LCA results, LCA report, and TR.

1.4. Status

All information in this report reflects the best possible data inventory by Garden on the Wall® at the time it was collected, and Sustainable Minds and Garden on the Wall® adhered to best practices in transforming the inventory into this report.

Primary data was provided for manufacturing activities from January 2024 through December 2024 from Garden on the Wall® and its suppliers. Where data was missing, assumptions were made for the facility based on expertise from Garden on the Wall® and its upstream suppliers. This study also includes background data to complete the inventory and fill gaps where necessary.

This is a supporting LCA report for the Transparency Report [EPD]™ of Garden on the Wall® preserved wall gardens and was evaluated for conformance to the PCRs according to the ISO 14025 and ISO 14040/14044 standards. The LCA review and verification of the Sustainable Minds Transparency Report [EPD]™ were carried out by Beth Cassese, Horizon LCA for conformance to ISO 14040/14044, ISO 21930:2017, and the relevant PCRs.

2. GOAL AND SCOPE

This chapter explains the goal and scope of the study. The aim of the goal and scope is to define the product under study and the depth and breadth of the analysis.

This LCA study involves several value choices as defined in ISO 14040/44, ISO 21930, and the PCR. These choices were made in accordance with the applicable ISO standards and PCR, the actual product life cycle activities, and data availability, with the aim of reflecting the intended representativeness of the study. These value-based decisions are explicitly documented to ensure transparency and interpretability of the results.

2.1. Intended application and audience

This report aims to define the specific application of the LCA methodology to the life cycle of Garden on the Wall®'s preserved wall gardens. The report serves both internal and external purposes and is intended for a diverse audience. The intended audience includes the program operator (Sustainable Minds) and reviewers who will be assessing the LCA for conformance to the PCR, as well as Garden on the Wall®'s internal stakeholders involved in marketing and communications, operations, and design. A third-party LCA report, excluding any confidential information, is planned to be made publicly available and linked to from the Transparency Report [EPD]™.

The results presented in this document are not meant to support comparative claims. The outcomes will be made available to the public in a Sustainable Minds Transparency Report [EPD]™ (Type III environmental declaration per ISO 14025), which is intended for communication between businesses and consumers (B2C).

2.2. Product description

Preserved gardens are a no-maintenance plant art system made from all-natural preserved moss and plant species. They provide a wide range of benefits to occupants, enhancing well-being in subtle and restorative ways. Garden on the Wall® is dedicated to re-establishing the human-nature connection by helping designers curate human-centric spaces with botanical installations.

Garden on the Wall®'s production process includes cutting and marking the panels, hand-applying sorted moss and foliage with adhesive, and conducting quality checks before acclimation. The finished panels are then crated and shipped to the installation site.

Once on site, the installation team secures each panel in its designated location using deck screws. Garden installation technicians then inspect the seams to ensure consistent moss coloration. They close any visible seams by applying small amounts of moss and the same adhesive used during fabrication, allowing the moss sheets on adjacent panels to blend naturally with no visible gaps. The result is a handcrafted, low-impact installation process that requires no water.

Figure 2 provides representative product images for the preserved wall gardens evaluated in this study.

Product before application	Application of product
	

Figure 2. Visual representation of preserved wall gardens and its application

Table 1 and Table 2 list the product information in accordance with the PCR, including the declaration name, CSI MasterFormat® classification, manufacturing location, the type of declaration, and other relevant information.

Table 1. Declared product information and type of declaration

Transparency Report [EPD]™ name	Product name	CSI MasterFormat® classification	Manufacturing location(s)	Type of declaration
Preserved wall gardens	Preserved wall gardens	09 77 00 Specialty Wall Covering 09 78 00 Interior Wall Paneling	Fairfield, NJ	Product-specific, plant-specific declaration for one manufacturer

Table 2. Other product information

Product name	Product specifications
Preserved wall gardens	• Compliance with the fire safety requirements (ASTM E-84 Class 1) • Compliance with VOC Emissions standards (CDPH/01350 for Classroom and Office Scenarios) • Confirmed 100% Biobased Content for preserved plants (ASTM 6866)

For more information about the product, including details about the materials that conform to the relevant standards, visit https://www.gardenonthewall.com/home.

2.3. Functional unit

In accordance with the PCR, the functional unit in this study was determined to be 0.093 m^2 (1 square foot) of constructed area using the product, including all layers required to achieve the expected performance.

The estimated service life of the building (ESL) is 75 years per the PCR [4], and the preserved wall gardens are assumed to have a reference service life (RSL) of 30 years.

The reference flow indicates the mass of product required to fulfill the functional unit and is shown in Table 3 along with the other functional unit properties. The mass of preserved wall gardens per functional unit is 0.64 kg including all raw materials, fasteners, ancillary materials and adhesives.

Table 3. Functional unit properties

Name	Value
Functional unit	1 square foot (0.093 m²)
Declared thickness	1 inch (2.54 cm)
Reference flow	1.6 lb (0.64 kg)
Density	16.91 lb/ft³ (270.9 kg/m³)

2.4. System boundary

This section describes the system boundary for the analysis. The system boundary defines which life cycle stages are included and which are excluded.

This LCA's system boundary is from cradle to grave. Therefore, the life cycle activities and related processes shall include all life cycle stage modules from A1-C4 as illustrated in Figure 3. Table 4 lists specific inclusions and exclusions for the system boundary. This study follows the modularity principle, where all environmental impacts and potential impacts are declared in the life cycle stage where they can be attributed.

Scope	PRODUCTION STAGE			CONSTRUCTION STAGE		USE STAGE					END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY	Reference Service Life
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D	
	Extraction and upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Deconstruction/Demolition	Transport to waste processing or disposal	Waste processing	Disposal of waste	Reuse, Recovery, Recycling Potential	
						B6 Operational energy use										
						B7 Operational water use										
Cradle to grave	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**MND**	**75 years**

Figure 3. Applied system boundary

Table 4. System boundary inclusions and exclusions

Included	Excluded
• Raw material extraction for components • Transport of raw materials/purchased components to the manufacturing facility • Processing of raw materials into components • Material, manufacture, and transport of packaging materials associated with the final product • Packaging of raw materials and their disposal • Energy production • Manufacturing waste and its disposal • The weight of wood crate packaging for environmental impact calculation associated with transportation	• Construction of major capital equipment • Human labor and employee transport • The environmental impacts associated with the disposal of packaging materials for the final product were excluded due to multiple reuse cycles • Building operational energy and water use for office work • Energy consumption of electric screwdriver

2.4.1 Production stage (A1-A3)

The production stage starts when raw materials are extracted from nature, including the technical processes that bring those raw materials into the system, and ends when the product is packaged and ready to be loaded onto a transport vehicle at the facilities.

The production stage includes three product life cycle modules:

Extraction and upstream preprocessing (A1)

- Extraction and processing of raw materials
- Biomass production and processing (e.g., agricultural or forestry operations)
- Production of relevant inputs where they are used
- Transport of raw materials from extraction/production to manufacturer of components
- Energy consumption for raw material manufacturing

Transport to factory (A2)

- Transportation of components from suppliers to the Garden on the Wall® manufacturing facility

Manufacturing (A3)

- Energy and water consumption for product manufacturing
- Product packaging inputs
- Manufacturing waste transportation from plant to disposal sites
- Manufacturing waste disposal/recycling/reuse/energy recovery
- Final product preparation for outbound shipment

2.4.2 Construction stage (A4-A5)

The construction stage starts when the product is shipped from the Garden on the Wall® facility and ends once the product is installed at the building site. It includes two product life cycle modules:

Distribution (A4) The distribution stage includes the following:

- Transportation of finished products from facility to building sites

Installation (A5) The installation stage includes the following:

- Installation in the building including materials specifically required for installation
- Material consumption for product installation
- Total packaging and waste resulting from on-site installation

2.4.3 Use stage (B1-B7)

The use stage includes:

- Use (B1)
- Maintenance (B2)
- Repair (B3)
- Replacement (B4)
- Refurbishment (B5)
- Operational energy use (B6)
- Operational water use (B7)

Replacement covers all technical services and associated operations during the ESL associated with replacing the whole product once its RSL is over. Replacements must be counted proportionally to the nearest tenth of a product and must include the sum of impacts from stages A1-A5 and C1-C4 multiplied by the number of replacements.

Since the RSL is 30 years, 1.5 product replacements are needed to fulfill the ESL.

2.4.4 Disposal/reuse/recycling (C1-C4)

The end-of-life stage begins when the used product is ready for disposal, recycling, reuse, etc., and ends when the product is landfilled, returned to nature, or transformed to be recycled or reused. Processes that occur because of the disposal are also included within the end-of-life stage.

When preserved wall gardens reach the end of their use, Garden on the Wall® offers a Take-Back Program through which products are donated to medical systems and hospitals for reuse. The following life cycle stages describe the end-of-life processes.

Deconstruction (C1)
- The deconstruction stage includes dismantling/demolition

Transport (C2)
- The transport stage includes transport from building site to final disposition

Waste processing (C3)
- The waste processing stage includes processing required before final disposition

Disposal (C4)
- The disposal stage includes final disposition (e.g., recycling, reuse, landfill, waste incineration, or conversion to energy)

2.4.5 D: Benefits and loads beyond the system boundary

This study does not account for benefits and loads beyond the system boundary.

3. LIFE CYCLE INVENTORY ANALYSIS

This chapter includes an overview of the obtained data and data quality that has been used in this study. A comprehensive life cycle inventory calculation workbook, which catalogs the flows crossing the system boundary and serves as the starting point for life cycle impact assessment, can be found in the appendix.

3.1. Data collection procedures

The data used for this study comprises a mix of primary data and background data. Primary data was provided by Garden on the Wall® representing the supply chain (A1-A2), manufacturing (A3), construction (A4-A5), use (B1-B7), and end-of-life processes (C1–C4) for the product. Data was collected in a consistent manner and level of detail to ensure high-quality data. All questions regarding data, including gaps, outliers, and any inconsistencies, were resolved with Garden on the Wall® and their suppliers. The results represent a plant-specific, product-specific process where the product is shipped from Garden on the Wall®'s facility in New Jersey to construction sites in the US. Twelve months of data (January 2024 to December 2024) was collected. The resulting inventory calculations were developed by an analyst at Sustainable Minds and subsequently checked internally.

Background data was sourced from established life cycle inventory (LCI) databases to represent generic materials, processes, and energy sources, ensuring that all stages of the product system were consistently modeled. This combined approach enabled the integration of specific, high-quality primary data with credible secondary sources to address data gaps and maintain consistency throughout the assessment. The model was developed in SimaPro with consistency in mind. Expert judgment was used in selecting appropriate data sets to model the associated activities in this study, including materials and energy, which have been noted in the following sections. Databases adopted in the model include ecoinvent v3.11, US-EI 2.2, and World Food LCA databases. Overall, the quality of the data used in this study is considered to be good and representative of the described systems. All appropriate means were employed to guarantee the data quality and representativeness as described below.

3.2. Primary data

Primary data were collected to represent manufacturing operations and the supply chain. Primary data were collected using either direct measurement or the manufacturing facility representative personnel's best engineering estimates based on actual production if measurements were not available.

3.2.1. Raw materials acquisition and transportation (A1-A2)

These modules represent raw materials extraction, preprocessing/upstream processing, and transportation to the manufacturing facility.

The full bill of materials (BOM) was provided with a detailed breakdown of the product into raw materials. Raw materials are extracted and manufactured into components by suppliers and transported to the manufacturing plant where they are assembled into the final product. Supply chain primary data, including information on shipping distances to the final manufacturing plant, was provided. Waste and scrap created during raw material manufacturing and the emissions associated with transporting waste and scrap to the point of disposal were included in the background data sets used to model the raw materials. This product does not contain hazardous substances according to the standards or regulations of the Resource Conservation and Recovery Act (RCRA), Subtitle C.

The material composition, mass, and transportation data are reported in Table 5.

Table 5. Preserved wall gardens component mass per functional unit and associated transportation

Raw materials	Mass %	Transport mode	Distance to supplier (km)
Plywood panels	40-50%	Van	[redacted]
Adhesive	20-30%	Van	[redacted]
Moss	15-25%	Ocean Freight	[redacted]
		Semi-truck	[redacted]
Plant species	10-25%	Ocean Freight	[redacted]
		Semi-truck	[redacted]
Material inputs	**100%**	--	
Adhesive packaging	[redacted]	**Shipped with adhesive**	
Cardboard packaging for plant species	[redacted]	**Shipped with plant species**	
Cardboard packaging for moss	[redacted]	**Shipped with moss**	
Total	[redacted]	--	

3.2.2. Manufacturing (A3)

All raw materials are transported to Garden on the Wall®'s facility. The company emphasizes sustainability through composting and resource efficiency, resulting in minimal machine use and no water consumption during the manufacturing process.

The manufacturing team uses a table saw to cut plywood panels, which are then numbered and marked for design transfer. For complex or curved designs, a CNC machine is used. The garden layouts are drawn or carved onto the panels for artisans to follow. The crafting process is almost entirely manual. Moss sheets, plants, and foliage are carefully sorted by color tone and texture, with moss applied using adhesive and foliage inserted with adhesives according to the design.

Once completed, the finished panels are packaged in custom-built crates and shipped to job sites. Unused or low-quality moss and plants are composted weekly, and no byproducts are generated during manufacturing.

Energy inputs for operations such as the table saw and CNC machine are monitored and recorded. Table 6 presents the manufacturing inputs needed per functional unit of preserved wall gardens.

Table 6. Manufacturing inputs and outputs needed per functional unit of preserved wall gardens

Resource category	Flow	Amount	Unit
Energy	Electricity	[redacted]	kWh
Auxiliary material	Floral Picks (4")	[redacted]	kg
	Cleaning wipes	[redacted]	kg
Packaging	Wood crate	[redacted]	kg
Waste treatment	Landfill - Sawdust	[redacted]	kg
	Compost - Unused moss, plants	[redacted]	kg
	Recycling - Plastic container	[redacted]	kg
	Recycling - Cardboard boxes	[redacted]	kg

Figure 4 provides an overview of the product flow during its life cycle.

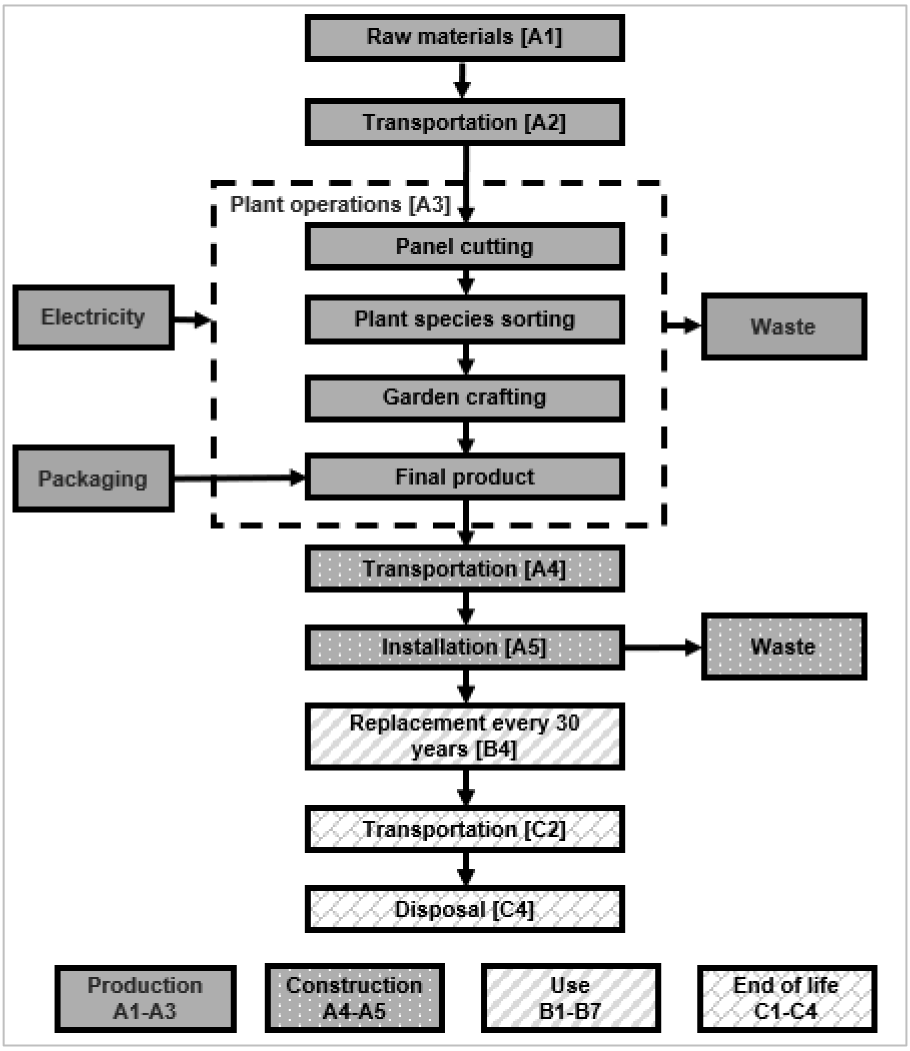

Figure 4. Product flow diagram of preserved wall gardens

3.2.3. Product distribution (A4)

This module refers to the transport and delivery of products from the manufacturing facility to the sites where the products are installed and used. The average transportation distance is 429.15 km, which was calculated as a weighted average based on Garden on the Wall®'s order history. Relevant technical information is shown in Table 7.

Table 7. Relevant technical information for distribution (A4)

Name	Value	Unit
Fuel type	Diesel	
Vehicle type	Truck and trailer (3.5-7.5 metric ton)	
Liters of fuel	23	L/100 km
Transportation distance		
Average distance from manufacturing to installation site	429.15	km
Capacity utilization (The ecoinvent transportation dataset includes empty backhaul by default)	50	%
Gross density		
Weight of products transported (if gross density not reported)	0.64	kg
Volume of products transported (if gross density not reported)	0.0024	m^3

3.2.4. Installation (A5)

This module represents the installation phase of the product, making it ready for use. At the installation site, the team secures the panels in their designated locations using deck screws. The installation area is typically prepared with plywood backing or blocking by the general contractor, allowing the team to mount the product elements directly onto the plywood surface.

Once each panel is fixed on the wall (or horizontally on planters), the garden installation artisans begin the touch-up process. They carefully check the seams to ensure the moss sheet colors are well-matched and close any visible gaps. To seamlessly weave the moss sheets together, the installation technicians apply small amounts of the same adhesive used during the fabrication process.

The installation team manually installs the product, securing the panels in their designated locations using deck screws. Once installed, the product requires no periodic cleaning, repairs, or replacement throughout its reference service life. All wood crate packaging is returned to the Garden on the Wall® facility for reuse. Based on historical records, about one percent of the product becomes scrap, which is returned to the Garden on the Wall® facility for composting.

The mass of waste is shown in Table 8. A one percent installation scrap rate was included.

Table 8. Relevant technical scenarios for installation (A5) per functional unit

Name	Amount	Unit
Auxiliary material - Deck screws	0.01	kg
Net freshwater consumption specified by water source and fate (e.g., X m3 river water evaporated, X m3 city water disposed to sewer)	0	m^3
Other resources	0	kg
Electricity consumption	0	kWh
Other energy carriers	0	MJ
Product loss per functional unit	0.0064	kg
Waste materials at the construction site before waste processing, generated by product installation	0.0064	kg
Output materials resulting from on-site waste processing (specified by route; e.g., for recycling, energy recovery, and/or disposal)	No on-site waste processing. All wastes are returned to the facility for composting.	
Mass of packaging waste specified by type – wood crate (Reuse)	0.73	kg
Biogenic carbon contained in packaging	1.33	kg CO_2
Direct emissions to ambient air, soil and water	0	kg
VOC emissions	0	µg/m^3

3.2.5. Replacement (B4)

Replacement covers all technical services and associated operations during the ESL associated with replacing the whole product once its RSL is over. Per the PCR, replacements must be counted proportionally to the nearest tenth of a product and must include the sum of impacts from stages A1-A5 and C1-C4 multiplied by the number of replacements.

Since the RSL is 30 years, 1.5 product replacements are needed to fulfill the ESL. The replacement activity inputs have been listed in Table 9.

Table 9. Preserved wall gardens replacement inputs per functional unit

Name	Value	Unit
Replacement cycles over ESL	1.5	(ESL/RSL) -1
Electricity consumption	-	kWh
Liters of fuel	-	liters/100 km
Replacement of worn parts	-	kg
Auxiliary materials	-	kg

3.2.6. Deconstruction (C1)

It is assumed that all product is sent to reuse at the end of life. Removal at end of life primarily requires human labor, and any use of equipment for removal of the wall gardens is negligible; therefore, product removal does not contribute impacts associated with the deconstruction work after the service life ends.

3.2.7. End-of-life transport (C2)

Garden on the Wall® offers a Take-Back Program that enables the reuse of its preserved wall gardens by donating end-of-life products to institutions such as healthcare systems and hospitals. The company is committed to minimizing the environmental impacts associated with shipping returned products. To optimize transportation, trips are consolidated whenever a new installation is located in the same destination area as a take-back project.

Although Garden on the Wall® has not landfilled any returned installations to date, this study applies a conservative end-of-life (EOL) assumption: 85% reuse, 10% recycling, and 5% landfill disposal. The team collects EOL products when there is an installation site nearby, allowing take-back logistics to be integrated into planned travel routes.

This study applies a typical and conservative transport distance of 100 km for landfill disposal, as recommended by ISO 21930:2017. For recycling and reuse, a transport distance of 429.15 km is used, representing the average distance from manufacturing to installation site. This reflects the fact that the installation team returns EOL products as part of combined transportation when installation routes align with take-back locations.

3.2.8. Waste processing (C3)

This module represents the processing of waste generated resulting in materials for reuse, secondary materials, and secondary fuels. There is no activity considered in this module for the studied products.

3.2.9. Final disposal (C4)

The weight of the waste product per functional unit is 0.64 kg of preserved wall gardens. A conservative end-of-life (EOL) assumption is applied in the study: 85% reuse, 10% recycling, and 5% landfill disposal.

As the biobased materials such as moss and plant species are assumed to leave the studied product system at the end of life, they are reported with an output of biogenic carbon emissions characterized with 1kg CO_2e/kg CO_2 of biogenic carbon.

The disposal pathway is defined in accordance with the disposal routes and collection processes referenced in Table 10. The biogenic carbon emissions are reported in Table 18, under the sections "Biogenic Carbon Emission from Product" and "Biogenic Carbon Emission from Packaging" in the C4 module.

Table 10. Relevant technical scenarios for final disposal (C4) per functional unit

Name	Amount	Unit
Collection process - Collected separately	0.64	kg
Recovery – 85% Reuse	0.544	kg
Recovery – 10% Recycle	0.064	kg
Recovery – 5% Landfill	0.032	kg

3.3. Background data

This section details the background data sets used for modeling all relevant activities associated with the cradle-to-grave life cycle of preserved wall gardens. Each table lists the data set name, database, reference year, and geography. The LCA model was created using SimaPro Craft 10.2 software. ecoinvent v3.11, US-EI

2.2, and World Food LCA databases provided the life cycle inventory data for the raw materials and processes for modeling the products.

3.3.1. Materials

Data representing upstream and downstream raw materials were obtained from the ecoinvent v3.11, US-EI 2.2, and World Food LCA databases. Data sets matching each transportation mode were found in the available databases. Where country-specific data were unavailable, global or rest-of-world averages were used to represent transportation in those locations. Where data sets matching the raw materials were unavailable, proxy data sets were chosen to represent those materials. Table 11 lists the most relevant LCI data sets used in modeling the raw materials.

Table 11. Key material data sets used in inventory analysis

Raw material	Data set	Database	Technology	Reference year	Geography[1]
Plywood	Plywood {RoW}| plywood production | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
Adhesive	Latex {RoW}| latex production | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
	Water, deionised {RoW}| water production, deionised | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
	Lubricating oil {RoW}| lubricating oil production | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
	Urea {RoW}| urea production | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
Plant species	Sunflower, organic {CH}| sunflower production, organic, plain region | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
Plant species for sensitivity analysis	Tea, fresh leaves, at farm (WFLDB)/CN U	World Food LCA Database	Appropriate technology	2023	CN
Moss	Peat moss {RoW}| peat moss production, horticultural use | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
Steel screw	Steel, low-alloyed {RoW}| steel production, converter, low-alloyed | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
	Metal working, average for steel product manufacturing {RoW}| metal working, average for steel product manufacturing | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
Floral picks (4")	Wood chips, dry, measured as dry mass {RoW}| market for wood chips, dry, measured as dry mass | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
Cleaning wipes	Tissue paper {GLO}| market for tissue paper | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	GLO
Preservation solution for rejuvenation program	Triethylene glycol {RoW}| ethylene glycols production, thermal hydrolysis of ethylene oxide | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
	Peat moss {RoW}| peat moss production, horticultural use | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW

[1] 'RoW' stands for Rest of World (non-Europe) geography; 'CH' stands for Switzerland; 'CN' stands for China

3.3.2. Transportation

Raw materials are transported to the product manufacturing facility from the suppliers via different transportation modes. Raw materials are shipped by road and train. The typical vehicles used for shipment via road are a 3.5-7.5 metric ton truck, and sea transport for shipment overseas. As the transportation data sets represent load factors as an average of empty and fully loaded (i.e., average load factor), empty backhauls are accounted for in the model. Table 12 shows the most relevant LCI data sets used in modeling transportation.

Table 12. Transportation data sets used in inventory analysis

Transport mode & legs	Data set	Database	Technology	Reference year	Geography[1]
Sea transport	Transport, freight, sea, container ship, heavy fuel oil {GLO}| transport, freight, sea, container ship, heavy fuel oil | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	GLO
Road transport	Transport, freight, lorry, 3.5-7.5 metric ton, diesel, EURO 4 {RoW}| transport, freight, lorry, 3.5-7.5 metric ton, diesel, EURO 4 | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW

[1] GLO' stands for global geography; 'RoW' stands for Rest of World (non-Europe) geography

3.3.3. Energy and packaging

National and regional averages for fuel inputs and electricity grid mixes were obtained from SimaPro. The grid mixes used were the most recent from eGRID for each subregion. For Fairfield, New Jersey the RFCE electric grid was used. Table 13 shows the most relevant LCI data sets used in modeling the product systems.

Table 13. Key energy data set used in inventory analysis

Name	Data set	Database	Reference year	Geography[1]
Manufacturing electricity	Electricity mix, eGrid subregion, RFCE/US U	US-EI 2.2	2023	Fairfield, New Jersey

3.3.4. Disposal

Disposal processes were obtained from the ecoinvent v3.11 database. Processes specific to waste types were selected to correspond to the disposal of facility waste streams, packaging waste, and waste product treatment. Table 14 lists the relevant disposal data sets used in the model.

Table 14. Key disposal data sets used in inventory analysis

Disposal activity	Data set	Database	Technology	Reference year	Geography[1]
Road transport for collecting municipal waste	Municipal waste collection service by 21 metric ton lorry {RoW}| municipal waste collection service by 21 metric ton lorry | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
Compost	Biowaste {RoW}| treatment of biowaste, industrial composting | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW
Landfilled sawdust	Waste wood, untreated {RoW}| treatment of waste wood, untreated, sanitary landfill | Cut-off, U	Ecoinvent v3.11	Appropriate technology	2024	RoW

[1] 'GLO' stands for global geography; 'RoW' stands for Rest of World (non-Europe) geography

3.4. Cut-off criteria

The cut-off criteria on a unit process level can be summarized as follows:

- All inputs and outputs to a (unit) process shall be included in the calculation of the pre-set parameters results, for which data are available. Data gaps shall be filled by conservative assumptions with average, generic or proxy data. Any assumptions for such choices shall be documented. Assumptions and proxies, whenever used, have been explained in this report.
- Mass – If a flow is less than 1% of the cumulative mass of the model it may be excluded, providing its environmental relevance is not a concern. No known mass flow has been omitted in this study.
- Energy – If a flow is less than 1% of the cumulative energy of the model it may be excluded, providing its environmental relevance is not a concern. The energy consumption of the electric screwdriver was omitted from this study, as it contributes less than 1% to the cumulative energy demand.
- Environmental relevance – If a flow meets the above criteria for exclusion, yet it is thought to potentially have a significant environmental impact, it is included. The environmental impacts associated with the disposal of packaging materials for the final product were excluded due to multiple reuse cycles.
- Hazardous and toxic materials – The study shall include all hazardous and toxic materials in the inventory therefore the cutoff rules shall not apply to such substances. No substances required to be reported as hazardous are associated with the production of this product including upstream raw material supply and raw material manufacturing.
- The sum of the neglected material flows does not exceed 5% of mass, energy or environmental relevance for flows indirectly related to the process (e.g., operating materials). No known mass flow has been omitted in this study.

In this report, no known flows are deliberately excluded; therefore, these criteria have been met. The completeness of the bill of materials defined in this report satisfies the above-defined cut-off criteria.

3.5. Allocation

Whenever a system boundary is crossed, environmental inputs and outputs have to be assigned to the different products. Where multi-inputs or multi-outputs are considered, the same applies. The PCR prescribes to report where and how allocation occurs in the modeling of the LCA. The model used in this report ensures that the sum of the allocated inputs and outputs of a unit process are equal to the inputs and outputs of the unit process before allocation. This means that no double counting or omissions of inputs or outputs through allocation is occurring. The allocation procedures used in background data sets were accepted without modification.

Garden on the Wall®'s annual facility resource consumption and the total area of preserved gardens and planter inserts were first collected and then scaled down to a per-unit level based on annual production quantities. Packaging and waste flows (solid waste collected on-site) were allocated using the same approach.

Garden on the Wall®'s manufacturing facility in New Jersey serves multiple operational purposes and is not solely dedicated to preserved wall garden production. However, product-specific electricity use was provided for the CNC and table saw, so no additional energy allocation was needed.

This approach aligns with ISO 21930:2017, which requires allocation based on physical relationships when they provide the most representative and transparent basis for distributing inputs and outputs. By using production area as the allocation parameter, this study ensures relevance, transparency, and accuracy in impact attribution across product systems.

The model used in this report ensures that the sum of the allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation. This means that no double counting or omissions of inputs or outputs through allocation is occurring. The allocation procedures used in background data sets were accepted without modification.

3.6. Discussion of data quality

Inventory data quality is judged by its precision (measured, calculated, or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source), and representativeness (geographical, temporal, and technological).

To cover these requirements and to ensure reliable results, first-hand industry data in combination with consistent background LCA information from the ecoinvent v3.11, US-EI 2.2, and World Food LCA databases were used.

Precision and completeness

- *Precision*: As the relevant foreground data is primary data or modeled based on primary information sources of the owner of the technology, precision is considered to be high. Background data are from ecoinvent v3.11, US-EI 2.2, and World Food LCA databases with documented precision to the extent available.
- *Completeness*: Sustainable Minds worked with Garden on the Wall® and its manufacturing partners to obtain a comprehensive set of primary data associated with the manufacturing processes. The product system was checked for mass balance and completeness of the inventory. The data set was considered complete based on our understanding of the manufacturing site and a review with key stakeholders on the Garden on the Wall® team, and cut-off criteria were observed consistent with those prescribed in the PCR. Besides capital equipment, no data was knowingly omitted.

Consistency and reproducibility

- *Consistency*: Primary data were collected with a similar level of detail, while background data were sourced primarily from the ecoinvent database. Other databases were used if data were not available in ecoinvent or the data set was judged to be more representative. Other methodological choices were made consistently throughout the model.
- *Reproducibility*: Reproducibility is warranted as much as possible through the disclosure of input-output data, data set choices, and modeling approaches in this report. Based on this information, a knowledgeable third party should be able to approximate the results of this study using the same data and modeling approaches.

Representativeness

- *Temporal:* All primary data were collected for January 2024 to December 2024, ensuring the representativeness of the manufacturing process. Secondary data were obtained from the ecoinvent v3.11, US-EI 2.2, and World Food LCA databases and are typically representative of recent years.

- *Geographical*: The geographical coverage for this study is based on United States system boundaries for all processes and products. Whenever US background data was not readily available, rest of world (non-Europe) data or global data were used. Input and output data for modeling come from the manufacturing facility which is responsible for production.
- *Technological*: All primary and secondary data were modeled to be specific to the technologies under study. Technological representativeness is considered to be high.

3.7. Comparability

ISO 21930:2017 section 5.5 highlights the following limitations and clarifications in EPD comparability: EPDs are comparable only if they use the same PCR (or sub-category PCR where applicable), include all relevant information modules, and are based on equivalent scenarios with respect to the context of construction works.

EPDs can only be compared when the same functional requirements between products are ensured and the requirements of ISO 21930:2017 section 5.5 are met. However, variations and deviations are possible. For example, different LCA software and background LCI data sets may lead to different results for the life cycle stages declared.

3.8. Assumptions and limitations

A life cycle assessment of a product system is broad and complex, and it inherently requires assumptions and simplifications. The following assumptions and limitations of the study should be recognized:

- Primary data were modeled based on the information provided by Garden on the Wall®. The data covers annual manufacturing data from January 2024 to December 2024 from Garden on the Wall® and their suppliers.
- Variations in color choices and designs using different types of moss and other plant species are assumed to be negligible.
- While wood crates would be potential impact contributors in A3 due to their raw material extraction and manufacturing, Garden on the Wall® reuses these crates multiple times. This reuse policy helps mitigate the impacts attributed to wood packaging, and the reused wood packaging is assumed to have zero impact in this study.
- Generic data sets used for material inputs, transportation, and waste processing are considered to be of good quality; however, actual impacts may vary depending on specific material suppliers, transport carriers, and local waste management practices.
- Some data sets, such as those for adhesives and cleaning wipes, were developed using proxy data sets or by combining chemical composition data based on the proportion of raw materials in the adhesive. As a result, actual impacts associated with specific manufacturing processes or suppliers may differ.
- The plant species used in the product include multiple types of plants. While best available practices were applied, a single data set was used to represent all plant species in this study. This approach may not fully capture variations in impacts related to the cultivation and transportation of plants from different suppliers.
- The data sets applied in this study may not fully reflect the most current or specific material production and manufacturing processes.
- The impact assessment methodology categories do not represent all possible environmental impact categories.

- Characterization factors used within the impact assessment methodology may contain varying levels of uncertainty.
- LCA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins, or risks.

4. Impact assessment methods

4.1. Impact assessment characterization

The methods used to calculate indicators and the underlying assumptions were developed in accordance with the applicable ISO standards and the PCR, the actual product life cycle activities, and data availability. These choices were made to best reflect real activities throughout the value chain and to ensure the intended geographic representativeness of the study.

The environmental indicators as required by the PCR are included as well as other indicators required to use the SM2013 Methodology [6] (see Table 15). GHG emissions resulting from land-use change are reported as part of the GWP quantification. These emissions are assessed using the direct land-use change factors provided in the IPCC Sixth Assessment Report (AR6) (2021). The impact indicators are derived using the 100-year time horizon[1] factors, where relevant, as defined by TRACI 2.1 classification and characterization [7]. Long-term emissions (>100 years) are not taken into consideration in the impact estimate. USEtox indicators[2] are used to evaluate toxicity. Emissions from waste disposal are considered part of the product system under study, according to the "polluter pays principle".

Table 15. Selected impact categories and units

Impact category	Unit	Description
Acidification	kg SO_2 eq (sulphur dioxide)	Acidification processes increase the acidity of water and soil systems and causes damage to lakes, streams, rivers and various plants and animals as well as building materials, paints, and other human-built structures.
Ecotoxicity	CTUe	Ecotoxicity causes negative impacts to ecological receptors and, indirectly, to human receptors through the impacts to the ecosystem.
Eutrophication	kg N eq (nitrogen)	Eutrophication is the enrichment of an aquatic ecosystem with nutrients (nitrates and phosphates) that accelerate biological productivity (growth of algae and weeds) and an undesirable accumulation of algal biomass.
Global warming (GWP 100)	kg CO_2 eq (carbon dioxide)	Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere.
Ozone depletion	kg CFC-11 eq	Ozone depletion is the reduction of ozone in the stratosphere caused by the release of ozone depleting chemicals.
Carcinogenics	CTUh	Carcinogens have the potential to form cancers in humans.
Non-carcinogenics	CTUh	Non-Carcinogens have the potential to causes non-cancerous adverse impacts to human health.
Respiratory effects	kg $PM_{2.5}$ eq (fine particulates)	Particulate matter concentrations have a strong influence on chronic and acute respiratory symptoms and mortality rates.
Smog	kg O_3 eq (ozone)	Smog formation (photochemical oxidant formation) is the formation of ozone molecules in the troposphere by complex chemical reactions.
Fossil fuel depletion	MJ surplus	Fossil fuel depletion is the surplus energy to extract minerals and fossil fuels.

[1] The 100-year period relates to the period in which the environmental impacts are modeled. This is different from the time period of the functional unit. The two periods are related as follows: all environmental impacts that are created in the period of the functional unit are modeled through life cycle impact assessment using a 100-year time horizon to understand the impacts that take place.
[2] USEtox is available in TRACI and at http://www.usetox.org/

With respect to global warming potential, biogenic carbon is included in impact category calculations. The biogenic carbon measured in this study originates from packaging materials and the moss and plant species used in the wall gardens. Greenhouse gas emissions from land-use change are expected to be insignificant and were not reported. Carbon emissions during carbonation and calcination were also considered in this study, and no carbonation or calcination is expected to occur during the production and manufacture of the wall gardens. No delayed emissions from a temporary carbon sequestration are expected to occur.

It shall be noted that the above impact categories represent impact potentials. They are approximations of environmental impacts that could occur if the emitted molecules follow the underlying impact pathway and meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen functional unit (relative approach).

The results from the impact assessment indicate potential environmental effects and do not predict actual impacts on category endpoints, the exceedance of thresholds, or safety margins or risks.

4.2. Normalization and weighting

To arrive at a single score indicator, normalization [8] and weighting [9] as shown in Table 16 conforming to the SM 2013 Methodology were applied. The SM 2013 Methodology uses TRACI 2.1 impact categories developed by U.S. EPA, and North American normalization and weighting values developed by EPA and NIST respectively, to calculate single figure LCA results. Sustainable Minds recognizes that weighting is socially defined based on the importance that society attaches to the different environmental impact categories. However, these single score indicators serve as an easy starting point to get to know the product under consideration across all impact categories, rather than focusing all efforts on just one impact category (like global warming potential). The interpretation of the results starts with the Sustainable Minds single score results and then allows users to further explore the underlying impact categories individually. Details including the characterization models, factors, and methods used, including all assumptions and limitations, can be found in the SM 2013 Methodology Report [6].

Table 16. Normalization and weighting factors

Impact category	Normalization	Weighting (%)
Acidification	90.9	3.6
Ecotoxicity	11000	8.4
Eutrophication	21.6	7.2
Global warming	24200	34.9
Ozone depletion	0.161	2.4
Carcinogenics	5.07E-05	9.6
Non-carcinogenics	1.05E-03	6.0
Respiratory effects	24.3	10.8
Smog	1390	4.8
Fossil fuel depletion	17300	12.1

5. Assessment and Interpretation

This chapter includes the results from the LCA for the products studied. It details the results per functional unit, outlines the sensitivity analysis, and concludes with recommendations.

5.1. Data quality assessment

The quality of inventory data is evaluated based on its precision, completeness, consistency, and representativeness. The data used in this study is regarded as reliable and representative of the described systems, as well as their geographical, temporal, and technological contexts. When direct measurements were unavailable, the best engineering estimates based on actual production were applied. Every effort was made to ensure the highest data quality.

5.2. Resource use and waste flows

Resource use indicators, output flows and waste category indicators, and carbon emissions and removals are presented in this section. These life cycle inventory (LCI) indicators reflect the flows from and to nature for the product system, prior to characterization using an impact assessment methodology to calculate life cycle impact assessment (LCIA) results (as shown in section 5.3).

LCI flows were calculated with the help of American Center for Life Cycle Assessment's (ACLCA) guidance for calculating the ISO 21930:2017 metrics [10]. The consumption of freshwater indicator, which was calculated in accordance with this guidance, is reported in compliance with ISO 14046. Use of renewable and non-renewable energy resources with energy content were calculated using the Cumulative Energy Demand (LHV) impact assessment methodology [11][12]. Abiotic depletion potential was calculated using the CML impact assessment methodology [12]. LCI flows were reported in conformance to ISO 21930:2017.

Resource use indicators represent the amount of materials consumed to produce not only the product itself but also the raw materials, electricity, natural gas, etc. that go into the product’s life cycle.

Primary energy is an energy form found in nature that has not been subjected to any conversion or transformation process and is expressed in energy demand from renewable and non-renewable resources. Efficiencies in energy conversion are considered when calculating primary energy demand from process energy consumption. No renewable energy was used in production beyond that accounted for in the eGRID datasets, and no energy was recovered.

Hazardous and non-hazardous wastes are calculated based on the amount of waste generated during the life cycle of the product, primarily during the product’s manufacturing process. Biobased wastes such as unused plant species and moss in the models were assumed to be 100% composted. Paper and plastic wastes were assumed to be recycled. Table 17 represents all the resource use and waste flow indicators, with the acronyms used, evaluated in this study.

Table 17. Resource use and waste flow indicators

Indicators	Acronyms used
Resource use indicators	
Renewable primary energy used as energy carrier (fuel)	**RPR_E**
Renewable primary resources with energy content used as material	**RPR_M**
Total use of renewable primary resources with energy content	**RPR_{total}**
Non-renewable primary resources used as an energy carrier (fuel)	**$NRPR_E$**
Non-renewable primary resources with energy content used as material	**$NRPR_M$**
Total use of non-renewable primary resources with energy content	**$NRPR_{total}$**
Secondary materials	**SM**
Renewable secondary fuels	**RSF**
Non-renewable secondary fuels	**NRSF**
Recovered energy	**RE**
Use of net fresh water resources	**FW**
Abiotic depletion potential for fossil resources	**ADP_{fossil}**
Output flows and waste category indicators	
Hazardous waste disposed	**HWD**
Non-hazardous waste disposed	**NHWD**
High-level radioactive waste, conditioned, to final repository	**HLRW**
Intermediate- and low-level radioactive waste, conditioned, to final repository	**ILLRW**
Components for re-use	**CRU**
Materials for recycling	**MR**
Materials for energy recovery	**MER**
Exported energy	**EE**
Carbon emissions and removals	
Biogenic Carbon Removal from Product	**BCRP**
Biogenic Carbon Emission from Product	**BCEP**
Biogenic Carbon Removal from Packaging	**BCRK**
Biogenic Carbon Emission from Packaging	**BCEK**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	**BCEW**
Calcination Carbon Emissions	**CCE**
Carbonation Carbon Removals	**CCR**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	**CWNR**
Units	
Megajoules, net calorific value	**MJ, MCV**

Table 18 shows resource use, output and waste flows, and carbon emissions and removals for preserved wall gardens at each stage of the life cycle.

Table 18. Resource use, output and waste flows, and carbon emissions and removals for preserved wall gardens per functional unit

Parameter	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B4	C1	C2	C3	C4	
Resource use indicators												
RPR$_E$	MJ, NCV	1.38E+01	3.75E-04	6.91E-02	2.67E-03	4.41E-02	2.09E+01	0	2.54E-03	0	6.05E-05	**3.48E+01**
RPR$_M$	MJ, NCV	8.46E+00	0	0	0	0	1.27E+01	0	0	0	0	**2.12E+01**
RPR$_{total}$	MJ, NCV	2.23E+01	3.75E-04	6.91E-02	2.67E-03	4.41E-02	3.36E+01	0	2.54E-03	0	6.05E-05	**5.60E+01**
NRPR$_E$	MJ, NCV	1.82E+01	2.04E-01	1.19E+00	1.41E+00	4.87E-01	3.73E+01	0	1.34E+00	0	7.60E-03	**6.02E+01**
NRPR$_M$	MJ, NCV	5.98E+00	0	0	0	0	8.96E+00	0	0	0	0	**1.49E+01**
NRPR$_{total}$	MJ, NCV	2.42E+01	2.04E-01	1.19E+00	1.41E+00	4.87E-01	4.63E+01	0	1.34E+00	0	7.60E-03	**7.51E+01**
SM	kg	0	0	0	0	0	0	0	0	0	0	**0.00E+00**
RSF	MJ, NCV	0	0	0	0	0	0	0	0	0	0	**0.00E+00**
NRSF	MJ, NCV	0	0	0	0	0	0	0	0	0	0	**0.00E+00**
RE	MJ, NCV	0	0	0	0	0	0	0	0	0	0	**0.00E+00**
FW	m^3	2.66E+00	5.84E-03	2.30E-01	3.64E-02	2.63E-01	4.79E+00	0	3.46E-02	0	1.64E-03	**8.07E+00**
ADP$_{fossil}$	MJ, NCV	1.65E+01	1.92E-01	6.88E-01	1.32E+00	4.31E-01	3.34E+01	0	1.26E+00	0	7.08E-03	**5.09E+01**
Output flows and waste category indicators												
HWD	kg	0	0	0	0	0	0	0	0	0	0	**0.00E+00**
NHWD	kg	0	0	9.81E-02	0	6.40E-03	2.53E+00	0	0	0	1.58E+00	**4.22E+00**
HLRW	kg	1.40E-06	2.57E-09	1.31E-06	1.82E-08	1.29E-07	4.36E-06	0	1.73E-08	0	2.93E-10	**7.20E-06**
ILLRW	kg	3.11E-06	5.43E-09	2.94E-06	3.82E-08	2.63E-07	9.67E-06	0	3.63E-08	0	7.23E-10	**1.60E-05**
CRU	kg	0	0	0	0	0	0	0	0	0	5.39E-01	**5.39E-01**
MR	kg	0	0	0	0	0	0	0	0	0	5.62E-02	**5.62E-02**
MER	kg	0	0	0	0	0	0	0	0	0	0	**0.00E+00**
EE	MJ	0	0	0	0	0	0	0	0	0	0	**0.00E+00**
Carbon emissions and removals												
BCRP	kg CO_2	-1.04E+00	0	0	0	0	-1.56E+00	0	0	0	0	**-2.60E+00**
BCEP	kg CO_2	0	0	1.70E-01	0	1.04E-02	1.56E+00	0	0	0	8.61E-01	**2.60E+00**
BCRK	kg CO_2	-6.23E-03	0	0	0	0	-9.35E-03	0	0	0	0	**-1.56E-02**
BCEK	kg CO_2	0	0	6.23E-03	0	0	9.35E-03	0	0	0	0	**1.56E-02**
BCEW	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0.00E+00**
CCE	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0.00E+00**
CCR	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0.00E+00**
CWNR	kg CO_2	0	0	0	0	0	0	0	0	0	0	**0.00E+00**

5.3. Life cycle impact assessment (LCIA)

It shall be reiterated at this point that the reported impact categories represent impact potentials; they are approximations of environmental impacts that could occur if the emitted molecules follow the underlying impact pathway and meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen functional unit (relative approach). LCIA results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks.

Life cycle impact assessment (LCIA) results are presented per functional unit for preserved wall gardens. Unlike life cycle inventories, which only report sums for individual inventory flows, the LCIA includes a classification of individual emissions with regard to the impacts they are associated with and subsequently a characterization of the emissions by a factor expressing their respective contribution to the impact category indicator. The end result is a single metric for quantifying each potential impact, such as “Global Warming Potential”.

100-year time horizon GWP factors as provided by the IPCC 2013 Fifth Assessment Report (AR5) are used to report global warming potential.
Direct land use change factor as provided by the IPCC 2021 Sixth Assessment Report (AR6) is used to report greenhouse gas emissions from land-use change. The impact assessment results for other impact categories are calculated using characterization factors published by the United States Environmental Protection Agency. The TRACI 2.1 (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts 2.1) methodology is the most widely applied impact assessment method for U.S. LCA studies. The SM 2013 Methodology is also applied to come up with single score results for the sole purpose of representing total impacts per life cycle phase to explain where in the product life cycle greatest impacts are occurring and what is contributing to the impacts.

These six TRACI impact categories are globally deemed mature enough to be included in Type III environmental declarations. Other categories are being developed and defined and LCA should continue making advances in their development; however, the EPD users shall not use additional measures for comparative purposes. All impact categories from TRACI are used to calculate single score millipoints using the SM2013 Methodology, but it should be noted that there are known limitations related to these impact categories due to their high degree of uncertainty.

It is important to note that the LCIA indicators for carcinogenics, non carcinogenics (CTUh), and ecotoxicity (CTUe) are subject to significant uncertainty. EN 15804 includes the following disclaimer: *"The results of this environmental impact indicator shall be used with care, as the uncertainties associated with these results are high, or there is limited experience with the indicator."*

The LCIA results of preserved wall gardens per functional unit are shown in Table 19. The percentage contribution of each of the cradle-to-grave life cycle modules to the total impacts is tabulated in Table 20 and is also presented in Figure 5.

Table 19. Life cycle impact assessment results for preserved wall gardens per functional unit

Impact category	Unit	A1	A2	A3	A4	A5	B4	C2	C4
$IPCC_{Land\text{-}use\ change}$ (2021 GWP 100)	kg CO_2 eq	8.54E-04	6.52E-07	1.72E-04	5.42E-06	3.24E-05	1.61E-03	5.15E-06	1.50E-07
$IPCC_{Total}$ (2013 GWP 100)	kg CO_2 eq	-2.07E-01	1.52E-02	5.75E-02	1.02E-01	4.27E-02	1.73E+00	9.67E-02	1.05E+00
$IPCC_{Biogenic}$ (2013 GWP 100)	kg CO_2 eq	-1.05E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E+00
$IPCC_{Fossil}$ (2013 GWP 100)	kg CO_2 eq	8.40E-01	1.52E-02	5.75E-02	1.02E-01	4.27E-02	1.73E+00	9.67E-02	2.11E-03
Ozone depletion	kg CFC-11 eq	4.61E-09	2.24E-10	2.63E-09	1.43E-09	3.24E-10	1.59E-08	1.36E-09	8.83E-12
Acidification	kg SO_2 eq	4.67E-03	2.43E-04	4.04E-04	3.31E-04	1.57E-04	9.18E-03	3.14E-04	2.00E-06
Eutrophication	kg N eq	2.85E-03	9.37E-06	2.97E-05	2.38E-05	2.71E-05	4.45E-03	2.26E-05	7.12E-07
Smog	kg O_3 eq	8.12E-02	4.72E-03	2.68E-03	8.77E-03	2.05E-03	1.62E-01	8.33E-03	5.50E-05
Additional environmental information									
Respiratory effects	kg $PM_{2.5}$ eq	6.40E-04	1.45E-05	2.35E-05	2.66E-05	5.13E-05	1.17E-03	2.53E-05	3.01E-07
Carcinogenics	CTUh	5.73E-09	9.84E-12	1.26E-10	7.67E-11	1.11E-09	1.07E-08	7.29E-11	7.08E-13
Non carcinogenics	CTUh	6.47E-07	6.83E-10	5.97E-09	8.14E-09	5.42E-09	1.01E-06	7.73E-09	2.38E-11
Ecotoxicity	CTUe	5.07E-01	1.13E-02	1.18E-02	1.58E-01	4.54E-02	1.32E+00	1.50E-01	1.20E-04
Fossil fuel depletion	MJ surplus	1.84E+00	2.69E-02	8.58E-02	1.80E-01	3.09E-02	3.50E+00	1.71E-01	9.85E-04

Table 20. Percent contributions of each life cycle stage to each impact category for preserved wall gardens per functional unit

Impact category	Unit	A1	A2	A3	A4	A5	B4	C2	C4
$IPCC_{Land\text{-}use\ change}$ (2021 GWP 100)	kg CO_2 eq	31.92%	0.02%	6.44%	0.20%	1.21%	60.00%	0.19%	0.01%
$IPCC_{Total}$ (2013 GWP 100)	kg CO_2 eq	-7.18%	0.53%	1.99%	3.52%	1.48%	60.00%	3.34%	36.32%
Ozone depletion	kg CFC-11 eq	17.44%	0.85%	9.94%	5.39%	1.23%	60.00%	5.12%	0.03%
Acidification	kg SO_2 eq	30.51%	1.59%	2.64%	2.16%	1.02%	60.00%	2.05%	0.01%
Eutrophication	kg N eq	38.47%	0.13%	0.40%	0.32%	0.36%	60.00%	0.30%	0.01%
Smog	kg O_3 eq	30.13%	1.75%	0.99%	3.25%	0.76%	60.00%	3.09%	0.02%
Additional environmental information									
Respiratory effects	kg $PM_{2.5}$ eq	32.76%	0.74%	1.20%	1.36%	2.63%	60.00%	1.29%	0.02%
Carcinogenics	CTUh	32.18%	0.06%	0.71%	0.43%	6.21%	60.00%	0.41%	0.00%
Non carcinogenics	CTUh	38.34%	0.04%	0.35%	0.48%	0.32%	60.00%	0.46%	0.00%
Ecotoxicity	CTUe	22.96%	0.51%	0.54%	7.15%	2.06%	60.00%	6.79%	0.01%
Fossil fuel depletion	MJ surplus	31.50%	0.46%	1.47%	3.09%	0.53%	60.00%	2.93%	0.02%

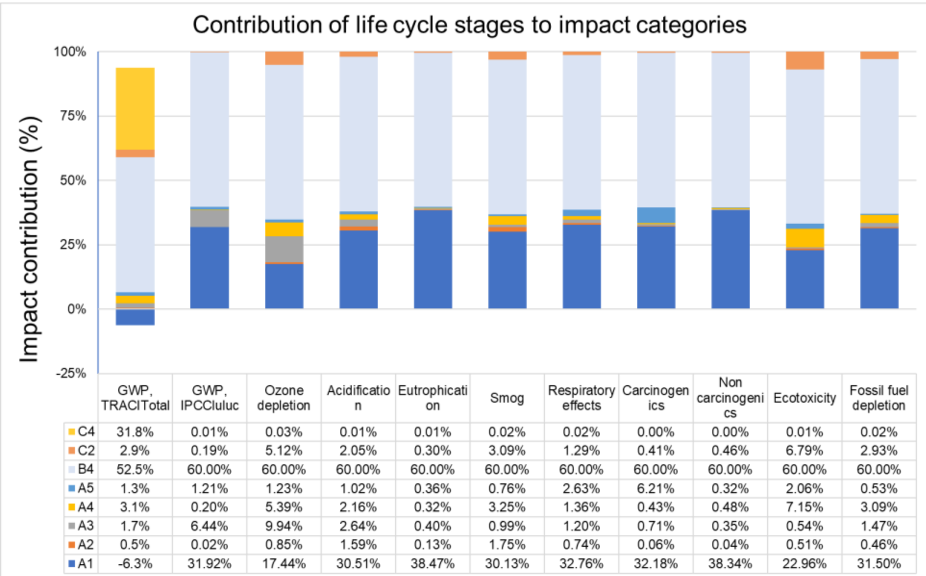

Figure 5. Contribution analysis of each impact category for preserved wall gardens per functional unit

Overall, the study found that the environmental performance of the product is primarily driven by the use phase. The impacts within this phase are largely influenced by product replacements. The product needs to be replaced 1.5 times to meet the prescribed estimated service life (ESL) of 75 years. The impact includes the sum of impacts from stages A1-A5 and C1-C4 multiplied by the number of replacements.

The total potential CO_2-equivalent emissions generated during the cradle-to-grave stage of Garden on the Wall®'s product is 2.89E+00 kg CO_2 eq. The raw material extraction phase (A1) contributes -2.07E-01 kg CO_2 eq. The negative global warming potential (GWP) values in the production stage (A1–A3) are attributed to the substantial biogenic carbon uptake from natural sources by using bio-based materials. Aside from the use phase, the raw material supply stage (A1) dominates the results across all impact categories except global warming potential, followed by the manufacturing stage (A3). A1 accounts for roughly 30% of the impacts across seven of the ten TRACI impact categories.

The manufacturing phase (A3) is the second-largest contributor, accounting for roughly 10% of ozone depletion and 2.64% of acidification impacts across the product's life cycle. In stage A3, the primary contributor to overall environmental impacts is energy use. Although electricity consumption in this stage is only 0.075 kWh per functional unit, it is still the dominant driver of global warming potential and ozone depletion in A3. It accounts for approximately 65% of the global warming impact and 91% of the ozone depletion impact in this stage.

Transport to the building site (A4) and transportation to waste processing or disposal (C2) contribute more significantly to smog formation. Vehicle activity contributes to smog formation because it emits nitrogen oxides, a key precursor of photochemical smog. Additionally, older vehicle air conditioning systems used chlorofluorocarbons (CFCs), a chemical that is known to destroy stratospheric ozone.

The bio-based materials containing biogenic carbon leave the studied product system during the waste disposal phase (C4). This outflow of bio-based material, along with the associated biogenic carbon, is reported as an export of biogenic carbon (expressed as CO_2) in the life cycle inventory (LCI) and is characterized as +1 kg CO_2eq per kg CO_2 of biogenic carbon in the calculation of the global warming potential (GWP).

The SM2013 Methodology single figure milli point (mPt) score by life cycle module for this product is presented in Table 21.

Table 21. SM millipoint scores for preserved wall gardens per functional unit

	Unit	Production			Construction/ Installation		Use	End-of-life	
		A1	A2	A3	A4	A5	B4	C2	C4
SM single figure score	mPts	7.85E-02	9.04E-04	2.53E-03	5.15E-03	4.02E-03	1.52E-01	4.07E-03	6.07E-03
	%	31.01%	0.36%	1.00%	2.04%	1.59%	60.00%	1.61%	2.40%

In terms of single-score results and overall environmental impacts, the replacement (B4) has the greatest contribution. The next highest contribution comes from the raw material extraction stage (A1). It has the greatest contribution, accounting for approximately 31% of the total. This is followed by the disposal stage (C4), which contributes about 2.4%. The rest of the phases have comparatively minor contributions.

5.4. Sensitivity analysis

A sensitivity analysis was performed to check the robustness of the results where the highest potential environmental impacts are occurring. Acidification, ozone depletion, and global warming potential (GWP, IPCC 2013) were selected for analysis.

Since a large portion of the raw materials are bio-based, the adhesive used in preserved wall gardens is a major contributor to the overall impacts. Therefore, the adhesive was selected for sensitivity analysis due to its relatively high contribution to the total results. The adhesive mass was varied by ±20%. This change in mass resulted in a ±5.88% change in total global warming potential, a ±1.52% change in ozone depletion, and a ±6.19% change in acidification.

This study also evaluated alternative modeling scenarios, including (1) adopting a different LCI dataset to model impacts associated with plant species and moss, and (2) assuming the product's end-of-life (EOL) is 100% landfilled. Switching the LCI dataset resulted in a +1.4% change in total global warming potential, a +93.89% change in ozone depletion, and a 0.19% change in acidification. Assuming 100% landfilling at EOL led to a +3.46% change in total global warming potential, a +1.58% change in ozone depletion, and a 0.62% change in acidification. The results are summarized in Table 22.

Table 22. Sensitivity of adhesive mass on total impact assessment results per functional unit

Adhesive consumption	GWP, $IPCC_{Total}$		Ozone depletion		Acidification	
	kg CO_2 eq emissions	% change	kg CFC-11 eq	% change	kg SO_2 eq emissions	% change
Preserved wall gardens						
Baseline	2.89E+00	N/A	2.65E-08	N/A	1.53E-02	N/A
+20% adhesive consumption	3.06E+00	+5.88%	2.69E-08	+1.52%	1.62E-02	+6.19%
-20% adhesive consumption	2.72E+00	-5.88%	2.61E-08	-1.52%	1.43E-02	-6.19%
Tea leaves data set	2.93E+00	+1.40%	5.13E-08	+93.89%	1.53E-02	+0.19%
100% landfill	2.99E+00	+3.46%	2.69E-08	+1.58%	1.54E-02	+0.62%

The results of the sensitivity analyses show that the cradle-to-grave life cycle impacts are not highly sensitive to the amount of adhesive used. While the adhesive accounts for ~26% of the total mass of the applied and cured product, decreasing the mass of adhesive by 20% could result in a potential decrease of total GWP impacts by approximately 6%. However, ozone depletion is highly sensitive to the LCI dataset; switching datasets caused a +93.89% change.

5.5. Overview of relevant findings

This life cycle assessment (LCA) report assessed a multitude of inventory and environmental indicators. The primary finding was that raw material supply and manufacturing were responsible for much of the impacts to categories except for global warming potential.

Since the bio-based materials (e.g. moss, plant species, plywood board in the raw material supply phase) originate from renewable resources that contain biogenic carbon, they effectively remove carbon from the atmosphere and are therefore represented as negative values in the GWP calculation for that stage.

Removals of biogenic CO_2 are characterized with -1 kg CO_2eq/kg CO_2 of biogenic carbon in the calculation of the GWP. In this study, the negative global warming potential value in the raw material supply phase is attributed to the substantial biogenic carbon uptake from natural sources, such as bio-based materials and wood crates, when bio-based materials enter the product system. The flows of biogenic carbon (expressed as CO_2) in bio-based materials that are reused, recycled, or combusted at end of life are characterized with +1 kg CO_2e/kg CO_2 of biogenic carbon in the calculation of the GWP, resulting in a net zero contribution to GWP when the global warming potential is considered over the entire life cycle.

5.6. Conclusion and recommendations

The goal of this study was to conduct a cradle-to-grave LCA on Garden on the Wall® preserved wall gardens so as to develop a Transparency Report [EPD]™. The creation of this TR will allow consumers in the building and construction industry to make better informed decisions about the environmental impacts associated with the products they choose. Except for global warming potential, the study found that the environmental performance is primarily driven by the raw material extraction and manufacturing phases, which together account for more than 30% of the total impacts across most of the impact categories.

In most cases, the greatest opportunity to reduce a product's global warming potential lies in the raw material supply phase, primarily because of the energy and materials required for raw material extraction. However, since Garden on the Wall® products contain more than 70% bio-based materials, the global warming potential in that phase is negative. This indicates that the use of bio-based materials leads to the removal of carbon from the environment, although the same amount of carbon will eventually return to nature at the end of the product's life.

The greatest opportunity to reduce the product's CO_2-eq emission lies in the transport to the building site (A4) and transportation to waste processing or disposal (C2) phases. Adopting vehicles that meet the latest EPA emission standards, reducing packaging weight, and maintaining Garden on the Wall®'s existing policies for managing delivery routes and schedules, such as combining transportation when installation sites are close to each other, can help mitigate these impacts. Sourcing plant species from local suppliers in North America can also be a viable approach to reduce the need for ocean transportation, where applicable.

In addition, the results indicate that electricity consumption is a major contributor to impacts in the manufacturing phase. Collaborating with the processing facilities to adopt renewable energy options can help mitigate the environmental impacts associated with energy use.

Garden on the Wall® offers a Take-Back Program that reuses end-of-life products by donating units to medical systems and hospitals. Since no preprocessing is required and Garden on the Wall® states that the preserved wall gardens are designed to be highly reusable, the impacts generated during the end-of-life stage are minimal.

Regular updates to this LCA and the associated Transparency Report [EPD]™ would enable high-quality year-over-year comparisons and serve as the basis for a potential optimized EPD, which is assigned a higher credit value under the Materials and Resources category in LEED and would help customers looking to increase the performance of their building projects. A post-study review may provide opportunities for improving the data collection process in future years and for continuing to align with Garden on the Wall®'s goals for sustainability.

6. References

[1] ISO 14025, “Environmental labels and declarations -- Type III environmental declarations -- Principles and procedures”, ISO14025:2006

[2] ISO 14040 ISO 14040:2006/Amd 1:2020, Environmental Management — Life Cycle Assessment — Principles and framework; and ISO 14044/Amd1:2017/Amd2:2020, “Environmental management - Life cycle assessment - Requirements and guidelines”, ISO14044:2006

[3] ISO 21930, “Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services”, ISO 21930:2017

[4] UL Part A: Life Cycle Assessment Calculations and Report Requirements, Version 4.0 (2022)

[5] UL Part B: Non-Metal Ceiling and Interior Wall Panel EPD Requirements, Version 2.0 (2021)

[6] Joep Meijer, Sustainable Minds SM2013 Methodology and Database, April 25, 2013. For a summary, see the Sustainable Minds single score page: http://www.sustainableminds.com/showroom/shared/learn-single-score.html

[7] Bare, J. 2014. Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) TRACI version 2.1 User’s Guide. US EPA Office of Research and Development, Washington, DC, EPA/600/R-12/554, http://nepis.epa.gov/Adobe/PDF/P100HN53.pdf

[8] Ryberg, M., Vieira, M.D.M., Zgola, M. et al. (2014). ‘Updated US and Canadian normalization factors for TRACI 2.1.’ Clean Technologies and Environmental Policy 16: 329. doi:10.1007/s10098-013-0629-z

[9] Gloria, T. P., B. C. Lippiatt & J. Cooper (2007). ‘Life cycle impact assessment weights to support environmentally preferable purchasing in the United States.’ Environmental Science & Technology, 41(21), 7551-7557

[10] "ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017”, ACLCA PCR committee working group for ISO 21930 metric calculation guidance, May 2019.

[11] Frischknecht R., Jungbluth N., et.al. (2003). Implementation of Life Cycle Impact Assessment Methods. Final report ecoinvent 2000, Swiss Centre for LCI. Duebendorf, CH, www.ecoinvent.ch.

[12] Heijungs R., Guinée J.B., Huppes G., Lankreijer R.M., Udo de Haes H.A., Wegener Sleeswijk A. Environmental Life Cycle Assessment of Products: Guide and Backgrounds. CML. Leiden University, Leiden, 1992.

Acronyms

ACLCA	American Center for Life Cycle Assessment
BOM	Bill of materials
ESL	Estimated service life
ISO	International Standardization Organization
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact analysis
PCR	Product Category Rule document
RSL	Reference service life
TR	Transparency Report [EPD]™
NCV	Net calorific value

Glossary

For the purposes of this report, the terms and definitions given in ISO 14020, ISO 14025, the ISO 14040 series, and ISO 21930 apply. The most important ones are included here.

Allocation	Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems
Close loop & open loop	A closed-loop allocation procedure applies to closed-loop product systems. It also applies to open-loop product systems where no changes occur in the inherent properties of the recycled material. In such cases, the need for allocation is avoided since the use of secondary material displaces the use of virgin (primary) materials. An open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties.
Cradle to grave	Addresses the environmental aspects and potential environmental impacts (e.g., use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of life
Cradle to gate	Addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of the production process ("gate of the factory"). It may also include transportation until use phase
Functional unit	Quantity of a product for use as a reference unit in an EPD based on one or more information modules
Life cycle	Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal
Life cycle assessment - LCA	Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle
Life cycle impact assessment - LCIA	Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product
Life cycle inventory - LCI	phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle
Life cycle interpretation	Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations

APPENDIX

[redacted]