An Approach to Environmental Justice in Design and Construction

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An Approach to Environmental Justice in Design and Construction

Why radical change is needed

What we do

Case study of our work
Why radical change is needed
2030 / 2050

UN: 1/2 current CO$_2$ levels by 2030
Net zero by 2050

Source: IPCC (2017), Global Warming of 1.5°C
Construction Greenhouse Gas

39% of global total comes from Building Industry

Source: UN Environment, Global Status Report 2017
Operational vs Embodied

**Operational carbon** from heating, cooling and electrifying our existing building stock.

**Embodied carbon** from extracting, manufacturing, installing, and disposing building materials.

Source: UN Environment, Global Status Report 2017
Operational vs Embodied

Source: UN Environment, Global Status Report 2017
Operational vs Embodied

Total Carbon Emissions of Global New Construction from 2020 - 2050

51

49

Operational Carbon

Embodied Carbon

Source: Architecture 2030
Embodied carbon

A new New York every month for 40 years

Source: Architecture 2030
Expected construction by 2060

Source: IEA, Energy Technology Perspectives 2017
Architecture is never neutral,
It either hurts or it heals.
Architecture is never sustainable, it is either climate negative or climate positive.
What we do
Organization

- **3** Offices
- **3** Studios
- **125** Team Members
- **51%** Women
- **20+** Nationalities
Over 10 years of delivering projects

- Butaro Hospital
  2008

- Butaro Doctors Share Housing
  2015

- University of Global Health Equity
  2019

- GHESKIO Cholera Treatment Center
  2015

- Ilima Primary School
  2015

- The National Memorial for Peace and Justice
  2018
Partners
Can a building heal?

Butaro District Hospital
Burera, Rwanda
Can a building help resist an epidemic?

GHESKIO Cholera Treatment Center
Port-au-Prince, Haiti
Can design amplify conservation efforts?

Ilima Primary School
Ilima, Democratic Republic of the Congo
Can a school's design improve the quality of education?

Mubuga Primary School
Musanze, Rwanda
Good
We believe everyone deserves good design. Good design is beautiful and just. It is essential to delivering human rights, essential services, and the spaces that will build a better world.
Clean
Being climate positive is an imperative. Our projects strive for not only efficient operation, but the design of the entire supply chain to be resilient, restorative and regenerative.
Looking at the design and construction process holistically—from material extraction to assembly and operation—ensures we have safe and equitable labour practices.
Butaro District Hospital

Rwanda, 2008
Operational Carbon

Natural ventilation

Daylight
Lo-Fab

Volcanic stone walling
Embodied Carbon

$\frac{1}{2}$

240kgCO2e/m2
Ilima Primary School

Democratic Republic of Congo, 2015
Material Sourcing

REINFORCING BAR
Sourced in Kinshasa, brought via barge to site (1300km)

SHINGLES
Wood harvested & cut on site (2km)

TRUSSES
Wood harvested & cut on site (6km)

STEEL TUBE
Fabricated in Kinshasa, brought via barge (1100km), and moto (88km)

CEMENT
Sourced in Kinshasa via barge (2300km)

EARTH BLOCK
Clay dug & dried on site (400m)

LATERITE BLOCKS
Sourced within 2km of site

COURSE SAND
Collected from within 1km of site
84% spent locally
$317,420 spent within 100km radius

95% spent regionally
$359,690 spent within 800km radius or country
Embodied carbon

The construction of Ilima emitted **28 times** less carbon/m² than the global average for educational construction projects.
Ilima Primary School

Wooden shingles

Timber trusses

Earth blocks
Project embodied carbon

[kgCO2e/m²]

- Umubano School (Girubunjto)
- Butaro Doctor’s Housing (Duplexes)
- Butaro Ambulatory Care Center
- Rwinekafu Neonatal Intensive Care Unit
- Maternity Waiting Village
- Illima Primary School
- Mubuga Primary School
- Butaro Doctor’s Housing 2 (Sharehouses)
- Cholera Treatment Center
- GHESKIO MDR-TB Hospital
- Munini District Hospital
- Redemption Hospital
- Njujuanje District Hospital
- UGHE Housing
- Oncology Housing
- One Acre Fund Phase 1
- One Acre Fund Phase 2
- Jabana
- Fossey Fund Campus Buildings
- Masaka Affordable Housing
- RICA - Residential
- RICA - Educational Center
- ELMA Education Center
- Grueneli Research Center

MASS.
Rwanda Institute for Conservation Agriculture: Good, Clean, Fair at scale
Land type

2016
Can design improve human, ecological, and animal health?
One Health

**Existing Conditions**
Degraded soil, food insecurity, deforestation

**One Health Conditions**
Ecological, Human, Economic Health

**Native Ornamental Landscapes**
Native species builds biodiversity, a seed bank, ecological stability.

**Silviculture**
Providing biomass, natural resources, livelihoods

**Agroforestry**
Soil improvement, biodiversity, food security

**Water Resources Protection**
Erosion prevention, filtration of nutrients, sediment
Enterprise buildings
Embodied Carbon

175 kgCO₂e/m²
How we reduced carbon at RICA
Influence the brief

Upstream with client
Natural Ventilation, Cooling and Daylight
Solar

Carbon payback period:

3 years
Local materials

96% of RICA’s materials excavated, harvested, and sourced in Rwanda
Sources:
1. Timber
2. Soil (Laterite)
3. Water
RICA | 1-10 Miles

Sources:
1. Stone
2. Aggregate
3. Sand
RICA | 10-100 Miles

Sources:
1. Timber
2. Sand

Manufacturers:
3. Cement
4. Terra Cotta
5. Ceramics

Suppliers:
6. Reinforcing Steel
7. Structural Steel
8. Windows and Doors
RICA | 100-1000 Miles

Sources:
1. Timber
2. Piping
3. Wiring

Manufacturers:
1. Structural Steel
2. Structural Fasteners
3. Light Fixtures
4. Sanware
RICA | > 1000 miles

Manufacture:
1. Solar Panels
2. Batteries
3. Water Treatment Plant
4. Wastewater Treatment Plant
5. Pumps
6. Gypsum Board
7. Fasteners
Low embodied carbon materials
Timber

Sourced in Rwanda and Tanzania

From forests with growing stock
Clay tiles

Sourced 60km away

Coffee husks used to fire the clay
Stone foundations

Alternative to concrete foundations
Swales

Natural infrastructure instead of buried concrete culverts
Earth construction

Sourced from site

25% of all building materials by weight
Calculating embodied carbon

How to calculate product stage embodied carbon

\[
\text{MATERIAL QUANTITY ESTIMATE} \times \text{EMBODIED CARBON PER UNIT MATERIAL} = \text{BUILDING EMBODIED CARBON (EC) ESTIMATE}
\]
Environmental Product Declaration

EPDs contain environmental impact data for products
Environmental Product Declaration

Little data where the most construction is happening
ICE (Inventory of Carbon & Energy)

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Version Control

Version: V3.0 Beta - 9 August 2019

Is this version still valid? Check link below to see if a newer version is available.

Check if this copy is up to date at: http://www.circularecology.com/embodied-energy-and-carbon-footprint-database.html

EMBODIED ENERGY OF VARIOUS MATERIALS AND TECHNOLOGIES

COMPILED AND CALCULATIONS

May 2005
Revision November 2013

Satprem Maini
Varun Thakur
Earth construction

Embodied carbon drove design decisions

Embodied Carbon for 3.3m High Wall Options (kgCO2e/m2)
Design
Measured Coefficient

A1-3: 0.046 kgCO2e/kg of CSEB
How we perform whole campus life cycle analysis
System boundary

Building assessment information

Building life cycle information

Supplementary information beyond the building life cycle

A1-3
PRODUCT stage

A4-5
CONSTRUCTION PROCESS stage

A1 A2 A3
Raw material supply Transport Manufacturing

A4 A5
Transport Construction-installation process

B1-7
USE stage

B1 B2 B3 B4 B5
Use Maintenance Repair Refurbishment Replacement

B6
Operational energy use

B7
Operational water use

C1-4
END OF LIFE stage

C1 C2 C3 C4
De-construction demolition Transport Waste processing Disposal

D
Benefits and loads beyond the system boundary

Reuse-
Recovery-
Recycling-

Extract raw materials
Transport to factory
Manufacture products
Transport to site
Construct the building
Use and maintain the building
Deconstruct the building
Haul away waste materials
Landfill (or recycle)
A1-3 Product stage

Building assessment information

A1-3
PRODUCT stage
A1, A2, A3
Raw material supply
Transport
Manufacturing

A4-5
CONSTRUCTION PROCESS stage
A4, A5
Transport
Construction-installation process

B1-7
USE stage
B1, B2, B3, B4, B5
Use
Maintenance
Repair
Refurbishment
Replacement
B6
Operational energy use
B7
Operational water use

C1-4
END OF LIFE stage
C1, C2, C3, C4
De-construction demolition
Transport
Waste processing
Disposal

Supplementary information beyond the building life cycle
D
Benefits and loads beyond the system boundary
Reuse-
Recycling-

Extract raw materials
Transport to factory
Manufacture products
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A1-3 Product stage

\[
\text{MATERIAL QUANTITY ESTIMATE} \times \text{EMBODIED CARBON PER UNIT MATERIAL} = \text{BUILDING EMBODIED CARBON (EC) ESTIMATE}
\]
### A1-3 Product stage

Reinforced 240mm Thk CSEB wall with earth plaster (Declared unit = 1m²)

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>CO₂e/kg</th>
<th>CO₂e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth</td>
<td>365kg</td>
<td>0.00438</td>
<td>1.60</td>
</tr>
<tr>
<td>Cement</td>
<td>20kg</td>
<td>0.798</td>
<td>15.96</td>
</tr>
<tr>
<td>Sand for mortar</td>
<td>90kg</td>
<td>0.00438</td>
<td>0.39</td>
</tr>
<tr>
<td>Cement for mortar</td>
<td>15kg</td>
<td>0.798</td>
<td>11.97</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>6kg</td>
<td>1.99</td>
<td>11.94</td>
</tr>
<tr>
<td>Earth for plaster</td>
<td>40kg</td>
<td>0.00438</td>
<td>0.18</td>
</tr>
<tr>
<td>Cement for plaster</td>
<td>2kg</td>
<td>0.798</td>
<td>1.60</td>
</tr>
</tbody>
</table>

**A1 - A3 Sum** = 44 kgCO₂e/m² of wall area

*Sources and assumptions*
- Sand and earth: ICE v3: from virgin land won resources, bulk, loose
- Reinforcement: ICE v3: Steel, Rebar
- Cement: ICE v3: CEM II/A-P - 13% natural pozzolanic ash
# A4-5 Construction process

<table>
<thead>
<tr>
<th>A1-3</th>
<th>Building assessment information</th>
<th>Supplementary information beyond the building life cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>PRODUCT stage</td>
<td>D</td>
</tr>
<tr>
<td>A2</td>
<td>Raw material supply</td>
<td>Benefits and loads beyond the system boundary</td>
</tr>
<tr>
<td>A3</td>
<td>Transport</td>
<td>Reuse-</td>
</tr>
<tr>
<td></td>
<td>Manufacturing</td>
<td>Recovery-</td>
</tr>
</tbody>
</table>

## Building life cycle information

<table>
<thead>
<tr>
<th>A4-5</th>
<th>CONSTRUCTION PROCESS stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A4</td>
</tr>
<tr>
<td></td>
<td>A5</td>
</tr>
</tbody>
</table>

### A4-5: Construction process stages
- **A4**: Transport
- **A5**: Construction-installation process

### A4-5: Building life cycle stages
- **A1**: Extract raw materials
- **A2**: Transport to site
- **A3**: Manufacture products
- **A4**: Transport to site
- **A5**: Construct the building
- **A6**: Operation energy use
- **A7**: Operational water use

### A1-3: Building assessment information
- **A1**: Extract raw materials
- **A2**: Transport to site
- **A3**: Manufacture products

### A1-3: Supplementary information
- **A1**: Benefits and loads beyond the system boundary
- **A2**: Reuse-
- **A3**: Recovery-
- **A4**: Recycling-

### A1-3: Additional information
- **A5**: Transport
- **A6**: Operation energy use
- **A7**: Operational water use

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**Note:** The diagram illustrates the stages of the construction process within the building life cycle, emphasizing transport and construction phases.
## A4 - Transport

<table>
<thead>
<tr>
<th>Transport scenario</th>
<th>Km by road</th>
<th>Km by sea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locally manufactured e.g. concrete, aggregate, earth</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>State manufactured e.g. plasterboard, blockwork, insulation</td>
<td>300</td>
<td>-</td>
</tr>
<tr>
<td>Nationally manufactured e.g. timber, carpet</td>
<td>1,500</td>
<td>-</td>
</tr>
<tr>
<td>Globally manufactured.</td>
<td>200</td>
<td>10,000</td>
</tr>
</tbody>
</table>

### Transport Types & kgCO2e/kgkm

<table>
<thead>
<tr>
<th>Transport Types</th>
<th>kgCO2e/kgkm</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorbike</td>
<td>0.001647</td>
<td>Motorbike average</td>
</tr>
<tr>
<td>Van</td>
<td>0.0008115</td>
<td>Vans petrol average</td>
</tr>
<tr>
<td>HGV (rigid)</td>
<td>0.00021334</td>
<td>HGV All rigids average laden</td>
</tr>
<tr>
<td>HGV (articulated)</td>
<td>0.00008525</td>
<td>HGV All artics average laden (Assume for road transport)</td>
</tr>
<tr>
<td>Air Freight</td>
<td>0.00123205</td>
<td>Freight flights international with radiative factors</td>
</tr>
<tr>
<td>Rail</td>
<td>0.00003351</td>
<td>Freight train</td>
</tr>
<tr>
<td>Cargo ship</td>
<td>0.00001614</td>
<td>Container ship Average</td>
</tr>
</tbody>
</table>
A4 - Transport

Reinforced 240mm Thk CSEB wall with earth plaster (Declared unit = 1m²)

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Distance</th>
<th>CO₂e Emission Factor</th>
<th>Total CO₂e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth</td>
<td>365kg x 5km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.39 kgCO₂e</td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>20kg x 150km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.64 kgCO₂e</td>
<td></td>
</tr>
<tr>
<td>Sand for mortar</td>
<td>90kg x 50km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.96 kgCO₂e</td>
<td></td>
</tr>
<tr>
<td>Cement for mortar</td>
<td>15kg x 150km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.48 kgCO₂e</td>
<td></td>
</tr>
<tr>
<td>Reinforcement</td>
<td>6kg x 75km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.10 kgCO₂e</td>
<td></td>
</tr>
<tr>
<td>Earth for plaster</td>
<td>40kg x 5km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.04 kgCO₂e</td>
<td></td>
</tr>
<tr>
<td>Cement for plaster</td>
<td>2kg x 150km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.06 kgCO₂e</td>
<td></td>
</tr>
</tbody>
</table>

A4 Sum = 2.67 kgCO₂e/m² of wall area

Sources and assumptions
- Rigid HGV used for transportation
- Actual distances from manufacturers known

RICA Campus Summary

<table>
<thead>
<tr>
<th>Category</th>
<th>CO₂e (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings</td>
<td>3,848</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>4,861</td>
</tr>
<tr>
<td>Landscape</td>
<td>1,123</td>
</tr>
</tbody>
</table>

A1-A4 Sum = 9,831 tonnes CO₂e
A5 - Construction

Consider electricity, fuel, waste and transportation impacts

<table>
<thead>
<tr>
<th>Activity</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>1.39 kgCO2e/m3</td>
</tr>
</tbody>
</table>
RICA Campus Construction

Buildings = 18,267m² × 20kgCO₂e/m² = 365 tonnes CO₂e
Excavation = 250,000m³ × 1.39kgCO₂e/m³ = 348 tonnes CO₂e

A5 Sum = 712 tonnes CO₂e
B1-7 Use stage

Building assessment information

Building life cycle information

Supplementary information beyond the building life cycle

A1-3 PRODUCT stage
A1 Raw material supply
A2 Transport
A3 Manufacturing

A4-5 CONSTRUCTION PROCESS stage
A4 Transport
A5 Construction-installation process

C1-4 END OF LIFE stage
C1 De-construction-demolition
C2 Transport
C3 Waste processing
C4 Disposal

B1-7 USE stage

B1 Use
B2 Maintenance
B3 Repair
B4 Refurbishment
B5 Replacement

B6 Operational energy use

B7 Operational water use

Extract raw materials
Transport to factory
Manufacture products
Transport to site
Construct the building

Use and maintain the building

Deconstruct the building
Haul away waste materials
Landfill (or recycle)
B1 - Use

Use EPDs if B1 is relevant e.g. GHG from HFC blown insulation
## B5 - Replacement

<table>
<thead>
<tr>
<th>Building element/ component</th>
<th>Expected lifespan (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure and foundations</td>
<td>Service life</td>
</tr>
<tr>
<td>Roof coverings</td>
<td>30</td>
</tr>
<tr>
<td>Internal partitioning and dry lining</td>
<td>30</td>
</tr>
<tr>
<td>Wall renders</td>
<td>30</td>
</tr>
<tr>
<td>Paint</td>
<td>10</td>
</tr>
<tr>
<td>Raised floor finishes</td>
<td>30</td>
</tr>
<tr>
<td>Floor finish layers</td>
<td>10</td>
</tr>
<tr>
<td>Substrate to ceiling finishes</td>
<td>20</td>
</tr>
<tr>
<td>FFE</td>
<td>10</td>
</tr>
<tr>
<td>Mechanical services</td>
<td>20</td>
</tr>
<tr>
<td>Electrical installations</td>
<td>30</td>
</tr>
<tr>
<td>Lighting and communications</td>
<td>15</td>
</tr>
<tr>
<td>Water and disposal installations</td>
<td>25</td>
</tr>
<tr>
<td>Sanitaryware</td>
<td>20</td>
</tr>
<tr>
<td>Lift installation</td>
<td>20</td>
</tr>
<tr>
<td>Opaque cladding</td>
<td>30</td>
</tr>
<tr>
<td>Glazed cladding</td>
<td>35</td>
</tr>
<tr>
<td>Windows and doors</td>
<td>30</td>
</tr>
</tbody>
</table>
Earth plaster replacement (Declared unit = 1m²)

Plaster service life: 11 years
Number of replacements: 60 years/11 years -1 = 4.5, this is rounded up to 5

Earth for plaster = (0.18 [A1-3]+ 0.04 [A4]+ 0.51 [C2]+ 0.52 [C3-4] kgCO₂e) x 5 = 6.25 kgCO₂e
Cement for plaster = (1.60 [A1-3]+ 0.06 [A4]+ 0.03 [C2]+ 0.03 [C3-4] kgCO₂e) x 5 = 8.60 kgCO₂e

B5 Sum = 14.85 kgCO₂e/m² of wall area

Sources and assumptions
Refer to other LCA stages to understand how numbers in calculation were developed
11 years has been used because it doesn’t fit evenly into 60 years for demonstration only

RICA Campus Replacements

Buildings 770 tonnes CO₂e
Infrastructure 6,567 tonnes CO₂e
Landscape 224 tonnes CO₂e

B5 Sum 7,562 tonnes CO₂e
Energy use x carbon intensity of source

Export to grid reported in module D

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Global warming potential, kgCO2e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas</td>
<td>2.26 per m³</td>
</tr>
<tr>
<td>Diesel fuel</td>
<td>3.24 per litre</td>
</tr>
<tr>
<td>Petrol</td>
<td>2.80 per litre</td>
</tr>
<tr>
<td>Coal</td>
<td>2.96 per kg</td>
</tr>
<tr>
<td>Wood logs</td>
<td>67.63 per m³</td>
</tr>
<tr>
<td>Biogas</td>
<td>0.46 per m³</td>
</tr>
<tr>
<td>Wood pellets</td>
<td>0.19 per kg</td>
</tr>
</tbody>
</table>
B6 - Operational

Can consider decarbonisation of grid if there is evidence

Can also be used for other B, C and D modules
RICA Camus Operational Energy
PV Panels meet majority of the need and generator used as back up.

Diesel generator: \(15,000 \text{ kWh/year} \times 60 \text{ years} / 3 \text{ kWh/litre} \times 3.24 \text{ kgCO2e/litre} = 97 \text{ tonnes CO2e}\)

B6 Sum = 97 tonnes CO2e

Sources and assumptions
Generator produces 3 kWh/litre of diesel
Generator energy use is from actual data
# C1-4 End of Life

## Building Assessment Information

<table>
<thead>
<tr>
<th>A1-3</th>
<th>A4-5</th>
<th>B1-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRODUCT stage</td>
<td>CONSTRUCTION PROCESS stage</td>
<td>USE stage</td>
</tr>
<tr>
<td>A1</td>
<td>A4</td>
<td>B1</td>
</tr>
<tr>
<td>A2</td>
<td>A5</td>
<td>B2</td>
</tr>
<tr>
<td>A3</td>
<td></td>
<td>B3</td>
</tr>
</tbody>
</table>

## Building Life Cycle Information

<table>
<thead>
<tr>
<th>Raw material supply</th>
<th>Construction-installation process</th>
<th>Use</th>
<th>Operational energy use</th>
<th>Operational water use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>De-construction demolition</th>
<th>Transport</th>
<th>Waste processing</th>
<th>Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Supplementary Information Beyond the Building Life Cycle

- Benefits and loads beyond the system boundary
- Reuse
- Recovery
- Recycling
C1 - Deconstruction

Generic demolition rate from central London:

3.4 kgCO2e/GFA
C1 - Deconstruction

RICA Camus Deconstruction
Buildings = 18,267m² x 3.4kgCO2e/m² = 62 tonnes CO2e

C1 Sum = 62 tonnes CO2e

Sources and assumptions
Deconstruction of infrastructure is not included because it is assumed this will remain operational and buildings may be replaced
### C2 - Transport

<table>
<thead>
<tr>
<th>End of Life Scenario</th>
<th>Transport distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reuse/ recycling on site</td>
<td>0km</td>
</tr>
<tr>
<td>Reuse/ recycling elsewhere</td>
<td>50km</td>
</tr>
<tr>
<td>Landfill/ incineration</td>
<td>Average between 2 closest landfill/incineration sites</td>
</tr>
</tbody>
</table>
Reinforced 240mm Thk CSEB wall with earth plaster (Declared unit = 1m²)

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Distance</th>
<th>CO₂e Emission Rate</th>
<th>CO₂e Emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth</td>
<td>365kg</td>
<td>5km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.39 kgCO₂e</td>
</tr>
<tr>
<td>Cement</td>
<td>20kg</td>
<td>5km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.02 kgCO₂e</td>
</tr>
<tr>
<td>Sand for mortar</td>
<td>90kg</td>
<td>60km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>1.15 kgCO₂e</td>
</tr>
<tr>
<td>Cement for mortar</td>
<td>15kg</td>
<td>60km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.19 kgCO₂e</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>6kg</td>
<td>5km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.01 kgCO₂e</td>
</tr>
<tr>
<td>Earth for plaster</td>
<td>40kg</td>
<td>60km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.51 kgCO₂e</td>
</tr>
<tr>
<td>Cement for plaster</td>
<td>2kg</td>
<td>60km</td>
<td>0.00021334 kgCO₂e/kgkm</td>
<td>0.03 kgCO₂e</td>
</tr>
</tbody>
</table>

C2 Sum = 2.30 kgCO₂e/m² of wall area

Sources and assumptions
Articulated truck used for transportation
Assumed reinforcement and CSEBs are recycled/reused

RICA Campus Summary

C2 sum 232 tonnes CO₂e
C3-4 - Waste processing and disposal

Use EPDs for C3 if waste is processed before disposal, reuse or recycle

<table>
<thead>
<tr>
<th>Construction waste</th>
<th>kgCO2e/kg waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical to landfill</td>
<td>0.013</td>
</tr>
<tr>
<td>Timber to landfill without gas recovery</td>
<td>2.15</td>
</tr>
<tr>
<td>Timber incinerated</td>
<td>biogenic</td>
</tr>
<tr>
<td>Energy recovery from timber</td>
<td>biogenic (reported in module D)</td>
</tr>
</tbody>
</table>
Reinforced 240mm Thk CSEB wall with earth plaster (Declared unit = 1m2)

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>CO2e/kg (kgCO2e)</th>
<th>Total CO2e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth</td>
<td>365kg</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cement</td>
<td>20kg</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sand for mortar</td>
<td>90kg</td>
<td>0.013</td>
<td>1.17</td>
</tr>
<tr>
<td>Cement for mortar</td>
<td>15kg</td>
<td>0.013</td>
<td>0.20</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>6kg</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Earth for plaster</td>
<td>40kg</td>
<td>0.013</td>
<td>0.52</td>
</tr>
<tr>
<td>Cement for plaster</td>
<td>2kg</td>
<td>0.013</td>
<td>0.03</td>
</tr>
</tbody>
</table>

C3-4 Sum = 1.92 kgCO2e/m2 of wall area

Sources and assumptions:
- Assumed reinforcement and CSEBs are recycled/reused and processed by hand

RICA Campus Summary

C3-4 sum = 191 tonnes CO2e
## D - Benefits and loads beyond system boundary

<table>
<thead>
<tr>
<th>Building life cycle information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A1-3</strong></td>
</tr>
<tr>
<td><strong>PRODUCT stage</strong></td>
</tr>
</tbody>
</table>

**A1** Raw material supply
**A2** Transport
**A3** Manufacturing
**A4** Transport
**A5** Construction-installation process
**B1** Use
**B2** Maintenance
**B3** Repair
**B4** Refurbishment
**B5** Replacement
**B6** Operational energy use
**B7** Operational water use
**C1** De-construction demolition
**C2** Transport
**C3** Waste processing
**C4** Disposal

**Supplementary information beyond the building life cycle**

- **Reuse**
- **Recovery**
- **Recycling**
D - Benefits and loads beyond system boundary

Accounts for all building benefits

- Reuse and recycle
- Biogenic carbon
- Exporting energy
## D - Benefits and loads beyond system boundary

### RICA Campus Sequestration

<table>
<thead>
<tr>
<th>Category</th>
<th>Area (Ha)</th>
<th>CO₂e Emission Rate (kg CO₂e/year)</th>
<th>Duration (years)</th>
<th>Total CO₂e Emission (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmland</td>
<td>128</td>
<td>800</td>
<td>60</td>
<td>6,144</td>
</tr>
<tr>
<td>Savanna Woodland</td>
<td>20</td>
<td>1400</td>
<td>60</td>
<td>1,680</td>
</tr>
<tr>
<td>Silviculture</td>
<td>20</td>
<td>15000</td>
<td>60</td>
<td>18,000</td>
</tr>
<tr>
<td>Other</td>
<td>20</td>
<td>15000</td>
<td>60</td>
<td>27,048</td>
</tr>
<tr>
<td><strong>D Sum</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>52,872</strong></td>
</tr>
</tbody>
</table>
Climate Positive

A-C: 19,000 tCO2e
A-D: - 34,000 tCO2e

12 years
Great. You can do that in Rwanda, but how could you do it in ______________? 

(insert country here)