Managing the Material Supply Chain for the Kigali Housing Sector

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1. COUNTRY-WIDE MATERIAL FLOWS FOR CONSTRUCTION MATERIALS
TYPICAL MATERIAL CONSUMPTION PATTERN DURING A DEVELOPMENT PROCESS

- Agrarian society
- Emerging economy
- Industrial society
- Transforming Society?

- Metals for structural elements, wires, etc.
- Fossil fuels for energy supply
- Construction of buildings, transport, communication and supply/infrastructure
- Minerals for maintenance of infrastructure
- Very basic infrastructure
- Biomass for food, feed
- Biomass for food, feed
- Biomass for food, feed, consumption products, e.g. paper
MATERIAL CONSUMPTION FLOW FOR GERMANY 1990-2010

Material consumption [million tonnes per year]

- Industrial minerals
- Construction minerals
- Metals
- Fossil fuels
- Biomass

Year:
- 1990
- 2000
- 2010
MATERIAL CONSUMPTION FLOW FOR VIETNAM 1990-2010
MATERIAL CONSUMPTION FLOW FOR RWANDA 1990-2010

- **Minimum estimate**
## Material Consumption in Rwanda, Vietnam, Egypt, and Germany, 2010 [Tonnes per Capita]

<table>
<thead>
<tr>
<th>Material</th>
<th>Rwanda</th>
<th>Egypt</th>
<th>Vietnam</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>1.7</td>
<td>1.8</td>
<td>1.8</td>
<td>2.1</td>
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<tr>
<td>Fossil fuels</td>
<td>0.023(^a)</td>
<td>0.82</td>
<td>0.62</td>
<td>4.7</td>
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<tr>
<td>Metals</td>
<td>0.036</td>
<td>0.13</td>
<td>0.12</td>
<td>0.49</td>
</tr>
<tr>
<td>Construction minerals</td>
<td>0.32(^b)</td>
<td>5.2</td>
<td>5.3</td>
<td>6.2</td>
</tr>
<tr>
<td>Industrial minerals</td>
<td>-0.000077</td>
<td>0.0021</td>
<td>0.057</td>
<td>0.32</td>
</tr>
</tbody>
</table>

\(^a\) data for 2009; \(^b\) minimum estimate
CONSUMPTION OF CONSTRUCTION MINERALS (2010)

Tonnes per capita and year

- Rwanda: 0.32
- Vietnam: 5.3
- Germany: 6.2
- China: 11

Source: http://www.materialflows.net
2. **City of Kigali Material and Energy Balance**
THE VISION: KIGALI CONCEPTUAL MASTER PLAN

The Green Financial Hub of Central Africa

- The Premier Financial Hub of Central African Region.
- The Landmark Activity Node of Rwanda.
- The Main Tourist Destination in Kigali City.
- A Sustainable and Green CBD.
CITY OF KIGALI MATERIAL AND ENERGY BALANCE

- Preliminary assessment
- Population: 1.3 million residents
- Water, energy and waste data for 2010
- Construction sector: 30,000 dwelling units per year (50% concrete and 50% bricks)
- Standardized GHG emission factors (need to be tailored to Rwanda conditions)
Construction of 30,000 dwellings per year would account for 40% of the mass flow for solids matter in Kigali, demanding 12% of the energy flow and account for 20% of the GHG emissions.

Potential for improvement:
- use of biomass-based building materials,
- light-weight and high-density building designs,
- optimizing infrastructure.
3. How local and green can and should construction materials be?
Pillar 2: Resource-Efficient Planning, Green Technology and Professionalism

Policy Statement # 7
Building concepts shall adopt energy efficiency building standards, grey and rainwater recovery, and ICT facilitation

- Develop energy efficient building standards
- Establish regulations for grey and rainwater recovery, water treatment, and waste management
- Establish ICT building facilitation
4.8.1 Local construction materials

This policy supports the use of local construction materials. Emphasis should be on an increase of quantity of material produced in Rwanda, its quality, and on competitive costs of locally produced products.

- Competitive costs will be achieved through larger production and high efficiency in production.

- The production of construction materials shall be “green”, considering any energy input required, carbon dioxide output reduction, labor creation, and ensuring no cause of reduction in food production.
PROPOSED INDICATORS FOR LOCAL AND „GREEN‟ CONSTRUCTION MATERIALS

- Cumulative energy demand (CED)
- GHG balance (CO₂-eq)
- Import quota
- Land use competition with food production
- Speed of construction
- Prices
- Other…
4. Case study: cement and sand
IMPORT OF CEMENT INTO RWANDA
ORIGIN OF CEMENT IMPORTS INTO RWANDA, 2014

- Uganda: 81.0%
- Tanzania: 11.6%
- Kenya: 4.7%
- Pakistan: 2.4%
- Others: 0.02%
- Dem. Rep. of the Congo: 0.05%
- United Arab Emirates: 0.3%
- China: 0.03%
CEMENT CONSUMPTION, RWANDA, 2011-2014
CASE STUDY SAND

Sand mining at Mukunguri river, (25 km SW of Kigali)

Cost for 15 m³ truck of sand:
- wages for miners: 15,000 RWF (18 €)
- purchase prices at site: 50,000 RWF (60 €)
- sale price in Kigali: ~300,000 RWF (360 €)

Cost per tonne for 25 km transport:
Kigali/Rwanda: 16,500 RWF (20 €)
Heidelberg/Germany: 4,500 RWF (5.50 €)
ROAD CONDITIONS IMPACT TRANSPORT COSTS

Research questions
- Cost factors for building materials (salaries, taxes, fees, transport, profit)
- Cost cutting options (e.g. infrastructure improvement (roads))
- Price setting mechanisms
5. LIFE-CYCLE ASSESSMENT (LCA) FOR BUILDINGS: STRAWTEC PANELS VS. CONCRETE BLOCKS
LIFE-CYCLE ASSESSMENT (LCA)
LIFE-CYCLE ASSESSMENT (LCA): COMPONENTS

Roof + Walls + Floor = House
**LIFE-CYCLE ASSESSMENT: SYSTEM BOUNDARY**

*House Type A STRAWTEC*
- exterior walls: Strawtec
- columns: -
- foundation slab: concrete

*House Type B CONCRETE*
- exterior walls: concrete hollow blocks
- columns: reinforced concrete
- foundation slab: concrete

*House Type C HYDRAFORM*
- exterior walls: hydraform bricks
- columns: -
- foundation slab: concrete

**Functional Unit: 45 sqm house**

Cradle-to-Gate LCA
## Life-Cycle Assessment: Data

<table>
<thead>
<tr>
<th>Process data</th>
<th>Data source</th>
<th>Reference area</th>
</tr>
</thead>
<tbody>
<tr>
<td>straw &amp; strawtec</td>
<td>Strawtec Group AG**</td>
<td>Rwanda</td>
</tr>
<tr>
<td>paper</td>
<td>ecoinvent 3*</td>
<td>Europe</td>
</tr>
<tr>
<td>glue</td>
<td>ecoinvent 3*</td>
<td>Europe</td>
</tr>
<tr>
<td>concrete</td>
<td>ecoinvent 3*</td>
<td>World</td>
</tr>
<tr>
<td>concrete hollow block</td>
<td>ecoinvent 3*</td>
<td>World</td>
</tr>
<tr>
<td>reinforcing steel</td>
<td>ecoinvent 3*</td>
<td>World</td>
</tr>
<tr>
<td>hydraform</td>
<td>Hydraform**</td>
<td>South Africa</td>
</tr>
<tr>
<td>cement CEM II/A-P 42,5N</td>
<td>ecoinvent 3*</td>
<td>World</td>
</tr>
<tr>
<td>laterite (soil)</td>
<td>ecoinvent 3*</td>
<td>World</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transportation data</th>
<th>km to production site</th>
<th>km to building site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawtec (straw+paper+glue)</td>
<td>(70+13500+14500*)</td>
<td>50</td>
</tr>
<tr>
<td>concrete</td>
<td>*</td>
<td>50</td>
</tr>
<tr>
<td>concrete hollow block</td>
<td>*</td>
<td>50</td>
</tr>
<tr>
<td>reinforcing steel</td>
<td>*</td>
<td>50</td>
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<tr>
<td>cement CEM II/A-P 42,5N</td>
<td>350*</td>
<td>0</td>
</tr>
<tr>
<td>laterite (soil)</td>
<td>0*</td>
<td>0</td>
</tr>
</tbody>
</table>

* Rwanda-specific adjustments planned, ** background data ecoinvent 3
Life-Cycle Assessment: Results

Climate Change Potential

- Phase 5 Transportation of building material to building site
- Phase 4 Production of building material
- Phase 3 Transportation of components to production site
- Phase 2 Production of components
- Phase 1 prechain electricity and heat
Life-Cycle Assessment: Results

Cumulative Energy Demand (fossil)

- Phase 1 prechain electricity and heat
- Phase 2 Production of components
- Phase 3 Transportation of components to production site
- Phase 4 Production of building material
- Phase 5 Transportation of building material to building site

- Strawtec House
- Concrete House
- Hydraform House

GJ per 45 sqm
LIFE-CYCLE ASSESSMENT: RESULTS

Acidification Potential

- Phase 5 Transportation of building material to building site
- Phase 4 Production of building material
- Phase 3 Transportation of components to production site
- Phase 2 Production of components
- Phase 1 prechain electricity and heat

Strawtec House
Concrete House
Hydraform House

kg SO2-Eq per 45 sqm
LIFE-CYCLE ASSESSMENT: RESULTS

Eutrophication Potential

- Strawtec House
- Concrete House
- Hydraform House

Phases:
1. Phase 1: Prechain electricity and heat
2. Phase 2: Production of components
3. Phase 3: Transportation of components to production site
4. Phase 4: Production of building material
5. Phase 5: Transportation of building material to building site

kg PO4-Eq per 45 sqm
LIFE-CYCLE ASSESSMENT: RESULTS

Particulate Matter (PM10)

- Phase 1: Prechain electricity and heat
- Phase 2: Production of components
- Phase 3: Transportation of components to production site
- Phase 4: Production of building material
- Phase 5: Transportation of building material to building site

kg PM10-Eq per 45 sqm
LIFE-CYCLE ASSESSMENT: RESULTS

Land Use

- Strawtec House
- Concrete House
- Hydraform House

Phase 5 Transportation of building material to building site
Phase 4 Production of building material
Phase 3 Transportation of components to production site
Phase 2 Production of components
Phase 1 prechain electricity and heat

m²a per 45 sqm
BUILDING MATERIALS CALCULATOR

Web-based / Excel-based tool to determine the sustainability of buildings
- Allows easy entry of material options for buildings
- Using LCA to quantify impacts
- Qualitative results for other indicators
- Cost data if possible

Construction materials for Rwanda conditions
- Traditional mud & wood houses
- Prefabricated concrete blocks
- Fired brick
- Strawtec
- Can be expanded to other components (windows, plumbing et.)
6. **Conclusions**
1. The construction sector is likely to dominate the material flows in Rwanda in the coming decades.

2. Extraction and production flows for cement, sand/gravel, wood, straw and other materials need to be monitored carefully.

3. Transparent material supply chain data can help identify cost-cutting (choice of materials, logistics etc.).

4. The LCA suggests the significant advantage of bio-based building materials; potential land-use conflict need to be monitored closely.

5. Rwanda needs easy-to-use indicators for local and green construction materials. A Building Materials Calculator can facilitate the sustainability assessment.
Thank You!

[English]

Cảm ơn!

[Vietnamese]

Danke!

[German]

Murakoze!

[Kinyarwanda]

Shukran!

[Arabic]

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