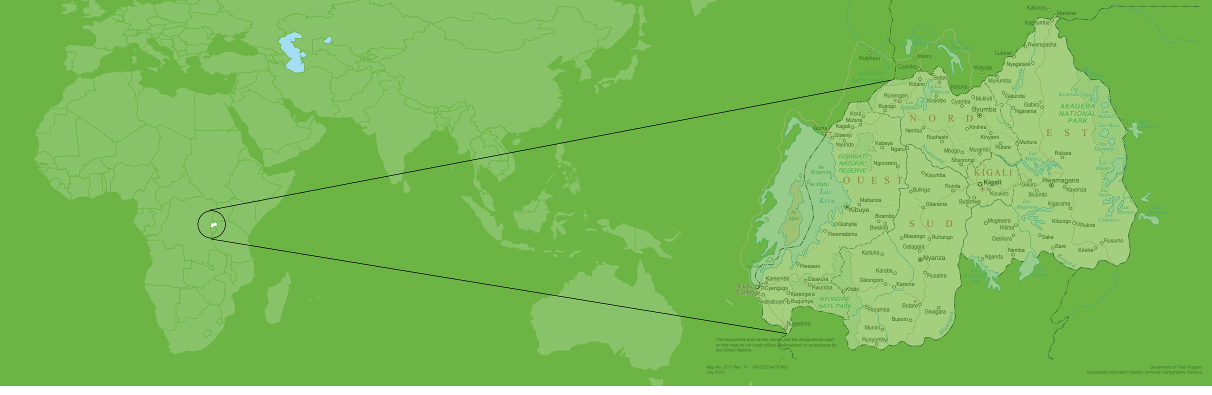
SUPPORTING AFFORDABLE AND GREEN BUILDINGS IN KIGALI/RWANDA



Rwanda's housing challenge

Rwanda's National Housing Policy which was rolled out in March 2015 aims at fast-tracking affordable housing projects and encourages the use of local, green and affordable building materials. Due to the cost of imports and expensive transportation, cement and even sand are more expensive in Rwanda than in Germany.

The manufacturing sector in Rwanda is comparatively small, accounting for 230 billion RWF in 2014 (290 million Euros, 24 Euros per capita) or 5.1 % of Rwanda's gross domestic product (GDP). That is why most building materials are imported and expensive.

Kigali envisions construction of 344,068 new dwelling units (DU) until 2022. The largest segment within the future housing demand is affordable housing with a demand of 186,163 DU (54.11%). The National Housing Policy which was rolled out in March 2015 aims of fast-tracking affordable housing projects and furthermore encourages the use of "local, green and affordable building materials".

Kigali envisions construction of
344,068
new dwelling units until 2022

Green buildings in the Rapid Planning entry project in Kigali

The objective of the *Green Building* component of the EP is to encourage the use of local, green and affordable building materials and sustainable infrastructures (e.g. rain water collection, greywater reuse, erosion control measures etc.) by giving scientific evidence on the environmental impact of building materials and on the potentials options using trans-sectoral synergies for the upgrading of informal settlements or developing new settlements. A life cycle assessment (LCA) is an adequate tool to address the impacts in a comprehensive and transparent fashion.

Building materials and their environmental impacts

The choice of building materials during the upgrading of unplanned settlements has a decisive impact on the mass and energy flows within the four RP sectors.

Traditional adobe

STRAWTEC ® panels

Bricks (traditional, modern)

Cement blocks

Sand from the Mukunguri river wages: 1.5 €/t, transport: 20€/t

Traditional brick burning with wood as fuel

CIMERWA cement plant uses peat as fuel

Impact analysis by building material type

The impacts of exterior wall construction using nine locally available materials were compared and assessed relative to their share of the city-wide flows in 2015. Solid materials flows (mainly by truck) in the city would increase by 8% to 140%, increasing truck transport impacts. Cement-based materials will increase the non-renewable energy demand and associated emissions of greenhouse gases (GWP-100) which can partially be offset by carbon storage from wood and straw. Smaller impacts are seen on water consumption and overall land use.

Table 1. Environmental impact of exterior walls construction for 30,000 dwelling units in Kigali relative to the city-wide flow in 2015

	Solid materials	GDP	Energy (CED) non-renewable	Energy (CED) renewable	GWP-100	Carbon storage	GWP-100 after storage	Water consumption	Land use
	Mg	*mRWF*	*GJ*	*GJ*	*Mg CO_2-eq*	*Mg CO_2-eq*	*Mg CO_2-eq*	*m^3*	*ha *a*
2015 Reference for Kigali	1,000,000	600,000	15,000,000	14,000,000	1,000,000	1,000,000	1,000,000	20,000,000	215,000
Adobe bricks	113%	3.4%	2.0%	0.0%	1.3%	-25.2%	-23.8%	2.1%	2.7%
Cement blocks	66%	5.5%	2.6%	0.1%	4.8%	0.0%	4.8%	5.9%	0.1%
Concrete walls	140%	3.2%	6.0%	0.3%	12.2%	0.0%	12.2%	13.1%	0.2%
Hydraform	133%	2.8%	6.4%	0.4%	14.4%	0.0%	14.4%	5.5%	0.2%
Modulus bricks	51%	7.2%	2.2%	0.2%	4.3%	0.0%	4.3%	3.5%	0.1%
RULIBA bricks	51%	5.5%	3.9%	2.2%	4.4%	0.0%	4.4%	5.9%	0.3%
Modern fired bricks	47%	2.8%	1.5%	5.1%	1.8%	0.0%	1.8%	1.8%	0.3%
STRAWTEC	8%	14%	3.0%	0.2%	2.7%	-11.2%	-8.5%	1.0%	1.2%
Traditional fired brick	55%	6.5%	2.1%	54%	2.5%	0.0%	2.5%	1.2%	12%

A case study of six houses

A house does not consist of exterior walls alone (e.g. metal frames are needed for floors and roofs. Also, different materials are used in combination. In order to provide a more comprehensive analysis, an LCA six representaive building options were compared. For each, a bill of quantity (BOQ) was determined, and the building material calculator was used to provide the life cycle data.

Strawtec
wheat straw
3-storey, 136m²

Dubois
traditional brick
1-storey, 112m²

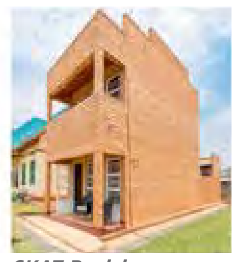
Batsinda I
masonry cement
1-storey, 48m²

Housing options in Kigali

The results of the assessment are presented in Table 1. Despite reliance on metal framing, the Strawtec house is asscociated with the lowest overall climate change impact, if CO_2 fixation is accounted for. The SKAT house, using Strawtec for interior partitioning does not come close, but agricultural land use reflects straw, forest land use is due to construction wood. Cement use (highest in Batsinda II and Vision City) is the driver for the non-renewable energy demand and extraction land use. Freshwater demand does not vary largely.

Batsinda II
cement soil blocks
3-storey, 176m²

Vision City
cement blocks
3-storey, 133m²

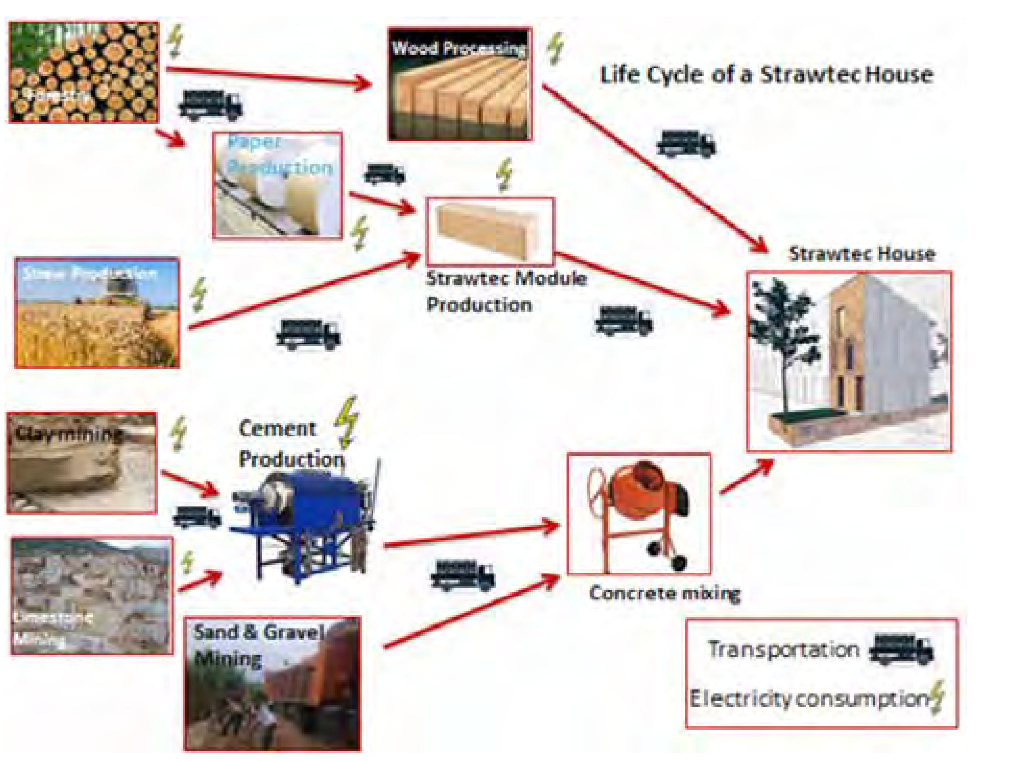


SKAT Rusizi
modern bricks
2-storey, 53m²

Table 2. Life cycle assessment per m2 of net floor space for the six housing options

Indicator	Unit	Strawtec	Dubois	Bastinda I	Bastinda II	Vision City	SKAT Rusizi
GWP-100	kg CO_2 -eq	580	440	590	1,400	1,200	900
CO_2 fixation	kg CO_2 -eq	-450	-80	-170	0	0	-480
CED (renewable)	MJ	13,000	12,000	6,200	690	700	20,000
CED (non-renewable)	MJ	5,900	5,400	2,800	11,000	14,000	9,700
Freshwater use	m^3	15	4.3	6.9	13	14	12
Land use agriculture	m^2 *a	220	0.3	0.22	0.3	0.2	440
Land use forest	m^2 *a	1,200	360	180	14	16	1,500
Land use extraction	m^2 *a	0.5	0.4	0.9	2	2	0.7

Life cycle assessment of a building (example STRAWTEC)



The objective of the Green Building component of the EP is to encourage the use of local, green and affordable building materials and sustainable infrastructures"

Input mask of the building material calculator

An Excel-based building material calculator was devised using Rwanda-specific data for materials along with *ecoinvent* ® version 3 data for imported materials and generic processes.

Support of the Rwanda Green Building Council

Green building rating systems and their indicators were reviewed, including BREEAM (UK), LEED (USA), DGNB (Germany), HE (France), Green Star (South Africa) and BCA Green Mark (Singapore). The BCA system is shown below as an example. The systems address the sectors energy, water, waste water and waste as well as building materials.

Rapid Planning provides ongoing support to MININFRA and the Rwanda Housing Authority. , supporting a science-based selection of Green Building Indicators and a subsequent monitoring scheme.

Training at University of Rwanda (UR)

Training was provided to students at the UR School of Architecture during lectures and workshop since future architects should become familiar with building life-cacle assessment and the Green Building Scheme being adopted in Rwanda.

Conclusion and outlook

The Rapid Planning project was able to provide a transparent and Rwanda-specific tool in support of Rwanda's ambitious goal to provide local, green and affordable buildings to its citizens.

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