Energy in Low Income Tropical Housing

ELITH UGANDA_Faculty of the Built Environment_Uganda Martyrs University

Schedule of Research Scope and Key Directions

About

Worldwide, there is a growing concern on the need to better manage the world's available resources as observed by increasing mobilisation and literature on the subject of sustainability. Buildings and their use have been noted to be a major consumer of energy and materials, that also comes at cost in terms of money. It is estimated that 40% of the world's energy is consumed by buildings, during construction and operation (Dixit et al., 2010; Menzies, 2012). Furthermore, the construction industry is reported to be the largest consumer of raw materials requiring 6 tonnes of material per person per year (Menzies, 2012). It is clear therefore, that the conservation of materials and energy within this sector will go a long way towards improving the management of the planets resources while generally reducing the cost of construction.

The topic of 'energy efficient', 'sustainable' or 'eco' housing has attracted huge interest in the developed world leading to new building design solutions, innovation with materials, publications and revised regulations. However for tropical housing, very little has been done to make them more energy-sustainable. With increasing living standards and explosions in population, the consequences of often-poor design/construction are beginning to strain finite resources.

In this light, the Energy and Low Income Tropical Housing (ELITH) project as a research programme set out to identify, and then begin to propagate methods of reducing the energy consumption (embodied and in operation) of low-income housing while contributing strategies for reducing the cost of construction in Uganda.

The following therefore is an attempt to scope the study succinctly.

Key Statistics on Housing in Uganda:

- Population growth @ 3.2% | Urbanisation @ 5.2%
- 7.3 million Households | 6.2 million housing units | 4.7 persons per household
- Backlog: 710,000 units overall | 900,000 units as a result of substandard housing
- Annual need: 200,000 units = 135,000 Rural and 65,000 Urban

Main causes of the housing deficit in Uganda

1. The cost of providing utilities/infrastructure.
2. Borrowing rates.
3. Cost of building materials.
4. The cost of land.
5. Prohibitive government investment models among others financing and policy issues.
6. The distortion in FOREX.

(Uganda's Ministry of Lands, Housing and Urban Development, 2016)

Research Aims and Objectives

1. To measure embodied energy in materials.
2. To measure operational energy in current low income housing.
3. To improve rural building materials production in Africa (Uganda).
4. To reduce housing embodied energy and costs.
5. To reduce housing - operational (use) energy and costs on building services and appliances.
6. To review and develop passive design strategies in tropical housing.

Identifying housing types and common materilas used in the construtions of housing is a key stage in determining the embodied energy of low income tropical housing.
Housing typologies and the circumstances in which they develop have an effect on the construction material pallette. Identifying housing typologies is a key component of embodied energy calculations

Fig 1, Fig 2: The "Cottage" - Developed as a stand alone home; often occupied by the developer/ householder

Fig 3: Determining bio mass requirement for brick burning

Fig 7: Traditional brick Kiln - Kayabwe, Mpigi District - Uganda

Fig 4: The "Duka" - A mixed retail and residential development often found along roads and commercial arteries

Fig 5: The "Row" house - Developed as multi houshold units for lease.

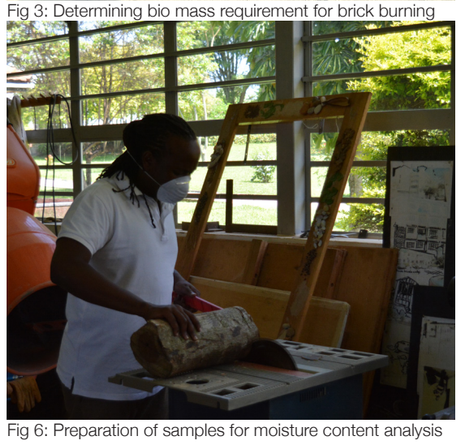

Fig 6: Preparation of samples for moisture content analysis

Implementation Streams		Contextual issues	Strategies/ Initiatives for Implementation	Related Sustainable Development Goal (SDG)	Best practice examples
Education *Scope and Objective* This stream dealt with probing approaches to architectural education as key contributors to sustainable development if they are cognisant of the fact that life long learning is key to dealing with problems today and into the future. As such, this stream interrogated emerging trends and approaches in architectural and design education, how cross-cultural and international exchanges in curricula and collaboration influence teaching and learning and, how methods for enabling students to design sustainable futures can be successful when interspaced with community outreach and design build initiatives. In addition, education's place in probing how national policy and regulatory frameworks have since evolved to link the role of government and governance on the one hand and, academia, finance, investment and community on the other, in developing instruments that promote and facilitate innovation in the built environment is explored. Indeed, a framework and discourse that supports and encourages the realisation of novel ideas is crucial in the education process.	1	Limited discourse.	Support research Create more platforms for discourse Actively seek opportunities to present information across professional boundaries	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	The Standing Conference of Heads of Schools of Architecture (SCHOSA) University of Virginia - Mayira, Lwengo - *Building Tomorrow Academy* University of Notre Dame - *Building tomorrow: A sustainable future starts in the classroom - Whitley Esteban and Professor Aimee P.C. Buccellato* (SFC Kampala, 2012) University of Texas at Austin - *Impact Design: A Sustainable Design Process for Primary Schools in Africa Michael Garrison* (SFC Kampala, 2012)
	2	Fragmented information resources.	Identify and set out to close data gaps Building and linking a database among disciplines and national/ regional actors.	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Regional Centre of Expertise - Greater Masaka (UMU) - Brings together interdisciplinary experts in the region to support community outreach. Mainstreaming education of sustainable development (UMU) - Seeks to analyse how sustainability is advanced in different courses and identify areas for collaboration.
	3	Inadequate pedagogical scope.	Evaluate existing curricula Engage community outreach	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Faculty of the Built Environment (FBE) curriculum Joint Development of Courses for Energy-Efficient, Sustainable Housing in Africa (JENGA) School and Production - A Sustainable Full- Scale Approach in Architecture Education (SCHAP!)
	4	Lack of documentation of local precedents that innovate about: *Key design and construction aspects including* • Foundations • Walling • Roofing • Finishes *Key design and quality environment aspects including* • Day Lighting • Passive Ventilation • Orientation/Shading Systems • Outdoor Space • Efficient and quality combined square metres • Urban agriculture and Gardening • Water Harvesting • Sanitation and Waste Management • Solar - lighting and water heating • Other renewables	Identify good local examples. Associate with local professional/ built environment practices/ institutions.	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	BASE Habitat The Standing Conference of Heads of Schools of Architecture (SCHOSA) Commonwealth Association of Architects (CAA) Royal Institute of British Architects (RIBA)

Fig 8: Eductation - Building material properties

Fig 9: Eductation - Expanding pedagogical scope; alternative use of common building materials

Fig 10: Eductation - Expanding pedagogical scope; rammed earth construction

Fig 10: Eductation - Expanding pedagogical scope; site practice

Implementation Streams	Context: Opportunities	Context: Limitations/ Risks/ Barriers	Action	Strategy | Action | Output: Output
Education *Scope and Objective* This stream dealt with probing approaches to architectural education as key contributors to sustainable development if they are cognisant of the fact that life long learning is key to dealing with problems today and into the future. As such, this stream interrogated emerging trends and approaches in architectural and design education, how cross-cultural and international exchanges in curricula and collaboration influence teaching and learning and, how methods for enabling students to design sustainable futures can be successful when interspaced with community outreach and design build initiatives. In addition, education's place in probing how national policy and regulatory frameworks have since evolved to link the role of government and governance on the one hand and, academia, finance, investment and community on the other, in developing instruments that promote and facilitate innovation in the built environment is explored. Indeed, a framework and discourse that supports and encourages the realisation of novel ideas is crucial in the education process. SUSTAINABLE BUILDING MATERIALS The FoBE Sustainable Materials Toolkit (FoBE SMT) highlights a wide range social, economic and environmental criteria that implementers (developers, designers, building managers etc.) and receivers (users, community, clients etc.) ought to deliberate upon when selecting their building romaterials. Materials choice in the built environment vary according to location and the selection of these materials is conditioned by different aspects - it is therefore the purpose of the FoBE SMT to describe process and parameters for material selection without being prescriptive giving various users the ability to highlight where criteria and weighting differs. The following data sheets present case study materials and the resutlant level 1 weighting grouped under social, economic and environmnetal critria.	Build from existing programmes and collaborations to promote interdisciplinary discourse. Tap into and reinforce existing CPD seminars. Poor quality articles in print media.	Orientations to knowledge for example between social scientists, medical and built environment practitioners. Divergent views. Quality assurance. Variance of commitment among implementors. Poor reading culture. Aversion to subscriptions and/or investment in sources of knowledge.	Augmented research and teaching through key publications, ongoing student research and delivering new courses. Mentored, grown and built a stream of researchers at the FBE. Hosted dissemination seminars. Expanded research collaborations and consultancy to include: • Belgian Technical Corporation - ongoing school (student housing) design. • Building Tomorrow - ongoing community school design. • Haileybury Youth Trust - dissemination/diffusion studies. • Ministry of Energy and Mineral Development - *Developing a road map for energy efficiency.* • Ministry of Energy and Mineral Development - *Reviewing the 2002 National Energy Policy.* • Ministry of Works and Transport - *Developing a Building Code for Uganda.* • A database of interested professionals.	***Surveys/ Reports/ Working Papers/ Publications*** Ndibwami, A., Niwamara, T. Sustainability in buildings: A call in vain or simply a misnomer. (ongoing study) Minutes of meetings, resolutions to date. Proceedings (Presentations, Conclusions and Recommendations) from ELITH Workshop/CPD, April 2015 Kampala, Uganda. ***ELITH Blog - www.elithumu.wordpress.com*** Niwamara, T. Low income housing - Musings Niwamara. T. Did German architect Ernst May invent the 'muzigo.' Ahimbisibwe, A., Ndibwami, A. Is fired brick all we know? Niwamara, T., Ahimbisibwe, A., Ndibwami, A. Time to test yourself Ndibwami, A., Niwamara, T. Diffusion of appropriate building technology in housing in Uganda
	Acknowledge existing reference points and knowledge banks. Exploit open source learning platforms: MIT Opencoursweare: Architecture [https://ocw.mit.edu/courses/architecture/] edX: Architecture [https://www.edx.org/course]	Divergent views. Requires time, funding and skilled personnel.	Taken advantage of remote collaboration utilising knowledge co-construction banks and trending dissemination platforms including: • Dropbox • Google docs • The ELITH blog - www.elithumu.wordpress.com Building a database of local/ traditional/ earth based materials/ technologies in housing in Uganda.	***Surveys/ Reports/ Working Papers/ Publications*** Niwamara, T. Ndibwami, A. Olweny, M. 2015. Popular building techniques and material utilisation in low income tropical housing: A contextual review on Uganda. Tusubira, Y. Building a database of earth based mortars in Uganda. (ongoing study) Building on: Okello, P. A. (2008) *Studying key attributes of common clay brick from selected locations in Uganda*. Masters Thesis. Uganda Martyrs University, Nkozi. ***ELITH Blog - www.elithumu.wordpress.com*** Niwamara, T., Ndibwami, A., Ahimbisibwe, A. Popular building techniques and material utilisation in low income tropical housing: A case for a sustainable materials selection toolkit.
	The Building Control Act The Machakos East African Schools of Architecture Resolution on Environmentally Conscious Design in Curricula The Uganda National Housing Policy The University in a community/ specific context Regional Centre of Expertise - Greater Masaka (UMU)	Conflicting philosophies. Priorities and capacity available. Quality assurance. Prevalent apathy and aloofness. Limited knowledge base.	Ongoing benchmarking. Reinforced/ Improved existing curriculum. Introduced support courses. Ongoing design build to act as a display of good/alternative construction in the community.	***Special Topics/ Elective Courses - 2013-2016/ CPDs / Exhibition*** ENDS 3504/2504_MATERIALS IN USE ENDS 3501/2501_DEMYSTIFYING CONSTRUCTION. LET'S BUILD! ENDS 3362_FIELD EXPERIENCE II ENDS 3144_DESIGN AND CONSTRUCTION TECHNOLOGIES Conclusions and recommendations from ELITH Workshop/CPD, April 2015 Kampala, Uganda. ELITH Exhibition (Planned)
	The Building Control Act The Machakos East African Schools of Architecture Resolution on Environmentally Conscious Design in Curricula The Uganda National Housing Policy The University in a community/ specific context Regional Centre of Expertise - Greater Masaka (UMU)	Conflicting philosophies. Priorities and capacity available. Quality assurance. Prevalent apathy and aloofness. Limited knowledge base.	Applying lessons from a related summer school on two courses: Field Experience II and a design-build module. Expanded research collaborations and consultancy to include: • Belgian Technical Corporation - ongoing school (student housing) design. • Building Tomorrow - ongoing community school design. • Haileybury Youth Trust - dissemination/diffusion studies. • Ministry of Energy and Mineral Development - *Developing a road map for energy efficiency.* • Ministry of Energy and Mineral Development - *Reviewing the 2002 National Energy Policy.* • Ministry of Works and Transport - *Developing a Building Code for Uganda.* • A database of interested professionals.	***Surveys/ Reports/ Working Papers/ Publications*** Niwamara, T., Ndibwami, A. (2016) Adoption of appropriate technology in construction: A pilot study of compressed earth blocks uptake in Kamuli district - Uganda Ndibwami, A., Niwamara, T. Sustainability in buildings: A call in vain or simply a misnomer. (ongoing study) ***Special Topics/ Elective Courses - 2013-2016/ CPDs / Exhibition*** ENDS 3501/2501_DEMYSTIFYING CONSTRUCTION. LET'S BUILD! ENDS 3362_FIELD EXPERIENCE II ELITH Exhibition (Planned)

CRITERIA		SOCIAL					TOTAL
SUB - CRITERIA		Health and safety	Taste and preference		Decentralising resources and power	Enhancement of community/ social relationships	
PARAMETER		Low toxicity	Relevance to local culture	Social/ political acceptability of the project			
MATERIALS	Roofing						
	Clay tile	3	1	4	1	2	11
	Concrete slab	1	1	2	1	1	6
	Steel Sheet	2	1	3	1	2	9
	Thatch	4	4	1	4	4	17
	Walling						
	Fired clay brick	2	3	4	3	3	15
	Fired soil brick	2	3	3	4	4	16
	ISSB	3	2	5	2	2	14
	Mud brick	4	4	2	5	5	20
	Sandcrete Block	1	1	6	1	1	10
	Wattle and daub	4	5	1	6	6	22
	Flooring						
	Cement screed	2	2	2	2	2	10
	Ceramic tiles	2	1	4	1	1	9
	Clay tile	3	2	3	2	2	12
	Concrete screed	1	2	2	2	2	9
	Earth	4	3	1	3	3	14

CRITERIA		ECONOMIC							TOTAL
SUB - CRITERIA				Cost			Job creation for local people	Reduction of money/ foreign exchange outflow	
PARAMETER		Unit (s.m)	Tsptn	Maintenance	Demolition	Disposal			
MATERIALS	Roofing								
	Clay tile	2	1	3	2	3	1	2	14
	Concrete slab	1	3	2	1	1	1	1	10
	Steel Sheet	3	2	3	2	2	1	1	14
	Thatch	4	4	1	3	4	2	2	20
	Walling								
	Fired clay brick	3	2	4	2	2	2	3	18
	Fired soil brick	4	3	3	2	2	2	3	19
	ISSB	2	3	4	2	2	2	2	17
	Mud brick	5	3	2	2	3	3	3	21
	Sandcrete Block	1	1	4	1	1	1	1	10
	Wattle and daub	5	3	1	3	3	3	3	21
	Flooring								
	Cement screed	3	3	2	1	1	1	2	13
	Ceramic tiles	1	1	3	1	1	1	1	9
	Clay tile	2	2	3	1	1	1	3	13
	Concrete screed	3	3	2	1	1	1	2	13
	Earth	4	3	1	2	2	2	4	18

CRITERIA		ENVIRONMENTAL										TOTAL
SUB - CRITERIA		Preservation of environmental quality		Building indoor environmental quality			Preservation of natural resources (wastage)		Life cycle			
PARAMETER		Threat to flaura and fauna	Embodied carbon	Thermal load	Moisture resistance	Acoustic performance		Durability	Recyclability	Re-usability/ Re-purpose	Degradability of demolition waste	
MATERIALS	Roofing											
	Clay tile	3	3	3	2	2	3	4	1	4	3	28
	Concrete slab	1	1	2	3	2	1	3	2	2	1	18
	Steel Sheet	1	2	1	4	1	2	2	3	3	2	21
	Thatch	2	4	4	1	3	4	1	1	1	4	25
	Walling											
	Fired clay brick	1	3	2	5	2	2	3	1	4	2	25
	Fired soil brick	1	3	2	3	2	2	2	3	3	3	24
	ISSB	2	2	3	4	3	3	3	2	3	2	27
	Mud brick	3	4	2	2	2	4	1	3	2	4	27
	Sandcrete Block	2	1	2	5	3	1	3	2	4	1	24
	Wattle and daub	3	4	4	1	1	4	1	4	1	4	27
	Flooring											
	Cement screed	1	2	2	2	2	2	2	2	1	2	18
	Ceramic tiles	2	1	1	4	1	1	2	1	2	1	16
	Clay tile	2	1	3	3	2	3	2	1	2	2	21
	Concrete screed	1	2	2	2	2	2	2	2	1	2	18
	Earth	3	3	4	1	3	4	1	3	3	3	28

Implementation Streams		Contextual issues	Strategies/ Initiatives for Implementation	Related Sustainable Development Goal (SDG)	Best practice examples
Skilling *Scope and Objective* The objective of this steam is to share knowledge about and skills necessary for empowering local communities to thrive on their own. Key issues that have been interrogated include selection of and building with alternative or emerging materials/technologies, that not only reduce the impact of construction on the environment but also could reduce the cost of construction while offering opportunities to grow income bases. In addition, case studies that demonstrate the presence and impact of projects on communities are being presented.	1	Inadequate training	Evaluate existing curricula Identify and co-opt local and regional champions of good practice	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all 4.4 - By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship	Haileybury Youth Trust (HYT) Faculty of the Built Environment (FBE) curriculum Engineering Ministries International (EMI) Studio FH Architects
	2	Lack of documentation of local precedents that innovate about: *Key design and construction aspects including* • Foundations • Walling • Roofing • Finishes	Strengthen artisanal bodies and groupings Promote local peer platforms Create local merit/ certification systems	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all 4.4 - By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship	Mittul Vahanvati, *RMIT University* Rural Housing Resilience in India: Is it Reliant on Appropriate Technology or Labour Skills?
	3	Poor work ethic and Negligence: • Wasteful application of mortar/plasters • Expenses in transportation yet local solutions could be employed • Poor timing and proportions in mixing materials like concrete, mortar, plaster	Develop tools for self audits Promote good practice value systems Promote a culture of accountability Activate the built environment/ architecture appreciation/ criticism platform	12. Ensure sustainable consumption and production patterns 12.5 - By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse 11. Make cities and human settlements inclusive, safe, resilient and sustainable 12. Ensure sustainable consumption and production patterns 13. Take urgent action to combat climate change 13.3 - Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	*Safe boda; My boda* - self audits and appraisal Iain Low,*The Production of Locality: Design Agency as Enabler of Participatory Praxis - The Case of the Training for Self Reliance Project (TSPR)* (SFC Nairobi, 2016) The Nadukupam Vangala Women's Centre in Tamil Nadu by *Architecture For Humanity and the Pitchandikulam Bio-Resource Centre of Auroville, India* 10 x 10 Housing Initiative, Cape Town (South Africa) by *Design Indaba, MMA Architects*

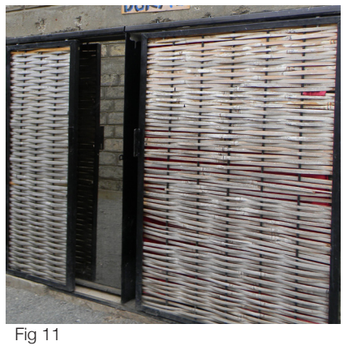
Fig 11

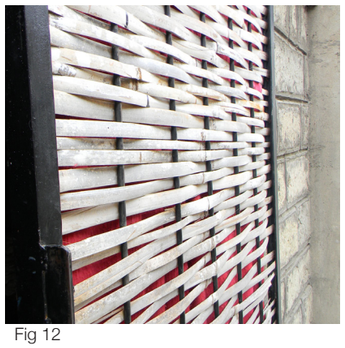
Fig 12


Fig 15


Fig 16


Fig 19


Fig 13


Fig 14


Fig 17


Fig 18

	Context		Strategy | Action | Output
Implementation Streams	**Opportunities**	**Limitations/ Risks/ Barriers**	**Action**	**Output**
Skilling *Scope and Objective* The objective of this steam is to share knowledge about and skills necessary for empowering local communities to thrive on their own. Key issues that have been interrogated include selection of and building with alternative or emerging materials/technologies, that not only reduce the impact of construction on the environment but also could reduce the cost of construction while offering opportunities to grow income bases. In addition, case studies that demonstrate the presence and impact of projects on communities are being presented.	Housing deficit. The Building Control Act The Machakos East African Schools of Architecture Resolution on Environmentally Conscious Design in Curricula The Uganda National Housing Policy The University in a community/ specific context Regional Centre of Expertise - Greater Masaka (UMU) The number of technical institutions in the country. The promotion of entrepreneurship today. Global market trends.	Divergent views and expectations Mismatched scope and state of practice environment. Priorities and capacity available. Quality assurance. Prevalent apathy and aloofness. Limited knowledge base. Attitude toward local/traditional materials/ technologies	Reinforced/ Improved the existing and introduced support courses to the FBE curriculum. Ongoing design build to act as a display of good/alternative construction in the community. Expanded research collaborations and consultancy to include: • Belgian Technical Corporation - ongoing school (student housing) design. • Building Tomorrow - ongoing community school design. • Haileybury Youth Trust - dissemination/diffusion studies. • Ministry of Energy and Mineral Development - *Developing a road map for energy efficiency.* • Ministry of Energy and Mineral Development - *Reviewing the 2002 National Energy Policy.* • Ministry of Works and Transport - *Developing a Building Code for Uganda.* • A database of interested professionals.	***Special Topics/ Elective Courses - 2013-2016/ CPDs / Exhibition*** ENDS 3504/2504_MATERIALS IN USE ENDS 3501/2501_DEMYSTIFYING CONSTRUCTION. LET'S BUILD! ENDS 3362_FIELD EXPERIENCE II ENDS 3144_DESIGN AND CONSTRUCTION TECHNOLOGIES Continuous Professional Development seminars - *Uganda Society of Architects among other Built Environment Professionals* ELITH Exhibition (Planned)
	Housing deficit. The Building Control Act The Machakos East African Schools of Architecture Resolution on Environmentally Conscious Design in Curricula The Uganda National Housing Policy The University in a community/ specific context Regional Centre of Expertise - Greater Masaka (UMU) The number of technical institutions in the country. The promotion of entrepreneurship today. Global market trends.	Divergent views and expectations Mismatched scope and state of practice environment. Priorities and capacity available. Quality assurance. Prevalent apathy and aloofness. Limited knowledge base. Attitude toward local/traditional materials/ technologies	Applying lessons from a related summer school on two courses: Field Experience II and a design-build module. Expanded research collaborations and consultancy to include: • Belgian Technical Corporation - ongoing school (student housing) design. • Building Tomorrow - ongoing community school design. • Haileybury Youth Trust - dissemination/diffusion studies. • Ministry of Energy and Mineral Development - *Developing a road map for energy efficiency.* • Ministry of Energy and Mineral Development - *Reviewing the 2002 National Energy Policy.* • Ministry of Works and Transport - *Developing a Building Code for Uganda.* • A database of interested professionals.	***Surveys/ Reports/ Working Papers/ Publications*** Ndibwami, A., Niwamara, T. Sustainability in buildings: A call in vain or simply a misnomer. (ongoing study) Minutes of meetings, resolutions to date. ***ELITH Blog - www.elithumu.wordpress.com*** Ahimbisibwe, A., Ndibwami, A. Revisiting earth as a viable alternative construction material Niwamara, T., Ndibwami, A., Ahimbisibwe, A. Popular building techniques and material utilisation in low income tropical housing: A case for a sustainable materials selection toolkit. ***Special Topics/ Elective Courses - 2013-2016/ CPDs / Exhibition*** ENDS 3501/2501_DEMYSTIFYING CONSTRUCTION. LET'S BUILD! ENDS 3362_FIELD EXPERIENCE II ELITH Exhibition (Planned)
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Fig 20

Fig 21

Fig 22

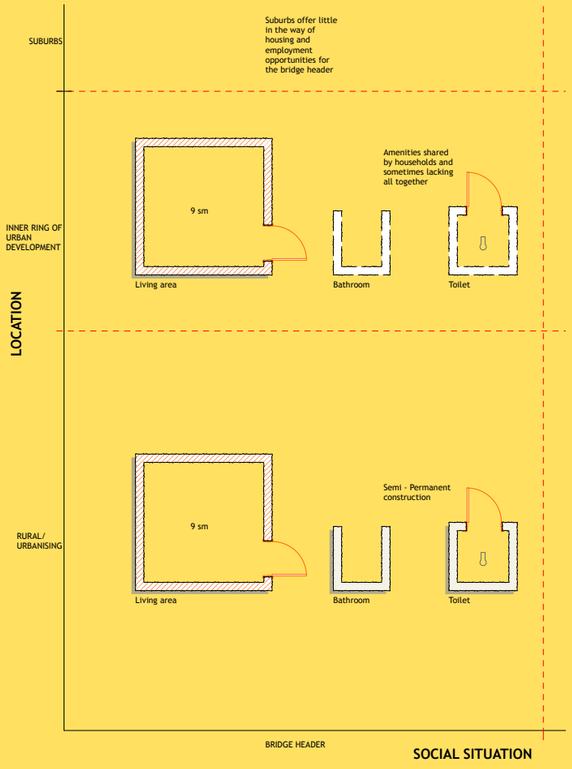
Fig 23

Documentation of existing good practice examples
Fig 11, Fig 12, Fig 13, Fig 14 - Walling
Fig 15, Fig 16, Fig 17, Fig 18 - Roofing and structural details
Fig 19 - Low embodied energy stone foundation clear of concrete
Fig 20 - Skilling professionals
Fig 21, Fig 22, Fig 23 - Appropriate use of local technology

Procurement/Propagation

Scope and Objective

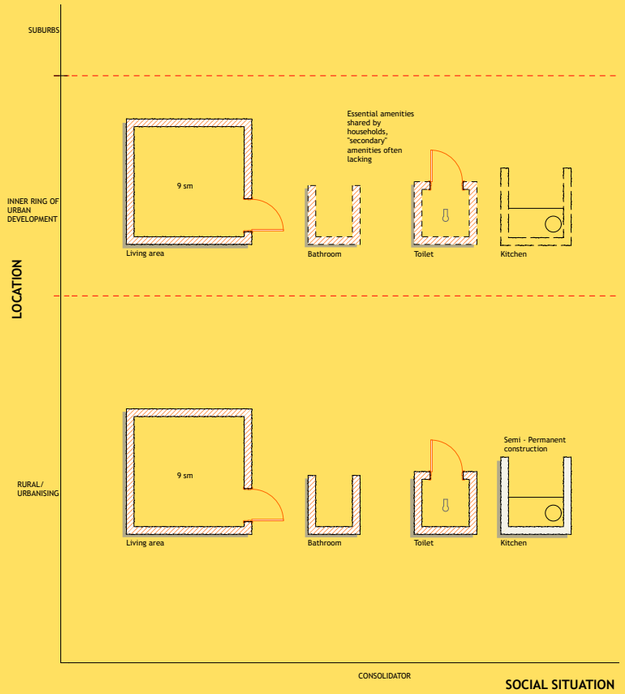
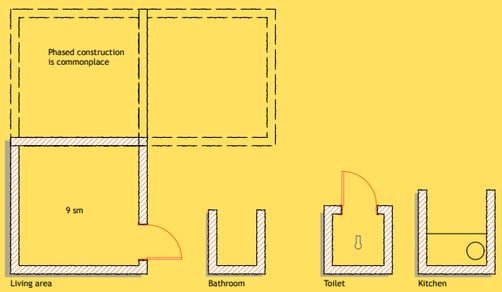
The objective of this stream is to share knowledge about and skills necessary for social or socio-economic engagement in as far as they influence attitudes toward procurement and propagation of materials/ technology. The stream captures best practice examples moving in the direction of participatory and socially-driven planning, informed by key stakeholder engagement, local context and culturally aware processes that empower end users all the while improving the building construction process.



Dwelling environments provide three basic functions: location, tenure and amenity. The level of importance of these in relation to each other is dependant on the level of social economic security achieved. Three social situations (Turner, 1968) are identified which roughly parallel income: the lowest income is the 'bridge header' seeking a toehold in the urban system. The second is the 'consolidator' who has obtained a relatively firm hold but is in danger of losing it unless he can consolidate his newly achieved socio-economic status. The third level is the higher income 'status seeker'. These three can be compared according to their priorities in terms of location, ownership, and amenity, rated according to the level of need.

Increased competition for scarce resources in urban areas leads to a higher level of improvision and restriction in built space.

Implementation Streams		Contextual issues	Strategies/ Initiatives for Implementation	Related Sustainable Development Goal (SDG)	Best practice examples
	1	Fragmented information resources	Identify and set out to close data gaps Establish and build/ reinforce the links among various codes, acts and actors Exploit increasingly abundant ICT platforms	12. Ensure sustainable consumption and production patterns	*EcoSpecifier: Welcome to Ecospecifier South Africa,* www.ecospecifier.co.za *Athena Sustainable Materials Institute,* www.athenasmi.org/ ICE: The home of civil engineering | Institution of Civil Engineers
	2	Lack of documentation of local precedents that innovate about: *Key design and construction aspects including* • Foundations • Walling • Roofing • Finishes *Key design and quality environment aspects including* • Day Lighting • Passive Ventilation • Orientation/Shading Systems • Outdoor Space • Efficient and quality combined square metres • Urban agriculture and Gardening • Water Harvesting • Sanitation and Waste Management • Solar - lighting and water heating • Other renewables	Identify information streams for local precedents Strengthen key professional/ practitioners'/ builders' associations	12. Ensure sustainable consumption and production patterns	S house by Vo Trong Nghia Architects British High Commission, Florence Nightingale Architects
	3	Unregulated practice environment	Probe the state of affairs in the practice environment through research. Invest in formulating building codes	12. Ensure sustainable consumption and production patterns	Examples in developing/ developed nations context
	4	Prohibitive methods/ Institutions	Probe the state of affairs in the practice/ procurement environment through research. Encourage/ Engage in design competitions Attract key collaborations as a model of research, design and build procurement.	12. Ensure sustainable consumption and production patterns	Vastu-Shilpa Foundation, Community-led effort to reconstruct the village of Ludiya
	5	Counterfeit products	Promote labelling and certification - products/ supply chain actors	12. Ensure sustainable consumption and production patterns	*EcoSpecifier: Welcome to Ecospecifier South Africa,* www.ecospecifier.co.za *Athena Sustainable Materials Institute,* www.athenasmi.org/
	6	Liberalised market - hinders local production	Promote local materials	12. Ensure sustainable consumption and production patterns	Good fiscal policies around the world

	Context		Strategy | Action | Output
Implementation Streams	**Opportunities**	**Limitations/ Risks/ Barriers**	**Action**	**Output**
Procurement/Propagation *Scope and Objective* The objective of this stream is to share knowledge about and skills necessary for social or socio-economic engagement in as far as they influence attitudes toward procurement and propagation of materials/ technology. The stream captures best practice examples moving in the direction of participatory and socially-driven planning, informed by key stakeholder engagement, local context and culturally aware processes that empower end users all the while improving the building construction process.  **SOCIAL SITUATION**  The minimum requirement for status seekers represents the minimum standard for appropriate housing keeping in mind the need for future	Acknowledge existing reference points and knowledge banks. Exploit open source learning platforms: MIT Opencourseware: Architecture [https://ocw.mit.edu/courses/architecture/] edX: Architecture [https://www.edx.org/course]	Divergent views. Requires time, funding and skilled personnel.	Taken advantage of remote collaboration utilising knowledge co-construction banks and trending dissemination platforms including: • Dropbox • Google docs • The ELITH blog - www.elithumu.wordpress.com Building a database of local/ traditional/ earth based materials/ technologies in housing in Uganda. Probed basis for material selection.	***Surveys/ Reports/ Working Papers/ Publications*** Tusubira, Y. Building a database of earth based mortars in Uganda. (ongoing study) Building on: Okello, P. A. (2008) *Studying key attributes of common clay brick from selected locations in Uganda*. Masters Thesis. Uganda Martyrs University, Nkozi. Niwamara, T., Ndibwami, A., Ahimbisibwe, A. Popular building techniques and material utilisation in low income tropical housing: A case for a sustainable materials selection toolkit. ***ELITH Blog - www.elithumu.wordpress.com*** Niwamara, T., Ndibwami, A., Ahimbisibwe, A. Popular building techniques and material utilisation in low income tropical housing: A case for a sustainable materials selection toolkit.
	Housing deficit. The Building Control Act The Machakos East African Schools of Architecture Resolution on Environmentally Conscious Design in Curricula The Uganda National Housing Policy The University in a community/ specific context Regional Centre of Expertise - Greater Masaka (UMU) The number of technical institutions in the country. The promotion of entrepreneurship today. Global market trends.	Conflicting philosophies. Priorities and capacity available. Quality assurance. Prevalent apathy and aloofness. Limited knowledge base.	Applying lessons from a related summer school on two courses: Field Experience II and a design-build module. Expanded research collaborations and consultancy to include: • Belgian Technical Corporation - ongoing school (student housing) design. • Building Tomorrow - ongoing community school design. • Haileybury Youth Trust - dissemination/diffusion studies. • Ministry of Energy and Mineral Development - *Developing a road map for energy efficiency.* • Ministry of Energy and Mineral Development - *Reviewing the 2002 National Energy Policy.* • Ministry of Works and Transport - *Developing a Building Code for Uganda.* • A database of interested professionals.	***Surveys/ Reports/ Working Papers/ Publications*** Ndibwami, A., Niwamara, T. Sustainability in buildings: A call in vain or simply a misnomer. (ongoing study) Minutes of meetings, resolutions to date. ***ELITH Blog - www.elithumu.wordpress.com*** Ahimbisibwe, A., Ndibwami, A. Revisiting earth as a viable alternative construction material Niwamara, T., Ndibwami, A., Ahimbisibwe, A. Popular building techniques and material utilisation in low income tropical housing: A case for a sustainable materials selection toolkit. ***Special Topics/ Elective Courses - 2013-2016/ CPDs / Exhibition*** ENDS 3501/2501_DEMYSTIFYING CONSTRUCTION. LET'S BUILD! ENDS 3362_FIELD EXPERIENCE II ELITH Exhibition (Planned)
	Housing deficit. The Building Control Act The Machakos East African Schools of Architecture Resolution on Environmentally Conscious Design in Curricula The Uganda National Housing Policy The University in a community/ specific context Regional Centre of Expertise - Greater Masaka (UMU) The number of technical institutions in the country. The promotion of entrepreneurship today. Global market trends.	Divergent views and expectations Mismatched scope and state of practice environment. Priorities and capacity available. Quality assurance. Prevalent apathy and aloofness. Limited knowledge base. Attitude toward local/traditional materials/ technologies	Examined building and materials procurement Expanded research collaborations and consultancy to include key policy/ regulatory players: • Ministry of Energy and Mineral Development - *Developing a road map for energy efficiency.* • Ministry of Energy and Mineral Development - *Reviewing the 2002 National Energy Policy.* • Ministry of Works and Transport - *Developing a Building Code for Uganda.*	***Surveys/ Reports/ Working Papers/ Publications*** Niwamara, T., Olweny, M., Ndibwami, A., 2016. Embodied energy of low income rural housing in Uganda. PLEA2016 Los Angeles - Cities, Buildings, People: Towards Regenerative Environments, 11-13 July, 2016 ***ELITH Blog - www.elithumu.wordpress.com*** Niwamara, T., Ndibwami, A. (2016) Adoption of appropriate technology in construction: A pilot study of compressed earth blocks uptake in Kamuli district - Uganda Ahimbisibwe, A., Ndibwami, A. Building and Materials: Waste less, gain more, check the ecological footprint Niwamara, T. Ndibwami, A. A tripartite approach to dealing with embodied energy in housing. Niwamara, T. Embodied energy and carbon - the tip of the iceberg
	Housing deficit. The Building Control Act The Machakos East African Schools of Architecture Resolution on Environmentally Conscious Design in Curricula The Uganda National Housing Policy The University in a community/ specific context Regional Centre of Expertise - Greater Masaka (UMU) The number of technical institutions in the country. The promotion of entrepreneurship today. Global market trends.	Divergent views and expectations Mismatched scope and state of practice environment. Priorities and capacity available. Quality assurance. Prevalent apathy and aloofness. Limited knowledge base. Attitude toward local/traditional materials/ technologies	Examined building and materials procurement Expanded research collaborations and consultancy to include: • Belgian Technical Corporation - ongoing school (student housing) design. • Building Tomorrow - ongoing community school design. • Haileybury Youth Trust - dissemination/diffusion studies. • Ministry of Energy and Mineral Development - *Developing a road map for energy efficiency.* • Ministry of Energy and Mineral Development - *Reviewing the 2002 National Energy Policy.* • Ministry of Works and Transport - *Developing a Building Code for Uganda.* • A database of interested professionals.	***Ditto***
	Emerging smart technologies/ applications Building Control Act.	Political/ Market forces	Ditto	***Ditto***
	Housing deficit. The Building Control Act The Machakos East African Schools of Architecture Resolution on Environmentally Conscious Design in Curricula The Uganda National Housing Policy The University in a community/ specific context Regional Centre of Expertise - Greater Masaka (UMU) The number of technical institutions in the country. The promotion of entrepreneurship today. Global market trends.	Divergent views and expectations Mismatched scope and state of practice environment. Priorities and capacity available. Quality assurance. Prevalent apathy and aloofness. Limited knowledge base. Attitude toward local/traditional materials/ technologies	Ditto	***Ditto***

Implementation Streams		Contextual issues	Strategies/ Initiatives for Implementation	Related Sustainable Development Goal (SDG)	Best practice examples
Resource Efficiency *Scope and Objective* The objective of this stream is to share knowledge about and skills necessary for promoting responsible use of and access to resources for building construction. Key issues that have been probed include the causes and implications of un/poorly planned development in especially fast urbanising sub saharan nations and concomitant high cost of building construction and energy emissions. The intended impact is the improvement of the quality of housing, reduction of the cost of housing and mitigation of the effects of climate change.	1	Unregulated practice environment	Protection of woodlots Support material production units Improve kiln efficiency and thermal sealing	11. Make cities and human settlements inclusive, safe, resilient and sustainable 12. Ensure sustainable consumption and production patterns 13. Take urgent action to combat climate change 13.3 - Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	Good fiscal policies around the world
	2	Lack of documentation of local precedents that innovate about: *Key design and construction aspects including* • Foundations • Walling • Roofing • Finishes *Key design and quality environment aspects including* • Day Lighting • Passive Ventilation • Orientation/Shading Systems • Outdoor Space • Efficient and quality combined square metres • Urban agriculture and Gardening • Water Harvesting • Sanitation and Waste Management • Solar - lighting and water heating • Other renewables	Identify and catalogue local precedents/ best practice examples	11. Make cities and human settlements inclusive, safe, resilient and sustainable 12. Ensure sustainable consumption and production patterns 13. Take urgent action to combat climate change 13.3 - Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	Susanne Gampfer - Nairobi skills Centre Francis Kere - Schools in Gando
	3	Poor work ethic and Negligence: • Wasteful application of mortar/plasters • Expenses in transportation yet local solutions could be employed • Poor timing and proportions in mixing materials like concrete, mortar, plaster	Develop tools for audits Inadequate targeted incentivisation Identify and catalogue local precedents/ best practice examples	11. Make cities and human settlements inclusive, safe, resilient and sustainable 12. Ensure sustainable consumption and production patterns 13. Take urgent action to combat climate change 13.3 - Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	May (Ghana), Huang, Hao, Du Zhang. 1132, 1302, 1395 *Developing a Community-Driven Modern Vernacular,* Justin Twinere, Rwanda Village Enterprise *Minimising Materials Wastage at the Construction Stage of a Project Through the Implementation of Lean Construction,* Kofi Agyekum, College of Architecture and Planning, Department of Building Technology - Kwame Nkrumah University of Science and Technology.

Fig 24

Fig 25

Fig 26

Fig 27

Fig 28

Fig 29

Fig 30

Resource efficiency
Fig 24 - Excavation and collection from source
Fig 25 - Material refinement
Fig 26 - Material processing/ Onsite material management
Fig 27 - Compact material sourcing, production and management accrues embodied energy and financial savings
Fig 28 - Planning for services leads to efficient construction and minimises wastage
Fig 29 - Onsite management minimises wastage; offcuts are stored and utilised as necessary
Fig 30 - All waste can be reused and/ or recycled

		Context		Strategy | Action | Output
Implementation Streams	**Opportunities**	**Limitations/ Risks/ Barriers**	**Action**	**Output**
Resource Efficiency *Scope and Objective* The objective of this stream is to share knowledge about and skills necessary for promoting responsible use of and access to resources for building construction. Key issues that have been probed include the causes and implications of un/poorly planned development in especially fast urbanising sub saharan nations and concomitant high cost of building construction and energy emissions. The intended impact is the improvement of the quality of housing, reduction of the cost of housing and mitigation of the effects of climate change.	Proximity of informal material production units. Look to the agricultural or Industrial waste for fuel options. Reduce over reliance on wood fuel/ energy intensive materials. Increasing number of engineered production processes.	Divergent views and expectations Mismatched scope and state of practice environment. Priorities and capacity available. Quality assurance. Prevalent apathy and aloofness. Limited knowledge base. Attitude toward local/traditional materials/ technologies	Examined building and materials procurement Expanded research collaborations and consultancy to include key policy/ regulatory players: • Ministry of Energy and Mineral Development - *Developing a road map for energy efficiency.* • Ministry of Energy and Mineral Development - *Reviewing the 2002 National Energy Policy.* • Ministry of Works and Transport - *Developing a Building Code for Uganda.*	***Surveys/ Reports/ Working Papers/ Publications*** Niwamara, T., Olweny, M., Ndibwami, A., 2016. Embodied energy of low income rural housing in Uganda. PLEA2016 Los Angeles - Cities, Buildings, People: Towards Regenerative Environments, 11-13 July, 2016 ***ELITH Blog - www.elithumu.wordpress.com*** Niwamara, T., Ndibwami, A. (2016) Adoption of appropriate technology in construction: A pilot study of compressed earth blocks uptake in Kamuli district - Uganda Ahimbisibwe, A., Ndibwami, A. Building and Materials: Waste less, gain more, check the ecological footprint Niwamara, T. Ndibwami, A. A tripartite approach to dealing with embodied energy in housing. Niwamara, T. Embodied energy and carbon - the tip of the iceberg
	Proximity of informal material production units. Look to the agricultural or Industrial waste for fuel options. Reduce over reliance on wood fuel/ energy intensive materials. Increasing number of engineered production processes.	Divergent views and expectations Mismatched scope and state of practice environment. Priorities and capacity available. Quality assurance. Prevalent apathy and aloofness. Limited knowledge base. Attitude toward local/traditional materials/ technologies	Examined building and materials procurement Expanded research collaborations and consultancy to include: • Belgian Technical Corporation - ongoing school (student housing) design. • Building Tomorrow - ongoing community school design. • Haileybury Youth Trust - dissemination/diffusion studies. • Ministry of Energy and Mineral Development - *Developing a road map for energy efficiency.* • Ministry of Energy and Mineral Development - *Reviewing the 2002 National Energy Policy.* • Ministry of Works and Transport - *Developing a Building Code for Uganda.* • A database of interested professionals.	***Surveys/ Reports/ Working Papers/ Publications*** Niwamara, T., Olweny, M., Ndibwami, A., 2016. Embodied energy of low income rural housing in Uganda. PLEA2016 Los Angeles - Cities, Buildings, People: Towards Regenerative Environments, 11-13 July, 2016 Minutes of meetings, resolutions to date. ***ELITH Blog - www.elithumu.wordpress.com*** Niwamara, T., Ndibwami, A. (2016) Adoption of appropriate technology in construction: A pilot study of compressed earth blocks uptake in Kamuli district - Uganda Ahimbisibwe, A., Ndibwami, A. Building and Materials: Waste less, gain more, check the ecological footprint Niwamara, T. Ndibwami, A. A tripartite approach to dealing with embodied energy in housing. Niwamara, T. Embodied energy and carbon - the tip of the iceberg
	Proximity of informal material production units. Look to the agricultural or Industrial waste for fuel options. Reduce over reliance on wood fuel/ energy intensive materials. Increasing number of engineered production processes.	Divergent views and expectations Mismatched scope and state of practice environment. Priorities and capacity available. Quality assurance. Prevalent apathy and aloofness. Limited knowledge base. Attitude toward local/traditional materials/ technologies	Registered the state of affairs through community surveys. Developed and constantly improving tools for peer/self evaluation. Presented the benefits of good practice. Unpacking familiar concepts - wood fuel use, bases for selection of wall materials and aspirations. Engaging key policy and regulatory stakeholders.	***Surveys/ Reports/ Working Papers/ Publications*** Niwamara, T., Olweny, M., Ndibwami, A., 2016. Embodied energy of low income rural housing in Uganda. PLEA2016 Los Angeles - Cities, Buildings, People: Towards Regenerative Environments, 11-13 July, 2016 ***ELITH Blog - www.elithumu.wordpress.com*** Niwamara, T., Ndibwami, A. (2016) Adoption of appropriate technology in construction: A pilot study of compressed earth blocks uptake in Kamuli district - Uganda Ahimbisibwe, A., Ndibwami, A. Building and Materials: Waste less, gain more, check the ecological footprint Niwamara, T. Ndibwami, A. A tripartite approach to dealing with embodied energy in housing. Niwamara, T. Embodied energy and carbon - the tip of the iceberg

DESIGN AND CONSTRUCTION STRATEGIES

Housing is an aspirational construct across social statuses. Key to the provison of diverse solutions is acknowledging that while construction/ building can be improved in terms of cost and embodied energy, it needs to deal with its site and socio-cultural issues; and this can happen in the context of design, procurement options and construction approach.

CONSIDERATIONS		PRE-CONSTRUCTION		DESIGN/CONSTRUCTION OPTIONS	POST-CONSTRUCTION			
		EMBODIED ENERGY	COSTS		OPERATIONAL ENERGY	SAVINGS	GAINS	RISKS/ GAPS
Siting								
The stream is concerned with issues of locating and laying out a building in its environment.	Site use/ Site planning Building configuration Lanscaping				Energy for cooling	Materials	Green space/ Outdoor living Quality of life	
Fenestrations								
The purpose of this unit is to present design considerations in the disposition of windows and exterior openings.						Energy for cooling	Day lighting	
Efficient square metres								
Appropriate space planning aims to provide maximum housing benefit from limited resources while dealing with aspirational concerns within fair limits.	Form Space					Materials	Volume of space and associated envionment benefits.	
Transition spaces								
This stream identifies opportunities presented by adjacencies of spatial functions.	Outdoor transitions Indoor transitions				Energy for cooling		Outdoor living Privacy Privacy	
Materials								
Building materials constitute more than half of the cost of low income housing. This stream prsents various issues for considerationin material deployment.	Raw material sourcing					Cost reduction	Environmental protection Job creation for local people Reduction of money/ foreighn exchange outflow	
	Transportation		CEB - 0 Kj SCEB - 25.3 Kj/ km/ s.m Brick - 268 Kj/ km/ s.m (stretcher bond)					CEB requires weather cover and periodic maintenance. SCEB requires high level of quality assurance at the production phase for benefits to be meaningful. Block making equipment is costly but the costs can be brought down depending on procurement options as part of mass housing or community partnerships. Country brick is readily available in many locations and yet Is associated with consumption of considerable ammounts of bio mass at the production phase.
	Unit (s.m)		CEB - 28 units/ s.m (stretcher bond) ISSB - 34 units/ s.m Brick - 52 units/ s.m (stretcher bond)