International Journal of Technoscience and Development (IJTD)

Vol 1, Issue 1, 2014, ISSN 2001-2837

CONTENT

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An Object Based Geographical Information Systems for Transportation (GIS-T) Data Model for Road Maintenance in Uganda

Mazzi Lydia Kayondo-Ndandiko[1], Gerhard Bax[2] and Sandy Stevens Tickodri Togboa[3]

[1] Lecturer College of Engineering, Design, Art & Technology, Makerere University, P. O. Box 7062, Kampala, Uganda.
Corresponding author e-mail: Lndandiko@gmail.com; mklydia@tech.mak.ac.ug; lmk@bth.se
[2] Professor, Blekinge Institute of Technology, P.O. Box 214, S-374 24, Karlshamn, Sweden
[3]Professor, College of Engineering, Design, Art & Technology, Makerere University, P. O. Box 7062, Kampala, Uganda.

ABSTRACT
This paper presents an object based Geographical Information Systems for Transportation (GIS-T) data model for road maintenance in Uganda. It is part of research aimed at accentuating the use of Geographical Information Technologies for road maintenance. Specifically, the study aimed at defining a GIS-T data model for road maintenance based on the data requirements in the sector as a process towards establishing standards for geographical datasets. This was accomplished through identification of road maintenance data requirements, review of organisational reports, workshop proceedings, organisational terms of reference for various projects, understanding and consideration of the Information Quality Levels (IQL) and a review of existing data models and standards in transportation. This resulted into a conceptual and logical data model for road maintenance based on concepts of dynamic segmentation and linear referencing. The study concludes that understanding of the transportation network of the country is essential to adoption of the proposed model. The choice of the GIS software for the physical model implementation with a full set of dynamic segmentation tools is fundamental.

Key words: GIS-T, Data model, Road maintenance, Uganda

1.0 INTRODUCTION

The maintenance of a country's transport network is pivotal to the overall infrastructural development of that nation. In Uganda however, there are several cases of poor transport services caused by the bad state of roads. Uganda, geographic coordinates of 1^0 00' N and 32^0 00' E is located in Eastern Africa, in the west of Kenya, south of Southern Sudan and in the east if the Democratic Republic of Congo. Road maintenance in that pearl of Arica has since proved ad hoc until recently when the need for preventive maintenance is being appreciated and plans of making it a priority are in place. As the road features are geographically located, the use of Geographical Information Technologies (GITs) in collecting, managing and analysing road condition is paramount. And yet, these technologies are underutilized in the road maintenance sector. GITs are specialised Information and Communications Technologies (ICT) that are useful in collecting, managing and analysing Geographical Information (GI) for decision-making purposes. Despite the tremendous advances in GITs, the country has not fully institutionalised these technologies. These technologies include but are not limited to Geographical Information Systems (GIS), Remote Sensing (RS) and Global Positioning Systems (GPS). GIS are powerful computer-based tools for integrating and analyzing spatial data from multiple sources. GPSs are accurate worldwide navigational and surveying facilities based on the reception of signals from approximately 24 orbiting satellites which were placed into the orbit by the U.S. Department of Defense in the 1970s (Mintsis and Basbas, et al 2004). RS is the acquisition of information about an object or phenomenon without making physical contact with it. It is the detecting of the earth's surface from satellites and airplanes by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects (Ehrensperger and Wymannvon et al 2007). There are various initiatives in which the above technologies have been used to collect and manage data for road maintenance decision support in Uganda. However, these initiatives have either ended prematurely or their expectations have not been realised. Examples of these projects include the Management Information System (MIS) that was intended to assist the District, Urban and

Community access road authorities in the management of the roads in their jurisdictions. Kampala City Council, now Kampala City Council Authority (KCCA), in 2003 housed a capacity building project where GIS was used to collect and manage relevant information on Kampala city roads. This project also ended prematurely. And yet there has not been research on ground that is investigating the challenges faced by the use of these technologies.

This paper is part of research aimed at accentuating the use of GITs for Road Infrastructure Maintenance (RIM) in Uganda. The study accessed the gaps and limitations to GIT initiatives for road maintenance and developed a methodological framework for enhancing the use of GITs in RIM. One of the limitations earmarked was the absence of standards for geographical datasets. Data standards are considered to come by easy from models of the entire structure of required data. The scope of this paper is presentation of a model for the structure of road maintenance data. This model was developed basing on the principles of dynamic segmentation and linear referencing.

2.0 METHODS

The following methods were adapted in the above study. Identification of the road maintenance data requirements was mainly through document and datasets review, observations and interviews. Interviews were also conducted to generate an in depth understanding of the processes of decision making for road maintenance. A broad picture of the data requirements involved was obtained. This was combined with reviews of organisational reports, workshop proceedings, organisational terms of reference for various projects, etc. An understanding and consideration of the Information Quality Levels (IQL) data categories was made. IQL correlate to the degree of sophistication required for decision-making and the methods for collecting and processing the data (Bennett and Chamorro et al 2007). This entailed generating knowledge of the various data views at the different levels of decision-making. Also, a review of existing data models and standards in transportation was made. Reference is made to Kayondo and Bax et al (2011). This was linked to an assessment of the existing data models within road maintenance organisations in the sector. The different data structures, attributes of the road as the transportation feature of interest, etc. were analysed. Field visits and observations were cyclically conducted. Lastly, in a workshop attended by personnel from the organisations in road maintenance, aspects of the proposed data model were presented and discussed. This harmonised position led to the conceptual and logical data models presented herein. In these developed models, the concepts of dynamic segmentation and location referencing are emphasized.

2.1 Dynamic Segmentation

Dynamic Segmentation is the process of computing the location of events along a linear feature, the road in this case. As documented by Kennedy and Shalaby et al (2000), the usefulness of the road maintenance data can be greatly enhanced by applying a segmentation procedure to produce uniform and consistent sections. Butler and Dueker (1998) comment and advise accordingly "Individual agencies can use whatever methods they desire to segment and attribute highways and other transportation features. However, such customized approaches preclude easy data sharing with other potential users. The first step in facilitating data sharing is to adopt a uniform way of identifying maintenance required transport facilities. To do this, user needs of the participating organisations need to be translated into a data model as a first step to reach consensus on the database design and data sharing standards". Dynamic segmentation has been earmarked as effective in highlighting these consistent segments. It is a way of referencing linear attribute data on demand, based on a variable segmentation of a single network. The dynamic segmentation process imposes two requirements on the data; 1: Each event in an event table must include a unique identifier and position along a linear feature and 2: Each linear feature must have a unique identifier and measurement system.

2.2 Location Referencing

The road condition data necessary for road maintenance decision-making should refer to specific points or sections of the road. Reference to these points and sections is a prerequisite for planning strategies to undertake maintenance. Since roads and geographically placed, geographical reference to these locations is paramount. Equally important and fundamental is the geographical location of the entire road in consideration within the jurisdiction context. Bennett and Solminihac, 2006 maintain

that location referencing is the singularly most important consideration in conducting a survey. They argue that unless the data are properly referenced, they will be of limited use in making management decisions. This makes location referencing a very important aspect of road maintenance systems. It enables the user to, precisely locate an object along the road and correctly reference the objects to each other in the database (HTC, 2002). There are majorly two ways of locating location of features on the road network; linear and spatial location referencing.

2.2.1 Linear Referencing

The linear referencing system of a road is the foundation to the location and analysis of events on the road network. It locates information on a linear feature using a single relative position on the feature by giving an address consisting of a distance and direction from a known point location. It is the process of identifying location(s) on a network or specific link in a network by specifying a start position, direction and distance (Smith and Harkey et al 2001). Various linear referencing methods exist, for example, location can be given in terms of kilometre point method (measured from the start of the road), kilometre post method (measures from a physical km post) reference point method (distance from known physical reference object along the road), reference post method (distance from well-established reference stations) and the link node method. The link node method is a special implementation of the generic referencing system. The nodes refer to specific logical locations on the roads and the links are logical sections between the nodes. It is a special application of the reference point method where permanent features e.g. bridges, intersections, road junctions, etc. are given node numbers.

2.2.2 Spatial Referencing

Under spatial referencing, the position of reference points and sections on the road is expressed in terms of a set of spatial coordinates. There are tremendous advances in GITs that necessitate the collection and use of spatial data for decision making. GPS data is commonly used to spatially reference roads and other linear networks objects. Dynamically linking the spatial and linear reference methods should therefore become essential in the road information system. Even though many of the road condition attributes require a position that can be spatially referenced, the basic rule for GPS referencing is that only those data that are most suited to spatial referencing should be spatially referenced (HTC, 2002). In principle, spatial referencing should not take over linear referencing! The two-dimension coordinates are hard to obtain and hard to match the maps (Zhu and Jiang, 2009), and since the transportation network is linear, attribute information is stored on some road sections and points, so one-dimension linear reference system is suffice to be adopted as the method of reference to this attribute information. Spatial referencing is generally required for: reference stations and other key referencing features, the road centreline, off road objects, such as signs, which cannot be referenced using displacements and offsets (HTC, 2002) and other emergent road features that may need to be communicated for ease of location either as reports of critical road condition (like very big potholes) or as events during the implementation of road maintenance works. These however also need linear locational reference as a complement.

3.0 RESULTS

3.1 CONCEPTUAL DATA MODEL

The success of GIS is highly dependent on information structure analysis and conceptual data modelling (Demirel, 2002). In reality, there are numerous views that result into conceptual models. Figure 1 shows the levels of data modelling, and points to the several views from which a conceptual data model can be taken. The choice of which presentation to use at this stage depends on what data is being modelled, the modeller and in other circumstances, the audience.

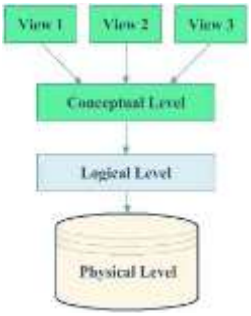

Figure 1: Levels of Data Modelling
Source: Elmasri and Navathe (2007

The view taken in this research is presented using an Entity Relationship Diagram (ERD). Figure 2 shows the proposed conceptual data model for road maintenance in Uganda. Basically, three groups of entities are modelled. The road's network, the point and line events that exist on it. Clearly from the figure these three entities are distinguished.

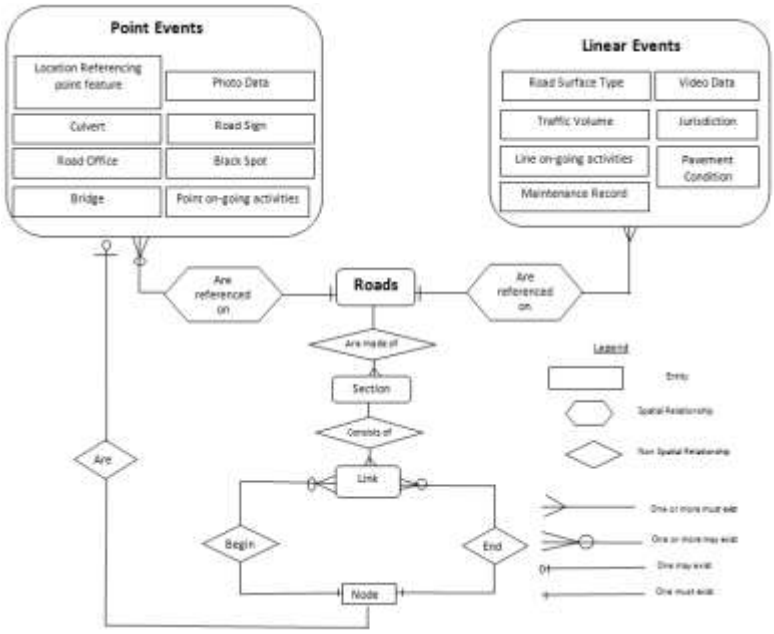

Figure 1: Conceptual Data Model - Entity Relationship Diagram
Source: adapted from Niaraki et al., (2009)

3.2 LOGICAL DATA MODEL

The object relational data model was selected for the logical data model. This was intended to balance between the combined advantages of the concepts of objects and methods from the object oriented model and those from relations of the entity relationship models. The relational data model has superiority in effecting standard queries using the standard query language (SQL). Additionally, it accommodates database versioning, is secure, widespread and mature on the market. Object oriented modelling on the other hand allows for the generation of complex objects with user defined data types based on defined business rules. With an object oriented database, the amount of data in the GIS database is quite large compared with others systems. This is envisaged to make the system performance low. The design of a combined object relational data model to benefit from the relational database technology that is available across a variety of platforms was fundamental. Furthermore, object oriented data modelling offers advantages of enhanced abstraction concepts, simplicity in interfacing with other data sources and providing solutions for generalised problems. Within the object relational data model, complex data structures can be stored using the concepts of entity relationships in relational data models. In effect, the model is strong in performing queries of complex structured

data. These model types are quite handy in GIS because of their searching capabilities, multi user support and handling complex data. Since majority of the existing databases in the study area were relational, and yet object oriented data modelling possess superior advantages of providing solutions to identified problem areas, a hybrid object relational data model was considered for the sector. It has enhanced spatial query opportunities that can be easily performed since the complex objects are stored in tables each with their object identifiers.

ESRI provides data model templates for use, extension and adoption to various systems. Its ArcGIS software provides the capability for logical data models in UML to be directly transferred into an object relational model named Geodatabase using CASE tools. Besides logically documenting the various classes from the conceptual data model, the ESRI provided template for logical data modelling was used. Figure 3 shows the proposed logical data model for the sector[1].

The model was based on 5 business rules guided by the mandate and objectives of the organisations involved in road maintenance. These rules include;

1. Emphasis of the model is on the events that occur on the transportation system. The geographic datum, links and nodes that form the base network are only inferred.
2. The point and linear events on the road as the transportation feature are located using a linear location referencing system based on a cumulative distance offset, referred to as chainage, from the beginning point of the road section.
3. Only one linear referencing system is used to relate point and linear events to the road.
4. All events must be related to the road; i.e., exist on, at, or adjacent to the road.
5. Because of the complexity in implementing Many to many (*...*) relationships, they have been avoided in the model

The multiplicity in the model is explained in table 1.

Table 1: Multiplicity Explained

Indicator	Meaning
0..1	Zero or one
1	One only
0..*	Zero or more
1..*	One or more

[1] Even though developed from the ESRI provided UNETRANS data model template as acknowledged in the paper, this proposed model is generic and can be adapted by any GIS vendor with dynamic segmentation capabilities.

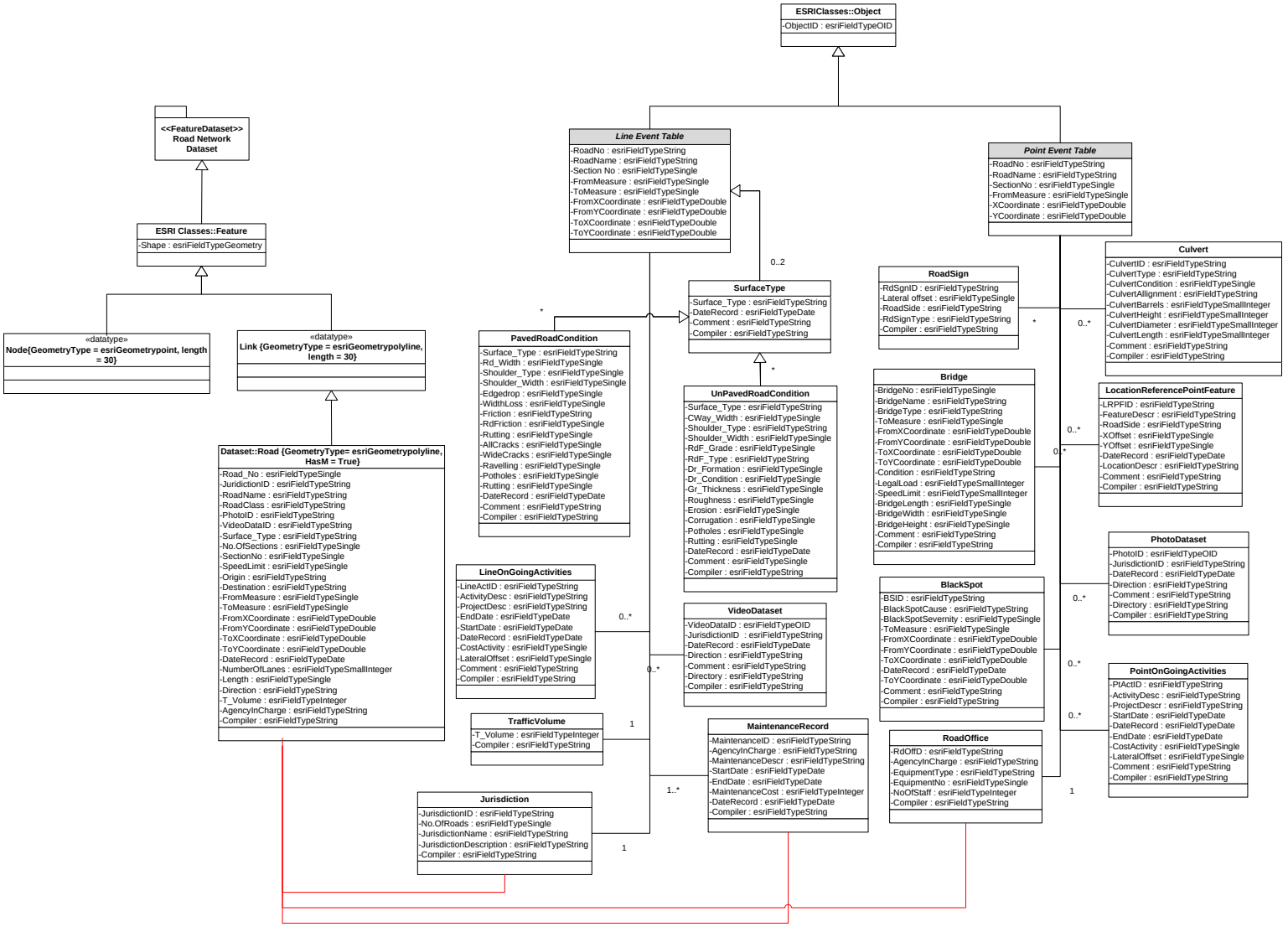

Figure 3: The Proposed Logical Data Model

From the logical model, we identify with a total of 17 classes namely; Road, Jurisdiction, MaintenanceRecord, Line On Going Activities, Unpaved Road Condition, Paved Road condition, Traffic Volume, Bridge, Culvert, Photo dataset, Video dataset, Road Surface Type, Road Sign, Black Spot, Road Office, point On Going Activities and location Reference Point Feature. The road is the route class of the model on which the linear and point event objects are located. The MaintenanceRecord, Road office and Jurisdiction are referenced directly to the road. The Unpaved and Paved road condition classes are subclasses of the Road Surface Type. Each of the classes has a couple of named attributes with assigned data types.

4.0 IMPLEMENTATION OF THE PHYSICAL DATA MODEL

A common understanding of the transportation system in Uganda is the backbone to using this proposed model. An explicit definition and documentation of the anchor points and sections that define the road network of the country is fundamental. These should be inclusive in the location referencing points feature dataset. This requires uniform and agreed mechanisms of defining road sections. Dueker and Butler (1999) propose the use of either pavement type, functional type, jurisdiction, and intersections to define logical sections so as to create discrete transportation features according to some business interest. Specific locations for the beginning and ending point measures for linear objects should be assigned and documented accordingly.

The ability to access and use tools that can manage and query linearly referenced data in GIS is quite critical especially now, as the use of GIS in transportation (GIS-T) agencies is being advocated for. A GIS platform that supports dynamic segmentation will be ideal. Not all GIS have the capability to perform analyses based on dynamic segmentation. The choice of the GIS platform should take this into consideration. Most users with ArcView, Geomedia and other desktop GIS software do not have access to the full set of dynamic segmentation tools (Sutton and Wyman, 2000). However, ESRI's ArcGIS and Intergraph have dynamic segmentation data models in their software.

5.0 CONCLUSIONS

The purpose of the developed model is to aid spatial analysis for decision making in road maintenance operations. It is the linear referencing system that allows dynamic segmentation capabilities to be implemented on the road network. Linear referencing and dynamic segmentation together provide the user with the ability to perform spatial analysis. The existence of a GIS-T data model is a drive to enhancing the use of GITs in road maintenance. It is a step towards standardising datasets for the sector. However, before assuming the proposed model, an in depth assessment of the software to adopt is a requirement.

6.0 ACKNOWLEDGEMENTS

The authors would like to acknowledge the organisations under which the research was accomplished. The study was sponsored by Sida, Sweden for whom we are indebted. The administration, staff and colleagues from the academic institutions of Blekinge Institute of Technology, BTH, Karlsahmn Campus, Sweden, and Makerere University, Uganda are similarly acknowledged for the good administration, guidance and comradeship during the research undertaking.

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An assessment of the usage and the improvement of interlocking stabilized soil block technology - A case of northern Uganda

Ejem Noel Owino[1], Peter Okidi Lating[2], Henry Alinaitwe[3]

[1]Formerly Masters student, College of Engineering, Design, Art & Technology, Makerere University, P. O. Box 7062, Kampala, Uganda
[2]Lecturer, College of Engineering, Design, Art & Technology, Makerere University, P. O. Box 7062, Kampala, Uganda. Corresponding author e-mail. plating@tech.mak.ac.ug
[3]Associate Professor, College of Engineering, Design, Art & Technology, Makerere University, P. O. Box 7062, Kampala, Uganda

ABSTRACT

Northern Uganda is recovering from civil wars which have left communities without adequate housing. Attempts to introduce Interlocking stabilized soil blocks (ISSB) provide low cost housing haven't been very successful. The main purpose of the study was to find ways of encouraging use of ISSB. The study was both an experimental study and a survey. Tests were done on soil and block samples from projects selected from the region in the districts of Gulu, Amuru, Pader, Kole, Lira and Oyam. Questionnaires were also given to Engineers, Technicians and craftsmen from the same study location and data collected were analyzed using the Statistical Package for Social Sciences (SPSS) to test, rank and correlate them.

Tests on soil samples and block samples indicated that they are of generally acceptable quality and strength however, water absorption was generally high. Low incomes and low durability of the blocks were found to be the greatest barriers, whereas the greatest enablers are the fast speed of erection, and environmental friendliness. It is recommended that: UNBS commission ISSB standards; government provides more funding; policies are developed that promote the use of ISSBs: and more research is done on the durability of the ISSBs.

Keywords: *Factors; Adoption; Interlocking stabilized soil blocks; Appropriate Technology; Northern Uganda.*

1.0 INTRODUCTION

1.1 Background

According to the Uganda Bureau of Statistics (2006), 80% of housing in the rural areas is of temporary wall whereas nationally it is 70%. In Northern Uganda insurgencies displaced more than 1.8 million people into internally displaced persons camps for more than a decade (SPRING, 2010). Interlocking Stabilized Soil Block (ISSB) technology, an appropriate technology, was one of the methods introduced to help build houses to resettle the people. In June 2009, government of Uganda handed over several new Hydraform block making machines to 40 Northern Ugandan districts (Hydraform, 2009).

Interlocking means that the blocks/bricks are manufactured with special protrusions, dents and holes (Picture 1), that allows them to bond in wall construction without the use of mortar in construction.

Picture 1: Interlocking block work bonding

In 2009 in Uganda, with funding from the United Nations International Children's Education Fund (UNICEF), implemented a resettlement project to facilitate the sustainable return and re-integration (UN-HABITAT, 2009). The technology uses environmentally-friendly building materials and construction techniques that are more affordable to the poor while still meeting rigorous building standards. Similarly, the PRDP program, has distributed ISSB making machines to several districts in Northern Uganda for the construction of model houses to show case for the use of ISSB.

"Although these machines [hydraform] were meant to help the various vulnerable communities to afford reasonable housing at a low cost, it was noted that there was no evidence of work done using the machines …" (Office of the Auditor General, 2009). Even where attempts were made to construct low cost houses, it has been reported that some contractors carried out shoddy work. This increased the costs of supervision in the district …, while in some cases the works had to be demolished as was the case with the Staff House Construction at Aber Health Centre II in Aber Sub-County, (Northern Uganda Data Centre, 2010).

1.2 Problem Statement

Attempts to introduce the use of Interlocking Stabilized Soil Blocks (ISSBs), an appropriate technology in Northern Uganda, under the PRDP, has not yielded the expected outcomes in some of the districts like Oyam, Lira and Kole. In some districts like Oyam, ISSB technology is characterized by very low usage. Furthermore, projects that have been completed in the area do not seem to measure well with established standards and works accomplished in other areas. There has also been no attempt to analyze the reasons as to why the technology is not being easily adopted by the communities in this region.

1.3 Objectives

The general objective of this research was to establish ways of improving the use of ISSB technology in northern Uganda. The specific objectives of this research were to characterize current local materials and practices in ISSB technology in northern Uganda in comparison with standards and the machine manufacturers' recommendations and to assess the factors affecting adoption of ISSB technology.

1.4 Hypothesis

The hypotheses to study the characteristics of soil and block properties are summarized in the table below.

Table 1: Summary of Hypotheses

Property	Null Hypotheses	Alternate Hypotheses	Standard/ Recommendation
Clay content of soil	H_o: x > 30%	H_1: x ≤ 30%	Less than 30%
Plasticity index of soil	H_o: x ≠ 20%	H_1: x=20%	Average of 20%
Compressive strength of block	H_o: x < 2.5N/mm^2	H_1: x ≥ 2.5N/mm^2	At least 2.5N/mm^2
Dry density of block	H_o: x < 1600Kg/m^3	H_1: x ≥ 1600Kg/m^3	At least 1600Kg/m^3
Water absorption of block	H_o: x > 15%	H_1: x ≤ 15%	Not more Than 15%

2.0 METHODOLOGY

The research was quantitative and involved the use of both laboratory tests on soil and block samples and questionnaires that were given to engineers, technicians and craftsmen. The study was carried out in the districts of Gulu, Amuru, Pader, Kole, Lira and Oyam. Due to the large geographical area, purposive sampling was carried out in order to collect block and soil samples, and to distribute questionnaires. Soil samples used in the manufacture of blocks were taken from ten selected sites in the Northern Uganda sub-region. A minimum of five (5) block samples were also collected from each of the 10 project sites visited and taken to the laboratory in Gulu for tests. The number of five block samples is the minimum requirement for compressive strength testing (UNBS draft standard No. FDUS849). Tests on the soil samples were carried out according to methods for testing civil engineering soil (British Standards Institution, 1990) whereas for the blocks were according to Uganda National Bureau of standards methods (UNBS, 2009)

The reliability of factor ratings for the questionnaire was tested using Cronbrach's α Coefficient of Agreement which is a component within SPSS package. This provides a range from 0 to 1.0 which is used to determine how reliable the responses were with 0 being unreliable and 1.0 being reliable as the extremes of the continuum. Reliability of laboratory experiments on the other hand, was checked using t-tests and z-tests at 95% level of confidence for testing the hypotheses. Quantitative data gathered from the study were summarized and analyzed using Statistical Package for Social Scientists-(SPSS 12). One sample t-tests and z-tests were carried out on the results of the findings to test the research hypotheses.

The t-test was used for results with samples less than 30 whose population mean and standard deviation were unknown.

Where x: sample mean, μ: population mean, s: standard deviation, n: number of samples & df: degrees of freedom. For tests with more than 30 samples, z-tests were used

Where x: sample mean, μ: population mean, s: standard deviation & n: number of samples.

3.0 RESULTS

Table 2: Summary of Statistical Tests on Laboratory Tests

Property/ Test Statistic	Results			Hypotheses	Standard/Desired
Clay content of soil (t-Test)	x=24.40% n =10	μ =30% d.f = 9	s =2.91% t = -6.078	H_o: x > 30% H_1: x ≤ 30%	Less than 30% (Davis, 2003 & Ewan, 2003)
Plasticity index of soil (t-test)	x =19.70% n =10	μ =20% d.f = 9	s =5.85% t = ±0.162	H_o: x ≠ 20% H_1: x=20%	Average of 20% (Walker, 1995)
Compressive strength of blocks (z-Test)	x =3.586 N/mm^2 n =50	μ =2.5 N/mm^2 z = 6.19	s =1.24 N/mm^2	H_o: x < 2.5N/mm2 H_1: x ≥ 2.5N/mm2	At least 2.5N/mm^2 (UNBS, 2009)
Dry density of block (z- Test)	x =1787kg/ m^3 n =50	μ=1600 kg/m^3 z = 7.64	s =172.98 kg/m^3	H_o: x < 1600Kg/m3 H_1: x ≥ 1600Kg/m3	At least 1600Kg/m^3 (UNBS, 2009)
Water absorption of block (t-Test)	x=18.58% n =25	μ=15% d.f= 24	s = 4.63% t = 3.866	H_o: x > 15% H_1: x ≤ 15%	Not more Than 15% (UNBS, 2009)

3.1 Questionnaire

A total of 60 questionnaires were given to respondents and were returned giving an overall response rate of 88.33%. Responses from the questionnaires were analyzed using SPSS 12. To test the consistency of the ratings, a null hypothesis H_o was set as "there was no significant agreement among the respondents on the rating of factors". The alternative hypothesis H_1 was set as "there was agreement among the respondents on the rating of factors". The analysis aimed at establishing that the ratings had not been arrived at by chance but rather that there was true agreement in the ratings and therefore the results are reliable. To test the hypothesis, non-parametric tests using Cronbrach's α Coefficient of Agreement was used (Salkind, 2008). The null hypothesis was rejected since the Cronbrach's α Coefficient was 0.711 which shows that the results were reliable according to ratings by George & Mallery (2003).

3.2 Factors Affecting the Adoption of ISSB Technology

Findings on factors affecting the adoption of ISSB technology through questionnaires is shown in Table 4.7. The results were analyzed through SPSS and the factors were ranked using a five (5) point Likert scale with one (1) as barrier, three (3) as the neutral or no effect and five (5) as the enabler. The mean ratings, standard deviations and correlations were then determined as perceived by persons that have been actively involved in using this technology. Rankings of the factors according to their mean ratings are summarized in Table 4.7.

Bivariate correlation analysis was also performed on the mean ratings and standard deviations of the barriers and enablers shown in Table 4.10. The correlation analysis indicated significance for most of the factors at levels of 0.05 and 0.01 respectively.

From Table 4.8 it is seen that the speed of erection (C9) with mean rating of 4.40 is the greatest enabler. The next in ranking is the strength of blocks (C2) with a rating of 3.91. On the other end of the continuum as a barrier is income of users (C6) with a mean rating of 1.53. It is the greatest barrier followed by awareness (C7) with a mean rating of 1.70

Table 3: Ratings for Factors in the Questionnaire

Code	Factors	Mean	Std. Deviation
C9	Speed of erection	4.40	0.72
C2	Strength of blocks	3.91	0.97
C10	Suitability of soils	3.30	1.05
C1	Standardization of technology	2.98	0.99
C8	Design of buildings	2.81	0.62
C4	Skills and workmanship	2.62	0.88
C5	Tools and equipment	2.55	1.05
C3	Durability of blocks	2.45	1.19
C7	Awareness	1.70	0.58
C6	Incomes of users	1.53	1.03

Test t- statistics

The t-test was carried out on the significance of the ratings with the test value being set as 3 because the rating scale was form 1 to 5 with 3 as a neutral position. The two tailed test for level of significance shows that all the factors have a value less than 0.05 except for standardization of the technology, therefore ratings are significant. Also the 95% interval of difference shows that all factors have both the upper and lower limits either below or above zero except for standardization of technology meaning that they are all significant.

Table 4: Results of t-Tests Analysis

	Test Value = 3					
	t	d.f	Sig.(2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
1. Standardization of technology	-0.139	52	.890	-.019	-.29	.25
2. Strength of blocks	6.825	52	.000	.906	.64	1.17
3. Durability of blocks	-3.359	52	.001	-.547	-.87	-.22
4. Skills and workmanship	-3.115	52	.003	-.377	-.62	-.13
5. Tools and equipment	-3.145	52	.003	-.453	-.74	-.16
6. Incomes of users	-10.398	52	.000	-1.472	-1.76	-1.19
7. Awareness	-16.494	52	.000	-1.302	-1.46	-1.14
8. Design of buildings	-2.209	52	.032	-.189	-.36	-.02
9. Speed of erection	14.191	52	.000	1.396	1.20	1.59
10. Suitability of soils	2.096	52	.041	.30189	.0129	.5909

Correlation analysis was also done on the factors identified and some of the factors showed significant correlation at 0.05 level (two tailed) while others showed significance at 0.01 level (two tailed).

4.0 DISCUSSION

4.1 Laboratory tests

4.1.1 Silt and clay Content

ISSB technology is designed to use earth which is typically a sandy clay or lateritic soil, stabilized with between 5-7% cement (Browne, 2009). Montgomery (2002) observed that more cement is needed to counter the effect of high fines contents that result in high expansion. For contents of clay higher than 30% lime is recommended as a binder (Browne, 2009). Actually the best soils are those with sand contents of between 60-70% (Ewan, 2003). The silt and clay content in soils that were tested contained less than 30% of silt and clay [Fines] which is acceptable. In cases where the silt and clay content is high, sand is added to improve its grading other than using more cement.

4.1.2 Plasticity Index

Plasticity index (PI) of the clay soil is usually in the range of 15 to 25. However, according to Walker (1995), the best earth soils for stabilization are those with low plasticity index below 20%. He also adds that they are not suitable for manual compaction. Due to the variation in PI therefore, it's important to first of all, test soils in order to decide whether to use the manual machine or diesel operated one, and to establish whether or not to modify the soil grading as a way of improving the PI.

4.1.3 Compressive Strength

Tests on block samples indicated that they had average compressive strength of 3.58 N/mm^2. The draft UNBS standard FDUS849 (UNBS, 2009) that is based on the Kenya standard KS 02 -1070:1993P (KEBS, 1993) specifies a value of 2.5N/mm^2. This is in agreement with studies that strength of blocks is generally acceptable (Browne, 2009; Kerali, 2001). Also a typical internal cavity wall load-bearing block in the UK is manufactured to a compressive strength of 3.5 N/mm^2 (Browne, 2009). This result therefore means the block strength is acceptable.

4.1.4 Dry Density

Results of tests carried out on block samples indicated a mean strength of 1,787Kg/m^3which is higher than the allowable standard of 1,600 Kg/m^3 (FDUS 849). Since Montgomery (2002) classifies dry densities between 1900 and 2000 kg/m^3 as excellent, it may still be necessary to raise this property to 1,800 Kg/m^3.

4.1.5 Water Absorption

Water absorption of blocks is one of the indicators that can be used to determine its durability. Specifications by UNBS give a maximum value of 15%. Findings indicated an average of 18.78% which is high and unfavorable. Generally un-rendered low-cement (<6%) and low-density (<1800kg/m^3) ISSB exhibit an unacceptably low tolerance to humid conditions and will deteriorate during less than10 years (Montgomery, 2002). This could explain the low durability and it's also recommended that they should not be used in the foundations.

4.2 Questionnaire Results

4.2.1 Factors Affecting the Adoption of ISSB Technology

Speed of Erection
This was ranked as the greatest enabler with a mean of 4.40. Due to the interlocking mechanism of the blocks, wall construction is much easier and quicker (UN-HABITAT, 2009). This is achieved through mortar-less construction by dry stacking of blocks. In addition to the speedy construction process, the block production process is also generally shorter unlike clay bricks where the clay has got to be mixed large amounts of water and heaped into mounds and weathered for days. However, fast speed of erection can only be possible when all the resources needed for construction are ready including roof construction and covering to protect the blocks from rainfall.

Strength of Blocks
Strength of blocks came in second as an enabler and laboratory tests on samples from most sites showed compressive strengths over 2.5N/mm^2 the minimum recommended by UNBS. Browne (2009) states that block strength should not be an issue as studies have generally yielded adequate strength of ISSB blocks. However, strength of the blocks is very dependent on the quality of materials used and workmanship. Although this is acceptable, as noted already, this strength may be acceptable as per draft standard of UNBS but may need to be raised to 3.5 N/mm^2.

Suitability of Soils
The suitability of soil came third with a mean rating of 3.30 which makes it an enabler. Parameters that were used in the laboratory experiments to determine soil suitability included silt & clay content and the plasticity. Silt and clay content was less than 30% recommended by Browne (2009). The plasticity index however varied from the recommended average of 20%. On the whole however, the soils were generally suitable. This implies that soil is not transported from far off borrow pits, no need to use lime (binder) that is not commonly found and for variations in silt and clay contents only sand can be added to improve the grading.

Standardization of Technology
This factor got a neutral position rating of 2.98; however there are important benefits that come with standardization of technology which can only be appreciated after long term use of the technology. These include: setting and enforcing the correct minimum standards; using accurate machines since mortar is not used and the buildings only depend on the shape and dimensions of the block. From the observations on the different blocks made by different machines, some had deeper interlock depressions than others. This factor can either undermine overall wall strength or improve it since the tolerance of the blocks determines how tightly they fit (UNBS, 2009).

Design of Buildings
Design of buildings also got a near to neutral rating of 2.81, however, in spite of the fact that most of the buildings to be made are simple in nature, its design plays a key role in strength and durability. Firstly, ISSBs are very prone to weather therefore larger roof overhangs protect the walls form rain and secondly length of straight walls is normally limited 4.5m. This also improves its stability especially when cross walls are introduced (Nasley *et al*, 2009). Therefore design features on a building go a long way in making it an enabler for adoption.

Tools and Equipment

Observations made on construction sites visited indicated that most of the works were being done with very few tools most of which were very basic. The assumption they seem to make is that these blocks are so precise that as long as the first course is level and plumbed, it's just a matter of piling subsequent courses on top. This however is not the case as the tools recommended by most machine manufacturers like Hydraform include dumpy levels and spirit levels up to 1.5m long.

Durability of Blocks

Browne (2009), Ewan (2003) and Kerali (2001) all agree that blocks made out of stabilized earth are generally not very durable. Generally, low-cement (<6%) and low-density (<1800kg/m³) ISSBs with un-rendered surfaces exhibit an unacceptably low tolerance to humid conditions and will deteriorate during less than 10 years (Montgomery, 2002). Durability is a barrier that can be overcome with surface treatments like render, burnt oil application, use of more cement binder in ISSB manufacture or other coatings. This implies that costs become higher making the technology otherwise more unfavorable.

Skills and Workmanship

Skills and workmanship had a rating of 2.62. According to Alinatwe (2008), the knowledge and skills of the workers is a barrier to productivity. This technology is a little different from the conventional construction using mortar for bonding. It's not been included in the curriculum of most technical institutions and it has always been assumed that only intensive training is sufficient; however, some form of certification and testing is necessary. In the country as a whole the practice of licensing and certification of tradesmen is not in force except at professional levels of engineers, architects and surveyors. This is one of the factors that is difficult to overcome and can only effectively be dealt with if government policies are developed and enforced.

Incomes of Users

The biggest economic activity in the region is subsistence farming (Uganda Bureau of Statistics, 2006), which really does not bring in much income that can be saved for construction. The incomes of users is a major barrier and is indirectly linked to the speed of erection and the durability of the blocks that requires substantial funding that should at least go up to roofing. This is important in preventing the deterioration of walls by the effect of rainfall. The low incomes of the beneficiaries are indicated by the fact that the majority of projects are mainly funded by NGO's and government. The low incomes also affect the choice machines to be used which should be the manual type that is not only much more affordable but also easy to operate and maintain.

Awareness

Awareness of the potential users was rated as the greatest barrier. The common and effective ways of creation of awareness in order to decrease this problem as used in other places include; model projects, community education, training in schools and distribution of brochures (Good Earth Trust, 2008; U.N- HABITAT, 2009 & U.N., 1976). Some of these have been used but to a small extent and a lot can still be done even through the local leaders.

5.0 CONCLUSIONS

The properties of the soil used for making the blocks and the blocks themselves are generally of acceptable standards; however the water absorption of the finished block is high. This makes ISSB's less desirable for construction in these areas which are characterized by heavy rainfall. The machines commonly in use are diesel operated as opposed to the manual ones that are of much lower costs and easier to operate. Most the projects were the construction of houses implying that there is underuse use of the technology which could be very useful in the construction of rainwater storage tanks. The majority of projects are also funded by NGO's and Government implying that the poor are not able to afford.

Key factors that seem to favor the technology are fast speed of erection and environmental friendliness of the materials which avoid the destruction of forests for the production of burnt clay bricks. Despite the generally favorable materials and technology exhibited by ISSB technology, the predominant barriers include affordability for the poor, the stigma associated with the technology which is seen as mud and the generally low durability of the blocks. The other factors that were also identified and studied including; standardization of technology, design of buildings, skills and workmanship, tools and equipment, durability, awareness and incomes still feature predominantly as barriers which could explain the slow spread of this technology.

Recommendations

- Use of manual machines other than electric
- Stones and rocks should be used for the construction of foundations.
- sand should be added to soils with clay and silt fractions greater than 30%,
- The draft standards developed by UNBS should be commissioned.
- Design of buildings when using this technology be seriously considered
- Awareness in terms of publicity and sensitization.
- More Funding should be made in terms of grant schemes.
- The curriculum in technical schools should also include this technology(ISSB)

Areas for Further Research

Further studies should be made with regard to cost effective controls to enhance the durability of ISSB's. Studies should also be carried out to develop a simple and affordable tests on the block that can be used as an indicator of strength and durability.

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UGANDA'S EXPERIENCE IN IMPLEMENTING ENABLING SHELTER

Stephen Mukiibi[1], Dave Khayangayanga[2]

[1]Senior Lecturer, Department of Architecture and Physical Planning, Makerere University, P.O. Box 7062 Kampala, Uganda.
Corresponding author email: smukiibi@tech.mak.ac.ug
Kampala
Uganda.

[2]Part-time Lecturer, Department of Architecture and Physical Planning, Makerere University, P.O. Box 7062 Kampala, Uganda.
Corresponding author email: dkhayanga@yahoo.co.uk
Kampala
Uganda.

ABSTRACT

In order to implement the Global Shelter Strategy, Uganda was identified as one of the countries to participate in the Shelter Strategy Support Programme implemented by the UN-Habitat in 1986. This meant formulation of a national Shelter Strategy and its translation into a viable and replicable shelter programme under the broad umbrella of enablement. Under this approach, the Government pursued complimentary policy objectives and strategies to improve the housing conditions in the country, so as to address the country's housing need that was so great that it could not be met through other efforts.

This paper reviews the background to, and implementation of enabling strategies since the formulation of the National Shelter Strategy in 1992. It argues that enablement per se cannot firmly address the challenge of the housing problem because there are certain sections of society who need direct intervention for them to access descent and affordable housing.

Finally, the paper discusses the challenges that have been faced and the lessons learnt in implementing enabling shelter strategies in Uganda, and the implications for policy. It concludes that the enabling policy had good intentions but the weak institutional structure and low technical capacities at local governments have made it a hard task to achieve. Additionally, the poverty levels at both national and household level have rendered the enabling approach inadequate in addressing the housing challenge.

Key words: Enabling Strategy, Habitat Agenda, Housing Policy, Human Settlements, Shelter Strategy

1.0 INTRODUCTION

Uganda was one of the countries identified by the UN-General Assembly in December 1986, to participate in the Shelter Strategy Support Programme implemented by UN-HABITAT (Government of Uganda, 1992a). Under the programme, technical assistance was provided in the formulation of national shelter strategies and translating them into viable and replicable shelter programmes. The government therefore adopted the enabling policy approach whereby Government facilitates the participation of a wide range of actors in housing development and improvement. This meant that Government was responsible for creating an environment in which households, firms, NGOs and community groups could operate effectively and efficiently. (Government of Uganda, 1992a: 1992b).

Under the enabling approach, the Government was to pursue complimentary policy objectives and strategies as highlighted in the National Shelter Strategy (1992), among them the following:

- To rehabilitate the housing industry and renovate factories producing building materials
- To increase the housing stock through cooperative effort, self-help, private sector development and public housing agencies
- To improve housing conditions generally through improved access to infrastructure and services
- To divest government from the commitment to provide housing to civil servants and to put in place a system of housing allowances to assist civil servants to meet their housing needs through the private sector and individual home ownership
- To foster a health housing finance environment and facilities in which government would use public funds to generate and support policy measures that would encourage private sector participation and community initiative in housing finance development

2.0 METHODOLOGY

This paper examines the extent to which the enabling shelter strategies in Uganda have been implemented. The methodology involved studying and evaluation of literature and archival documents from different sources on Uganda's housing environment, examination of the policy framework on housing, housing programmes executed by the Government of Uganda and conducting interviews with key persons from Ministry of Lands, Housing and Urban Development and scholars on the subject.

3.0 POLICY FRAMEWORK FOR IMPLEMENTATION OF THE SHELTER STRATEGY

The housing sector in Uganda is multi-faceted, with different institutions, including the private sector. There is, thus, need for effective coordination of all the stakeholders involved in housing development and provision of related services in Table 1 below:

Table 1. Responsibilities in implementing the shelter strategy in Uganda

Services	**Responsible Person/Organ**
▪ Land Accessibility	Private landlords, Land Registrar, Uganda Land Commission (ULC), District Land Boards.
▪ Planning- both Spatial and non-spatial	Physical Planning Department by local authorities and Ministry responsible for housing and Local authorities
Infrastructure Provision eg Water, Sanitation, Drainage, Solid Waste and Roads	Ministry of Lands, National water and Sewerage Corporation, Local authorities, Developers, owners, private sector
▪ Maintenance	Private sector, Individual households and Ministry
▪ Management	- Private sector, Local Governments, Ministry
Source: The Constitution of the republic of Uganda, 1995.	

The role of the Central Government is to establish policy, legislative, institutional and financial frameworks that can enable the private sector, both formal and informal, NGOs, CBOs and Households to make and optimize their contribution to the national shelter delivery system. The

Ministry responsible for housing handles formulation of policies, legislative tasks, establishment of Standards, capacity building, provision of technical support as well as monitoring and evaluation of policies, programs and projects. Responsibility for service delivery in Uganda lies with the local authorities and private sector.

Table 2. Responsibilities in housing development.

Service	**Responsibility**
Quality assurance	Government
Maintenance	Private/Government/Local government
Mobilisation	Local authorities/NGOs/CBOs
Sensitisation Program	Government/Local authorities and community
Source: Ministry of Works, Housing and Communications Ministerial policy statement 2003	

Current legislation pertinent to housing development includes the Decentralisation Act (1993), the Land Act (1998), the Public Health Act (1964), the Condominium Property Act (2001), the Building Societies Act, The Building Control Bill (2002), The Local Government Act (1997), the NEMA Statute (1995) and the Town and Country Planning Act (1964), The National Land Use Policy (Draft) (2011), The Physical Planning Act (2010).

The decentralisation policy in Uganda started in 1992 and is fully entrenched. It is a framework for sharing obligations, competencies and revenues, and above all, moving decision making as close as possible to the citizens. The 1997 Local Government Act provides further details for the operationalisation of the decentralization policy (Government of Uganda, 1997). However, there is inadequate quantity and quality of staff at lower levels.

The Land Act (1998) which vests all land into citizens of Uganda poses tremendous challenges for orderly urban development. This is especially the case where local authorities do not have resources to compensate owners. Implementation of the Land Act has also met problems arising out of controversy and misunderstandings owing to inconsistencies in land use planning requirements in the country (Busingye, 2002).

The Public Health Act empowers the Local Governments to undertake planning and determine their own priority programmes. It is nevertheless important to note that many local governments are passive to ensure planning and provision of services yet they levy property taxes.

The Condominium Property Act (2001) provides for ownership of flats and management of common property by co-operation. A total of 350 condominium plans were prepared by the Government and submitted to the local authorities for approval to enable the public access property under this Act (Government of Uganda, 2005). However, there is need for further sensitisation of the public to increase awareness about this Law and how developers and investors should be interested in investing in Condominium Properties. This would help optimise on use of land and economise on the cost of infrastructure costs.

In the absence of large real estate developers, individual household developers have played a significant role in increasing the housing stock. The formal private sector does not, however, develop rental housing for the urban poor in urban areas. The informal sector, therefore, responds to meet the needs of the urban poor by building sub-standard un-serviced housing rentable at low rents.

4.0 KEY ASPECTS OF HABITAT AGENDA ADDRESSED BY THE GOVERNMENT OF UGANDA

The Habitat Agenda is a global call that sets out approaches and strategies towards the twin goals of adequate shelter for all and sustainable human settlements development (UNCHS, 1996). Uganda embarked on the implementation of the Habitat Agenda as an integral part of the overall fight for the eradication of poverty (Government of Uganda, 2000: 2004). The following analysis is based on key national strategies and projects undertaken by Government of Uganda and they include:

4.1 The National Plan of Action for Human Settlements: This was formulated within the overall framework of the Habitat Agenda (1995a). At the National level it has contributed to the realization of the goals and principles of the Habitat Agenda. The NPA recognizes the strong inter-linkage between housing development, economic development and environmental management (Government of Uganda, 2001). It therefore identified the following as key priority areas for development of human settlements: Eradication of poverty and job creation, Access to land and shelter for all, and Promotion of integrated environmental infrastructure and services

4.2 The National Shelter Programme: This programme was formulated to operationalise the National shelter strategy. It had several projects earmarked for implementation. However, due to financial constraints, only a limited number of projects have been implemented (Government of Uganda, 2005).

4.3 Low Cost Housing and Slum Upgrading Projects: The Government of Uganda with support from the Development partners has been able to implement Slum Upgrading Projects as described:

With funding from UNDP, the **Namuwongo** low-cost housing and slum upgrading project was conceived as a strategic intervention to improve the living conditions in the Namuwongo slum in Kampala. The land was acquired, planned and demarcated into 1,000 plots, which were then allocated to beneficiaries. The beneficiaries were given loans to buy the land and building materials for house construction (Government of Uganda, 2008).

The **Malukhu** Integrated Poverty Eradication Project was conceived in 1992 and implementation started in 1996. It was intended to benefit 460 households in Malukhu slum in Mbale, eastern Uganda. The beneficiaries were given building materials loan to enable them construct descent affordable houses. In addition, members of the community have also benefited from the business loans advanced and there has been tremendous improvement in loan recovery due to intensive community sensitization and involvement (Government of Uganda, 2008).

The **Oli** Low cost Housing project was started way back in 1995. The first phase was intended to benefit 180 households in the Oli community in Arua Municipality in the first phase. It was funded by the Africa Housing Fund. So far 151 houses have been built. Most of these are occupied and others are at different stages of development (Government of Uganda, 2008). The project is still ongoing. However, owing to the civil war in Northern Uganda, loan recovery has been a big problem.

The **Masese** Women's self Help Project was conceived in 1989 to benefit the residents of Masese Slum in Jinja who were very poor and inadequately housed. The majority were women employed in the informal sector. The project was funded by DANIDA and was intended to benefit 700 households. Some 400 houses have been completed to date, and 60 are at different stages of development. The project has a building materials plant for imparting skills to the project community (Government of Uganda, 2008). The members were also offered business loans to support their income generating activities. However, due to the high levels of poverty among the project beneficiaries, loan recovery has been a big problem.

The Naalya Housing Project was conceived by National Housing and Construction Corporation of Uganda to develop a fully integrated housing estate to benefit the low, middle and high income earners. It involved acquisition of land, its planning, provision of infrastructures (water supply, sewerage, electricity and roads), Construction of houses and linking the buyers to Housing Finance Company of Uganda for financing. The downside to this project is that it has ended up benefiting only middle and high income earners, leaving out the low-income earners.

New housing projects. The Government of Uganda has embarked on developing new housing projects – Otuke Housing Project and Kasooli Housing Project, where 50 proto-type plans have been developed for use (Government of Uganda, 2012). However, careful planning and implementation of the projects will be vital if mistakes experienced in similar past projects are to be avoided.

4.4 Eradication of Poverty Housing - Habitat for Humanity

The eradication of Poverty Housing programme was started in the early 1990s targeting the poorest of the poor in the urban and rural areas. The beneficiaries are mobilised into "affiliate groups" sensitised and then given a loan in form of building materials for houses according to standard plans. Beneficiaries are expected to contribute "sweat equity", for example, providing unskilled labour, making their own bricks etc. The loan ranges between Uganda shillings. 1.5 to 1.8 million (Approximately US$ 1,000) repayable over a period of ten years at no interest. However, the success of the programme with respect to loan repayment and sustainability is yet to be determined.

4.5 Land Use Management

In 2007 the Government of Uganda adopted a National Land Use Policy (2007) whose objective was to achieve sustainable and equitable socio-economic development through optimal land management and utilisation in Uganda, little has been achieved. Under the Act, local authorities are engaged in the process of land use management and physical planning of the developments in their areas of jurisdiction (UN-Habitat, 2010). District land boards were established after being recognised in the 1995 constitution to handle land matters within their areas of jurisdiction.

5.0 CHALLENGES, LESSONS LEARNT AND IMPLICATIONS FOR POLICY

Government of Uganda adopted the enabling approach to play an active role in economic development in general and human settlements in particular. However, many challenges have been faced, lessons learnt, and implications for policy have emerged as follows:

5.1 Urbanisation

The rate of urbanization in Uganda is estimated at 5.87 percent per annum (UN-Habitat, 2003). These urban areas are developing with no planning or proper guidance. Development of such settlement poses a big challenge as it contributes to the growth of the informal settlements. There is, therefore, need to evolve a National Urbanisation Policy to guide the urban development.

5.2 Capacity to plan, guide and manage urban development

There is inadequate capacity at both the national and local levels to plan, guide and manage urban development. At national and local levels, the departments responsible for planning and management of human settlements are grossly understaffed and under-funded. The situation is aggravated by weak institutional co-ordination and lack of appropriate institutional structures at the district level. There is therefore need for public intervention in supporting capacity building of local authorities by working together through Public-Private Partnerships (PPP). Government delays in dealing with policy issues have also undermined the development of the housing sector. For example, the review of the National Housing Policy has been on for over ten years and to date it is not yet near completion. At the same time, the Landlord –Tenant bill and Uganda Land Commission Bill that were prepared some years back are yet to be considered by cabinet (Government of Uganda, 2012). Likewise, the National Land Use Policy is still in draft form.

5.3 Human Settlements Development

Curtailing the spread of informal settlements/slums to new areas is proving a major challenge. So far the public interventions are geared towards upgrading existing informal settlements/slums which has proved to be a difficult task due to limited financial capacity.

5.4 Access to land and security of tenure

There has been significant improvement in access to land and security of tenure following the Constitutional Reform in 1995. While it is now possible to buy and sell land at an agreed price

between the buyer and the seller, the present multiple land tenure systems are not conducive for orderly urban development. There is need for Central Government to support local authorities to enable them acquire land for re-development through land-banking or consolidation schemes. Facilitating the supply of planned and serviced land with security of tenure at affordable prices is one of the biggest challenges. The provision of secure tenure for land in adequate quantities, in suitable locations at affordable prices and on equitable terms is a fundamental requirement for clearing the backlog of housing demand for the poor and meeting the rapidly growing need to house new poor families in urban areas.

Despite adoption of the National Land Use Policy (2007), there is still lack of adequate information on land use, inadequate land use planning structures and capacity at all levels in the country, lack of harmonisation of laws and policies related to land use, insufficient and uncoordinated land evaluation for suitable land allocation, poor implementation of existing policy and legal instruments related to land use and inadequate financial resources for institutions responsible for land management (UN-Habitat, 2010). In addition, although the District Land Boards were recognized and established, they still remain largely un-functional due to lack of human resource capacity and funding.

5.5 Building materials

At national level, 71 per cent of the housing stock is constructed of temporary materials, 11 per cent of semi-permanent materials and only 18 per cent of permanent materials. At the same time, there is a large discrepancy between materials used in urban and rural areas. The 2002 National Census indicated that about 59 per cent of urban dwelling units were constructed using permanent materials compared to 10 per cent in rural areas and this picture has not changed much to date (UN-Habitat, 2010).

The supply of building materials on the Ugandan market has increased in quantity (see table 3). This has been as a result of macro-economic stability and liberalization, the rehabilitation and expansion of local industries, and increased imports. Accessibility to building materials has improved largely in terms of proximity from the site of construction within 41.9 percent to a radius of 5 kilometres (UN-Habitat, 2010). However, there still remains a problem of limited quality and variety of building materials for use. Therefore, in spite of increases in production and supply of building materials, the proportion of permanent houses has not increased at corresponding rate as the cost of materials is still high. Costs of building materials have risen steadily in the past recent years and this has been partly attributed to conflicts in Uganda, Southern Sudan and the Congo, with key stakeholders describing more profitable materials markets in neighbouring countries leading to higher prices for local residents in Gulu and Kampala (UN-Habitat, 2010). Under the prevailing circumstances, it is still difficult to advocate for the use of permanent building materials in low income settlements.

The ministry of Lands, Housing and Urban Development plans to establish a national cost database for building materials and to supply 25 districts with equipment and specialized materials. Although this seems to be a step in the right direction, the ministry is very much limited in terms of resources. For example, the Ministry requires UGX 30 billion (USD 13,953,500) in the medium term to implement the land fund, yet only UGX 19.97 billion (USD 9,300,000) is provided in financial year 2009/10 for the budget (UN-Habitat, 2010). Government should therefore consider removing taxes on building materials to stimulate building construction.

Table 3. Trends in the housing materials supply to the market

Materials	**1997**(Tonnes)	**2001**(Tonnes)	**Percentage increase**
Cement, Lime	289,560	431,084	48.9
Bricks, Tiles, etc	17,427	29,570	69.7
Iron Sheets	29,710	58,054	95.4
Source: 1999/2000 Uganda National Household Survey			

5.6 Provision of Basic Services

According to UBOS (2005), rural access to safe water stands at 61.3 percent and 52 percent in the wet and dry seasons respectively. Overall coverage of the 19 large towns served by National Water and Sewerage Corporation, a major supplier of piped water in the country, stands at 68 percent; overall coverage of 143 small towns is estimated at 36 percent. The 2006 statistics revealed that 95 percent had access to safe water in the urban areas compared to 54 percent in the rural areas. Access to improved sanitation stood at 43 percent (2004) and about 14 percent did not have toilet and helped themselves in the bush (UNFPA, 2007). This is of great concern as it affects the quality of water that the households use. While the national figures indicate a more convincing picture, in urban informal settlements, especially Kampala, the situation is worse and deserves special attention.

5.7 Financing of Housing Development

The majority of the households have been mobilising their own savings to build their houses over a period of time – only a very small proportion are able to access mortgage finance. Until recently, there were only two mortgage finance institutions in Uganda, Housing Finance Company of Uganda (HFCU) and Development Finance Company of Uganda (DFCU). The terms that are offered can only be afforded by the rich who are able to pre-finance up to 30 percent of the project cost. This is not conducive for the long-term housing development. The formal housing finance institutions also lack long term savings deposits, have low capital base, high interest rates and high building costs. There is consequently, a shortage of mortgage finance coupled with unfavourable lending terms.

Some community financing efforts have been used to assist disadvantaged members of society to access housing finance. For example, through the Uganda Women Finance Trust, women groups get loans of UGX500, 000 (USD 230) repayable within four months (UN-Habitat, 2010). There is therefore, a need for Government intervention to mobilise long-term capital to support housing development programs under the local authorities, especially for the low and middle-income groups. This can be done by supporting micro-lending through micro finance institutions and Savings and Credit Co-operative Organisations (SACCOs).

The above challenges, lessons and implications can be summarised as in table 4.

Table 4: Summary of challenges, lessons learnt and implications

	Challenges	Lessons learnt	Implications
1.	*Urbanisation* High urbanisation rates, lack of planning or guidance	High urbanisation rates are leading to spread of informal settlements	Growth of informal settlements will continue in the foreseeable future unless efforts are made to address the situation
2.	*Capacity to plan, guide and manage urban development* Inadequate capacity at both the national and local levels to plan, guide and manage urban development	Capacity to plan, guide and manage urban development at national and local levels are essential for achieving organised development	There is a need to develop capacity to plan, guide and manage urban development by reviewing/developing relevant policies and building institutional framework for their implementation
3.	*Human Settlements Development* Challenge of urban sprawl	Unguided development is facilitating spread of urban sprawl	Cost of provision of infrastructure service is likely to increase, thereby negatively affecting access to decent housing
4.	*Access to land and security of tenure* Poor land use information Poor land evaluation and	Interventions so far made to regulate the land market in Uganda are still lacking	There is need to develop a functional legal framework for implementing land management

	management Un-functional District Land Boards		strategies in the country
5.	*Building materials* Poor quality and quantity of building materials	Supply of quality building materials is still lagging behind demand for the materials	Scarcity and poor quality of building materials are hampering access to decent and affordable housing
6.	*Provision of Basic Services* Inadequate provision of basic services	Level of access to basic services is still low in the country	Many Ugandans are living in unhealthy living conditions
7.	*Financing of Housing Development* High interest rates High building costs Lending terms not poor friendly	Many poor people cannot access housing loans from formal financial institutions.	Access to housing finance in Uganda is still limited.

6.0 CONCLUSION

Government of Uganda's adoption of an enabling approach in addressing human settlements is broad-based and multi dimensional. Despite the good intentions, the weak institutional structure and low technical capacities at local governments have made it a hard task to achieve. Additionally, the poverty levels at both national and household level have rendered the enabling approach inadequate in addressing the housing needs. For effective delivery there is need for Government to strengthen the housing financial institutions to adequately play their role in availing the finances to the sector at reasonable rates. The problem of rapid urbanisation is real and growing fast. Its effects need to be addressed now before they get out of hand. For this to be effectively done, appropriate studying of its dimensions and planning for mitigation measures are crucial elements for achieving a planned and organised urban environment.

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User Participation in the Eyes of an Architect and Gendered Spaces

Assumpta Nnaggenda-Musana[1], Eiman Ahmed Elwidaa [2], Barnabas Nawangwe[3]

[1]Lecturer, Faculty of Technology, Makerere University, P. O. Box 7062, Kampala, Uganda

[2] PhD Student, Faculty of Technology, Makerere University, P. O. Box 7062, Kampala, Uganda
Corresponding author email: nagendaa@gmail.com
[3]Associate Professor, Faculty of Technology, Makerere University, P. O. Box 7062, Kampala, Uganda

ABSTRACT

In Kampala City the high rate of urbanisation has led to sprawling informal settlements, which are characterised by substandard housing conditions. Urban sprawl wastes valuable land and makes services and infrastructure delivery expensive. Several housing projects were undertaken by government to provide affordable, adaptable and convenient housing solutions to low-income households. Most of these projects adopted a "top-down" approach in design, which seems not to have considered the way low-income households actually use space. The paper shows that considerations of how low-income households use space would lead to the development of more appropriate housing designs. It also shows that outdoor space use, which has been insufficiently addressed in government housing projects, is both functional and a resource to the low-income households.

The paper utilises a combination of methods such as literature, personal observations, document searches and reviews, in-depth interviews and systematic sketching. It illustrates that involving housing users in the preliminary stages of architectural design, as well as studying the way they use both indoor and outdoor space can be a solution towards attaining more suitable housing designs for low-income households. The paper argues that to low-income households, the house as external and internal space is not only a home but a space for subsistence and sustenance. It further argues that the provision of houses with considerations for how gender is enacted spatially could lead to the development of houses that can be user friendly to low-income households.

The paper ends by suggesting ways of developing house designs that adapt to the way low-income households use space while preventing urban sprawl in the informal settlements is an important step towards the development of more effective housing designs.

Keywords: Low-income housing; Gender; Outdoor Space Use, Indoor Space, Communal Space, Urban Sprawl

1.0 INTRODUCTION

In Uganda formal housing provision by governments has been inadequate due to scarce resources. Attempts to house the low-income households in low-income houses resulted in isolated interventions at Namuwongo in Kampala, Malukhu in Mbale and Masese in Jinja. Unlike the original housing of the beneficiaries, which were mainly constructed in temporary materials like mud and wattle walls and thatched roofs, low-income houses in this context are houses constructed with permanent roofing materials like iron sheets or tiles. The walls are made out of baked or unbaked bricks and are mud mortar bonded. The floors are cement screed, and the sub-structure is often a brick foundation. These houses comprise of more than two rooms (http://cn.unhabitat.org/downloads/docs/3603_98525_HS-617.pdf).

The Namuwongo and Malukhu housing schemes seem not to have benefited their beneficiaries, since most moved to other informal settlements elsewhere (Nnaggenda-Musana, 2008). The houses developed for the Masese housing scheme, which was developed mainly for low-income women, has also been greatly transformed, which points to the users' efforts of making them user-friendly. There appears to be a mismatch between the housing that government provides and what the low-income households actually need. Failure of government to provide appropriate housing for low-income households has forced them to develop detached one-storey houses through self-help. These houses are contributing immensely to urban sprawl and the wasteful utilisation of public utilities.

Professor *Nabeel Hamdi* an architect at the Architectural Association in London and one of the pioneers of participatory planning argues that it is important to involve the users of buildings in housing decisions (Hamdi, 1991:*xii*). Hamdi (1981) puts forward the concept of enablement – a way of designing without detailed programs that encourage rather than discourage pluralism in built form. Hamdi (1991) also considers participatory design which refers to the involvement of users and the community in design as an important part of project management and also as a way of ensuring that building design is a rigorous inquiry of building form, user needs and habits. He states that he spent a lot of time trying to understand the tools and skills (alternate design strategies) that need to be explored with community groups to achieve an integrated design response (Hamdi, 1991: *xi- xii*). We as architects need to develop more appropriate design interventions that "*get things started"* according to Hamdi (Hamdi, 1991:*xii*). As Hamdi (1981) suggests architects should be able to develop appropriate housing through the involvement of users in design decisions.

The availability of funds to develop appropriate houses is one of the problems faced by low-income households, thus ways of promoting spontaneity, improvisation and incremental housing development need to be sought. An issue which is usually not tackled in design is the issue of gendered spaces. This paper discusses gendered spaces in housing and focuses on how low-income housing can be developed by studying how space is used in relation to gender. The problem of the sprawling informal settlements and how they can be controlled is also examined.

2.0 GENDER CONSTRUCTED SPACE

The concept of gender is related "*to the social, economic and political differences*" amidst women and men (UNCHS (Habitat), 1993:03) including their perceptions "*of the different quality of life and livelihood opportunities*" (Fadda *et al.*, 2000:167). Gender should be discussed when referring to informal settlements. Fadda *et al.* (2000) observe that since women spend more time at home they perceive problems acutely and are affected more by these problems (Fadda *et al.*, 2000:179).

The basic elements of women's economy include part-time work and work at home. Women indulge in domestic chores and are more likely to have their work located within their neighbourhood. It is common to find them modify their domestic space to accommodate home-based enterprises (HBEs), and gardening areas in housing neighbourhoods. Women tend t be more concerned with income generating activities like renting of space, and rearing of domestic animals and gardening either for sustenance, income or both (Veenhuizen, 2006:125).

The houses for the low-income in Kampala are spatial contexts in which the social order is reproduced. Public and private space in a home are understood in gender specific terms. For example houses constructed by men were found to have been transformed according to women views since they usually stay at home most of the day and do more chores in it thus show more design awareness towards spatial needs.

In the United States several books have been written about space and gender. Spain (1992) a professor of urban and environmental planning in Virginia in her book "*Gendered Spaces*" argues that in homes as well as academic institutions and work places spaces have been defined by gender; cultural constructions of gender have determined the definition of space. Women's access to shelter has an impact on their improvement, that of their children and the whole society and ought to be a global concern. Most past international policy documents argue that "*governments should*" do any number of things, this may have a rationale in the abstract but it ignores the real forces which generate change on the ground (Dandekar ,1993). Hayden an urban historian and architect (1981) wrote about the need to change the designs of American homes, neighbourhoods and cities. The main impulsion in writing her book was to acclimatise the newly industrialised society and create an ideal standard of living, such that everyone, including the women and children would live up to their potential in their daily activities. To Hayden (1981) social problems can be addressed when spatial problems are dealt with.

3.0 METHODS TO SOLVE THE PROBLEM

Having carried out research in different but similar low-income housing areas in Uganda the researchers endeavoured to bring their experiences together to see if their findings could be corroborated. The results presented are an investigation into ways in which housing can be made more user-friendly for low-income households since it was noted that such households tend to transform their spaces. The concept of user-friendly refers to housing that can be well suited to the needs of the user households. The researchers note that various efforts and resources have been directed towards developing user-friendly housing, but the problem persists. The present study considers alternative design solutions with the overall objective of developing low-income houses that will make the intended users stay in them without needing to shift. To fulfil this objective the following methods were utilised:

(i) Literature surveys and reviews of different but similar researches done elsewhere globally to understand how more appropriate low-income housing have been developed;
(ii) Personal experiences from different but similar study areas;
(iii) Desk studies of documents and design proposals about housing projects and other government documents about low-income housing provision. This enabled the researchers to gain awareness on housing issues in Uganda;
(iv) Field observations to allow the researchers understand the problem in its context;
(v) The researchers conducted in-depth interviews with house users and key-persons to acquire a comprehensive understanding of how space is used by the low-income households;
(vi) An inventory of the existing houses was made by the researchers and different design variants were worked out through systematic sketching to arrive at more appropriate solutions.

The researchers triangulated empirical, personal, theoretical and methodological findings as a way of cross verifying from several sources to augment the credibility and validity of their findings. The different methods used led to the similar findings.

4.0 FINDINGS

4.1 User Participation in Housing Design

An effort has been made to integrate the participation concept in all low-income housing schemes of Uganda. A large percentage of the Ugandan housing schemes adopted the participation approach for example by involving the users in preliminary discussions, building materials provision or house construction. However user participation is rarely applied in architectural design. For example at Masese project, designs are prepared at the technical offices with different prototypes from which the users can choose. It is noted that choices are made not according to the suitability of the architectural design to the needs of the

users, but mainly due to household size or due to potential users' capability to repay loans. There appears to be a mismatch between the provided design solutions and what the low-income households actually need, which compels them to alter the designs of their houses to suit their ways of living and lifestyle or in some cases forced them to move to other places. This further contributes to the horizontal housing expansion which aggravates the problem of urban sprawl.

4.2 Gender Constructed Space

Low-income housing in Kampala portrays spatial contexts in which the social order is reproduced. Public and private space in homes is understood in gender specific terms, spatial relations in houses in the informal settlements show gender stratification. The main house "male sphere" usually occupies the front/important location while women and children are placed at the back and less important areas. It also signifies private versus public spheres where male sphere is closely related to sitting or public space compared to women backyard or private space.

Figure 1: The main house (centre). Mbuya. (Photo: Nnaggenda-Musana, 2003).

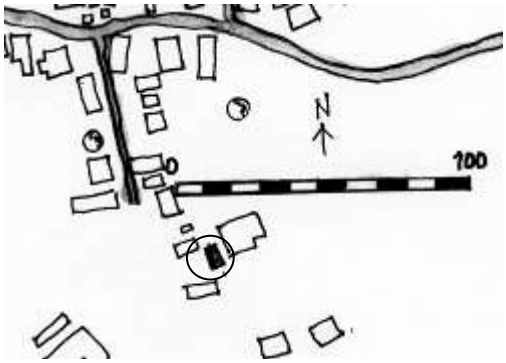


Figure 2: Location of the house in figure 1. Mbuya. (Photo: Nnaggenda-Musana, 2003).

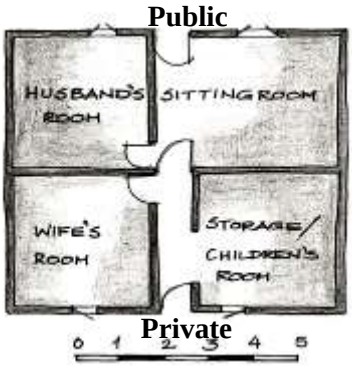


Figure 3: The floor plan of the house in figure 1, Mbuya. (Sketch: Nnaggenda-Musana, 2004).

In figures 1 - 3 the male domain is positioned at the front or public space portraying importance while the women's and children's domain is placed at the back or private space. The man can be able to receive visitors easily since his space is located at the front.

4.3 Gender Transformed Space

Spatial relations in houses in the informal settlements of Kampala show that gender is enacted spatially. Houses constructed by men have been altered by the women who usually use them more since they work from home.

The timber shade in figures 1-3 was a later addition to the house that was required by a woman. The house had no kitchen and the veranda at the front of the house was used for cooking. According to the woman cooking was uncomfortable in a semi-private space at the front of the house and also during adverse weather conditions. Needing some privacy and covered space she asked her husband to construct the timber shade.

Figure 4: Altered frontal space. The timber shade (foreground) used as a kitchen is a later addition required by a woman. Mbuya. (Photo: Nnaggenda-Musana, 2004).

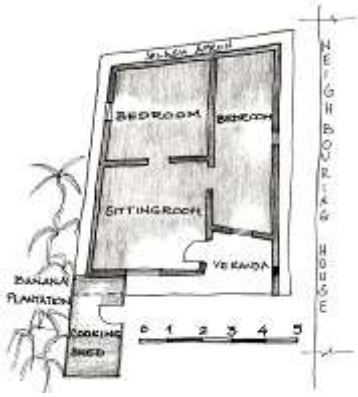


Figure 5: Plan of the house in figures 1 and 3 house. Mbuya. (Sketch: Nnaggenda-Musana, 2004).

Female and male spaces can be seen to be undefined in houses built newly (circa 90s). The dominance of the male space is reduced while women's space starts to emerge invading the formerly male-dominated public space. In figures 4 – 5 the cooking space conventionally placed at the back is now predominantly placed at the front (public space).

4.4 Outdoor Space as a Resource

In the low-income housing, outdoor space is a basic functional space just like the indoor space. This space is hardly considered when housing designs are prepared. It is considered as a leftover after locating the various rooms, conventionally referred to as the house, within the plot and what remains becomes the outdoor space, although, this space is used by women for cooking, nurturing children, washing clothes, entertaining guests, and also bathing.

Figure 6: Outdoor spaces are used by women for child rearing, cooking and washing clothes. Masese, (Photo: Elwidaa, 2010).

Figure 7: Entertaining visitors outdoors in Masese. (Photo: Elwidaa, 2010).

Outdoor spaces can also be a place for hosting visitors and socialising in good weather which would otherwise take place in the sitting room. It can also be used for storage of property during the day and as a place for children to play. Outdoor space acts as a place for income generating activities which can be performed while women attend to their daily activities.

Figure 8: A woman selling vegetables while washing clothes. Masese, (Photo: Elwidaa, 2010).

4.5 Indoor Space Usage

In almost all adopted designs, interior space has been modified and adjusted to suit the users. For example corridors are closed off at one end to act as stores, kitchens or bathing spaces. In figure 9 after the corridor was closed off following a woman's decision, a bed was placed at the end and the space was transformed into a children's bed room. The women stores clothes and personal belongings in room corners and on strings above the bed. Some internal space can have multi functions. An internal space can act as a sitting room in the morning, a reception in case of visitors, a sleeping space at night and a storage place for personal property.

The houses are modified as need arises, there is no specific number of rooms that are adequate. When children become adults or if extended family visits and stays over houses are modified to suit the household size then. The rooms are multi-functional whereby a sitting area can revert into a sleeping area by night.

Figure 9: Internal corridor turned to a sleeping area. Masese, (Photo: Elwidaa, 2010).

4.6 Communal Spaces

In the low-income housing intense use of outdoor areas was recognised.

Women usually cook and wash clothes while watching their children play. Home activities are sometimes carried out communally. Carrying out activities communally makes them less tiresome or boring and more enjoyable.

Figure 10: Several activities taking place in a communal space. Masese, (Photo: Elwidaa 2010)

Figure 11: Women watching their children play as they cook. Mbuya, (Photo: Nnaggenda-Musana, 2004)

Neighbours socialise while cooking, planting, washing clothes or selling produce. Some of these communal activities are carried out in spaces that have been modified indoor or outdoor, see figure 12.

Figure 12: A modified court yard serves as a communal cooking space. Mbuya, (Photo: Nnaggenda-Musana, 2008).

This solidarity among women combined with the insignificance of boundary walls and scarcity of land could indicate the need for architectural designs with communal spaces within the neighbourhood. Communal spaces would not only enable women to carry out activities in a more convenient way but can also create extra time for them away from routine chores, as well as minimise the need for house helps. As in figure 13, houses on individual plots can be joined together by backyards or front yards. This could be done easily by creating supervised play areas, to provide space for neighbourhood day care facilities, laundries, food or groceries kiosks, or elderly and homeless care centres. Toilets, kitchens or spaces for small scale agriculture can also be located in such spaces. Lack of public services such as garbage collection makes it necessary for the provision of communal efforts at the local level.

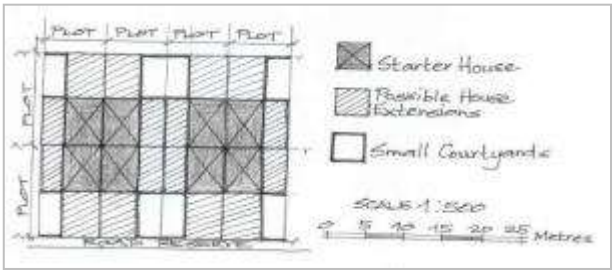


Figure 13: Extending houses to form smaller courtyards, which can be used as communal space. (Sketch: Nnaggenda-Musana, 2008).

5.0 CONCLUSIONS

User participation is not incorporated in low-income housing design resulting in a disconnection between the provided designs and what actually satisfies the users. User participation in design strengthens the ability of low-income households to participate efficiently in the development of good housing solutions and in decisions about priorities.

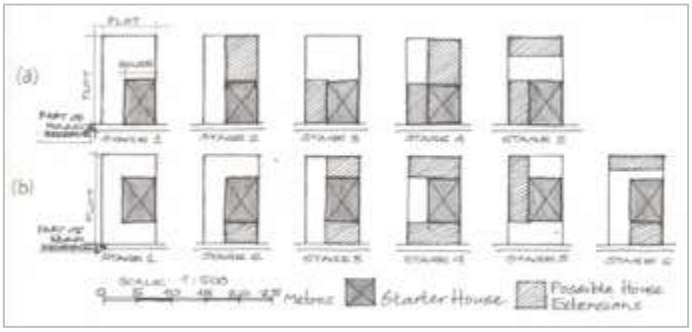
Housing should be viewed as a place where gender related forces and activities are continuously enacted. Design decisions should respond to these forces and activities whereby both women's and men's spatial, socio-cultural and practical needs are met.

Outdoor space as key habitual and functional space is not well appreciated missing out on opportunities of attaining more convenient designs that respond to the users' life styles

Space when designed should emphasise the way it can be effectively utilised to prevent future alterations that can squander both the users and government limited resources, as well as contribute to urban sprawl, which could be reduced by guided incremental expansion.

Communal space has proved to be an important functional space, therefore, integrating it in housing design can reduce gender segregation, lessen domestic work and could support home based enterprises, which enable women to earn some income towards a more resourceful and satisfactory neighbourhoods.

Low-income households keep modifying their houses according to need therefore their houses could allow for incremental modification. A *starter house* can be located on a plot in such a way that households can extend themselves when the need arises, see figure 14.



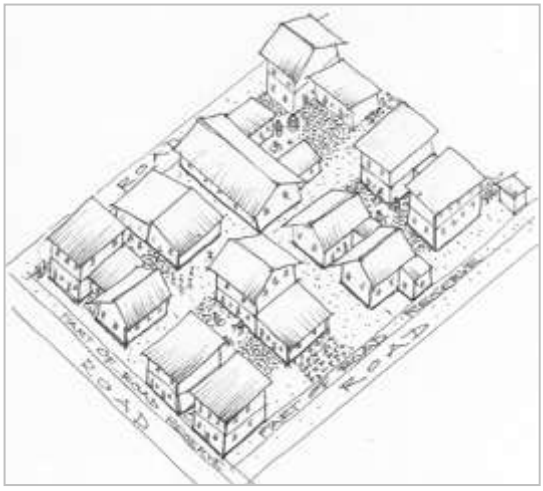


Figure 14: Left - *Plans (a) and (b) are examples of how a household can extend a starter house. The hatched areas represent the attachments. Right – the way the houses may look 3 dimensionally*
(Sketch: Nnaggenda-Musana, 2008).

If low-income houses are modified incrementally but in a systematic way neighbouring land, road reserves, green reserves, and wet lands would be impinged upon and thus their sprawling nature can be controlled.

6.0 ACKNOWLEDGEMENTS

The authors of this paper are grateful to Sida/SAREC for the financial support that enabled them to accomplish the present research.

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A technological innovation systems perspective on the emerging shea butter cluster in Uganda

Julius Ecuru[1] and Peter Okidi Lating[2]

[1]Doctoral Candidate, College of Engineering, Design, Art & Technology, Makerere University, P. O. Box 7062, Kampala, Uganda.
Corresponding Author: email: julius.ecuru@gmail.com
[2]Senior Lecturer, College of Engineering, Design, Art & Technology, Makerere University, P. O. Box 7062, Kampala, Uganda

ABSTRACT

This paper uses a technological innovation systems perspective to analyse the emerging shea butter cluster in east and northern Uganda. The aim of the paper is to describe the structure of the innovation system for shea butter and its associated products. In so doing, it highlights the system's functionality and the underlying policy issues affecting growth of the shea butter cluster in the region. Data was collected through interviews with 20 key informants in the shea districts, three focussed group discussions with farmers' group leaders, processors, local government officials, private sector and development aid practitioners, and observations of shea butter processing in firms. Findings reveal that shea butter production and processing is very much a cottage industry, which is supported mainly by women groups. It could evolve rapidly into a dynamic business cluster if actors and institutions, which currently exist in isolation, start to interact more intensely It means that local governments, universities, private businesses and the community in the shea districts should be willing to interact and learn from each other. The findings point to the need for universities and research organizations in the area to work collaboratively with local government, businesses and the community to promote growth of the shea butter cluster.

Keywords: *Cluster, community, innovation system, triple helix, Shea butter, university, Uganda*.

1.0 INTRODUCTION

From time immemorial, communities in east and northern Uganda (who numbered about 25 percent of the total population in 2002) have used shea butter from the tree *Vitellaria paradoxa* (the shea tree) for food, cosmetics and medicine. Women and children gather ripe shea fruits from the wild, eat the minerals, proteins and vitamins-rich pulp, and keep the kernels (Maranz, 2004). Shea butter/oil is extracted from the kernels and used to flavour food. The oil is also used to smear new born babies, and to relieve muscle aches and soothe the skin. Clinical studies have shown efficacy of shea butter as a nasal decongestant (Tella, 1979). Nectar from shea tree flowers attract honeybees and birds in large numbers (Dukku (2010), which pollinate farmers' crops and provide honey for the community. Traditionally, mortars and pestles (indispensable household tools in this community) are made from the hard wood shea tree. The shea tree is endemic to this part of the country. It extends to southern South Sudan and stretches about 5000 kilometres to Senegal in West Africa (Chalfin, 2004; Okullo et al., 2010). The trees grow in the wild, mature and start fruiting at 15-20 years. They continue fruiting for nearly 400 years (Ferris, Collinson, Wanda, Jagwe, & Wright, 2004). These unique and valuable attributes of the shea tree, have made communities in northern

Uganda to believe and say that, 'shea tree is a gift from God!' Recent studies have confirmed the immense traditional values communities attach to the shea tree and shea butter (Gwali et al., 2011) .

The value of shea butter is widely acknowledged, although it has not been fully translated into tangible economic benefit for the communities in east and northern Uganda. New micro and small scale enterprises have recently emerged, and introduced new methods (cold press) for producing shea butter. These small firms also produce a variety of novel shea butter products like soap, cosmetics and ointments. However, the firms do not have a shared strategy for investing in shea butter production and value addition. For example, it is less understood how firms and other organizations in the shea districts could work together to harness knowledge and technology for value addition to shea butter.

The aim of this paper therefore is to highlight the key policy issues in the development of the shea butter cluster in the region using a technological innovation systems approach. The paper focuses on the diversity of actors interacting in different ways in the production, processing and value addition of shea butter. The structure and dynamics of an emerging shea innovation system is described, as well as the factors affecting shea butter production and value addition.

The technological innovation systems (TIS) approach draws from earlier works of Christopher Freeman, Bengt-Ake Lundvall and Richard Nelson and other scholars who consider it a useful approach to understand the barriers and factors that enable growth and competitiveness of firms (Lundvall, Joseph, Chaminade, & Vang, 2009; Edquist & Johnson, 1997). The innovation system concept is defined by relationships within and between organizations, and how these relationships eventually lead to innovations and competence building (Lundvall, 2010). Learning is a central activity in any innovation system. Therefore, formal educational organizations including schools, colleges and universities, are essential for the system to function well. But equally important is the learning that takes place in non-formal settings through apprenticeship or by using a product or service, where knowledge is gained through experience, practice and sharing (Lundvall, 2010; Oyelaran-Oyeyinka, 2006).

The TIS approach adopted in this paper is based on the framework suggested by Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, (2008). It is a framework for analysing innovation systems in terms of their functions, and usually revolving around diffusion in society, at various levels, of a technology, product or process (Bergek, Hekkert, & Jacobsson, 2008). In this paper, the focus is on shea butter and its derivative value added products. Table 1 is a summary of Bergek et al's framework, specifically presented in relation to shea butter.

Table 1: Functions of technological innovation systems

Function	Description
1. Knowledge development and diffusion	The breath of scientific, traditional and local knowledge, in this case, on shea butter production, processing and value addition;
2. Influence on the direction of search	Factors which make investment in shea butter attractive, including incentives, policy preferences, new markets, etc.
3. Entrepreneurial experimentation	Emerging entrepreneurial activities, for example, new firms venturing into shea production and value addition, the range of products and processing methods employed.
4. Market formation	Trends in the development of the shea butter market, type of the market (nursing, bridging, mature), potential size of the market, and what is generally driving the formation of this market;
5. Legitimation	General perception about shea butter and its products, and acceptability by the community and other actors.
6. Resource mobilization	Resources that are available, e.g. financial, human, and other complimentary products or services for shea butter production and value addition;
7. Development of positive externalities	External economies brought about by the performance in the above functions--political support, advocacy coalitions, etc.

2.0 METHODS

A combination of qualitative research techniques were used in the study. These included focused and open ended interviews; focus group discussions, observations, and review of policy and related documents. Verbal consent was obtained for all interviews and focus group discussions. Questions and topics discussed were related to the respondent's knowledge or experience in shea butter production and their relationships with other actors. The respondents were purposively selected based on their work and experience with shea butter production and processing.

Seven shea butter producers were visited in the shea districts of Soroti, Lira, Pader, Otuke and Moyo. Shea butter production process was observed in three firms. The process was also explained at each of the other firms visited. At each firm an interview was held with either the

owner of the firm, or a senior staff heading the production unit. The firms were located by referral from individuals in the community and other firms earlier met.

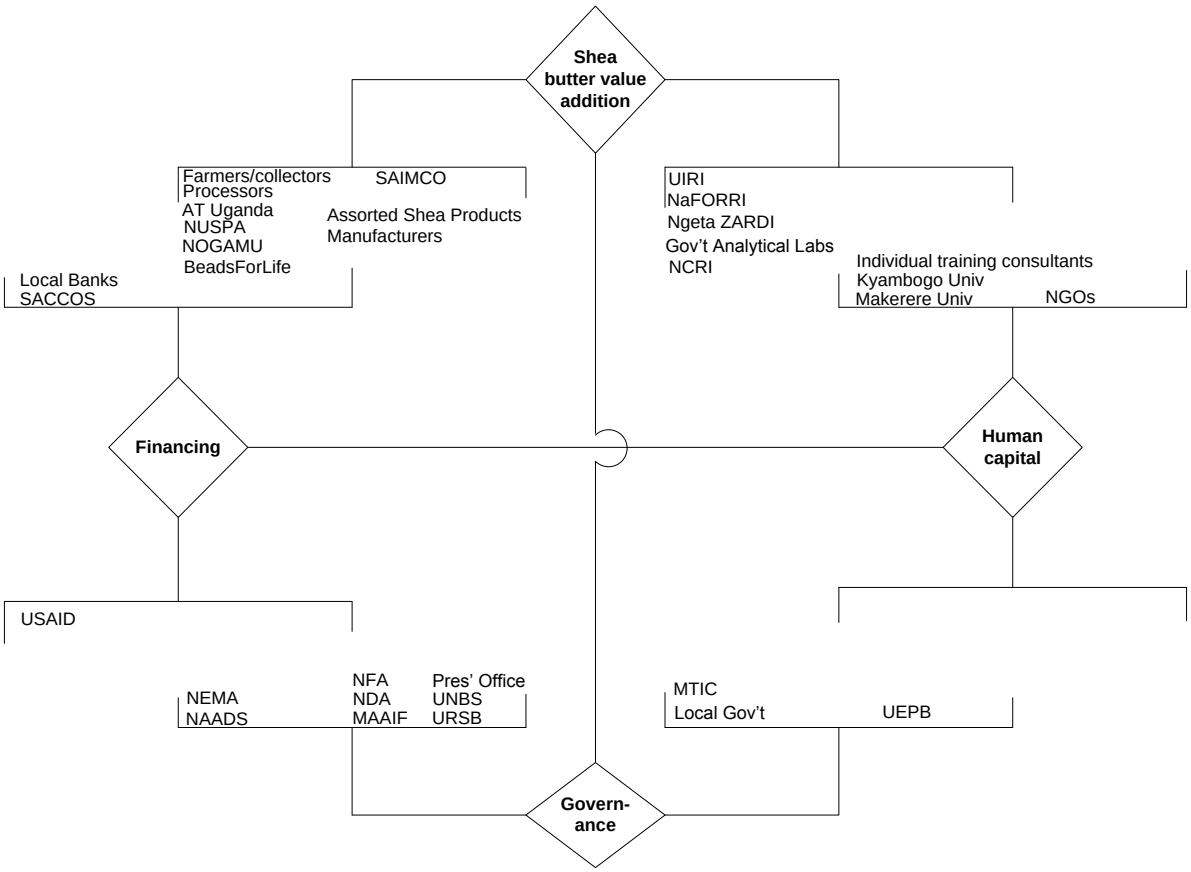
Four focussed group discussions were held with representatives of farmers' groups involved in shea collection in each of the shea districts of Moyo, Agago, Otuke and Amuria. Another focus group discussion was held in Kampala (Uganda's capital city) involving processors, scientists, finance specialists and development aid workers. Each focus group discussion was attended by seven to 12 participants. Three homes of shea kernel collectors were visited in Moyo, Amuria and Agago districts to observe how shea kernels are collected and stored, and how the trees are protected in the gardens.

Furthermore, a total of 20 local government officials were interviewed in all the shea districts in respect of local government policies and plans for shea butter production. These officers included District Forest Officers, District Commercial/Production Officers, District Administrative Officers, and Local Council III Chairpersons (elected officials who head a sub-county). An official from a local non-governmental organization in Lira, two officials from two public research organizations, and one official from an international shea processing plant were also interviewed. A firm which makes shea butter processing machines in Soroti was also visited. Data was transcribed and analysed in accordance with the TIS scheme of analysis.

3.0 RESULTS AND DISCUSSION

3.1 Structure of the Shea Innovation System

First, the structure of the shea innovation system in east and northern Uganda, that is, the actors, networks and institutions involved in shea butter production and value addition is described in this part (Figure1). The structure is looked at in four parts: a) activities directly involved in shea butter production and value addition in Uganda, b) the financing of the activities, c) governance in terms of policy and regulations for shea butter, and d) human resources and skills available. Shea butter value addition includes all activities, which relate to production and processing of shea butter.



Acronyms
URSB-Uganda Registration Services Bureau
NEMA-National Environment Management Authority
NDA-National Drug Authority
UNBS-Uganda National Bureau of Standards
NAADS-National Agricultural Advisory Services
Pres' Office-President's Office
NFA-National Forestry Authority
MAAIF-Ministry of Agriculture, Animal Industry & Fisheries
UEPB-Uganda Exports Promotion Board
SACCOS-Savings and Credit Cooperative Organizations
NOGAMU-National Organic Manufacturers in Uganda
NUSPA-Northern Uganda Shea Processors Association
SAIMCO-Soroti Agricultural Implements and Machines Company
UIRI-Uganda Industrial Research Institute
NaFORRI-National Forestry Resources Research Institute
NCRL-Natural Chemotherapeutics Research Institute
Ngeta ZARDI-Ngeta Zonal Agricultural Research & Dev't Institute
NGOs-Non-Governmental Organizations
MTIC-Ministry of Trade, Industry and Cooperatives

Figure 1: Actors and their roles in the shea butter production and value addition

3.2 Shea Butter Production and Value Addition

Shea butter is produced from kernels left after eating the shea fruit pulp. The fruit is harvested in the months of May through August every year (Okullo, Hall, & Obua, 2009). Harvesting is usually done early in the morning by women and children. The pulp is eaten, and the kernel is sun dried and stored. Yields of 15 to 55 kilograms of fresh fruit per tree have been reported in literature (Ferris et al., 2004).

Women process some of the kernels into oil for household consumption. First the dry kernels are cracked with a hard object (usually wood or stone) to remove the outer shell. It is then put in sand in a large saucepan or pot and roasted. After roasting to dark colour, it is left to cool.

The roasted kernels are ground to fine paste, and boiled with water in a pot or saucepan. After some time, a light yellowish liquid (oil) is decanted into clean vessel, ready to be eaten or used as baby oil. Local communities report a shelf life of up to two years for shea oil produced in this traditional way.

Other kernels are sold in the market or to local shea butter producers. Most of them are cottage firms, that is, small family owned processing units in the backyard of homes in trading centres or small towns. The exact number of shea butter producing firms or cottages is unknown. At the time of this study, only one small scale firm called Guru Nanak Oil Mills in Lira Town produced shea butter at factory scale; but even then, it produced shea butter as a very small fraction (approximately one tenth or less) of its oil products. A substantial amount of shea butter is produced by the wider community using the traditional method. They produce it mainly for household consumption. A little bit of it is also sold in local markets.

Usually middlemen buy kernels and sell to producers of shea butter. Some producers buy directly from organized women or farmers' groups. In such a case, the producers organize and establish their own groups and enter a contract with them to buy/supply shea kernels. A group may be up to 50 women. Besides shea collections, the groups also deal in other commodities like simsim (sesame) and sun flower. In a good harvest season, each group member on average reportedly may collect more than 100 kilograms of shea kernels. Each kilogram of kernels cost up to USD 0.6 at the time of this study.

Producers buy the kernels and sort them into three grades A, B and C according to size, moisture content, and breakage. The cold press method is used to extract shea butter from the kernels. In this method, the kernels are cracked manually to remove the outer shell, and then ground to fine paste using a motor operated grinding/crushing machine. The machines are powered by electricity or most commonly by a diesel generator. After grinding, the paste is put in the oil pressing machine and pressed. The resultant light yellowish liquid (shea butter) is collected in a dry container ready to be used. Producers report a shelf life of two years. It is commonly packaged in plastic containers of various sizes and sold as a raw material for the manufacture of other value added products like ointments, hand and body lotions, hair creams, baby jellies, soap, and other skin care products. In most cases shea butter producers also ventured into making shea butter value added products, especially cosmetics and soap. The left over shea cake is removed and discarded as waste. Some local producers report the cake repels mosquitos. No commercial or other use of this waste by product was reported. Although, local production is beginning to take root, an unspecified amount of shea kernels are also exported and processed abroad.

The cold press machines are manufactured locally, notably by Soroti Agricultural Implements and Machines Company, located in one of the shea districts, Soroti. One local artisan in Lira Town may also be able to fabricate the machine. Some machines are, however, imported from India or China. Each complete unit manufactured locally cost Uganda Shillings three to five million (approximately USD 1200 to 2000).

Bridging organizations helped to organize women groups and producers. They also assisted with machine acquisition and marketing of shea butter. For example, the Northern Uganda Shea Processors Association (NUSPA) supported shea producers with machines for cold press and assisted in marketing the shea butter. NUSPA was formed in 1996 by a United States Agency for International Development funded Shea Project for Local Conservation and Development (COVOL). NUSPA later became a cooperative society. However, when

COVOL project scaled down in 2008/9, NUSPA ceased to be active. Another organization, the National Organic Agricultural Movement of Uganda (NOGAMU) also promoted the production, processing and marketing of organic shea butter. NOGAMU and NUSPA were instrumental in having national standards for shea butter set by the Uganda National Bureau of Standards. Other notable actors were BeadsforLife and Appropriate Technology (AT) Uganda. These non-governmental organizations bought and helped market shea butter from the communities and local producers.

A number of public organizations were involved in research with shea butter. For example, Uganda Industrial Research Institute developed some value added products from shea butter. Makerere University and National Forestry Resources Research Institute carried out research on physico-chemical characteristics of shea butter and ecology of shea trees. Ngeta Zonal Agricultural Research and Demonstration Centre was used for experiments with grafted shea trees. The Government Analytical Laboratories and the Natural Chemotherapeutics Research Institute collaborated in carrying out quality tests on shea butter samples.

3.3 Financing for Shea Butter Value Addition

As Figure 1 shows, financing for shea butter value addition was predominantly by individual firms, especially firms manufacturing shea butter value added products. Cottage firms financed shea butter production with income they obtained from other side businesses or jobs. Occasionally bridging organizations like NUSPA, BeadsForLife, AT Uganda, and NOGAMU provided financial support. In a few instances, communities of collectors formed Savings and Credit Cooperative Organizations to finance their activities. Banks offered financial services, and sometimes micro credit for shea butter production. In the mid-1990s, USAID through COVOL project provided financing for shea butter processing in the region. COVOL operated in almost all the shea districts of Uganda, providing implements, training, and helping establish farmer groups for shea kernel gathering. However, after COVOL scaled down its operations, a number of the initiatives stalled. Some of the then COVOL employees established their own cottage firms for shea butter production.

3.4 Governance of Shea Butter Value Addition

Governance issues were concerned more with the conservation status of the shea tree. Being a hard wood tree species, the shea tree makes good charcoal. Charcoal burning is a serious threat to the shea tree. In some districts like Soroti and Lira, the shea tree is almost depleted due to charcoal burning and clearing land for farming. Charcoal burning became the main source of income for the region which was recovering from two decades of civil unrest and the brutal Lords' Resistance Army rebel insurgency. Government has listed the shea tree as endangered, and through local government councils, it has passed bye-laws banning the cutting of shea trees for charcoal. Enforcement of the bye-law is still weak, but it is welcomed by some local community members who say it reminds them of their old traditional sacred beliefs, which prohibit cutting shea trees. They believe that the shea tree is a divine gift and anyone who cuts it would be cursed.

In a lot of places, individuals and families take initiatives to preserve shea trees in their gardens. They prevent unauthorized felling of the tree for charcoal. It is easier for them do so where land is privately owned, than where it is owned communally (as is the case in most shea districts). In such instances they have to convince their relatives to recognise the value of preserving the shea tree. Those who take initiatives to preserve the shea tree acknowledge that the long term benefit from preserving shea trees is much more than the short term gain from cutting the tree for charcoal. The communities are aware of the importance of the shea tree in

attracting honey bees, which pollinate their crops and gives them honey, as well as manure for their soils. A local community member remarked during an interview:

'This tree [shea tree] is very important because it provides oil, and even when it has flowered…that is where bees go and collect nectar; and its honey is very nice—when you eat, that odour which you smell…'

In 2006, the President of Uganda issued a directive to protect the shea tree from overexploitation. The President also directed that a factory for shea butter production be established in the region. In response partly to this directive, the National Environment Management Authority prepared a National Strategy on Shea aimed at promoting sustainable utilization of the shea tree. The Uganda Exports Promotion Board also included shea butter as a biotrade product to be promoted. Uganda National Bureau of Standards, on the other hand, developed national standards for shea butter and a certification scheme for small businesses, which shea producers could benefit from.

3.5 Human Capital Development

The human resource capacity for shea butter exploitation exists but it is latent. Most of the shea butter producers are schooled individuals with formal education: certificate, diploma or degree certificates. However, majority of them operate cottage firms. Extremely few cottage firms hire full time employees. Those working in the cottage firms have either formal or informal learning from their previous employment. There are no specialised training programmes in shea butter production and processing. However, some work has been done by undergraduate and postgraduate students from Makerere University and Kyambogo University. The students' work is mainly on the processing methods, physico-chemical characteristics of shea butter, and ecology of the shea tree. Occasionally non-governmental organizations hire private consultants to train and provide skills in postharvest handling of shea kernels and processing of shea butter.

4.0 FUNCTIONALITY OF THE SHEA INNOVATION SYSTEM, POLICY ISSUES AND RECOMMENDATIONS

The functional elements within the shea innovation system are discussed here using the technological innovation systems scheme of analysis highlighted by Bergek *et al* (see Table 1 above).

4.1 Knowledge Development and Diffusion

Shea butter has been studied quite extensively especially in West Africa. Carney and Elias (2006) have traced the earliest records on shea butter to the 13th century when it was traded for salt and fish from the West African coast, and by Muslim travellers along trade routes in the Sahara. European explorers, notably Mungo Park in the 1790s, made the first recorded descriptions of shea butter, and how it was processed traditionally (Carney & Elias, 2006). By the 1920s shea butter was traded between West Africa and Europe as a raw material for margarine and candles (Ferris et al., 2004). Recent studies have focused on the ecology of the shea tree, its natural regeneration and propagation by farmers (Okia, Obua, Agea, & Agaro, 2005; Orwa, 2009; Sanou et al., 2004). Other studies by the National Forestry Resources Research Institute plan to develop fast maturing and better yielding varieties of the shea tree. These studies and the shea projects by non-governmental organizations, helped highlight the importance of shea tree in the livelihoods of communities in the shea districts. However, there has been no mechanisms yet to further these studies beyond the academic interests of the students.

Physico-chemical characteristics and fatty acid profiles of Ugandan shea butter show that is it a high value vegetable oil (Okullo et al., 2010; Honfo et al., 2010; Maranz, Wiesman, & Garti, 2003). These studies have shown important differences in the West African and East African varieties of shea butter. A key difference is in the fatty acid profiles. The West Africa variety (*Vitellaria paradoxa sp paradoxa*) has more stearic acid, which makes it a good cocoa substitute in chocolates; while the East African variety (*Vitellaria paradoxa sp nilotica*) on the other hand is richer in oleic acid, which makes it a good moisturizer. The Ugandan shea butter therefore would find greater use in cosmetics, edible oil, soaps, and other skin care products. Firms in Uganda have developed some of these products, but they have not tested them to ascertain their efficacies and to compare quality with other similar products on the market. More research and product development is needed for novel formulations and product blends, design and testing of shea butter products.

Communities in the shea districts have used the traditional method of producing shea butter for decades; and more recently cottage firms have adopted the cold press method. However, efficiency of these methods has not been fully studied. In order to close this gap, firms and local artisans should explore possibilities of collaborating with knowledge centres, like universities and local research organizations, to optimize production efficiencies. This arrangement can propel and enable growth of a vibrant shea butter cluster in the region. A cluster is defined by Colgan and Baker (2003) as a concentration of firms in a geographic region that are interconnected by the market they serve and the products they produce, as well as by the suppliers, trade associations, and educational institutions with which they interact.

4.2 Influence on the Direction of Search

Main drivers for investment in Ugandan shea butter seem to be the anticipated growing global markets especially for shea butter derived cosmetics and other skin care products. Ugandan shea butter is promoted as a good moisturiser because of its higher oleic content. It is also promoted as an organic product because it grows naturally and is collected in the wild. However, it means that if firms are to meet the certification requirements for organic shea butter, the kernels must be collected from farmlands where no pesticides or herbicides have been used. In other words, farmers who wish to trade in organic shea kernels should neither spray their crops nor apply fertilizers in fields with shea trees. Use of fertilizers and agrochemicals is generally low in Uganda (less than 0.6kg/ha), but may rise as farmers begin to grow more commercial crops like maize and sunflower (Ministry of Agriculture Animal Industry and Fisheries, 2010). When this happens, it may pose a challenge in sustaining the organic shea market.

Shea butter production may also be promoted to supplement household incomes in the shea districts, which are recovering from two decades of tyranny of the Lord's Resistance Army rebels. The latter had displaced over one million people from their homes between 1986 and 2006. As communities return to their settlements, diversified sources of income become necessary for households, particularly for the women. In this regard, investing in shea butter production may contribute to inclusive growth in the region, given also that shea butter has received the global Fair Trade certification (Fair Trade Foundation, UK) (Greig, 2006). Fair trade is a global social movement which advocates for fair trading conditions for disadvantaged producers and consumers so that the latter can extricate themselves from poverty and have a sustainable livelihood. Fair trade arrangements offer premium prices for farmers and helps cushion them from fluctuations in the global markets.

A great opportunity for shea butter investment in Uganda, however, comes from the good political will towards shea butter production. The President's directive of 2006 to build a shea butter processing factory in the region is a good example of this political will. This directive has not yet been fully implemented. The holistic strategy for sustainable utilization of shea in Uganda proposed by the National Environment Management Authority aims to support conservation of the shea tree, marketing of shea butter, research in shea and promotes capacity building, collaboration and coordination. A key challenge is to ensure that all shea butter actors engage and interact in a manner that promotes learning and innovation. It seems that the strategy would add greater value if it focused on innovations from shea butter as its locus, in order to enhance collaboration and cooperation among the shea actors.

4.3 Entrepreneurial Experimentation

Shea butter production in Uganda is still very small compared to West Africa (Ferris et al., 2004), and very much a cottage and community activity. Most cottage firms emerged in the last five to ten years. Most of these cottage firms are engaged in shea butter production using the cold press method, and also in very small scale manufacturing of shea butter cosmetics, soaps, and ointments. There is no organized marketing of these products yet. The products are usually sold through networks of friends and families. This may be partly because the shea butter cluster is not yet fully developed. Cottage firm owners and employees also lack entrepreneurial skills. Trade secrecy characterises much of the marketing of shea butter and its products in Uganda.

4.4 Market Formation

Global demand is projected to rise as shea butter is increasingly recognized for its superior properties in making beauty and skin care products, and, in the case of West Africa shea butter, as cocoa substitute in chocolates (Elias & Carney, 2007). However, to penetrate both local and international markets, local shea butter producers and processors, may need to work towards certifying their products for safety and quality. The National Drug Authority is capable of certifying safety of cosmetic and medicinal products; and a quality mark can be obtained from the Uganda National Bureau of Standards. Also, by registering their trademarks (either individually or collectively) with the Uganda Registration Services Bureau, local producers of shea butter and manufacturers of value added shea butter products may have greater control of their markets. Shea butter is also one of the products, which can be geographically indicated because it is endemic to this part of the country.

Within Uganda, the tax regime is favourable for locally manufactured goods and for Ugandan exports. All exports of goods and services is zero rated (Government of Uganda, 2005). This along with other incentives such as the liberalized foreign exchange market and availability of land for investors could promote investment in shea butter production and processing.

4.5 Legitimation

As a product traditionally consumed and used for decades, shea butter is acceptable in the shea districts and communities. Its use as a food flavour is common only among communities in the shea districts. Some people, especially those outside the shea districts, find the flavour quite strong and unpleasant (personal communication). Possibilities of blending with fragrant perfumes and other mechanisms to suppress the smell may be explored when promoting shea butter as cosmetic. However, its fragrant smell especially when traditionally processed is what makes it a delicacy for the communities that consume it as an edible oil and food flavour. This point was emphasised by one of the focus group participants who said,

'…the traditional method of producing the oil we may think produces oil with a bad smell, but that smell makes it what it is, and when you remove the smell, it ceases to be commercialisable among the people who know it….therefore, we should promote both technologies which remove the smell and also retain it.'

4.6 Resource Mobilization

Shea butter production using the traditional method is an art which can be easily learned and perfected with time. About one in ten households in the shea districts are capable of producing shea butter using the traditional method. Similarly, the conventional cold press method can be easily mastered and perfected with time. Therefore, the necessary human resources for shea butter production cannot be in short supply. However, expertise may be required to optimize production processes, and to design and develop shea butter value added products. This expertise and the infrastructure for quality testing and assurance can be made available in the private sector as well as the universities and local research organizations, and could be reasonably afforded at prevailing labour market rates.

This notwithstanding, there is an untapped potential in the three public universities located in the shea districts. These universities are: Busitema University College of Agricultural Sciences in Soroti, Muni University in Arua, and Gulu University of Agriculture and Environment Sciences in Gulu. There are also public agricultural research organizations in the region viz, the National Semi-Arid Resources Research Institute in Serere district and Ngeta Zonal Agricultural Research and Development Institute in Lira, among others. These are potential knowledge providers, which are all within reach in the region. They can make a significant contribution to the development of the shea butter cluster in east and northern Uganda. To begin with, these universities should learn from the experience of Makerere University in creating and working with innovation systems and business clusters.

Most of the investments in Shea butter production and value addition are financed by shea producers themselves through savings and micro credit. Of recent some financial opportunities were put in place, which could support farmers, women groups and small firms involved in shea butter business. An example is the Youth Entrepreneurship Venture Capital Fund, which was set up by government in 2010/11. Under this scheme a youth can access up to USD 2000 to support his/her business, while a group of five youth can access up to USD 10,000 for a joint business venture. Another useful scheme is the Agribusiness Initiative Trust (aBi), which was set up in 2010 by development partners and led by Government of Denmark and Uganda. The aBi offers financial services and technical support for private sector driven agribusiness development ventures. Oil seeds is one of the value chains eligible for aBi support. However, red tape (i.e. severe conditions and bureaucracy) in accessing these financial services is one of the limiting factors for the majority of individuals and small firms engaged in shea butter production and processing.

Another concern is that, whereas financial services are being created to support private sector initiatives, there is no clear mechanism to link this support with potential contribution from the knowledge actors like local universities and research organizations. If shea butter cluster is to grow and become competitive, local governments, universities, research organizations and shea producers should be closely linked. It has been demonstrated by the triple helix concept that innovations thrive and more value is created where universities, industry and government effectively collaborate (Etzkowitz, 2003).

4.7 Development of Positive Externalities

The shea butter cluster in Uganda is still very young. Although the value of shea butter is widely recognised, no real investments have yet been made to fully exploit it. Suffice to say, however, that recognition of shea butter as a high value product has made local governments to pass bye-laws for conservation of the shea tree. Other than the bye-law, local governments of shea districts have not yet prioritized shea butter as a potential investment opportunity. Thus local governments should include shea butter production in their district development plans.

5.0 CONCLUSIONS

The emerging shea butter cluster in east and northern Uganda is characterised by cottage firms and community groups. Therefore, the participatory involvement of the local community and especially of women is critical in any future effort to develop the cluster. A vibrant shea butter cluster in the region would arguably supplement many household incomes. Clustering in the production and processing of shea butter and its associated products is crucial because annual per capita returns from shea kernel collection alone may be small at individual level. While at an aggregate regional level (i.e. as a cluster) returns to investment on shea butter production and processing could be enormous, considering the intrinsic ecological and traditional values people attach to the shea tree and the potential variety of high value shea products on the international market. In order for the shea butter cluster to grow and become competitive, local governments in the region should include shea butter in their district development plans, and promote interaction and learning with like local universities, shea butter cottage firms, other businesses, and the local community. It is apparent, from a technological innovation system perspective, that the essential ingredients for development of a vibrant shea cluster and innovation system are in place. Support is required to close essential knowledge gaps and to improve interaction and learning among the shea actors.

6.0 ACKNOWLEDGEMENTS

This work would not have been possible without financial support from the Swedish International Development Cooperation Agency (Sida) through Makerere University, and field assistance from Margaret Laloyo, Jimmy Ouni, Denis Okumu and Isaac.

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