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Interactions between Public Research Organizations and SMEs: A Case of Uganda Industrial Research Institute

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ABSTRACT
Knowledge Translation (KT) is important to understand how knowledge is transformed to economic value. This paper seeks to scrutinize the synthesis, dissemination, exchange and application of knowledge produced by Uganda Industrial Research Institute (UIRI). Theoretically, the study relates to the area of public research organizations (PRO) – industry linkages with regard to knowledge uptake by the SMEs in LDCs. Through a case study approach, this paper contributes to the field of KT by discussing how interactions affect the usefulness of knowledge produced by research organizations. The study is based on original data collected through interviews carried out with UIRI researchers between November 2012 and January 2013. Knowledge Translation Indices were developed for sample projects. The findings revealed that both Mode 1 and Mode 2 types of knowledge generation existed, with the former leading to underutilization of knowledge or wasted results. Generally, KT is complex and cannot be achieved through linear relationships, thus, the study concludes that more interactions with the indigenous agro-processing SMEs will lead to industrial development.

Keywords: Interactions, Knowledge Translation, Mode 2, Public Research Organizations, Uganda

1.0 INTRODUCTION

1.1 Background

Public Research Organizations (PRO) have a key role in the creation and diffusion of knowledge with more specific focus on solving problems and attending to social needs (Etzkowitz and Leydesdorff, 2000). The need to match research outputs with customer needs and with market and processing opportunities dictates that research institutes build closer links with private sector and advisory service providers in ways that will increase both research efficiency and effectiveness. The conventional argument for linkages is that by working together, these actors stand better chances for establishing the institutional relationships that can facilitate access to technology, information, capital and marketing arrangements (Kimenye, 2006).

Most of the existing literature on PRO–industry linkages was produced in the context of developed countries. The particular characteristics adopted by PRO–industry interactions in developing countries justify the need of specific research based on the experience of these countries (Arza & Lopez, 2011). Uganda's agro-processing industry is still highly lacking in competitiveness in the regional and international markets. Agro-processing refers to the activities that transform agricultural commodities into different forms that improve handling, increase shelf-life and add value to the product (Mhazo, Mvumi, Nyakudya & Nazare, 2012). In Uganda, there are hardly any academic studies available related to the process of knowledge creation and diffusion in PRO.

Therefore, the aim of this paper is to discuss knowledge creation and diffusion between UIRI and SMEs, and thereafter, develop strategies for KT. Uganda Industrial Research Institute, established to spearhead industrialization of Uganda, is a Centre of value addition, business incubation, innovation, product and process design and technology transfer. It also offers outreach services for creation of agro-industry facilities (UIRI Strategic Plan 2007-2012). It is important to know how interactions between the PRO and industry might affect the possibilities of achieving industrial development. The research question that this paper answers is: how is UIRI interacting with agro-processing industries from creation of knowledge to its application? The research hypothesis is that greater UIRI – Industry interactions will lead to industrial development in Uganda.

For purposes of this paper, KT is defined as a dynamic and iterative process that includes synthesis, dissemination, exchange and ethically sound application of knowledge within a complex system of interactions between researchers and users. KT is broader in scope than technology transfer and this operational definition encompasses the steps necessary to move knowledge into action (Sibley, Straus, Webster & Jaglal, 2011).

The paper is structured as follows. The following subsection reviews the existing literature on KT. Section 2 describes the methodology used to carry out this study. Section 3 presents the main findings. Section 4 discusses the empirical results with interpretations and Section 5 provides the concluding remarks.

1.2 Theoretical Framework

Different conceptual frameworks have emerged in the literature aiming at understanding the way scientific and technological knowledge should be produced and supported (Arza & Lopez, 2011). The concept used as a basis for this study is "Mode 2" Production of Scientific Knowledge (Nowotny, Scott & Gibbons, 2003; Gibbons, 1997). This framework proposes change from Mode 1 thinking (production of knowledge governed by the academic interests of a disciplinary community), to a broader social and economic context of application of knowledge, which intends to be useful and usually involves more than one discipline and more than one community (Mode 2). Figure 1 below represents the conceptual framework used guide
this study.

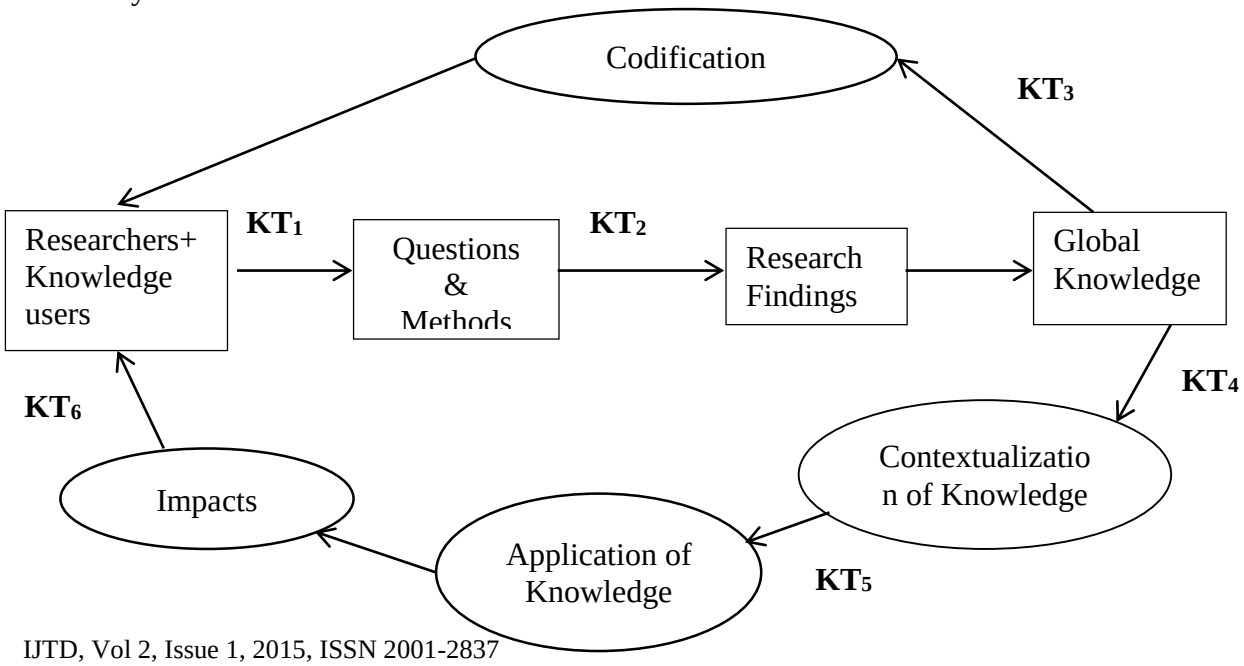

Figure 1: Important KT Stages in Research Cycle

Source: adopted from www.cihr-irsc.gc.ca with modification

KT_1: defining research questions and methodologies
KT_2: conducting research (as in the case of participatory action research)
KT_3: publishing research findings in plain language and accessible formats
KT_4: adapt knowledge to local context by addressing related barriers and facilitators to knowledge use
KT_5: making decisions and taking actions informed by research findings
KT_6: influencing subsequent rounds of research based on impacts of knowledge use

The framework holds similar view points with the KT theory and the Triple Helix perspective (Etzkowitz and Leydesdorff, 2000), which highlights the benefits associated to a more direct interaction and contribution to the industry. The focus of KT is to improve the dissemination and uptake of knowledge in decision-making. The audience of KT includes various decision makers such as entrepreneurs, intrapreneurs, consumers, researchers, policy makers, educators and the general public (Sibley et al., 2011). According to one of the major models of KT, the Knowledge-to-Action framework by Graham and Tetroe (as reprinted in Sibley et al., 2011), first, a gap must be identified between current practice and the evidence. Subsequently, to address the identified gap, the evidence must be adapted to the local environment while simultaneously addressing related barriers and facilitators to using the evidence in that particular situation. Strategic interventions (targeted to the barriers and facilitators) are required to facilitate uptake of the knowledge, followed by ongoing monitoring and evaluation to assess the impact of knowledge use and ensure knowledge use is sustained.

Dissemination and exchange are critical components of KT. Gagnon (2011) defines dissemination (also known as Knowledge Transfer or End-of-project KT) as targeting research findings to specific audiences. According to Acworth (2008), Cambridge Massachusetts Institute (CMI) defines knowledge exchange as a two-way flow of information, primarily between academia and industry, in which problems and market needs of the latter are the basis for defining the goals of research for the former. The fruits of this research are fed back in the form of solutions that can be implemented for the benefit of industry and the economy in general. Gagnon, (2011) further defines knowledge exchange, as involving active collaboration and simultaneous exchange between researchers and knowledge users throughout the research process from identifying and shaping the research questions to collecting data and interpreting findings and disseminating and applying the results.

2.0 METHODOLOGY

2.1 **Research Design**

This was a single case study involving analysis of UIRI's interactions with the agro-processing SMEs.

2.2 Research Approach

Basing on the questions that the study aimed to answer, the research approach was qualitative. The rationale for this was the need for detailed information and an in-depth understanding of the specific case.

2.3 Description of Population

This study established the nature of interactions by examining how stakeholders were involved in the UIRI project cycle. The population of projects from which samples were selected comprised agro-industry activities undertaken by UIRI since 2005.

2.4 Sampling Strategy

Purposive sampling method was used in this study. The categories of agro-industry projects which UIRI had carried out include production of foods and beverages, paper and wood products, and textiles. Food and beverage processing projects were selected because the largest number of projects done by UIRI was in this category. The sample included 10 UIRI food processing projects.

2.5 Data Collection Methods

Primary data was collected through face-to-face interviews and field notes on observations. Secondary data sources included reports, policy documents and the UIRI website (www.uiri.org). An interview guide for UIRI researchers was developed based on KT literature to build information on the nature of the interactions between UIRI and the agro-processing industry. Questions on what led to initiation of projects, how dissemination was done and existence of criteria to assess project outcomes were analyzed. The end was to scrutinize dissemination and check for the important stages of KT in the research cycle. The data was collected between November 2012 and January 2013.

2.6 Data Analysis

The empirical material from interviews was summarized and analyzed according to how the different issues asked and answered were interrelated.

3.0 FINDINGS

This section summarizes the findings of the study.

3.1 Agro-processing projects

The projects studied are described in table 1 below.

Table 1: Description of UIRI agro-processing projects

	Project	Reason for Initiation	Financial Support
1.	Food fortification 2007-2011	To reduce micronutrient malnutrition in the East, Central and Southern African region and improve child and maternal health, with various stakeholders.	(Academy for Educational Development (A2Z), US Agency for International Development (USAID)
2.	Development of value-added meat products	motivated by the UIRI business incubation programme	Government of Uganda (GOU) + Millennium Science Initiative (MSI)
3.	Dairy processing	motivated by the UIRI business incubation programme	GOU + MSI

4.	Fruits and vegetable processing	motivated by the UIRI business incubation programme	GOU + MSI
5.	Design and construction of hybrid solar drier	Food preservation. Equipment using solar energy and biogas to dry food	GOU
6.	Design and construction of manually driven threshers/shellers	Increase productivity. Extraction of maize grains, coffee beans, groundnuts seeds	GOU
7.	Design and construction graders	Increase productivity. Sorting coffee, groundnuts, maize	GOU
8.	Design and construction of Ewing III	Value addition. Producing groundnut paste	GOU
9.	Design and construction of maize mill	Value addition. Hammer mill to produce maize flour	GOU
10.	Construction of manual and motorized cassava graters	Value addition. To tear the cassava flesh into pulp for subsequent processing	GOU (pool from National Agricultural Advisory Services (NAADS) and UIRI)

3.2 Channels of Interaction

Uganda Industrial Research Institute interacted with industry through a variety of channels. Table 2 below describes the common channels.

Table 2: Channels used for UIRI-SME interaction

Interaction Channel	Description
SME incubators/creation of physical facilities	The incubators were all addressing local economic development related problems that aim to improve the entrepreneurial competence including training in production, business development, ICT skills, marketing, among others.
Training	Interested persons applied and some of them were offered training in different areas of food processing depending on their interest. Students from universities and other tertiary institutions were also offered industrial training in different areas.
Trade shows/exhibitions	Products developed were exhibited at trade shows for public awareness.
Networking	Entrepreneurs also made valuable contacts with suppliers, market, etc., through UIRI
Joint research projects	This involved research undertaken by both parties
Conferences/workshops/seminars	Information was diffused by bringing stakeholders together.
Consultancy work	This refers to work commissioned by industry which did not involve original research e.g. conducting routine tests (analytical testing) or providing advice to industry.

3.3 KT and the Research Cycle

Knowledge Translation is based on involvement of users in the research process (interactions). To construct the measure of the *involvement of knowledge users*, focus was on the 6 KT stages relevant in the research cycle. The sample projects were explored for these stages. Each stage was coded 1 if it was indicated that it was undergone and 0 otherwise. The scores were added up so that a project scored 6 when all KT stages were undergone and 0 otherwise. The total score of each project was calculated and expressed as a fraction of 6 to give the index of *involvement of knowledge users* in the cycle. The aggregate score of the 10 projects was expressed as a fraction of the aggregate whole (60, for 10 projects) to give a measure of the *extent of involvement of knowledge users overall* depicted by the sample projects. The results are summarized in table 3.

Table 3 : Projects with KT stages covered in the research cycle

Project	Total KT Score	No. of KT Stages	KT Index
Food fortification 2007-2011	5	6	0.83
Development of value-added meat products	5	6	0.83
Dairy processing	5	6	0.83
Fruits and vegetable processing	5	6	0.83
Design and construction of hybrid solar drier	1	6	0.17
Design and construction of manually driven threshers/shellers for maize, coffee, groundnuts	0	6	0.00
Design and construction graders for coffee, groundnuts, maize	0	6	0.00
Design and construction of Ewing III for producing groundnut paste	0	6	0.00
Design and construction of maize mill (hammer mill)	0	6	0.00
Construction of manual and motorized cassava graters (graters tear the flesh into pulp for subsequent processing)	4	6	0.67
Total	**25**	**60**	**0.42**

4.0 DISCUSSION

Findings revealed that UIRI projects are mainly built around identified social and economic needs, for example, low productivity, poor quality/low value of products, malnutrition, and expensive production equipment/technology, among others. Researchers developed products, and then an incubatee was identified to commercialize the products. In other cases, researchers worked with an incubatee to develop the incubatee's product for the market. The first is Mode 1 while the second is Mode 2 generation of knowledge.

The analysis indicated greater involvement of knowledge users (Mode 2) in the projects that were driven by the business incubation programme and those that were financially supported by other stakeholders, with KT indices 0.83 and 0.67. The Meat Processing, Dairy Processing and Fruits and Vegetable Processing projects were motivated by the business incubation programme, and the

facilities were boosted by an additional fund from MSI. The Cassava Grater Project was a UIRI-NAADS collaborative project bringing a pool of resources from both organizations, and the Food Fortification project was a UIRI-USAID-A2Z collaboration, funded by USAID and A2Z.
Solutions to some problems were unsuccessful or underutilized because of poor quality of output, high production cost leading to high cost of the unit, farmers lacking business skills, therefore, not appreciating easily the use of technology and the population finding some of the technology unaffordable and, therefore, being unable to implement it. This was the case with the design and construction projects of the hybrid solar drier, threshers/shellers and Ewing III, details of which are presented in table 4 below.

Table 4: Details of project outcomes

Project	**Outcome**
Hybrid solar drier project	It was not possible to sustain the project because of the challenge of storing solar energy and lack of a constant supply of biogas for users, which made long hours of drying persistent. Fossil fuel driers remained more adaptable despite the high cost of operation. Modern remedies have to be adopted as drying area per unit solar is large.
Manual threshers/shellers	Electric-driven shellers are preferred due to the toughness of the shells. Farmers are also subsistence and do not easily appreciate use of technology.
Groundnut sheller	The quality of seeds was not good because of the variation in size of seeds produced in different areas… Farmers also lack business skills so they do not easily appreciate/buy the technology and thus some of it has not been utilized. Also, cost of the unit was high for the farmers.
Ewing III	Sustainability of the project was not achieved due to the high cost of fabrication and difficulties in sourcing material requirements.

The six KT stages are opportunities/points of interaction within the research cycle. From the results, the KT index of the same projects is 0. Therefore, there is a link between interactions and project success. This result is in agreement with the study of Lundvall (2004) which explains learning and innovation as an outcome of interaction.

Much as the economy faces social and economic needs such as mentioned earlier in this discussion, it is insufficient for researchers to generate solutions in isolation. Mode 1 (where problems are set and solved in a context governed by the largely hypothetical interests of researchers) is seen to have resulted in push efforts which were sometimes futile because there were disparities in the specific context of application. Push efforts take place when producers of research knowledge plan and implement approaches to push (disseminate) knowledge toward audiences who they believe need to receive it (Gagnon, 2011). To solve the shortcomings of lack of knowledge exchange, CMI implemented a Knowledge Integration Community (KIC) model which brought together four human components, comprising academic researchers and educators, industry participants and government policy makers. Among the lessons learnt through CMI projects was to solicit industry input to identify areas where research could contribute a solution before calling for proposals (Acworth, 2008).

The traditional channels of interaction are observed as in Rast et al. (2012), Arza and Lopez (2011) and D'Este and Patel (2007) as the vehicles for KT between UIRI and the industry, except the Intellectual Property Rights (IPR) channel which involves technology licenses and patents. Communicating knowledge generated to improve industry through conferences/workshops/seminars and trade shows/exhibitions may be appropriate for some audiences, for example, policy makers, consumers and the general public, where the KT goal is to communicate knowledge. However, these forms of interaction are quite linear for the case of industry where the KT goal is to change behaviour. The impacts of knowledge use were largely unknown in the case of working outside UIRI's physical facilities, monitoring and evaluation to assess the impact of knowledge use therefore demanded improvement. Overall, the index of *involvement of knowledge users* in the UIRI project cycle was 0.42. The maximum value that the index can have is 1. This therefore indicated that interactions with knowledge users were inadequate.

Knowledge generated to improve industry requires appropriate contextual considerations (Gibbons 1997; Sibley et al., 2011). During one of the projects where CMI implemented the Knowledge Integration Community (KIC), there were regular visits to industrial partner sites resulting in personal interactions for purposes of addressing specific issues of a technical nature. Diffusion (e.g. use of word of mouth, publications, presentations) is valued for fundamental research, as fundamental discoveries are exposed to the scrutiny of readers and conference participants so as to ultimately be replicated or refuted (Kerner & Hall, 2009).

While dissemination strategies foster collaboration and associations between actors, there is little evidence of their effectiveness at actually changing practice (Sibley et al., 2011). Lavis and Reardon (as cited in Gagnon, 2011) propose some fundamentals that reinforce dissemination, among which is to understand the audiences and their information needs through ongoing relationships between them and those who are producing the research. Part of the reason for underutilization of knowledge/technology was that farmers did not appreciate its use due to lack of entrepreneurial skills. Gagnon (2011) emphasizes existence of a dissemination plan which puts into consideration the nature and size of the audience, the available resources to devote to dissemination as well as what impact the proposed activities will achieve before the plan is implemented to enhance the plan's success and facilitate evaluation of the plan. According to Acworth (2008), CMI discovered that knowledge exchange is a 'full contact sport' and there is no substitute for people moving around and meeting face-to-face.

Therefore, for applied research, as is the objective of UIRI, Mode 2 has greater potential to impact industry and policy in the short run. One outcome of this kind of work is practice-grounded research, research that is based on data that comes directly from practice and yields findings that can inform practice (Rynes, Bartunek, & Daft, 2001). In Graham and Teroe's KT model (Sibley et al., 2011), the knowledge creation phase involves knowledge syntheses with systematic reviews and meta-analyses, and ultimately forms knowledge products such as best practice guidelines. The goal is that knowledge becomes more useful to the end-user as it is funneled through this refinery.

The study of Ecuru et al. (2012) proposed a framework which can be used to describe innovation systems in low income countries, defining Science, Technology and Innovation (STI) as a function of financing (F), governance (G), human capital (Hc) and interactions within the organization and across functional spheres (r).

$STI = f(F, G, Hc, r)$…… (i)

In this study, it was clearly demonstrated that financing and interactions are crucial elements for innovation to take place.

A policy implication emerged. One of the government investment priorities of the NDP (2010, p.49) is STI, and promotion of value addition is a specific intervention area. There is consistency in policy and persistence in the roles assigned to the PRO as a key agent in development. The intervention has led to building long-term research capacity, for example, physical production facilities/incubators within and off UIRI campus and other resources such as new laboratory tools and analytical methodologies that constitute fundamental inputs for the industry. However, the limitations of PRO facilities such as space available in a given time, point towards the need for additional interventions in knowledge user locations. Beside startups, existing enterprises with similar competitiveness challenges can be supported for more interaction with industry. The policy recommendation is that guidelines and regulations for Integrated Knowledge Translation/Mode2 are developed. To encourage complementary innovation efforts rather than firms simply interacting to substitute for innovation activities they do not perform, policy tools should attach some target in terms of investing in in-house innovation as a requirement for firms to interact with the PRO.

Lessons learnt:

The major issues that needed to be addressed are highlighted. Uganda Industrial Research Institute needs a paradigm shift from Mode 1 to Mode 2 thinking. The assumption that developing technologies to be taken to industry and organizing training programmes to pass on knowledge will create uptake by the industry or impact on the industry, for that matter, is challenged. In systems thinking, the technology developed should be together with the end users of the technology. Working together with the end users will also facilitate determination of what they can afford, specific sizes they need, among other details. All the failure in technology transfer or adoption is because of the two actors working in isolation.
Furthermore, developing knowledge/technology together will lead to joint monitoring and evaluation whereby the end use would even give the feedback on the efficiency of technology without necessarily requiring UIRI to demand this information. It is a sure way to facilitate knowledge exchange throughout the process.

Limitations of the Study
It was difficult to retrieve information on projects that were spearheaded by personnel who are no longer employees at UIRI. Nonetheless, personnel who had been involved in the respective sections for longer periods of time were consulted and, therefore, the author is confident that this did not greatly affect the data.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion
Uganda Industrial Research Institute is mandated with spearheading industrial development in Uganda. From the findings of the study, the approaches to knowledge production were both Mode 1 and Mode 2, the latter mainly facilitated by incubator facilities. Mode 1 especially led to underutilization of research results or impracticable results. The findings, therefore, suggest that

to improve the agro-processing subsector, there is need for a paradigm shift from Mode 1 to Mode 2 thinking, since Mode 1 has implications on the usefulness of research results.

5.2 Recommendations

A paradigm shift to Mode 2 research suggests an integrated approach which is potentially more time consuming, demanding, and resource intensive because it requires both researchers and knowledge users to develop new skills, knowledge, and perspectives such as systems thinking and relationship management. Temporary teams can be built to facilitate Mode 2. These can be achieved through collaboration with universities, involving several research groups depending on their area of competence. This solves concerns of human capital shortage. In addition, taking advantage of university human capital partly solves the demand on new skills and knowledge as the university is dynamic with changing student generations, nurturing new persons and new ideas. The institute should adopt the concept of the KIC for every project carried out to bring the researcher and knowledge user communities together through an interactive process. Uganda Industrial Research Institute could explore the possibility of developing consulting opportunities within the industrial partners as an alternative revenue channel that would support costs associated with further research. This is one way the industry can contribute financially towards the KIC's long-range objectives. The projects explored in this study revealed that the impacts/desired outcomes of projects executed were defined. Appropriate indicators for measuring outcomes of an intervention should be developed to facilitate evaluation of projects.

5.3 Further Work

This study has empirical limitations as it is a single case study which means the generalization of results is bounded by specificities of UIRI. A general set of new questions this paper has opened relates to the extent to which the findings can be generalized to other public research institutions in Uganda and more so to other LDCs. Future research should design a larger comparative study that analyzes interactions beyond a case.

Despite the empirical limitations of the study and possibilities for further research, this study is believed to help in deepening our understanding of the status of interactions between public research organizations and industry in Uganda.

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Towards Interoperability: Has theoretical knowledge of Ontologies and Semantics had any impact on Geospatial Applications in GI Science?

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ABSTRACT
The problem faced by Geographic Information Systems (GIS) today is the lack of interoperability among the various systems. Scientists do better when they share resources: computing power, data, tools, models, protocols, and results but making resources available is not the same as making them useful to others. Thus there is need to share common understanding of the structure of information among people or software agents, to enable reuse of domain knowledge, to make domain assumptions explicit and to automatically integrate disparate databases. This research focuses on how theoretical and conceptual research visions in the field of Ontologies and Semantics have impacted on spatial applications today. Using scholar search engines such as Web of Science, Google scholar, Research Gate and GI Science journals, a document review of ontology publications in GI Science was evaluated. Results showed a growing number in Ontology and Semantics publications in the geospatial domain since 1991 and that major research efforts have revolved around creation and management of geo-ontologies, ontology integration, and matching geographic concepts in web pages. Results further showed that ontologies and semantics have been used in SDI implementation, spatial databases, OGC web services, VGI, symbol grounding, semantic similarity, ´big' Geodata and sensor networks, location based services, geocoding and so many other applications in the geospatial domain. This shows an evolution in different methods in representing multiple epistemological perspectives of same spatial events and entities as well as attaching contextual information in interest of enhancing interoperability across institutions and geography.

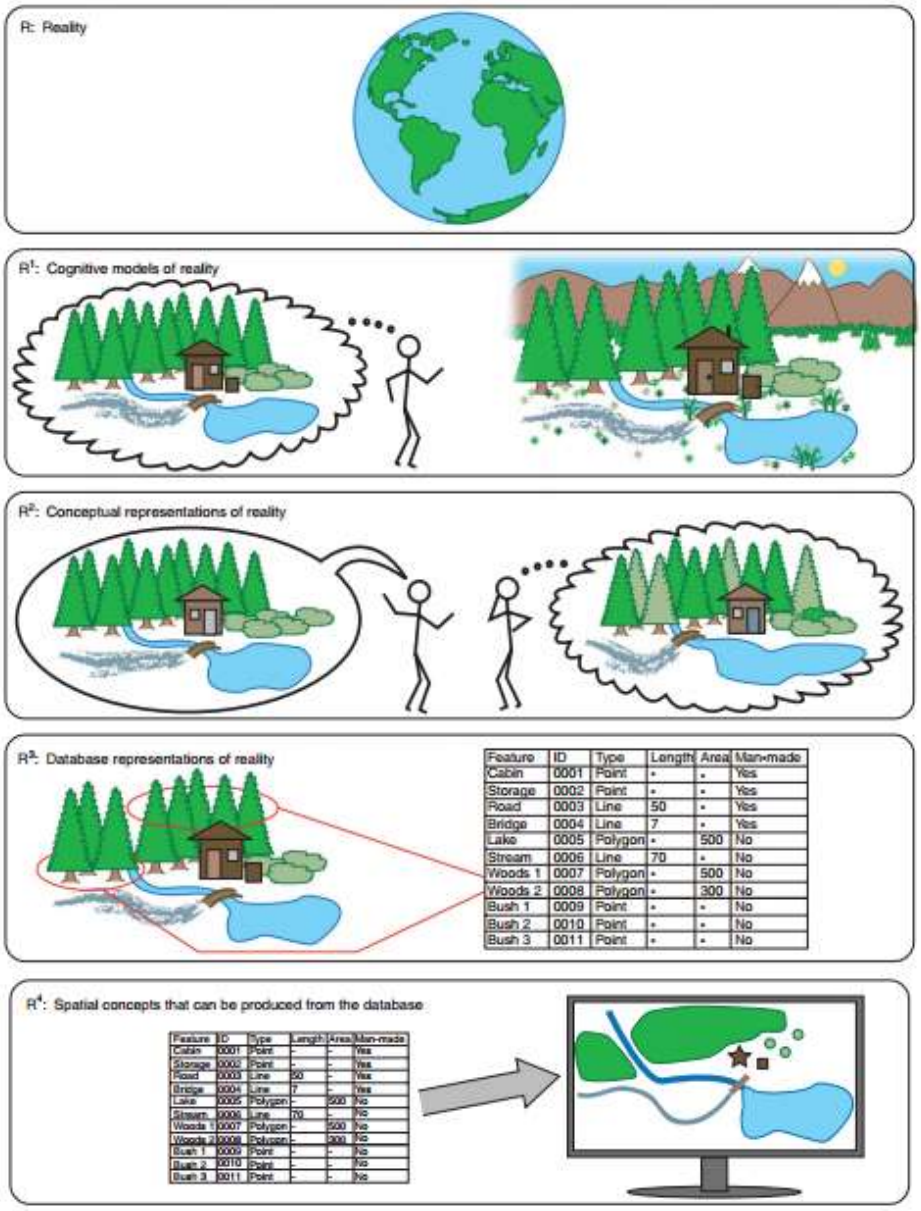
KEYWORDS*:* GI Science, GIS applications, Interoperability, Ontologies and Semantics.

1.0 INTRODUCTION

Scientists do better science by sharing their resources i.e. computing power, data, tools, models, protocols, and results;- but making resources available is not the same as making them useful to others. There is need to share common understanding of the structure of information among people or software agents, to;- enable reuse of domain knowledge, make domain assumptions explicit and automatically integrate disparate databases. Ontologies have been proposed as a solution to the 'Tower of Babel' problem that threatens the semantic interoperability of information systems constructed independently for the same domain. In information systems research and applications, ontologies are often implemented by formalizing the meanings of words from natural languages (Mark *et al*., 2003). However, words in different natural languages sometimes subdivide the same domain of reality in terms of different conceptual categories. If the words and their associated concepts in two natural languages, or even in two terminological traditions within the same language, do not have common referents in the real world, an ontology based on word meanings will inherit the 'Tower of Babel' problem from the languages involved, rather than solve it (Mark *et al*., 2003).

Guarino and Giaretta, (1995) stated that Ontology means something very different in philosophy than it does in information systems. In philosophy, ontology is defined as "what is" while in

Information Science, ontology is defined as "an explicit specification of a conceptualization" (Gruber, 1993), where a conceptualization is a way of "thinking about a domain" (Uschold, 1998) while semantics refers to the meaning of terms. As a GIS community we embrace the information science perspective. The widely accepted conceptualizations of geographic world are fields and objects (Couclelis, 1992 and Goodchild 1992) which are generic conceptual models. Ontologies of the geospatial domain define geographic objects, fields, spatial relations, processes and their categories. Egenhofer and Mark (1995) introduce a body of knowledge that captures the way people reason about geographic space and time. Fonsesca *et al* (2002) explain the ontology driven GIS architecture that can enable geographic information be integrated in a seamless and flexible way based on semantic values regardless of the representation and for that reason they propose a conceptual model for geographic information with its computer representation. Figure 1 shows the different geographic conceptualizations of same reality and their computer representation stressing the need for ontologies and semantics to ensure interoperability.



Feature	ID	Type	Length	Area	Man-made
Cabin	0001	Point	-	-	Yes
Storage	0002	Point	-	-	Yes
Road	0003	Line	50	-	Yes
Bridge	0004	Line	7	-	Yes
Lake	0005	Polygon	-	500	No
Stream	0006	Line	70	-	No
Woods 1	0007	Polygon	-	500	No
Woods 2	0008	Polygon	-	300	No
Bush 1	0009	Point	-	-	No
Bush 2	0010	Point	-	-	No
Bush 3	0011	Point	-	-	No

Figure 1: Levels of abstraction associated with computational ontologies. *Source: (Shuurman 2009)*

According to Schuurman (2006) ontology research in GI Science arguably began in the mid-1990 and three salient issues have been addressed in formal terms through the ontology lens since the mid-1990s namely; *Categorization, Data Models, and Semantic Interoperability*.
And as such there has been a trend in ontology research in that;

- There has been an evolution in different methods of representing multiple epistemological perspectives of same spatial events and entities as well as attaching contextual information to database elements in order to identify different ontologies in interest of enhancing interoperability across institutions and geography (Schuurman, 2009).
- Multiple stakeholders representing different scenarios, agenda and interpretations of the geographical world.

2.0 METHODOLOGY

Using scholar search engines such as web of science, Google scholar, research gate, GI Science journals like *International Journal of Geographical Information Science Computers and Geosciences Transactions in GIS, Cartography and Geographic Information Sciences*; and international conference proceedings; a count of all publications with the words "*GIS/GI Science, ontologies and/or semantics"* was made to determine the trends in publications of work related to ontologies and semantics. Furthermore, a search of major top level and domain ontologies in GI Science that have been developed in the last two decades was done to evaluate whether there are researchers who have devoted efforts in the creation of ontologies with a view of explaining the meaning of geospatial concepts. Finally, a document review of publications on applications of ontologies and semantics in GI Science was done together with interviews with GI experts on the applications utilizing ontologies and semantics. The sample of interviewees was randomly selected from GI authors in ontologies and semantics from citation web in the web of science to validate the document review. The applications were then discussed in detail in a view of understanding how theoretical knowledge in the field of ontologies and semantics has had an impact on geospatial applications.

3.0 RESULTS AND DISCUSSION

Results from Web of Science and Google scholar search show a growing trend in ontology and semantics research as shown in figure 2. This is an indicator of growth of theoretical research in the field of Ontologies and Semantics as well as ontology enabled applications.

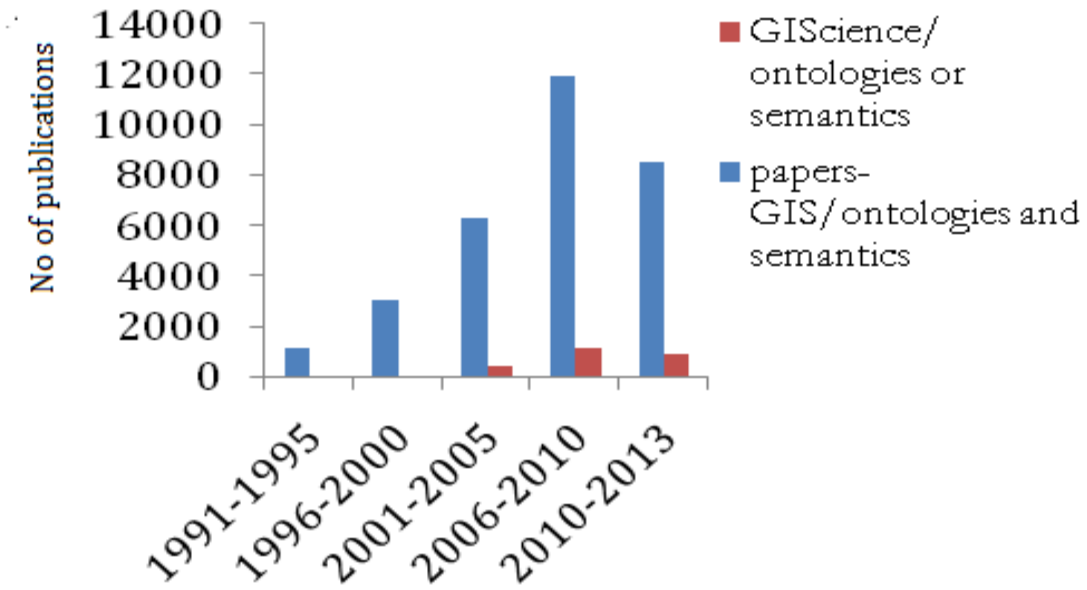


Figure 2: Searched publications with words "GIS/GIScience, ontologies and/or semantics"

Search results further indicated that recent GI research has been devoted to developing ontologies with a general view of explaining the meaning of geospatial concepts leading to development of top level ontologies and domain ontologies that are compliant to the W3C standards stack for the semantic web. Such ontologies include;

- SUMO (The Suggested Upper Merged Ontology)
- SWEET (Semantic Web for Earth and Environmental Terminology)
- DOLCE (Descriptive Ontology for Linguistics and Cognitive Engineering) *(Sieber, Wellen and Jin, 2011)*
- DIGEST (Feature and Attribute Coding)
- USGS Spatial Data Transfer Standard (SDTS)
- Geographic Data Description Directory (GDDD)
- Alexandria Digital Library feature Type Thesaurus
- GEMET (General Multilingual Environmental Thesaurus)
- AGROVOC (Agricultural Information Management Standards)
- EuroVoc (Multilingual Thesaurus of the European Union)
- Ttired ontologies

This indicates that researchers have considered use of ontologies as a means of knowledge sharing among different geographical databases (Smith and Mark 1998, Fonsesca and Egenhofer 1999). Results from the search and interviews further revealed that the GI Research visions arising from ontologies and semantics research in GIScience include; SDI (Geoportals), OGC web services, big Geodata, volunteered Geographic information (VGI), symbol grounding, Digital earth research initiative, sensor networks, spatial databases, semantic web, linked data, and web 2.0, Mobile computing and location-based services, Geocoding, and semantic similarity. Therefore, several semantic conceptual and interoperability frameworks have been proposed in recent years, in the geospatial domain (Bishr 1998; Brodeur *et al.,* 2003; Rodriguez and Egenhofer 2003; Ahlqvist 2005; Kuhn 2003; Lutz et al. 2003; Kavouras *et al*., 2005; Lutz and Klein 2006; Bian and Hu 2007; Hess *et al.,* 2007; Cruz and Sunna 2008; Schwering 2008; Staub *et al.,* 2008). Below is a discussion of some concepts and applications in GI science that have resulted from ontologies and semantics research and how they have had impacts on several applications in GIScience.

3.1 Semantic Similarity

Due to their analogy to spatial proximity functions, semantic similarity measures have been widely studied and applied in GIScience (Rodríguez and Egenhofer, 2004; Li and Fonseca, 2006; Raubal and Adams, 2010**).** Over the last years, the concept of semantic similarity has gained attention as a non-standard inference service for various kinds of knowledge representations and as such Semantic similarity measurement is a key methodology in various domains ranging from cognitive science to geographic information retrieval on the Web (Janowicz *et al.,* 2008) which is used to measure the degree of potential semantic interoperability between data or different geographic information systems (GIS). The power of similarity lies in providing a graded structure instead of a rigid Boolean matching (Janowicz *et al*., 2009). Similarity is essential for dealing with vague data queries, vague concepts or natural language and is the basis for semantic information retrieval and integration (Schwering 2008). A number of studies have focused on measuring user similarity using various methods like Feature-based approach (Tversky 77; Rodriguez and Egenhofer 2004), Network approach as modified by Janowicz (2010), geometric approach to trajectory, semantic annotations for venue categorization where the concept of semantic signatures can be applied in assessing user similarities (Ye *et al*., 2011, Li *et al.*, 2008, Lee *et al*., 2007), Alignment models and transformation models. The Semantic similarity concept has impacted spatial applications in that it enables efficient;

- Geographic Information retrieval (e.g. in web services and emergence response), theories established for (geographical) information retrieval and in the cognitive sciences use similarity functions to mimic human similarity reasoning as influenced by language, age, and cultural background data integration. Figure 3 below shows two web-based user interfaces implementing similarity and subsumption-based retrieval (Janowicz *et al* 2009) which have been in implemented and are available as operational free and open source software.
  The concept of similarity measures is also being used in assessing user similarity for personalized recommender location based systems and Geographic Information retrieval as illustrated by Mckenzi *et al.,* (2013) based on social data such as twitter, foursquare face book etc.
- Ontology merging,
- Searching and browsing through ontologies (semantic web) and hence in knowledge acquisition (Janowicz *et al*., 2008).
- Spatial decision support (identifying regions with certain characteristics) (Janowicz *et al*., 2008).
- Volunteered geographic information
- Land mark based navigation illustrated by where facades of buildings locally dissimilar to the neighbouring facades, were selected as prominent landmarks for route instructions in a pedestrian navigation service (Janowicz *et al.,* 2008)

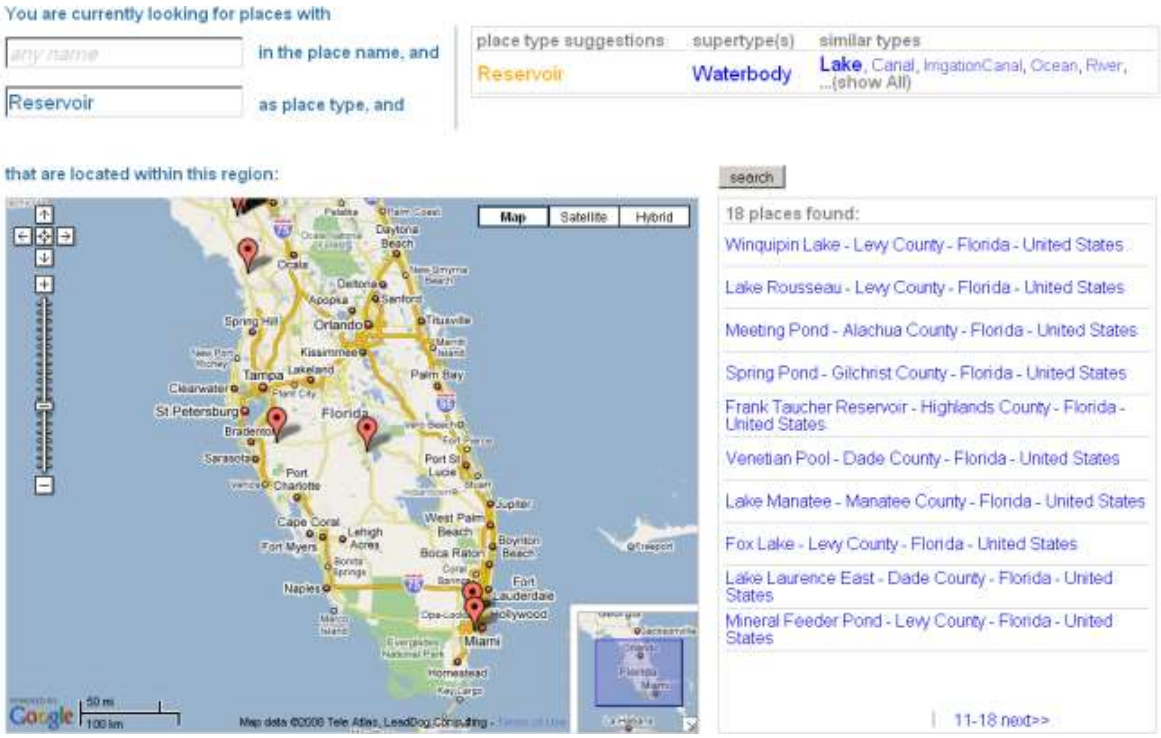


Figure 3: A subsumption and similarity-based user interface for Web gazetteers *(source: Janowicz, et al, 2009)*

3.2 Semantic Sensors

The use for networking sensors and measurement in GIScience is increasing now and again, this implies an increase in volumes of data thus heterogeneity of devices, data formats and measurement procedures. As such the OGC created Sensor web enablement initiative which caters for syntactical interoperability between sensors. But to achieve full inter-operability and management of the large volumes of data as well as sensor interoperability, there is need for adding semantic interoperability element.

Semantic Web technologies have been proposed as a means to enable interoperability for sensors and sensing systems. Semantic technologies can assist in managing, querying, combining sensors and observation data (Compton *et al.*, 2012). And as such, the Semantic Sensor Network (SSN) incubator group has developed a formal OWL DL ontology for modelling sensor devices (and their capabilities), systems and processes. This semantic sensor network ontology is based on concepts of systems, processes and observations as well as revolves around the central Stimulus-Sensor-Observation pattern. While developing this ontology, a thorough consideration of previous sensor ontologies and concurrent development of informal vocabulary of the main terms, drawing on earlier vocabularies like OIML/VIM and OGC/SWE (SensorML and OandM) was done. Examples of applications where such ontologies have been used include a semantic web based GIS application for environmental management (Tanasescu *et al* 2006), and disaster emergency management. Figure 4 shows an application that was developed under sensei FP7 EU project where linked-data location information were associated to local location ontology descriptions enabling navigation through a set of linked sensor data and querying sensors based on their deployment and other attributes as well as their physical locations.

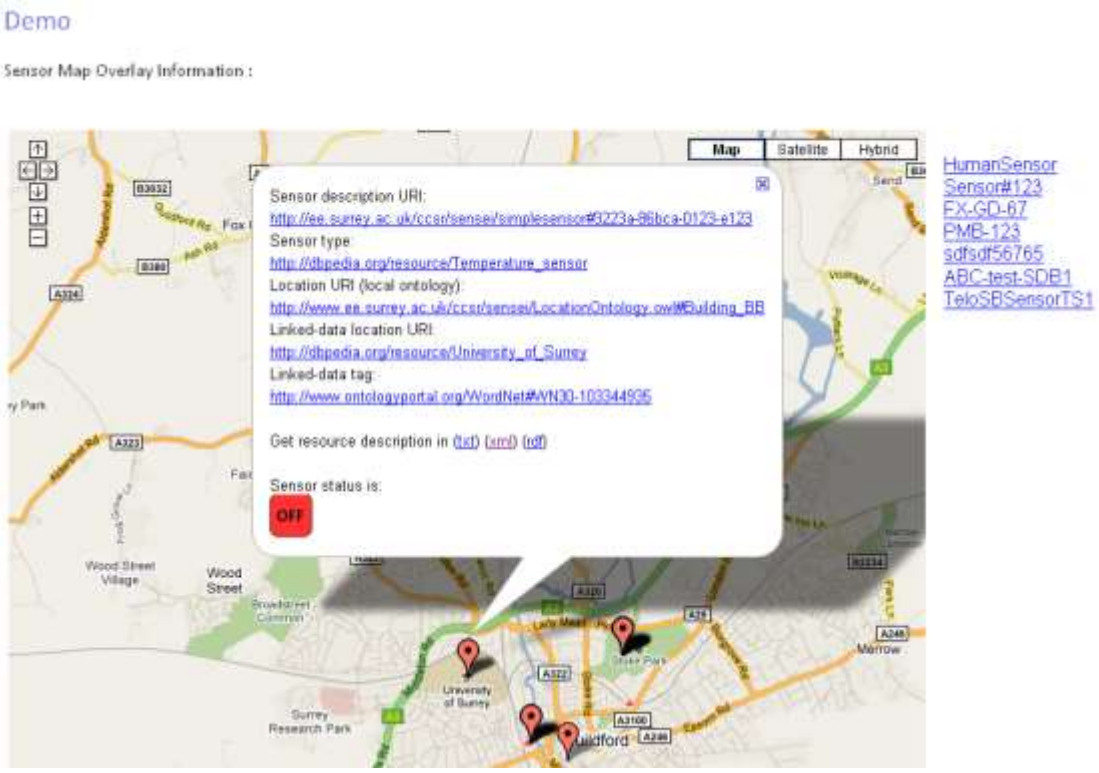


Figure 4: Navigation through linked sensor data and querying sensors (Source: SSN wiki [1])

3.3 Big Linked Geo Data

Big data is often characterized by *volume* (size of data, its multidimensional nature and inter-linkage in the global graph), *variety* (data formats, social media data, and authoritative data) and *velocity* (speed at which the data is created and updated). With big data, there is a rapidly increasing information universe with new data created at a speed surpassing our capacities to store it, therefore it requires improved methods to retrieve, filter, integrate, and share data (Janowicz 2012).

While the Web has changed with the advent of the Social Web from mostly authoritative towards increasing amounts of user-generated content, it is essentially still about linked documents. In contrast, the upcoming Data Web is about linking data and not about linked documents. With a growth rate of millions of new facts encoded as Resource Description Framework (RDF)-triples per month, the Linked data cloud approach allows users to answer complex queries spanning multiple sources. Due to the uncoupling of data from its original creation context; semantic interoperability, identity resolution, and ontologies are central methodologies to ensure consistency and meaningful results. Prominent geo-related Linked data hubs include *Geonames.org* as well as the *Linked Geo Data project*[2], which provides a RDF serialization of Open Street Map. These hubs have ontologies e.g. *Geonames* ontology which ensures meaningful and consistent results.

3.4 Geoportals/OGC web Services: Semantic interoperability of web services

[1] http://www.w3.org/2005/Incubator/ssn/wiki/images/9/96/Mashup-uni-deployment.png
[2] http://linkedgeodata.org/About

Although OGC web services have undoubtedly improved the sharing and interoperability of spatial information there are limitations such as difference in semantics in data from different sources (i.e. semantic heterogeneity). As a result, it is difficult for users to automatically compose and perform context-based search thus issues of low recall or low precision. Ontologies and semantics have been identified to overcome this problem of semantic heterogeneity and thus enabling searching, querying and discovery of spatial information. This necessitated research that led to establishment of semantic enablement layer for OGC services. This is achieved by first encoding data and service protocols linked to formal specifications stored in ontologies using annotations; secondly a service has to be established for managing and maintain these ontologies and finally encapsulate the semantic web reasoners to integrate them into SDIs. This research also led to several new services and tools such as conceptVISTA for ontology creation and visualization, the SWING concept repository, to name but a few.

In the Spatial Data Infrastructures (SDI) realm, the research community is aware of the potential benefits of using ontologies as a knowledge representation mechanism (Sen *et al.*, 2007). Ontologies in SDI are used in data sharing and systems development, facilitating resources and information retrieval, and discovery of web services. One typical SDI benefiting from ontology research is the INSPIRE portal which has an ontology-based architecture for Geographic Information (GI) discovery and GI retrieval.

Another application area for ontologies and semantics is the spatial decision support (SDS). Spatial decision support is a dynamic and heterogeneous domain that benefits from a detailed description of its existing process workflows, methods and tools (Li, *et al.*, 2012). Ontologies cover various aspects of spatial decision support ranging from decision problems, processes, methods and technology, over tools, models and data sources, to relevant case studies and literature (Li, *et al.*, 2012). In other words ontologies and semantics support the documentation and retrieval of dynamic knowledge in SDS by offering flexible schemata instead of fixed data structures. And as such SDS ontology was developed. Figure 6 shows architecture of an SDS Knowledge Portal application that incorporates ontologies and semantics to enable search, query and discovery of knowledge.

Figure 5: System architecture and workflow of the SDS Knowledge Portal application, *(Source: Li et al, 2012)*

An example of such applications was developed under the harmonISA project whose goals was to automatically integrate land-use and land-cover data in the three regions of Friuli Venezia-Giulia (Italy), Slovenia and Carinthia (Austria) as shown in figure 6. The HarmonISA provides several applications and services which include OGC Web Map Services, an ontology viewer, land use ontologies and a harmonized land use viewer a web application with which one can query, filter and navigate through land uses. It addresses the need to add semantics to land use classes in order to enable seamless integration of disparate data sources (in relation to trans-boundary issues)

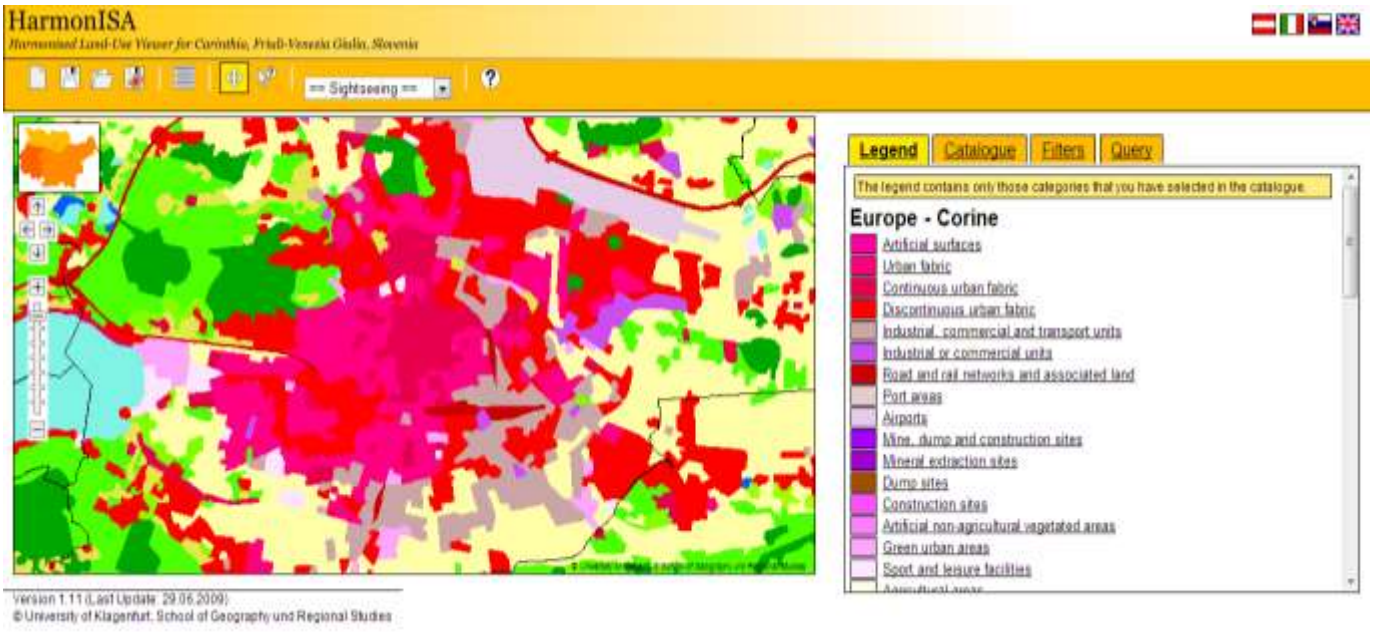


Figure 6: HamonISA land cover viewer. Source: HarmonISA website[3]

3.5 Symbol Grounding

There has been much discussion about the scope and limits of purely symbolic models of the mind and about the proper role of connectionism in cognitive modelling. Research has proposed that ontologies are part of the solution to the symbol grounding problem:-How can the semantic interpretation of a formal symbol system be made intrinsic to the system, rather than just parasitic on the meanings in our heads? How can the meanings of the meaningless symbol tokens, manipulated solely on the basis of their (arbitrary) shapes, be grounded in anything but other meaningless symbols? (Hanard, 1990). The concept of symbol grounding in GI Science has been applied in semantic image interpretation by Heudelot *et al* (2004) where there is mapping between numerical image data and high level of semantic representations thus a step towards automated extraction of meanings(semantics) of an image.

3.6 Semantic interoperability in spatial databases

[3] http://harmonisa.uni-klu.ac.at/harmonisa/application.jsp

Geospatial semantics is an emerging research theme in the domain of geographic information systems and spatial databases. Currently, we observe a wide use of geospatial databases that are implemented in many forms. Ontologies play an important role in enabling semantic interoperability between agents by providing them a common understanding of the reality. Ontologies contain some elements of context which are usually defined in the assumptions that help in interpretation of concepts. Ontology of geospatial data cubes would include definitions, assumptions, and properties (spatial and non-spatial) of the data cubes concepts (Sboui *et al.*, 2007). Research in ontology and semantics has been key in providing a conceptual framework and models for supporting semantic interoperability in geospatial data databases/data cubes. Interoperability in these databases helps in enabling simultaneous and rapid navigation through different data cubes, rapid insertion and retrieval of data in a data cube, interactive and rapid analysis of phenomena changes. An example of such conceptual frameworks is provided by Sboui *et al.,* (2007) based on communication patterns between people.
Today, the most successful applications in the ontology field as far as spatial data bases are concerned are database interoperability, and cross database search.

3.7 Semantics of Volunteered Geographic Information

With the advent of Volunteered Geographic Information (VGI) as coined by Goodchild (2007) where volunteers contribute to geographic data and access under public license via platforms like Open-street map, there are a variety of conceptualizations stemming from the variety of data sources e.g. if one wanted to map a certain disaster area, this may be conceptualized very differently by communities thus there is need for some kind of standardization. If one is to map and use VGI, then it is essential that one understands the different conceptualizations and can as well map between them as well as the data, semantics of volunteered geographic information. With increasing success VGI in different domains like disaster management (known as crowdsourcing), and thus being vital in daily lives of citizen, there need to ensure information obtained is quality and useful rather than focus on coverage. Semantic Web technologies have been proposed as a means to enable interoperability for sensors for VGI and systems. According to Kuhn (2007) some of the challenges range as far as exploiting the grounding effect of VGI on semantics; enabling and capturing semiosis in the social networks around VGI; and combining ontologies with folksonomies exist. Folksonomies use user applied tags of document for searches with in the document but the decision to use ontologies or folksonomies depends on application. AVGI/VGS framework ontology has been developed (Savelyev *et al* 2011) where a linked data model is used. The framework ontology is able to incorporate external vocabularies e.g. FOAF[4] (friend of friend) and because of VGI ontologies there has been rapid urge to develop ontologies tailored to needs of mobile applications coupled with best practices because mobile phones are the major platforms for VGI.

3.8 Geocoding

Geocoding is the act of turning descriptive locational data such as a postal address. Some of the geocoding services include Geonames (open source), yahoo, Google, Open-street map. Previously, the existing geocoding services were generally limited to assign a geographic coordinate to an absolute location such as a street address. Conventional geocoding services that work with absolute locations may not be able to determine the coordinates of the place of incident

[4] http://www.foaf-project.org/

always. For example, a geocoding service might assign coordinates of a particular place to another country or place with a similar name which is not right. In order to obtain exact longitude and latitude of a location, geolocation via ontologies and semantics is necessary. For example one can search for a place using the Geonames geocoding services, what happens here is that the search service returns the results as defined by Geonames semantics web ontology. This ensures that context is attached on the result being given depending on the quality of service.

4.0 CONCLUSION

The problem faced by Geographic Information Systems (GIS) applications today is the lack interoperability among the various systems. Applications may use different terminologies to describe the same conceptualization. Even when applications use the same terminology, they often associate different semantics with the terms. This obstructs information exchange among applications. The role of semantics for interoperability and integration of heterogeneous data, including geospatial information, has been long recognized (Sheth 1999). Research in the field of ontologies and semantics has enabled sharing of common understanding of the structure of information among people or software agents, to enable reuse of domain knowledge, to make domain assumptions explicit. Indeed, there is no doubt that that the field of ontologies and semantics has had an impact on applications in GI Science. This paper highlights the various research visions in the field of ontology and semantics for GI Science and gives examples how they impact various Geospatial applications. Major research efforts in ontologies and semantics have revolved around 1) creation and Management of geo-ontologies that constitutes activities involved in ontology management including designing, developing, registering, storing, discovering, visualizing, querying, and maintaining ontologies, 2) Matching geographic concepts in web pages to geo-ontologies 3)ontology and semantics integration thus new research visions/application areas in GI like OGC web services, SDI,SDSS, geocoding, big Geodata, linked geo data, volunteered Geographic information, image interpretation and so many other areas of GI Science. In all these application areas, the major role played by ontologies and semantics is that of enabling interoperability. In this era of big data, we envisage that future work in will focus ontology driven data science especially with real time or near real time streams of data, and geospatial modelling especially on the web with hope of resolving semantic ambiguity.

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Choice of Alternative Dispute Resolution Process in Uganda's Construction Industry

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Abstract

Construction disputes are one of the obstacles to successful project execution world over usually leading to increase in project cost and in worst cases stalling or suspension of the project may occur. The ability, therefore, to resolve contract disputes quickly and effectively makes a difference between a successful project and a failed one. Whereas attempts are in many cases made to resolve disputes, there has been no well laid criterion for the choice of the dispute resolution strategy. This study provides a framework for the choice of Alternative Dispute Resolution (ADR) based on the project risks. The study analysed the suitability of the Alternative Dispute Resolution Methods (ADRMs) to settle disputes arising from the above mentioned risks. It was found out that Negotiation is suitable for settling disputes from all risk items except for changes in laws and regulations. The result of this research will not only help construction practitioners and researchers in choosing the dispute resolution clause(s) to be included in the contract but also the choice of a suitable Dispute Resolution Method (DRM) to settle disputes arising during contract implementation. It is recommended that the construction industry in Uganda should put more emphasis on the suitability of a DRM to settle disputes right from the onset of contract design. In addition, the government legal system in partnership with the professional bodies in construction should introduce construction arbitration boards and Dispute Adjudication Boards in order to overcome the lengthy and costly litigation procedures.

Keywords: Alternative Dispute Resolution, Construction, Dispute Resolution Methods

1.0 Introduction

Construction like any business is risky. It has been observed that construction ventures are characterized by a high degree of uncertainty and complexity and that there are very few construction projects that do not give rise to some form of dispute during the construction stage (Cheung, 1999). Important to note is that most of the construction projects are executed through contracts which are generally not easy to comprehend even by professionals (Lyer*et al*., 2008). The other challenge affecting the construction industry is the adversarial attitude (Cheung &Yiu, 2007). All these combined have made the proliferation of disputes a regular phenomenon of the construction projects.

The process of dispute resolution lends itself to third party intervention (Fenn*et al*., 1997). Over the past two decades the construction industry has made tremendous progress in developing more efficient methods of dispute prevention and resolution. In China, for instance, flexible out-of-court dispute resolution (Alternative Dispute Resolution) mechanisms are the preferred options for

locals and foreigners wishing to bypass the uncertainties associated with the country's judicial system (Chan, 1997).

It has been pointed out that the use of Alternative Dispute Resolution (ADR) techniques has gained great momentum in the public sector during recent years in the construction industry (Cheung, 1999; Yousefi e*t al*., 2010). For instance, governments have initiated the inclusion of ADR methods as an integral part of the dispute resolution procedure in the standard forms of contracts for use in Government projects. Important to note is that no single dispute resolution mode can be universally applied successfully to every individual case and the choice of the most suitable dispute clause to resolve the disputes depends on various factors including the nature of the dispute (Chau, 2007). Construction contracts in Uganda either employ Adjudication or Arbitration clauses. However, it is reported that, even with these measures in place the government loses substantial amounts of money to contractors. One such a loss is when it lost over Uganda shillings 8.5 billion ($3.32 million) of taxpayers' money in arbitration awards to the contractor over a dispute during the construction of 21km of the Northern Bypass (Lumu, 2007). Uganda Shillings 20 billion ($7.81 million) was lost by the National Social Security Fund (NSSF) in Litigation awards during the construction of 19 storey Worker's House building (Nsamba&Mugisha, 2009). This shows a weakness in the dispute resolution process which would have been countered by a well designed dispute resolution mechanism whose implementation would require an assessment of the suitability of a Dispute Resolution Method (DRM) to counter the likely disputes in a project right from contract formation. With the use of a suitable DRM, minimal losses will be incurred by either party to the contract.The objective of this paper is to identify factors affecting the choice of an ADRM and the suitability of the dispute resolution method to settle disputes arising from specific project risks in Uganda..

1.1 ALTERNATIVE DISPUTE RESOLUTION METHODS

Alternative dispute resolution (ADR) is a non-adversarial technique which is aimed at resolving disputes without resorting to court. Randall (1996) provides a comprehensive list of ADR methods used in the construction industry in USA as arbitration, negotiation, mediation, mini-trials, Rent-a-Judge, and dispute review beards. All these methods advocate for resolution of disputes without parties embracing the legal professionals and the confrontational approaches of the other methods. In Hong Kong the common forms of ADR in the construction industry include; mediation, dispute resolution advisor and adjudication (Cheung, 1999). In Uganda ADR is seen as those techniques alternative to litigation (Kiryabwire, 2005). In this study ADR was taken to include techniques such as negotiation, mediation, mini trial, rent -a –Judge, Dispute Review Boards, Expert determination, Adjudication and Arbitration.

1.2 ADVANTAGES AND CONSTRAINTS OF ADR

Specific studies about the different techniques of ADR identified the following as the advantages

in Table 1.

According to Brooker and Lavers (1997), the weaknesses of ADR are of two types:

a) That ADR might share the main deficiencies of Litigation, because it would be hijacked by the legal profession. There is suggestive evidence that both sections of the legal profession, solicitors and barristers have already begun to seek a leading role in it.
b) That ADR might prove to be inferior to litigation in the following ways;

i) Use of ADR would indicate a weakness in one's case, compromising one's position in the overall picture of the dispute. ADR would reveal too much to the other side either of strategy or of substance.

Dispute resolution method	Key statements	Reference
Arbitration	Arbitration involves use of judges who understand the relevant technical issues and industry practices reduces the probability of unpredictable results, reduces costs and delays.	Galloway & Nielsen, 2011
	Arbitration is, in most cases, a cost-effective, expeditious, and efficient process that provides finality to a dispute. The arbitration award is final and binding, and easily enforceable in court.	Gardner, 2011
	The decision reached is final and binding and is usually enforced through the courts of any jurisdiction.	Gad *et al*., 2011
Mediation	Mediation facilitates sustainability of a good working relationship between the disputants. It is relatively economical, parties have greater control over their preparation phase, leads to a quick resolution and enables continuity of construction work on site.	Kumaraswamy, 2010
	The parties retain full control over how their dispute is to be resolved , the mediation process is strictly confidential and designed to preserve the relationship among the parties involved.	Gad *et al*., 2011
	Mediation has been recognized as an economical, faster method and with the flexibility in procedure.	Yan, 2010
	The use of mediation has been regarded as a flexible, cost-effective, and non-threatening way to dispute resolution.	Cheung &Yiu (2007)
Negotiation	Negotiation achieves objectives of decision makers while maintaining harmony, and reducing time, cost, and hostility.	Yousefi*et al*., 2010
Dispute Resolution Board (DRB)	The decision issued by a DRB is often advisory in nature and not binding.	Gad *et al*., 2011
Expert determination	The expert's decision is usually final and binding. This form is usually chosen in complex technical issues in which the parties themselves may lack the technical expertise.	Gad *et al*., 2011
Rent-a-judge	The process can greatly expedite an outcome.	Randall, 1996
Mini-trials	The benefit is that the parties can often derive their relative positions without going through long, drawn out procedures. This will result into the dispute being resolved in days or weeks.	Randall, 1996

ii) ADR would jeopardize one's position in subsequent litigation by delaying or disrupting it

Table 1: Advantages of ADR

1.3 RISKS IN CONSTRUCTION

Risk in construction projects is derived from two main sources as indicated in Table 2.

- Project – specific risks are uncertainties existing in the project itself and may include the unexpected occurrences during the construction period that are inherent to the companies involved, or they may be determined by the nature of the project. They primarily lead to time and cost overruns or short falls in performance parameters of the completed project (Bing *et al.*, 1999).
- External risks are factors relating to national or regional or the local construction industry that significantly impact the success of the project. External risks originate from the competitive macro environment that the project operates within (Bing *et al*., 1999).

Table 1: Risk items in construction

Risk	Risk items	Reference
Project specific	Excessive demands and variations,	Gad *et al*., 2011
	Lack of communication and poor relationships	Kalayjian, 2000 & Gad *et al*., 2011
	Schedule delays, incomplete designs, late construction site possession, inclement weather, unforeseen ground conditions,	Kalayjian, 2000
	Cost overruns from ambiguous project scope, unclear project boundaries, inaccurate estimation, price fluctuations	Kalayjian, 2000
External risks	Political risks including inconsistencies in policies, changes in laws, import restrictions, war, revolution and civil disorder.	Kapila & Hendrickson, 2001;Bing *et al*., 1999; Zhi, 1995
	Legal Risks	Bing *et al*., 1999
	Environmental risks (catastrophes)	Bing *et al*., 1999
	Social risks (language barriers, different traditions and religious back ground	Bing *et al*., 1999

2.0 Methodology

The subjects of this study came from a population of practitioners with Contractors, Consultants and Government organizations that are involved in construction. The researcher obtained a list of contractors from Uganda National Association of Building and Civil Engineering Contractors (UNABCEC) and a list of consultant firms from the Uganda Association of Consulting Engineers (UACE). For the case of client organizations; Ministries, Departments and Agencies (MDAs) of government involved in routine construction, procurement and contract management were considered. Top technical managers were selected because such categories of people are believed to be knowledgeable about contract management and dispute resolution in Uganda. The questionnaire was tested with academics and professionals having experience in this area before being subjected to the targeted respondents

A target of 120 respondents from the population was considered. A total 60 respondents were targeted in the contractors category, 30 for consultants and 30 to clients' organizations. The respondents were required to rank the attributes of ADR and the risk items on a scale of 1 to 5.Data collected from the questionnaire surveys were analysed using statistical data analysis tools with the aid of SPSS 17, it was then tabulated to obtain relationships and divergences.

The coefficients of variations were used as a measure of the respondent's priority ranking. A principal component factor analysis was performed on the set of data obtained from the rankings to identify the interrelations among the different attributes from which the factors affecting the choice of ADR were derived and the most important factors were identified after ranking all of the factors. The risk items were ranked and t-test carried out to determine the significant enablers of disputes in the construction industry.

3.0 RESULTS AND FINDINGS

3.1 RESPONSE RATE

The overall response rate was 51%. The response rate for Contractors was 50%, for Consultants was 67% while that of client organizations was 37%. The gross total of the responses was 61 of which 30 were for contractors, 20 consultants and 11 for client organizations.

3.2 IMPORTANCE RANKING OF THE ATTRIBUTES OF ADR

Responses from clients, consultants and contractors were combined to give a basis for collective analysis.

Basing on the results in Table 3,the respondents identified remedy as the most significant attribute of ADR determining its choice with the lowest coefficient of variation of 0.173; this was closely followed by speed with coefficient of variation of 0.1954, fairness (0.2116), control (0.2199) and communication (0.2234). The high rank for remedy and speed can be justified from the point of view that projects have need such as timeliness of completion (Hewitt, 1985 and Alinaitwe, 2008) and as a result practitioners would not be willing to engage in processes that are time wasting in nature. The respondents ranked the attributes 'relationships' and 'enforceable' the lowest. This means that these have the lowest significance in their choice for use of ADR. The respondents' low choice for 'enforceable' could be due to the fact that ADR leaves the disputants with an option of appealing to other courts in case of dissatisfaction therefore rendering the result of ADR process not enforceable.

3.3 RESULTS OF THE PRINCIPAL COMPONENT FACTOR ANALYSIS

The Principal Component Factor Analysis (PCFA) was performed by SPSS 17 program. The Kaiser-Meyer-Olkin (KMO) measure of Sampling Adequacy was 0.549, which is greater than 0.5, hence considered acceptable (Coakes, 2005). The Bartlett's Test of Sphericity is 301.110 with p-value of 0.000. These indicate that the sample data were adequate for the purpose of carrying out Factor Analysis. Four factors with Eigen values greater than 1 were extracted. Factor Matrix after VARIMAX rotation is presented in Table 4 which gives the final statistics of the Principal Component Factor Analysis. The results show that four (4) factors were extracted as follows; Factor 1 comprises of three (3) items with factor loadings from 0.683 – 0.795, factor 2 has three (3) items with factor loadings from 0.533 – 0.830, factor 3 with four (4) items with factor loadings from 0.535 – 0.815 while factor 4 has two (2) items with factor loadings 0.619 – 0.912.

Table 3: Ranking of the attributes of ADR

Variable	Mean	Std. Deviation	Coefficient of variation	Rank
Remedy	3.8000	0.6587	0.1733	1
Speed	4.1167	0.8045	0.1954	2
Fairness	3.3500	0.7089	0.2116	3
Control	3.9000	0.8577	0.2199	4

Communication	3.8500	0.8601	0.2234	5
Flexibility	3.4500	0.7903	0.2291	6
Privacy	3.6000	0.9057	0.2516	7
Bindingness	3.5500	0.9284	0.2615	8
Economy	4.0500	1.1112	0.2744	9
Confidentiality	3.8000	1.1016	0.2899	10
Relationships	3.7167	1.1061	0.2976	11
Enforceable	3.4667	1.1118	0.3207	12

3.4 INTERPRETATION OF THE FACTORS AFFECTING THE CHOICE OF ADR

From Table 4, the attributes extracted as significant for factor 1 are: Economy, Speed and Control. The first two attributes address the benefits that may result from a successful ADR process (Cheung, 1999) whereas Control relates to the nature of the process of ADR (Cheung *et al*., 2002).

Factor 2 includes the attributes: Communication, Relationship and Remedy. The three attributes are inter – linked in that if good communication is exhibited between the parties then a strong working relationship will be developed and thus a remedy to the dispute will be easily got. According to Cheung *et al* (2002) these attributes address the ability of the ADR process to produce creative solutions; through effective communication and that the scope of the remedy to the dispute is comprehensive enough to satisfy the interests of the parties.Factor 3 included attributes: Flexibility, Fairness, Privacy and Confidentiality. It is apparent that these relate to the nature of the proceedings critically designed to avoid the dispute becoming known to public (Cheung, 1999). Factor 4 includes attributes: Enforceable and Bindingness; these address the settlement agreement as may be obtained in the ADR process (Cheung *et al.,* 2002).

Table 3: Results of the PCFA (Rotated Factor Matrix) for the ADR attributes

Attribute	Factor			
	1	2	3	4
Economy	0.795	0.293	0.271	0.139
Control	0.750	0.148	0.293	
Speed	0.683	0.394	-0.157	0.145
Communication	0.342	0.830	0.181	
Relationships	0.144	0.746		0.140
Remedy	0.348	0.533	0.324	0.229
Flexibility	0.237	-0.130	0.815	0.137
Fairness	-0.112	0.110	0.731	0.428
Privacy	0.328	0.338	0.542	-0.144
Confidentiality	0.360	0.469	0.535	-0.274
Enforceable	0.260		0.165	0.912
Bindingness		0.180		0.619

Therefore, the factors which affect the choice of ADR were found out to be;

(i) Benefits resulting from a successful ADR process
(ii) Ability of ADR to produce creative solutions
(iii) Nature of the proceedings of ADR
(iv) Nature of the settlement agreement

3.5 RISKS AS A SOURCE OF DISPUTES

From Table 5, excessive variations, followed by cost overruns, schedule delays and design and construction issues were rated to have the highest 'fueling' effect to construction disputes during project execution. It is important to note that these risks fall under project specific category of risks (Bing *et al.*, 1999). All these risks have got mean ratings of more than 3.0 which implies that they are having at least a fairly significant effect on 'fueling' construction disputes in Uganda.

Local customs backgrounds and different cultures were ranked the lowest enablers of construction disputes. These low values in the rankings suggest that these risks do not have significant effects on causation of disputes. It has also been established that these risks fall under the external risks category of risks (Bing *et al.*, 1999). The low rank of local customs background and different cultures could be justified considering the fact that the sampling involved only consultants and contractors with membership to UACE and UNABCEC respectively and did not cater for foreign companies.

One sample t-test was used to test the level of significance of the various risks as enablers of disputes and the results are presented in Table 6.The test value was set at 3.0 that corresponds to the neutral position of average (that is; the risk has a fairly significant effect on the project) on the scale in the questionnaire.

The null hypothesis H_0:$\mu=\mu_0$ (no significant difference between sample mean and the mean of the population) against the alternative hypothesis H_1:$\mu\neq\mu_0$ where μ is the population mean and μ_0 represents the critical rating above which the risk is considered significant. It can be seen from Table 6 that seven out of the twelve risks have significant levels less than 0.05.The decision was to reject the null hypothesis for the seven risks that have significant levels less than 0.05. For the seven risks there is a significant difference between the sample mean as viewed by the respondents and the population mean. This therefore suggests that the seven risks namely, excessive variations, schedule delays, cost overruns, design and construction issues, foreign exchange rates, different cultures and local customs background are the significant enablers of disputes on construction projects as viewed by the respondents.

Table 5: Overall view of the respondents

Risk item	Mean	Std. Deviation	Coefficient of variation	Rank
Excessive Variations	4.09	0.866	0.212	1
Cost over runs	4.29	0.97	0.226	2
Schedule delays	3.94	1.099	0.279	3
Design and construction issues (Technical issues)	3.91	1.164	0.298	4
Economic fluctuations	3.32	1.273	0.383	5
Inflation	3.29	1.268	0.385	6
Policy inconsistencies	2.91	1.24	0.426	7
Lack of Communication	3.12	1.533	0.491	8
Change in Laws and Regulations	2.62	1.326	0.506	9
Foreign Exchange Rates	2.35	1.323	0.563	10
Different Cultures	1.29	1.169	0.906	11
Local customs backgrounds	1.27	1.232	0.97	12

Table 6: One sample t- test for the risks

Risk item	Test Value = 3.0							
							95% confidence interval of the difference	
	Mean	Std. deviation	T	df	Sig.(2-tailed)	Mean Difference	Lower	Upper
Excessive Variations	4.090	0.866	7.329	54.000	0.000	1.088	0.790	1.390
Lack of Communication	3.120	1.533	0.448	54.000	0.657	0.118	-0.420	0.650
Schedule delays	3.940	1.099	4.992	54.000	0.000	0.941	0.560	1.320
Cost over runs	4.290	0.970	7.778	54.000	0.000	1.294	0.960	1.630
Design and construction issues (Technical)	3.910	1.164	4.566	54.000	0.000	0.912	0.510	1.320
Policy inconsistencies	2.910	1.240	-0.415	54.000	0.681	-0.088	-0.520	0.340
Change in Laws and Regulations	2.620	1.326	-1.681	54.000	0.102	-0.382	-0.850	0.080
Economic fluctuations	3.320	1.273	1.482	54.000	0.148	0.324	-0.120	0.770
Inflation	3.290	1.268	1.353	54.000	0.185	0.294	-0.150	0.740
Foreign Exchange Rates	2.350	1.323	-2.852	54.000	0.007	-0.647	-1.110	-0.190
Different Cultures	1.290	1.169	-8.512	54.000	0.000	-1.706	-2.110	-1.300
Local customs backgrounds	1.270	1.232	-8.056	53.000	0.000	-1.727	-2.160	-1.290

3.6 RISK – DRM MATRIX

The Risk –DRM matrix is presented in Table 7 and represents the respondents' views on the suitability of the DRM for a particular risk. In Table 7, '√' indicates that the dispute arising from such a project risk can be solved using the DRM in the top most row whereas '×' indicates the converse.

Table 7: Risk – DRM matrix

Risk category	Risk No.	Risk item	Negotiation	Mediation	Adjudication	Rent-a Judge	Dispute review board	Arbitration	Expert determination
Project specific	1	Excessive variations	√	×	√	×	×	×	×
	2	Lack of communication	√	√	×	×	×	×	×
	3	Schedule delays	√	×	×	×	√	×	√
	4	Cost overruns	√	×	√	×	√	×	√
	5	Design and construction issues	√	×	×	×	√	×	√
External	6	Policy inconsistencies	√	×	√	×	√	√	√
	7	Changes in laws and regulations	×	×	√	×	√	√	√
	8	Economic fluctuations	√	×	×	×	√	×	√
	9	Inflation	√	×	×	×	√	×	√
	10	Foreign exchange rates	√	×	×	×	√	√	√
	11	Different cultures	√	√	×	×	×	×	×
	12	Local customs backgrounds	√	√	×	×	×	×	×

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

Twelve attributes of ADR were identified and the key attributes which determine its choice for use were ranked as Remedy, speed, Fairness and control. Relationships and enforceability were ranked lowest.Following the principal component factor analysis; four factors affect the users' choice of ADR. The factors were identified as; the benefits that may result from a successful ADR process, ability of the ADR process to produce creative solutions, Nature of the proceedings and Settlement agreement.Seven (7) out of twelve (12) risks were identified as significant enablers of disputes in construction projects. These include; excessive variations, schedule delays, cost overruns, design and construction issues, foreign exchange rates, different cultures and local customs background.

4.2 RECOMMENDATIONS

The researcher identified that there is need to consider the nature of a project before choice of a DRM. This is evidenced by the DRM – Risk matrix which shows the suitability of a DRM for the various risks. It is recommended that the construction industry in Uganda should put more emphasis on the suitability of a DRM to settle disputes during contract design and at implementation stage. Including suitable dispute resolution clause(s) at contract formation stage will save time and money spent on unrealistic and unsuitable DRMs at the time of dispute resolution.

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Next-Generation Wireless Networks for Uganda 2020

Theme: Information and Communication Technology

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ABSTRACT

Next-generation wireless networks entail a high degree of flexibility, efficient use of available radio resources and an energy-efficient operation at low operational costs. They typically integrate use of technologies such as spectrum management, interference mitigation and management, and energy efficient technologies. This paper aims to project a next generation wireless networks scenario of Uganda by 2020. It identifies major environmental constraints that current and future network architectures will face, in particular in regards to deployment density and throughput requirements from 2012 to 2020. The paper further compares the current and forecast traffic patterns of Kampala District as an urban area and Gulu District as a rural but fast growing area. The WWRF wireless traffic model adopted projects throughput requirements as an aggregation of individual service requirements, service usage and user behavior. This paper focuses on voice, mobile Internet and video that are currently among the highly utilized services in Uganda. In similar studies for developed countries, next generation radio access networks are expected to deliver twenty times more throughput and capacity than current 4G/LTE networks while core networks are expected to handle a projected 1,000 times throughput increase, with a more flexible design that can cope with unpredictable demands more intelligently. The analysis for Uganda in 2020 showed a subscription growth to over 90%, and an almost five times increase in throughput. To meet future requirements with Uganda being largely rural by classification, there is need to foster public-private partnerships in addition to innovative spectrum management and efficient energy management.

Keywords: LTE, Next-generation wireless networks, Capacity, Traffic forecasting

1. INTRODUCTION

Since liberalization of the telecommunications sector, Uganda has witnessed remarkable growth in the sector. The GSM Association (GSMA) reports that by 2011, the mobile telecommunication sector was associated with 4.4% of the Gross Domestic Product (GDP) of Sub-Saharan Africa (GSMA and Deloitte, 2012). It has also created more than 3.5 million full-time equivalent jobs across both the formal and informal sectors.

The growth of demand in the telecommunication sector is expected to continue to grow even up to 2020, although at slightly slowing pace (Blume *et al.*., 2013). Studies conducted in developed countries have shown exponential growth and a 1,000-fold improvement in 2020 traffic compared to a 2010 reference (Blume *et al.*, 2013, Gelabet *et al.*, 2013, Zander *et al.*, 2013). It is also expected that the current second generation (2G) and third generation (3G) wireless networks shall be replaced by fourth generation (4G) and beyond-4G networks (Blume *et al.*, 2013, Mogensen *et al.*, 2012).

In terms of services, growth is expected in five major categories, web, video, peer-to-peer, wireless data and wireless voice (Kilper *et al.*, 2011). These services represent only a fraction of the currently available or future services. In general, wireless and mobile Internet access are expected to emerge as a dominant technology in which wireless access would be abundant and virtually free (Zander *et al.*, 2013).

Statistics from Uganda Communications Commission (UCC) reveal an increase in internet penetration per 100 persons which seems to be largely driven by a growth of mobile internet subscription (UCC, 2013). This growth is attributed, in part, to the growing popularity and usage of smart phones in Uganda. This also means a growth in demand for 3G services and beyond. Such growth does need to address constraints including access to spectrum, sector-specific taxes on mobile terminals and usage, standardized rights of way due to significant investments required, and a collaborative public-private partnership approach to the sector's development (GSMA and Deloitte, 2012). In general, next-generation wireless networks entail a high degree of flexibility, efficient use of available radio resources and an energy-efficient operation at low operational costs. They typically integrate use of technologies such as spectrum reframing/aggregation, cognitive radio/software defined radio, beam forming and distributed multiple-input multiple-output (MIMO) antenna systems, interference mitigation and management, cooperative radio resource management, and energy efficient technologies.

This paper aims to project the next generation wireless networks scenario of Uganda by 2020. It identifies major environmental constraints that current and future network architectures will face, in particular in regards to deployment density and throughput requirements by 2020. In particular, the paper compares traffic patterns and throughput requirements by year-end 2012 to that forecast for 2020. The focus is on three services, namely, voice, mobile Internet and video that are currently among the highly utilized services among Ugandan mobile subscribers, and that are expected to have increasing throughput requirements over the period to 2020. The paper further compares the current and forecast traffic patterns of an urban and a rural area.

2. TRAFFIC PROFILE IN UGANDA

Given the nature of investment required and the need for appropriate policy direction, it is important to map out Uganda's communications scenario for 2020. This includes analysis and specification of traffic requirements, the development and integration of new technical solutions, and the dissemination of results to ensure the required impact (Osseiran *et al.*, 2013). The focus of this paper is on the analysis and specification of Uganda's traffic requirements.

While one can assume that there will be traffic growth across the country, the rate is certain to differ between urban and rural areas. The urban-rural dimension is also important as operator intervention may be limited in rural areas due to poor returns on investment. As such, government intervention through public-private partnerships (PPP) may be required. For purposes of this work, Kampala District was selected as an urban area (with a population density of over 1,000 persons/km^2, Blume *et al.*, 2013) and Gulu District was selected as a rural area (with a population density of under 300 persons/km^2). Gulu District is also considered a fast-growing area of interest for the telecommunication sector since Gulu Municipality is among the top ten most populated municipals and towns in Uganda. Table 1 presents a demographic profile of the two districts. It is assumed that the district land area remains the same over the period 2012 – 2020. Annual population growth rates of 3.4%, 2.8% and 3.2% from the Uganda Bureau of Statistics (2012) are used to estimate 2020 population statistics for Kampala, Gulu and Uganda respectively.

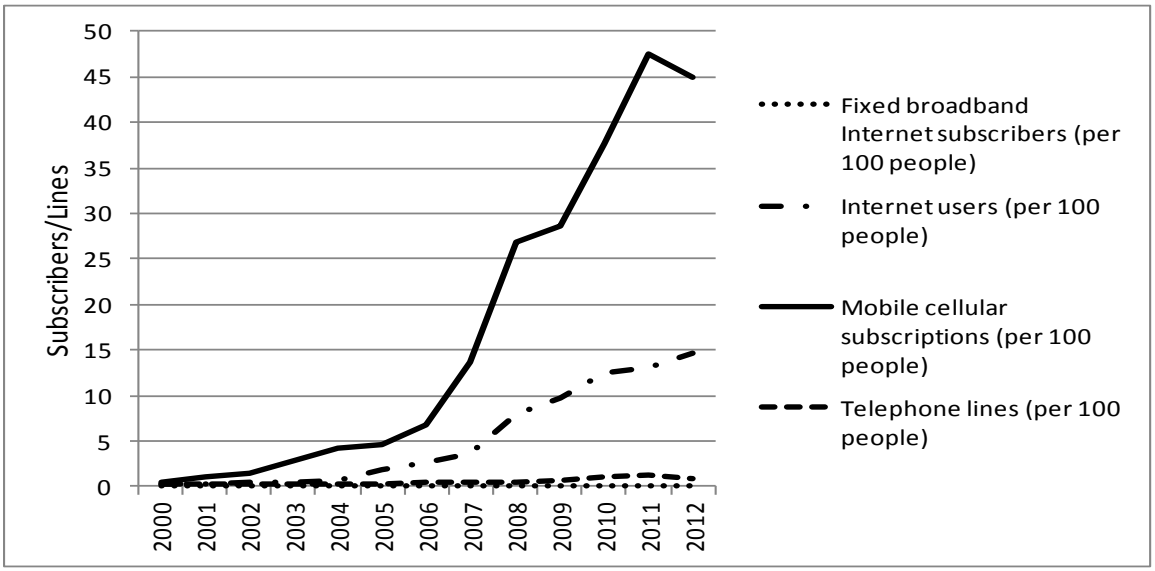
Table 1: Demographic profile of Kampala and Gulu Districts

	Area (km^2)	Population (2012)	Pop. density (2012, pop/km^2)	Population (2020, est.)	Pop. density (2020, pop/km^2)
Kampala	839	1,720,000	2,050	2,250,000	2,682
Gulu	3,449.08	396,500	115	494,525	143
Uganda	241,550.7	34,100,000	141	44,364,715	184

Source: Uganda Bureau of Standards (UBOS, 2012), Authors estimates for 2020

Typical of many Sub-Saharan African countries, Uganda's telecommunications needs are largely served by wireless and mobile networks. By 2011 year-end, the mobile internet subscriptions were more than

four times the fixed internet connections (UCC, 2012). Furthermore, speeds of up to 21 Mbps were available on 3G and beyond networks but only around Kampala. Figure 1 highlights the growth in fixed and wireless services over the period 2000 – 2012.



Source: International Telecommunication Union (ITU)

Figure 1: Trends in fixed and wireless subscribers in Uganda, 2000 - 2012

3. ASSESSING UGANDA'S TRAFFIC REQUIREMENTS BY 2020

The objective of this paper is to assess Uganda's traffic requirements by 2020 with a focus on the throughput requirements. The throughput or data rate required for various services will in turn affect the technical solutions for provision of connectivity including the spectrum requirements.

At the outset, it is important to acknowledge the difficulty in predicting capacity demands – more so, since different forecast studies provide varying results (Gelabert *et al.*, 2013). Nevertheless, for planning purposes, it is important to generate information on likely requirements. Secondly, as previously mentioned, a number of the traffic forecasts project exponential growth up to the order of 1,000 times growth. However, these forecasts are based on subscription and services trends in developed countries and may not be directly utilized for in the context of a developing country. Examples of these models include the GreenTouch framework applied in the most mature markets of North America, Western Europe and Japan (Blume *et al.*, 2013, Gelabert *et al.*, 2013); and use of historical, annual U.S. and global compound annual growth rates for traffic reported by a number of large carriers and industry analysts (Kilper *et al.*, 2011).

For this work, the wireless traffic model used is by the Wireless World Research Forum (WWRF) that is able to account for several demographic scenarios and user capacity estimates (Wu, J. *et al.*, 2011). The model accounts for the following environmental constraints: population density, penetration rates, user/subscriber density, energy constraints, and the regulatory environment. The WWRF results tend to a conservative maximum ceiling since the model does not account for indoor/outdoor traffic as well as combined wireless/wired infrastructure (Gelabert *et al.*, 2013). Furthermore in this work, the traffic requirements are estimated taking into account only population density, penetration rates, user/subscriber density and regulatory aspects. The user/subscriber density is obtained as a product of the population density and the penetration rates. Depending on the age structure of a population and the population aged above 15, there could be a saturation of penetration rates due to the actual number of wireless users/subscribers. Other factors that could affect saturation of penetration rates are literacy rates as well as accessibility and affordability of wireless services.

To assess the penetration rates over the period up to 2020, there is need to apply an appropriate trend for Uganda's traffic growth. Figure 2 compares different trend lines for the period 2000 – 2020.explored to estimate Uganda's traffic growth. The trendlines were developed based on existing data on subscriber growth from 2000 – 2013 and investigation of different exponential and polynomial growth patterns for Uganda's traffic.

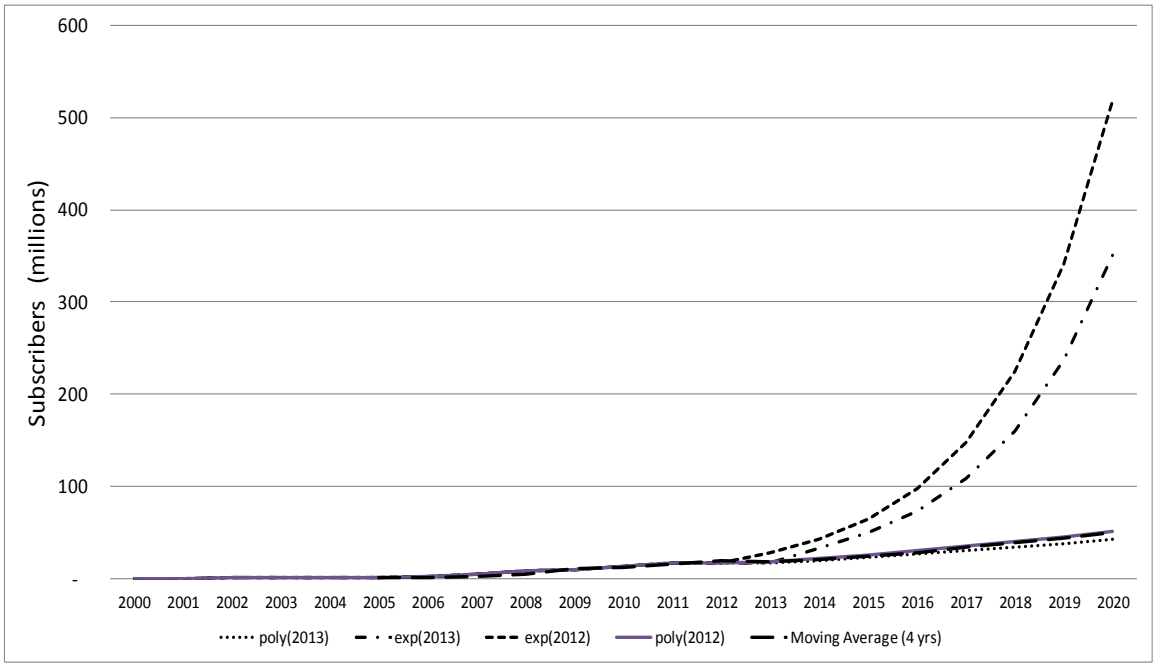


Figure 2: Possible trends of Uganda's subscriber growth up to 2020

From Figure 2, a conservative estimate of 42,147,920 was adopted to represent Uganda's subscribers in 2020. Figure 2 also reveals that an exponential subscriber growth trend would result in unrealistic predictions for Uganda's subscribers by 2020. This is because it would mean that Uganda shall achieve penetration saturation by 2014. The user densities are then obtained as highlighted in Table 2 for penetration rates of 0.48 and 0.95 in 2012 and 2020 respectively.

Table 2: User densities for Kampala District, Gulu District and Uganda

		Population Density (people/km^2)	User Density (people/km^2)	Classification
Kampala	2012	2,050	983	Suburban
	2020	2,682	2,548	Urban
Gulu	2012	115	55	Rural
	2020	143	136	Rural
Uganda	2012	141	68	Rural
	2020	184	174	Rural

3.1 Throughput Requirements for 2020

According to the WWRF traffic model, throughput requirements for services per user, *T(s)*, introduced by a wireless service, *s*, may be estimated as a function of the bit rate requirement of each service, service usage rates, and user behavior (Wu, J. *et al.*, 2011). Equation 1 estimates the throughput requirements for a user with multiple services.

$$T_{user} = \sum_{s=1}^{S} T(s) = \sum_{s=1}^{S} P_u(s) P_t(s) R(s) \quad (1)$$

where $P_u(s)$ is the percentage of users using service s, $P_t(s)$ is the probability that service s is used by wireless devices of a user at a given time and is a function of user behavior statistics and busy hour statistics, and $R(s)$ is the bit rate required to deliver service s such as voice, data, video, etc.

While there are models that estimate the busy hour traffic by activity for mature markets such as Europe, no such models are in place for developing countries such as Uganda. Secondly, even for developed countries, it is very difficult to estimate $P_u(s)$, $P_t(s)$ and $R(s)$ for all services in 2020. This is primarily because service statistics and user behavior are difficult to predict. To overcome the challenge for developing country predictions, Wu, J. *et al.* (2011) propose the use of total traffic estimates per user. These estimates can then be used to determine the throughput requirement per area, T_{area} – where T_{area} may be estimated as a product of the user density and throughput requirements per user.

To estimate Uganda's requirements, we use estimates reported by the Program for Infrastructure Development in Africa (PIDA, 2011). By 2018, it is expected that at least 10% of the population has high speed access, that 20 to 30% of the population has ready access to internet, and that 120 Kbps of OnNet broadband (including 60 Kbps for international broadband) available per access. For high speed access, we consider the average rates for Africa projected by Cisco which are from 529 Kbps in 2013 to 1 Mbps in 2020 (Cisco, 2014). Table 3 presents the throughput requirements for Kampala and Gulu Districts.

Table 3: Throughput requirements for Kampala and Gulu Districts

	2012 (Mbps/km^2)	2020 (Mbps/km^2)	Growth Rate 2012 - 2020
	10% high speed (529 Kbps), 20% good internet (120 Kbps)	*10% high speed (1Mbps), 30% good internet (120 Kbps)*	
Kampala	75.6	346.5	4.6
Gulu	4.2	18.5	4.4

The PIDA study forecasts Uganda's bandwidth requirements by 2018 at about 600Gbps (PIDA, 2011). The 2020 results presented in Table 3 represent about 59% of Uganda's throughput requirements. Not surprising as Kampala being a key urban centre would dominate the throughput requirements. It is important to acknowledge that the figures presented in this paper are indicative of the expected magnitudes of throughput required and are not absolute values.

4. ANALYSIS OF RESULTS

Using Kampala and Gulu as samples of throughput requirements in Uganda, the results show at least a four-fold growth from 2012 to 2020 as highlighted in Table 3. This is also consistent with the expected growth in Africa of smart devices and connections having advanced computing and multimedia capabilities with a minimum of 3G connectivity (GSMA and Deloitte, 2012). These devices will have capabilities to carry various traffic include voice, data and video.

Table 4 highlights the need for development of Uganda's national broadband infrastructure since even rural areas of Uganda will have increasing need for high-speed services. Secondly, the results obtained further point to two additional constraints that need to be addressed regulatory aspects and energy constraints. Increasing spread of infrastructure will have increasing energy requirements with wireless networks consuming up to 80% of the energy required for communication networks (Blume *et al.*, 2011, Kilper *et al.*, 2011, Zander *et al.*, 2013). However, study of the energy constraint is outside the scope of this paper.

Table 4: Major Mobile Broadband Access in Uganda

	EDGE/GPRS	CDMA	3G+	WiMax	LTE (4G)
Coverage	Most areas with GSM phone coverage	Mostly around Kampala	Mostly around Kampala	Mostly around Kampala	Around Kampala and Entebbe
Maximum speeds supported	175 Kbps	Up to 3.5 Mbps	Up to 21 Mbps	3 Mbps	100 Mbps downlink and 50 Mbps uplink
Number of providers	4	3	4	1	3

Source: Uganda Communications Commission

The primary regulatory aspect is availability of spectrum to support increasing throughput requirements via wireless networks. For instance of the five spectrum bands identified for LTE, the uplink spectrum range lies with the digital dividend expected to result from the digital migration process. This process due to be completed by 2015 is reportedly behind schedule in Uganda. However, while frequency re-allocation and dynamic spectrum access may provide rapid market entry possibilities, they will not be sufficient to make available the necessary spectrum for increasing throughput requirements (Zander *et al.*, 2013). There will also be need for techniques and enablers for innovative spectrum sharing and flexible spectrum management (Osseiran *et al.*, 2013).

Another regulatory aspect to be addressed is multi-stakeholder collaboration through public-private partnerships, for example, to spur both rollout of infrastructure and motivation of demand for the infrastructure. In terms of user density, Uganda is largely classified as a rural scenario and hence the need for innovative approaches to grow the country's telecommunications infrastructure and its usage.

5. CONCLUSION

Remarkable growth in the telecommunication sector is being witnessed in Uganda and beyond. Consequently new networks are needed to service the growing demand. For Uganda, this growth shall largely be met by wireless networks as highlighted in Figure 1. The design of Uganda's next generation wireless networks entails the need to assess future traffic requirements and major environmental constraints. The networks shall also entail a high degree of flexibility, efficient use of available radio resources and an energy-efficient operation at low operational costs.

Analysis of Uganda's 2020 traffic requirements reveals growth by over four times over the period 2012-2020 – even with much of Uganda being classified as rural. Innovative technical and policy interventions will thus be required to support the traffic requirements. This shall include fostering public-private partnerships as well as development of innovative spectrum management techniques coupled with efficient energy management. At the foundation of these interventions is the need for further research focused on the environmental constraints typical of developing countries such as Uganda.

6. ACKNOWLEDGMENT

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Analysis of the Accuracy of GMF, NMF, and VMF1 Mapping Functions with GPT 50 a Priori Zenith Constraint in Tropospheric Delay Modelling

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Abstract
When modelling the tropospheric delay in Global Positioning System (GPS), the zenith delay is mapped to the slant with numerous mapping functions. The accuracy of the modelled tropospheric delay will be affected by the kind of mapping function used. Fixing the a priori zenith constraint as Global Temperature Pressure Humidity 50 (GPT 50), this paper compares the accuracy of the different mapping. Global Mapping Function (GMF), Niell Mapping Function (NMF) and Updated Vienna Mapping Function (VMF1), the update of Vienna Mapping Function (VMF) are the mapping functions studied. All these are used with the saastamoinen tropospheric delay model which is used in the GPS Analysis Software for the Massachusetts Institute of Technology software (GAMIT_GLOBK). For the north and east offsets these mapping functions achieved the same accuracy and can therefore be used interchangeably in modelling of the tropospheric delay effect in the planner. However, for the up offsets VMF1 achieved better accuracy compared to GMF and NMF however, being more consistent with GMF than NMF. In the future, if more mapping functions are incorporated in GAMIT_GLOBK, the accuracy of these new mapping functions should be investigated and use another a priori zenith constraint – meteorological data, which will improve positioning using Global Navigation Satellite System (GNSS).

Key words: GPT50, GPS, GMF, NMF, VMF1.

1.0 Introduction

Mapping functions of tropospheric delay models based on data from the numerical weather models have now been developed. Mapping functions use information about the vertical distribution of the refractivity therefore they can assess the thickness of the troposphere which is a basis for the determining of the value for the mapping function (Niell, 1996). Even though these mapping functions have been available for some years now, many analysts still use NMF because it depends only on the station latitude, height and the day of the year thus can be easily implemented in GPS software (Niell, 1996). However when NMF was compared withVMF1 it was discovered that it has deficiencies in the temporal behaviour and large static deficiencies in certain areas. Therefore GMF was developed similar to NMF as it is determined from the station latitude, height and day of the year. However GMF is based on spherical harmonics up to degree and order 9 and the aim is to make it more consistent with VMF1 than NMF. Boehm et al. (2006a) used the rigorous ray trace at 3^0 elevation to determine VMF1. VMF1 is available on a 2.5 X 2.0 degree grid with a grid of 0.25x0.20 degree at some places at a temporal resolution of 6hours with planned reduction in this temporal resolution. GMF and NMF have larger standard deviations because they contain only a seasonal term and thus cannot reproduce the short-term variations sampled by VMF1

and IMF which have 6 hour temporal resolution (Boehm et al, 2008). In GAMIT_GLOBK software, a priori zenith constraint is modelled first then the mapping functions are applied. GPT 50 is based on spherical harmonics up to degree and order nine and provides pressure and temperature at any site in the vicinity of the Earth's surface. It is used for geodetic applications such as the determination of a priori hydrostatic zenith delays and reference pressure values for atmospheric loading (Kouba, 2009). When modelling the tropospheric delay in GPS, the tropospheric zenith delay is mapped to the slant with numerous mapping functions. The accuracy of the modelled Tropospheric delay will be affected by the kind of mapping function used. New mapping functions are now based on numerical weather models compared to the earlier ones based station latitude, height and the day of the year. The accuracy of the new mapping functions is compared to that of the earlier ones for easting, northing and height of points. In this research we analyse the accuracy of GMF, NMF, and VMF1 mapping functions with GPT 50 a priori zenith constraint and investigate the application of VMF1 in tropospheric delay modelling.

2.0 Study Area

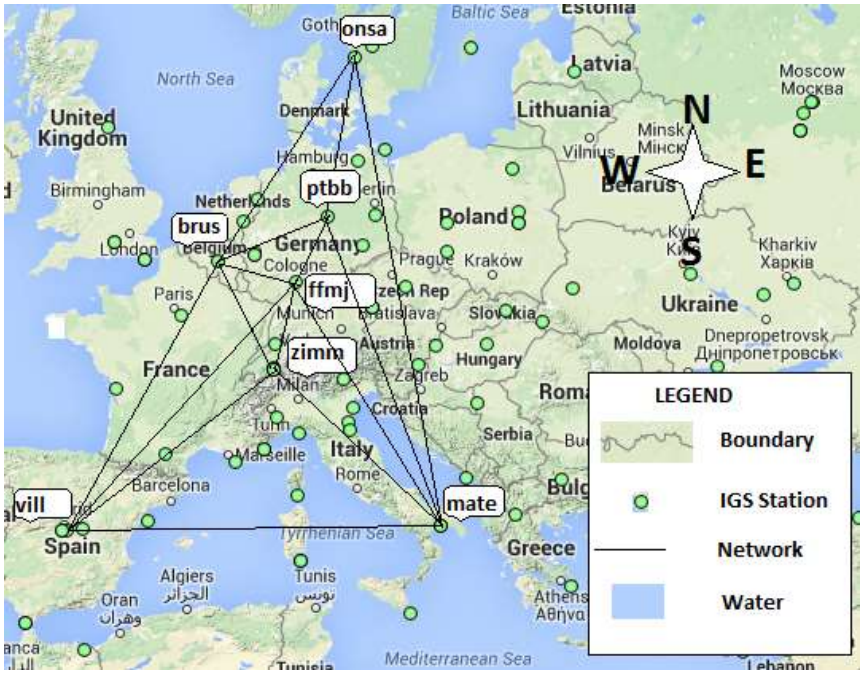

Figure 2 IGS stations used in the network

GPS data for six years was collected from seven International GNSS Station (IGS) stations located in Europe as shown in figure 1 above. The network was tested and found to be stable and sufficient for this study. These stations were Zimmerwand (zimm) - Switzerland, Villafranca (vill) - Spain, Braunschweig (ptbb) - Germany, Onsala (onsa) - Sweden, Matera (mate) - Italy, Frankfurt (ffmj) - Germany and Brussels (brus) – Belgium (figure 1).

3.0 METHOD

GPT 50 a priori zenith constraint was used with GMF, NMF and VMF1 mapping functions one at a time as shown in figure 2. GPT 50 was used because it is the default a priori zenith constraint that is used in the GAMIT_GLOBK software. During the processing all the other GPS errors were efficiently modeled so that the error that would propagate to the fixed GPS points would only be due to applied mapping functions. Two gradients were modeled each day for the azimuth effect on the tropospheric delay. The other errors modeled included the atmospheric loading, multipath, ionosphere (including the higher order effects) - The higher order error terms do not cancel out in the (first order) ionospherically corrected observable and as such, when not accounted for, they can degrade the accuracy of GNSS positioning, depending on the

level of the solar activity and geomagnetic and ionospheric conditions (Hoque and Jakowski, 2007) and the antenna phase center. Repeatability graphs were plotted to show the accuracy of the fixed GPS points. These repeatability graphs were plotted for each combination of a priori zenith constraint and mapping function. The Weighted Root Mean Square (WRMs) from the repeatability graphs for each IGS stations were extracted and plotted for each a priori zenith constraint and mapping function combination figure 3, 4 and 5.

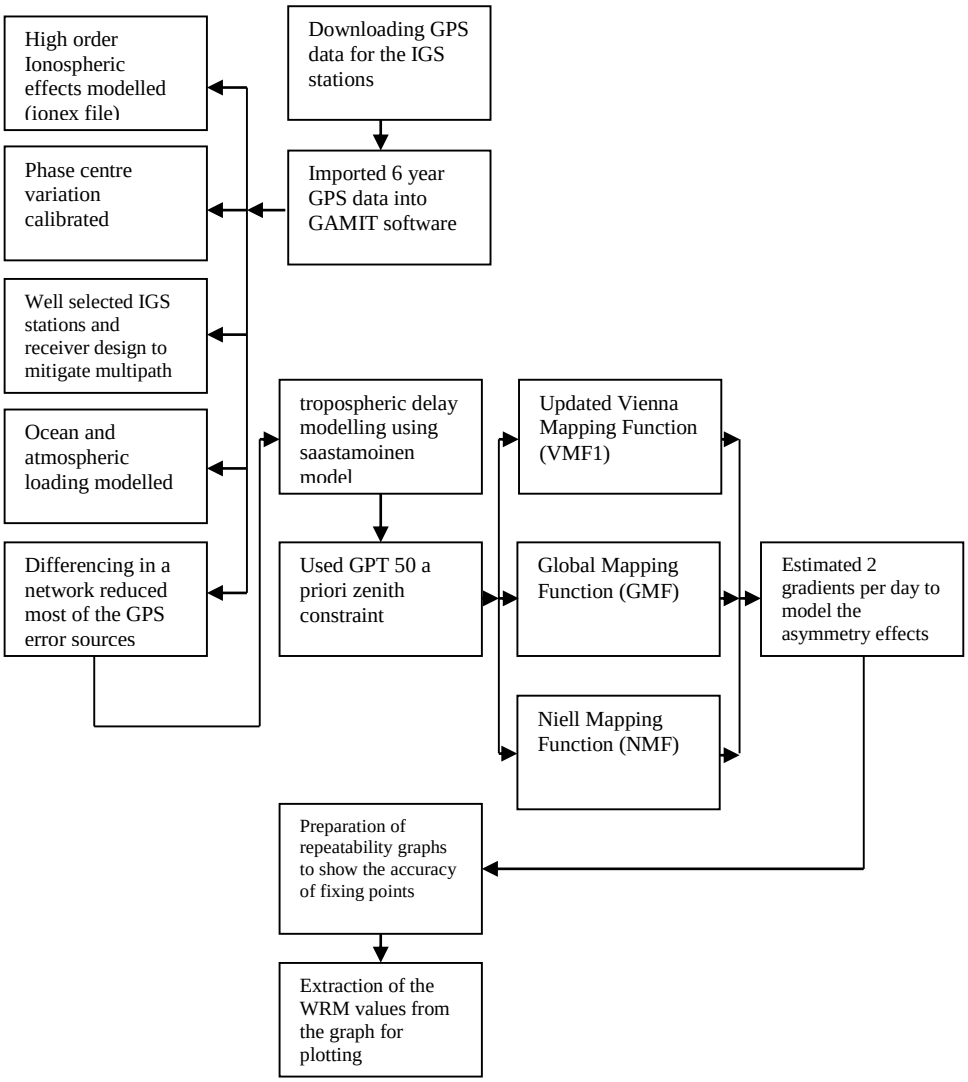

Figure 3 Methodology used in the research

4.0 RESULTS PRESENTATION AND ANALYSIS

The WRMs for the seven stations are all below 2mm for the north offset, implying that the north offset for all these points have been well fixed. zimm was fixed with the highest accuracy while brus was fixed with the lowest accuracy. During the processing of the GPS data, instability was noticed in the planar coordinates of brus IGS station, this is shown in figure 3 as the station has a WRMs of 1.7 mm for all the mapping functions. VMF1-GPT50, GMF-GPT50, NMF-GPT50 combinations have the same WRMs for the north offset. This implies that the NMF, GMF and VMF1 mapping functions achieve the same accuracy when modelling the north offset. This is because the effect of the tropospheric delay has minimal effect on the planner coordinates of points.

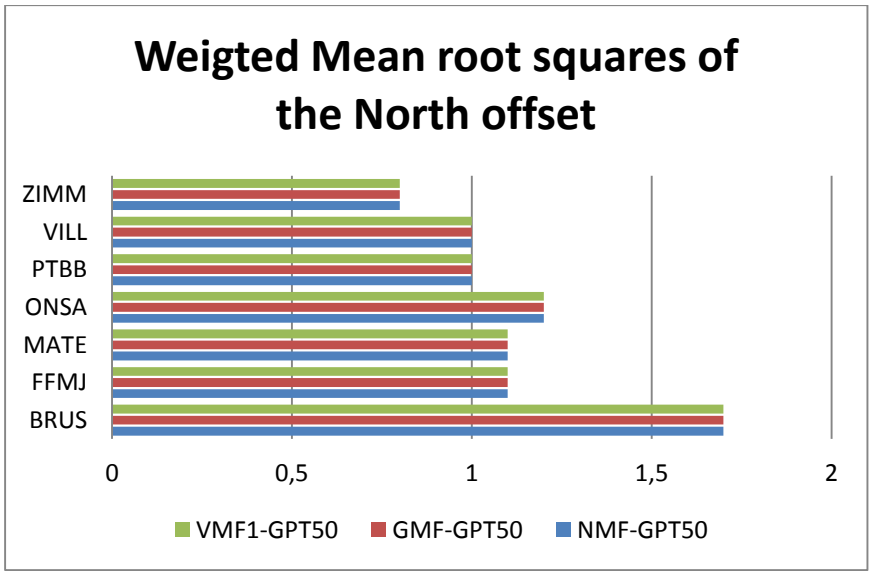

Figure 4 Repeatability graph for the North offset

The case for the east offset is similar to that of the north offset where the WRMs for all the seven IGS stations are below 2mm hence showing that the east offset of these stations are well fixed. Stations zimm and ptbb are fixed with high accuracy compared to brus fixed with a low accuracy again as seen in figure 4 and figure 3 previously. VMF1-GPT50, GMF-GPT50 and NMF-GPT50 combinations all achieve the same WRMs for the east offsets again showing that the effect of the tropospheric delay is minimal to the east coordinates.

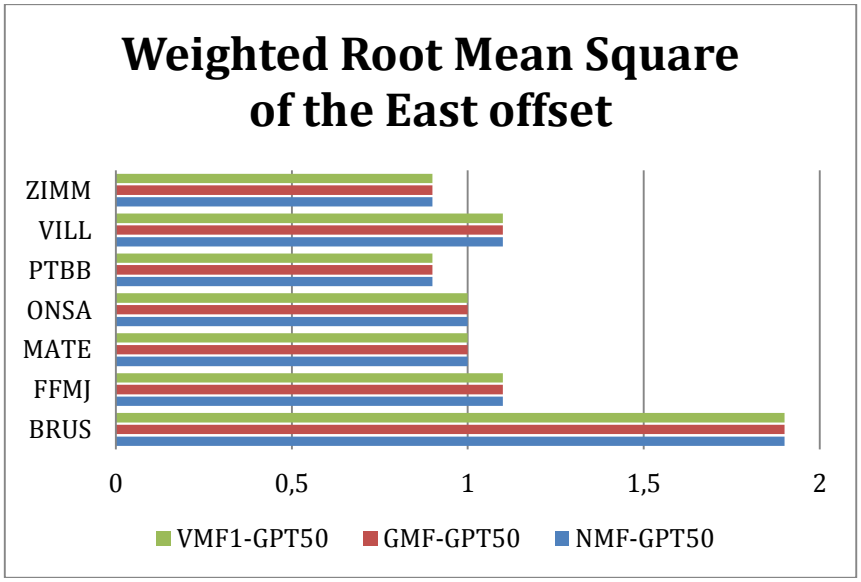

Figure 5 Repeatability graph for the East Offset

The WRMs for the fixed up offsets for all the seven IGS stations are below 10mm. This shows that the up offset for all the IGS stations are well fixed. The WRMs acceptable for the up offset are larger than those for the north and east offset because GPS achieves results better in the planar than in the vertical. This is due to the fact that the GPS error sources in the planar counsel due to symmetry as the satellites are traced from horizon to horizon while this is not possible for the vertical as the symmetrical errors won't counsel as GPS receivers cannot trace the GPS satellites both above and below the horizon.

The VMF1-GPT50 combination attains the least WRMs for the up offset at zimm, vill, onsa and ffmj IGS stations (figure 5). The mapping functions achieve different accuracies in this instance because the residual range errors from the tropospheric delay propagate most to the heights of the points compared to the planner coordinates, this implies the tropospheric delay affects the fixed heights of the GPS points more than the planner coordinates (Rothacher,2002). The VMF1-GPT50 combination attains the best accuracy here because it is based on data from numerical weather models, unlike the other mapping functions, it uses information about the vertical distribution of the refractivity and thus can assess the thickness of the troposphere which is a measure for the value of the mapping functions (Neil, 1996) and it is has a grid separation (2.0 x 2.5 degrees) small enough and a high temporal resolution of 6 hours (Boehm et al. 2006b).
GMF-GPT50 combination attains the same accuracy as VMF1-GPT50 for IGS stations ptbb, mate and brus (figure 5). This is because GMF mapping function is based on spherical harmonics up to degree and order 9 and the aim was to make it more consistent with VMF1 during its creation. Though when we compare GMF to VMF1, GMF is easily implemented into GPS software compared to VMF1 because it depends on station coordinates and the day of the year, then if it attains the same accuracy as VMF1 at some stations it could be used as a substitute for VMF1 in software where implementation of the VMF1 mapping function is not possible.

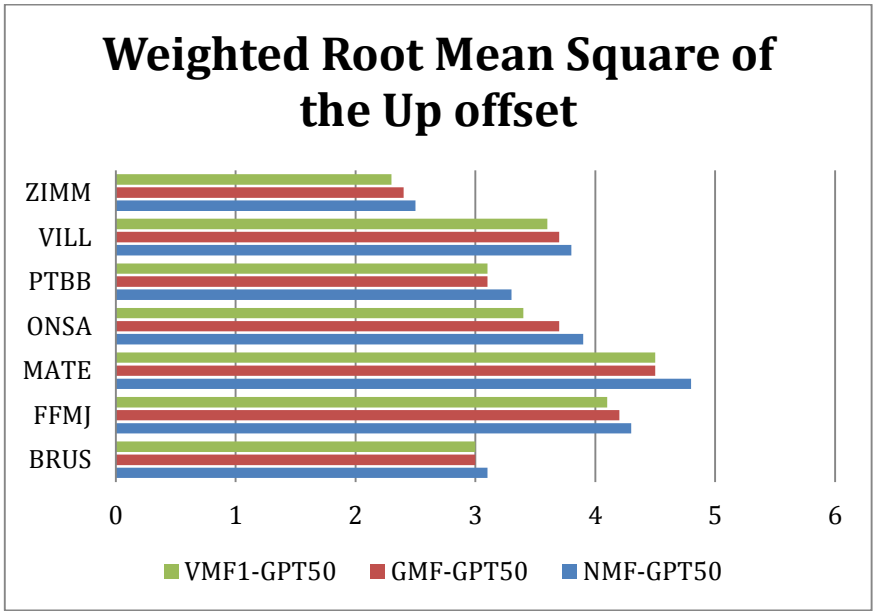

Figure 6 Repeatability graph for the up offset

NMF-GPT50 combination achieves the lowest accuracy for all the IGS stations used in this case study. Though NMF can also be easily implemented into the available GPS software because of its dependence on station coordinates and day of the year, when compared with VMF1 it was discovered that it had deficiencies in the temporal behaviour and large static deficiencies in certain areas.

5.0 Conclusions and Recommendations

5.1 Conclusion

- The accuracy achieved modeling the tropospheric delay from the mapping functions based on data from numerical weather models (VMF1) is greater than that from mapping functions that depend only on station latitude, height and day of the year (GMF and NMF) when fixing the heights of points. Though the later, due to the data they are based on, station

latitude, height and day of the year they are easily implemented in GPS software than their counterparts based on data from numerical weather models (VMF1). Those based on data from numerical weather models achieve better accuracy because they use information about the vertical distribution of the refractivity and thus can assess the thickness of the troposphere which is a measure for the value of the mapping function.

- For the east and north offsets, there is no significant accuracy differences as it is in the up offsets where VMF1 is more consistent with GMF than NMF but VMF1 being more accurate overall for the up offsets. GMF is more consistent with VMF1 than NMF because it is based on spherical harmonics up to degree and order 9 developed with the goal to be more consistent with VMF1.

5.2 Recommendations

- More mapping functions will be incorporated in GAMIT_GLOBK (i.e. IMF). They should be investigated to determine how well they model the tropospheric delay using GPT 50. VMF1 has been implemented in few GPS software, though its behaviour could be investigated in other GPS software. The VMF1 grid is becoming smaller as more meteorological data is collected with the increase in the IGS stations, investigations could be carried out with such smaller grids to determine the improvement in the accuracy of modelling the tropospheric delay using VMF1.

- All the mapping functions could be compared using meteorological files (met files) as the a priori constraints. This is when Temperature, Pressure and Humidity are locally recorded at the IGS stations.

- This research could be done in the future modelling more than two gradients a day when determining the effects of the azimuth on the tropospheric delay.

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Innovation Propensity and Collaborations of firms in the Wood and Furniture Clusters in Kampala, Uganda

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ABSTRACT
99% of the businesses in Uganda fall in the SME category, however, their growth, performance and contribution to the Uganda's GDP is limited most especially those in the manufacturing sector.

The importance of collaboration and business linkages has been identified in innovation studies as a key determinant of productivity and growth of SMES. The aim of this study was to understand the level and types of linkages and cooperation of technology sources with SMEs in the wood and furniture industry in Kampala and the factors affecting the linkages.

The study revealed that SME firms have very low innovation propensities, have strong linkages with suppliers and customers but have weak linkages with large firms, government, academia and financial institutions. Strategies for sector upgrading ought not to be solely based on creation of innovation system linkages/networks but should rather be based on collaborations that address the specific underlying weaknesses/challenges that firms are currently facing.

Key words: Clusters, Collaborations, Furniture, Innovation propensity, Linkages, Productivity, SME.

1.0 INTRODUCTION
99% of the business in Uganda fall in the SME category, but their growth, performance and contribution to the Uganda's GDP most especially those in the manufacturing sector (7% of businesses in Uganda) is still low (UBOS, 2011, Gauthier, 2001). Most of the SMEs have low levels of productivity; produce poor quality products which are supplied to only small localized markets. Many of the SME businesses are not formalized which limits their access to credit, subcontracting and business linkages (EAC, 2010).

Ugandan SMEs need to be supported to grow from micro to small, small to medium and from medium to large firms (UIA, 2008) and some of the key drivers for upgrading and increased competiveness of SMEs is through business linkages and collaboration (Enterprise Uganda, 2008; Machikita & Ueki, 2011). Business linkages stimulate innovation, they are a key determinant of productivity and growth, and they are the engine that moves the economy, reshapes industries, firms and markets (Carvalho, 2005).
The wood and furniture industry has several constraints that have curtailed its growth and some of these include the limited cooperation of SME firms with research institutions/university, government, financial institutions and most importantly with large wood working firms in the industry. This has created a sector disparity with large firms serving high end customers and the cluster firms serving the low and middle class with very small profit margins. The SME firms are also limited in terms of technological, human, financial and management resources which contribute to high levels of wastage, inefficiencies and poor quality products (Inshengoma & Kappel, 2008). The furniture produced by

these firms is also regarded inferior to the imported and that produced by the large firms (Yoshida, 2008).

The aim of this study was to understand the level and types of linkages and cooperation of technology sources (large firms, industry, government parastatals and academia) and SMEs in the wood and furniture industry and the factors affecting the linkages. This research specifically focused on the wood and furniture cluster firms in Kampala district agglomerated in areas of Kubiri-Makerere/Bwaise, Nsambya and Natete-Nalukolongo areas. This was because Kampala district has about 35% of the total number of furniture workshops in the country (UBOS 2010; Seremba et al., 2011). Figure 1.1 below shows some of the firm product innovations in the study.

Figure 1.1: A special set of unique furniture only found with specific firms in Nsambya, Kampala

2.1 The cluster concept

For the purpose of this research, the clusters in developing countries are defined as geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in similar or related economic activities that compete but also cooperate, government and associated institutions (e.g., standards agencies, trade associations, financial, universities) which provide specialized training, research and technical support(Porter, 2001; Porter, 2000; ECEIDG, 2013).

Firms in developing countries are now under intensive pressure to improve their performance and increase their competitiveness (Humphrey and Schmitz, 2002). Good quality furniture is now a luxury to the ordinary Ugandan, which has resulted into the increased import of cheap furniture into the country and thus highly intensive competition in the industry (Muleme, 2010; Seremba et al., 2002). Literature on competiveness indicates that the most viable option for firms is to upgrade. Upgrading is defined as the capacity of a firm to innovate and increase the value added of its products and processes. 2.3 Innovation

2.2 Innovation Propensity

Popular definitions of innovation focus on new combinations of productive resources to increase profit (Schumpeter, 1961); newness related questions 'what is new, how new, and new to whom' (Johannessen et al., 2001); the importance, improvement of existing technologies and market success of inventions (Corre & Michke, 2005). The definition context for developing countries also includes miniature improvements in quality and product designs; changes in production organization, process, techniques and knowledge management; creative marketing; introduction of new maintenance routines and process innovations with new purchase of equipment and through technology licensing and subcontracting relationships (Patarapong, 2007). The creation of ties with established large firms, government institutions, universities and research institutions creates a significant impact in the innovation activities of cluster firms (Nganga et al., 2003; Baum et al., 2000).

The innovation construct includes taxonomy of types/categories: process, product, organizational and market innovations (Schumpeter, 1961; OECD, 2005; Bonen, 2007, Johannessen et al., 2001).

2.3 Study Objective

Assess the level of innovation propensity as affected by linkages and collaborations between the wood and furniture actors (clusters, clients, large firms, government and academia) in Kampala district

Hypothesis: Linkages and collaborations of SMEs in the wood and furniture clusters with different partners has ~~a~~ no significant impact on innovation propensity

3.0 RESEARCH METHODOLOGY

3.1 Research approach

A quantitative approach was used for the study which enabled us to obtain numerical data from the survey interviews with use of structured questionnaires about the number of innovations, levels of linkage/collaborations of cluster and the variables that affect them, number of staff at different education levels, firm age, new staff training period and enumeration of the specific areas of collaboration with large firms, government, academic, financial institutions. It also enabled us obtain the main constraints/obstacles to firm innovation activities thus leading to the current low level of competiveness.

3.2 Sample population and sampling

The target interviewees were the workshop managers/owners and managers. 42 firms provided a representative sample in this study and a simple random sampling method was used. The sampling frame was the official and non-officially enumerated, agglomerated firms in Kubiri-Makerere, Nsambya and Natete-Rubaga areas.

The author established the number of firms engaged by physically counting the firms engaged in production of wood and furniture products as he walked through the area. A total population of 148 firms was counted in an estimated area of 7 square kilometers. The sample size was determined using the Equation 3.1 (Watson, 2001):

$$n = \frac{\frac{P(1-P)}{\frac{A^2}{Z^2}+\frac{P(1-P)}{N}}}{R} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{equation 3.1}$$

Where:

- The estimated total number of enterprises in the selected areas of the wood and furniture sector is 148 as per the calculations indicated in this sub-section i.e. N = 148.
- The estimated variance for this population was 0.3 i.e. P = 0.3 (Watson, 2001)
- The desired margin of error was 10% i.e. A = 0.1
- A confidence level of 90% was chosen i.e. Z =1.6449
- The estimated response rate was 95% i.e. R = 0.95
- $\Rightarrow n = \frac{\frac{0.3(1-0.3)}{\frac{0.1^2}{1.6449^2}+\frac{0.3(1-0.3)}{148}}}{0.95} \approx 43$ Firms ……equation 3.2

A total of 43 firms were interviewed, however only 42 interviews provided complete information that would be used for the statistical evaluations.

3.3 Measurements

To determine the importance of external knowledge to firms innovation propensity, the level of collaborations/linkages over the last 3 years with Suppliers, Customers, Universities/Research institutions, Large Firms/competitors, Government, and Financial institutions was analyzed on a 5 point likert scale where the value of 1 signified no collaboration, 2 indicated 1-2 interactions, 3 indicated 3-5 meetings/interaction, 4 indicated 6-8 interactions and 5 indicated 9 and more interactions (an average of 3 or more per year).

Innovation propensity was analyzed in form of count data that was obtained by summing the different innovations as per the Innovation categories of product, process, procurement, organization and market innovation. The total innovation was used to analyze the innovation propensity quartile/level of innovation propensity.

To obtain the innovation propensity quartile, the ratio of the total number of firm innovations to total number of possible innovations (80 in total) as per this research model was obtained. The innovation propensity quartile ranged from (0-0.24 for low level; 0.25-0.49 for medium level; 0.5-0.74 for high level and 0.75 to 1 for very high level).

The data collected was entered into Epidata version 3.1, and later exported to STATA for descriptive and multiple regression analysis.

4.0 RESULTS

4.1 Total number of innovations

The minimum number of innovations was 2 and the maximum from the firms was 26 out of a possible total of 80 innovations

Table 4.1 shows that the minimum number of Product innovations, Product process innovations (PPI), Market Innovations (MI), Organizational Innovations (OI), and Procurement Innovations are 0,0,1,0 and 0 respectively. The maximum number of Product innovations, Product process innovations (PPI), Market Innovations (MI), Organizational Innovations (OI), and procurement Innovations are 10, 5, 14, 3 and 4 respectively.

Table 4.1:

Innovation	Observations	Mean	Std. Dev.	Min	Max
Product	42	6.2381	2.18431	0	10
Product process	42	0.5	1.21475	0	5
Marketing	42	5.45238	3.20976	1	14
Organization	42	0.19048	0.5942	0	3
Procurement	42	0.33333	0.8165	0	4

4.2 Level Innovation propensity/ innovation

Table 4.2 shows that 83.33% of the firms have their innovation propensity belonging to the first 1st quartile and 16.67% belong to the 2nd quartile. There are no firms with innovation propensity in the 3rd and 4th quartiles.

Table 4.2 Innovation Indice/Quartile

Innovations indice		Freq.	Percent	**Cum.**
0- 0.24	1st quartile	35	83.33	83.33
0.25-0.49	2nd quartile	7	16.67	100
Total		42	100	

4.3 Sources of knowledge for innovation and linkages

Figure 4.2 shows the knowledge sources based means of level of linkages/interactions/collaborations SMEs with stakeholders in the innovation system**.**

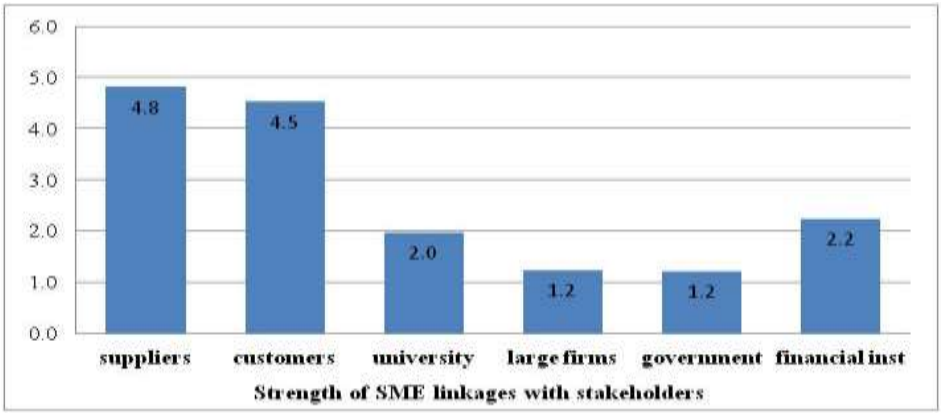

Figure 4.2: Strength of SME linkages with with suppliers, customers, university, large firms, government and financial institutions

Figure 4.2 shows that firms have very high levels of interaction with suppliers (4.8) and customers (4.5), weak collaborations with universities/research institutions (1.97) and financial institutions (2.2) and no collaborations with large firms (1.2) and governments (1.2) basing on the likert scale of 1-5. The linkages/collaborations with customers was the strongest as highlighted above with levels of 4.8 and 4.5 basing on the likert scale of 1-5.

4.4 Firm absorptive capacity

4.4.1 Highest attained education of the Owner/CEO/Director/Manager

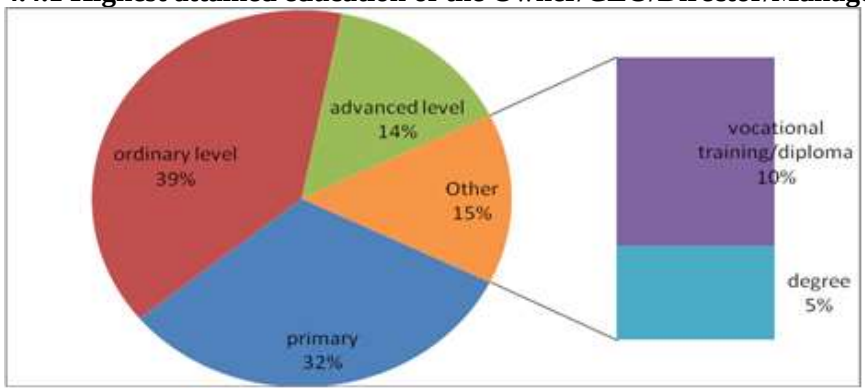

Figure 4.3: Highest attained education of CEOs

Figure 4.3 shows that only 5% of the CEOs have attained a degree education, 10% have obtained a highest education of a diploma or vocational training, 14% have obtained advanced level training, 39% have obtained a highest education of ordinary level and 32% have attained only primary level education. This clearly shows that the firms have low absorptive capacities due to the low level of CEO education.

4.4.2 Type of CEO/Owner/Director/Business manager's education

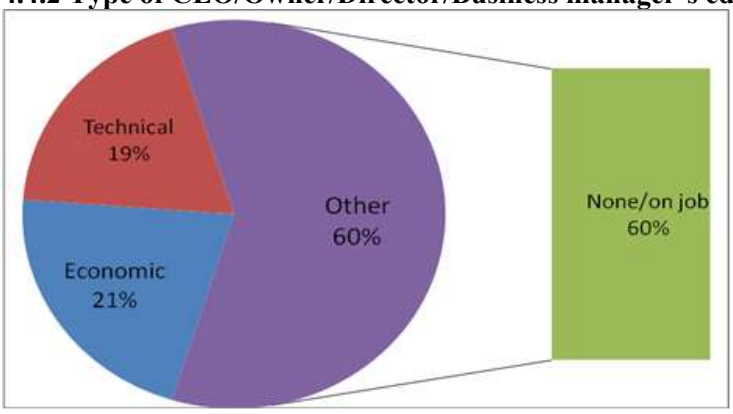

Figure 4.4: Type of CEO/owner/manager's education

Figure 4.4 shows that 60% of the business owners/directors/CEOs have obtained their skills by learning on the job. Only 19% have received some form of technical training and 21% have received economic/business training. This result implies that firms' absorptive capacity is low.

4.4.3 Staff with different levels of education

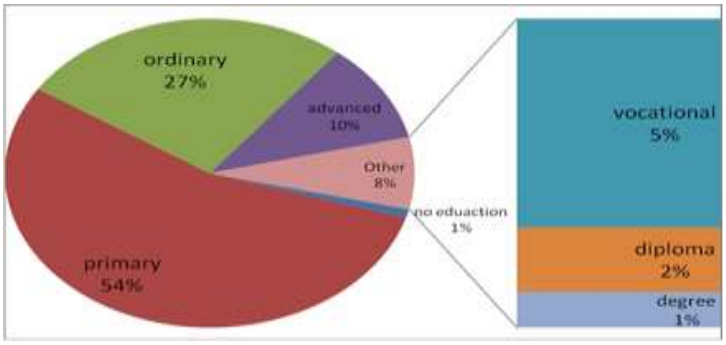

Figure 4.5: The highest level of education attained by the staff

Figure 4.5 shows that 54% of the firm's employees have highest education of primary level. 27% of staff have ordinary level education in addition to the primary education, 10% have advanced level education in addition to primary and ordinary level education, 5% have vocational education in addition to ordinary education or advanced education. 1% have no education at all, only 2% have a diploma and only 1% have highest of degree education. The high number of staff with primary education and the lack of sufficient staff with a diploma or degree shows the low absorptive capacity of the firms.

4.4.4 Firm size

The minimum firm size is 2 staff and 20 staff is the largest firm size. The mean firm size is 8 staff each firm has an average of 4(four) permanent employees, 3(three) temporary employees and 1(one) apprentice

4.5 Hypothesis testing

4.5.1 Hypothesis

Null hypothesis: Linkages and collaborations of SMEs in the wood and furniture clusters with different partners has a no significant impact on innovation propensity

The hypothesis was evaluated through the following regression analysis as obtained in the stata output. Table 4.4 below shows the values of the coefficients of the significant variables, as key extracts from the regression analysis.

Table 4.4: Impact of Impact Of linkages and collaborations of SMEs in the wood and furniture clusters with different partners on firm innovation propensity

Dependent Variable	Innovation propensity/ Y_{innov}
University/Research Institutions	2.2253**
Constant	4.375***

Notes: All non significant variables (Gov't, large firms, suppliers, customers and financial institutions) obtained from the stata output were omitted.

R^2= 0.32, Adjusted R^2=0.29

**P < 0.05, ***P<0.01

From the regressions results highlighted in Table 4.4, the following regression model was developed.

$Y_{innov=}$ 4.38 + 0.03 (suppliers)^3 + 0.01(customers)^3 + 2.23 university/research + 0.87 1/(largefirm^3) - 3.19 1/(government^3) + 11.09 1/(finance institutions^3)

The above model was significant since its P value of 0.0262 was less than 0.05 level of significance. The R-squared (R^2) indicates that 32.17% of Innovation propensity is being predicted by the variables under consideration of this model.

This model above was further checked to find out which variables were statistically significant to the model through a stepwise regression. As a result the most insignificant variables at 95% level of confidence were eliminated from the model one by one and the final regression analysis output has only one variable (university/research institution collaboration) out of the 6 variables.

Table 4.5 shows the output of the impact of collaborations on Innovation propensity after a stepwise regression.

Table 4.5: Impact Of linkages and collaborations of SMEs in the wood and furniture clusters with different partners on firm innovation propensity after as step wise regression

Dependent Variable	Innovation propensity/ Y_{innov}
University/Research Institutions	2.6043***
Constant	7.567****

R^2= 0.23, Adjusted R^2=0.21

***P<0.01, ****P<0.0001

From the regression outputs highlighted in Table 4.4 above, the following model was obtained as final model for hypothesis 1.

$Y_{innov=}$ 7.567 +2.60 university/research institution

The above model as a whole was significant since its P value of 0.0014 was less than 0.01 level of significance. This is slightly lower than the R^2 in the first model (0.33), attributable to the fact that the final model was obtained with only one variable. In addition, the adjusted R^2 of this new model is 0.21, which is also lower than 0.29 of the first model.

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The final model for the hypothesis, clearly shows that of all the external linkages, only the collaborations with universities/research institutions have an impact on firm innovation. Thus, the null hypothesis was rejected and an alternate hypothesis of "**Only University/research institution linkages significantly positively impact firm innovation propensity"**.

5. DISCUSSION OF RESULTS

In this chapter, the findings presented in chapter four are discussed.

5.1 Total innovations

In light of the low level of innovation propensity, the Table 4.1 shows that current innovations pursued by the firms are mainly in the area of Product and Market innovations and firms hardly engage in Organisational, Process and Procurement innovations. This perspective is contrary to Thai firms which have more process than product innovations (Intarakamnerd, et. al., 2002).
The high level of product and market innovations shows that firms are only concentrating on improving product image with inspirations from magazines, imported furniture and other SME firms so as to attract more customers and to increase sales. Thus no efforts are put on improving efficiency and productivity through process, procurement and organisational innovations, and yet these are key aspects of sustaining firm competiveness.

5.2 Level of Innovation propensity and collaborations

Table 4.2 shows that 83.33% of the firms belong to the first 1st quartile and 16.67% belong to the 2nd quartile. There are no firms with innovation propensity in the 3rd and 4th quartiles. This clearly shows that generally firms are not highly innovative since most of them only belonged to the first quartile. Figure 4.2 shows that firms have very high levels of interaction with suppliers (4.8) and customers (4.5), weak collaborations with universities (1.97) and financial institutions (2.2) and no collaborations with large firms (1.2) and governments (1.2) basing on the likert scale of 1-5.

The firms depend on suppliers for the wood and furniture since the firms do not own any forests. Firms also depend on customers who purchase their products, for they must have a market. Without the customers, the firms would not be in business. Further, the customers are good sources for new product innovations and the suppliers make sure that they help the firm execute their product innovations through raw material supplies. This explains the very high collaborations firms have with the suppliers and customers for the businesses thrive on these two collaborations with or without innovation, their business' survival depends on them.

5.3 Discussions of the hypothesis results

The null hypothesis in hypothesis was rejected and an alternate hypothesis of "**Only University/research institution linkages significantly positively impact firm innovation propensity"** was adopted. The final model is shown below;

$$Y_{innov=} 7.567 + 2.60 \text{ university/research institution}$$

The model above implies that the creation of linkages/collaborations between SME firms with government institutions, large firms and financial institutions, customers and suppliers shall not guarantee an increase in innovation propensity of the firms. This result is contrary to several scholars who have documented that creation of linkages between SMEs with large firms, universities, research institutions, financial institutions, customers and suppliers increases the firm's innovation propensity (Temell et al., 2013; Baum et al., 2003; Basil, 2012).

The lack of impact on collaborations on Innovation propensity may be attributed to the weak collaborations with academic/research institutions, financial institutions, large firms and government institutions at levels of 1.97, 2.2, 1.2 and 1.2 respectively on a likert scale of 1-5. Due to the low collaborations, this affects any opportunity of having a significant impact on innovation propensity.

6.0 CONCLUSION

In general the SME firms in this industry have very low innovation propensity and they have weak linkages with large firms, government, academia and financial institutions. All firms also have very strong collaborations with suppliers and customers with whom they engage on a daily basis. The low firm absorptive capacity explains their limited ability to develop and sustain collaborations, hence the lack of collaborations with government institutions & large firms and the weak collaborations with universities & financial institutions.

Study showed that the creation of linkages/collaborations between SME firms with government institutions, large firms and financial institutions, customers and suppliers does not necessarily guarantee an increase in innovation propensity of the firms. This implies that, the strategies for sector upgrading ought not to be solely based on creation of innovation system linkages/networks but should rather be based on raising the firms' absorptive capacities so as to raise the innovation propensities in mainly process and organizational innovations.

7.0 FURTHER RESEARCH

An in depth study is needed so as to evaluate all the actors that have linkages to the wood and furniture industry so to effectively correlate the views of the firms with those of the different actors and thus develop more a comprehensive strategy.

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Prioritizing maintenance of highway bridges in Uganda

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Abstract
Highway bridges constitute the most critical components in surface transportation infrastructure. Reliable bridge stock is crucially important for interlinking road transport networks. The negligence of bridge maintenance and delayed actions may translate to enormous costs of repair, rehabilitation and replacement. In view of the importance of bridges to the sustenance of the economy and livelihoods in the face of limited funds, there is a need to prioritize highway bridges for maintenance actions. The study made use of data and information obtained through field surveys which were conducted in the months of May, June and July in 2011, 2012 and 2013, respectively, using a combined methodology, non-destructive (NDT) and semi-destructive techniques (SDT). A priority ranking system to support highway bridge maintenance has been developed. The system can be useful in the process to develop a suitable model of a Bridge Management System (BMS) for Uganda

Keywords: Highway bridges, priority ranking, bridge maintenance, non-destructive and semi-destructive techniques.

1.0 INTRODUCTION

Worldwide, inadequate maintenance is the major reason for deficiencies in surface transport infrastructure which undermine their safety and functionality. A reliable bridge stock is crucially important for interlinking road transport networks. Aging, increase in traffic volumes and the harsh environmental conditions coupled with the limitation of funds justify for bridge managers to prioritize maintenance. The laxity in bridge maintenance may translate to huge costs of repair, rehabilitation and replacement. Therefore, for an effective maintenance, bridge managers must invest more time and energy in strategic planning.

Previous studies (Bakamwesiga *et al*., in press; UNRA, 2009) indicate that the bridge network in Uganda is marred by neglect, defective maintenance, environmental actions as well as aging. As a result, in the past decade, bridge failures and collapses have become of great concern for managers, policy makers and the donor communities. This coupled with the absence of a formal Bridge Management System (BMS) and the fact that the bridges are crucially important linkages in a highway network are factors that motivated this study.

Elsewhere, studies on priority maintenance of bridges have been done. The ranking procedures, widely used to prioritize bridges for maintenance (Wakchaure *et al.*, 2013), suggest that bridge condition cannot be regarded as the only criteria for prioritizing bridge maintenance activities. Chassiakos, *et al*. (2005) suggested a knowledge-based maintenance planning of highway bridges. Decision parameters, such as defect type, severity and extent, bridge age and environmental conditions are employed. The system was evaluated to provide a valuable tool

for short-term maintenance decisions. Wakchaure *et al*. (2013) developed factors affecting priority of maintenance for bridges. The 27 factors which were obtained through preliminary results, expert consultations as well as literature reviews were later used for the development of Maintenance Priority Index (Wakchaure *et al.*, 2014).

From literature, bridge management systems may use the knowledge from other systems to capture site-specific information which can be adjusted to existing bridge management techniques in order to come up with a system to plan and prioritize the maintenance actions.

This paper aims to develop decision support regarding the prioritization of highway bridge maintenance needs, to provide an insight of bridge condition with careful consideration of environmental conditions as a major causal factor of deterioration for reinforced concrete and give necessary policy options regarding bridge maintenance. It is, then, reasonable to combine different methodologies which consider the bridge surface integrity, environmental conditions and aging.

The results from the study will be a methodology for prioritizing bridge maintenance which will help to minimize premature bridge failures through timely and cost effective maintenance. This will improve the ability of the Uganda National Roads Authority (UNRA) to make bridge specific-decisions and allocate funds for specific intervention programmes. The study recommends that priority maintenance planning be an integral process to the development and establishment a BMS.

2.0 METHODS

A total of 18 highway bridges were sampled. Of these, 68.4% were steel-concrete composite bridges and the rest were concrete. The study sites and highways (Figure 2) were identified during a survey carried out in the months of June and July 2011, as part of an ongoing PhD programme. The bridges, located along 5 highways, radiate from Kampala city to the western, south western, northern and eastern parts of Uganda (Bakamwesiga *et al*., 2014a). All the chosen sites were under the management of UNRA. A big proportion of bridges (67%) were constructed in the 1950s and 1960s. The bridge age range is 52 years.

2.1 Field surveys and data

A combined methodology of simple and inexpensive non-destructive (NDT) and semi-destructive techniques (SDT) was used to assess bridges' condition without affecting their functionality and serviceability (Table 1). Field surveys were carried out in the months of May, June and July in 2011, 2012 and 2013 (Bakamwesiga *et al*., 2014a).

Table 1. Bridge damages identified, their description and methods used.

Distress	Description	Methods
Corrosion	Exposed rusty steel bars	Visual and photography
Rust	Brown discoloring	Visual and photography
Cracks	Cracks on the deck, pier and abutment	Visual
Spalls	Detached concrete cover	Visual and photography
Carbonation	Drilling a hole in concrete	Phenolphthalein test
Chloride	Powdered concrete collected from drilled hole	Chloride ex-situ test
Compressive strength	In-situ compressive strength on deck, pier and abutment	Rebound hammer tests

The methodology maximises advantages and overcomes the limitations of the individual methods (Table 2). The methodology assumes "more-is-better-than-less", and hence by combining more than one method errors produced by one method (Qasrawi, 2000) are reduced. This is important because the quality of inspection heavily influences the accuracy of condition assessment which, in turn, determines the reliability of decisions to prioritize bridge maintenance (Rashidi and Gibson, 2012).

Table 2. Advantages and limitations of semi- and nondestructive techniques

Technique	Advantages	Limitations	Reference
Rebound hammer test	Easy to use, portable, and cheap	Type of formwork and carbonation on bridges could result in variable rebound values and ultimately the predicted concrete strength.	Rens and Kim, 2007; Long *et al.*, 2001
		Suitable to evaluate the surface of the concrete and therefore has limited use in massive structures and relatively old structures.	Rens and Kim, 2007
Carbonation and chloride content	Minimal destruction to the structure	Require a great deal of work, time and money.	Mitra *et al*., 2010
Visual inspection	Rapid and inexpensive	Only superficial flaws can be detected.	Yehia *et al*., 2008
		Qualitative data. Subjective judgment of the inspector is crucial.	Mitra *et al*., 2010
		Broad knowledge on concrete materials and construction methods is needed in order to extract most information.	ACI, 1998

The data gathered were largely qualitative as summarized in Table 3.

2.2 Why the proposed system?

Road and bridge construction activities often impact on traffic, livelihoods of nearby communities and natural environment. The impacts may be direct or indirect. While the indirect impacts include increased road accidents, noise and dust pollution, the direct impacts include soil erosion, changes to rivers and streams and underground water. These impacts may vary in

severity depending on magnitude and extent of coverage of the project. However, in the design and execution of road and bridge works, environmental issues are seldom overlooked (http://web.worldbank.org). It is for this reason that this study puts more emphasis on environmental factors that may affect the safety and functionality of bridges. This work aims to provide a methodology to support decision-making in prioritizing bridge maintenance.

2.3 Criteria for selecting and ranking bridges

Several criteria have been used for ranking priority maintenance of bridges. These are described below.

2.3.1 Damage types

The number, severity and extent of damage types vary between bridges. Previous survey (Bakamwesiga *et al*., 2014a) on visible damage types indicate that although all bridges have damages, some bridges are more affected than others.

2.3.2 Surface concrete strength

Normal rebound values reflect the soundness of concrete cover. Average Rebound values obtained during field surveys which were carried out in the months of May, June and July, 2013, showed that a couple of bridges had below- normal (30 – 50) concrete strength values (Bakamwesiga *et al*., 2004b).

2.3.3 Age

The assumption is bridges degrade with age. Analyses conducted on the average Rebound values obtained in 2.3.2 revealed slightly higher negative correlation between age and abutment than age and pier values. Considering this information, bridges which are less than 20 years old were rated Low, 20-50 year, Medium and above 50, High.

2.3.4 Flood potential

Bridge inspection reports by UNRA reveal flooding as a major factor that leads bridge failures and collapses between 2010 and 2013 (Bakamwesiga *et al*., in press). Although the causes of floods are numerous, in this study a combination of soil types, vegetation cover and topography (Table 4) have been considered and weighed based on previous study on flood risk (PreventionWeb, 2011) and researchers' experience.

2.3.5 Erosion potential

Factors that influence soil erosion include rainfall erosivity, soil erodibility, slope steepness, slope length, and vegetation cover (Claessens *et al*., 2008). In assessing the individual bridges a weighing system shown in Table 4, soil type which determines soil erodibility, catchment slope and flood potential have been used. The assumption is that given the same rainfall intensity over the study area, the steeper the catchment, the lower the flood potential.

2.4 Multi-criteria model structure

A multi-criteria type model structure depicted in Figure 1 is used to compute the maintenance priority index for each bridge. First is the composition of the input parameters to assess the criteria. Second the criteria are weighed and rated. Third is to provide priority index and ranking.

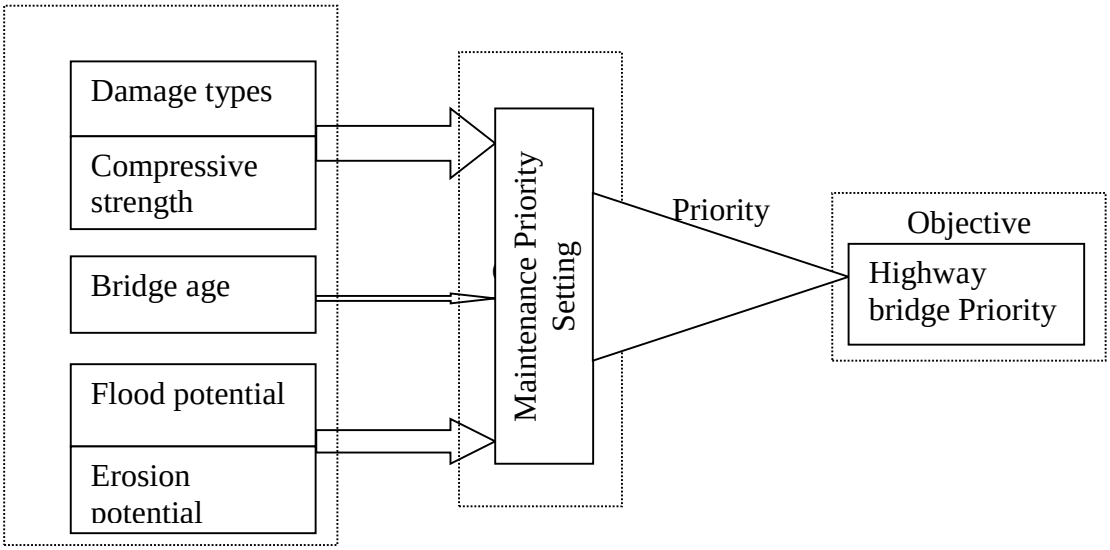

Figure 1. Multi-criteria model structure of bridge maintenance priority

Table 3. Decision parameters of maintenance selection

Attribute	Parameter	KAF	TIT	KAR	TOR	MP1	MP2	RWI	MUB	NYA	KAT	NGM	KAN	OMU	KEM	MAT	KIB	MAL	MAN
Damage type	Corrosion/rust/cracks	√	√	√	√	x	√	√	x	√	√	x	√	x	x	x	√	√	x
	Delamination/spalls	√	√	√	√	x	√	x	x	√	x	x	-	-	x	-	√	√	√
	Blocked deck drainage	x	x	√	√	x	x	x	√	√	√	-	√	√	-	√	√	√	√
	Abrasion/gabion rupture/pitch failure	√	x	√	x	x	x	√	√	√	x	√	x	x	√	x	√	√	x
	Railing damage	x	x	x	x	√	c	√	x	x	c	x	√	x	x	c	m/c	x	x
	Carbonation[&]	A	-	-	A	A	P	A	A	A	P	A	-	A	P	-	A	-	A
	Chloride content[#]	7.5	-	-	15.0	7.5	4.3	3.2	-	2.8	14.5	-	-	4.0	11.2	-	16.5		17.0
	Av. rebound values	43	41*	36	46	43	23	47	43	28*	45	41	42	50	46	47*	43*	39	-
Bridge physical condition	Age	48	48	48	48	58	59	7	7	24	46	45	46	46	46	11	40	41	42
	Soil type	si	si	si	si	w	w	w	w	w	w	w	w	w	w	p	w	w	w
	Catchment type	v	m	r	m	h	r	h	mo	h	v	m	m	v	m	v	v	m	v
	Land use	sva	sva	dve	sva	gco	gco	icu	icu	sva	icu	icu	sva	sva	sva	sco	icu	est	icu
	Catchment slope (%)	0.32	0.6	0.25	0.25	0.3	0.3	2.0	8.3	8.0	0.4	1.4	3.5	3.5	3.5	0.62	0.5	0.7	4.0
	Clear height (m)[@]	5.1	2.6	8.5	5.1	3.5	3.4	4.4	7.5	3.9	2.8	8.1	5.2	3.8	2.7	2.2	1.6	1.1	4.4
Bridge characteristic	Span length (m)	73.7	24.7	84.5	30.5	16.45	16.4	16.35	31.5	18.5	35.2	55.3	31.3	30.8	13.1	61.7	64.1	35.4	20.3

[*] Either the bridge abutment or the deck was tested

[&] and[#] Previous results show absence and negligible concentrations of carbonation and chloride and, therefore, excluded in the system.

[@] Average height of river channel as measured from the topmost water level up to the deck-bottom.

Key:

Site codes: KAF = Kafu, TIT = Titi, KAR = Karuma, TOR = Torchi, MP1 = Mpanga 1, MP2 = Mpanga 2, RWI = Rwimi, MUB = Mubuku, SED =Sebwe, NYA = Nyamwamba, KAT = Katonga, NGM = Ngaro-Mwenda, KAN = Katinda-Ntinde, OMU = Omungyenyi, KEM = Kemyenda, MAT = Mate, KIB = Kibimba, MAL = Malaba, MAN = Manafwa.

Damage types: - no data, x = damage absent, √ = damage present, N/A = not applicable, c = concrete barrier, m/c = metal and concrete railings

Carbonation and chloride content: A = absent, P = present

Bridge physical condition:

Soil type: si = soils with slightly impeded drainage; w = well drained; p = poorly drained

Land type: v = very flat; m = moderate; r = rolling; h = hilly; mo = mountainous; e = ephemeral stream

Land use: sva = Swamp filled valley; dve = dense vegetation in valleys; gco = grass cover; icu = intense cultivation; est = Ephemeral stream

Sources of information: Bakamwesiga *et al*., 2014a, Claessens *et al*., 2008, http://chimpreports.com/index.php

2.5 Priority setting and rating

The objective was to set maintenance priorities according to existing bridge damages and other characteristics such as environmental exposure, age and concrete surface strength. The decision parameters are appropriately weighed (Table 4) to reflect the urgency of repair.

In this study, a multi-criteria analysis and scoring model suggested by Chassiakos *et al*., (2005) were adopted to calculate the priority index:

$$\mathrm{PI}(y) = \sum_{x} w_x r_{xy} \qquad (1)$$

Where w_x is the weight for attribute x; r_{xy} is the weight of option y with respect to attribute x. These were then allocated ratings of *High*, *Medium* / *Moderate* and *Low*, based upon criteria shown in Table 4. For the sake of modelling the priority ratings are transformed into numerical values. Relative weights initially set by experience of the researchers, were then adjusted to fit the expert views. Priority rating values are based on consideration of bridge safety and functionality and expected damage rates. A priority index was automatically calculated through an MS-Excel application using actual data inputs for each bridge.

Table 4. Decision parameters and their weights

Attributes	Weight	Options	Rating	Weight
Damage types	0.30	Rebar		0.40*
		corrosion/cracks/rust/delamination/spalls		0.15*
		Railing damage/absent		0.25*
		Abrasion/gabion raptures/failed stone pitch		0.20*
		Deck drainage failure		
Compressive strength	0.05	Normal rebound values, 30 -50		0.45
		Less than normal rebound values, <30		0.55
Bridge age	0.10	Less than 20 years	Low	0.26
		Between 20 and 50 years	Mediu	0.32
		More than 50 years	m	0.42
			High	
Flood potential	0.35	Dense vegetation/grass/swamp filled valleys		
		Well drained soils	Low	0.25
		Mountainous/hilly; Catchment slope, >2%		
		Dense vegetation/grass in valleys		
		Poor/well/slightly impeded drained soils	Mediu	0.30
		Moderate terrain; Catchment slope, <4%	m	
		Intensely cultivated valleys		
		Well drained/slightly impeded soils	High	0.45
		Very flat/rolling; Catchment slope <1%		
Erosion potential	0.20	Intensely cultivation valleys		
		Well drained soils		
		Hilly/Mountainous	High	0.45
		High flood potential		
		Densely vegetated/Swamp filled valley		
		Well drained soils		
		Mountainous/Hilly/Moderate terrain	Medim	0.30

	High/Medium flood potential Grass/Swamp filled/densely vegetated valleys Well/poorly drained/slightly impeded soils Moderate/rolling and very flat terrain Medium/Low flood potential	Low	0.25

*The weights for damage type are multiplied by 1.5, 1.3, and 1.0 to account for high, medium or low severity extent, respectively.

Table 5 presents input information from 18 bridges located along 5 highways. The study bridges present single and multiple damage types in almost equal numbers, 10 and 9, respectively. For bridges with multiple defects, because the damage types are independent of each other, they are considered separately, and then summed up to determine total weight per bridge.

Table 5. Bridge priority ratings of input information

Bridge Code	Damage type	Damage extent	Compressive strength	Age	Flood potential	Erosion potential
KAF	Rust and cracks	Medium	Normal	20-50	Low	Moderate
	Blocked drainage	Low				
	Abrasion on abutment	Medium				
TIT	Cracks and spalls	Medium	Normal	20-50	High	Low
KAR	Corrosion on pier	Medium	Normal	20-50	Low	Low
	Blocked drainage	Low				
	Abrasion on pier	High				
TOR	Deck cracks and spalls	Low	Normal	20-50	Low	Low
	Silted surface drains	Low				
MP1	Blocked drains	High	Normal	>50	Moderate	Low
MP2	Crack on abutment	High	Less than normal	>50	Low	Low
RWI	Corrosion under deck	Low	Normal	<20	Low	High
	Railings damaged	High				
	Abrasion on substructure	Medium				
MUB	Blocked drains	Medium	Normal	<20	Low	High
	Abrasion on substructure	High				
NYA	Delaminations/Spalls	Low	Less than normal	20-50	Low	Moderate
	Blocked drainage	High				
	Abrasion on abutments	Low				
KAT	Cracks and spalls	High	Normal	20-50	High	Low
	Blocked drainage	High				
NGM	Abrasion on pier columns	Low	Normal	20-50	High	Moderate
KAN	Delamination and spalls	Low	Normal	20-50	Moderate	Moderate
	Silted drains	High				
	Railings damaged	High				
OMU	Silted drainage	Medium	Normal	20-50	Moderate	Moderate
KEM	Abrasion of abutments	Medium	Normal	20-50	Moderate	Low
MAT	Silted drainage	Low	Normal	<20	Moderate	Low
KIB	Deck crack and rust	High	Normal	20-50	High	Low
	Gabions needed	High				

	Blocked drainage	Low				
MAL	Corrosion and spalls	High	Normal	20-50	High	Low
	Stone pitching/gabions	High				
	Blocked drainage	Medium				
MAN	Delamination and spalls	Medium	Normal	20-50	Low	High
	Blocked drainage	Low				

Table 6 also shows the priority index calculated for each bridge using Eq. (1) and the parameter weights from Table 3. The priority index reflects the degree of urgency of maintenance in relation to other bridges. For the ease of differentiating the PI values, the calculated PI is further converted to percent PI using Eq. (2).

$$\mathrm{PI}_{100} = {PI_{cal}}/{PI_{\max}} \times 100 \tag{2}$$

Where PI_{cal} is the bridge (calculated) priority index value, $PI_{\max}$ is the maximum total priority index for a bridge, which is 0.767.

2.6 Priority ranking and model validation

The priority indices obtained were sorted in descending order and then assigned ranks; 1 and 18 being the highest and lowest ranks (denoted as x_1 in Table 6), respectively. To validate the multi-criteria model used, a bridge expert was asked to independently rank the bridges (denoted x_2 in Table 6). The question posed to the expert based at the bridge unit in UNRA was; *supposing you are given resources for maintenance, prioritize the following bridges, 1 being the highest and 18 the lowest priority rank*? To evaluate the performance of the model the root-mean-square deviation (RMSD) and the normalized root-mean-square deviation (NRMSD) expressed as percentage were used in this study. The two criteria are frequently used to measure differences between predicted and actual observations, neither of which is accepted as the standard. They are defined as follows:

$$RMSD = \sqrt{\frac{\sum_1^n (x_1 - x_2)^2}{n}} \tag{3}$$

$$NRMSD = \frac{RMSD}{x_{\max} - x_{\min}} \times 100 \tag{4}$$

where x_1 and x_2 are the actual (system ranking) and prediction (expert ranking) values, respectively, $x_{\max}$ and $x_{\min}$ are the difference between the maximum, 18, and the minimum expert, 1, ranking values. From Eqs. (3) and (4), the values of RMSD and NRMSD are found to be 2.6 and 15.4%, respectively.

Table 6. Priority ranking for maintenance

Bridge code	Priority Index (PI_{cal})	Percent Priority index, (PI_{100})	Priority ranking		x_1- x_2	(x_1- x_2)^2
			x_1	x_2		
KAF	0.511	66.6	5	6	-1	1
TIT	0.452	58.9	7	5	2	4
KAR	0.576	75.0	3	4	-1	1
TOR	0.390	50.8	12	15	-3	9
MP1	0.309	40.4	16	12	4	16
MP2	0.387	50.5	13	11	2	4
RWI	0.444	57.8	9	10	-1	1
MUB	0.417	54.3	10	9	1	1
NYA	0.484	63.1	6	8	-2	4
KAT	0.532	69.4	4	3	1	1
NGM	0.369	48.2	14	7	7	49
KAN	0.365	47.6	15	14	1	1
OMU	0.409	53.3	11	15	-4	16
KEM	0.380	40.0	17	17	0	0
MAT	0.282	36.7	18	18	0	0
KIB	0,615	80.1	2	2	0	0
MAL	0.633	82.5	1	1	0	0
MAN	0.450	58.4	8	12	-4	16

3.0 DISCUSSION

This section presents the results of the ranking system used. Inferences are drawn from the results, and complimented by previous studies and the experience of the authors.

Altogether, the prioritization exercise indicates a variation in the condition of bridges. From the ranking system the highest maintenance priority should be given to Malaba, followed by Kibimba, Karuma Katonga bridges. Kibimba, Malaba and Katonga bridges are located in the eastern and central parts of Uganda. The finding concurs with previous report (PreventionWeb, 2011) that the eastern and central regions are most vulnerable to flooding. The report further reveals that risk to soil erosion is comparatively higher in western and southwestern Uganda than most of the rest of the study area.

In general, the system and expert rankings compare adequately, with a difference of 15.4% in the rankings. The system registered same ranking of 2 highest and the 2 lowest priority bridges for maintenance. Several other bridges registered slight differences in between the highest and the lowest ranks. There were considerable differences among a few bridges. A number of reasons could explain the findings. The few similarities are probably due to obvious damages which were easy to identify by both the researchers and expert. The differences could be a result of several factors, which this study will not cover. However, perhaps a major limitation to model verification, the study used one expert. Results of several experts would probably change the trend.

Nevertheless, a couple of advantages endeared us to use the knowledge-based system. First, it is quite adjustable and easy to use in varying conditions. Second the system helps keep record of expert knowledge for future reference. Quite often specialized knowledge disappears with the death or unavailability of the experts because of lack of documentation. As a result, a lot of resources are spent to get the same information time and again. This justifies the importance of this kind of study to bridge management agencies.

4.0 CONCLUSION

In this paper, a knowledge-based system that can be used for maintenance planning of bridge has been presented. The system is intended to aid decision-making process on the urgency of maintenance, repair and rehabilitation of some bridges over the others. Bridge damages such as reinforcement corrosion, spalls, and delamination, and age and environmental conditions, flood and erosion potential are employed to determine priority bridges for maintenance. Flood potential was considered to pose more risk than superficial bridge damages. The multi-criteria model has been evaluated with expert's views and is seen as one of several decision supports which can be used by bridge managers for planning maintenance actions. In a multi-criteria model structure each bridge is considered with respect to every parameter and a value is assigned depending on how the bridge is rated with regards to the parameters. Then, a total index is calculated for each bridge. For better results it is important to consider other factors such as availability of funds, design factors, bridge importance and political considerations, among others. Once these factors are considered, the system can be useful in the process to develop a suitable model of a BMS for Uganda.

5.0 RECOMMENDATIONS

This ranking system should be integral element of wider decision-making and policy formulation processes on priority planning of bridge stock countrywide. In order to achieve the best compromise, priority planning should be done as part of the processes to develop and establish a BMS. The BMS will help establish cost effective maintenance strategies at both bridge-specific and countrywide levels. However, it is worth noting that the allocation of funds is a sensitive political issue, therefore, decisions made on the establishment of programmes for maintenance of highway bridges should be politically defensible.

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To What Extent Have the Existing Land Tenure Systems Affected Urban Land Development?

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Abstract
In Uganda, urban areas develop in pockets compared to other countries with a uniform land tenure system. This research sought to investigate the extent to which the existing tenure systems affect urban land development. In this research, different land tenure systems were identified in the urban areas, development patterns on different land tenure systems were described, constraints imposed by land tenure systems on development were examined and services together with the nature of housing on different land tenure systems were investigated. Observations were made in Mbarara and Arua Municipality on the nature of developments on registered land and non-registered land. In each municipality, some areas were observed to be more orderly and better spatially organized than others for example in Mbarara municipality, Kamukuzi area, which is a predominantly residential area under leasehold and freehold tenure, was found to be more spatially organized than Kisenyi, a residential area for the poor under customary tenure. Houses on untitled land were mainly one roomed houses, constructed from inferior materials such as mud/wattle and grass well as housing on titled land were one, two and three bedroom houses and constructed with expensive materials such as burnt bricks, iron sheets and tiles. Areas on untitled land had a limited access to piped water, electricity, roads, education facilities, drainage, garbage collection points, and toilets compared to titled land that had better services. Formalization – resurveying of land for documentation should be done in a participatory incremental manner so as to avoid possible resistance from the settlers. This would enable the planning of the areas the people live in.

Key words: Formalization, Land Tenure Systems, Urban land Development.

1.0 INTRODUCTION

Land is an important factor of production. Land is used for construction of human shelter, agriculture and other economic activities (UN-habitat, 2008). Fast increase in population numbers in the urban places has increased the pressure on the limited land (Payne, 2007). The pressure is high in the urban areas compared to rural areas where the economic activities are low (Cohen, 2006). United Nations-World Urbanization Prospectus (2008) has projected that the population would have doubled by 2050. This population explosion will be due to the rapid expansion of the urban areas UN-Habitat (2008). UN-Habitat (2008) projected the built up areas of developing countries to expand from 200,000Sq Km to 600,000Sq Km by 2030.The growth of the urban cities of developing countries has exceeded capacities that planning for such cities has become difficult. Therefore these cities have developed tenure

insecurity, overcrowding, environmental health problems and limited access to good shelter (Cohen, 2006). Systems present in administering land rights in the urban centres are ineffective thus this has led to development of informal settlements (Sliuzas, 2004). Some of the causes of the informal settlements include; illegal tenure, not following subdivision rules when subdividing land and landowners not following building codes when constructing building (Farvacque and McAuslan 1992).

Land tenure system is the way people own land, occupy it, use it and dispose of it in the community (Payne, 2001). To ensure balanced and sustainable development, the land tenure system should be properly defined and managed (Postiou and Ioannidis, 2006). Before 1975, land in Uganda was under four tenure systems; freehold, mailo, customary and leasehold. After the land reform decree of 1975 land was given to the government, however people were allowed to settle anywhere they wanted provided they managed the land efficiently. Though in the 1995 constitution, the four tenure systems were restored (Bantungi and Rüther, 2008).

Uganda is mostly dominated by customary land tenure. Land under this tenure system is owned and disposed of according to the customary regulations of a particular community (Bantungi and Rüther, 2008). The rules governing the use and exchange of customary land vary among the ethnic groups and regions. One of the advantages of this tenure system is that people have lived with this system of land use and administration for a long time that they completely understand how it works. It has a problem that records are not kept making it difficult to resolve land disputes on this land (Bantungi and Rüther, 2008). There is little interest from the people on this tenure system to conserve the land resources hence there is a lot of mismanagement and degradation experienced. Mailo tenure system was introduced after the signing of the 1900 Buganda Agreement. Land was shared amongst the Kabaka of Buganda, other notables and the British protectorate. The basic unit of division was a square mile hence the name mailo. Originally mailo tenure was of two categories private and official mailo. The official mailo was transformed to public land later on. This tenure system is held for perpetuity and a certificate of title is issued (Okuku, 2006). The main advantage of this tenure system is that one has tenure security and so permanent investment can be made on such land. Regulatory agencies lack access to such land and hence cannot manage this land. This tenure also has a problem of squatters resulting from the absentee landlords. Land under the freehold tenure is also held in perpetuity and a certificate of title is issued. This tenure system was created to address the requirement of organizations like the religious and institutional organizations. It was also granted in other areas as a result of the Toro Agreement 1900, Ankole Agreement 1901 and Bunyoro Agreement of 1933. The British colonial authorities were given power to alienate land in freehold through the Crown Lands Ordinance (Okuku, 2006). This tenure system is mainly found in parts of eastern and western Uganda. Land parcels in this tenure system are small, though other features still remain the same as those of mailo making it experience the same environmental problems. Under the leasehold tenure system, land is held basing on the agreement made between the lessor and lessee. Leasehold tenure is divided into two types, private and official or statutory lease. Private lease is that given to individuals while official lease is that given to individuals or corporate groups under public Act terms (Okuku, 2006). The advantage of the leasehold system is that the lessor can attach conditions to the leases and has the right to revoke ownership in case of abuse. This tenure system is however very expensive and they have not addressed the environmental problems as they should (Bantungi and Rüther, 2008).

2.0 METHODOLOGY

The study was carried out in two municipalities; Arua and Mbarara municipality because of the evident development disparity and economic relevance of these municipalities in their respective regions (Northern and Western). Settlements were chosen purposively from each of these settlements for the study. The settlements were; Congo, Enyau and Nsambya - Arua and Kajogo, Kizungu and Kiyanza - Mbarara. Unprocessed Google earth satellite imagery taken on 18th February 2014 for Mbarara and Arua municipality was used. Document review was done to gain a profound understanding on land tenure systems, informal settlements and the urban development process. Photographs were taken to capture the types of buildings, and services on the different tenure systems. Key informant interviews with the municipality physical planners, Slum Dwellers Federations members, Deputy Clerks, Community District officers and the LC chairmen were conducted and questionnaires were administered to the local residents. To gain a deep insight into the issues affecting these people, focus group discussion were conducted with groups of females, landlords and tenants in these settlements.

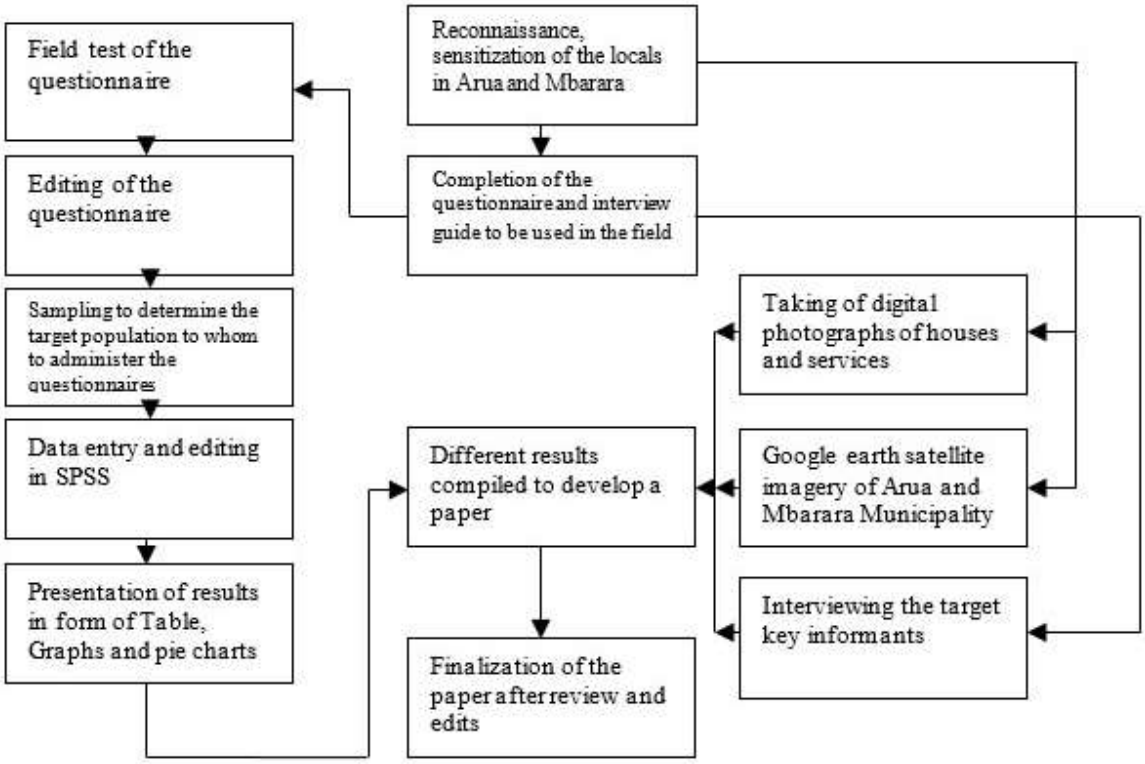

Figure 1: The flow of the Methodology used

3.0 RESULTS AND DISCUSSIONS

3.1 Evidence of Better Spatial Ordering on Titled Land

In each municipality, some areas were observed to be more orderly and better spatially organized than others. For example in Mbrarara Municipality, Kamukuzi area, which is a predominantly residential area under leasehold and freehold tenure was found to be more spatially organized than Kisenyi, a residential area for the poor under customary tenure Figure 2. Kamukuzi is located on a gentle hill while Kisenyi is located in a swampy valley within Mbarara Municipality. A further disparity was observed in plot sizes, which in the case of Kamukuzi were properly and neatly fenced off. The plots in Kamukuzi appeared larger in size; the observed houses were more beautiful, bigger with large and well maintained compounds. A second example where disparities

in developments is visible is Arua Municipality (Figure 3) in which Arua Hill, a predominantly leasehold residential area is visibly better spatially organized than River Oli, a settlement for the urban poor, where the land is predominantly held customarily.

Figure 2: (left) Kamukuzi residential area (right) Kisenyi residential area in Mbarara

Figure 3: (Left) Arua Hill-titled (Right) River Oli – Customary

3.2 Better Housing Units and Services on titled land

In the two municipalities, the study revealed distinct disparities between informal settlements and other better organized settlements based on the nature of housing structures and services. Houses in informal settlements were very small (one roomed), constructed from inferior materials such as mud/wattle and grass (Figure 4),well as the housing structures in other settlements were larger (one, two or three bedrooms) and constructed with more expensive materials such as burnt bricks, iron sheets and tiles. Access roads in informal settlements were very narrow, dusty and did not serve all the houses. A number of houses did not have access roads reaching them and one would have to wind through footpath, house verandas in order to reach some of the housing units. Other basic infrastructure, such as water and sanitation, electricity and community facilities were found to be sorely deficient, if they existed at all (figure 6).

Figure 4: Examples of housing structures in informal settlements

Figure 5: Examples of Houses in informal settlements

Figure 6: Poor Sanitation facilities in urban poor settlements

3.3 RESULTS FROM THE SURVEY

To assess the nature of houses in the urban poor settlements, respondents were asked to describe the kind of houses they were living in. The information was further verified through observation. The majority of the respondents (39%) possessed houses made of mud and wattle – thatched with iron sheets while others (15%) were living in houses built from unburnt bricks. Only 29% lived in permanent houses with burnt bricks and thatched with iron sheets. Only 29% lived in permanent houses with burnt bricks and thatched with iron sheets. Figure 4 shows examples of some of the houses observed in the settlements. Regarding services and facilities, respondents were requested to give their opinion on the adequacy of selected services provided in their settlements. The selected services included water, electricity, roads, education facilities, medical facilities, drainage, garbage collection points and toilets/pit latrines. The responses are summarized in Figure 7. From the results, garbage collection, drainage and electricity came out as the most outstanding problems for the urban poor settlements. These problems are largely associated with lack of planning. The poor state of these services is demonstrated in Figure 6.

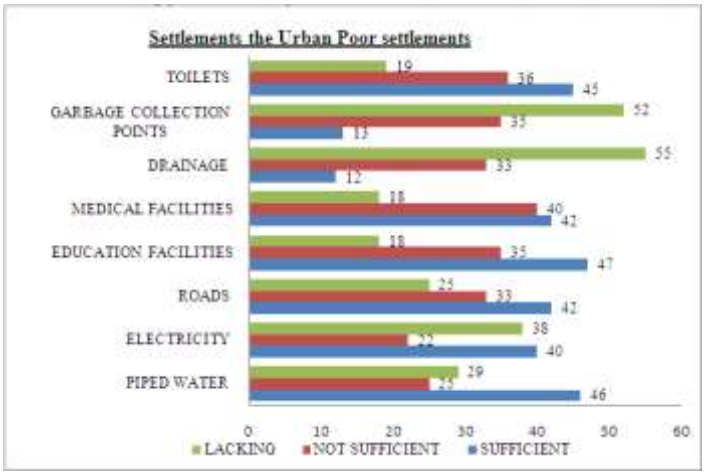

Figure 7: Satisfaction levels on the provision of services

3.4 DISCUSSION

In the two municipalities, it is clear that most of the better planned areas were located on titled land (leasehold and freehold) while most of the disorganized settlements were located on customary land Gidding (2009) , in the land market study for Kampala argues that failure by urban councils to enforce minimal planning standards has led to chaotic, unplanned land development, the inefficient use of ever-scarcer land, the occupation of environmentally fragile areas and the formation of large, poorly-serviced slum areas.

In this study, we concur that the disorganisation and chaos observed in the urban settlements for the poor is essentially as a result of lack of planning or lack of enforcement of plans by the urban authorities. This may not be directly related to land tenure types as there is always a requirement for government to approve any development or building plans before implementation, and this should not depend on land tenure. However, in Uganda, there is a requirement to provide proof of land ownership before building plans can be approved by the urban authority and this is where issues of land tenure come into play. Land owners on customary land where the ownership is not properly documented may not easily acquire planning permissions and hence end up acting in the informal sector (Nkurunziza, 2008). Furthermore, some land tenure systems such as mailo and customary are not perfectly individualised since they hold overlapping multiple interests. Security of tenure may lead to fear of eviction which will in turn lead to investments of a short term or temporary nature. Respondents complained of high standards for the requirements to have building plans approved. Many of the requirements were considered to be time consuming, unclear, prohibitive and extremely expensive to the urban poor. With meagre financial resources, but in need of basic housing, the remaining logical alternative for the urban poor is to take a risk of constructing a low cost housing unit without following the formal procedure. The biggest risk as perceived by the urban poor was demolition of their houses during or after construction and prosecution in courts of law (Kombe and Kreibich, 2000). However, because of corruption and weak enforcement mechanisms, the urban dwellers would find ways of minimising the risks. On the other hand, it was established through informant interviews that the middle class were not more likely to take a risk of development without legal land ownership documents and approved plans because the size of investments was in most cases relatively large. In case the funds for housing construction were to be borrowed from financial institutions, a formal procedure was mandatory, as a precondition for financing (Olima and Obala, 1998). As a result of the constraints explained above, the nature of developments on

customary land included mainly semi-permanent and temporary structures used for residential purposes.

Commercial premises on customary land included small scale businesses such as stalls and make-shift village markets. On the contrary, freehold and leasehold land was mainly occupied by high value permanent buildings for residential purposes and multi-storeyed buildings for commercial purposes. In the order of ranking, the most developed and planned land tenure was leasehold followed by freehold and customary. The explanation for this trend is probably because leasehold tenure sets conditions which, if not adhered to may lead to loss of the lease offer and associated land rights. Therefore leasehold tenants ensure that all processes and planning standards are complied with so as to avoid the heavy penalties associated with noncompliance. Freehold tenure on the other hand gives the owner a sense of perpetual ownership which may sometimes become a dis-incentive to planning compliance (Schwartz, 2008). Since the urban council does not own the land, the level of control on use may not be as good as in the case of leasehold where the urban council owns the land. Planning for common facilities such as garbage collection areas, drainage, access roads, becomes complicated when land does not belong to urban council (Nsiah-Gyabaah, 2005). Finally, customary tenure limits development because the land is not documented and hence not available for planning. More so, some customs such as those prohibiting sale of land outside the clan do not promote maximum utility of land.

4.0 CONCLUSIONS

Settlements for the urban poor in Uganda are predominantly under the customary land tenure system. Areas outside the informal settlements have land on leasehold, freehold and Mailo, most of the land holding businesses is on leasehold, religious and educational institutions on freehold. Titled land under both the leasehold and freehold tenure has developments that are more orderly and spatially organised compared to the untitled land under customary land. Buildings on titled land are large and made of quality materials compared to the small (one roomed) sized buildings on untitled land that are made of inferior building materials. Customary tenure does not encourage record keeping except for some areas where certificates of customary occupancy have been issued which makes the resolution of disputes and the approval of building plans difficult. In freehold, land is held in perpetuity and a title is issued thus resolution of disputes and the approval of building plans is easier. On leasehold land the lessor attaches conditions to the leases and the lease can be revoked in case of abuse hence orderly developments are most on such land. These tenures are however very expensive to get and the slum dwellers cannot afford land in this tenure. Land under customary ownership has semi-permanent buildings because of the tenure insecurity on such land as the owners have no proper documentation to show ownership. Buildings on leasehold and freehold are permanent and large sized made from standard material due to the tenure security on such land as the owners have titles over the land.

5.0 RECOMMENDATIONS

An inventory should be carried out on customary land to assert the landlords in the settlements so that this could be used as evidence enough to grant such owners building permission. Over a long term these should be encouraged to formalize their land converting it to either leasehold or freehold. Community planning should be encouraged so that the people can voluntarily avail land for the provision of the services compared to the forceful evictions with little compensation given

to the people affected. The most outstandingly lacked services are the garbage collection points and the drainage facilities which could be handled first due to limited finances that are available.

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The potential of local building materials in the development of low cost housing in Uganda

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ABSTRACT

In Uganda, limited availability of building materials, rapid population growth and limited household incomes cast a serious challenge to low-income earners' access to decent shelter. The supply of decent shelter is hampered, among others, by constrained access to appropriate and affordable building materials and designs, security of land tenure, inappropriate building by-laws, standards and regulations. In examining problems of low cost housing in Uganda, the study focuses on the use of local building materials' potential to improve low-income earners' access to decent shelter. The study is based on primary and secondary data from around the country, literature and archival reports, and interviews of key personnel in the building sector. The study concludes with the view that local materials have potential to positively contribute to improving access to decent housing by low income earners. It observes that demand for housing cannot be met by solely using imported materials. On the other hand, results indicate that most local building materials are of poor quality. The study advocates improving the quality of local materials and their standardisation as a way of improving their potential use in the development of housing in the country. It also recommends sustainable exploitation and commercialisation of the production of the materials as a way of attaining affordable decent shelter.

Keywords: Indigenous building materials, affordable housing, decent housing.

1.0 INTRODUCTION

In the last half a century, Uganda's population increased from 4.96 million in 1948 to 25.3 million in 2003, and it is estimated to have reached 30.7 million in the National Household Survey 2009/2010. This has since grown to 34.1 million (2012), 35.4 million (2013) and it is estimated to reach 38 million people by 2015 (Uganda Bureau of Statistics (UBOS), 2010; 2012; 2013). Rapid population growth, poor state of the national economy, constrained access to appropriate and affordable building design and materials, limited access to land, inappropriate building by-laws, standards and regulations have had the effect of concentrating low-income earners in poor housing conditions that lack planning and servicing (UBOS, 2010). In an environment of wide spread poverty and increased demand for housing there is a need to increase the supply of decent housing to all income categories in the country.

Uganda is listed among the seven countries in sub-Saharan Africa that are in need of low cost building projects (International Centre for Science and High Technology (ICS), 2008). Many Ugandans face an uphill task accessing decent shelter. This is more widely experienced among low-income earners who find it costly to develop housing using contemporary building materials that are often imported or transported long distances from the manufacturer to sites of construction. With limited options, low-income earners often resort to locally available materials for house construction. 71 per cent of the housing stock in Uganda is constructed of local materials that are temporary in nature (UN-Habitat, 2010). However, most of these local building materials are of poor quality, as they are unprocessed, non- standardised and their properties not well understood.

Under this background, this paper examines the potential of local building materials in the development of low-cost housing in Uganda.

2.0 MATERIALS AND METHODS

The study examines the potential of using local building materials to develop affordable and acceptable, decent shelter in Uganda. The methods used were limited to evaluation of literature which consisted of both qualitative and quantitative data, official/government documents and archival documents about local building materials. This was supplemented by information gathered through field observation in the four regions of Uganda - west, east, south and central, interviews of some key personnel in the building sector – contractors, local builders and artisans, to while focusing on its potential of local building materials in the context of Uganda. This information from the field was used to gather responses on the use, and potential local materials in filling the gap of materials that can be used in the housing construction sector in Uganda.

3.0 RESULTS

The results here discussed are outlined in four sections – use of local materials, their acceptability, cost and sustainability.

3.1 USE OF LOCAL OF LOCAL BUILDING MATERIALS IN UGANDA

Use of local building materials is examined with respect to the major building component of the house – roof, wall and floor. Table 3.1 shows the use of building materials in the country.

Table 3.1: Distribution of households by main type of construction materials, residence and survey period (%)

	2005/06			2009/10		
Materials	**Rural**	**Urban**	**Uganda**	**Rural**	**Urban**	**Uganda**
Roof						
Iron sheets	55.9	82.7	60.6	56.7	84.1	61.8
Thatched	43.2	14.2	38.2	42.6	12.0	36.9
Other roof	0.9	3.1	1.3	0.7	4.0	1.3
Wall						
Bricks	48	79.2	53.4	50.9	83.9	57.1
Mud and	47.2	17.2	42	45.7	12.4	39.4
Other walls	4.8	3.6	4.6	3.4	3.8	3.5
Floor						
Earth	82.8	29.6	73.5	82.1	25.2	71.4
Cement	16.5	68.6	25.6	16.9	70.8	27.
Other floor	0.7	1.8	0.9	1.0	4.0	1.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: UBOS (2010: 114).

Roofing materials

Examination of the houses in Uganda shows that there is a limited choice in the use of roofing materials. Construction of roofs for low cost housing in the country has largely been restricted to the use of iron sheets, thatch and in some cases salvaged materials. According to UBOS (2010), at a national level, use of iron sheets rose from 60.6 per cent (2005/06) to 61.8 per cent (2009/10) and that of thatch reduced from 38.2 per cent to 36.9 per cent in the same period respectively. Although iron sheets are the most commonly used roofing materials on houses in Uganda, their affordability and supply sustainability are in question. Uganda still imports iron sheets and the few industries that manufacture the material locally rely heavily on imported raw materials and scrap. Scrap contributes 70 per cent of the raw material for Uganda's iron and steel industry (Senfuka et al, 2011). Steel, a major construction material in the country is mostly imported. The demand for steel in Uganda stands at 140,000MTpa. The installed production capacity for the local mills is 123,500MTpa, yet actual production is at a mere 57,200MTpa, giving a deficit of 66,300MTpa. On the other hand, Uganda has enough iron ore to meet the country's demand and leave 50 per cent of the production for export (ibid). This is an indication of unexploited potential.

The use of other roofing materials such as clay tiles did not have any significant change between 2005/06 and 2009/10. Because of its high cost and limited production, despite its good construction properties, the use of clay tiles is still limited to a small proportion of the overall housing stock in the country. Clay tiles are largely used in high grade housing and other non-residential constructions. It is, however, important to note that these are considered as cladding materials. Predominantly, timber, whether processed or unprocessed is used as the structural frame for the roof. The complex nature of choosing building materials is further surmised upon in the observation made by Government of Uganda (2010:131) that posits that "*Construction materials indicate the durability of a dwelling unit and denote the economic status of the household*". Apart from influential factors identified by UN-Habitat (2010) as durability, scarcity of material and personal choice other issues such as cost, acceptability and local building regulations also play a role. For example, in Kampala, building regulations do not permit the use of thatch in urban areas as it is considered to be a temporary, non-standardised material and a fire risk. Musoke, one the local artisans who was interviewed in the study stated that many of his colleagues and the clients they work for look upon thatch as a backward building material whose use should be restricted to rural areas. Unless protected, thatch is a non-durable material in Uganda's hot and humid climate. It is susceptible to rot, termite attack and fire. The material is also becoming scarce and expensive in the urban environment, where vegetation is steadily disappearing due to other human activities. Interview with residents in northern and western parts of the country stated that on average thatch on a local dwelling is changed every three years. On the other hand, use of thatch can be improved by growing the raw material to increase supply, use of fireboards and chemical treatment to improve its resistance to vermin and fire attacks, use of high roof pitches to facilitate easy run off of water to avoid leakage and good workmanship to achieve quality work (CSIR-CBRI, 2011).

Walling materials

Bricks and mud and poles are the major walling materials for constructing residences in Uganda. Use of bricks rose from 53.4 per cent (2005/06) to 57.1 per cent (2009/10) while mud and pole reduced from 42 per cent (2005/06) to 39.4 per cent (2009/10) (Table 3.1). This situation points to the potential these local materials have and the need to improve them for house construction. However, the use of mud and pole construction may also be affected by factors earlier mentioned, including depletion of forest cover leading to rising cost of poles and timber, building regulations that do not allow use of mud constructions in urban environment, people's attitude to the material, its durability and so many others.

In Uganda, there are three types of bricks used mainly in the construction of houses. These are adobe bricks (burnt and un-burnt), clay bricks (burnt and un-burnt) and cement sand bricks. Many are non-standardised, of varying sizes and structural properties. In addition, use of stabilised bricks has become popular of recent. These may be compressed or uncompressed. Nonetheless, their application is still looked upon (often wrongly) by residences with suspicion, and the technology used as being foreign, expensive and un-sustainable. Adobe and clay bricks are the most used options. In the urban setting, other non permanent options used include salvaged tins, polythene sheets, timber and other vegetable materials (fig. 1-2).

Fig 1: Timber used for constructing temporary structures

Fig. 2: Papyrus used for constructing temporary structures

Conversely, other materials such as stone have not been considered as important although they are widely used both in residential and non-residential construction in the country. Stone is widely used either dressed or undressed in many ways. For example, as a walling material in water logged places, a permanent, maintenance free, water proofing and decorative material as well (Fig. 3-4).

Fig. 3: Use of thatch and stone for a simple dwelling in Mbarara, western Uganda.

Fig. 4: An example of stone used as a maintenance free building material.

Achieving decent shelter sometimes requires simple but innovative design and construction interventions to ensure durability of the house. These interventions may include; improvement of functioning of roofs by ensuring proper roof; protection of floors and walls from rain and water by the use of roof overhangs, burnt clay bricks around openings, use of lintels to span openings, use of plaster or other material on the external walls, construction of splash aprons, damp-proofing foundations, and allowing for proper drainage of water away from the building; improvement of lighting and ventilation by ensuring cross-ventilation and use of glass windows and vents to allow in light and ensuring adequate ceiling heights.

3.2 ACCEPTABILITY OF LOCAL BUILDING MATERIALS

The use of local building materials is wide-spread not only in rural areas, but also in urban areas of the country. Despite this wide use, formal acceptability of the materials is still yet to be achieved. In urban areas of Uganda, the use of indigenous materials, such as thatch, mud and wattle, sun dried bricks, is not recognised by the local authorities (SSA:UHSNET, 2014). Just like in Kenya, in Uganda even stabilised soil blocks are not yet integrated in the local planning standards, and are looked at with suspicion (UN-HABITAT, 2005). On the other hand, the UN-Habitat identifies the need to encourage growth and regularisation of the informal sector and informal building materials as one of the interventions in the rapidly growing urban housing market (UN-Habitat, 2010).

3.3 COST OF LOCAL MATERIALS

A large proportion of contemporary building materials in Uganda are imported. Even materials such as roofing sheets and paint that are locally manufactured are made from imported raw materials, thereby significantly raising their production costs. In addition, rising fuel costs have also drastically contributed to high costs of building materials. For example, in Kampala, transportation costs of a track of sand are about 20-25 times the cost of the material. At the same time, both costs are expected to continue to rise as current sources of the local materials near building sites gradually get depleted. This means that it may be possible in certain circumstances to reduce the cost of construction of a house by using indigenous materials that can be procured within the locality of construction. On the other hand, the cost of some of the indigenous materials such as timber, thatch, papyrus and local bricks is also rising owing to un-guided and unsustainable exploitation of the materials.

Table 3.2: Changes of average building materials costs in Kampala

DESCRIPTION	UNIT SIZE	COST (UGX) 1USD ≈ 2500 UGX		
		DEC 2008	APRIL 2009	JANUARY 2010
CEMENT	50 kg	22,000	23,800	26,500
Cement Hima (Portland pozolanic)	50 kg	23,000	23,800	27,000
Cement Tororo	40 kg	33,000	42,000	45,000
LIME				
Building lime white (Kenya)	25 kg	13,500	14,000	15,000
Tiger Lime Uganda	50 kg	13,500	14,000	15,000
ROOFING				
Mangalore Tiles (Selected)(16Pcs/sqm)	pc	1,540	1,540	1,540
Mangalore Tiles (Standard)(16Pcs/sqm)	Pc	1,340	1,340	1,500
New Portuguese Tiles (16 Pcs/sqm)	Pc	2,140	2,140	2,500
Roman Tiles(35 pcs/sqm)	Pc	1,340	1,340	1,500
CLAY BRICKS				
Selected Bricks (215X105X65mm) (120pcs/sqm)	Pc	491	500	550
Standard Bricks (215X105X65mm) (120pcs/sqm)	Pc	415	440	450
Local Bricks (90pcs/sqm)(215X105X65mm)	Pc	120	135	150
GALVANISED IRON SHEETS				
G32 (0.18mmBC/0.215mmAC)	Pc	12,300	19,500	20,000

G28 (0.29mmBC/0.305mmAC)	Pc	18,750	25,500	26,000
G26	Pc	27,150	42,000	42,500
STEEL				
Mild steel round R6 40'X6mm	Pc		7,300	10,500
Mild steel round R10 40'X10mm	pc		12,000	14,000
Mild steel twisted Y12 38'X12mm	pc		25,500	35,500
Mild steel twisted Y16 38'X16mm	Pc		42,000	55,000
Mild steel twisted Y20 40'X20mm	Pc		70,000	95,000
TIMBER AND BOARDS				
Block Boards (Local)(8'X4'X1")	pc	70,000	80,000	85,000
Soft Board (Kenya)(8'X4'X1")	pc	25,000	29,000	31,000
Pine Timber Machine cut (4"X2"X14')	pc	7,000	9,000	11,000
Pine Timber Machine cut (6"X2"X14')	pc	12,000	16,000	17,000
Cypress Timber Machine cut (12"X1"X14")	pc	25,000	27,000	28,000
Seasoned Mahogany-Masindi (12"X2"X14')	pc	50,000	65,000	80,000
AGGREGATES				
Lake sand	7 ton trip	110,000	120,000	150,000
Plaster sand	7 ton trip		110,000	140,000
Hand crushed aggregates ½"	7 ton trip	160,000	175,000	180,000
Machine crushed aggregates ½"	7 ton trip	245,000	280,000	320,000
TRANSPORT around Kampala for a 7 ton & 15 ton tipper ranges from shs.70,000 and 120,000-150,000 respectively depending on distance.				

Source: Adopted from UN-Habitat, 2010:137-8.

Examination of the building materials for the major house construction components in Uganda (Roof, Wall and Floor) indicate that the country still lacks variety of these materials, and that the situation did not change much between 2005 and 2010 (table 3.2). Cost of average building materials has been on the rise in recent years. For example, between 2008 and 2010 the cost of cement (Tororo) rose from Shs.23,000 (2008) to Shs.27,000 (2010); Mild steel twisted Y12 38'X38'X12mm Shs.25,000(2009) to Shs35,000 (2010); pine timber machine cut from Shs 12,000 (2008) to Shs. 17,000 (2010) and lake sand from Shs.110,000 to Shs.150,000 (2010) Table 3.2. This tends to limit the capacity of low-income earners to access decent shelter.

3.4 SUSTAINABILITY OF LOCAL BUILDING MATERIALS

Depletion of raw materials

Poor and unsustainable utilization of the natural resources have had a major impact to the disappearance of some of the natural resources. It is, therefore, imperative to develop systems of exploiting the resources in a sustainable manner (UN-Habitat, 2012). In Uganda, many indigenous materials are available in abundance, although of recent some are becoming scarce. For example, owing to environmental degradation, timber has become scarce in the northern and south-western parts of the country. In the past 10 years, the price of timber has risen by four folds. For example, timber harvesting by licensed pit-sawyers in Uganda increased from 51,000m^3 (1997/98) to 90,000m^3 (2004/05), round wood harvest increased from 215,723m^3 (2003) to 258,522m^3 (2007) yet forest cover is reducing fast. According to National Development Plan, forest cover in Uganda reduced from 4.9 million hectares in 1990 to 3.6

million in 2005 (Government of Uganda, 2010). At the present, much of the timber used in the construction industry in Uganda comes from the Democratic Republic of Congo. This puts its sustainable supply in question. Rising scarcity and increased demand for the building materials, have in turn, led some individuals to compromise the quality of the materials. For example, in a number of cases suppliers of building timber have harvested young trees and of poor quality for use, cement adulterated for money, and poor quality materials imported into the country (Mwesigwa, 2012; Sseremba et al, 2011). All these factors negatively impact on the quality of housing supplied.

Standardisation of the materials

In additions to the threat of depletion, many local building materials in the country are still used in their raw form, in ways that subject them to the elements, consequently rendering them temporary, as they may be used for a short time. There is also lack of research in the standardisation and improvement of some of these materials (Alinaitwe et al, 2006). For example, local earth bricks are not standardised, and the improved cement earth blocks have not yet been accommodated in the country's building by-laws despite their wide potential and practical application.

Although consumption of cement has increased in the country significantly in the last 10 years, its supply is still below the market demand, and a significant amount of the material is imported. In Uganda, the two major companies that produce cement are Tororo Cement and Hima Cement. They have a combined capacity of 1.9 million tons, which is expected to increase to 3.6 million tons by 2014. Tororo Cement and Hima Cement contribute 51 percent and 9 percent of the total share of cement in the country's market respectively. This means that the remaining proportion of 40 per cent is imported. As a result of the huge demand and that is not met by the supply, the price of a 50kg bag of cement increased from $10 in 2010 to $12 in 2012 (Muchira, 2013).

Other non-conventional building materials such as compressed earth block, adobe, thatch stabilised cement and soil bricks whose standards are not yet established in the country lack information about them, despite their use in the country's construction industry.

Timber is one of the building materials that are used widely in Uganda. Despite that, there are over forty five species on the market without quality control measures and grading of the material is mainly visual and subjective, leaving the material un-standardised to date (Zziwa et al, 2009).

Sustainable exploitation of local materials

According to Moreal et al (2001) local materials have the potential to drastically reduce the environmental impact of construction. Materials selection, design and construction play a major role in minimizing the environmental impact of new buildings. For example, in France adopting local materials for house construction reduced the energy used by up to 215% and the impact of transportation by 453% (ibid). Use of local materials, if rationally implemented, also contributes to mitigating negative impacts of climate change (UN-Habitat, 2012).

Development of local building materials in a sustainable way has a number of economic, environmental and health merits. It reduces the house production costs, a very important aspect for the successful access to decent housing by low-income earners; it protects the eco-system, and it contributes to the improvement of the living environment of a given community through the prudent use of local resources. Oktay (2002:1003) observes that, *"Each region has its own climatic conditions and cultural patterns, which must be the basis for the solutions in each individual case"*.

In Uganda where resource are limited, poverty is rampant and the building industry largely undeveloped sustainable exploitation of the local building materials is a vital component for

the development of low-cost housing. Sustainability does not stop at rational utilisation of the materials, but it entails developing and applying strategies of replenishing those materials that can be re-stocked. Uganda needs to industrialise its construction sector as a way of improving the supply of housing to its citizens. This industrialization includes developing and standardizing local materials. As observed by Alinaitwe et al (2006:222) "*Industrialisation assumes that most materials are standardised that materials and components can be manufactured in several places but they can fit in the final product without discrimination based on origin".*

4.0 CONCLUSIONS

Accessing decent shelter in Uganda is still a challenging issue, especially, for low-income earners. The country is having a growing demand for housing that cannot be met by the current supply mechanism, partly owing to the growing cost of housing development arising out of a scarcity of affordable building materials. This deficiency is of both quality and quantity.

The poor state of local building materials has greatly contributed to the development of substandard housing in the country. With high and escalating costs of imported materials, indigenous materials are viable alternative building materials for the majority of the country's citizens.

Indigenous constructions have the potential of supporting sustainable development of decent, low-cost housing through the use of locally available building materials and designs, that require little input in terms of labour, technical knowledge and skills, further facilitating more efficient energy use and energy conservation systems. For long, this potential has remained latent and untapped by the formal construction sector. Because of this situation, little has been done to develop local building materials. In exploiting this potential, it is imperative to do so in a sustainable manner to ensure that the finite resources are used rationally.

The use of local building materials in Uganda has the potential of increasing access to decent housing through reduced housing costs, especially for low-income earners. While local building materials are abundantly available, their efficient utilisation in developing decent housing is still a challenge as they are largely unprocessed, underdeveloped and un-standardised, limiting their potential. All these factors lead to inefficient and unfavourable exploitation of the materials and manifest themselves in low acceptability, unstable cost of local building materials in Uganda and put their sustainability in question.

5.0 RECOMMENDATIONS

In order to improve access to decent shelter, there is a need to reduce the house development costs through the use of improved local building materials. The country should employ initiatives and incentives for scaling up production of improved local building materials through industrialisation and use of more efficient technologies to take advantage of economies of scale. In partnership with the private sector, government should develop interventions for processing local building materials to products with better properties and value for improved acceptability. While doing so, effort should be focused on favourable and efficient exploitation of the materials to ensure sustainability of their use.

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AN INVESTIGATION OF PUBLIC PARTICIPATION PROCESSES IN THE PREPARATION OF THE 1994 KAMPALA STRUCTURE PLAN

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ABSTRACT
The Kampala Structure Plan (KSP) of 1994 was developed by Government of Uganda as part of the Kampala Urban Study aimed at developing, organising and modernising the city. This paper is part of a research carried out with the objective of examining public participation in the planning and implementation of the Kampala Structure Plan (1994). The study was carried out in Kampala city, using multifaceted methodological approaches. A purposive sample of key informants, including; Kampala City Council planners, government officials and technical team that directly took part in the development of the structure plan was selected. The study sought both empirical and documentary evidence and data obtained were analysed using SPSS and Microsoft Excel programmes.

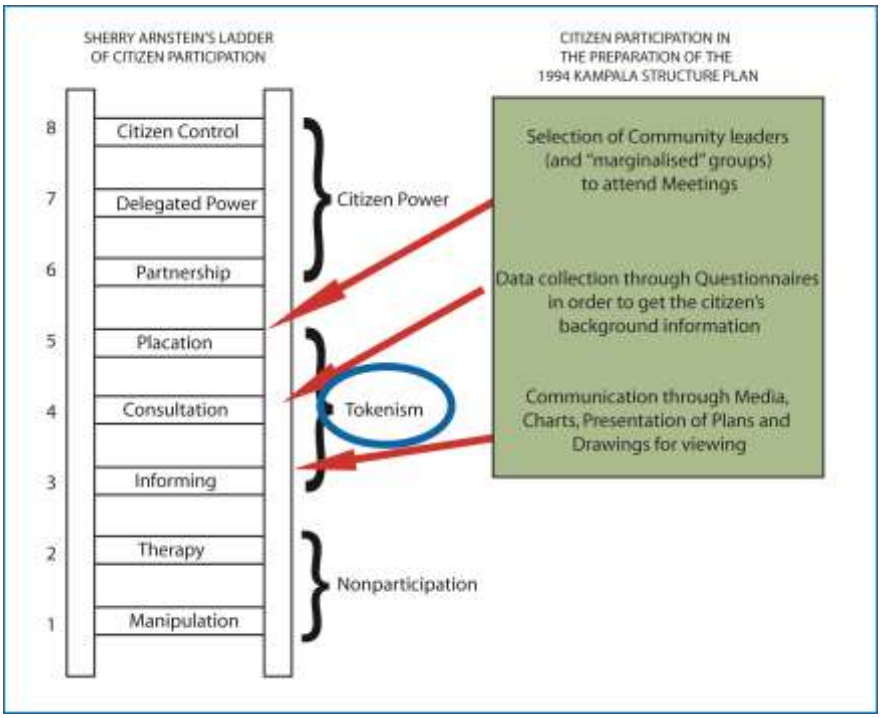
Findings from the study revealed that flawed planning process greatly undermined achieving the objectives of the Kampala Structure Plan. There was low citizen participation in the planning process of the structure plan, limited political support to back up the planning and implementation process, citizens were not adequately sensitised about the core values of planning and zonal plans at parish levels were not developed to guide local area development. The study makes recommendations on how the planning process can be improved, where sensitisation, role definition and responsibilities of all the participants are clearly defined.

Key words: Community participation, Participatory physical planning, Structure plan.

1.0 INTRODUCTION

Participation is the involvement by a local population and at times additional stakeholders in the creation of content and conduct of a programme or policy designed to change their lives. Built on the belief that citizens can be trusted to shape their own future, participatory development uses local decision making and capacities to steer and define the nature of an intervention (Jennings, 2000). It is often a result of lower levels of communities, predominantly the poor, being exploited most especially in the implementation of development programmes (Friere, 2005). It is about learning to respect and listen to the opinions, feelings and knowledge of those being targeted to improve their livelihoods. It is therefore, about the experts and the technical people letting go of the ideology that they are the only ones who can provide solutions and the best plans (Lawino, 2012). According to Arnstein (1969), there are eight rungs on the ladder of citizen participation; manipulation therapy, informing, consultation, placation, partnership, delegated power and citizen control. The first two are related to non-participation of the citizens; middle three are more of tokenism while in the last three that is where citizen power is exhibited. Participatory planning is guided by six basic principles of Diversity, Equity, Openness, Transparency, Accountability and Trust (Fisher, 2001). Participatory planning is used to create a platform for learning rather than plunging directly into problem solving. Its key values lie in identifying "felt needs of the people, bringing forth consensus, empowerment of local disadvantaged groups, integration of local knowledge systems into project design, accountability in local governance and political commitment and support" (Lawino, 2012:29).

Figure 1: Comparison of Arnstein's Ladder of Citizen Participation with Participation of the 1994 Kampala Structure Plan



(Source: Arnstein, 1969, with Author's Annotation)

From Figure 1, it can be observed that the community participation during the preparation of the 1994 structure plan when compared with the Arnstein's Ladder was more of Tokenism

than either Non-participation or Citizen Power. At the level of Citizen Power is when real participation is undertaken.

Participatory planning in projects execution in Uganda came as a result of the need to involve the people in the planning and implementation of projects in their communities with a purpose of ensuring project accountability. In accordance with the Town and Country Planning Act, 1964, public participation was limited to scrutinising plans and written provisions displayed for a period of 90 days. The Kampala Structure Plan was made after the Kampala Urban Study where one of the terms of references put emphasis on encouraging public participation in the planning process. Involving communities in the planning of their settlements in Uganda is a necessity as the 1995 Constitution of the Republic of Uganda mandates the public to participate in the decision making process of projects to be implemented in their communities.

The preparation process of the 1994 Kampala Structure Plan was designed to take a public participatory approach. However, despite public involvement during preparation of the Structure Plan, Kampala city still faces numerous visible physical planning problems such as development of unplanned settlements in the city suburbs, encroachment on wetlands causing flooding, inefficient transport systems and poor road networks leading to traffic congestion in the city, and poor land use systems with little of what was planned being implemented (Lawino, 2012; Kiggundu and Mukiibi, 2012).

The continued deterioration in the physical planning conditions and non-adherence to the agreed planning activities in Kampala warranted investigating what took place during the planning stage, by understanding the participatory planning approaches used in the development of the 1994 Kampala Structure Plan and assessing the impact of citizen participation during the development of the plan. Participation was limited to public institutions such Kampala City Council, Ministry of Lands Housing and Urban Development, Ministry Finance and Economic Planning, Ministry of Local government, Ministry of Justice, and John van Nostrand consultants. However, the Kampala Urban Study report was silent about how the general public was involved and in what stages. The objective of this paper, therefore, is to examine approaches that enhance public participation in physical planning activities.

2.0 THE METHODS

The study was conducted between 2009 and 2011. Its objective was to examine approaches that enhance public participation in physical planning activities. Primary sources of data involved gathering relevant information from targeted respondents for the study and observations during the data collection process. The target population comprised of a purposively sampled population from two of the five divisions of Kampala – Makindye and Rubaga (Fig. 2).

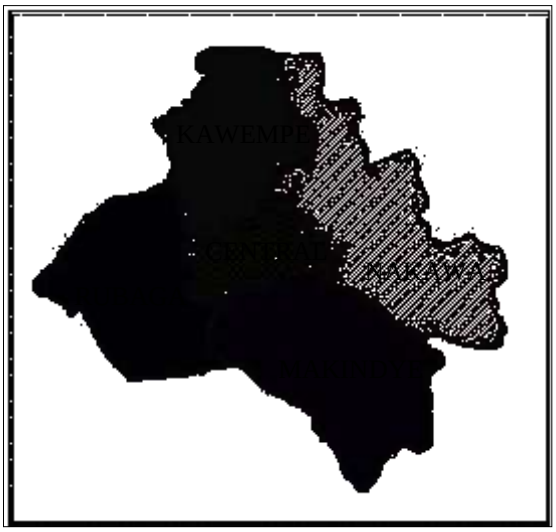


Figure 2: Map of the five divisions of Kampala
Source: UN-Habitat, 2007:5

The two divisions were chosen because of their large populations compared to the other divisions (Table 1). Respondents from the community were purposively selected as all persons in the sample areas who were of the age 18 and above in 1994 when the Structure Plans were being developed. Semi-structured questionnaires were administered to 150 respondents to help ascertain the level of citizen participation during the establishment of the 1994 Structure plan.

Table 1: Kampala's population per division

ITEM	DIVISION	POPULATION (Persons)
1	Central	112,787
2	Kawempe	153,900
3	Makindye	186,997
4	Nakawa	133,813
5	Rubaga	179,328
6	Makerere University[5]	4,710
7	Uganda Polytechnic Kyambogo[6]	2,706
	TOTAL	774,241

Source: Lawino, 2012: 48.

Through interviews, other primary data were gathered from the Kampala City Council[7] planners and officials from the Ministry of Lands, Housing and Urban Development, and Ministry of Works, Transport and Communication that directly took part in the development of

[5] Makerere University is currently part of Kawempe Division
[6] Uganda Polytechnic Kyambogo is now Kyambogo University and it is under Nakawa Division.
[7] Kampala City Council was transformed into Kampala Capital City Authority by an Act of Parliament in 2011.

the Kampala structure plan. The data collected were about the roles and stages in which each of the representatives from the above institutions were involved.

Data from secondary sources such as official documents for 1994 KSP Part I – III, the 1991 National Population and Housing Census documents and other policy and legal documents were used in the study to compliment the primary data (qualitative and quantitative data from questionnaires and semi-structured interviews). Data collected were checked, coded, analysed and interpreted according to the objectives of the study using SPSS and the major features analysed included descriptive statistics and cross tabulations.

3.0 RESULTS OF THE STUDY

3.1 The Kampala Structure Plan, 1994

The 1994 Kampala Structure Plan was developed as part of a Kampala Urban Study which aimed at improving living conditions, alleviating poverty, improving urban financial management and strengthening institutional capacity by supporting decentralised local governments. According to Omolo (2011), the planning idea was to address and provide a physical socio-economic and financial framework for the direction and management of urban growth for Kampala for the period 1994-2004. The assumption was that this plan once it was operational and implemented would address vital questions including; Increased economic productivity in the private sector, particularly the informal private sector, and provision of improved access to land, housing and services in order to improve the living conditions and alleviate poverty for all income groups in proportion to their demand. The Major Contents of the 1994 Kampala Structure Plan included;

Environmental Land-use

The plan provides for several green spaces intended to provide improved environmental protection for important ecological areas, particularly the existing shoreline and wetlands, but also to accommodate permanent urban agricultural activities and major dedicated pedestrian and bicycle paths. The idea behind this was the understanding that wetlands perform a critical role in the drainage of ground water and the natural treatment (scouring) of polluted water. In further support of the Plan's objective to improve water conditions in Kampala, it recommended that the existing sewerage works be relocated from the Lake Victoria watershed to the Lake Kyoga watershed in order to separate the city's major water intake from its largest sewerage outlet (Fig. 3).

Industrial Land-Use

It was proposed that all vacant land/industrial lands having slopes of less than 10%, and lying outside the wetlands (that is, approximately 5,000 acres) be designated as potential industrial zones in order to reinforce the priority which needed to be given to accommodate the full range of anticipated formal and informal businesses. The plan also sought to consolidate existing industrial zones so as to render them more directly accessible both on foot and by bicycle from adjacent residential communities. Both these proposals were intended to reinforce the strategy of ensuring that a balance is maintained between residential accommodation and formal and informal jobs at the local community level. In turn this was intended to promote increased economic activity in the private sector, particularly the informal private sector (Fig. 3).

Commercial Land-Use

The Structure Plan designates the existing Central Business District (CBD) as well as series of existing commercial nodes, and major shopping streets as commercial land-use zones (Fig. 3).

Four new commercial sub-centres were also proposed at Nakawa, Nateete, Kibuye and Bwaise with the aim that these centres would relieve the pressure that was placed on the CBD. These sub centres were also meant to serve as secondary transportation nodes. It is vital to note that these centres were already in existence and served the populace informally. In addition, the Structure plan identified and recommended for upgrading and expansion of a series of local centres spread throughout Kampala, these included; Kabalagala, wandegeya, Nakulabye, Gaba, among others.

Residential Land-Use

The Plan proposed to designate as 'residential' all existing lands which were occupied primarily by residential uses or such vacant/agricultural lands not designated primarily for industrial, commercial, or environmental uses (Fig. 3). Unlike the previous plans for Kampala, the 1994 Structure Plan does not differentiate between high, medium and low densities at the District level, but assumed that such differentiation would be made at the Division and/or Parish levels.

Transportation

The Structure Plan was based on the assumption that the upgrading and maintenance of the existing primary and secondary roads structure was of key importance over the plan period of ten years. One of the major components of upgrading of the existing primary road system was the inclusion and improvement of public transport, bicycle and pedestrian traffic routes and furniture.

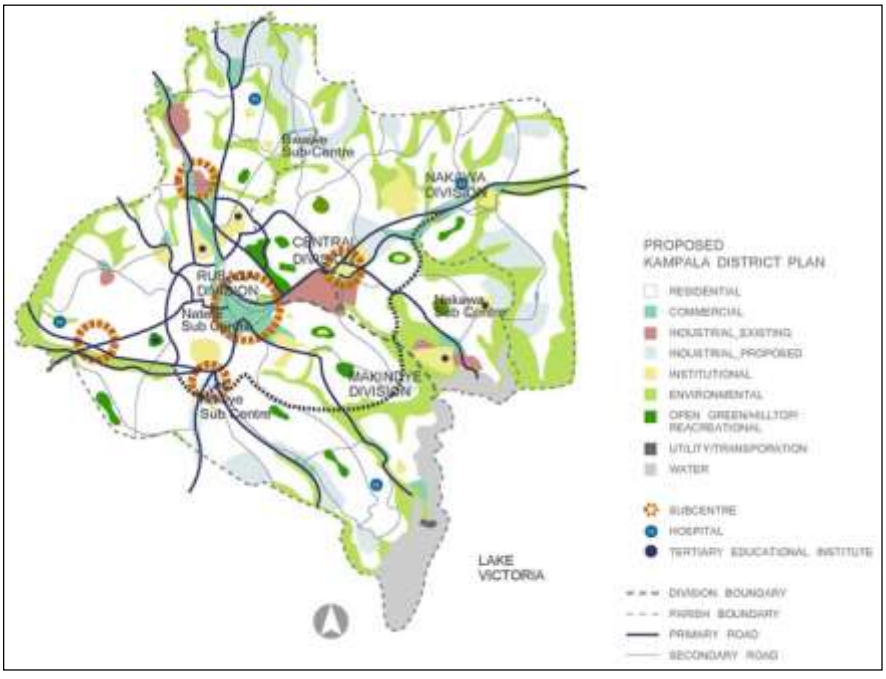


Figure 3: Kampala Structure Plan, 1994. (Source: Plan alliance, 2009. Online: http://www.planningalliance.ca/portfolio/regions-cities/kampala, Accessed May 21, 2011 in; Omolo, 2011.

3.2 Stakeholders involved in the Planning Process

The Kampala Urban Study Final Report (1994) exemplifies the change in approach towards stakeholder involvement. In his conceptual approach, Van Nostrand remarked, ''….the planning process should result in the identification of achievable and affordable action programmes which benefit all income groups...'' (Van Nostrand, 1994). Thus, the Key

stakeholders involved in the preparation of the Kampala Urban Study included consultants - John van Nostrand Associated Limited, counterparts from the Ministry of Lands, Housing and Urban Development (MoLHUD), Ministry of Local Government (MoLG), Ministry of Justice and Constitutional Affairs (MoJ) and Kampala City Council (KCC). Their planning objectives in the development of the 1994 KSP included covering the general, institutional/financial, demographic, social, environmental aspects, infrastructure, urban development and administration of Kampala area.

John van Nostrand Associates Limited were responsible for preparing the KSP drawings and documentation of all the reports on the KSP; the Ministry of Finance, Planning and Economic Development (Project Coordination Unit) handled overall co-ordination of the KSP preparation process. Ministry of Lands, Housing and Urban Development (MoLHUD) was responsible for dealing with land issues and the implementation of the land policy overseeing the physical planning activities through the Physical Planning Department. It was also responsible for co-ordinating the planning activities with all the other stakeholders, developing the Building Regulations and Standards for Kampala and developing standards for infrastructure (roads, water supply, solid waste, drainage, telecommunication and energy). Ministry of Local Government was the link between the District Administration and Central Government and was responsible for regulating and supervising the development of the Kampala Structure Plan. The Ministry of Justice had to ensure that the KSP was undertaken following the constitutional guidelines and legal framework in Uganda. It also stipulated the mandate and constitutional rights of each stakeholder in the plan formulation process and drafted the legal provisions within the KSP. Kampala City Council was responsible for implementing the structure plan by enforcing the development control measures as proposed by KSP and it was also tasked with sensitisation and providing public awareness about the project. Community leaders were responsible for providing planning information of the planning problems, gaps and the needs of their respective areas to the planning team, representing their community members and sensitising them on the benefits of the KSP and why it was being undertaken. The general public, through their community leaders, were required to provide information about planning problems and gaps in their respective areas.

Among other stakeholders included Makerere Institute of Social Research that assisted with feasibility studies, while the Uganda Society of Architects aided with the formulation of building regulations and standards. Uganda Institute of Professional Engineers assisted with developing standards for infrastructure, and Uganda Institute of Physical Planners handled land use proposals.

The method of choosing participants in the preparation of the 1994 KSP was of importance in establishing the extent of involvement of community members. Analysis of the criteria used for KSP public participation showed that 91% of community members did not know the criteria used to choose participant. Only 2% were specifically chosen from Local Council members, 4% from elders and 2% from professional organisation and 1% was randomly chosen as shown in Figure 4

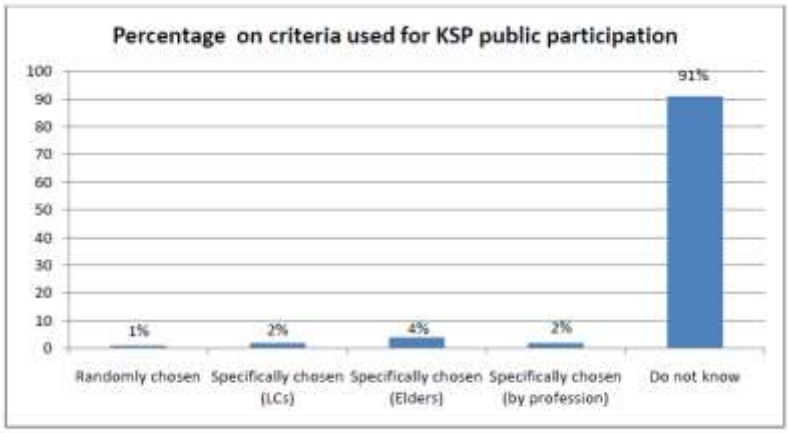


Figure 4: Findings on criteria used for KSP public participation
Source: Lawino, 2012: 76.

As far as decision making was concerned, 80% of community members noted that although they were informed of what was being planned, they were not involved in decision making process at the planning and implementation stages (table 2). This denied them conviction to own the developed Structure Plan.

Table 2: Citizen participation in physical planning decision making

Involvement of citizens in decision making processes		Frequency	Percentage
1.	Very often	1	0.7
2.	Often	10	6.7
3.	Seldom	19	12.7
4.	Never	120	79.9
		150	100

Source: Lawino, 2012:83.

In addition, community members claimed lack of transparency especially by the KCC officials in the planning process, especially regarding among other things, the intentions, benefits and outputs of the KSP. 67% of respondents felt that the KCC officials were never transparent and 28% stated that the officials were seldom transparent in their dealing with the community (table 3). This undermined community's attitude towards KCC as regards participatory planning.

Table 3: Level of transparency of KCC officials

Transparency of KCC officials in communication		Frequency	Percentage	Cumulative %age
1.	Very transparent	2	1.3	1.5
2.	Transparent	5	3.3	5.3
3.	Seldom transparent	42	28.0	36.8
4.	Never transparent	109	67.3	100
Total		150	100	

Source: Lawino, 2012:84

Results of the study revealed that the main type of participatory planning used in the preparation of the 1994 Kampala Structure Plan was tokenism. Citizens were limited to being informed by radio and television of what was to be done while seeking their views was not prioritised.

Consultation with the public was limited to involving their leaders and only at the planning stage. This was contrary to what the community expected. 86.7% of respondents preferred to be involved at every stage of the project. Few people (13.3%) preferred to be consulted at individual stages of the structure plan preparation (table 4).

Table 4: Stages preferred for consultation

		Frequency	Percentage
1.	At the initial stage of the project	12	8.0
2.	In the middle stage of the project	2	1.3
3.	At the end of the project	4	4.0
4.	At every stage of the project	132	86.7
Total		150	100

Source: Lawino, 2012:89

Consultation with citizens during data collection was limited to collecting population demographic data and socio-economic compositions of the population. Placation which was characterised by choosing leaders (LCs and opinion leaders) to participate in meetings was done to create the impression that meaningful participation took place. The participation process was passive rather than active or interactive whereby predetermined plans were imposed on the citizens. The study also revealed that the basic principles of effective participatory planning such as diversity, equity, openness, trust and transparency were limited in the process of developing the 1994 KSP. The planners and the controlling authorities (Central Government and KCC) dominated the planning process despite the fact that other key stakeholders like Kampala community and the private sector could have helped positively influence the planning process if they were fully involved. Diversity in selecting the citizens' representative was lacking because focus was only placed on the local leaders (LCs) and elders.

For consultations and adequate involvement, community members preferred to use public meetings (55%) and public hearing (37%) as fora for airing their views and participating in the KSP development process (table 5).

Table 5: Preferred form of participation

Means of participation mode		Frequency	Percentage
1.	Public hearing	37	24.7
2.	Public meeting	55	36.7
3.	Questionnaires	29	19.3
4.	Discussion	29	19.3
Total		150	100

Source: Adopted from Lawino, 2012:88

4.0 DISCUSSION AND CONCLUSIONS

The study revealed that the key stakeholders in the preparation of the 1994 KSP were foreign consultants, Government ministries, Kampala City Council, Development partners and the general public. However, there was very limited participation of the general public. The

planning of the time had the intention to have a more managerial approach with continuous review and adaptation, and with emphasis on the planning concepts and strategies, all these to be operationalized by the "Written Provisions" which constituted a legal code governing the administration and enforcement of the Structure Plan, superseding many other laws having to do with planning and land-use in Kampala. As exemplied by Omolo (2011), this approach reflects the strong elements of 'rationality', where the technical personnel saw the involvement of the lay person as a mere formality and possibly a waste of time.

The study found that the interaction between the community representative and the public was not effective, leaving the latter largely uninformed of what was going on. Findings also revealed that while roles and responsibilities of the Local and Central Governments and development partners were clearly stated this was not the case with the public key stakeholders. As the public were not sure of their role it made them passive participants in the whole process. Public participation in the planning process was also undermined by the public's ignorance of the physical planning aspects of the Kampala Structure Plan. The public was not adequately sensitised about the concept of physical planning and the objectives of the development of the 1994 KSP. As a result, there was mistrust between the citizens and the officials from Kampala City Council.

Because of inadequate sensitisation, community members were ignorant of the salient physical planning issues under consideration. Citizens had little trust in KCC officials to implement and deliver on what was agreed upon during the participatory planning meetings and as such people shunned the planning process. In addition, the planning team lacked some of the core skills such as citizen awareness, shared leadership and team work. This situation was further aggravated by the limited experience in physical planning community participation among the general public. The community members did not have enough exposure to any decision making process on the key planning issues that affected their neighbourhoods.

The study reveals that participatory planning is very crucial for the success of any project plan and implementation. It ensures project sustainability and project ownership through problem and needs identification made through wide consultation.

In order to achieve responsive physical planning there is need to ensure public participation in the planning process throughout all the stages of planning (design/formulation, implementation, monitoring and evaluation) by incorporating all categories stakeholders in the process. Roles and responsibilities of key stakeholders should be clearly defined and explained. This should be supported by building relationships between citizens and their representatives and technocrats at various levels to ensure transparency and avoid duplication of roles and suspicion. It also motivates community members and raises their self esteem, leading to a feeling of ownership in what is being developed. Sensitisation of community members at the planning stage and rallying political support of leaders at all levels should be given adequate attention as these largely affect the success of the planning process.

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Geophysical Investigations of a Rural Water Point Installation Program in Nampula Province, Mozambique

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ABSTRACT

There are many projects in Mozambique for poverty reduction. One of these projects is funded by Millennium Challenge Account (MCA) which is aimed to install a total of 600 rural water points each consisting of a well, a water pump and a communal washing basin in the province of Nampula and Cabo Delgado. The proposed investigation method was Vertical Electrical Sounding (VES) and despite research and field investigations several boreholes have come out with an insufficient yield and the failure rates in certain areas are as high as 40 %. Electrical Resistivity Tomography (ERT) were carried out to explain the high failure rate. In total were 11 sites investigated, seven boreholes with sufficient yield and five boreholes with insufficient yield. A perpendicular cross with two 400m survey lines were made over 7 boreholes and four single 400m survey lines were made over 5 boreholes. Due to lateral variation the geology in study area is well described in 3D therefore ERT has proven to be a suitable method for groundwater exploration and could lower the failure rate.

Keywords: water supply, borehole failure, groundwater, resistivity, VES, ERT

1.0 INTRODUCTION

Like other developing countries in sub-Saharan Africa, Mozambique is facing major challenges in water infrastructure. To address this issue the government of Mozambique was given a large five year grant by a MCA (Cowater & Salomon) 1, 2010). Starting in September 2008 it has the overall objective of poverty reduction through economic growth. One of the key projects within the grant is to increase access to safe drinking water and sanitation. In order to do so, the Rural Water Point Installation Program started. A total of 200 rural water points each consisting of a well, a water pump and a communal washing basin, was to be installed in the province of Nampula and Cabo Delgado.

Vertical electrical sounding (VES) was used as survey method but this method gives point information (Kirsch, 2006). This method worked well in unconsolidated rock area but in weathered and fractured zone they faced high number of unsuccessful borehole. The high failure rate, i.e. a high percentage of boreholes with insufficient yield or unsuitable water quality in fractured or weathered zones, motivated this study.

Electrical Resistivity Tomography (ERT) was tested aiming to assess the lateral variation of the geology and its influence in the VES results. ERT method is widely used in groundwater investigations (Owen et al, 2005) with advantage to be extended for long distance by applying the roll along technique (Dahlin, 2001). In total 11 previously drilled boreholes were investigated in Rapale District, Nampula province. The investigated boreholes, 7 has sufficient yield and 4 were discontinued due to insufficient yield (2) or completely dry (2). The resistivity

measurement at each investigated borehole was made in two perpendicular 400 m sections except in four borehole that was only a single 400m section. The aim of the study is to investigate the lateral variation of underground´s resistivity, to identify different geological layers close to the borehole and to correlate the result of both VES and ERT. The main finding of this investigation is that there is no correlation between these two methods regarding the last layer due to heterogeneity that increases with depth and highly influence the VES results.

2.0 THE SUDY AREA

Rapale district is located in Nampula complex composed by granites and migmatite gneiss (Lächelt, 2004). These rocks have low porosity and hydraulic conductivity and hence low potential for groundwater abstraction (Fetter, 2001). The Groundwater in Nampula complex is controlled by fractures, fissures and weathered layers (Costa, 1981).
The Mozambican Hydrogeological map classifies the aquifers as (A) continuous and productive aquifers, (B) discontinuous and medium production and (C) discontinuous and low productive or with no water (DNA, 1997). The class A aquifers are non-consolidated sedimentary rocks and classes B and C are igneous, metamorphic and consolidated sedimentary rocks.

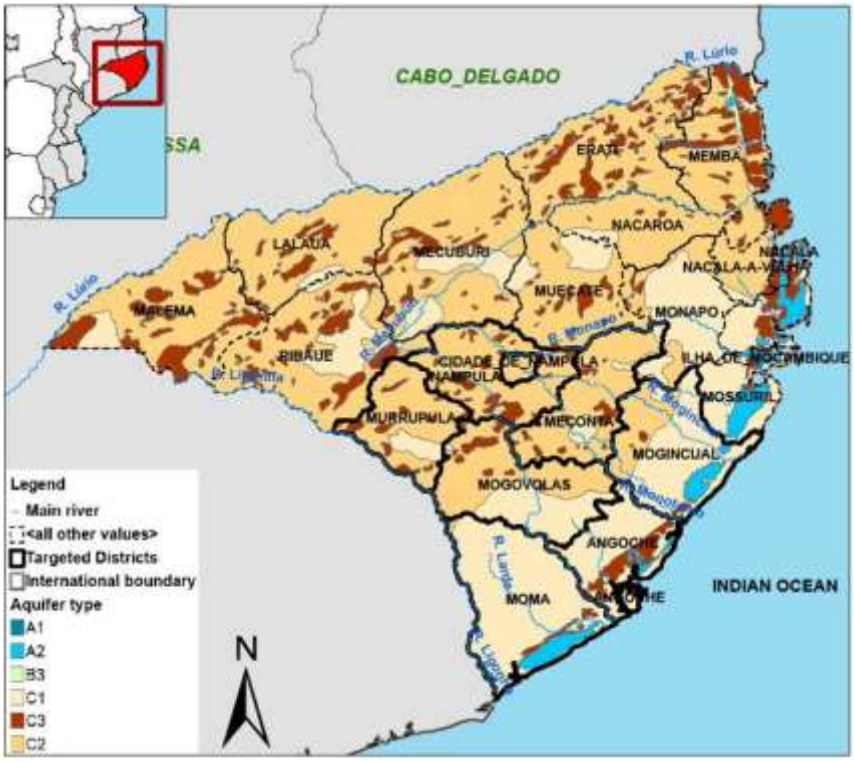

Figure 1. Map over types of aquifers in Nampula province. The map is adapted from Design report 2 (2010).

Figure 1 shows different types of aquifers in Nampula province. In the study area, the main aquifer types found are Type C1, C2 and C3, all rather shallow aquifers with a productivity flow from under 1-5 m^3/l. Type C1 are local aquifers that develop over the weathered mantle of the migmatite gneiss complex. They reach approximately 40 meters into the deeper regolith zones and their flow does not exceed 5 m^3/l. Type C2 is found where the weathered layer is less developed (DNA, 1997). Aquifers in these settings are limited to faults below the weathered rock, there thickness seldom reaches over 20 meters and flow does rarely exceed 3 m^3/l.

Aquifers with limited, sporadic or no groundwater are classified type C3. The average productivity of these aquifers is under 1 m^3/l and is found in the gneiss-complex.

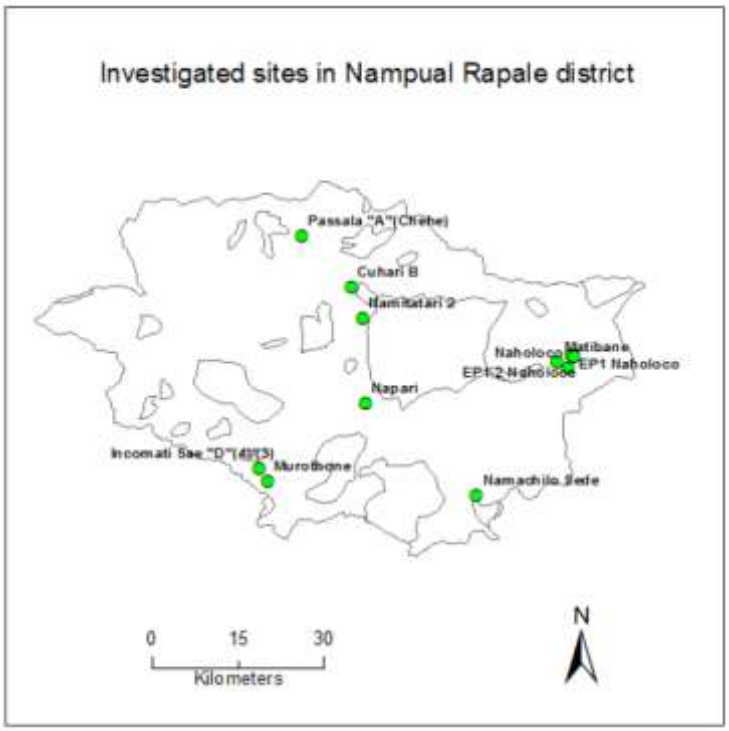

Figure 2. Map of 11 investigated sites in Rapale district. The boreholes with sufficient yield are Cuhare B, Incomati Sae, Matibane, Murothone, Naholoco, EP1 And EP2 Naholoco and EP1 Naholoco. Boreholes with insufficient yields are Namachilo Sede and Namitatare. The boreholes completely dry are Napari and Passala.

3.0 METHODODOLOGY

The geoelectrical 2D measurements (ERT) were carried out using a version of ABEM Lund Imaging System that allows measuring in 4 channels simultaneously using ABEM SAS4000 with multiple gradient array (Dahlin & Zhou, 2006). The most significant advantages when using ERT instead of VES is the high vertical and lateral resolution along the profile and comparatively low cost thanks to computer-driven data acquisition (Dahlin, 1993). In total 11 sites were investigated using the roll along method, seven boreholes with sufficient yield and five boreholes with insufficient yield. A perpendicular cross with two 400m survey lines were made over 7 boreholes and four single 400m survey lines were made over 5 boreholes. The single lines were determined by accessibility to the site and also due to valialbility of 400m to perform the study. The measured data were inverted in the program Res2dinv using robust inversion (Loke, 2003). The program was set to a minimum damping factor of 0.25 and no change in model discretization because the quality of data was enhanced by removing bad data points manually.

The drilling project used VES method to identify the optimum points to site the boreholes.

In this method, the current is sent to the ground through 2 electrodes (current electrodes - AB). The terrameter SAS 100 will measure the potential with other two electrodes (potential electrodes- MN). The variation in position of current electrodes will provide the potential of the subsurface downward. The instrument will measure the apparent resistivity of the subsurface in one dimension because it considers that subsurface has no lateral variation (Kirsch, 2006).

The VES data was inverted using IPI2Win software. This software gives an automatic interpretation of the apparent resistivity (Kirsch, 2006).The VES layer models were correlated with the ERT results both the thickness and resistivity value of each identified layer.
A drilling report was prepared for each borehole with information about drilling rate, geological logging, casing, pumping test and water quality. This information was used in the interpretation of the results together with other information such as hydrogeological and geological maps.

5.0 RESULT

The result from the ERT suggested a geological 3D environment with vertical and lateral differences along the survey lines. The majority of the inversions showed only small deviations from the measured readings. Two profiles had mean residuals over 10 %, one above 6 % and the rest ranged between 1.4 - 4.8 %. The subsurface was generally divided into three layers with varying resistivity. A high resistive surface layer interpreted as coarse sand, a low resistive middle layer interpreted as weathered metamorphic rock consisting of humid clayey sand and a high resistive last layer interpreted as fissured, fractured or fresh metamorphic rock. A typical inverted cross section of the subsurface resistivity is seen in figure 3, displaying the result of a borehole with insufficient yield in Namchilo Sede.

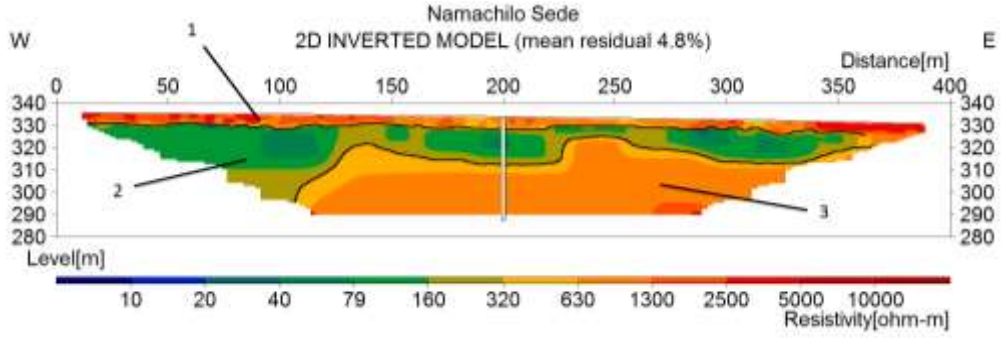

Figure 3. Result of resistivity surveying at Namachilo Sede.

Figure 3 shows the different resistivity layers at Namachilo Sede. There is a surface layer with high resistivity values (630-5000 Ωm) indicated as layer 1 at figure 3. This layer is followed by a low resitivity layer (79-320 Ωm) indicated as layer 2. The layer 3 is a high resitivity layer (320-2500 Ωm). Layer 1 is interpreted as dry coarse sand, layer 2 is interpreted as extensively weathered metamorphic rock, consisting of humid clayey sand and layer 3 is interpreted as fissured and fractured metamorphic rock. The white line at 200m indicates position and depth of the borehole.

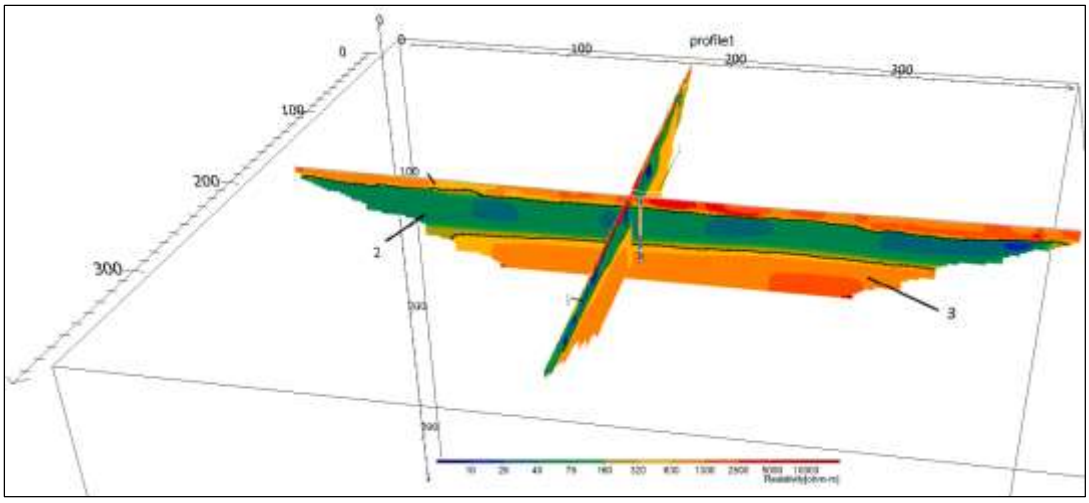

Figure 4. Resistivity variation in two perpendicular profiles at Cuhare B.

Figure 4 is an example of two perpendicular geophysical profiles. The same measurement was made in other 7 boreholes. All gave same result of 3 different geophysical layers. At Cuhare B (figure 4) the surface layer 1 and bottom layer 3 have high resistivity values (630 – 2500 Ωm). They are separated by a low resistive layer (10 – 79 Ωm) indicated as layer 2. These values are in accordance with other studies in weathered (Owen at al, 2015). The borehole, indicated in figure 4 as a vertical white line in the centre, is extracting water from layer 2 and layer 3 which are interpreted as porous media and fractured zone respectively. The thickness of all 3 layers varies in all directions as result of complexity of the geology in this area. The complexity will also influence the quality of the aquifers both in thickness and yield.

Table 5. Location and number of screens in porous and fractured aquifers, divided on investigated sites.

Site	Number of screens in porous medium	Number of screens in fractured medium
Cuhari B	1	1
Incomati Sae "D"	1	2
Matibane		2
Murothone	1	1
Naholoco comunidade		2
Namachilo Sede		2
Naholoco EP1-2		2
Total:	3	12

Table 1 shows the number of screens allocated in each borehole. It is an indication that the fractured aquifer is the main water source and in case of Cuhari B, Incomate Sae "D" and Murothone the groundwater is also extracted in the weathered aquifer. It is an important finding because future groundwater investigation in Rapale district should consider the weathered zone as the main target.

Table 6. Correlations and differences between ERT and VES measurements of investigated sites based on resistivity value and thickness of each layer.

Site	First layer(s)	Second layer(s)	Last layer(s)
Cuhare B	Correlate	Correlate	Difference in resistivity
Matibane	Correlate	Correlate	Difference in resistivity and depth
Murothone	Difference in thickness	Correlate	Difference in resistivity
Naholoco Comunidade	Correlate	Correlate	Correlate
Naholoco EP1	Correlate	Correlate	Difference in resistivity
Namachilo Sede	Difference in resistivity	Difference in thickness	Difference in Depth
Passala	Correlate	Difference in resistivity	Difference in resistivity

Table 2 indicates the correlation of the results of the ERT and VES measurements. The correlation takes into consideration the range of resistivity value from ERT of each layer with the absolute value of VES. Therefore it is considered as correlated layers if the value of VES falls into Range of resistivity values of ERT. The first layer (table 2) is well correlated for both methods in terms of resistivity value but there is difference in thickness in two boreholes. The second layer is also well correlated both thickness and resistivity value. The third layer however, shows differences either in resistivity value or in thickness of the layer (table 3).

6.0 DISCUSSION

The result of the field survey only reflects the resistivity values of the subsurface and not the actual geological environment. The appearance of the subsurface is based on assumptions and interpretations of the resistivity results. Consequently there are uncertainties of how well the interpretation of the result reflects the reality.

There are no apparent trends that distinguish boreholes with sufficient yields from boreholes with insufficient yields. The conditions in the inverted resistivity profiles look largely the same. There is thereby no clear explanation to the differences in yields. However since most productive boreholes were found in fractured aquifers (table 1) it is questionable why drilling was stopped at rather shallow depths.

The interpretation is to a large extent based on “The resistivities of common earth materials” by Palacky (1987), which is used to derive which resistivities correspond to which earth materials. The main difficulty is that the resistivity of common earth materials scope over large value spectrums and that many materials share the same resistivity ranges. When adding variables like water content, degree of weathering, fractures etc. the material distinctions will be loosened up even more. Furthermore the conceptual model is broad and can accommodate different interpretations. Thus the geological interpretation will also be relatively broad and can not be seen as precise.

Comparing the interpreted resistivity cross sections with interpreted material in drilling reports there are both correlations and differences (table 2). The more common difference is the thickness of the layers but there also differences in material, which makes the interpretations questionable. However the drilling reports are not a hundred percent trustworthy and have thus not functioned as reference data in the way planned for making interpretations or validating the results.

It is complex to compare ERT and VES. The VES method does not account for lateral variations in resistivity as the measurements are conducted and interpreted using an assumption of a horizontally layered earth. ERT on the other hand measures in 2D and takes lateral variations in resistivity into account. Table 2 is a tentative way to compare the results of both methods. It

showed that the layer 3 is not correlated both in resistivity value and in thickness. For both methods the accuracy decreases downward. The VES results are highly influenced by the complex geology underground and for the reason not correlated with results of ERT. The ERT results are thereby more comprehensive. Comparisons were made at the position of the borehole and no account has been taken to resistivity, depth or layer thickness further away from the borehole. The lack of information on the VES modeling and interpretation made it even more difficult to assess correlations and differences of the two methods.

7.0 CONCLUSIONS

There is no straightforward answer whether ERT surveys can give a geological explanation to why several boreholes have come out dry. The complexity of the geology makes the interpretation difficult, and the insufficient quality and detail plus missing data in the drilling documentation is a problem. Comparisons between the VES and ERT surveys resulted in both correlations and differences. The last layers in the VES measurements show significantly lower resistivities than the corresponding layers in the ERT measurements. Consequently the propagation of the weathered zone appears to be deeper when interpreting the VES measurements compared to the ERT measurements. The aquifer conditions can thus seem better when using the VES models in this case. The VES method is based on the assumption of a horizontally layered environment. Thereby no consideration is taken to the 3D environment, which is certain to influence aquifer conditions and particularly the groundwater gradient. Clearly it is easy to make misinterpretations using a 1D method in a 3D environment. ERT surveying is thereby to prefer in this area, it is intuitively easy to interpret, more expressive than the VES curves and contain more information.

8.0 ACKNOWLEDGEMENTS

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Boundary-less Living

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ABSTRACT

Governments of developing countries initiate low-income housing schemes with the objectives of enabling the urban poor: upgrade their living conditions, acquire house construction skills and, own houses. In Uganda, most of the low-income housing schemes are estate-driven. Most estate-driven housing correlates with the modernisation development paradigm that holds the assumption that modernity includes the adoption of presumed attributes of western society (Venter and Marais, 2006). This is evident in the plans of most of the low-income housing schemes in Uganda, which were developed with the assumption that each house would be encased by boundary markers to demarcate the plot boundaries by separating the public spaces outside the plot from the private space within. Siting the house block in a plot is usually stipulated by the project, thus further dividing the plot into back and front yards, with the latter posing as a transitional zone between the public space outside the plot and the very private space in the house. A hierarchical spatial pattern of a public space outside the plot, a semi-public in the front yard, the private space inside the house and the semi-private space in the backyard is assumed.

In a home setting, the backyard conventionally houses most of the home chore activities usually performed by women, while public spaces are male-dominated (Nnaggenda-Musana, 2008:147). Thus a gendered space use pattern is expected to be associated with the spatial patterns that emerge due to the existence of boundary walls around the houses both at the house and neighbourhood levels. However, it is observed that in almost all government-provided low-income housing schemes, boundary walls are rarely constructed resulting in the emergence of blurred spatial patterns whereby distinction between private, semi-private, semi-public, and public space is vivid.

This paper explores the effects of the emerging organic spatial patterns on the gendered space use, and the appropriateness of the proposed housing designs to their users. Findings of this study are expected to inform low-income planning and design both nationally and internationally, so as to enhance their appropriateness and efficiency.

The study employs the case study research approach where the Masese Women Housing Scheme (MWHS), manifesting the highest ambition of reducing women's marginalisation with respect to housing in Uganda, was selected as an atypical case for exploration of gendered space in housing. Data was collected through in-depth interviews, observation, photography, sketching together with document and drawing review and analysis.

The study revealed that the spatial patterns that resulted due to absence of boundary walls are conducive to the low-income households' life styles, of women, as they provide security, social interaction and enhance home-based enterprises. The study further revealed that the blurred

spatial patterns that emerged due to absence of boundary walls have no significance on the gendered usage of the space both at the house and neighbourhood levels. The study thus recommends low-income housing that is devoid of boundaries when planning and designing low-income housing.

Key Words: housing, boundary-walls, spatial patterns, gendered space-use.

1.0 INTRODUCTION

Sixty per cent of the urban population in Uganda lives in inadequate housing, (MLH&UD, 2008: iv). This prompted the Ugandan government, through the Ministry of Land Housing and Urban Development (MLH&UD), to implement housing projects targeting low-income groups to uplift their living environments in different parts of the country, for example the Namuwongo project in Kampala, Oli in Arua, MWHS in Jinja, and Malukhu in Mbale.

Most of the low-income housing schemes were established in the early Museveni era of the eighties (Nnaggenda-Musana, 2008:59). In the same period, Uganda underwent a period of gender awareness as a result of the impact of the Third World Conference for Women (TWCW) that took place in Nairobi in 1985. Since then, the Uganda government has been committed to engendering all sectors including housing. Hence the MWHS, which targeted low-income women as a way of reducing their marginalisation, was launched. Most of the low-income housing projects, including MWHP, emphasised providing access to housing for the low-income through credit, land ownership formalisation, building by-laws stipulation, construction material and technology introduction, as well as users' participation in the construction activities on the assumption that these would contribute to housing adequacy and convenience (MLH&UD, 2012:. 42). This reflects a quantitative approach to housing that views a house as a dwelling unit over the qualitative one which considers housing as a system of activities concerned with housing an individual household and the entire community (Horelli, 2005, p.18). The latter approach gives more importance to the socio-cultural context and values households embrace, more than the quantitative approach that focuses mainly on the mass production of housing units (Goodchild, 1991:133).

For proper management and speedy delivery of the low-income housing projects, standardised house types, plot sizes and space layouts were encouraged in their planning. These restrictions sometimes included dictating of building off-sets, orientations of buildings within the plots, and location and sizes of fenestration, leaving optimal opportunity for the households to personalise their domestic space (MLH&UD, 1992). The probable assumption was that these restrictions would yield an orderly physical setting to the neighbourhoods, hence implying upgraded living standards.

2.0 PROBLEM

Housing units within housing schemes that target low-income groups are expected to be developed encased within boundary walls, which are usually not highly emphasised, to demarcate plots and to secure the houses. But, in most housing schemes that target the low-income groups, boundary walls are rarely observed even in cases where these walls are fragmented and very modest both in size and construction material. This, coupled with the transformations that the households make to accommodate their changing needs, results in the emergence of spatial patterns that differ from the original designs. The resultant spatial configurations are characterised by blurring of spatial configurations.

Conventionally, in African Islamic societies (Fathy, 1973) and patriarchal societies like Uganda, public domestic spaces are male-dominated while women are confined to the private spaces of the home. Even within the home space, women's presence is expected to be at the backyard where they carry out domestic chores while the front is where the men sit and or host visitors. In the case of MWHS the fuzzy and intermingled spatial patterns that emerge due to the absence of boundary walls not only deconstruct the conventional private, semi-private, semi-public and public demarcations of space at the home and neighbourhood levels, but also lead to tension between the associated gendered space usages due to the lack of boundaries.

3.0 SITUATING THE STUDY

The TWCW that took place in Nairobi 1985 had a major role in raising awareness regarding gender issues in housing by promoting women as beneficiaries and agents of change in the area of human settlements (Celik, 1992). In 2002, Anita Larsson, a prominent architect and researcher in the fields of gender, housing and urban planning, advocated for mainstreaming gender in housing at all levels including but not restricted to, accommodating and responding to the needs of women in spatial planning and design of their houses. She argued that,"*Housing,... both as a shelter and its social and physical surrounding is... crucial for women as a center for their activities*" (Larsson, 2002). Research on low-income housing emphasises that women should be focused on in housing design since they spend more time and do more chores in the housing environment, and are thus affected most by inadequate housing conditions (Dandekar, 1992). This argument can apply well to the low-income women in Uganda's urban areas.

Attempts to reduce low-income women's marginalisation in housing have been made in Uganda. The MWHS located in Jinja, in eastern Uganda, is proof of such an attempt because it was mainly aimed at improving the social and economic conditions of low-income women.

4.0 STUDY OBJECTIVES

The study explores housing schemes that target the low-income groups, and analyses the spatial patterns emerging in boundary-less neighbourhoods. The influence of gender on space use and the extent to which the low-income housing is conducive to women's life styles is also explored. Findings of the study will inform housing research about ways of developing more gender-sensitive low-income housing designs.

5.0 METHODOLOGY

The study utilises a case study research approach, which allows the researcher to capture various realities that are not easily quantifiable. The approach warranties that the research topic is well explored and that the essence of the phenomenon is revealed (Stake, 1995; Yin, 1995). In this case MWHS, which manifests the highest ambition among Uganda's low-income housing schemes to reduce women's marginalisation, was selected for an in-depth analysis. In practice oriented fields, case study has a special strength of enriching the professional repertoire which in turn enhances the designer's ability to provide appropriate solutions through relating and comparing between "*known cases from the repertoire and actual design situations"* (Johansson, 2005, p.32). As researchers and reflective practitioners in the field of architecture, the authors use their personal experiences and observations to relate and deliberately reflect (Schon, 1983) on empirical evidence, existent theory and their practical experiences to generate knowledge that can inform future actions and interventions in regard to the production of flexible designs that can be more appropriate to low-income women.

Multiple research methods were employed to collect and interpret data on spatial use patterns in neighbourhoods that are boundary-less. These included personal observation, photography, in-depth interviews, sketches and document analyses, and review of archival records. Personal observation entailed the researcher actually going the study area to observe and record behavior in its natural setting. Photography, which complemented the personal observations helped in obtaining and recording of visual data. In-depth interviews were carried out with key persons and the households in the study areas to get comprehensive information and views. Houses and other physical artefacts were sketched after taking measurements of houses, and recording of how interior and exterior space was used in order to comprehend the spatial quality and space use. Analyses of archival records, and documents like maps, plans, and aerial photographs were done to understand past and present inclinations of housing development in the study area.

6.0 Findings and Discussions

6.1 Organic Growth of Plots

Plots at MWHS were designed in an iron-grid layout allowing for an open space per every cluster of 8 to 18 houses for public and communal use. This physical setting is assumed to promote orderly and upgraded living environments as is figure 1. A hierarchical spatial pattern of private, semi-private, semi-public and is expected to materialise. Fathy notes that most architects when re-planning places are prone to re-arranging houses *in straight, orderly streets, parallel to one another* (Fathy, 1973, p. 54). In present-day MWHS however, the spatial pattern in that has emerged is different from what was anticipated.

Figure 1: MWHS as planned originally

Figure 2: Actual housing development at MWHS

Adapted from Ministry of Lands, Housing and Communication, Masese Women Housing Project map. Developed by Elwidaa, Drawn: Bukulu Ismail, 2013.

In MWHS women who have traditionally been relegated to the private space of the back yard have started to move to the semi-public front yard. Housing extensions, coupled with the absence of clearly identified boundary walls, makes the distinction of the originally planned private, semi-private, semi-public and public spaces difficult to discern, see figure 2 (orange shades).

6.2 Open Public Space

Open public spaces that were for recreational activities appear to be neglected, see figure 4. The open public spaces are sometimes encroached upon by makeshift structures for domestic and

home-based enterprises (HBEs) such as bars, worship places, video halls, stand pipes for water selling, as seen in figures 5 and 6.

Photo: Elwidaa Masese, 2012

Photo: Elwidaa, Masese, 2012.

Figure 4: Neglected open spaces. **Figure 5:** Makeshift structures in an open space **Figure 6:** Stand water pipe outside plot premises

In open spaces with favourable environmental conditions the multi-use of this space by some households was noted. The households sometimes fenced-off some of the open space to accommodate subsistence farming, therefore converting part of it to individual private space, see figure 7.

Figure 7: Laundry being done in public space.
Photo: Elwidaa, Masese, 2013.

6.3 Absence of Boundary Walls

The grid-iron housing arrangements that were planned at MWHS connote gendered spatial configurations that are related to the gender division of labour, whereby men are expected to occupy public spaces outside the home attending to paid labour, while women are consigned to the home space attending to unpaid home chores, (McDowell, 1999, Hayden, 1980). Today the formal boundary walls that were planned for MWHS to encase houses are absent in most cases, in the few scenarios where they do exist , they are in the form of light boundary markers such as unmaintained hedges, reeds, and other plants as illustrated in figure 8.

Figure 8: Fragmented irregular fences between plots
Photo: Elwidaa, Masese, 2012

Solid boundary markers are preferred by a few households as they promote, privacy, territory demarcation to avoid conflict between neighbours, and facilitate tidiness by keeping property free of strewn garbage. Boundary markers were usually light or short and did not impede visual or physical interaction between neighbours, see figure 8. Although hedges were sometimes appreciated they were thought to be expensive and hard to maintain.

To ensure tight security against burglary in a few cases, solid types of boundary walls were observed around houses that are occupied by higher-income households, see figure 9. Household members occupying such houses are considered snobbish and are thus alienated. One respondent stated: "*When you place wiring around your house, it means that you do not approve of my presence in your space. So in case you or your home are in danger, I will not come to your rescue as I might be accused of trespassing"* (Joyce, interview, 2013).

Figure 9: Chain links and solid walls common to higher-income households at MWHS. Photos: Elwidaa, Masese, 2013.

6.4 Space Use at the Plot Level

The households in MWHS intimated that they preferred living without boundary walls since their absence allowed for natural surveillance whereby they could watch over each other's children and property, and interact with neighbours, see figure 10. The absence of boundary walls makes the detection of strangers easier thus enhancing security.


Figure 10: Absence of boundaries facilitates watching over children and properties. Photos: Elwidaa, Masese, 2013.

Some female respondents mentioned that the absence of boundary walls reduced domestic violence since passers-by would easily see or hear any commotion and come to the rescue of anyone who called out for help. Women also preferred to live without boundary walls around the houses as it enabled them to socially interact with neighbours and passers-by and still be able to attend to their domestic chores, like washing clothes, cooking and watching over children. The women further mentioned that a boundary-less setting facilitated the promotion of their HBEs since the potential buyers could see their goods easily. The front yards, being exposed to passers-by along the road, offered better opportunities to promote HBEs. The spaces used for HBEs sometimes extend beyond plot limits due to the absence of boundary walls without causing any disputes with neighbours, see figure 11.

Figure 11: A groceries kiosk run by a woman erected at the front yard of the house and extending beyond the plot limit.
Photo: Nsereko, Masese, 2013.

7.0 CONCLUDING OBSERVATIONS

MWHS has not developed the way its initiators envisaged that it would. The MWHS houses have transformed naturally as a response to habitation, corroborating Tipple's (2000) findings from his various researches in different countries, concerning informal housing, whereby ascertained that both the houses and households with time shape and reshape themselves to each other until there is a tolerable fit between the two.

Instead due to the absence of solid boundary walls and the on-going extensions, more organic spatial patterns emerged. To a large extent these growth patterns resemble the boundary-less physical setting of the Ugandan informal settlements where most of the low-income households live, see figure 12.

Figure 12: (Left) Part of MWHS; and (Right) An adjacent informal settlement. Both are devoid of boundary walls.
Photos: Elwidaa, Masese 2013.

Clear distinction between public and private spatial patterns is not evident; and there are no distinct variations in gendered space use patterns both at the neighbourhood and house levels.

Boundary-less housing areas are more conducive and responsive to the ways of living of low-income households and should be considered when planning for and designing housing schemes that target these groups so as to enable them realise their different gender roles and dispositions more appropriately.

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