Web-based Cadastral Information System for Land Management

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Key words: Cadastral, Web, Land, Management

SUMMARY

Data and information (Cadastre inclusive) about land, land use and land ownership are scattered among different actors. The managers and resources necessary for the management of such data and information are distributed across several professionals, and the various users of the above lies at different locations. Web technology has become an important technology in attaining and ensuring better interoperability, accessibility and scalability on a large scale. Leveraging the potentials of the web with cadastral information management is the purpose of this research. This work describes a research and analysis into the current cadastral information management process of Ekiti State, Nigeria. A web-based prototype of the above was proposed, designed and developed as a modification to the existing system. The development of the prototype was guided by the research conducted into the choice of system, software and required functionalities for the proposed "Web-based Cadastral Information System". During the research, it was discovered that while 73.68% of public users prefer the use of web browsers to access cadastral information, 71.43% of professional users prefer the use of a web enabled application. While 41% of professional users like to access information about land on the web, only 2.56% will like to interact with their clients using the web. The overall result of the process describes the indispensability of web-based cadastral information management system in ensuring a much more informative and users' participatory cadastral information system for land management. Opportunities for further research, such as; building web-based tools with less intensive internet connectivity, developing or contributing to existing Web-enabled applications for land management by Professionals was identified.

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1. INTRODUCTION

Land is a non-increasing factor of production that houses an increasing population. A great percentage of man's activities depend on land. The quests for land ownership, registration, transfer of ownership etc., are concepts that affect land management. Estimations show that about 70% of people – land relationships worldwide are not documented, whereas, population grows and the pressure on land and natural resources increases. Oftentimes, the poor suffer most. These result in many land conflicts and competing claims on land. (Kadaster Abroad, 2014). Even the documented 30% have to be "re-documented" due to technological changes and new user demands. Hence, the saying that man is never done administering land.

Data and Information regarding land acquisition, adjudication, demarcation, and transfer are significant to the effective management of land. In Nigeria, the land Surveyors are known to be the custodian of land data and information. Other actors involved in the interest to land includes the town planners, the lawyers, security agents, the office of the surveyors' general and the Governor of the state who confers the right to land ownership on an individual or group of individuals. The process of gaining right to land; which require passing through all of these actors, is a long process that is termed frustrating by some.

In securing land rights for the world, United Nations Global Geospatial Information Management (UN GGIM) formulated some global needs, Food and Agricultural Organisations of the United Nations developed Voluntary Guidelines, and the World Bank monitors good practices in the land sector with a Land Governance Assessment Framework (LGAF). Together with the International Federation of Surveyors (FIG), they promote Fit for Purpose Land Administration approaches (Kadaster Abroad, 2014). According to LGAF, focusing only on specific aspects such as land administration or surveying may not only miss important synergies to other parts of the system but, in the end also prove to be ineffective and unsustainable, hence, the need to consider the concept of cadastre and land management in relation to computer science.

The massive network of networks that connects millions of computers (Fu & Sun 2011) known as the internet has become an effective tool in information sharing, collaboration and interoperability. Harnessing the potentials of Geographic Information Systems (GIS) with that of the internet has led to the development of the concept of Web GIS; which has led to a transformation in the world of Geoinformatics by enabling problem solving with the full functionality of the internet. Web technologies are deployed on desktop computers and as well on mobile devices. The internet offers Web based information systems a robust platform for data and information processing, data storage and consequently a performance that supersedes its non-web based desktop and mobile counterparts.

Accessibility and interoperability are part of the comparative advantages of Web based information systems. The "scalability" from one or more users to millions of internet users rendered by well

configured Web systems is an advantage. Data used by various users can be utilized by several other users, whereby reducing redundancies and promoting usability. These are pros of web based systems among others yet to be discovered or developed.
The web has transformed the way many things are done these days. Hence, this paper discusses the methodology and results obtained from the prototye designed to harness the potentials of web technology with the existing framework for cadastre administration, using Ekiti State as a case study, so as to engage the challenges of Land administration and enhance the relevance of Land Management, Cadastral Information System (CIS) and web-based technologies to produce a synergy of the trio.

2. LITERATURE REVIEW

a. The Cadastral Concept

The non-increasing nature of land has raised many questions in the heart of researchers, and this among other factors has led to the exploration of other planets in an attempt to discover their adaptability for man and its environment. The limited quantity of land among other factors contributes significantly to land disputes among persons, states, countries and even continents, especially at their urban centres. The ownership of land, its tenure of ownership, precise and accurate location and the its value are
Land parcel is the basic unit for access and control of land, as well as land use decisions. Current and reliable land information is necessary for many public programs, for land planning, and for infrastructure development. (Babawuro, 2010). Cadastre systems include the interaction between the identification of land parcels, the registration of land rights, the valuation and taxation of land and property, and the present and possible future land use (Enemark, 2005). The relationship between Land, People and Rights, Responsibilities and Restriction is one that varies significantly from place to place. Cadastre is the product of Land Registration exercise. The word Cadastre is often confused with Land registration as it is defined as "a record of interests in land encompassing both the nature and extent of those interests", whereas Land Registration has been defined as "the official, systematic process of managing information about land tenure" (Nichols, 1993). Hence Land Registration is the process, while Cadastre is the product. The effective management of the two in solving and resolving issues such as Land Ownership, Occupancy, Tenure, Transfer and Use rights is the term referred to as Land Management in this project.
There are three categories of cadastre, namely; juridical cadastre, fiscal cadastre and multipurpose cadastre. Juridical cadastre is a legally recognized record of land tenure as well as a register of ownership of land parcel. Fiscal cadastre is developed primarily for property valuation; it is a register of properties recording their value. Multipurpose cadastre encompasses both parcel related information, and is as well a register of attributes of parcels of land (Dale, 1976; Dale and McLaughlin, 1988).
Land Administration encompasses aspects such as, Cadastral Survey, Mapping, Land Registration, Land Information Systems, Legal, Fiscal and Multipurpose Cadastre. The term is defined as "the process of determining, recording and disseminating information about the tenure, value and use of land when implementing management land policies" (Tan & Looi, 2013). In Nigeria, a cadastre is the product of a cadastral survey exercise conducted by a land surveyor for the purpose of

determining the location, size, and obtaining description of a land parcel with reference to a geographic framework. Often times the cadastre is used for securing legal rights to land, but the fiscal ability of cadastre are not maximized.

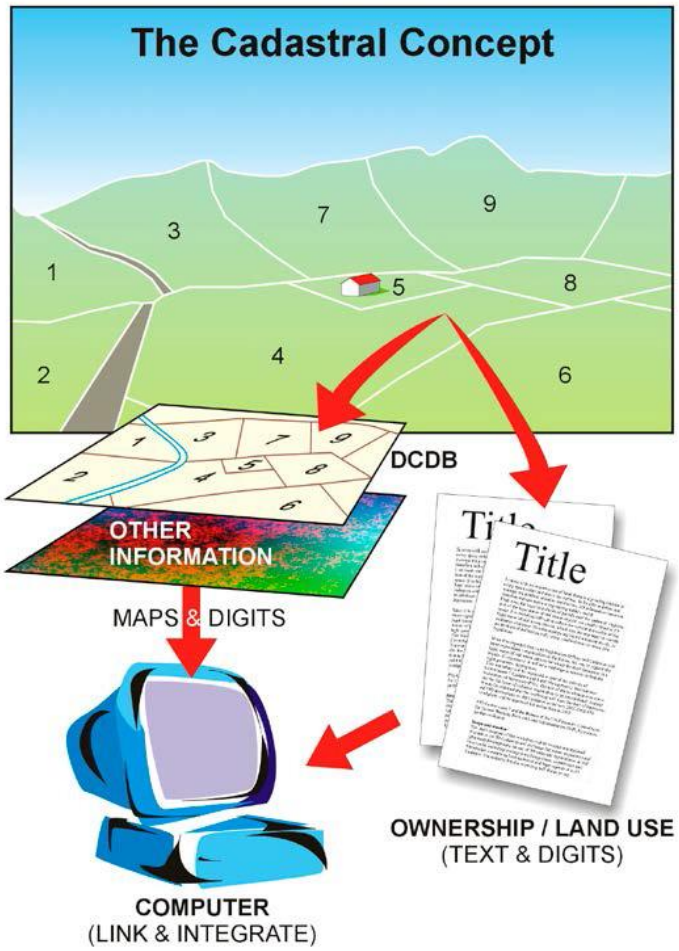

Figure 1: The Cadastral Concept(Source: CADASTRE 2014 and Beyond)

b. Web based Systems

The advent of the Internet and the Web are great milestones in the evolution of human civilization (Fu & Sun, 2003). The Web brings database information to the world (Bra, 2003). Web-based information Systems have also grown rapidly in scope and extent of use, significantly affecting all aspects of our lives. Industries such as manufacturing, travel and tourism, banking, education, and government are Web-enabled to improve and enhance their operations (Worwa, 2010). In recent years, the Internet and World Wide Web (www) have become ubiquitous, surpassing all other technological developments in our history. In web based systems, the user interacts with the web server from the web interface with websites by using a web application. In recent times, the web

server is linked with a database server that manages the data and reduces the workload of the web server for optimal use.

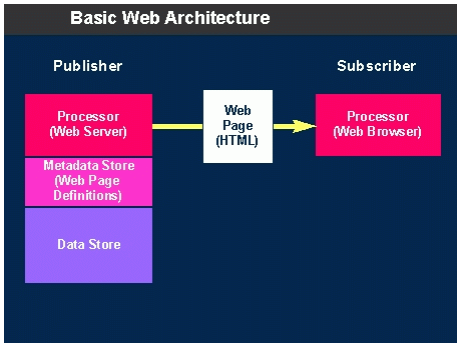

Figure 2: Basic Web Architecture

c. Modified Framework for Land Management

In the existing framework for land management in Ekiti State, procurers of rights to land have limited information about the status of land. They purchase the land, then meet with a land surveyor to carry out the cadastral survey of the area. The surveyed plan is taking to the Surveyor's General (SG) of the state who then inspect, chart and check the parcel against polygons of prior acquisitions. If the parcel does not fall within any prior acquisition, the SG then gives an "SG approval" which is used in processing the Certificate of Occupancy (C of O) to the Land. When such surveys fall within a prior acquisition; dispute is created, and its accruing circumstances are often devastating.

The proposed system is to provide a web based interface where information about land could be published and accessed by the respective users prior to procurement. Such information about land includes the ownership status, prior acquisitions, availability for sales etc., Accessing land information on the web will be carried out by prospective owners of right to land before procuring the portion, incurring expenses on the survey plan and before requesting for an SG approval. Information about land will be published by the Office of the Surveyor's General of the state on timely basis and owners of rights to the land could access and share this information anywhere at any time using the web-based system.

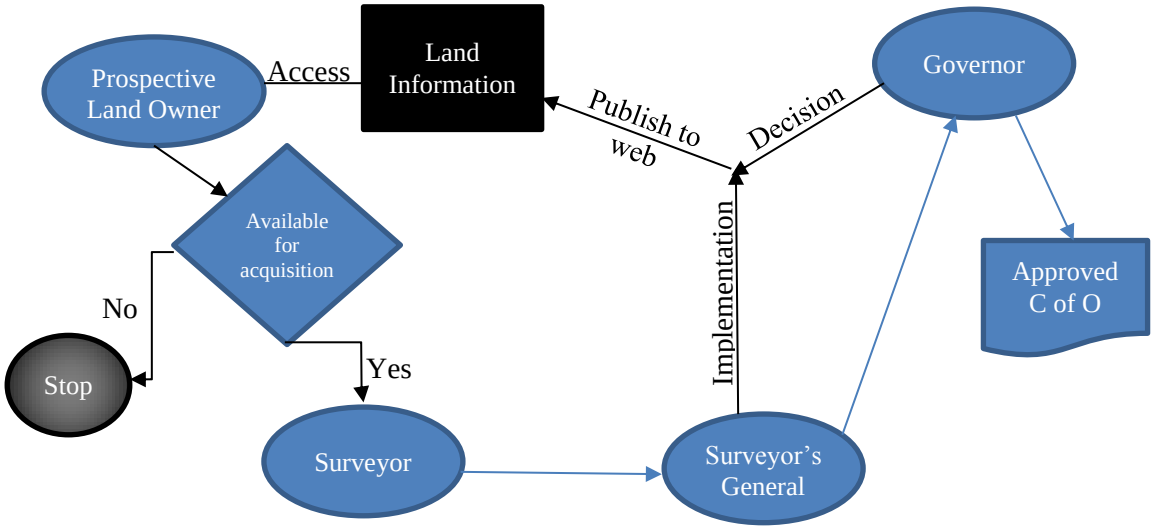

Figure 3: Modified Framework of Land Management

2. SYSTEM DESIGN

a. Use Case Analysis

In prioritizing the design objectives, a survey was conducted amidst surveyors in the state to determine what objectives should be the priority of the proposed system. The following are results obtained from the survey carried out after a multiple response analysis of SPSS package:

Table 1:Priority of Design Objectives

$necesiti Frequencies				
		Responses		Percent of Cases
		N	Percent	
Necessities[a]	Publish and View cadastral information on the web	5	12.8%	38.5%
	Identify Land parcel available for acquisition on the web	**8**	**20.5%**	**61.5%**
	See government acquisitions on the web	4	10.3%	30.8%
	Identify the approximate cost of land in an area on the web	3	7.7%	23.1%
	Inquire history of land ownership on the web	**8**	**20.5%**	**61.5%**
	Allow you to interact with other Surveyors on the web	5	12.8%	38.5%
	Allow You to interact with your Clients on the web	**1**	**2.6%**	**7.7%**
	Allow you to interact with the office of the surveyors general on the web	5	12.8%	38.5%
Total		39	100.0%	300.0%

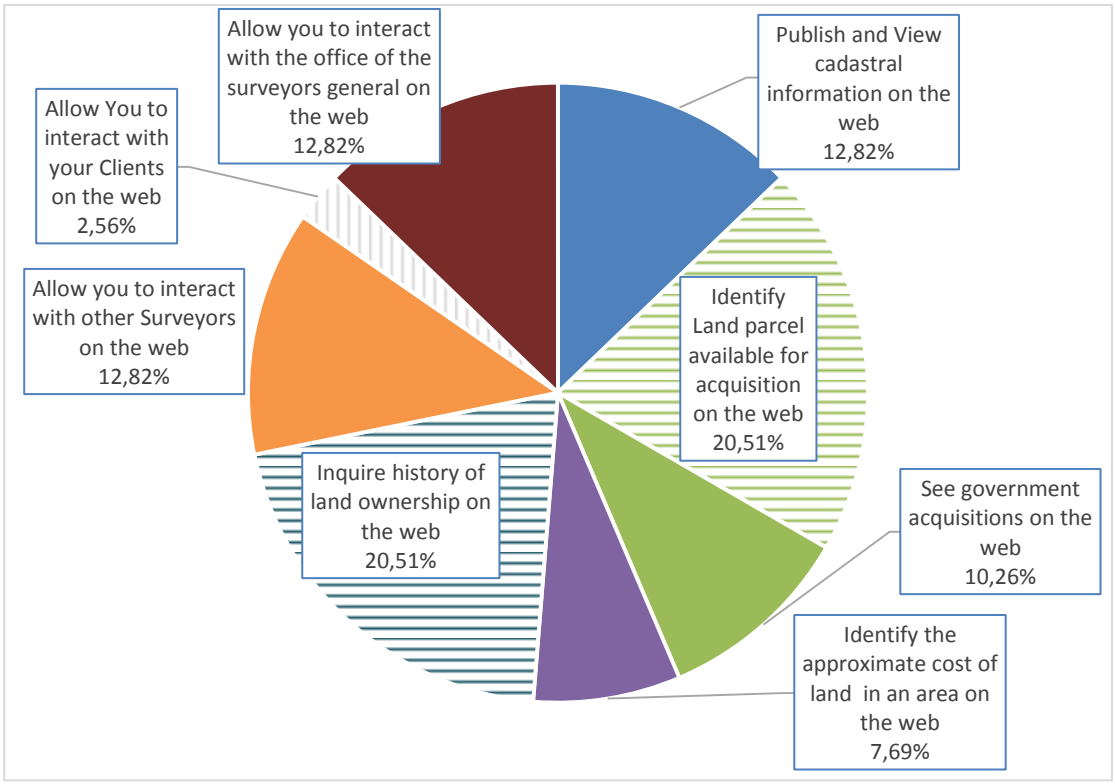

Figure 4: Priority of Design Objectives

The designed system was designed such that professionals could log on to access their respective pages. The system comprised five types of access right conferred on the under-listed categories of users. The generic page available to all users is the homepage; this contains links to other pages of different access rights. The users of the system include the following:

i. Public Users (Land Owners)
ii. Land Surveyors
iii. Surveyors' General
iv. Governor's Page
v. Administrators Page

The use case diagram for the system is shown below:

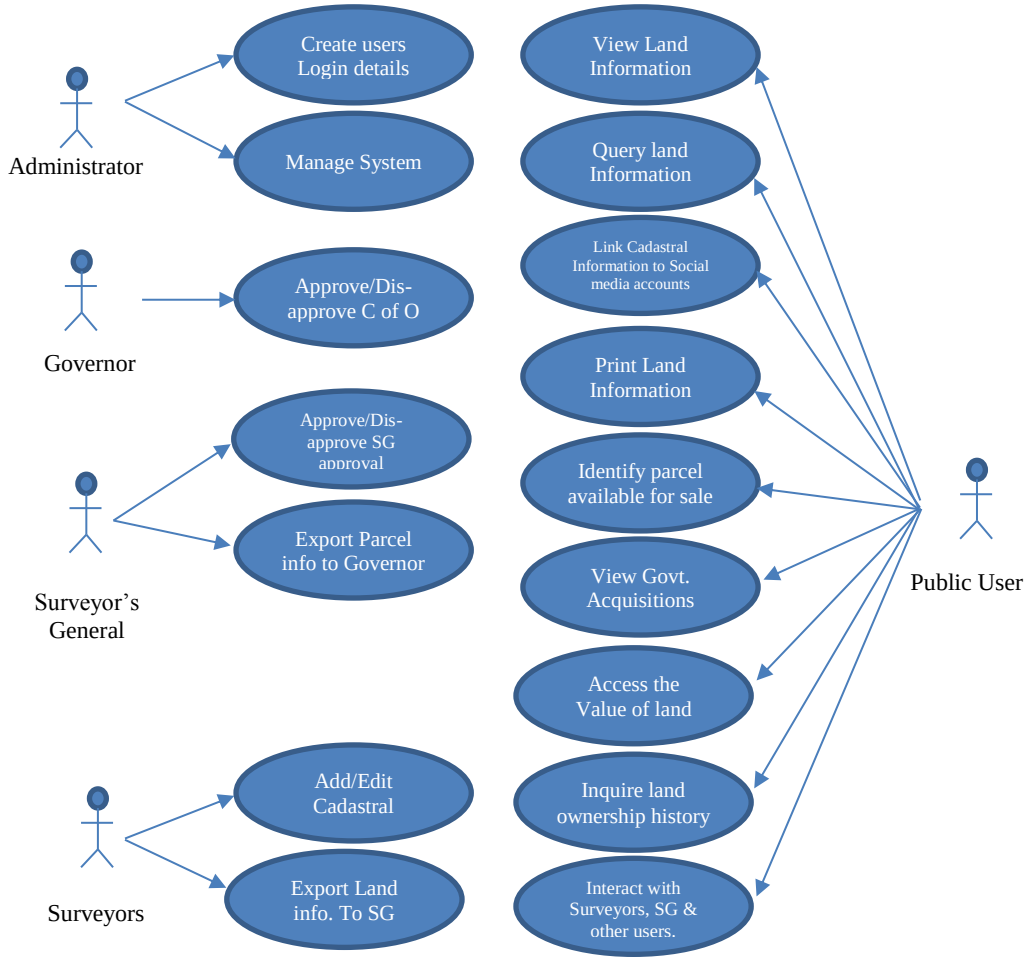

Figure 6: Use Case Diagram

b. **Proposed Interface**

A sketch of the proposed homepage/public users' page made on AutoCAD 2012 is presented below:

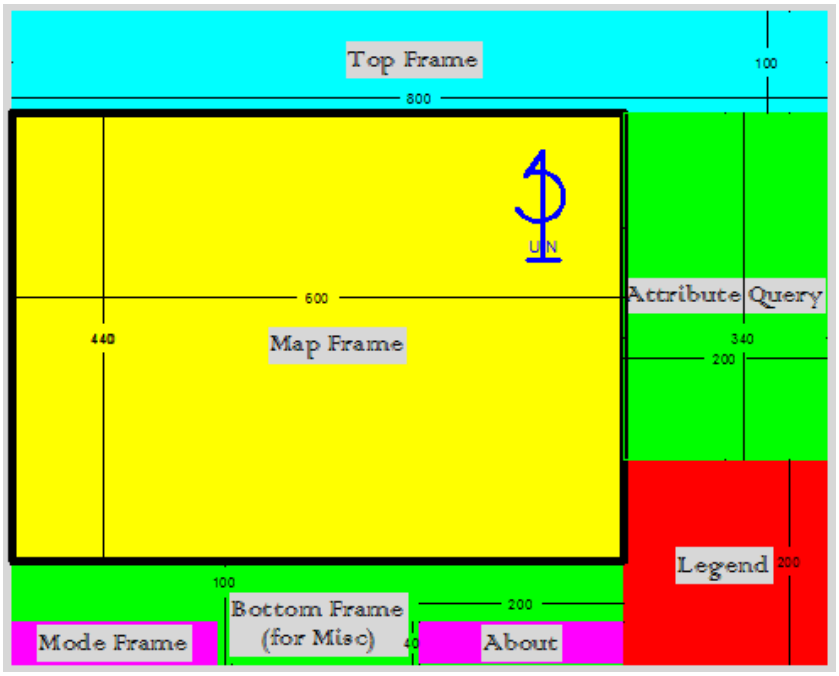

Figure 7: Proposed Users Interface

4.1 METHODOLOGY

4.2 Data Collection

Data is the fundamental part of any management tool (Taiwo et.al, 2013). The effectiveness of spatial information systems depends on the comprehensiveness, consistency, and integrity of its spatial database. Open standard map layer (OSM layer) was used as a base map for the interface. The OSM layer was acquired with QGIS leaflet from the open layers data repository. Being an open layer, the source of the data needs to be verified. Editing and updating the layer was another challenge. In order to verify the OSM layer and to break the reliance of the system on internet connectivity during the development phase, shapefiles (.shp) and drawing (.dxf) files cognate to the course were acquired from the office of the Surveyor's General of the federation, from DgitalFIRM and from Chief P.A.O. Adeleye and associates. The layers under listed below were eventually used in the execution of the prototype:

i. Ekiti State Boundary
ii. Ekiti state LGA Boundary map
iii. Road map
iv. Towns
v. Parcel Layer.

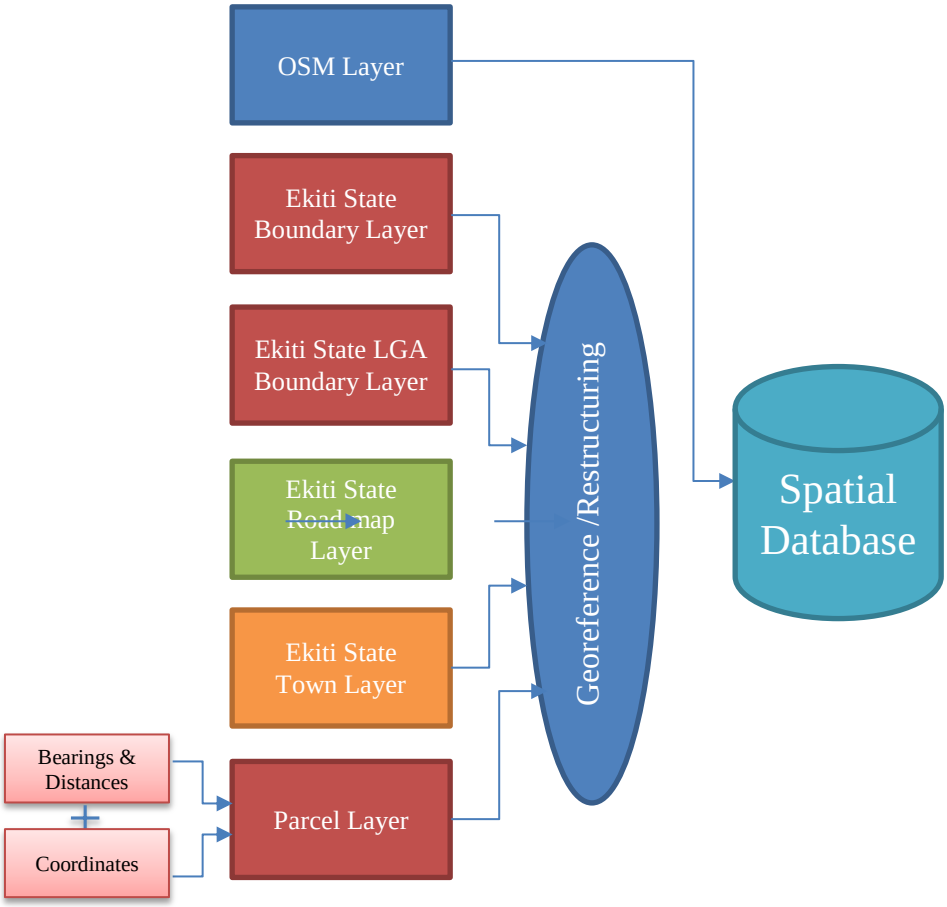

Figure 8: Cartographic model of the Project

4.3 System Tools and Methods

4.3.1 Projection Parameters

The layers acquired were of different projection and coordinate systems. The acquired layers were re-projected into a common coordinate system using the "on the fly" function of QGIS 2.6 software. Currently, WGS 84 uses the EGM96 (Earth Gravitational Model 1996) geoid, which was revised in 2004. This geoid defines the nominal sea level surface by means of a spherical harmonics series of degree 360 (which provides about 100 km horizontal resolution). The deviations of the EGM96 geoid from the WGS 84 reference ellipsoid range from about −105 m to about +85 m.

Projection System: EPSG 4326 (WGS 84)
Equatorial Radius: 6378137
Flattening f : 1/298.257223563.

Figure 9: Projection Parameters (Source: Wikipedia Dictionary)

WGS 84 was adopted as the projection system because of its uniform referencing system for all points on the earth surface.

4.3.2 Geometric Primitives

The layers acquired were based on the three known geometric primitives (points, lines and polygons). Below is a categorization of the geometric primitive associated with each layer:

Table 2: Geometric Primitives of Spatial Layers

Layer	Geometric primitive
Ekiti State Boundary	Polygon
Ekiti State Local Government	Polygon
Road Map	Lines
Towns	Points
Parcel Layer	Polygons

During the research, it was discovered that polygon maps delineating towns within the study area were not available, therefore, it was identified during the research work that there is need for town demarcation within the study area, such that queries can be carried out using town criteria other than the Local Government Area criterion which was implemented in this prototype.

4.3.3 Implementation Requirements and tools

In designing, developing and implementing the system, wares with the following capacities were used:

Hardware:

i. Asus VIVObook F200L Notebook PC (Core i3, 500GB Hard disk, 4GB RAM)
ii. HP TouchSmart tm2-2050us Notebook (Core i3, 500GB Hard disk, 4GB RAM)

For the enterprise level implementation, a machine with the following minimum requirements are advised:

a. Hard disk size: 40Gb
b. 1GB RAM

Software:

In developing the prototype system, the following were used:

i. Microsoft windows 8
ii. Microsoft Office Suite
iii. QGIS 2.6 (Brighton)
iv. Internet Explorer
v. Mozilla Firefox
vi. WAMP server
vii. Macromedia Dreamweaver 8

For an enterprise level implementation computer machines with browsers such as Internet Explorer, Google chrome, or Mozilla Firefox can be used.

5. SYSTEM ANALYSIS

5.1 System Preference

During the research, questions was asked to determine the type of system surveyors would prefer for cadastral information management. This is owing to the fact that there are two different types of systems commonly used in the management of cadastral information. This includes Cadastral Information System and Land Information System. Cadastral information system is explicitly for managing cadasters, while Land information system allows more manipulations aside cadastre management. One significant difference between the two systems in question is that –Cadastral Information System could be seen as a subsidiary of Land Information System.

Table 3: System Preference

Which of these do you prefer					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cadastral Information System	3	21.4	23.1	23.1
	All-in-One Land Information System	10	71.4	76.9	100.0
	Total	13	92.9	100.0	
Missing	0	1	7.1		
Total		14	100.0		

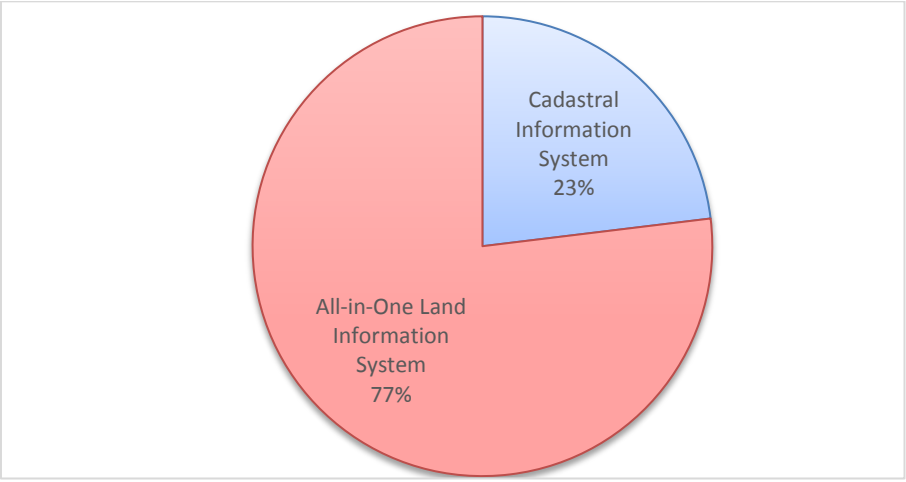

Figure 10: System Preference

From the above, despite the fact that Land Information System will require more professionals in addition to the Land Surveyors for its manipulations compared to a Cadastral Information System, the Surveyors preferred an all-inclusive LIS where several professionals will meet to produce synergy, without trading efficiency for profit gain.

5.2 Choice of Software

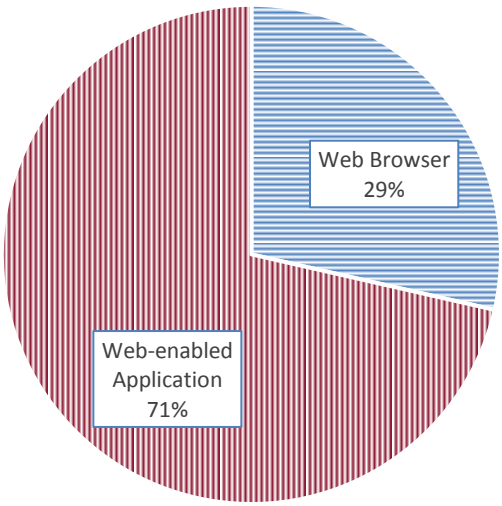

Figure 11: Software Preference (Surveyor's Response)

The above result reveals that Surveyors prefer using a web-enabled application for cadastral information management to web browsers.

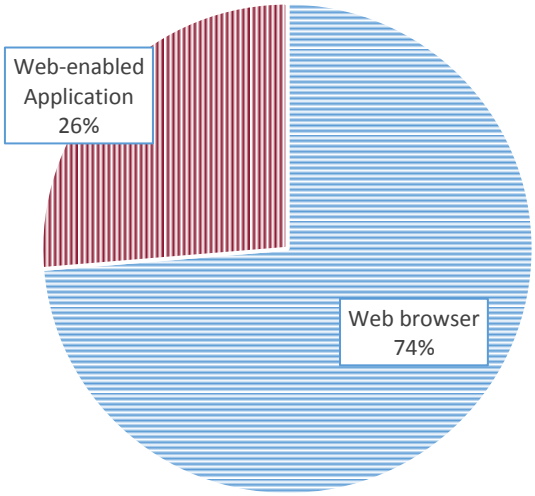

Figure 12: Choice of Software (Public Users Responses)

Unlike the observations and inferences made from the Surveyors responses, the public users preferred the use of Web browsers for accessing and manipulating cadastral information on the web, hence a web based application was developed to be deployed on web browsers for the management of Cadastral Information.

6.SYSTEM OUTPUTS

6.1 WBCIS Home Page

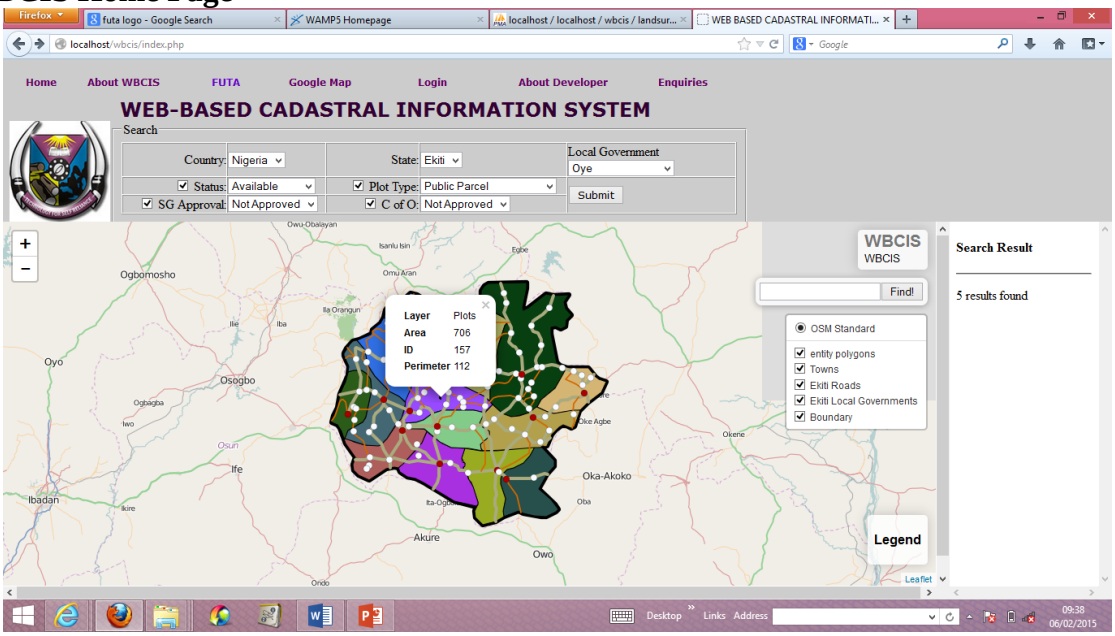

Figure 13: WBCIS Homepage

6.2 Queries and Prototype Snapshots

Figure 14: List of Land Parcel without Certificate of Occupancy Request or Approval

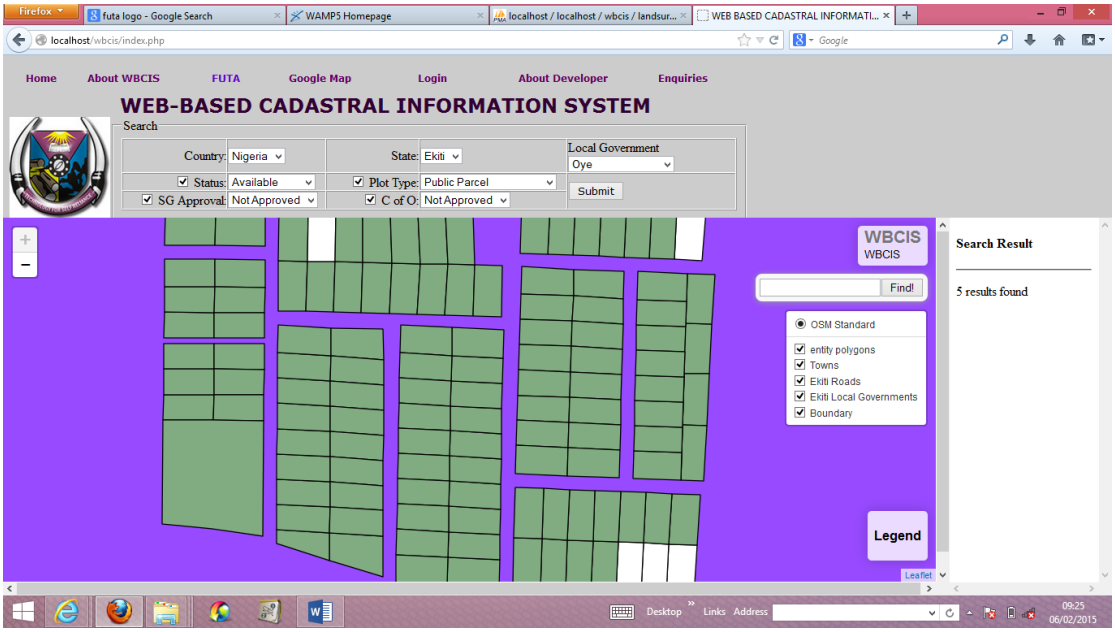

Figure 15: Query Showing Land granted SG Approval (Viewed on the Public users page)

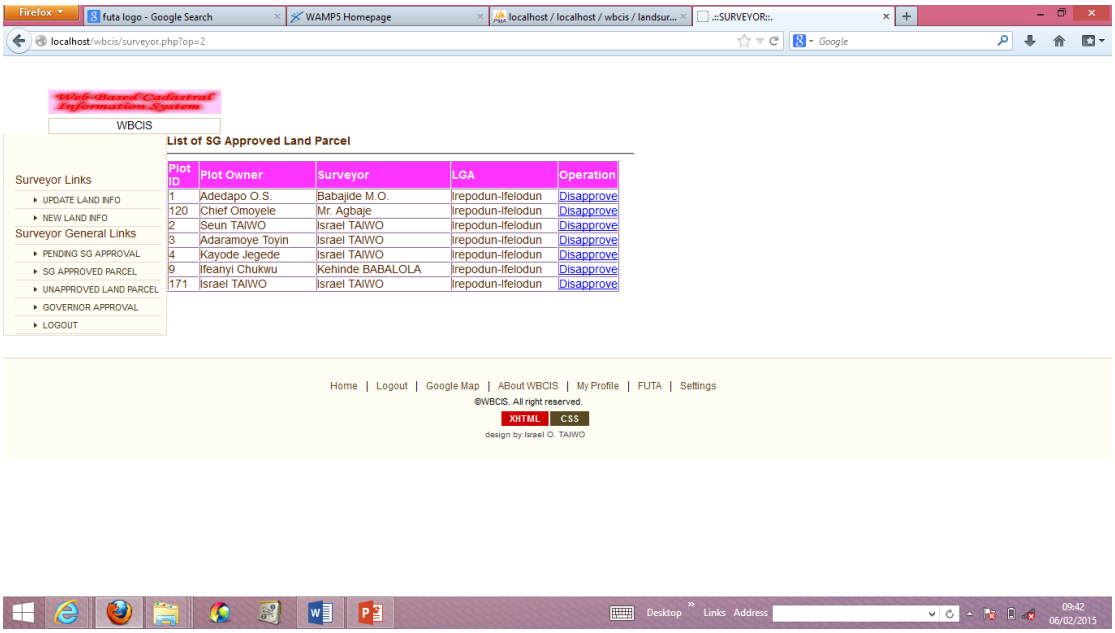

Figure 16: List of SG approved Land Parcels

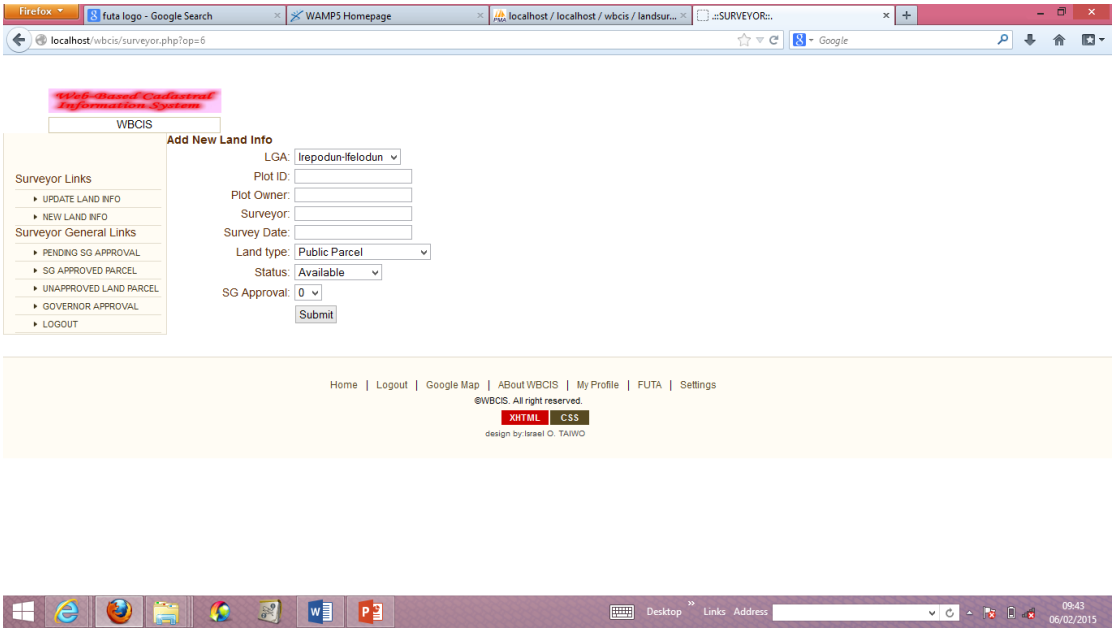

Figure 17: Surveyors' Add new Land Information page

7.CONCLUSION

a.Research Contributions

The research revealed salient points regarding land registration and management in Ekiti State Nigeria. The research into how a web based framework should be implemented as a modification to the existing system was as well a contribution into best practices of the implementation of web based cadastral systems.

If implemented, this work will benefit owners of rights to land by saving the cost of trial and error land procurement and registration because the status of a land can be checked on the system before procurement. It will benefit the professionals by helping to facilitate land registration and management, easier and faster than it is possible in the existing framework. The Government will also benefit by the possible drastic reduction of land dispute and tenure related challenges and "land in dispute resolution" as the system stores a database of history of land ownership.

b.Limitations / Problems Encountered

As revealed by the research, the development of a Web based Land information system for land management is being considered by the authors, to avail a more robust system for land management in the state.

The non-availability of polygon maps of town layers restricted the execution of queries by town. Queries of parcels by Local Government Areas and other available polygons layers were possible, but this queries will be better narrowed if data for town delineation were available for the study area.

After overlaying all the layers, the overlaid layers do not superimpose perfectly with the overlaid OSM layer. The non-conformity of OSM layers with the overlaid spatial layers should be subjected

to further research, such that factors producing these inconsistencies would be identified and solutions proffered.

c.Recommendations

It is recommended that as revealed by the research carried out, for further research; the activities of other land actors concerning land management should be incorporated with the system to produce an all-inclusive Land Information System for Land Management. It is as well recommended for further research that public users should be able to login with their social media accounts.

It is recommended that this project should be implemented in an enterprise level, first, simultaneously with the existing cadastral information management system in Ekiti State as a testing phase, then after modifications and proven efficiency, it could be generalized for use in Nigeria and places with similar land management systems.

Towns should be delineated accurately, with points, such that polygon maps can be created from the points. This identifies the need for Land Surveyors, Communities, Towns, Local Government Authorities, States and the Federal Government to engage in the delineation and demarcation of towns within Local government areas.

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BIOGRAPHICAL NOTES

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