MODELING PGIS FOR MULTIPURPOSE CADASTRE IN GHANA

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ABSTRACT

Ghana is a middle income country with fast accelerated rate of infrastructure and socio-economic development. Land acquisition is on the increase, and new buildings are being erected almost every day in the urban and peri- urban centres. Accessibility to a reliable tenure and value records of landed property will serve a great purpose to the planning and development of the nation. A good indicator for a reliable parcel data is the stakeholder's involvement in the participatory survey and mapping of geospatial data and relevant physical, cultural and legal attributes. Participatory Geographic Information system (PGIS) is an emergent practice in its own right. It is a merger between Participatory Learning Action (PLA) methods with Geographic Information Technology (GIT). PGIS facilitate the representation of stakeholder's spatial knowledge by the use of a 2 dimensional (2D) or a 3 dimensional (3D) map which can promote communication and community advocacy. PGIS parcel data model is very significant and can be adopted for MPC. The objective of this study was to investigate whether a Participatory Geographic Information System (PGIS) can be modelled for a multipurpose cadastre in Ghana. A wide range of literature on other researchers work has been reviewed. A conceptual model of PGIS for MPC has been established with an implementation plan. Integration of the established model in the national cadastre system in Ghana will be an asset for the nation's sustainability development. The concept of developing a PGIS MPC for Ghana is right on target as the country +needs it most for its Land Administration (LA) system and socio-economic development. This model when implemented in Ghana can also be adopted by neighbouring countries since it has the capacity of reducing or avoiding detrimental community resource conflicts.

1. INTRODUCTION

Cadastre is the pivot of the Land Administration (LA) system, and it describes the right, restrictions and responsibilities (RRRs) associated with land (Njuki, 2001). The current cadastre system package is made up of the following; a cadastral plan (geometric dimension of the parcel), the interest, right (ownership), and values. Other vital information such as cultural attribute, physical attribute, utility data, and legal attributes are not considered. Though no one can claim absolute ownership of land, every individual traces a lineage to land. This means that, every one owns right to land with respect to and in accordance with the

local laws, practice and encumbrances. Multipurpose Cadastre which combines geospatial data to cultural, physical and legal attributes with utility data through technical integration is very essential for developing countries like Ghana. The model has a potential to support spatially enabled government, private sectors, society and to expand Information Technology Communication (ICT) support in the process of visualization, organization and management of useful land information (Bin Taib, 2012). Figure 1 illustrates the potentials of MPC.

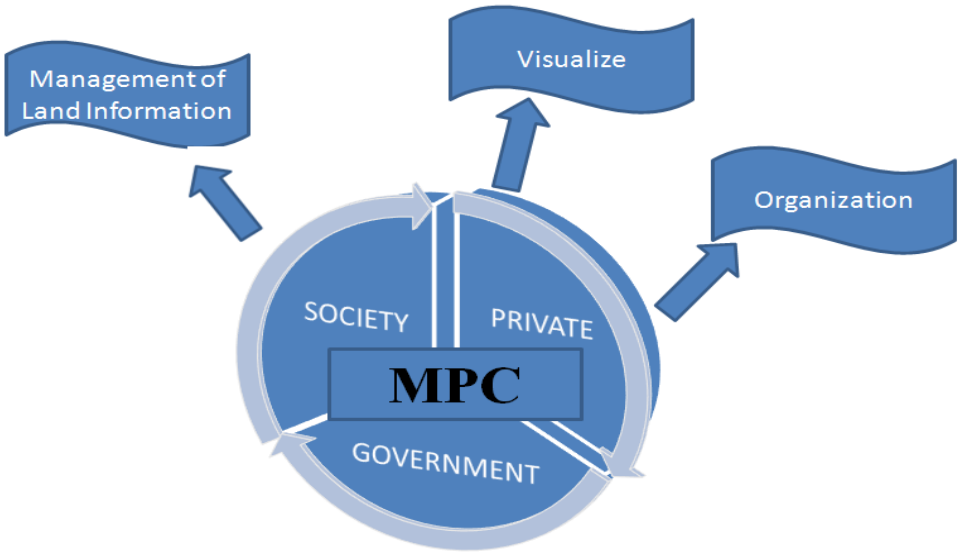

Fig. 1. Potentials of Multipurpose Cadastre

According to Untong (2013), Multipurpose cadastre is a land information system that incorporates legal (property right or cadastre), physical (topology, artificial features etc.), and cultural (land use, demographics etc.) information about land into an accurate framework. PGIS facilitates the presentation of local people's spatial knowledge using two or three dimensional maps (Corbett *et al.*, 2006). PGIS practice is geared towards community empowerment through tailored, demand-driven and user-friendly applications of these geospatial technologies. Good PGIS practice is flexible and adaptable to different socio-cultural and biophysical environments. It often relies on the combination of expert skills with local knowledge. Unlike traditional GIS applications, PGIS places control on access and use of culturally sensitive spatial data in the hands of those communities who generated it.
Involvement of the local community in developing a multipurpose cadastre in Ghana will be good for sustainable development. Candler et al., (2006) concluded that since the first Traditional Use Studies (TUS) in the Treaty 8 area in 1974, PGIS has proved itself as a valuable tool in communicating first nations relationship to interests on land. Through changing political, social, cultural and ecological environments, PGIS has been able to adapt and maintain an important role.

Countries like Italy, Sweden, and the Netherlands have already started MPC and deriving enormous benefits. In Ghana, MPC is implemented in the form of Land Title Registration (LTR). LTR was established purposely to replace the deed registration which was flawed due to the occurrences copious lands conflicted that created a lot of tension in the country. Multiple sales of land were a major failure of the deed registration. Meanwhile, the LTR also has a lot of short falls due to the limitation of geospatial data in its composition. The current LTR which is being used for taxation and financial transaction, have the following deficiencies among others; inadequate archival process, foot prints are not being included in the cadastral plan for most areas and also, the process is not fully automated (Arko-Adjei, 2010).

The need for Ghana's MPC is long overdue, hence, the purpose of this work. MPC when adopted and implemented in Ghana by the use of PGIS will improve upon the current LTR by a number of ways including: the provision of fully automated geospatial database with good archival records. All attributes related to land parcel information will be captured in to the database. The GIS involvement will aid in detailing every foot print in the preparation of a site plan. This will then minimize land conflict due to stakeholders' active participation in the initial process of MPC which is the participatory mapping and Survey.

PGIS as a tool for resolving land and resource related conflicts have been widely used. Reyes-García, *et al., (*2012), used a randomized evaluation to assess the effects of participatory mapping in conflicts resolution. It was concluded that participatory mapping can help in conflict resolution or contribute to conflict generation or exacerbation depending on the political and socio-economic context. Tudor *et al*., (2014) investigated four different cases of land-use conflicts in Switzerland and Romania by the use of PGIS. For conflict-resolution to be successful, the findings indicated that it is important to foster on long-term ecological benefits and to take into consideration, people's needs. Brown et al (2014) used PGIS to described and evaluated alternative methods for identifying land use conflict potential. Jankowski (2009) explored the potentials of using PGIS as a tool to help the public become meaningfully involved in decision making processes affecting their communities and promoting the sustainable use of natural resources. GIS-generated maps need highly skilled facilitators to generate and interpret, and this posed a fiscal constrain for small community to developing GIS capability. Bojorquez- Tapia *et al*., (2001), also used a GIS-based multivariate application for land suitability assessment taking into account issues and concerns of stakeholders, and employed a multivariate statistical procedure for classifying land units into land suitability. PGIS had some difficulties, which included varied understanding of the assessment's objectives, inability of the some stakeholders to grasp the analysis because of lack of formal education. Cinderby*et al.*, (2011) discussed the development and piloting of PGIS techniques to facilitate decision making that integrates the knowledge of local stakeholders from individual communities with information from environmental managers at the watershed scale, the environmental decision making scale. It was noted that, there is a significant potential that PGIS aids informed-decision making.

Whiteet*et al.*, (2010) reviewed the emerging lessons from utilizing PGIS in Shoreline Management Planning. The research also examined the potentials for improving stakeholder dialogue and involvement in flood risk management with access to mapping. It was concluded

that incorporating PGIS and other visual approaches offset the weaknesses and maximizes the usable responses from the stakeholders. It is also important to engage citizens in PGIS process which enhances their collaboration with the policy making community and their participation in policy making. Bemigisha *et al.,* (2009), investigated the utility of evidential belief functions (EBFs) and Dempster's rule of combination to represent classification uncertainty and integrated the PGIS-based grazing intensity maps. Tracing the social history of PPGIS, Sieber (2006) argues that PPGIS has been socially constructed by a broad set of actors in research across disciplines and in practice across sectors. Finally, Duncan *et al.,* (2012), modelled 3D for multipurpose cadastre. An initiation of 3D modeling for 3D cadastre was established with an introduction of a concept for volume parcels.

Upon all the research works that have been done on PGIS and MPC, none has been able to model PGIS for MPC in Ghana, and that is what this paper seeks to achieve. The concept is expected to benefit government and society. Among a lot of the benefits are increased sharing of datasets, public transactions of data and reduction of administrative costs.

2. COMPONENTS OF MPC

The component of an accurate MPC is predominantly the formulation of the Ghanaian Digital Cadastral Database (GDCD) that has been populated, and have undergone strict adjustment and quality checks at every formation level with large scale geospatial data sets. The MPC can be described as a spatially enabled system that consist of the integration information system which contains survey accurate cadastre, topology, manmade features and cultural (e.g., land use, demographics) in a common and accurate reference framework (Bin Taib, 2012) Figure 2 present the components of MPC that enhances delivery system to the public and connected governmental realization.

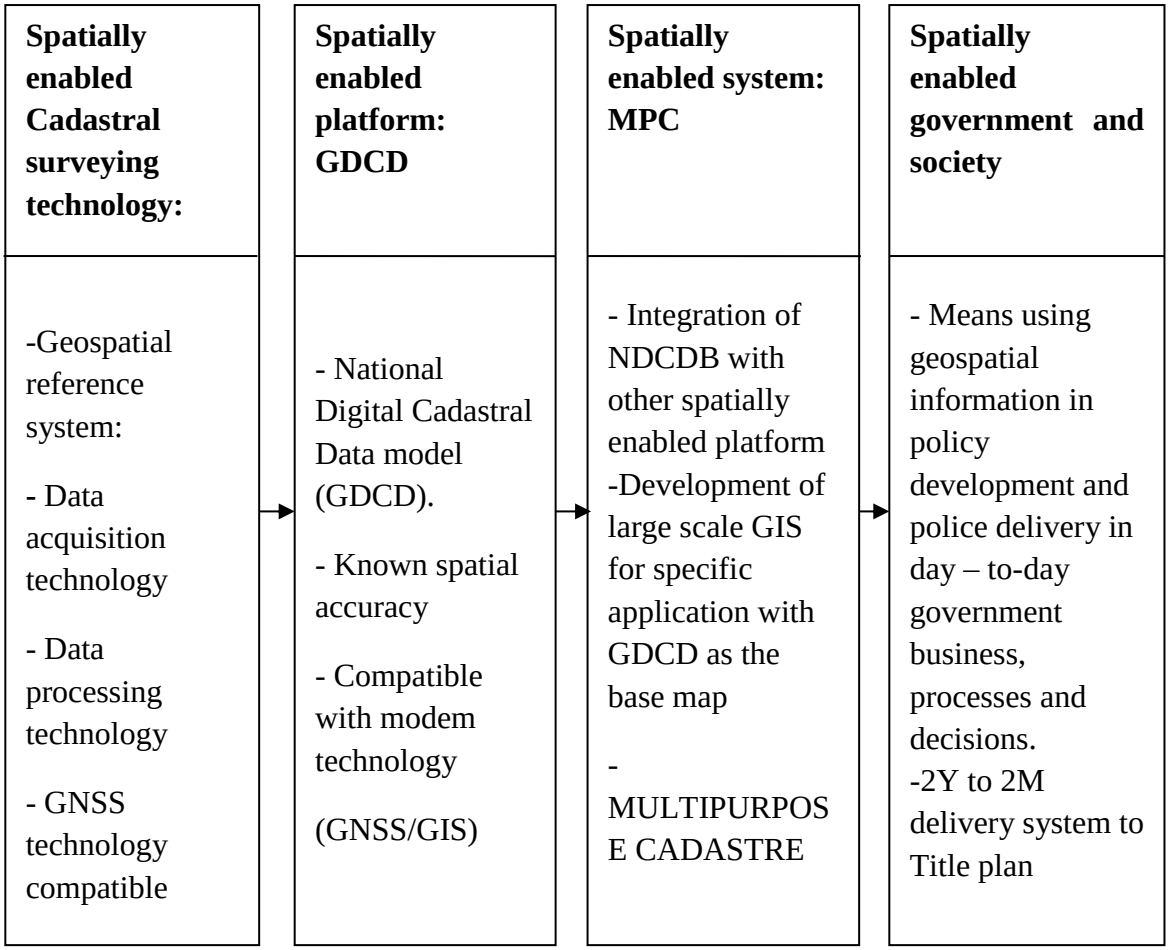

Fig. 2. MPC component

The main constituent of MPC is the addition or the combination of NDCDB and Large Scale Geographic Features (LSGF). A Unified Modelling Language (UML) class diagram for MPC constituent is shown in figure 3.

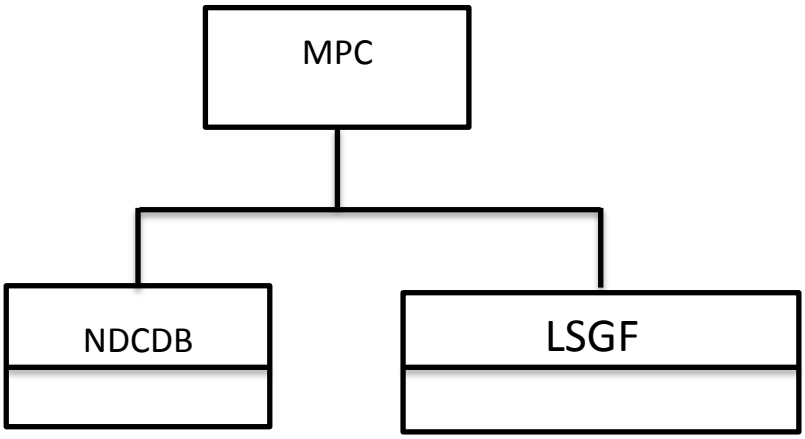

Fig. 3. Class diagram for MPC constituent

Traditionally, MPC is made up of five to six phases as shown in figure 4. The first and essential phase, which is NDCDB, provides a survey accurate fundamental layer in MPC. This is followed by large scale data acquisitions by the use of MTLS. Large scale spatial features such building, road, utility, vegetation, etc. will be detailed during the survey. MTLS is a main source of spatial data for MPC. Geospatial Data Centre (GDC) dataset that is made up of GIS layers and large scale topographic map will then be captured. This is followed by the application of modules for integrating multiple data sources, validating MPC data base and the update of new spatial features. MPC database is then created with the provision of Online access Web (OWA) so that it can be accessed on the internet. The UML class diagram for MPC phases is shown in figure 4.

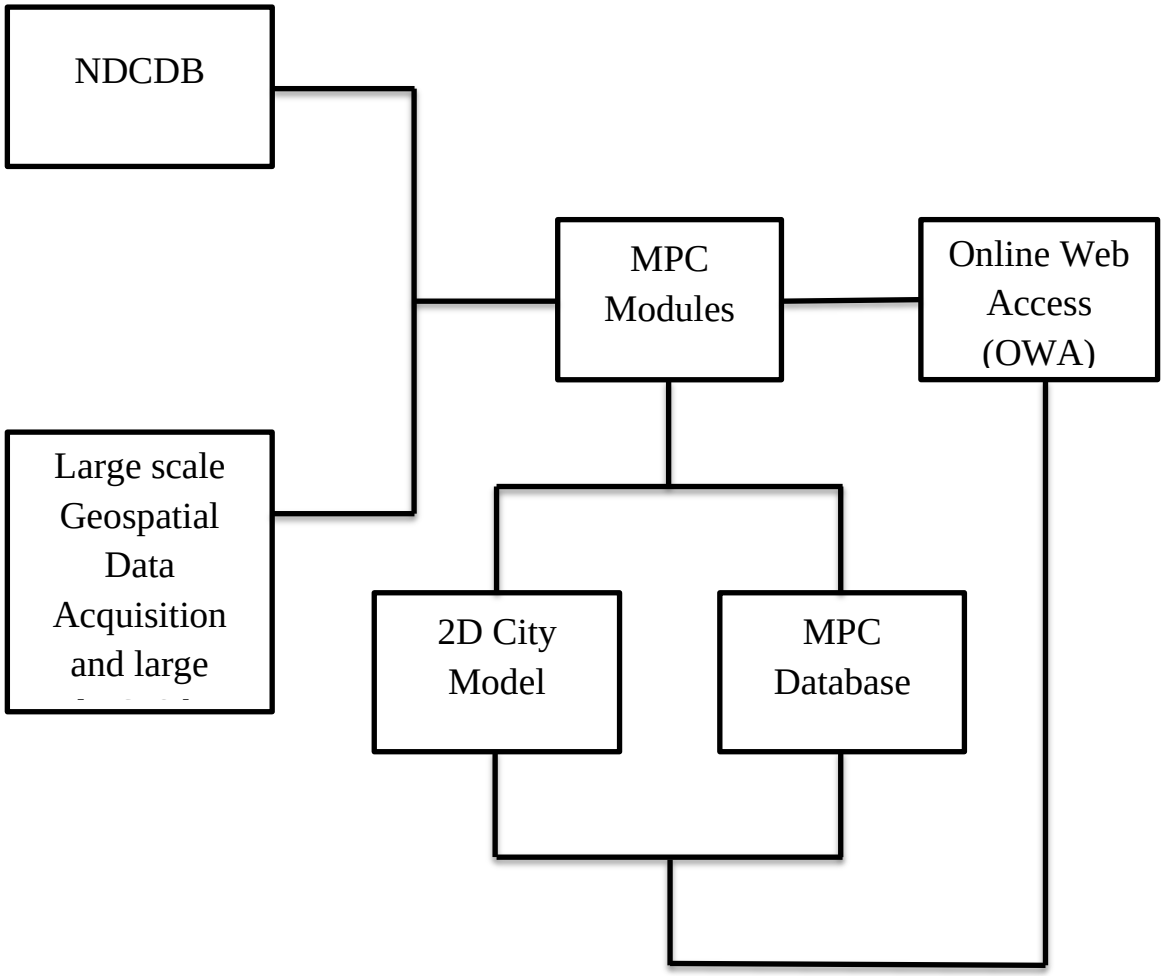

Fig. 4. UML class diagram for MPC phases

3. MPC CORE DATASET

The core dataset for MPC are as follows:

1. National Digital Cadastre Database (NDCDB)
2.

To maintain a homogenous spatial accuracy of cadastral boundary coordinate to a better unit is the main objective of survey accurate NDCDB which is the most important element in the development of large scale geospatial database and will facilitate the development of large scale Spatial Data Infrastructure (SDI). Figure 5 present the main ingredient of NDCDB in a UML class diagram.

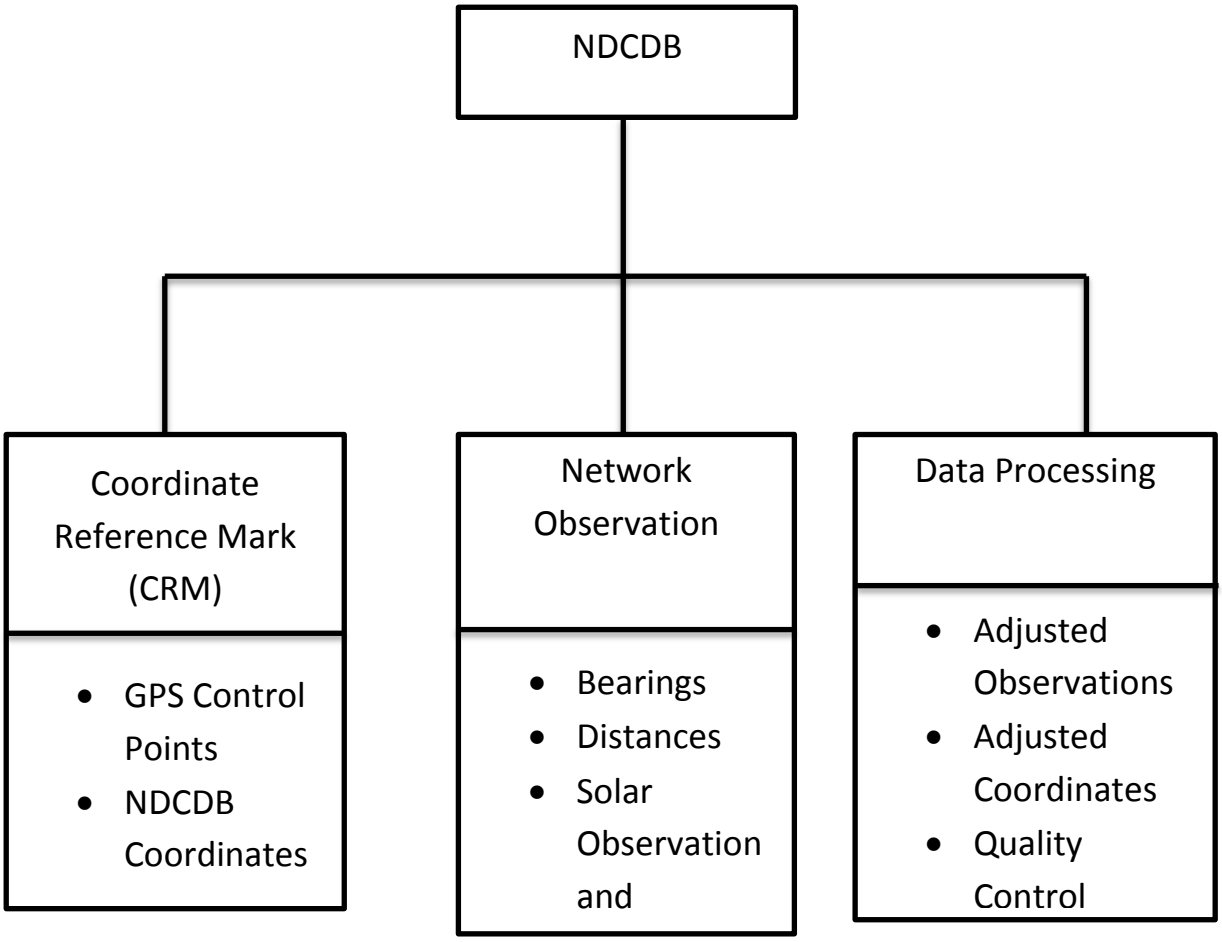

Fig. 5. UML diagram for MPC ingredient

3. Large Scale 2-D MTLS based Geographic Features Dataset

This is the main source of MPC. It includes point clouds data that has undergone initial adjustment by post-processed kinematic GNSS procedures from separate GNSS base by a local transformation to a point that is well defined through the project area to produce the final station placed throughout a particular area.

4. 3D City Model

Relevant details and buildings in 3-D representation have added opportunity to include semantic information about facade and thus not limited to geometric data only. Areas of buildings covered by dense and accurate measurement are used to model spatial features like transportation network, grounds, water bodies, buildings, city furniture, electric power lines and land cover. Thus, 3-D city models are now becoming the essential basis for city planning, development and control (Bin Taib, 2012).

4. Utility Dataset

Utility features are features like water mains, sewerage system, telephone lines, power lines, gas lines etc. and they are needed to be mapped well in order to contribute to the benefit of MPC. it will critically aid city authorities to plan, maintain, and control infrastructure development. Repairs and replacement of utility lines become easy and efficient with GIS/Utility mapping system. Damages due to exaction can be easily avoided. Location and characterization of features can be systematically stored with easy access to information such as utility lines dataset and base maps. Updating, extraction and analysis become efficient and flexible with easy map distribution via digital or hard copy and internet access. A good link to data register and consumer information is added advantage.

5. Street Address

This provides a very pertinent data support for MPC to function well. Geocoding process can systematically be conducted by the use of cadastral lot numbers, UPI, and OID. The data can then be linked to zip, postal or sit us method to generate street addresses based on MPC GIS base map integration.

6. State Geospatial Data Centre (SGDC)

By the use of SGDC dataset as a core geospatial data impute, peri-urban MPC can be developed.

4. PGIS-MPC CONCEPTUAL MODEL DEVELOPMENT

Multipurpose Cadastre consists of multiple independent, interrelated layers commonly used to describe the graphic component of a GIS database **(**Organization Of American States, 2010). The fundamental constituent of the multipurpose cadastre is a cadastral overlay delimiting the current status of property right. The individual building block for the overlay is called cadastral parcel, which is also defined as a unit of land within which unique property interests are recognized. The overlay will consist of a series of maps showing the size, shape, and location of all cadastral parcels within a given jurisdiction. The modern cadastral system is a step towards the Multipurpose Cadastre concept. In his view, Kaufman (1998) defined a Multipurpose Cadastre as a systematically arrangement of public register of data concerning all legal land objects in a certain country or district, based on a survey of their boundaries. The Multipurpose Cadastre is an extension of the modern cadastre to include other land information registers (Jamil *et al.*, 2013). These registers might include databases with planning and valuation information.

From the Committee on Geodesy, 1980 report, the basic requirements for MPC are listed below;

i. The development of technical standards and specifications and the means to enforce these
ii. The development of linkage mechanisms in order to relate other land information to the basic components
iii. An emphasis on gradual, phased reorganization and quality control of existing governmental functions, rather than creation of new functions and agencies
iv. A focus on the county level as the place where much of the work in developing and maintaining a multipurpose cadastre will occur, with appropriate support by state and federal governments; and
v. The development of qualified personnel through encouragement and support of university research and education.

A conceptual model of PGIS for MPC has been derived and presented in figure 6. It begins with the initial field inspection and subsequent participatory mapping by stakeholders of land management and administration in Ghana. The stakeholder's composition is made up of the Local Community, House of Chiefs, Government institutions and department (e.g. Lands commission, Town and Country planning, Stool lands administration, the police, Judicially, CHRAJ etc.), interested NGOs, and individual investors who matter. The mapping is done by any GIS tools. This is followed by technical integration of a Geoscientist who will make sure that statutory requirement and standardization is achieved. Geospatial data and utility features will be captured together with legal (land right), physical (topology) and cultural (demographic) attributes. A parcel information database will then be produced after strict adjustment, computation and coordination of the geospatial and the utility data. The output will then be subject to scrutiny; validation, editing, formatting by stakeholder representatives to produce a valid, and reliable tenure and value record.

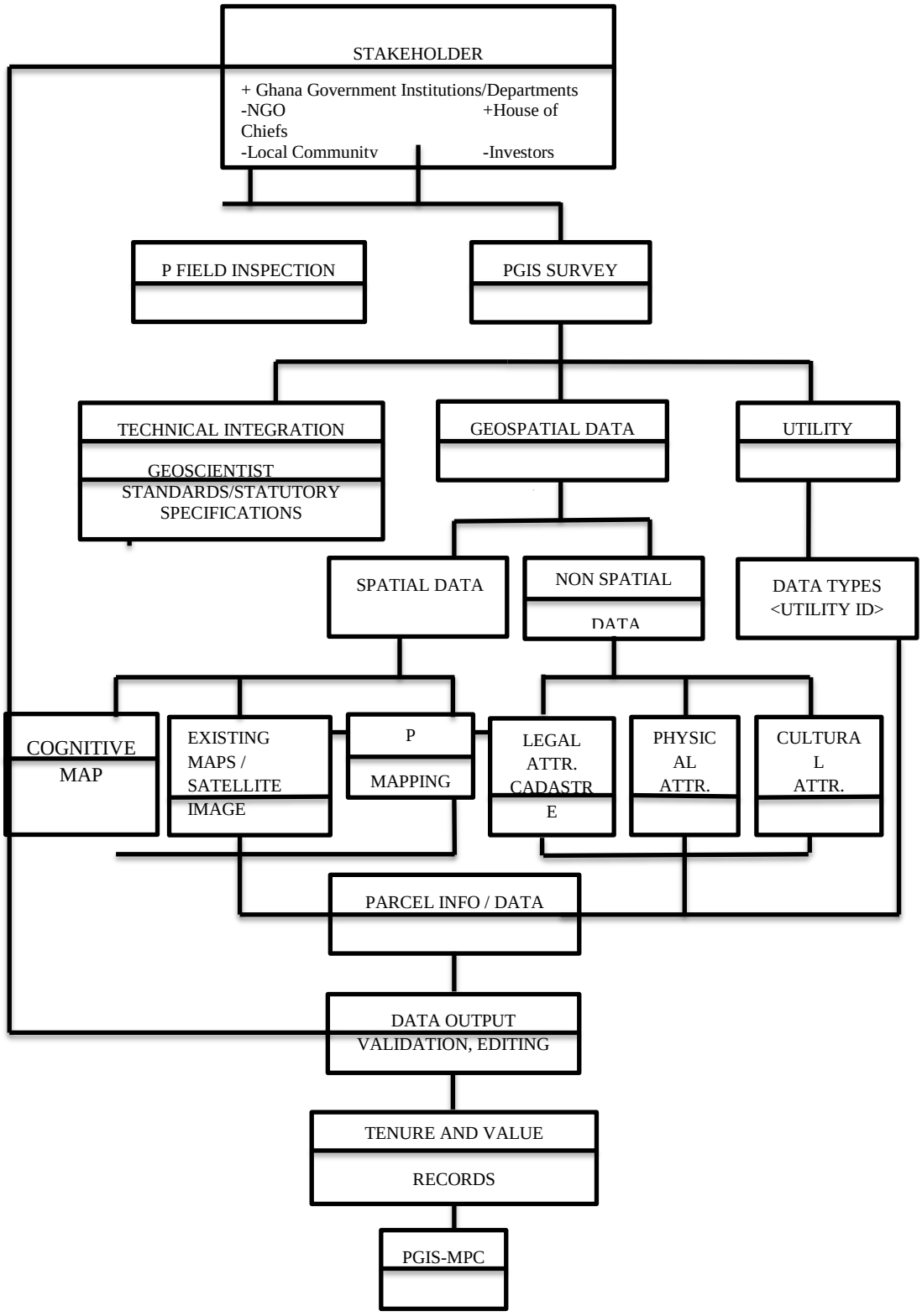

Fig. 6. PGIS model for MPC

5. IMPLEMENTATION CONCEPTS

The entire process will follow the following steps:

i. Stakeholders' consultation meeting to define the task and the need to work together.
ii. Meetings with the community for site analysis and also to elicit knowledge on historic to present geospatial information
iii. Participatory mapping where the community will be thought how to GPS and GIS instrument which are simple, user-friendly and very accurate.
iv. Technical integration whereby the Geo-Scientist will produce the cadastral map or base map with boundary information's impute from the local authority having considered all lay down statutory requirements. The Geo-Scientist with a shared computer display to selected and trained community members.
v. Legal (property right, or cadastre), physical (topographic and relevant feature), and cultural (land use and demographics) details or attribute will then be incorporated.
vi. Data processing (Validation, editing, translating and formatting of output).
vii. System output

6. CONCLUDING REMARKS

Participatory Geographic Information system model for Ghana's MPC has been proposed. An integration of spatial data (land parcels) with cadastre information has been gathered with community involvement through participatory mapping and interviews. Adopting PGIS MPC in Ghana by 2016 will help in land tenure and management system in the country. Due to continually changing humankind to land relationship, demands and resource management, these will largely depend on the ability to adopt and integrate PGIS model for MPC in an enhanced land administration systems. The PGIS model for MPC is driven by the needs of users that critically require accurate surveyed data. PGIS-MPC will prop up effective land development and administration, increase sustainable economic development activities, agricultural productivity, and environmental management. It can also empower different levels of stake holders at communal authority, state authority and national authority for participatory decision making processes which will enhance delivery system to the public. The pilot project towards the development of MPC for only one region in Ghana will provide informative insight on the future direction in implementing nationwide MPC and new cadastre management system.

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