

A Brief Review of Land Administration Domain Model and Its Temporal Dimension

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Abstract – *Land Administration Domain Model (LADM) is published by the International Organization for Standardization as ISO19152:2012. LADM stimulates the development of software application and accelerates the implementation of proper land management system in support of sustainable development. LADM covers essential information related to the components of land management including those over water and elements above and below the earth surface. LADM standard provides an abstract, conceptual model with three packages and one sub-package. LADM defined terminology for land administration that allows a shared description of different formal customary or informal tenures. The standard provides the basis for national and regional profiles and enables the combination of land management information from different sources in a coherent manner. In this paper, Land Administration Domain Model and basic knowledge were treated. The effort of the experts with the pioneers in the standardization and publication of LADM was discussed in order to set the foundation for the review. Some of the available works from 2006 when the standardization processes began were reviewed with more emphasis on the time (temporal) dimension of LADM. From available journal and papers, the authors agreed that there is need for addition of the time dimension with the existing 3D to manage the land use complexity in this recent time. We therefore concluded in this paper that, the design and development process for International Standard ISO 19152:2012 temporal schema will be adopted as a methodology to achieve the aim of this research. Copyright © 2015 Penerbit Akademia Baru - All rights reserved.*

Keywords: temporal; pioneers; conformance; country profile; international standard; LADM.

1.0 INTRODUCTION

Land is the habitat of man and animal; it is created for administrative and economic purposes. It is indeed the foundation of all forms of human and animal activities, from which the food, shelter, a space to work and even a room to relax emanates. Therefore, it is the most valuable resource without which man could never exist and on which his continued existence and progress depend on. Land is the natural gift of nature, and the extent cannot be extended by any means, because it is fixed; the demand and it's usage keep increasing every day. Subsequently, the space to build, to construct and to live is becoming unavailable because of the increased in the demand on the land, man builds up more interest in the way it should be managed. Every activity on earth takes place on the land; therefore, people began to look for ways to manage the land. Land administration system seems to be an immediate solution man can engage to solve the problem. Land administration began before the colonial period in Malaysia (Asian countries) and most of the developing countries although, it was not practiced the same way as it is being practiced now. After the colonial period came the

computer application in survey that brought in Geographic information system (GIS), Land information system (LIS), Cadastral information system (CIS) and multipurpose Cadastre (MPC).

In 1994 the International Federation of Surveyors (FIG) was founded in 1878 in Paris. FIG is an International organization representing the interests of Surveyors worldwide, mandated the (Commission 7 Cadastral and Land management working group) to work on the existing cadastral, and the vision for future cadastre system (Cadastre 2014, FIG1998) [1].

Consequently, the process of development in cadastre 2014 gave birth to Core Cadastral Domain model (CCDM) and Land Administration Domain Model [2], [3]. The development process for the standard took more than four years within ISO/TC211 (Geographic Information) while it took up to six years of preparation within the FIG, but the original idea was launched at the 2002 FIG congress in Washington D.C., United State of America [4]. The ISO/TC211 is one of the over 200 technical committees of ISO; its scope covers the standardization of digital geographic information with more than 60 published standards [5]. The editing team and pioneers of LADM, Peter van Oosterom, Christiaan Lemmen and Harry Uitermark made decisions regarding the design change, adjustment and documentation of the changes as proposed by the LADM project team. Since then LADM has been developed incrementally [5]. However, between 2002, to 2006 and 2008, to 2012 version 0.1 to 0.6 and versions A to C were developed and presented at different occasions respectively. In October 2006 at Munich Germany under the version 1.0 of FIG Core Cadastral Domain model version 1.0 was presented [6].

The standardization project of LADM started from year 2006 with a discussion between FIG and ISO/TC211 based on the report by Lemmen and Oosterom [18]. By 2008, a proposal for the standardization received an affirmative vote, the project team, a group of expert and international institutions contributed to this development. There were a series of meetings between 2007 and 2011 by the project team where most of the inconsistencies were corrected (figure 1 shows the project team). The ISO secretariat processed all these in an efficient manner, and LADM was formally published on the 1st of December 2012 by the International Standard ISO19152 [4].



Figure 1: Project Team in Molde, Norway, 2009: [7]

Land Administration Domain Model (LADM) is identified to be International standard organization of ISO 19152 under the technical committee TC/211 for Geographic Information/Geomatics. It was designed as a standard for all land registration and transactions within the country and countries or local and localities. LADM is an abstract conceptual reference model which enables the concerned party or parties to communicate on the same platform based on a shared vocabulary. LADM supports the development of the application software and data quality management in land administration system [4]. It is an extendable, efficient and effective domain in which experts in other countries can develop packages based on LADM for their countries. However, the world is never static, the complexities in land administration demand a model capable of handling more complex land management where time as a temporal dimension will be included [8]. This paper presents LADM from 2006, although, the idea came up in 2002, the standardization projects only started in 2006. Therefore, the existing works done and the prospect for the future on its temporal dimension were reviewed. The increase in land used and land activities all over the world had made the land administration and management became complicated. The increase in land complexity requires LADM concept in land administration to have an improved capacity to manage the existing 2D/3D. In the recent time, the inclusion of the third dimension has been relevant for apartment units; physical objects above or below land parcel such as tunnel, underground shopping mall, underground car park, underground water, mineral resources and utility network figure 4. However, the addition of the fourth dimension (The temporal dimension) will enrich and improve the incremental development of LADM. Section 1 of this paper talks about the introduction and the historical evolution of LADM and its approval as an international standard for land administration with brief information on some of the basic knowledge as a fundamental principle in LADM, the overview of efforts of the pioneers in the design, and the development of LADM. Section 2 reviews the available literatures on LADM as well as the need for temporal (the fourth dimension) of LADM. Section 3 discusses the expected results. Meanwhile, section 4 presents conclusions and the future outlook.

1.1 Efforts of Pioneers in the Design and Development of LADM

In the thesis by Lemmen [8], the main objective of his Ph.D. thesis was “*To design a land Administration Domain Model (LADM).*” The model should be possible to be used as a fundamental for Land Administration System (LAS) development. It has to be accepted and adaptable to local situations, be useable to organise LA data within a Spatial Data Infrastructure (SDI) and the design should be based on the pattern of people to land relationship. The Land Administration Domain Model (LADM) standard has been developed and published as a Draft International Standard (DIS) by the International Organisation for Standardization ISO 2011 as ISO 19152. The thesis covers basic information related to land administration. The components are the water and elements above and below the earth surface and those components concerning party related data; data on RRRs and the basic administrative units where RRRs apply to, data on spatial units and on surveying and topology/geometry which are represented in Unified Model Language (UML) packages and class diagrams [8]. Having achieved the objectives of his research, answered all the research questions and performed validation, he however concluded that LADM was the creative approach resulted in finding the common denominators in land administration. The LADM standard has been designed in such a way that it can easily be changed depending on local demand, but further implementation is on-going.

Oosterom et al. [4] presented an overview of the last and minor technical modification from the Final Draft International Standard (FDIS) to IS in their article titled “*Land Administration Domain Model published by ISO*”. According to the authors, the main reason for the modification was the removal of the inconsistencies. They also further elaborated on the process to arrive at an International standard and the lessons the authors of the paper and the editors learned during the past years. LADM provides a comprehensive set of functionality based on Model Driven Architectures. The authors agreed that further issues will come including elaborating (country profile) and realizing a functional model suitable for implementation; database schema, temporal schema, exchange format and interface for edit and dissemination.

Uitermark [5] gave an overview of the paradigm aspects of the standardization process of land administration domain model during the years 2008 to 2012. During this period Harry Uitermark, Christiaan Lemmen and Peter Van Oosterom constituted the editing team of LADM. He also presented the start-up of LADM, the standardization project and the Final Draft International Standard. Lack of procedural knowledge and understanding of the rules for the structuring of ISO documents were identified as two major problems for the delay of IS approval in July 2012.

1.2 Basic Knowledge in LADM

LADM is a conceptual model schema of land administration that provides a reference model that enables the involved parties both within a single country and across different countries to communicate on the same platform based on the shared vocabulary [4]. LADM supports the development of the application software for and data quality management in land administration system. Therefore, it is applicable to both the local and International situations in land administration [4]. It is an international standard developed and published by the International Standardization Organization (ISO) under the technical committee (TC211) for Geographic Information and Geomatics. ISO 19152 (ISO2011c) provided efficient and effective cadastral system development [9]. However, during the development of LADM, three core classes were identified, namely “Person, Right and Parcel” [10]. LADM is organized into three primary packages and one sub-package which facilitate maintenance of different data sets by different organizations each with their responsibilities in data maintenance at all levels. The core LADM in Version C is based on four core classes namely;

1. Class LA_Party, parties;
2. Class LA_RRR, rights, restrictions or responsibilities;
3. Class LA_BAUnit, basic administrative unit;
4. Class LA_SpatialUnit, spatial units;

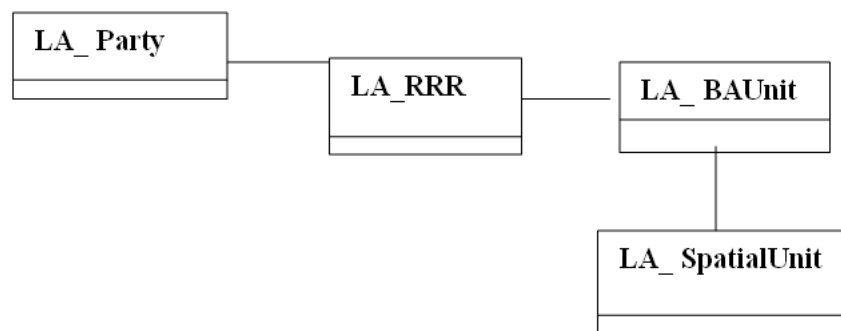


Figure 2: Four core classes of LADM (ISO 2011): [8]

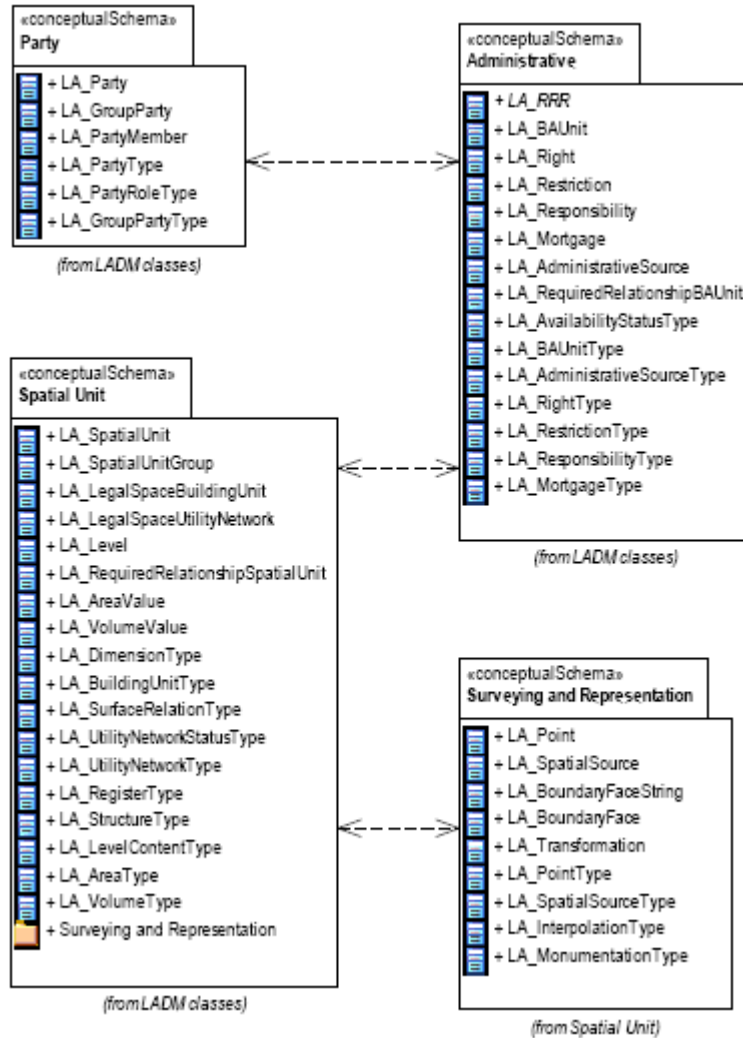


Figure 3: Basic classes of LADM: [8].

The three packages in LADM with one sub package are shown in Figure 3.

1. The Party Package
2. The Administrative Package
3. The Spatial Package

The sub-package is the Surveying and Spatial Representation, source points, Spatial Unit package offers lines and surfaces.

2.0 THE NEED FOR TEMPORAL LADM

- FOUR DIMENSIONAL MODELS
- 2D \Rightarrow X,Y = 2D
 - 3D \Rightarrow X,Y,Z = SPACE
 - 4D \Rightarrow 3D+D = 4D
 - \Rightarrow SPACE+TIME = (4D) TEMPORAL DIMENSION

The Land Administration Domain Model LADM supports both 2D and 3D parcels [39]. However, the inclusion of the fourth dimensions (time) will further demonstrate the strength and ability of LADM to handle the dynamic relations of people and the land. Figure 4 shows various underground utilities in 3D.

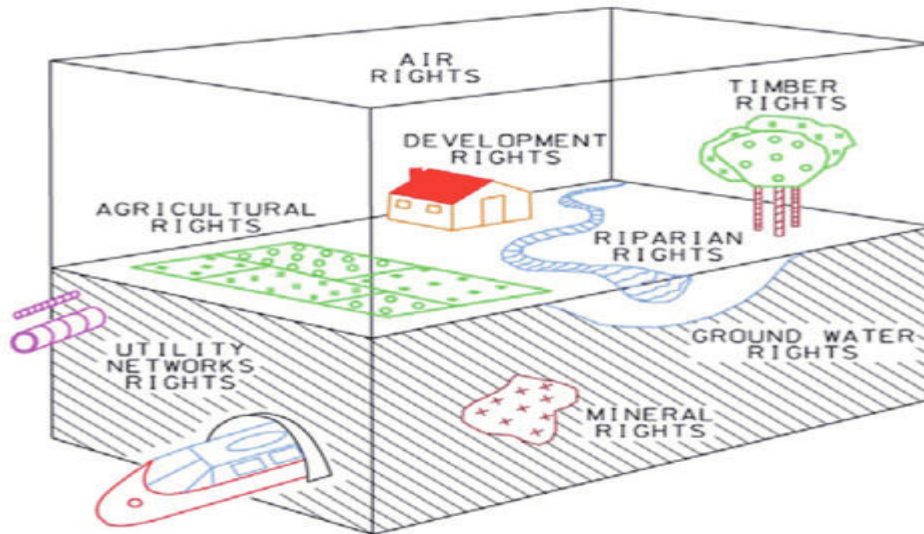


Figure 4: Rights and underground utilities in 3D space: [12]

Döner and Biyik [11] compared the approaches of Land Registry and Cadastre Information System (TAKBIS) in Turkish and Turkish National Geographical Information System (TUCBS) in Turkish conformity with LADM for modelling 3D/4D cadastre situation in Turkey. From the cases presented in the paper like many other countries, traditional cadastre showed some limitations to register and present 3D/4D situations, although the current cadastral can be improved to reflect better on all dimensions of land since land management, registry of lands and cadastre data model of (TUCBS) are compatible with LADM. However, the authors agreed in their conclusion that managing multidimensional and temporal aspect still needs further studies.

Siejka et al. [12] presented some reasons for discussing 3D+time being the integral factor in the relationship of man and land. They argued that some rights to the property are limited by time, such as tenancy, leasing, mining right, hunting, fishing right etc. Another example in favour of 3D+time is cadastre implementation that on its own needs access to historic data which they believed are needed in the recreation of the legal state of land or parcel boundary location as such information is also vital for creating a multipurpose cadastre. Having considered Polish cadastre, they concluded that the available information set provides a starting point for the creation of a 3D+time cadastre in Poland using modern database software tool and Computer Aided Design (CAD), GIS software and (DBMS) Data Base Management System. They agreed, however that the time aspect requires further study and additional research is also required for the methods of data acquisitions to satisfy the needs for multidimensional cadastre.

Döner et al. [13, 14] believed that due to the growing pressure on land and rising in land values as a result of more intensive and sophisticated land use, cadastres requires an improved capacity to manage the third dimension. In the paper, records of underground utility network in cadastre are considered in 3D+time=(4D) context. An empirical case study was performed, and the research was conducted in three countries; Turkey, Netherland and Australia on their legal, organization and technical structure. The physical and legal

registration of utilities in the three countries was examined and the legal, organizational and technical aspects of the current practice were analysed in an integrated way. A model was proposed for the management of physical and legal network. From their research, they discovered that the underground utility networks are the most typical objects with 4D characteristics in a cadastre. The authors agreed that in the context of their paper, the legal impact of a 4D cadastre could only be shortly addressed.

Döner et al. [15] asserted that the complex management tasks modelling dynamic and multi-dimensional spatial information have become one of the research topics in the current land administration and management systems. However, most of the individual approaches have shown some limitations in certain situations. They, therefore, proposed the foundation of LA for 4D that involves a partition both in space and time without gaps or overlaps. The summary for the conclusion of that paper was that the problems are the same for the technical and legal administration of these 4D objects in different countries but they agreed that countries with different legislation on LA and adjustment in land management can be required to apply the solution.

Ghawana et al. [16] discussed the adoption of a spatial information using science approach to bridge the gaps between the technical and administrative aspects of groundwater management. The authors presented that the solution for the global issues in groundwater resource management can be managed by the advancement in technologies. First step towards the implementation of techniques which are essential is to include spatio-temporal dynamics properly in the standard data models. Meanwhile, spatial and temporal dimension review was done for legal-administrative and spatial units under the components of the standard LADM model. The authors agreed that another research on this topic should focus on a number of issues in order to derive Groundwater Rights Profile as well as an Aquifer Spatial Profile.

Oosterom et al. [17] studied the needs for a 4D cadastral system by introducing time elements on cadastre by describing some case studies. Although the authors agreed that the paper is an initial analysis which does not provide a final solution, the aim is to start the international discussion on the requirements for a 4D cadastral registration. Having mentioned several aspects of temporal cadastral, they considered and analysed the following three cases:

1. A case of dynamic objects
2. Case of time sharing
3. Case of registration of utilities

The authors realized that interests in land have a component in time where most of the cases can be represented with separate spatial and time attributes. However, integrated treatment of space and time in one internal 4D data type representation might have some benefits for future realization of 4D cadastre. They concluded that, time aspect deserves further attention when it deals about system development thereby contributing to the improvement of land administration.

2.1 Conformance Testing, Country Profile and Application of LADM

The primary objective of ISO in the field of digital geographic information can only be achieved when data and system are tested to determine whether they conform to the relevant geographic information standard. ISO conformance and testing provides the concept, framework and methodology for testing and the criteria to achieve to claim the conformance

to ISO/TC211. Test methods are also addressed in this IS, but conformance testing does not include robustness testing, acceptance testing, and performance testing, as the geographic information standard does not establish requirements in these areas. ISO 19105 provides fundamental rules for specifying abstract test suites and for defining the procedures to be followed during conformance testing. Conformance may be claimed for data or software products or services or by specifications including any pattern or functional standard. The ATS is in conformance with ISO 19105. The LADM defines a conceptual schema. Actual use of the LADM requires that an application schema, such as a country profile, is developed [8]. The ISO 19105 of the draft standard specifies how to test whether a particular application schema is conformant with the LADM in terms of package and level. Testing whether a particular data set is conformant, this implied checking the data set content against the corresponding conformant LADM application schema [8]. It is important to know that the test suites of the international standard draft specify the requirements that the implementation under test has to meet some conditions in order to be conformant to this International Standard. For each of the test, the metadata conformity element takes one of the following values,

“Conformant (conformant), Not Conformant (notConformant), Not evaluated (notEvaluated)”

Elia et al. [18] gave the enhancement of the data model of the Cyprus land administration system (CLIS) with the adoption of the LADM being examined. The fundamental entities of CLIS was given and restructured to comply with the LADM. After analysing the characteristics CLIS and LADM, they concluded that they are compatible and can, therefore, be used as a framework for CLIS's data model upgrading. However, the authors hoped for the future work to carry out implementation of the Cyprus LADM country profile.

Zulkifli et al. [19] proposed a comprehensive Land Administration Domain Model country profile for 2D / 3D cadastral registration system in Malaysia. It is partly based on the existing spatial and administrative record systems, and on the new developments inspired by the land administration domain model (LADM). Within the country profile it is attempted to cover all Malaysian LA related information in the model, which is maintained by different Originations. The authors believed that this is the beginning of the work in Land Administration Domain Model in Malaysia; further researches are still needed for the application. Similarly, the country profile was developed for Portugal by Bydłosz [20]. An object-oriented conceptual model based on LADM was developed for Portuguese cadastre and the Real Estate Register; Poland country profile by Bydłosz [20], Turkey by Döner and Biyik[11], Brazil by Santos et al [21], India by Sengupta et al [22], Kenya by Siriba and Mwenda [23], and Croatia by Vučić et al [24]. For the country profiles mentioned above, the standard is suitable for the land administration system and can be adopted by mapping some concepts of the country system into the LADM and vice versa, this sets the stage and foundation for the standard to guide these countries on the efforts in improving their land administration but the studies have their limits because they only presented the design; the development of a technical model is required which will include the temporal dimension.

Dinoa and Coetzee [2] examined the core data model of against the corresponding LADM basic classes and discovered that LADM offered an opportunity to adopt an ISO conformant model in the City of Johannesburg Land Information System (CoJLIS). They showed that LADM can be used to describe land administration information at a municipality in South Africa but there are some differences, similarities and mismatches of attributes between the LADM and the CoJLIS. The result improved the understanding of land administration at the CoJLIS in South Africa; the authors admitted that more empirical explorations are necessary

to examine the applicability of the land administration domain model (LADM) within different contexts. Hespanha et al. [25] investigated the level into which LADM can contribute to a fair approach in large-scale land acquisition. The problem of large-scale land acquisition was briefly introduced with a focus on the transfer of rights and restrictions; fitness of purpose was tested using a series of cases from Africa. The authors tried and presented the situation in the context of (LADM) framework. They concluded that LADM provides generic data model for land administration based on common grounds. It is possible to use it in informal and customary environments having developed the African Land Specialization from LADM core classes although further alignment with LADM development is needed.

The classification of interests in land was used by paasch et al. [26] to describe the newly developed Legal Cadastral Domain Model to develop the LADM further. The result of the paper was a proposal on how the legal part of the LADM ('administrative package', interest in land) can be expanded to some few conceptual classes in the existing standard seems possible. According to the authors, more researches are still needed by investing more jurisdictions but the extended legal profile presented in the paper is seen as the first step towards detailed classification of rights, restrictions and responsibilities.

Mader et al. [27] linked land records in Croatia to the land administration domain model LADM. The goals of that research paper aimed at providing the conditions towards official records in the Republic of Croatia and their adjustment to the electronic data processing. The analysis carried out by the authors confirmed redundancy of data in the official records although some level of compliance with LADM was established. Therefore, the research is a prerequisite for the improvement of national system registers. Taking into consideration the LADM concept, part of this serves as a contribution in the development of the country profile for the Republic of Croatia. The authors recommended that a further development should follow the example of LADM that has shown how to handle LA data in the best possible manner.

Oosterom et al. [28] analysed Surveying and Spatial representation sub-packages of the LADM. The relevant parts to other ISO were examined in order to understand the modelling of surveying and the associates to the spatial units fully. A 2D terrestrial survey was used to illustrate the capabilities of LADM. The authors suggested that additional example case for alternative spatial data source should also be investigated.

A number of countries have considered the adoption and application of LADM to their local needs in land administration. In Europe, LADM was applied in the Infrastructure for Spatial Information (ISI) in order to prove the compatibility with INSPIRE. Also, further investigations were examined to the integration of LADM with European Land Parcel Identification System (ELPIS). Other notable works on LADM by other researchers from 2012 and 2014 were included [26, 29-36].

3.0 EXPECTED RESULTS AND DISCUSSION

The conceptual workflow will follow the mathematical model of 4D spaces and time modelling. In figure 5 below, one 2D model is seen as x and y in the first iteration (2D x, y) and two alternative 3D models in the second iteration (2D+time, 3D x, y, z), these models lead to the final 4D model which is produced from the lower model (2D and 3D). The approach and the fundamental knowledge gained from Oosterom and Stoter [37] are on how

best the modelling can be done and the integration of the lower dimension will be discussed in our next study.

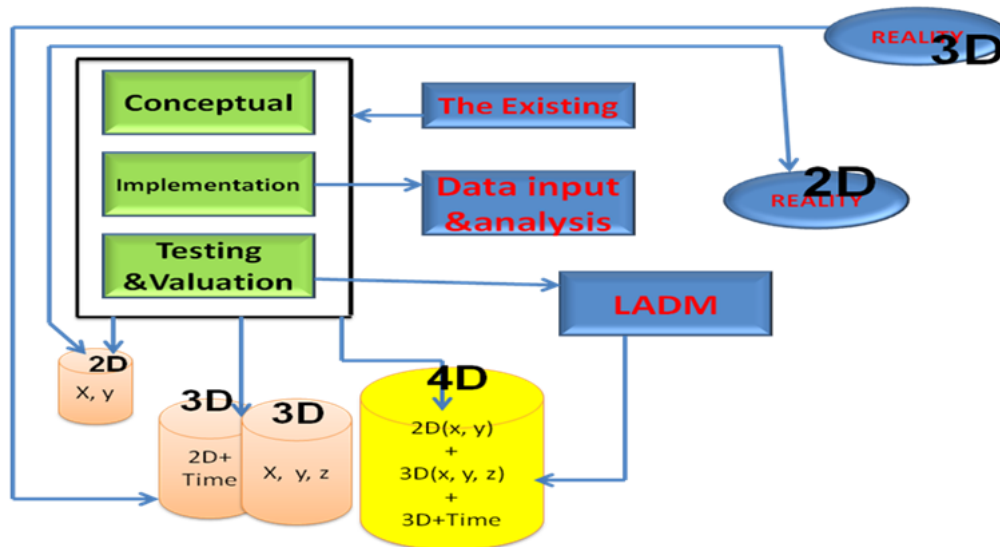


Figure 5: Workflow of Research Methodology developed from [37].

Land Administration Domain Model (LADM), being a new conceptual model that was published in 2012 is developing, and its effective use is becoming known all over the world. At the same time, the knowledge of people in LADM to land administration is spreading especially in the European countries. These may be a major reason why the awareness keeps increasing in the recent time among the researchers and academia. However, one can say that the knowledge of LADM has improved LA in the European, American and Asian countries. The tentacles are spreading right from the Netherland to Portugal, Germany to Turkey, South Korea, Ireland, Sweden and India, down to Malaysia and gradually to Africa and beyond. Critical review of the earlier work done on LADM revealed that the initial work was mostly on the testing and conformance of LADM with few of LADM applications. However, this has been the foundation upon which other works and researches were built.

The complexity and flexibility of modern land use require that land administration system gets additional and improved capacity to manage 3D (third dimension). The world is a dynamic one; the need in relation to the representation of the temporal dimension cannot be overemphasized; either integrated with the spatial dimension or as separate attribute(s) [8], [13], [14], [17] and [38]. Many researchers agreed that the 4D integrated space and time paradigm, as a partition of space and time without gaps and overlaps (in space and time) is generic and solid basis. Meanwhile, Lemmen et al. [10], believed this may be difficult initially but may be totally achieved by the year 2020. However, Döner et al. [14] proposed three solutions for 4D cadastre-with the case study on the utility as follows:

“Creating a link between the parcel and the documents containing 3D information as an attribute when legal space is established for the utility network; Copying 3D geometric description of the utilities into the cadastre (i.e. the description of the physical objects), which can be used to create the legal object; Creating 3D legal space and referring from the cadastre

system to the corresponding 3D descriptions in external registrations of representations of the physical utility networks”.

The proposals are useful in the case of underground infrastructure, gas network, electricity cables, underground water pipes, as well as space over land such as rail tracks etc. LADM in its conformance covers a vast area of applications with its external classes also but in this situation, time (temporal) the fourth dimension is an important element (dimension) that determines the dynamism of LA and as the component of the 4D (SPACE, x, y, z + TIME, t) has been a topic of research for decades, one should remember that land is a limited resource, fixed and non-expendable; the demand increases every time which reflected constant in land trading. Therefore, since LAS is meant to register people's interests in (RRR) lands, and the information regarding it must be known to the society in which the land occupies. Then, there is need for addition of time dimension (temporal dimension) to take care of the lands complexities arising as a result of high demand on land use. Registration itself takes time from the moment of the transaction through the data acquisition till the data is kept in the database, and the land documents are ready for collection. Temporal dimension 3D+time (4D) is important in LAS [19]. The interests in land have an element in time, the fourth dimension (temporal aspects) of the interests in real estate, is an important aspect of land administration and cadastral registration. A record of history may be required on a property, when information on the land uses development to support future land policy, when a history of the database content is needed, when the ownership is passed to other people, or in a real world time aspect and system time aspect, it is clear that time has always played an important role in land administration system.

The first groups of beneficiaries of the outcome of this study are the geo information data providers; Land Surveyor, Civil Engineers, Geo Planners, Geologist and Geomatics Engineers, to mention few. The advantages with respect to efficiency and consistency of data obtained since they are responsible for providing as well as storing large amounts of geo information data. The problem of under and over estimation for projects will be well managed since this will provide rough idea of the time needed to be spent on any project. Another group of beneficiaries are the individual, formal and informal land owner, land vendors and the government. As it was mentioned earlier in this study, people relationship in land are dynamic, people go and come, ownership changes over time but land remain fixed and unmovable. Government needs to use the land for developmental purposes, as well as to collect taxes on the already occupied land. All these are function of time which is important in the history tracking of records. Perhaps, the group of stakeholder that will benefit mostly is the land vendors because they are the end users of geo information data, if any problem will arise in land transactions, it is the size. However, the long term benefits of this research are that geo information technologies are important in the development of modern technology in land administration.

4.0 CONCLUSION

A more detailed research approach of the temporal and spatial aspect of LADM must be investigated in order to see more improvement on what is been obtained from other researchers. Having appreciated all the initial works done by other researchers, their works have been the basis for this research work. The review of the available literatures, on the earlier researches from 2006 till date, shows that much work has not been done on temporal dimension of LADM. However, developing a model for the time dimension of LADM will be

of immense advantage to land administrators, the governments and land users all over the world. Subsequently, to achieve a useful research outcome for temporal LADM, the principle and a design development process for International Standard of ISO 19152 Geographic Information (temporal schema) will be adopted as a methodology for the temporal LADM.

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