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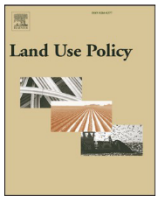

Developing an adapted land administration domain model profile for Kenya

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ABSTRACT

Land is an important resource globally and its administration and management are crucial in meeting the Sustainable Development Goals (SDGs) for example goal 15 and targets 1.4, 2.3, and 5.a. Most land information, more so in the developing countries, are paper based and manually managed. Several countries are working on digital migration for land processes and administration. This is done by first developing a data model for both land parcel and attribute information. International Standards Organization (ISO) Land Administration Domain Model (LADM) was developed in 2012 as a universally accepted model for managing land information. Since then, several countries have developed their country profiles, while others are in the process of developing their regional or country profiles based on their unique requirements. In Kenya, work on a country profile is underway.

Several factors need to be considered while developing or extending a LADM country profile. These include a defined scope and stakeholder involvement. Sound methodology is required to deliver a country model. Reviewing the existing legal framework and processes is key. Consequently, the needs of the users and reviewing the earlier proposed models is important. This research, has in addition, interviewed stakeholders and experts on land administration in Kenya and validated these through Focus Group Discussions.

To meet requirements related to gender rights and recordation, community land rights, pastoralists seasonal occupation of land and informal occupation required special attention in the process of developing the model for Kenya. The required attributes, Rights, Restrictions and Responsibilities (RRR) and relationship between the classes were also identified.

This paper provides a comprehensive set of requirements for developing an extended country profile for Kenya based on the ISO LADM.

1. Introduction

Land is a very important resource globally more so with its role in attaining the Sustainable Development Goals (SDGs) (United Nations, 2015). It is a source of livelihood for most people since the agrarian revolution to industrial revolution (Williamson, 1997). This is still evident now, in the modern society that is impacted by Information and Communication Technologies (ICT). Digital land information management is a concept that most countries are struggling with around the world, particularly, the developing nations, are critically affected since most of the land records were inherited from their colonial masters and they continued to use these legacy systems, while other countries have adopted other ways of managing the records over time (Land Equity International, 2020). Some countries are using a mix of both the old and new practices, that is, paper-based approach combined with digital approaches, respectively. In Africa, however, many countries are still stuck in the old traditional systems where majority of Land Administration operations are in paper format and the processes are manual based. While these traditional systems were well suited for the simple agrarian societies, the sophisticated economies of the 21st century need the services of modern Land Administration to effectively deliver the objectives of sustainable development (Wayumba and Milewa, 2015).

People relate to land differently and land tenure systems in each country are different too (Zevenbergen, 2002). Modernization of the land administration system to be developed for each country requires its own strategy. It should be recognized that every country requires a

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range of different Land Administration strategies depending on how the people relate to land (Williamson, 2000). As emphasized by Lemmen and van Oosterom (2010), until today most countries (or states or provinces) have developed their own different and unique cadastral systems. Some operates deeds registration, while others title registration (Zevenbergen, 2004), some systems are centralized, and others decentralized. Some systems are based on a general boundaries approach, others on fixed boundaries. Some cadasters have a fiscal background, others a legal one (Zevenbergen, 2002). Mburu (2017), recommends the decentralized system other than centralized one for Land registration in Kenya because it "facilitates more dealings in land and registration of inheritances in land since the public is able to easily access those services" and concludes that "it is only a matter of time before all land registration services are decentralized to the county and sub-county levels" (Mburu, 2017).

Different countries and regions have different land tenure systems. For example, in Kenya, there were five tenure systems: the Public, Private, Customary, the Informal and the Ten-Mile Coastal Strip (Wayumba, 2013), which were later classified as public, community or private in the Constitution of Kenya (Government of Kenya, 2010). According to Kenya's Land Act of 2012, the right to land and tenure security should apply to all, irrespective of the tenure system, gender and whether formal or informal. There should not be any discrimination in ownership of, and access to land under all tenure systems (Goverment of Kenya, 2012). However, in practice this may not be true, more so with regards to women, pastoralists, and holders of informal ownership of land (Mburu, 2017).

There have been several efforts to address land issues in Kenya, for example, revising the existing Acts and creating new ones such as the Kenya Community Land Act in 2016; all driven by the spirit of equal land rights to all as engraved in the Constitution. The Kenya National Land Policy (NLP) highlighted several land related issues that deserve special attention (Government of Kenya, 2009). These include historical injustices, pastoral land issues, coastal region land issues, land rights of the minorities and marginalized, land rights of women, land rights in informal settlements, and land rights of children (Mburu, 2017). All of which need to be addressed using the appropriate policies, tools and practices. Despite policy and legislative movements, approaches for practical recording remain unclear: As much as studies on both the spatial and temporal elements that describe the real world situation of pastoral rights were done (Lengoiboni et al., 2010), knowledge on how to record pastoralist tenures in a manner that ensures sustainable ecosystem conservation is almost non-existent (Wayumba, 2015). There could be many reasons to explain this, for example, the conventional land administration tools are not well equipped to capture the pastoralist tenures (Wayumba, 2015) and (Lengoiboni et al., 2010).

The registration system in Kenya is comprehensive, however most factors affecting land and the market, except indigenous land rights and the informal tenure systems that are not recognized in the registration laws. Matrimonial rights and trusts including customary trust are also recognized under the Act though not always indicated on title (Mburu, 2017). To achieve these goals for women access to and rights on land and to act according to the global policies on the same, land ownership and land use records need to include both genders (FIG, 2001), (Haldrup, 2002), (Food and Agriculture Organization, 2002), (Food and Agriculture Organization, 2012), (Food and Agriculture Organization, 2013), (FIG/Worldbank, 2014), and (Lemmen et al., 2019). It is also important to improve land administration systems and streamline the procedures in land transactions and establish appropriate land tenure to provide security of tenure for all (Mburu, 2017).

Globally, there have been several attempts to model cadaster and land registry over time and a great success was achieved when Land Administration Domain Model (LADM) was adopted as an ISO standard (ISO 19152:2012, 2012). This presented how a Basic Administrative Unit (LA_BAUnit) comprising of zero or more spatial units (LA_SpatialUnit) against which unique and homogenous Rights, Restrictions, and Responsibilities are associated with the whole entity in the Land Administration system. As much as the LADM does not include an attribute in the LA_Party class related to gender (Lemmen et al., 2019), it is important to include it in a (country) profile model, based on the Social Tenure Domain Model (STDM) which is a specialization of the LADM: Integration of STDM and LADM in this profile is under investigation. This means that one attribute of sex can be added to manage data that can be used for inclusion of gender related Unified Modeling Language (UML) methods or generation of statistics, etc. UML models can be modeled gender friendly or can be modeled in support of discrimination: i.e., unequal shares in inheritance processes. Shares can be equal for men and women or not - this depends on context: culture and customs (Lemmen et al., 2019).

Furthermore, a similar concept could be used to model the informal and pastoralists rights over land. Lengoiboni, et al. (2019) concluded that there is need for the cadastral model to expand to accommodate the pastoralists seasonal land rights. Investigations on going on the use of the LA_RRR attribute of *timeSpec* to address the temporal occupation of land (ISO 19152:2012, 2012). The LADM can be used to model both formal and informal systems of land rights. Informal systems of land rights fit in the STDM, which is a specialization of the LADM focusing on all people-land relationships (Kuria et al., 2016). However, the STDM functions need to be included into the LADM.

This paper is part of the wider research whose goal is to develop an extended Land Administration Domain Model (LADM) profile for Kenya. This will incorporate customary tenure, informal, temporary and women rights on land aimed to ensure interoperable and complete Land Administration process for the whole country, based on the available legal framework, regulations and processes. For this paper, the following questions are addressed: i) How to customize the ISO LADM profile for Kenya? ii) What are the missing but required classes or existing but not required classes on the existing ISO LADM model for Kenya? and, iii) how can the missing but required classes be modeled using the LADM? The next step of this work shall be to use the information from this research to design an adapted LADM profile for Kenya.

2. Developing the Kenyan country profile

LADM as is, cannot be complete for a particular country, Kenya included; local adaptions and extensions are possible and required. The model is expandable, and it is likely that additional attributes, operators, associations, and perhaps new classes, are needed for a specific country (Lemmen, 2012). Several country profiles have been developed globally since the LADM standard was published in 2012. Some were included in the Annex D of the standard, while others have been developed there after as listed in Tables 1 and 2 of (Kalogianni et al., 2019) and (Kalogianni et al., 2021).

To develop a comprehensive Kenyan country profile, a requirements analysis is needed just as was done to adapt the LADM to Ghana's context (Okyere et al., 2021). This is due to similarity of methodology used in their study and resembling land practices of both Ghana and Kenya. This could be done using a mix of different methods: interviews, questionnaires, documents review such as legal frameworks and regulations, group discussions, and workshops among others (Kalogianni et al., 2021). For Ghana, the study used semi-structured interviews and document analysis to draw data requirements from nine areas in Ghana with diverse customary land tenure reflected in their respective customary land registration systems (Augustinus et al., 2006), (Lemmen et al., 2007), (Paasch et al., 2015), and (Okyere et al., 2021).

2.1. Considerations for developing a profile for Kenya

All the LADM country profiles developed so far have not used a standard nor common methodology on factors for considerations (Kalogianni et al., 2019). When developing a Country profile for Ghana, Okyere et al. advised that it is important to start with overarching

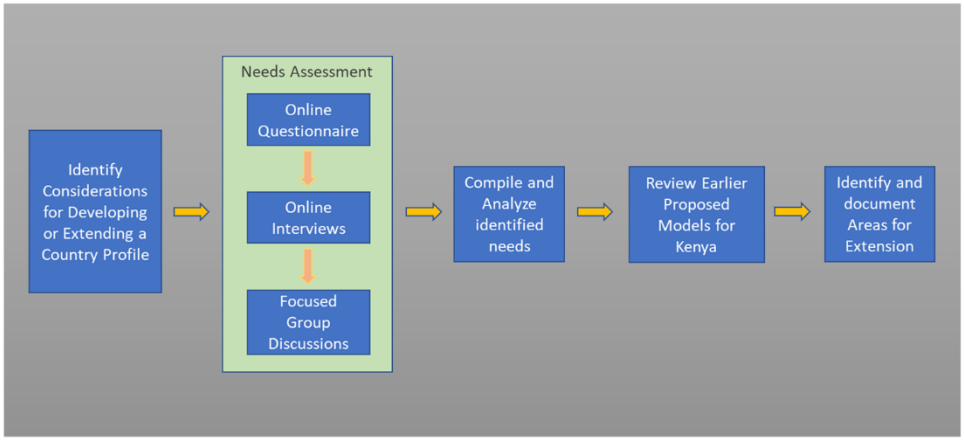

Fig. 1. Methodological Process followed in this paper.

requirements linked to the Constitution and then move to needs for the title registration system and different customary and informal registries (Okyere et al., 2021). While other countries approached it differently with considerations of their own factors based on priorities.

Kalogianni, et al. during the 8th International FIG workshop on the Land Administration Domain Model, presented the following as methodology and key factors to consider, which are necessary during the development of a country profile (Kalogianni et al., 2019) and (Kalogianni et al., 2021):

1. Determining who has to be involved, noting that it is important to involve as many. It should be emphasized that having governmental and/or land administration bodies involved to provide a better insight of current situation and a more "official/formal" status of the profile, is critical.
2. The analysis of the requirements defined in the national legislative framework and other relevant regulations is essential. This is because Rights, Restrictions and Responsibilities (RRRs) in the LADM profile are derived from the legislative framework of each jurisdiction such as counties in Kenya.
3. Have a defined scope of the country profile.
4. Begin the modeling process by mapping the key concepts of the existing model(s) with LADM classes before introducing new ones.
5. Use an UML conceptual model to capture concepts in the land information system.
6. Test the conformity of the UML model of the country profile developed with ISO 19152 according to the criteria presented in the

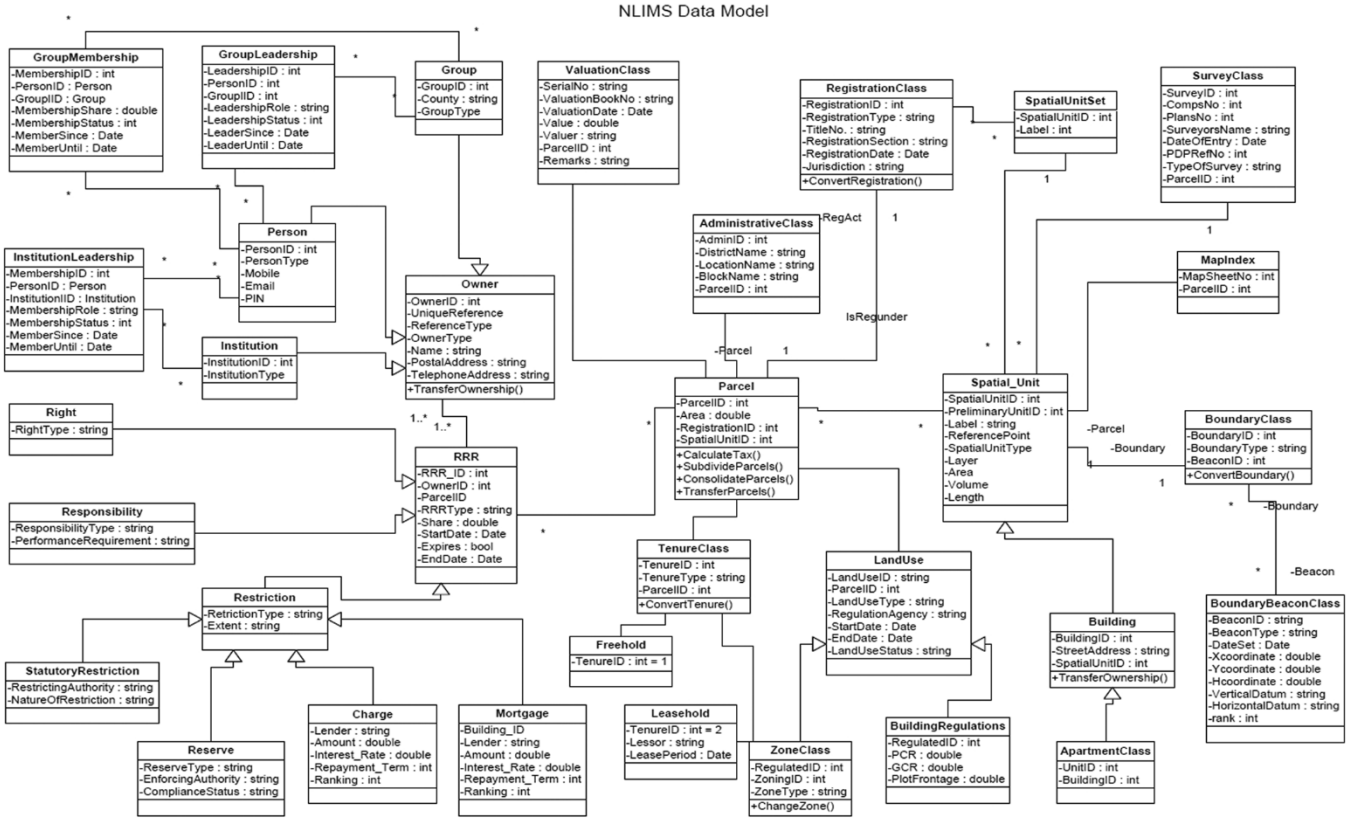

Fig. 2. The Africanized LADM for Kenya.
Source: (Kuria et al., 2016).

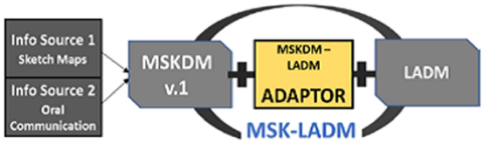

Fig. 3. Conceptual integration of MSKDM with LADM.
Source: (Karamesouti et al., 2014).

conformance test in Annex A of ISO 19152:2012. It is recommended that instance level diagrams using real-world use cases should be created to test the proposed model.
7. Organize stakeholder participation with stakeholders during various phases of the development process, to exchange opinions and agree on the final version of the model.
8. If there is a doubt of using the existing code lists, as proposed in the LADM, introduce new ones that better describe the situation and the needs of the jurisdiction, or extend the existing ones with new values when introducing new concepts.

2.2. Extending the LADM

As much as ISO LADM is widely used across the globe, it needs further development to better refine and cover land administration functions in totality (Lemmen et al., 2021). LADM improvements and extensions are therefore needed (Lemmen et al., 2019) to provide better tools for tenure security and better coverage of land administration (Lemmen et al., 2021) both for land and marine environment.

As an ISO standard, the LADM is subject to periodic revision, typically in a 6–10-year cycle.

aiming to improve the standard (Kalogianni et al., 2021). This process is already on going with several thematic areas of extensions being considered. Some of the existing parts of the current version of the LADM are being refined. The goal is that these refinements will add more semantics to the LADM (Lemmen et al., 2019). Extended functionality for 3D land administration will be developed (below, on and above the surface of the Earth). (Lemmen et al., 2021). Spatial planning/zoning with legal implications is also a further extension of the LADM functionality (Lemmen et al., 2019). The four main areas for the extension of the LADM being worked on within the Technical Committee 211 on geographic information of the ISO are:

1. Extended scope of conceptual model. This includes valuation, Performance Index, linking physical objects, indoor models, support to marine spaces, spatial planning/zoning with legal implications, other legal spaces: mining, archeology, utilities;
2. Improvement of the current conceptual model. This includes formal semantics/ontology for the LADM code lists; more explicit 3D+time profiles; an extended and refined survey model and legal model;
3. Encodings/technical models. This includes further integration with BIM/IFC, GML, CityGML, LandXML, LandInfra, IndoorGML, RDF/linked data, GeoJSON, and:
4. Process models for survey procedures, map updating, transactions (Lemmen et al., 2021).

3. Methodology

The goal of this research is to adapt the ISO 19152:2012: Geographic Information – Land Administration Domain Model (LADM) standard to fit into the context of Land Administration in Kenya. The figure below represents the methodological process used in this paper. This has a lot of similarities to the research methodology followed in the Methodology for the development of LADM country profiles paper (Kalogianni et al., 2021) because it is simple and comprehensive, and therefore used as a reference. fig1,2,3,

For this research the following research activities were undertaken and presented in Section 4, Results and Discussions:

1. Considerations for developing a country profile of the LADM and its extension, were identified through literature review.
2. User needs assessments was carried out and views of stakeholders in Land sector were gathered. This included, but not limited to, the Ministry of Lands and Physical Planning (MoLPP), National Land Commission (NLC), three county governments, surveyors and a representative number of the public and academia among other players. Two separate surveys were conducted via SurveyMonkey tool to determine 1), the current state of land administration in Kenya, 2) areas where Kenyan profile of the LADM should focus on, and 3) other areas necessary for extension to the model. Also, Online interviews, and Focus Group Discussions (FGD) were employed to facilitate this.
3. The needs were compiled and analyzed to 1) identify the missing but required classes and attributes, and 2) the available but not required classes and attributes.
4. Review of the earlier proposed Kenyan Profile of the LADM was done to form a starting point for modeling such as the spatial and temporal attributes of pastoralists in northern Kenya model by (Lengoiboni et al., 2010), the Africanized LADM for Kenya developed by (Kuria et al., 2016), and the Maasai of Southern Kenya Domain Model of Land Use developed by (Karamesouti et al., 2014). The review was based on the requirements in both the Constitution and Land Act of Kenya, and the existing land Administration processes for Kenya.
5. Documented how the identified areas of extensions to the Kenyan Profile could be modeled.

4. Results and discussions

This section presents the results of this work. First, it presents the state and outcome of land administration in Kenya, presenting the results of the surveys and the validation via the Focus Group Discussion by the Land Administration experts. Second, the four (4) identified areas for the extension of the model are introduced and discussed. And third, review the existing proposed profiles for Kenya.

4.1. State of land administration in Kenya

Kenya's land administration is neither complete nor electronic. There have been several attempts by the government to streamline land management and its processes in Kenya since independence in 1963 (Wayumba, 2015). Currently, there is no blueprint (model) that exists as guide in creation of the land information management system(s) envisaged in the land policy and in the new land legislations (Siriba and Mwenda, 2013). Some proposals have been made to adapt the ISO LADM for the country. This is because the standard is suitable for the land administration system in Kenya and can be adopted by mapping some concepts of the Kenyan system into the LADM (Siriba and Mwenda, 2013). Although there are some areas that it is felt not to be fully supported by the ISO standard, for example, area of Maasai of Southern Kenya, where the existing domain models cannot be directly employed to capture and express real concepts of land use such as a *boma* (a place where people live), social agreements, and land (Karamesouti et al., 2014), the majority of land practitioners feels that they can still be modeled as demonstrated in the spatial-temporal study in the Northern Kenya study (Lengoiboni et al., 2010).

4.1.1. Land administration professionals

This section presents the results from the information gathered from the filled surveys from Land Administration Professionals. This is a group of users who may have little to no knowledge of data modeling or data management but work in one way or the other in the land administration offices such as the land registries.

According to this group, all the land related data are stored in both

paper and electronic formats like Microsoft Excel worksheets. They were not sure whether there exists a standard model in use, therefore, they proposed to have one. The following are some of the attributes that they listed as kept in the model: ownership, acreage, National ID, Plot number, and location. Regarding who could be interested in land data, they listed the following are the key stakeholders: MoLPP, landowners, NLC, County departments of land and municipalities, land officers, GIS and database experts.

About whom and how the land information is kept, they listed the following as information kept by the land registries across the country: Land titles, ownership details, plot sizes, transfer history, location, parcel characteristics and maps. The following information is kept by the cadastral division, that is at the Survey of Kenya (SoK) headquarters and other regional and county offices: survey maps, registry index maps (RIM), and Preliminary Index Diagrams (PIDs). They also listed the following as common information kept by both the registries and the survey departments: Maps, location, land sizes, land reference number, owners' details, file number, payment details and allocating authority.

On the linkage and or integration to other systems and databases, the respondents indicated that there is currently no linkage or integration to other government databases such as registrar of persons and deaths. They also strongly recommended the need to link all survey or land ownership databases to the registrar of persons and deaths, and the Kenya Revenue Authority (KRA) database via the Personal Identification Number (PIN) for harmonization and use in transactions.

The respondents indicated the necessity for Gender attributes to be recorded. This is because of legal requirements in the Constitution of Kenya 2010 (Government of Kenya, 2010), gender empowerment and equity, land right and access to all – more so in meeting the Sustainable Development Goal SDGs number 5 of Gender equity, Target 5.a and indicator 5.a.1 (United Nations, 2015). Gender identity, age, marital status are the attributes proposed to be recorded. They also recommended Polygamy to be recognized in land rights since it is a form of marriage recognized in Kenya (Government of Kenya, 2014).

The respondents were not aware whether attributes of community land are recorded in the registry currently. They however, suggested a review of the Kenya's Community Land Act 2016, about the administration of the community land, (Government of Kenya, 2016) to identify the required attributes for recordation: which was done as part of this research and presented in Section 4.3.2.

There was a divided opinion on recognizing informal occupation of land and recordation. Those for their recordation indicated the following reasons: to enable formalization, or to help identify interests on land because of the entitlement of land through occupation provided for in the Kenya's Land Act 2012 (Government of Kenya, 2012). They listed the following attributes to be recorded: Parcel size, Parcel number, registered owner(s), name(s) of informal occupant(s), location, interests claimed, any developments, and disputes on the land if any. Those against this indicated that it might promote land grabbing and disenfranchising rightful owners of land leading to tenure insecurity.

Finally, the respondents suggested that the temporary occupation of land by pastoralists to be recorded to help mark the corridors and ensure regularization of usage purposes. They also indicate the following attributes to be recorded: Flexible time of the year/season occupied, land details and the community involved.

4.1.2. *Land administration experts*

This section presents the responses from the Land Administration Experts. These are individuals who have both practical and technical experience in land administration workflows, processes, and data modeling. All questions for them were open ended to allow for many explanations of their answers.

According to these experts, the status of land administration in Kenya in reference to cadastral modeling is still manual and archaic with very limited cadastral modeling. It is based on person-right-parcel relationship. They also noted that some preliminary modeling efforts exists although not formally packaged.

They noted the following as some of the challenges of adopting the ISO LADM in Kenya: lack of buy-in and support from the management of the current organization, lack of awareness and understanding on its implementation, lack of technical expertize of its contextualization, and slow adoption of technology and reluctance to change. They however, indicated a need for a customization of the model to the Kenyan situation by way of developing a country Profile.

Some respondents indicated that there have been attempts to have a LADM country profile for Kenya through NLC and piloted in Nyeri County (Kuria et al., 2016). There are also some ongoing works by the Kenya Bureau of Standards Technical Committee 168 mirroring ISO TC 211 on adapting the ISO LADM standard. The draft standard is underway and shall be informed by this study too. Some other respondents were not aware of any existing efforts.

They also pointed out the following as some of the challenges faced in developing a Kenyan profile for the LADM: Competing institutional interest, Bringing the different actors together to get-a buy-in for each actor in attempting to develop a Land Information Management System (LIMS) on their own, and that while there may be few technical challenges, there are significant institutional challenges in getting all stakeholders to agree on the Profile characteristics.

All the respondents agreed that the ISO LADM is not a complete representative of Kenyan profile. They were, however, not able to point out the missing but important classes and attributes. Some respondents needed to read the standard for understanding what it provides and to understand the modeling requirements of the Kenyan context and assess whether ISO LADM fits these requirements or not. Although, some pointed out the cultural aspects are not addressed in the standard.

The respondents indicated that it is necessary to model the gender related issues in the LADM. On how to go about modeling the same, some suggested that the current laws have factored in gender mainstreaming in land administration - the LADM should refer to the land laws, some say that they could be represented as parcel attributes, e.g. parcel inheritance open only to men etc., and while others say that they can be captured in the LA_Party class then gender-based attribution can be included in other classes for cross-referencing of data such as land related conflict, basic socio-economic information etc. Care should be taken that this is not used for discrimination purposes.

Regarding the modeling of the community land in the LADM, some said that it is possible and perhaps appropriate to look at similar efforts that have modeled the same using STDM, such as the Kwa Bulo slums in Mombasa county in Kenya, Bufumnbo and Mission cells in Namakwekwe Ward in Uganda and Chamuka chiefdom in Chisamba District in Zambia (Antonio et al., 2021), which is considered a special case of LADM. Some advised that the issue of how to better maintain an accurate register of community membership could be given a bit more thought, and others pointed out that cultural aspects of the communities to be incorporated in the model. They all agreed that it can be incorporated in the proposed Kenya profile while following the provisions of the Community Land Act (Government of Kenya, 2016).

On the rights, restrictions, and responsibilities (RRR) that the pastoralists could have on land, more so in their temporal occupation of land, the following were suggested, 1) right for grazing, access to water, and to manage their flock, 2) reference to the Community Land Act for some of the rights, and other provisions, and 3) for rights for temporal occupation largely grazing and water rights, while restrictions could include prohibition of overgrazing and responsibilities could include rotational use in order to allow the resources to regenerate. They also noted that this will require more detailed analysis to better understand the actual tenure types in these areas of concern.

With regard to informal occupation of land, they suggested that some cases of the STDM to be considered, use a continuum approach (United Nations Human Settlements Programme (UN-HABITAT), 2008), (Lemmen et al., 2015), and (Du Plessis et al., 2016), distinguish the informal use and the formal ones and that the legitimate rights along the

continuum can be incorporated as enumerations in RRR tenure type attribute.

The following are some of the other issues and factors to be considered in developing a LADM country profile for Kenya: Organizational structure, current land administration processes, rationale, stakeholder involvement, legal and regulatory framework (current and drafts), and existing laws and regulations. They also mentioned that some pending issues in Kenyan land administration (such as the minimum and maximum land sizes, restitution of historical injustices, etc.) should be accommodated in the model.

4.1.3. Focus group discussion

Focus Group Discussion by the experts was organized to validate the results from the surveys done. Eleven (11) representatives mainly from the universities and the Ministry of Land and Physical Planning (MoLPP) and others from various organizations both local in Kenya and international such as Cadasta Foundation, participated. Apart from consenting that the surveys' results represented an actual picture of the land administration status and need for the Kenyan profile while pointing out factors to be considered, they also pointed out the following:

1. Community Land Act 2016 provided for registration of the community lands but very few have done so due to political and historical issues on land.
2. Community lands consist out of 70% of the total land area in Kenya and need more attention where conflicts between communities exists with regards to ownership.
3. Specification of both maximum and minimum land size to be registered is required and should be legislated
4. There is no recognized tenure system for the seasonal rights to land, though they need to be mapped and well managed
5. There exists adequate legal framework for land both existing and drafts laws/acts
6. As much as there is currently no linkage/integration of land information to other government systems, there is need to do so to the registrar or births, deaths, and persons. This should be extended to the judiciary, Tax authorities (KRA), registrar of companies and land buying companies.
7. Reference to be made to the matrimonial laws to identify the rights they provide the marriage partners for properties, land included.

4.1.4. Summary

The Reponses from the two surveys and the experts' Focus Group Discussion indicated the need for a Kenyan profile for LADM. It also pointed out that there are Kenyan land laws that could help to develop this profile. On the other hand, there is a need to extend the model more so to clearly outline the gender attributes and issues, recording community lands, to pastoralists temporary occupation of land and to informal occupation of land; all necessary for the security of tenue and conflict prevention.

4.2. Existing profiles for Kenya

In their paper "*Towards Kenya's Profile of the Land Administration Domain Model (LADM)*" in 2013, Siriba & Mwenda presented how a Kenyan Profile for the LADM could be done. They review the ISO LADM and noted that a first draft of the profile can be delineated from the standard based on their paper. This is because they believed their work set the stage and the foundation for defining the Kenyan profile of the standard to guide the on-going restructuring efforts in land administration in Kenya and other countries with similar circumstances (Siriba and Mwenda, 2013).

A Land information system never operates in isolation (Siriba and Mwenda, 2013) and emphasis of the necessity for integration, more so, with the relevant external databases include issues such as: Registry of persons database, address database, taxation database, land-use database, property valuation database, utility networks database and the registration of sources database (Siriba and Mwenda, 2013).

The first attempt to model the Land Administration is Kenya was done by Lengoiboni et. al., in (2010). Published in a study that sought to study the pastoral spatial and temporal land use in Northern Kenya. The attributes identified were model using UML diagrams to fit in to the LADM to demonstrate how the spatiotemporal land rights could be accommodated in the LADM (Lengoiboni et al., 2010). The findings were presented as part of figure C.36 of the ISO LADM (ISO 2:, 1915, 2012, 2012) and have been borrowed more in this paper as described in Section 4.3.3.

In 2016, Kuria, et al. designed a second model which adapted the ISO LADM to capture the Kenyan context and was informed by the current land administration practice and prevailing regulations. (Kuria et al., 2016). This model represented much of the Kenyan land administration classes, attributes, and workflows. It was piloted in Nyeri County by developing a web application for land transactions. Data was collected and management within it while testing the usability of the model and land information system developed. The resultant model, which was subsequently referred to as the "Africanized LADM" (A-LADM) (Kuria et al., 2016) is presented in the figure below.

The following are some of the areas that the A-LADM should be improved to address:

1. Integration with other government databases
2. Unique requirements of community land were not identified other than generalization under a *Group* class.
3. Although the informal occupation of land could be addressed by STDM, the model did not provide for how that could be achieved or integrated with LADM.
4. Equal rights to land and property as outlines in the Kenya's Land Act was not provided for how to record in both the *Owner* and *RRR* classes.
5. The code list for the attributes were not provided leaving a lot of uncertainties as to the valid values for the attributes in the classes such as the *OwnerType, PersonType,* and *RightType* among others
6. As much as the *Spatial_Unit* class provided for the Volume attribute, both the *Building* and the *Unit* classes did not provide for the 3D recordation for the same (Governmennt of Kenya, 2020).

The thirds notable attempt to develop a Kenyan Profile of the LADM was by Karamesouti et, at. in 2018. This model focused on modeling the pastoralist land use, specifically, the Maasai of Southern Kenya and was believed to be the first proposal towards development of the LADM within the southern Kenyan Maasai framework (Karamesouti et al., 2014). The model was therefore called the Maasai of Southern Kenya Domain Model of land Use (MSKDM) for it collects and structures Maasai concepts that are pertinent to land use (Karamesouti et al., 2014), as envisioned in the Kenya's Community Land Act (Government of Kenya, 2016).

Because they could not find an existing domain model that could be linked for capturing the domain in a suitable manner, they connected it directly to the LADM, forming the MSK-LADM as shown in the figure below.

As much as they identified and listed 280 classes, not so many details were provided in form of either a table or UML diagram to demonstrate how the classes relate with each other, their attributes, and methods. The model illustrated using scenarios how different conflicts: Climate and Wildlife, and other uses could be addressed using queries dubbed Answer Set Programming (ASP) within the same tenure, it however, did not show how the model integrate with other tenures in Kenya such as private and public/government land.

It is noted that these earlier models contain key aspects of modeling the Kenyan profile. These shall be considered and used as building blocks for developing the new model. Although the areas for improving them have been identified, they shall be considered for improvements.

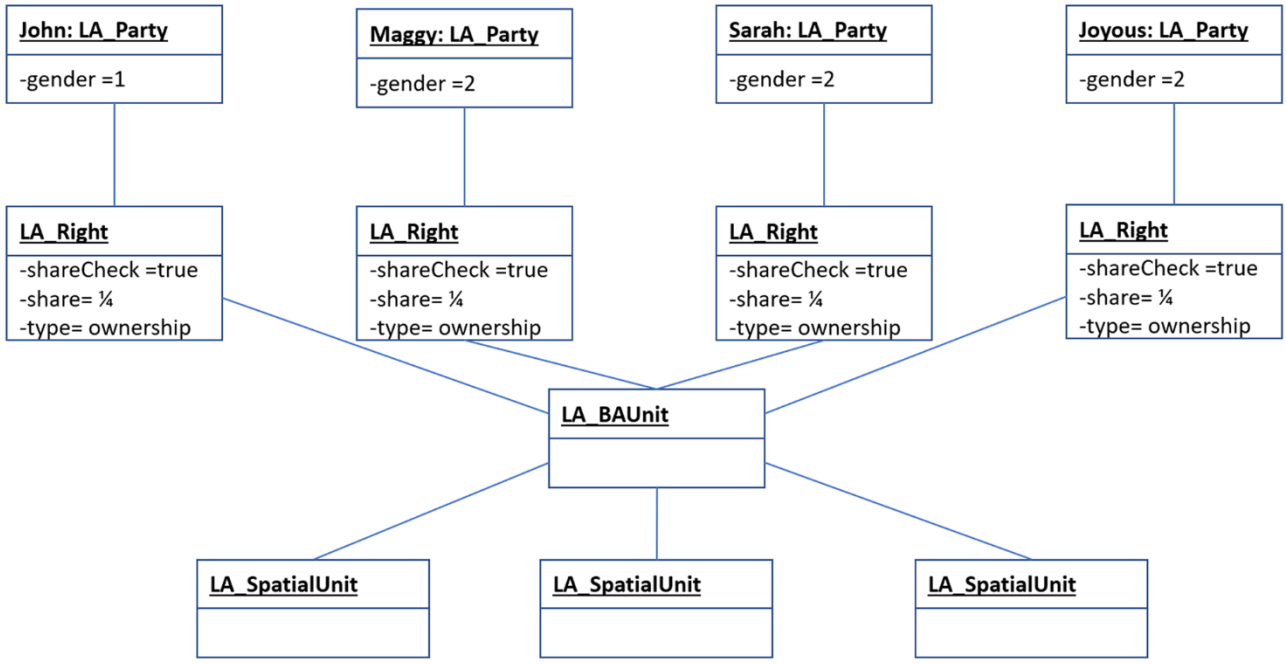

Fig. 4. Polygamous marriage.
Source: Adapted from (Lemmen et al., 2019).

These shall be together with other aspect that we totally not captured in them as mentioned in each of them.

4.3. Extending the LADM for Kenya

The ISO LADM opened the door for development of country profiles and extensions where necessary. Due to the uniqueness of Kenya, there is, therefore, the need to not only develop a Kenyan profile based on the existing standard: classes, attributes, and methods, but also extend on areas that are required but not present in the standard. In addition to the extension of the various parts of the conceptual model of LADM, there are other extensions to the scope that could be incorporated (Lemmen et al., 2019). Gender recordation, Community land, pastoralist temporary occupation of land and informal occupation of land were identified as areas needing extensions for the Kenyan Profile.

4.3.1. Gender recordation and rights

ISO LADM edition 1 provided a more generic way of adjusting the model, in case of a need for additional classes (ISO 19152:2012, 2012). For the LA_Party class, there is need for a further attribute relating to gender. Both male and female need to be recorded on what their RRR are for each parcel. According to their paper focused on providing options for gender-friendly design for data collection, maintenance, and schema design, (Lemmen et al., 2019) proposed a LA_GenderType attribute with different methods to model the RRR for every gender; male, female, and others according to the ISO/IEC 5218 codes. This is in line with the Constitution of Kenya, that firmed that there should not be any discrimination in ownership of, and access to land under all tenure systems (Government of Kenya, 2010).

Kenya, just like most African countries, recognizes polygamous marriages. According to the Kenya's Marriage Act 2014, a marriage celebrated under customary law or Islamic law is presumed to be polygamous or potentially polygamous (Government of Kenya, 2014). For this reason, Lemmen, 's et al. (2019)), instance level diagram for option 2, the case of polygamous marriage between one male and three females is adapted, with no ranking nor order of priority. Apart from the Islamic law that has a fixed maximum number of females to be four, the Kenya's customary law do not provide for any maximum number. In that case, the maximum number shall be the n^{th} *wife*. On the other hand, a Christian, Hindu or civil marriage is monogamous in Kenya (Government of Kenya, 2014). The one-male-one-female could still be modeled within the provisions of the polygamous option as illustrated in Fig. 4 below.

Because parties to a marriage have equal rights and obligations at the time of the marriage, during the marriage and at the dissolution of the marriage (Government of Kenya, 2010). Equal share of rights on land is required for the model. This means that where only one male and one female, ½ share is expected while in one male and many females, a share divided by the number of parties is expected and all shall add up to 1. This shall only not apply where the agreement on the contrary is arrived at, and written witness provided as part of the documentation and for the parties of Islamic marriages that have the rights granted under Islamic law (Government of Kenya, 2014).

4.3.2. Community land and rights

Land is Kenya is classified as public, private or community (Government of Kenya, 2010) with the following forms of tenure; freehold, leasehold, and customary or such forms of partial interest such as easement (Government of Kenya, 2012). It was not until 2016 that a legal structure was provided for community land to recognize and document it through the Community Land Act, 2016 (Government of Kenya, 2016).

Since then, all land belonging to a community is to be registered by the community for administration and management. This is specifically for the outer polygon for the community land, while the inner polygons are handled by the community land management committee. Before that happens, County Governments hold in trust all the unregistered community land on behalf of the community for which it is held (Government of Kenya, 2016). When registered, the community shall elect between seven and fifteen members of the community assembly to constitute the community land management committee whose functions shall be to- a) have responsibility over the running of the day to day functions of the community; b) manage and administer registered community land on behalf of the respective community; (c) coordinate the development of community land use plans in collaboration with the relevant authorities; (d) promote the co-operation and participation

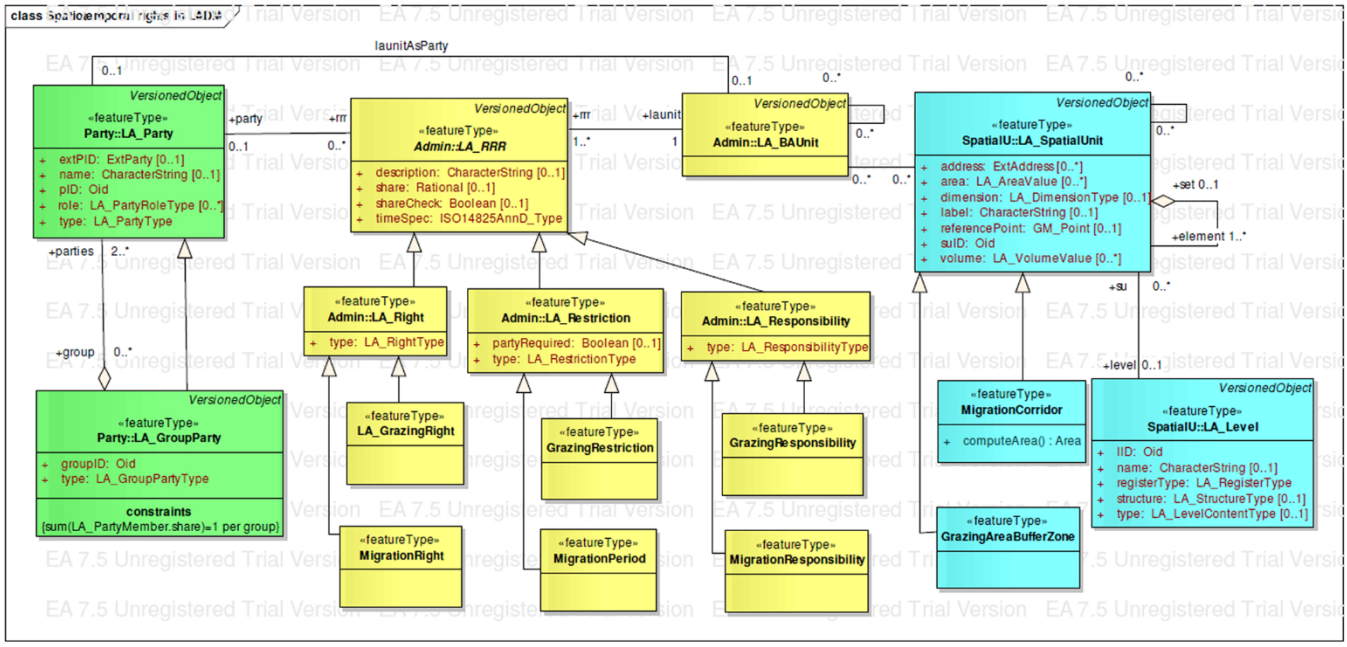

Fig. 5. Recording spatial and temporal elements of pastoralists' land rights in LADM.
Source; (Lengoiboni et al., 2010).

among community members in dealing with matters pertaining to the respective registered community land; and (e) prescribe rules and regulations, to be ratified by the community assembly, to govern the operations of the community (Government of Kenya, 2016).

During the preregistration period of the community land, the land shall be recorded and owned by the government as a *nonNaturalPerson* type of the LA_PartyType attribute, and *StateAdministrator* LA_PartyRoleType attribute. However, once registered, the LA_PartyType will change to *group* with a new list called *Community* as the LA_GroupPartyType attribute and new list called *LandManagementCommittee* as the LA_PartyRoleType attribute.

4.3.3. *Pastoralists rights*

Pastoralists live a nomadic lifestyle where they move from one location to the other in search of pasture and water for their cattle, from season to season. They are also part of the marginalized communities in Kenya (Government of Kenya, 2010). Northern and southern parts of Kenya is occupied by Maasai and Samburu communities among others who are pastoralists.

All these communities relate to land through the customary norms of communal use, and that migrations still occur in dry seasons (Lengoiboni et al., 2010). These are specifically concentrated in two periods: the first period runs roughly from January to March, after which the frequencies of encounters fall off. While the second period runs roughly from July to October, after which the frequencies of encounters again fall off (Lengoiboni et al., 2011). This suggests that seasonal migrations are still perceived as a viable traditional practice to sustain the pastoralist livelihood through drought. During migrations, all pastoralist communities agree to enter on non-pastoralist lands when the resources they require are on those lands (Lengoiboni et al., 2010).

In their pastoralism study in the northern Kenya, Lengoiboni et al. found out that there is strong evidence that regulation, documentation, and protection of pastoralists' dynamic land rights are urgent (Lengoiboni et al., 2015). However, most non-pastoralists are not willing to formalize arrangements allowing pastoralists access to private land in the form of real rights, except for the forest officers, all of whom were in favor of formalizing access arrangements (Lengoiboni et al., 2011). This is because, when pastoralists enter non-pastoralist land their interests may temporarily overlap or conflict with those of the landowner (Lengoiboni et al., 2010). Some of the reasons are that when pastoralists arrive at pastures, the herds spread out to graze. This phenomenon appears as a delta-like feature on some of the migration routes. It is reported that this spreading out could mean that the migration routes extend further into non-pastoral areas (Lengoiboni et al., 2010), resulting to even more conflicts. When this happens, the most common action taken by non-pastoralists when pastoralists violate access agreements is to evict them (Lengoiboni et al., 2011). It is however believed that the seasonal migration and grazing in non-pastoralists areas could be well coordinated and recorded (Lengoiboni et al., 2015) using a data model.

The LADM considers that pastoralists grazing rights in time and space can also be accommodated. However, it does not elaborate how those rights, including their varied spatial and temporal elements can be accommodated (Lengoiboni et al., 2010). It is therefore necessary to have a non-ownership form of tenure to support pastoralists' land rights within the non-pastoralists' areas (Lengoiboni et al., 2015). Currently, not so much of formalization is done during the migration and even on the grazing lands. It is noted that majority of non-pastoralists use verbal agreements to grant pastoralists access to their lands. Only private ranchers use written agreements. However, no access agreements have been made for access by pastoralists to forests (Lengoiboni et al., 2011). It its therefore necessary to records and provide for migration and grazing rights to private, public and community land as well. While private land might be very difficult due to different personalities and land uses, public land has so far not been a challenge, though informally. On the other hand, for community land, it is provided in the Community Land Act, (2012), that customs and practices of pastoral communities relating to land shall be taken into consideration by a registered community as long as they are consistent with the provisions of this Act or other applicable law (Government of Kenya, 2016).

To model this seasonal occupation of land for grazing, does accommodate the registration of individuals or groups in the class LA_Party. This means that if migration corridors or potential grazing areas would be registered to pastoral individuals or groups, the LADM already fulfils this requirement (Lengoiboni et al., 2010). As such, the codelist *group* shall be used for the LA_PartyType, while codelist *family* or *community* to be used for the LA_GroupPartyType and *farmer* codelist used for LA_PartyRoleType.

For the LA_RRR, LADM already provides for *grazing* as a LA_RightType. There is need to add *Migration* as a right, *MigrationPeriod* as a restriction, and *MigrationResponsibility* as a Responsibility (Lengoiboni et al., 2010). On the other hand, *MigrationCorridor* and *GrazingAreaBufferZone* are to be added as subclasses of LA_SpatialUnit to accommodate the migration routes for moving livestock and changing grazing area due to intensity of the dry season (Lengoiboni et al., 2010). Fig. 5 below shows how to record spatial and temporal elements of pastoralist land rights in the LADM.

4.3.4. *Information occupation and rights*

Kenya allows and recognizes the informal occupation of land only for the case of settlement of squatters, the poor and landless, and the internally displaced persons on public land (Government of Kenya, 2012). This could be temporarily and could be converted for permanent ownership either to those public lands they already occupy or on private lands they already occupy or on the absentee landlord's lands through the National Land Commission (NLC).

Apart from the informal occupation of land on private land, it is recommended that the temporary informal occupation, more so those caused by natural calamities and do not require permanent relocation, to be treated as temporary with limited rights, which should be recorded properly. However, for those requiring long term occupation of land, maybe more than six (6) months, a proper recordation is also required. This should be for the individuals, families, clans, or groups and granted the same RRR just like others on private ownership. The only difference will be that they do not have permanent ownership till such time that either they relocate back to their original lands or resettled by NLC according to the provisions in the Land Act.

For this temporary occupation to be recorded, LA_Party and LA_GroupParty attributes shall be used accordingly. The code list *naturalperson_Informal* and *group_Informal* are to be used for the LA_PartyType attribute. While code list *family_informal* and *clan_informal* to be used for the LA_GroupPartyType attribute. *Informal* code list to be used for LA_PartyRoleTpye attribute. Since the occupation here is not permanent but long term, an *allotment_Letter* code list with specific duration of occupation, which can be renewed, could be used for LA_AdministrativeSourceType attribute.

5. Conclusion

Land being a very important resource globally, needs a better way of recording and administering its ownership and utilization. Although different countries are in different stages of managing the land data, some have moved to fully electronic while others are slowly making the move from paper-based system to electronic. The success of an electronic land data management is through a standard data model that completely addresses the unique data types in a particular country or region. Globally, there have been several attempts to develop a standard model for land data. The apex of this was with the development of the Land Administration Domain Model (LADM) by International Standards Organization (ISO) in 2012. Several countries thereafter have been adapting the standard to develop a profile that accurately represent their state of land based on the LADM.

Kenya has been for many years, working on moving their land administration from paper-based system to an electronic one. This paper's objective was to answer questions of how the LADM profile for Kenya was to be developed. A methodology was developed to facilitate that process. This included the considerations of the key factors for developing a country profile and extensions, assessing the needs through online questionnaires, online interviews, and validation via Focus Group discussions, Analyzing the needs identified, review the earlier proposed models, and finally identify and document the areas for extension.

Based on the requirements identified, the classes necessary for adaption for Kenya were identified, leading to four main issues necessary for the extension of the model: Gender recordation and rights, community land rights and recordation, Pastoralists' season occupation of land and informal occupation of land. Also, other minor requirements like the use of the known terms for both the classes and attributes, adding more attributes and removing others, were also identified. These included considerations of the provisions on the enacted land laws in Kenya such as the land Act, Community Land Act, and the Sectional Property Act among others.

A review of the legal framework and guidelines was done together with existing proposed developments of the country profile for Kenya. The requirements identified and areas needed to be included, are now available for further detailed technical modeling with technical UML diagrams. These serves as a solid base for developing an adapted LADM

Table 1
Requirements from the land stakeholders and experts in Kenya.

Land Administration Issues	Attribute Requirements
Attributes Currently Kept	Ownership, acreage, National ID, Plot number, and location
Key Stakeholders Identified	MoLPP, landowners, NLC, County departments of land and municipalities, land officers, GIS and database experts
Attributes Kept by Land Registry offices	Land titles, ownership details, plot sizes, transfer history, location, parcel characteristics and maps
Attributes Kept by Survey/ Cadaster offices	survey maps, registry index maps (RIM), and Preliminary Index Diagrams (PIDs).
Common Attributes Kept by both Registry and Survey/cadaster offices	Maps, location, land sizes, land reference number, owners' details, file number, payment details and allocating authority
Data Linkages/integration required	Registrar of persons, births and deaths, and the Kenya Revenue Authority (KRA) via PIN, Registrar of companies, Judiciary
Gender recordation	Gender identity, age, marital status, land related conflict, basic socio-economic information
Polygamic Marriages	Need to be recognized, attributes: number of wives, percentage of shares on land…
Rights for Informal occupation of land	Parcel size, Parcel number, registered owner (s), name(s) of informal occupant(s), location, interests claimed, any developments, and disputes on the land if any
Rights for Pastoralist occupation of land	Migration corridors, Migration Rights, Time of the year/season occupied, land details and the community involved. Group Party Type family or community and Party Role Type farmer to be added codelists. Other attributes include Migration Right, MigrationPeriod, MigrationResponsibility, MigrationCorridor, GrazingAreaBufferZone
Community land attributes	Easement, Community Name,

Table 2
Other requirements for considerations.

Requirements for Consideration	Description
3D	Both above and below the ground. More relevant after the enactment of the Sectional Property Act, 2020 in Kenya on December 11, 2020, (Governmennt of Kenya, 2020).
Overlaps and Conflicts	In pastoralist migration and grazing areas on the private and community land
Ownership/tenure	This should include both Informal and community land
Coordinates	The latitudes, longitudes and altitude for the 3D
Areas and Volume where possible	This is to help in managing different areas: calculated area and the area in the titles
Mortgage	To include the rights on them
Spatial Unit	Could be pint cadaster for slums and polygon for the rest
Person Type	Different type of persons to be included: family, clan group, company, association, clan, married and single (including polygamy)
Data acquisition Methods	Include new methods like imagery from satellites, drones… apart from survey plan/map

country profile for Kenya.

Annex 1. : LADM Kenya country profile requirements

See appendix Table1andTable2.

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