

# **Pastoralism within Land Administration: Accommodating spatiotemporal land rights in the Land Administration Domain Model (LADM)**

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**Key words:** Pastoralists, Migration rights, grazing rights, Land Administration

## **SUMMARY**

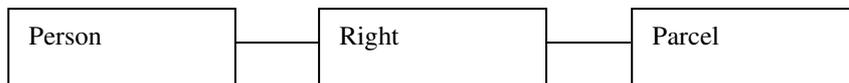
Cadastral models use three main concepts i.e. person, right and parcel to describe the people – land relationship. The rights registered are often represented on 2D or 3D parcel based spatial objects. While registration focuses on persons rights to a parcel (spatial aspect), the temporal aspects related to land rights are often neglected. This paper aims to study the temporary migration and grazing rights exercised by pastoralists as they move from place to place in search of seasonal pastures, and elaborate how these temporary rights could be included in a cadastral system. The paper uses an Object Oriented Analysis and Design (OOAD) method to study the real world situation of pastoral spatial and temporal land use. The spatial and temporal attributes of pastoralists in northern Kenya investigated. These attributes are treated as requirements for the cadastral systems and are introduced in the Land Administration Domain Model (LADM) UML diagrams. The outcome is a LADM that illustrates how pastoralists' spatiotemporal land rights could be accommodated in the Land Administration domain.

# Pastoralism within Land Administration: Accommodating spatiotemporal land rights in the Land Administration Domain Model (LADM)

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## 1. INTRODUCTION

Cadastral systems are generally concerned with keeping records about the relationship of people to land through formal or even non-formal land rights (Oosterom *et al.*, 2004). The cadastral systems have two basic principles: publicity and specialty. Publicity means that documents regarding the creation, transfer and deletion of rights and interest to land are open to the public, so that they are informed of the legal status of land, which in turn would determine their behavior when buying land, creating derived rights etc (Molen, 2003b). The documents can be a deed or a title, depending on the system of land registration. Specialty means that people and their relationship to land are specified, so that the public/third parties can know exactly which rightful claimants claim which rights and interests to which lot of land (Molen, 2003b). Person's rights/interests in land are currently represented on a 2D or 3D geometric descriptions of spatial objects to represent people's relationship to land (Lemmen and Oosterom, 2003, Stoter and Salzmann, 2003). Three concepts i.e. person, right and parcel are the core concepts used to describe the people – land relationship. Rights form the link between the legal owner of the right and the land parcel – and is often represented by the cadastral model (Fig. 1- shown below) (Navratil and Frank, 2004, Paasch, 2005, Kalantari *et al.*, 2008, Zevenbergen, 2002). Through this model, cadastral systems incline to focus on private interests (ownership) in land, with the view that those interests are equivalent to an exact dimension of a particular land parcel – 2D or 3D (Kalantari *et al.*, 2008).



**Figure 1: person-land relationship**

The representation of rights by registering a person to a parcel to represent the legal status of land could be viewed sufficient for land registration. Time, on the other hand, also plays an important role in cadastral systems, and yet this temporal aspect is treated as independent from the spatial aspects (Oosterom *et al.*, 2006b). Oosterom *et al.* (2006b) and Augustinus *et al.* (2006) point out that in cadastral systems, both the spatial aspects and rights, responsibilities and restrictions (RRR) also have a temporal element. Oosterom *et al.* (2006) differentiates these temporal elements in to three types. First, Database type, for example history of cadastral database updates; second, legal event time – for example the history of ownership; and last, variation of the rights with time – for example the limitation of tenures into 99 years, or even moving rights e.g. moving grazing cattle as where spatial extent also

'moves' over time. In the last example – the case of moving grazing cattle – the implications are that land rights are dynamic because they apply in different spaces over time. The dynamic nature of land rights does not pertain to the normal land market and land development especially in countries where adjudication and cadastral boundary survey results in issuing of titles to land, because processes involved to capture dynamic rights are considered as expensive and too demanding (Oosterom et al., 2006a). This paper focuses on the dynamic land rights in the context of pastoralists livestock grazing systems.

Paasch (2005) notes that a land parcel often contains one or more rights attached to it. But registration, from a legal point of view, confers ownership rights by concentrating the full ownership rights to an individual and others are excluded from it (Alden-Wily, 2008, Lavigne-Delville, 2000, Paasch, 2005). This conflicts with the pastoralists land rights which are concerned with seasonal movements and temporary access rights to grazing, rather than ownership rights (Galvin and Ellis, 2007). The users of the temporary access rights to grazing land are consequently deprived of access once land is individualized (Meinzen-Dick and Mwangi, 2009, Brink et al., 2005). This has endangered pastoralists' way of life which depends on the freedom of seasonal movements and access to required resources for economic production and sustainability (Davies and Hatfield, 2007). There is therefore need for the cadastral model to expand to accommodate the pastoralists seasonal land rights.

In relating the person-land relationship via land rights, the Land Administration Domain Model (LADM) expands on Fig. 1 with the view that it should be possible to relate several persons to a land parcel via a variety of RRRs. 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. This paper aims to study both the spatial and temporal elements that describe the real world situation of pastoral rights, using the pastoralists of Northern Kenya as an example. Their spatial and temporal attributes are treated as requirements for the cadastral systems. Those attributes will be introduced and incorporated in the LADM UML diagrams. The outcome is a LADM showing how pastoralists' spatiotemporal land rights be accommodated in a cadastral system.

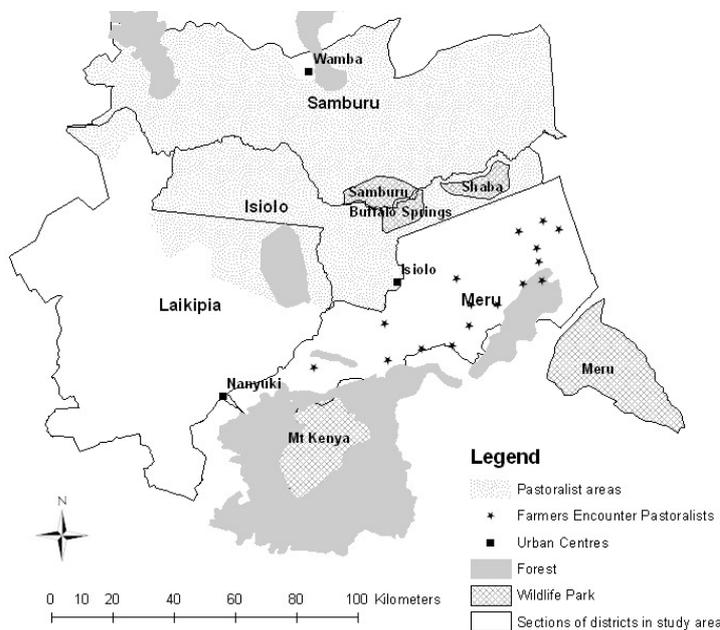
## 2. STUDY AREA AND MATERIALS

The case study area is the Samburu – Isiolo – Laikipia and Meru landscapes in Northern Kenya. The study area consists of diversities in land use actors, land uses and varied forms of land tenures. Six main categories of land use actors were identified for this study - as obtained from Lengoiboni et al. (2010). These land use actors are: farmers, private ranchers, urban residents, wildlife park wardens, forest officers and pastoralists. The farmers, private ranchers, urban residents, wildlife park wardens and forest officers practice sedentary land use, and their land rights are mostly under statutory tenures (individual or government land) (Lengoiboni *et al.*, 2010). In this study they are referred to as private right holders, or non-pastoralist land use actors, interchangeably. Previous study by Lengoiboni et al. (in review) found out that there are seasonal encounters between migrating pastoralists and non-

pastoralist land use actors in the dry seasons. Fig. 2 shows the study area, and the spatial extent of the non-pastoralist land use actors who encounter migrating pastoralists in the dry seasons. The encounters result from pastoralists migrating southwards into the non-pastoral territories in search of dry season resources/pastures.

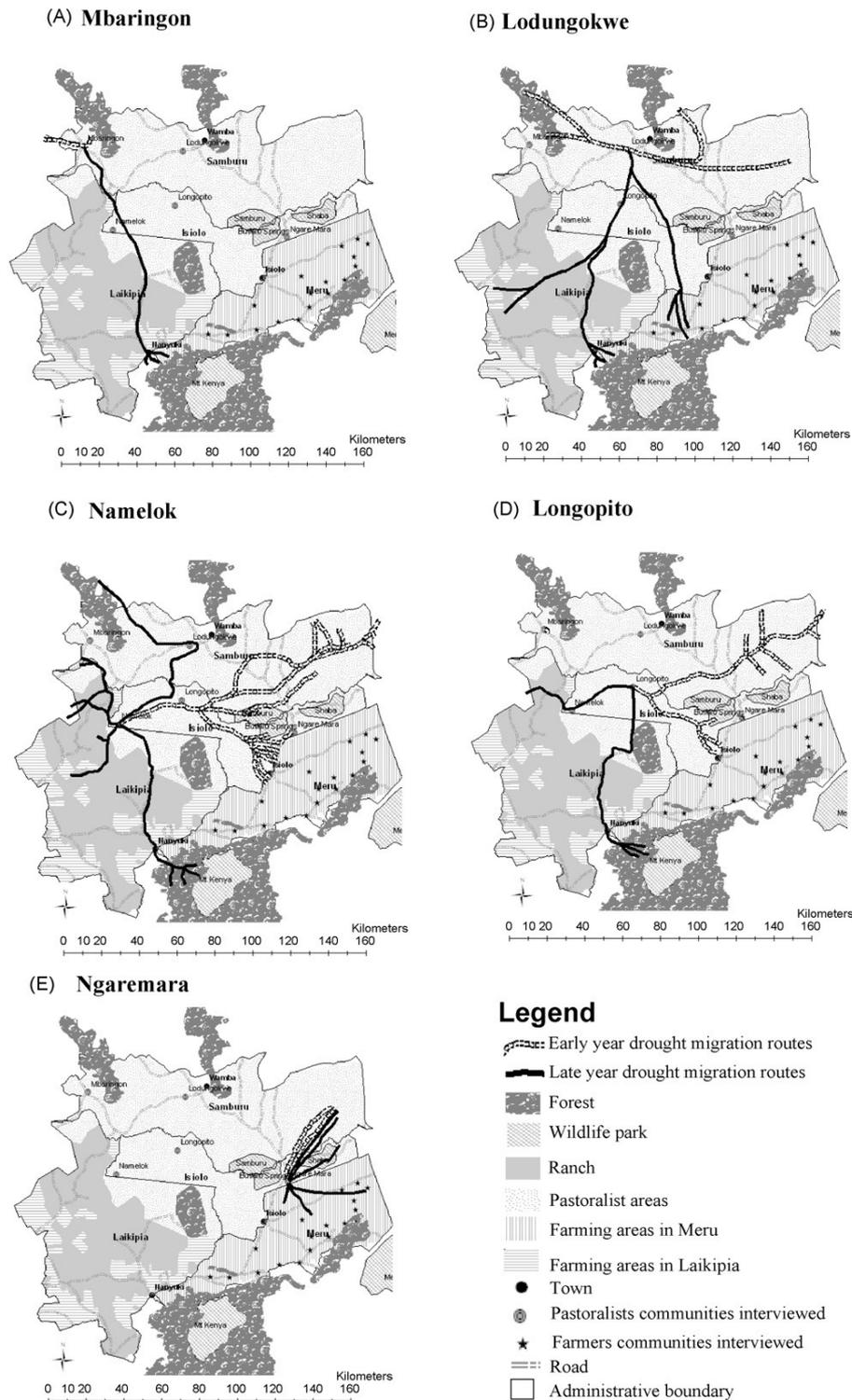
Meanwhile, pastoralists land rights are commonly based on communal tenure. Their land use is characterized by seasonal migrations in search of dry season pastures. There are two migration seasons a year in the study area. The two migrations are triggered by a two rainy and two dry season climatic conditions in northern Kenya (McClanahan and Young, 1996). During the migrations, pastoralists often migrate in groups to the grazing destinations. Previous study by Lengoiboni et al. (2010) found out that the migration routes follow different patterns depending on the time of the dry seasons: the migration routes of the early year dry season – usually in around January through March – are shown in dotted lines in Fig. 3; while the migration routes of the late year dry season – usually around July – October – are shown in thick black lines. These migration routes were obtained from 5 pastoralists communities in the study area. The migration routes show the spatial extents of the migrations, but do not show the entire expanse of where pastoralists potentially access in search of dry season resources. Also, whereas the migration routes are standard for pastoralists seasonal migrations, they are prone to change in pattern or spatial extents in times of extreme droughts.

On temporal aspects, Lengoiboni et al. (in review) described the periods in which the non-pastoralist land use actors encountered migrating pastoralists. These periods are shown in Fig. 4. Fig. 4 also gives an idea of the duration in which pastoralists remain in the non-pastoral areas before returning to their territories.



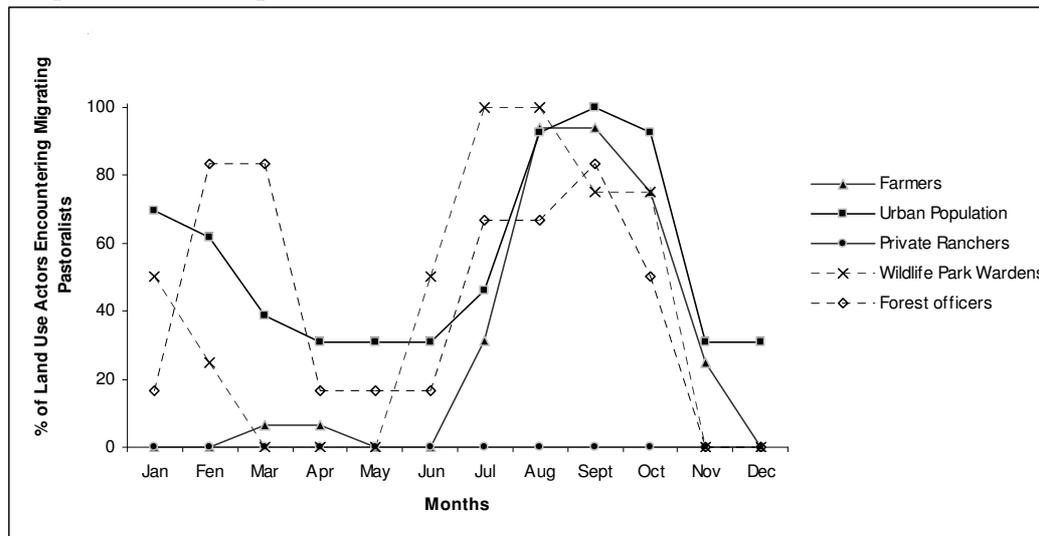
**Figure 2: Study area showing spatial distribution of non-pastoralist land use actors encountering seasonally migrating pastoralists in northern Kenya**

Source: Lengoiboni et al. (in review)



**Figure 3: Seasonal migratory routes drawn by pastoralists in participatory mapping sessions**  
 Source: (Lengoiboni *et al.*, 2010)

### Temporal elements of pastoral land use



**Figure 4: Months in which non-pastoralist land use actors encounter migrating pastoralists**  
(Source: Lengoiboni et al., under review)

### 3. METHODS AND INPUT MATERIALS

This study uses an Object Oriented Analysis and Design (OOAD) to study the real world situation of pastoralists seasonal land rights. According to Blackwell (2000) learning from the real world situation can enable developers to learn about the problem domain before constructing the models (Blackwell, 2000). Larman (2001) gives that the OOAD methodology contains two phases: the analysis; and the design phase. The analysis phase focuses on investigating the problem and requirements, rather than the solution; and the design phase emphasizes on a conceptual solution that fulfills the requirements in order to solve a problematic situation, rather than implementation (Larman, 2001). Only after describing the attributes and relationships of the concepts that they can be reassembled and expressed into a conceptual model to show how the system fulfills the requirements specified by the analysis (Blackwell, 2000, Larman, 2001).

#### 3.1 Phase 1: Analysis

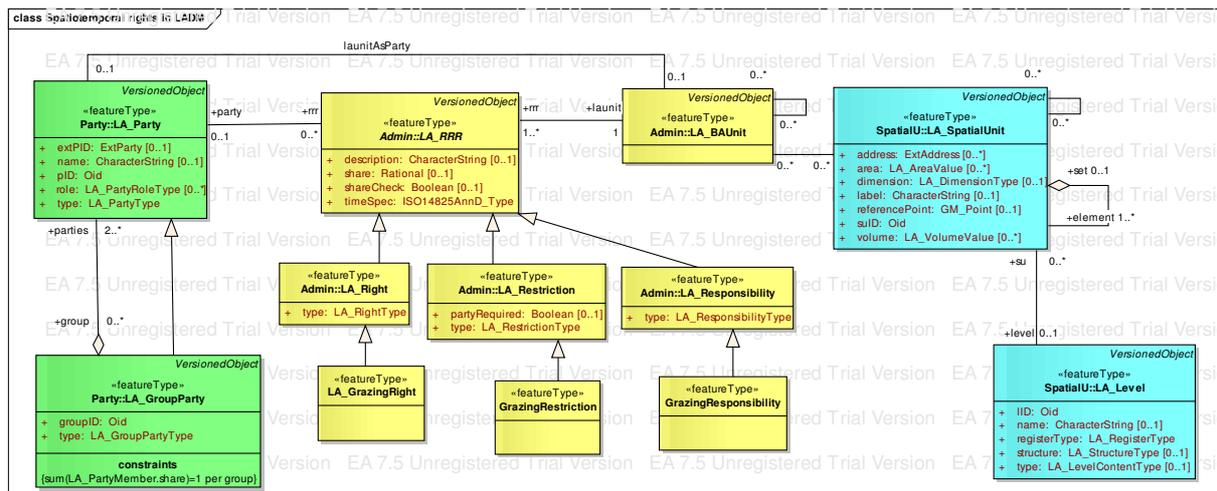
The analysis phase basically involves: identifying relevant concepts in the real world; identifying attributes of those concepts; and identifying relationships between those concepts (Blackwell, 2000). For this study, concepts of the real world are regarded as spatial and temporal elements of pastoral land rights. Instrumental case study is used in this analysis phase to assess the spatial and temporal attributes of the seasonal land rights. Instrumental case study is about exploring a particular case with a view to understand or gaining insights about a phenomenon of interest (Stake, 1999). According to Stake (1999), instrumental case study goes beyond just understanding the interaction of phenomenon, because the results of a

case may benefit a new research if attention is paid on constructive qualities, and lessons learnt may be used to inform, or provide insights on what is required to pursue other interests, for example in solving a problematic situation. Thus, the authors are conducting an instrumental case study to access the phenomenon of interest via an existing case, rather than studying a case itself. For this paper (hence new study), instrumental case study is used to derive the attributes of the spatial and temporal elements are from results of existing case studies. Prior results are obtained from Lengoiboni et al (2010) is based on seasonal migration routes from 5 pastoralists communities. The migration routes (Fig. 3) could provide insights of the spatial extents of where the pastoralists apply their land rights based on seasonal migrations and temporary grazing. Prior results are also obtained from Lengoiboni et al. (under review), which presents the frequencies of responses given by the different categories of land use actors in the study area, and the months in which they encountered pastoralists (Fig. 4). The months of increased encounters could provide insights of the periods in which pastoralists apply their land rights in the non-pastoral areas.

### 3.2 Phase 2: Design and LADM basic concepts

In the design phase, the spatial and temporal elements of migrations and grazing rights obtained from the analysis phase are introduced in the LADM architecture, so that LADM can accommodate the requirements of the seasonal land rights. Unlike the cadastral model shown in Fig. 1, the LADM abstract class consists of four core concepts that represent the person-land relationship (ISO, 2009, Oosterom *et al.*, 2009). These concepts, which are also referred as classes are: LA\_Party (in place of person in Fig. 1); LA\_RRR (in place of Right in Fig. 1); LA\_BAUnit (not included in Fig. 1); and LA\_Spatial Unit (in place of parcel in Fig.1). The relationships between person-right-land are given in UML notations. Notations used in this study are: [\*] to be read as ‘many instances’; [0..\*] – zero to many instances, [0..1] – zero to one instance; [1..\*]one or many instances etc. These notations show multiplicity. Multiplicity shows the number of objects in a class, for example, the rights as a class can have many different kinds of rights. Multiplicity would in this case show how many rights, including the kinds of right a person would have to a parcel. The section below describes the LADM architecture and relationships between the classes, as given in ISO (2009).

**LA\_Party :** Entities that belong to the class LA\_Party is a party. A party constitutes of a person or a group of persons that form an identifiable single entity. If a party constitutes a group, it is made up of 2 or more persons (shown by multiplicity attached to the open diamond). A group forming an identifiable single entity inherits the features and attributes of the LA\_Party. This inheritance is shown by the open arrow pointing from the group to the LA\_Party. For pastoralists, ‘Party’ in LADM, pastoralists often migrate in groups mainly for security purposes (Agrawal, 1999). The LADM 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.



**Figure 5: Core entities in LADM, and Grazing rights, restrictions and responsibilities**  
Source: (ISO, 2009)

**LA\_RRR** (Rights, Restrictions and Responsibility): This includes a description of a variety of rights for example ownership/customary Rights, Restrictions and Responsibilities to a spatial unit. Entities/instances belonging to LA\_RRR are LA\_Right; LA\_Restriction; and LA\_Responsibility.

- LA\_Right → consists of various types of rights.
- LA\_Restriction → A restriction means that a party allows another party to do something, or that a party shall refrain from doing something itself. Restrictions are both within private law, especially in the form of servitudes, or within public law, through zoning and other planning restrictions, as well as in environmental limitations (Zevenbergen, 2004).
- LA\_Responsibility → responsibility means that one shall actively do something (Zevenbergen, 2004). For example land users are supposed to contribute to management of resources by actively doing something.
- The LA\_Right; LA\_Restriction; and LA\_Responsibility inherit the features and attributes of LA\_RRR in the LADM. This is shown by the open arrow pointing to the LA\_RRR. A party is associated to zero or more [0..\*] instances of a subclass of LA\_RRR, meaning that a party can have zero or more rights, restrictions and responsibilities to a spatial unit. All rights, restrictions and responsibilities are based on an administrative source. An administrative source is a document showing evidence of a party's rights to a basic administrative unit or a spatial unit.

**LA\_BAUnit:** The LA\_BAUnit (Basic Administrative Unit): can be an area of jurisdiction, or a collection of spatial units treated as an entity to which RRRs are attached. There can be a number of LA\_BAUnit in a country, and different RRRs may apply in different jurisdictions. A LA\_BAUnit can itself be registered e.g. as an administrative unit. In Fig 5, LA\_BAUnit is associated to LA\_Party by a [0..1]. This means that 1 LA\_BAUnit can be registered as 1 party, or 1 party as an administrative unit. The

LA\_BAUnit is positioned between LA\_Spatial unit and LA\_RRR. One or more [1..\*] LA\_RRR can be associated with a LA\_BAUnit. Meanwhile the LA\_BAUnit can consist of zero or more [0..\*] spatial units.

**LA\_SpatiaUnit:** This can be a land parcel, building, etc. within a LA\_BAUnit.

**LA\_Level:** The LA\_Level is a collection of spatial units with geometrical or thematic consistency, and are used for the implementation of the notion of legal independence (ISO, 2009). For example, there can be a level for areas reserved as forests, and where forest laws apply, etc.

#### **4. RESULTS: REAL WORLD SITUATION OF PASTORALISTS SPATIAL AND TEMPORAL RIGHTS**

Distinctive and observable elements regarding the spatial and temporal aspects of seasonal migrations are extracted from Figures 3 and 4. Characteristics extracted are considered as requirements of pastoral land rights to be included in LADM.

The migration routes shown in Fig. 3 originate from pastoralists' customary productive systems. As can be observed from Fig. 3, the migration routes present two different patterns, which Lengoiboni et al. (2010) classified as: migration routes used in the early year dry season (shown in dotted lines in Fig. 3); and migration routes used in the late year dry season (shown in thick black lines in Fig. 3). They are described in the following sections.

##### **4.1 Spatial and Temporal attributes of seasonal migrations & grazing in the early year dry season**

In the early year dry season – in Fig. 3, the migration routes seem to be confined within the pastoral areas. On the basis of this, it can be determined that the spatial extents of the migration routes are confined in the pastoral areas. This could also suggest that potential grazing areas are also found within pastoral territories. This result characterizes the spatial attributes of migration routes and potential grazing areas to occur within pastoralists' territories in the early year dry season, where pastoral tenures are dominant.

On temporal attributes, Fig 4. shows the proportion of non-pastoralist land use actors who encounter seasonally migrating pastoralists. Some of them – mostly urban population, wildlife parks wardens and forest officers – report to encountering migrating pastoralists in the early year dry season. As can be derived from Fig. 2, urban population (Wamba) forests and wildlife parks are located within or in the vicinity of pastoral territories. This increases their probability for encounters with migrating pastoralists. The observed peaks around January – March indicate the encounter periods, and the duration of those encounters. This result also matches the answers given by pastoralists in Fig. 3, showing that their migrations are

exercised in this period within pastoral territories. This result characterizes the temporal attributes of migration and grazing rights to apply in the period around January through March, within the pastoral territories.

#### **4.2 Spatial and Temporal attributes of seasonal migrations & grazing in the late year dry season**

In the late year dry season, the migration routes (shown in thick black lines in Fig 3) cross in to non-pastoral areas, where land is mostly under private ownership. The length of the migration routes present the spatial extent to which pastoral rights based on migration routes overlap in the non-pastoral territories. At the end of the migration routes, pastoralists usually spread out in search of grazing land. The precise spatial expanse of where pastoralists potentially access for grazing is difficult to draw from Fig. 3. Fig. 2, on the other hand, presents the spatial distribution of non-pastoralist land use actors (farmers, forests, parks) who encountered migrating pastoralists. This map signals that pastoralists penetrate deeper into the non-pastoralist areas in the late year dry season. This result characterizes the spatial attributes of migrations and potential grazing areas to occur in the non-pastoral areas, where private tenures are dominant.

On temporal attributes, it can be observed from Fig. 4 that there is a heightened pastoralists – non-pastoralists encounter period between July – October. This result also matches the answers given by pastoralists in Fig. 3, showing that migration routes are directed towards non-pastoral areas in the late year drought. The duration of encounters can be observed to last for about four months. This result characterizes the temporal attributes of migration and grazing rights to occur around July through October, in the non-pastoral areas.

#### **4.3 Pastoralists Spatial and Temporal land rights in the LADM**

After describing the spatial and temporal attributes of the seasonal migrations and grazing through OOA, this section focuses on how those attributes can be implemented in the LADM. From sections 4.1 and 4.2, it can be determined that two aspects regarding spatial objects on which pastoral rights are exercised need to be considered:

- Potential dry season grazing areas (in early and late year dry seasons)
- Migration routes/corridors. The migration can be seen as a form of transit tracks that pastoralists use to move livestock to the seasonal grazing areas (in early and late year dry seasons)

Depending on the specific time of occurrence of the dry season (early year – around January through March; or late year – around July through October), the potential dry season grazing areas occur either within pastoral areas or in non-pastoral areas. Specific spatial units within which the dry season grazing occur are not given, but they could be on privately owned parcels (owned by farmers), or in the forests (mostly owned by government or local

governments) etc. Grazing rights, given as LA\_GrazingRight in the LADM already satisfies this requirement, hence no changes are introduced in Fig. 6.

Fig. 6 introduces rights concerning migrations on the migration corridors under LA\_Rights specialization as MigrationRight. Because the migrations are directed into different places depending on specific migration season, the limitations to restricts the time in which pastoralists should migrate to specific area is required. Restriction to the use of migration corridors are introduced as a sub-class of the LA\_Restriction as MigrationPeriod. Furthermore, responsibility coming along with the use of migration corridors are introduced in the LA\_Responsibility as MigrationResponsibility.

Fig. 6 introduces the MigrationCorridor as a subclass of the LA\_SpatialUnit to represent migration routes as different form of spatial unit required by pastoralists to move their livestock.

GrazingAreaBufferZone is also included as a subclass of the LA\_SpatialUnit, with the consideration that pastoralists migration patterns or potential grazing areas are likely to change depending on the intensity of the drought.

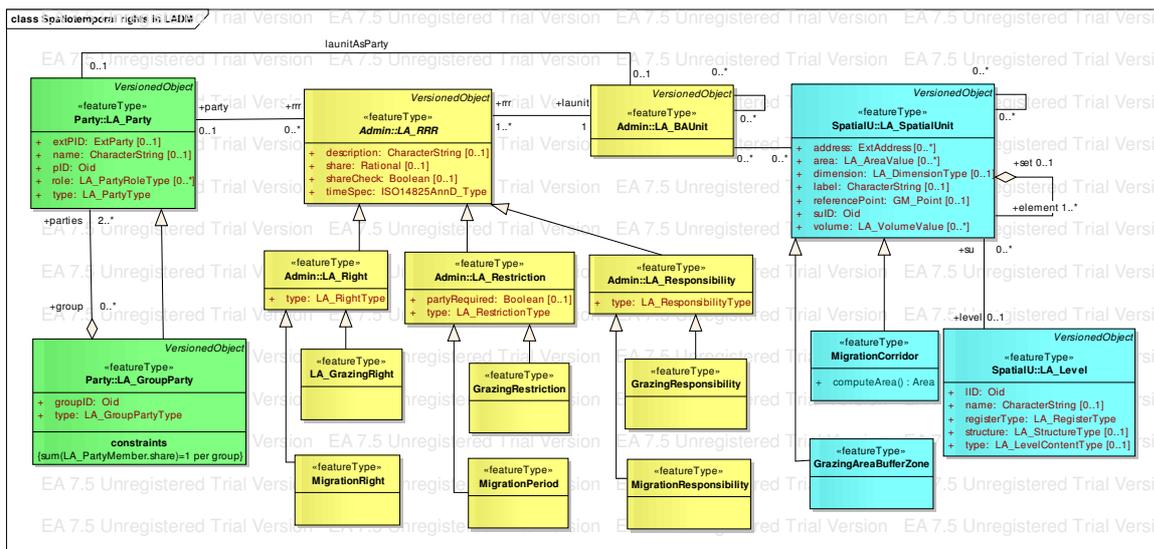


Figure 6: Accommodating spatial and temporal elements of pastoralists' land rights in LADM

## 5. DISCUSSION: PASTORALISTS SPATIAL AND TEMPORAL LAND RIGHTS IN LADM

All kinds of interests in land have the same logical construction for purposes of spatial identification (Kalantari et al., 2008). According to Lawrence (1985), an area of land needs to be determined before rights applying can be ascertained, thereby making land a legal object. Currently, the legal objects – in form of cadastral parcels – make it easier for cadastral systems to focus on ownership rights. Focusing on private rights however does not provide the complete picture about the legal situation of land, and so Cadastre 2014 proposes a shift from parcel based spatial units to land objects. Legal land objects is defined as a piece of land in which homogeneous conditions exist within its boundaries, and can be described/identified by the legal content of a right or restriction and the boundaries which demarcate where the right or restriction applies (FIG, 1998). The legal land objects, such as parcels, buildings, easements etc, and their spatial extents can be organized in independent layers (FIG, 1998). They can be represented as closed polygons in 2D or in 3D, and are allowed to overlap – even if they do not share common boundaries (Oosterom et al., 2006a).

### 5.1 Migration routes and migration rights in LADM

Fig. 3A-E was used to determine the spatial extents of migration routes. While the lengths of the corridors could be relatively determined (extending up to 200km from pastoral home areas), their widths could not be determined. Local contexts need to be taken in to account to determine the requirements of minimum widths of the migration routes, an approach considered in Article 27 of the Niger Pastoral Code (Niger). If known, the lengths and widths of migration routes could be determined and represented as spatial units.

In the early year dry season (when migration rights apply within their territories or administrative areas), the restrictions to use migration corridors may not be necessary. This is with the view that their customary land use is dominant may continue to be applied. In the late year dry season, (when pastoralists migrate to non-pastoral areas), limitations to migrate on the corridors can be described by a temporal interval of the periods in which pastoralists should use the migration routes. In northern Kenya, results indicated pastoralists migrate into the non-pastoralists areas in the period around July through October. According to Lengoiboni et al. (in review) this period coincided with the farmers harvesting of seasonal crops. Limiting migration periods within July-October may be very restrictive, and may not necessarily harmonize with the onset of migrations or farmers harvesting calendars. Article 22 of the Pastoral Code in Guinea describes the duration of pastoralists dry season grazing in farming areas as the period ranging from between the removal of harvest and the sowing period (Guinea). This approach allows a flexible way to balance herders' and farmers calendars, hence security for productive systems of parties involved. Similarly, MigrationPeriod (in farming areas, for example) could be restricted to "between harvesting and sowing" to represent the time interval in which pastoralists migration and grazing rights apply in the farming areas. Responsibilities attached to the rights of both the farmer and pastoralist on the same piece of land may need to be determined according to local contexts.

## 5.2 Dry season grazing areas and temporary grazing rights in LADM

To determine the spatial extents of potential grazing areas, the lengths of the migration corridors were also used. Fig. 3 showed that the grazing destinations are located towards the ends of the migration routes, where a delta-like (in Fig. 3) feature symbolize pastoralists spreading their herds for grazing (Lengoiboni *et al.*, 2010). In the early year dry season, the migration routes seem to be confined within pastoral areas. The fringes of pastoral areas could be delineated as LA\_BAUnit. GrazingRight could apply to the LA\_BAUnit or LA\_SpatialUnits therein. Just as MigrationRight in the early year dry season, GrazingRight could be applied according to their dominant customary tenures within the pastoral territories.

Delineating pastoral areas as a LA\_BAUnit or a LA\_SpatialUnit unit means that the early year migration routes will be enclosed in pastoral areas. According to Fig. 2 and 3, not only the migration routes would be enclosed, but also non-pastoral land uses such as urban centres (e.g. Wamba), forests and wildlife parks are also located within pastoral territories. The representation of boundaries of the different land objects/layers is necessary for the purpose of informing the public of the complete situation of land (Molen, 2003b, FIG, 1998). Moreover, different spatial units (e.g. of different land uses) can be arranged according to the laws by which they are defined, because this approach allows the immediate adaptation of the land administration to the development of the legislations; and if a law is cancelled, its respective level can be removed without reorganizing other levels (ISO, 2009)

Meanwhile, the spatial expanse of potential grazing areas in the late year dry season is difficult to determine. This is because their reach as they disperse in search of pastures is uncertain. Uncertainty about the boundaries conforms to Neate (1999), who expresses that strict boundaries in which customary rights are exercised are often not accurately defined. Such kinds of spatial extents need to be defined in manners other than accurate land surveys and geometrical measurements (Oosterberg, 2002). Fig. 2, on the other hand, shows the spatial distribution of non-pastoralist land use actors encountering migrating pastoralists (though not entirely representative of preciseness of the boundary). For the purpose of estimating the boundaries of potential grazing areas in this study, it can be assumed that Fig. 2 represents pastoralists' reach in the non-pastoral areas, as they migrate southwards. The extent of their reach could be viewed as the boundary wherein potential grazing areas are located. If required, specific LA\_SpatialUnits falling within the potential grazing areas need to be described.

The existence of ownership rights in the non-pastoral areas means that MigrationRight and GrazingRight on private land do not apply anymore, despite pastoralists' seasonal movements there. But on the other hand, ownership is often perceived as a *bundle of rights* that can be sub-divided into separate rights – i.e., a person can possess parts of the bundle of rights, and his rights can be separated from the *ownership* of land (Molen, 2003a). If spatial extents of migration corridors and potential grazing areas are overlaid with private tenures, they could present the extent to which pastoralists' MigrationRight and GrazingRight seasonally overlap with the private tenures.

New rights can be created after an agreement between person(s) requiring the a right for a particular duration (pastoralists requiring MigrationRight and GrazingRight on private land), and the land owners, who will restrict those rights (Oosterom et al., 2006a). This is in line with the approaches of some West African countries which recognize pastoralists migrations for temporary grazing in non-pastoral areas, in the sense that pastoralists access to grazing on private is subject to prior agreements with the land owners (Article 12 of Pastoral code in Guinea (Guinea); Article 27 Burkina Faso Pastoral Code (Burkina-Faso). Implications are that these access agreements are seasonally renegotiated, although recognized by the law. Another option would be to re-introduce the pastoral rights through means such as restitution of rights, if necessary.

It should be considered that the spatial extents of the migrations and grazing areas are likely to change as they are often influenced by climatic conditions. This means that although the boundaries of the migration routes and the grazing areas could be defined, pastoralists can move beyond these boundaries when extreme climatic conditions demand it. Considering buffer zones for dry season grazing areas would allow the margins to for other grazing areas in extreme drought periods (Behnke, 1994). Article 17 of the Pastoral Code in Bukina Faso and Article 29 of Niger Pastoral Code, for example, provides that in case of pasture scarcity or drought related crisis, forests could be temporarily opened up for herders, while restrictions and responsibilities may be included (Burkina-Faso, Niger).

The study provided an evidence base to meet the purpose of this research: to elaborate how pastoralists' seasonal migration and grazing rights can be accommodated a cadastral system. Interests and RRRs can be incorporated into the cadastral architecture through the modeling process, by abstracting different interests and recognizing their spatial dimensions in the real world (Kalantari *et al.*, 2008). Key to establishing the areas where land rights should apply is the identification of spatial boundaries (Simpson, 1976). A limitation in this study was the lack of detailed information especially for the potential grazing areas. This may have resulted to inaccuracy in the description of their precise spatial extents. However, the spatial distribution of non-pastoral land use actors encountering seasonally migrating was assumed give an indication of approximate areas where pastoralists reach in search of pastures for the late year dry season. This provided a basis for estimation of boundary for the purpose of elaboration in LADM. While this study elaborated on how pastoral land rights can be included in LADM, and how pastoral and non-pastoral land rights could overlap, it should be recognized that cadastral systems aim to register rights and interest to land that are recognized legitimate by law (Molen, 2003b). Hence, creating mechanisms for the definition and enforcement of rights including both formal procedures and social customs and attitudes concerning the legitimacy and recognition of those rights is important. Otherwise, without a definition of what constitutes land rights in the law – including pastoral rights –, and without legally defined mechanisms for acquisition, transfer, protection, restriction, creation, recording or registration of these rights and interest is meaningless (Molen, 2003b).

## CONCLUSIONS

This paper aimed to draw on the spatial and temporal aspects of migrations and grazing rights, which characterize pastoralists seasonal, and include their attributes in a cadastral system. Results from previous studies on spatial extents of migration routes and the specific time of migrations were used to derive the required attributes. Object Oriented Analysis and Design was used to realize how migration rights and grazing rights could be accommodated in LADM. It was described that pastoralists exercise two migrations a year. In the early year dry season migrations and potential grazing areas are located within pastoral territories. Meanwhile, migrations in the late year migration season are directed towards areas dominated by private tenures, mostly farming communities, where these rights temporarily overlap. In accommodating these characteristics in the LADM, this study suggests securing pastoral rights according to the dominant customary tenure, thereby protecting both migrations and grazing areas within their territories. However, if changes occur in tenures, for example an increase in demand for individual tenures, then restrictions should automatically apply on private land concerning migration and grazing rights. To secure pastoral rights where they seasonally overlap with private tenures, a system of shared rules between pastoralists and non-pastoralist land use actors is suggested. A calendar of how each actor uses their land can be studied and a method to harmonize pastoralists and non-pastoralists actors to exercise rights on the same piece of land is suggested.

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