

REFERENCE REPORT: SOUTHERN KENYA MAASAI ONTOLOGY (SKMO)

Mina Karamesouti, Carl Schultz, Malumbo Chipofya, Jan Sahib,
Cristhian Eduardo Murcia Galeano, Angela Schwering

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Introduction

its4land EU Horizon 2020-programme, attempts to address the issue of fast and cheap development of Land administration systems. Existing recording and mapping approaches have failed (disputes abound, investment is impeded, and the community's poorest lose outmapping of millions of unrecognized land rights in Kenya). The approach attempted to be developed from the its4land program incorporates technologies and processes that maintain information about people, land, and tenures. These are recognized as crucial tools for delivering sustainable economies, environments, and social cohesion. Land tenure recording helps to deliver tenure security, dispute reduction, investment opportunities, and contributes to good governance.

its4land combines an innovation process with emerging geospatial technologies, including smart sketchmaps, UAVs, automated feature extraction, and geo-cloud services, to deliver land recording services that are end-user responsive, market driven, and fit-for-purpose. The transdisciplinary work also develops supportive models for governance, capacity development, and business capitalization. Gender sensitive analysis and design is also incorporated. Established local, national, and international partnerships drive the project results beyond R&D into the commercial realm.

The limited spatial heterogeneity, in terms of geomorphology and constructed environment, but also the traditional Maasai perception on land use and land ownership (commonly used land), do not favor deterministic approaches for land tenure recording. For this reason, it is attempted the use of innovative geo-spatial technologies, which allow multi-aspect approach of the field of spatial analysis [1]. Real-life information will be used in order to develop an ontological model, aiming to formalize the Maasai community system as well as its main functions.

Comprehensive background knowledge on concepts related to socio-ecological and functional structures, local landscapes and spatial features of the Maasai communities, as well as knowledge and understanding of local language terminology was considered mandatory. Main sources for the linguistic information were primarily the online publicly available Maa language dictionaries by Payne and Ole-Kotikash [2] (referred herein as **Dictionary A**) and by Richmond [3] (referred herein as **Dictionary B**). The information of these dictionaries was cross-referenced in many cases with literature but also with direct contact with the locals. Initially, there were distinguished two broad categories, the one referring to the social characteristics and the other referring to the broader environment within which Maasai communities live. These two categories were later on enriched. The findings are presented in the following tables, divided into two main types, the **terms** and the **concepts**. Terms and concepts are classified based on the Maasai community aspects which they refer to, the main of which are the social aspect and the environmental aspect. For the social aspect were considered the characteristics, the main components as well as the activities. For the environmental aspect were considered the aspects of climatic, vegetation and land. The class related to the land is the broadest, since it incorporates not only biophysical land characteristics, but also characteristics related to land use type, land organization and land agreement, as addressed in the Maasai community. The livestock was another class, since animals play an important role in pastoral nomadic society.

It should be noted that some terms might describe more than one concepts, as it appears from the literature review but also from the contact with local communities, consequently they can appear in more than one categories (i.e the terms enkang, olmarei which might refer to social units or to a household) [4, 5].

Society

Two critical concepts related to the social organization are the concept of **man** and the **woman**. The male and female members of the Maasai society have very distinct roles but also social and political rights, while resources control and ownership, in any form, varies significantly among the two genders [6, 7]. Apart from the gender-related distinctions, age-related distinction among society members is evident as well [6]. Different kinds of leaders who make decisions on community's functionality, including land use decisions, leaders who control the pastoral processes, but also multi-level social groups (i.e. oloshon, oligata etc), were considered worth mentioning as other critical concepts in our model [6]. The interaction of individuals within the various social groups appears to be a key aspect of the Maasai societies.

Table 1. Terms related to society, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Society			
Term	Explanation	Source	Other Comments
oligata olgilata	Clans	A, [6, 8-10]	[6] - olgilata
en-gishomi	Clan	B	
oloshon	(sub-tribe sections) or [11] - territorial section	[10, 11]	
	Social groups / Ranches / Group ranches	[12, 13]	
	Group representatives	[12]	
	Management committee	[12]	
	Narok County Council - management authority	[14]	
olegwanan	Elder members who decide about land uses	A	
olmarei*	Family	A, [4, 5, 12]	
	Familly/ Descendants - Woman - Man - Young members	[12]	
orok kiteng	Descendants	A	
odo mongi	Descendants	A	
Oloiboni iloibonok	Spiritual leader [6] - iloibonok - ritual leader – diviner [9] - oloiboni, ritual expert	A, [6, 9]	
wazee	Highly respected member	[15]	
ol-arikoni	Leader	B	
Alaigwanani olaiguani	Political leader Age-set spokesman or chief	A, [6]	
laigwanak	Head of clans	A	
ol-abikoni	Inhabitant, resident	B	
ol-meeri	Native other than Maasai	B	
el-latia	Neighbour	B, [8]	
ol-morani moran ilmuran olmurani	Warrior	B, C, [4, 6-9, 12, 16]	C, [8] - moran [9] - olmurani [12] - ilmuran
ol-jogut olcekut	Shepherd, herder, pastoralist	B, [9, 12]	[9] – olcekut: herder
	Hired herders	[14, 17]	
ol-aikitalani	Sheriff	B	
	Ranch manager	[8]	
	Individual ranchers - herders	[10, 12]	
	Livestock-poor individuals	[12]	
	Livestock-rich individuals	[12]	
olkarsis	Rich pastoralist	[6]	

Table 2. Concepts related to society, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Society	
Concept	Source
Urban population in the study site is growing	[12]
Rich herders were against subdivision - large herds could not be sustained	[12]

under smaller sized parcels	
Ilmurran are the young warriors between 15 and 25 years old	[9, 12]
women do not have access to resources and therefore cannot wield power.	[9]
All members of Oloshon (sub-tribe sections) have exclusive claims to rangeland territories for grazing and on water resources. Natural resources were commonly used	[10, 11]
Women are not considered group ranch members - have no land rights unless in special cases	[12]
Elder members responsible for decision making	[12]
Elder leading members	[12]
Elders were against land subdivision - reduced land for grazing	[12]
Marriage is an important means by which individuals build up alliances in the pastoral economy.	[9]
People who go away to work in the cities, without regular return visits are treated as they do no longer exist - as if they are dead - no rights etc	[9]
The preferred way to act politically amongst the Maasai involves the use of influence. As a result, women may be able to influence the decisions reached by their husbands regarding stock	[9]
Main distinction - men care about cattle while women care about children	[9]
Politics is conducted through the interactions of everyday life	[9]
Extensive exchange networks underlie patterns of caring for cattle and ensure the long-term viability of the family herds. These patterns involve a system of "delayed-return"	[9]
Young members - grazing areas closest to the household	[14]
Older boys and young men - move cattle across different niche grazing areas	[14]
older men and most experienced herders graze animals during extreme drought and flood periods to assist with herding	[14]
Solidarity is a fundamental organizing principle	[12]

Animals

As indicated in previous group of terms, the household organization is tightly related not only to the position of the individuals in the social hierarchy, but also to the livestock. Various enclosure types are created for different kinds of animals. Young or sick animals are kept separately from the rest livestock (i.e. in olokeri), while the size of the herd might be indicative of social power and power to manage land resources [9]. For this reason some of the most popular animal species were included in current ontological model, since they can indirectly provide information for some important spatial organization components of the Maasai community.

Table 3. Terms related to animals, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Animals			
Term	Explanation	Source	Other Comments
	Livestock	[9, 12]	
	Seasonal livestock	[10]	
en-gine	zebu	[10, 18-20]	
en-gine	goat	B, C	C – the concept of goats exists also in sketches but without local term
il-lukunguni	poultry	B, C	C – the concept of chicken exists also in sketches but without local term
en-ger in-dare	sheep cow	B, C C	C – the concept of sheep exists also in sketches but without local term C – the concept of cow, calf exists

			also in sketches but without local term
inkishu	cattle	[9]	

Table 4. Concepts related to animals, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Animals	
Concept	Source
Zebu cattle - is the main cattle breed	[19], [18], [10], [20]
Ownership of stock is a crucial factor in deciding who has political control in the society	[9]
Stock associates can only be built up with others if one has a herd of animals.	[9]
Herd size reduction might be necessary in some areas	[12]

Activities

Agropastoral activities are the main source of income for Maasai communities, while supplementary income might derive from land leasing for cultivation, conservation (wild life) or touristic use [17, 21]. The fragmentation of the communally used grazing lands, due to the alternative activities, seems to be a serious cause of conflicts [17, 22]. Thus, the concept of activities was incorporated in the ontological model. The way that pastoralism is performed, and consequently the areas that are used, usually depends on the size of the herd, the household wealth, the social constraints as well as the climatic conditions [5, 12, 14, 17, 20].

Table 5. Terms related to activities, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Activities			
Term	Explanation	Source	Other Comments
e-turishoi e-tur enturore enkop	Cultivate, plough B - el-lidare , en-durgore (harvest)	A, B, [5]	
eunoto	The planting	[9]	
	Collecting wood	[9]	
	Chopping wood	[9]	
ol-amayio olkiyioi	Hunt	A, [23]	[23]
a-irrita	Look after the herd	A	
o-ramatei	Manage the cattle	A	
ronco	Drive the cattle to distant place for some months, seasonal pastoralism	B, [9, 17], [10], [20]	
	Transhumant pastoralism	[10]	
	Subsistence pastoralism	[12]	
Shoo perper	Grazing around A – perper – grazing around home	A, B, [6]	[6] – the right of “pasturing”
	Dry season grazing	[12]	
en-gias	Occupation	B	
	Washing cattle	C	
lagitim	Travel to get water for cattle	A	
emanyattas	Cultural events	C, [4, 9]	
Ilmala	Influence through a discussion of deputations	[9]	
	Tourism	[21]	
	Seasonal migration	[10]	

Table 6. Concepts related to activities, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Activity	
Concept	Source
Two types of lion hunting are identified: Olamayio – for prestige to the warrior, and Olkiyioi – to protect the herd.	[23]
The moran (or olmorani) is responsible to protect the neighborhood. For this reason, he lives in the emanyata (or manyatta), which is a camp outside the enkang	[4]
Common seasonal pastoralism practice during times of drought, is to move livestock to temporary camps, which are closer to areas of underutilized forage	[20]
Grazing animals into protected areas (PAs) , where both forage quantity and quality are higher is a common strategy during drought	[20]
Men spend most time away from enkang, checking the cattle or visiting other inkang'itie (enkang-plural)	[9]
During dry period herds are splitted among relatives and are droved in long distances to find water and food - [17]Joint herding usually occurs during drought	[9, 17, 24], [20]
Herd mobility is a central management strategy	[22]
Livestock exchanges reduce risks and improve recovery through herd ownership associations	[14]
Grazing differentials among group ranche members	[12]
During wet period majority of livestock walks less than 4 km away from boma	[7, 18]
During droughts herders with their livestock have to walk for 5 - 15 km from their enkang (or boma) to the watering places, in order to water their animals (half hour to 5 hours)	[18], [5, 25, 26]
Tourism industry promises more reliable and higher salaries	[14, 17]
Maasai pastoralists reside with their livestock (cattle, sheep, and goats)	[20]
Tourism - Maasai pastoralists do not always receive the benefits (income) from the wildlife tourism industry - not all landowners receive cash benefits equally	[21]
New income opportunities come from leasing pastures and cultivating	[14], [12, 17]
Herder's opinion...As much as I would like to be a pastoralist, farming is more suitable for this area. For instance, I grow tomatoes. The problem is that we don't have the know-how and water levels are decreasing. Farming is also safer.	[27]

Spatial organizations

The Maasai pastoralists are one of the traditional nomadic Nilo-Saharan groups, highly dependent on livestock, natural resources' availability and social organization. Spatial organization of the Maasai communities is one of the critical components that need to be described in an ontological model aiming at formalizing the Maasai community system. Main characteristics are the multi-household organizations and the commonly used, for grazing purposes, territories (**Table 1, 2**).

Table 7. Terms related to spatial organizations, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Spatial organizations			
Term	Explanation	Source	Other Comments
Enkang*	City – area where a family resides [4] – multi-household (6-12 households)	A, B, C, [11], [4], [5], [9], [12]	B – eng-ang (village, town) C – enkan [9] - village, settlement, home [12]- enkang
En-aitas	habitat	B,	

Kraal*	Settlement surrounded by thorn bush fences Afrikaans word used also as enclosure for animals	A, B, [24]	[24] – group of settlements = enkutoto
e- mingani	deserted kraal	B	
i-nuruan	deserted kraal	B	
olmarei	Household	[8], [28], [4]	[28] - one or more households (olmarei) [4]-enkang > olmarei (enkang has several olmarei)
<i>elatia/enkutoto</i> <i>inkutoto</i>	Neighbourhood/locality [28] - Cluster of bomas in favored localities	[8], [24, 28]	
Oloshon* olosho	Largest grazing unit [6] - primary unit of territorial political system [11] - territorial section commonly used	[6, 8, 11]	[11] - olosho

Table 8. Concepts related to spatial organizations, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Spatial organizations	
Concept	Source
The main sections (oloshon) in the Greater Amboseli Ecosystem are the Ilkisonko section and the Kaputei, Matapaato sections	[10]
In south Kajiado District is situated the Kuku Group Ranch	[29]
Other broader districts are the Kajiado and Narok districts	[10]
Shompole Group Ranch	[4]
Olkirmatian Group Ranch	[4]
The Western edge of the Ilkerin hills was used as a barrier for land encroachment	[9]

Land Use & Land Ownership

Two main concepts related to the Kenyan Maasai land ecosystem are the **domestic** ecosystem and the **wild** ecosystem, while in terms of conservation policy, the aforementioned areas can be classified as **protected** or **non-protected** [10]. The main issue these ecosystems are confronted with is the **functional and structural fragmentation**, leading to multi-layered (social, ecological, economic) system sustainability issues, but also to severe conflicts among the various social groups residing in the broader area, formerly characterized as the Maasailand [10, 27, 30, 31]. Although individualization of land might be related to a phenomenal security and provide additional income to few residents, through land leasing, land subdivision and the consequent land fragmentation often nurture serious conflicts [10, 31].

More specifically, for the study area (Kajiado District) the main land use patterns identified over the last decades are the **pastures**, the **agricultural** land, the **urban** areas and the **wildlife** reserves [17, 32]. During the last 30 years these land use has changed from a sparsely settled pattern, with dominant the grazing lands and forested lands, to a heavily settled pattern, where agricultural cultivations and urban system expand, in detriment to former land use status, and overlooking the basic land use and land management principles of the traditional Maasai societies, leading to serious social dichotomy [9, 10, 12, 14, 27, 33]. Although it is attempted by international organizations to re-define and re-introduce these principals in the current system [34], in an attempt to re-establish socio-ecological equilibrium, turbulences due to land use changes persist [35]. One significant aspect related to these changes, is the steady transformation of the wide **commonly used**, based on the traditional Maasai principles, land, into **individual** parcels of land and fenced areas [12, 14, 36]. Among the Maasai communities, the concept of **sharing natural resources** is not just symbolic, rather it works as a safety net for difficult periods, such as the extended droughts [17]. Consequently, the main land use types (i.e. **agricultural areas**, **grazing land**, **artificial land**, **ranches**, **boundaries**) as well as the ownership status (i.e. **private**, **public** etc), were considered as core components for the current ontological model.

Table 9. Terms related to land use, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Land use			
Term	Explanation	Source	Other Comments
	Domestic ecosystem	[10]	
	Wild ecosystem (wildlife conservation)	[10]	
	Protected areas - Reserves	[14], [10]	
	National Park	[12], [10]	
	Game reserve	[12], [10]	
	Amboseli ecosystem	[10]	
	Nairobi National Park	[11]	
	Tsavo National Park	[11]	
	Masai Mara National Park	[11]	
	Samburu National Park	[11]	
	Non-protected areas	[10]	
	Structural / functional fragmentation	[10]	
	Fenced irrigated agricultural areas	[21]	
	Greenhouses growing flowers	[11]	

emparnati	Permanent grazing settlement land use system	[10]	
enkaroni	Seasonal grazing settlement land use system	[10]	
	Land scarcity	[12]	
	Extensive / Intensive pastoralism	[10]	
	Sedentarized agropastoralism (herders settle permanently)	[10, 24]	
	Nomadic pastoralism	[9, 17, 27, 37, 38], [10]	
	Fragmentation (of pastural areas)	[10]	
	Swamps	[10, 21, 22]	
	Inhabited areas (artificial areas)		

Table 10. Concepts related to land use, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS – Land use	
Concept	Source
In Shompole/Olkirmatian Group Ranches , the ecological conditions permit rainfed irrigation of cash crops	[4]
Grazing areas are decreasing while fragmentation of these areas increases	[14]
Amboseli National Park is surrounded by six communally owned group ranches	[11, 21]
sedentarization, subdivision and the reduced pastoral land-use has resulted in a spatial separation of ecosystem processes and the removal of livestock grazing and settlement creation from certain areas of the landscape	[10]
Emparnati settlement zones evolved adjacent to newly installed local infrastructure, services, and/or other key resources (e.g., roads and swamps)... and attracted additional services (e.g. shops, grain mills)	[10]
Maasai Mara National Reserve is an unfenced area of ~1500 km ²	[14]
Mara National Reserve (MMNR) is grazed 99 % of the days during the drought and 70 % of the days in the wet season	[14, 17]
Herders now graze their cattle in the park at night	[16]
Loita Hills and plains around were used in the past as wet-season pasture	[9]
The Rift Valley was used in the past by British for farming	[9]
The Mount Kenya was used in the past for settler farming	[9]
During the last 30 years land uses in Kenya have changed from sparsely settled (shrublands and forests), to heavily settled (cultivated and urbanized)	[33]
Three western swamps at the base of Kilimanjaro highlight the effects of segregation compounded by land-use intensification	[10]
Some small-scale maize cultivation may be practiced immediately around bomas, but this is not generally a feature of ranch areas close to MMNR, due to the risks of crop-raiding by wildlife	[28]
Inhabited areas - very densely populated Kisii and Kericho districts - these settlement patterns show that permanent housing is encroaching southward	[39]
National Reserves caused permanent loss of access to key forage and water resources for local herders	[10]
Kilimanjaro and Chyulu Hills are reserve grazing “banks”	[10]
Three western swamps at the base of Kilimanjaro highlight the effects of segregation compounded by land-use intensification	[10]
Swamps are important for humans (for agricultural and domestic water use), livestock (as grazing reserves), and wildlife (for forage and water).	[10]
Large swamp areas have been converted to agriculture, resulting in significant conflicts over water management and grazing in reserves.	[10, 16]
Olopololos grazed in dry period	[12]

Table 11. Terms related to grazing-related areas, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Grazing-related areas			
Term	Explanation	Source	Other Comments
ol-alili	gazing field set apart for calves	A	
ol-alili orng'arua	Reserve in swampy area grazed only in dry season	[40]	
nembirika	basin grazed during wet period	[40]	
endonyo			
nadosoito	grazed in wet period	[40]	
ebalbal	grazed in wet period	[40]	
engusero	valley of arid scrub grazed in		
ondinyika	dry period	[40]	
oit ekituma	grazed in dry period	[40]	
oloudo	upland grazed in dry period	[40]	
ol-aleli	Enclosure set aside for calves to graze. This is outside of the enk-áŋ , and is enclosed by thornbushes. It may be 1 x 6 km or bigger	A	
	pasture	C	
oloshon	largest grazing unit	[8]	

Table 12. Concepts related to grazing-related areas, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Grazing-related areas	
Concept	Source
During dry season, many animals are kept near the enkang	[9]
During dry season herders have to lead animals in long distances to water them. Elder participate in herding during this period as well.	[9]
Grazing orbit /herding orbit - the path that cattle circumnavigate from their enclosures to grazing and water resources and back to their enclosures in a grazing day	[20, 26]

Table 13. Terms related to agricultural areas, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Agricultural areas			
Term	Explanation	Source	Other Comments
shambas	cultivated plots	A, C	
enkurma	garden field	A, B, C, [9]	
ol-campa	individual parcel of agricultural land	A	
e-mukunta	cultivated garden field	A	
	farming land /farm	C	
em-paret	field - garden	A, C	C-(?) emparet?
ol-ale loo nuesi	game reserve	A	

Table 14. Terms related to land ownership, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Land ownership			
Term	Explanation	Source	Other Comments
Green cards	this is a kind of indication for official land ownership	Unofficial source	
	Exclusion is a prime theme in group ranch subdivision	[12]	
	Initially Maasai herders supported ranch subdivision	[12]	
	Land Tenure - Land rights – title deeds	[11], [12], [10, 32]	
	Communal Land	[12], [10]	
	Individual ownership	[9], [12], [14]	
	Land grab	[12, 38]	
	Eviction of unauthorized settlers	[12]	
	Chasing of non-ranch members	[12]	
	Failure of collective decision making relate to land management	[12]	
	Individual ranchers are seen as menace to group ranches	[12]	
	Individual ranchers represent land grab	[12]	
	Fenced grazing areas only for individual ranchers - olopololis	[12]	

Table 15. Concepts related to land ownership, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Land ownership	
Concept	Source
Legal land tenure rights - title deeds [11, 32] - Massai viewed legal land titles as a means of securing their land from encroachment by immigrant farmers ,but that proved elusive	[11, 32], [12]
programs, Kenya titled much of the common land in the semi-arid regions to individual owners, usually in 5 to 10 hectare plots for small holders growing maize and other market crops, especially in Kajiado and Narok districts	[11]
High potential land on the mountain slopes was allocated to prominent individuals as Individual Ranches (IR), and most were quickly subdivided and sold to immigrant farmers.	[32]
The majority of the Maasai remained in the savanna lowlands where Group Ranches (GRs) were created that were based on traditional grazing areas and boundaries drawn to enclose sufficient wet and dry season water and grazing resources	[32]
Privatization into smaller individual holdings is for the registered members of the group ranches. Registration was stopped in the early 1980s, when most of the registers were closed	[36]
Rich herders were against subdivision - large herds could not be sustained under smaller sized parcels	[12]
Subdivision was expected to favor poor herders - they would lease excess pastures to the rish and milk their animals	[12, 17]
In the whole of Narok District, over 50,000 hectares of the subdivided land has already been sold to peasant farmers	[36]
corridors to water point /salt licks/ utilities (dips) were privatized after land individualization	[36]

The trend in 2000 was greater mobility in both subdivided and communal group ranches, but movement was towards unfragmented areas - importance of maintaining these "intact" areas for people and livestock within the system.	[10]
Conversion from Communal to individual land tenure (Land privatization)	[12], [14], [10]
Official division of swamp areas into private parcels	[10]
Inordinate expenses of individual parcel management	[12]
Masai fear that ranch establishment is more for the purpose of land grabbing than for efficient land management	[12, 38]
Right to ownership usually have adult married men, but sometimes woman might have some rights as well. Although woman might not be the owner, she might have control of resources (i.e. the stock)	[9]
Power relates to accessing resources, and resources are largely in the control of the adult married man	[9]
Woman and moran are less powerful in the Maasai society, because they do not control resources	[9]
private tourism and conservation groups lease land from pastoralists who have recently received individual title deeds from the privatization of former communal land (i.e., group ranches)	[17]
Conservation areas are often predicated on the assumption (implicit or explicit) that land is to be exclusively used for wildlife conservation and tourism purposes (Thompson et al. 2009). Payments are disbursed to pastoralists if the land is not used by domestic livestock.	[17]
that pastoralists around ProtectedAreas are negotiating a new, indeed transformed, pastoral landscape	[17]

Soil- Land, Land characteristics, Land formations,

Swamps, mountains, hills and rivers suggest key functional system and spatial perceptiveness components. The quality of the land and the soil types are included in the current model as well, since they provide different potentials to natural resources availability and consequently to land use potential [15, 31, 32]. The potential of land use, especially as a grazing land, determines the movements of the Maasai pastoralists and therefore the locations that are going to be used as permanent residences.

Table 16. Terms related to land and soil, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Land - Soil			
Term	Explanation	Source	Other Comments
en-kop	ground - earth - soil, land, field	A, B	B – en-gop (land - earth)
en-derit	ground	B	
en-kulukuoni	soil	A	
en-kuruma	plot of land	A	
e-dupo	plot	B	
o-sanyai	sand	B	
em-boliei			
em-bulioi	Clay soil	A	
	Volcanic soils	[32]	

Table 17. Concepts related to land and soil, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Land - Soil	
Concept	Source
Volcanic soils very fertile	[32]

Table 18. Terms related to land characteristics, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS – Land characteristics			
Term	Explanation	Source	Other Comments
paga	communal restricted land	A	
orpora	degraded restricted land	[40]	
orkoita	non-degraded grazing land	[40]	
ngulupo	heavily grazed areas	[40]	
lanata	flat country - treeles, plane-desert	A	
anata	Plain, desert, flat country	A	
onata	Plain, flat open country, wilderness	A	
n-kisiacata	treeles plain	A	
mula	Treeless plain, esp. where there is salt up to several centimeters deep on the ground	A	
nakurro	Bare grassless place	A	
orng'arua	swampy area - The soils are greyish in color with high salt content	[40]	
En-kusero	swampy ground	A	
I-kees	Arid land, desert	A	
Ol-purkel	Arid land, desert	A	
natet	Semi-arid land	A	
I-kárjáj	desert	A	
em-pusel	desert	B	
Il-mwateni	desert	B	
e-or / i-ori	dry plot	B	
en-atini			
eng-atini	stony	B	

Table 19. Terms related to land formations, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Land formations			
Term	Explanation	Source	Other Comments
endonyo nadosoito	red mountain - for grazing in wet period	A, C	
en-doinyo n-dónyío	hill	A, B, C	3 – the concept of hills exists also in sketches but without local term, however, there is a local term for the mountains (oldonyo)
ol-melíl	Small spur or range of hills	A	
e-marti	cliff	B	
ol-dóinyío	mountain	A, B, C, [15]	3- oldonyo:mountains odonyo orok? oldoinyo orok? ordonyo orok?
lo-doinyo le'ngima	volcano	B	
ol-manie	Surroundings - Perimeter; of a dam, river, mountains (ie. foot of mountains	A	
ebalbal	crater - grazed in wet period	[40]	
fanya juu	natural terracing structures	[41]	
ololukoti	The name means a high table land – High mountain flat on top. The	[40]	

	landscape is used both for grazing and settlement. Indigenous vegetation includes: Tondoluan and Esisinet		
enk-ashepani	small ravine or gully	A	
ol-baata	crack - gully	A	
ol-buaa	swamp - artificial or natural depression on the ground	A	
ol-are	swamp	A	
I-orrian	swamp	A	
ol-corro	dam		
ol-duroto	dam	B	
esilante	Swamps /marshland	C	
ol-baan	dry riverbed - seasonal river	A	
ol-keju	Small river, brook – river either permanent or seasonal	A, B, C, [10], [20]	B – ol-geju – river C – orkeju C – enkeju
e-guaso, ol-geju o-riet ol-mwipo ewaso	river	B, [15]	[15]– ewaso-water ways
I-baa	Stream of water, rivulet	A	
nk-apune	cave	A	
ol-baata	A long narrow depression in a surface; crack, eroded gully , ditch, channel	A	
n-damata	Slope of a mountain, hillside , face (of mountain)	A	
enk-oshoke	Slope of a hill	A	
I-mari	Slope of a hill	A	
osopuko	highlands	[15]	
e-marti	Upwards sloping land	A	
ol-dama	hillside	A	
I-dankal	Open location with no tree or house to hide in	A	
en-dapdapoi	rock	A	
o-soit	rock	A	
n-doroto	Bare ground	A	
ol-pura shenai opir	Bare ground Rocky outcrops	A, [15]	
en-gumotisho	Land depression: valley, ditch	A	
en-gumoto	Hole, esp. in the ground	A	
oyerata agarata	Valley	A, [15]	[15] – agarata or oyerata - marshes
olpurkel	Dry lowlands	[15]	
em-pukuroto	valley	A	
en-nongoto ongata	valley	A, B, [15]	[15] - ongata-plains
negum	valley	A	
e-ululu	Cave (or valley)	A	
I-karjaj	Wasteland, desert	A	
I-karrkarri	Stony place, gravelly area	A	
I-kuran	island	A	
I-orúko	High ground, as between watercourses; watershed, divide	A	
olosho onyokie	Plateau which is red	A	

o-subugo	plateau	B	
e-uluku			
ol-lumwa	pit	B	
em-bout	trench	B	

Homestead and homestead components

The nomadic way of living of the Maasai pastoralists gives the homestead a very particular role. Different kinds of permanent or temporary homesteads based on the used material but also based on the role they serve and the family member that resides in them, were enlisted in current ontological model. Characteristics of the human and animal homesteads, animal enclosures, as well as their main components provide important spatial information and were incorporated into the ontological model.

Table 20. Terms related to homestead, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Homestead			
Term	Explanation	Source	Other Comments
bomas*	Households, small collections of huts, homestead	A, C, [7, 26, 28, 36, 42], [19], [14, 17]	C – homested [42]– boma (Swahili) = enkang (Maa)=domestic settlement
kraal*	Settlement surrounded by thorn bush fences	A, B, [28]	[28] - ‘kraal camp’ for permanent or semi-permanent settlements.
enkang*	for people and cattle	A, B, [11, 28, 42] [9]	B – eng-ang – ing-agitie (kraal) – home [42] – boma (Swahili) = enkang (Maa)=domestic settlement [9] - village, settlement, home [11] - engang – homestead [28] - boma = enkang
ol-campa	ranches	A, C, [11], [39], [4, 41], [12]	A - A parcel of land that an individual owns and has a title deed for. [12] - only the term ranch
ol-kaji	huge house	A	VS enkaji (?)
Enkaji / enkajiji	house for wife [4] - in polygamous families each wife has her own house	A, B, C, [4]	B – eng-agji (house or hut) B - e'ngaji C – enji (?) /enkaji - enkajiji
house-top en-topij em-barnat e'ngaji	house	B	
olalasho	house for girls (?)	C	
	workers'house	C	
emanyata (pl. imanyat)	kraal for warriors	B, C, [28], [36, 39], [9]	C - manyattas (houses) [28] - Manyatta' is the Maasai word for the (generally unfenced) settlements of the warriors (Maa pl.: il-murrani), but has reached common usage to refer to any Maasai settlements with permanent or semi-permanent huts. [9] – emanyata: ceremonial village
	Youth house	C	
olmarei	normally means family but has also the meaning of household	A, [4, 5, 8]	[8]- household
enlwji	house made of dung and mud	A	

	mixture		
mabati	building with iron roof	A, C, [39]	
im-barnati	House out of stone (permanent)	B, [12]	
ol-ngobori	Hut out of skins	B	
en-gitagata	hut where elders meet	B	
osinkira	hut built <i>in emanyata at eunoto</i>	[9]	
	Temporary, Seasonal camps	[5, 20, 42]	

Table 21. Concepts related to homestead, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Homestead	
Concept	Source
The internal arrangement of houses also suggests variation between the sections. From the data available, the relative positioning of the beds to each other, and the orientation of the house relative to the central area of enkang' (village; pl. inkang'itie) appears to vary by section (clan)	[9]
Temporary camps , distant from permanent settlements are used to host herders and livestock during drought. [20] -These areas are usually close to National Parks and ProtectedAreas	[5, 20]
Each Maasai family builds a circular corral or boma of thorny branches from acacia trees and locates the huts around the inner perimeter	[28, 38]
Multi-generational households	[10]
in Kenya, enkangs might have a mean size of 2.6 households.... The household in physical terms refers to the collection of houses about a communal gate . The gate carries the name of the man and a separate gate is a symbol of his autonomy as a cattle owner and founder of a family	[4]
Several polygamous extended families (3–12 households, 10–50 people) live together in domestic settlements in order to share labor for herding and to protect the herds	[42]
Number of houses per settlement tends to decline	[10]
Larger settlements reflect larger traditional social and labor-sharing units (e.g., Lenkisim, Emeshenani and southern Eselenkei)	[10]
Temporary settlements (seasonal cattle camps, warrior encampments, meat-feasting sites)	[42]
In typical settlements houses are circularly arranged around a central cattle enclosure. The entire settlement is ringed with thorn fence. Central enclosure is surrounded by smaller livestock enclosures.	[42]
Each adult male has his own gate in the perimeter fence and the house of his first wife is to the right of this gate.	[42]
Wife's house has average 6x3x1.5 m. In this house live the woman, her children and young livestock	[42]
Wives' houses are made of a mixture of ash, cattle dung, and mud over a wooden frame	[42]
Men's house is usually under a shady tree, within 15m from the settlement.	[42]
manyattas are more widely distributed in the lower parts of the Mara region. There are more manyattas observed in Siana, followed by Koiyaki and Olkinyei where pastoralism is still strongly practiced	[39]
more grass-thatched houses in Oloirien group ranch where people are more sedentary	[39]

Table 22. Terms related to homestead components, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Components of homestead

Term	Explanation	Source	Other Comments
en-gishomi in-gishomi	door, gate	B, C, [42]	C - kishomi (gate)
ol-gerenget – il-gerengeti en-gikatata – in-gikatata	fence	B, C, [9], [7, 10, 15, 42]	C - en-kikarata
	Wind break	[9]	
ol-lengati	yard	B	
ol-tiren en-geberi	roof	B	
ol-gelata ol-pasne ol-marei	room	B	
e-hima	tent	B	
ol-ohurie en-gitagata	shelter	B	
en-guruma – in-gurman en-kurma ol-cjambai - il-chamba	garden	A, B, [9]	A - en-kurma: garden-field A- ol-campa: cultivated garden-field B - en-guruma – in-gurman ol-cjambai - il-chamba [9] – enkurma: fenced area for cultivation, flour.
	Fireplace	C	
	Father's bed	C	
	Mother's bed	C	
	Place for firewood	C	
oldiret	a packing frame closing the entrance of the woman house	[9]	
boo	area inside fence of enkang but outside the house	[9]	
oltiren	central area in house	[9]	

Table 23. Concepts related to homestead components, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Components of homestead	
Concept	Source
Oldiret is a packing frame closing the entrance of the woman house, indicating that she is sleeping - it is placed on a donkey when a household moves	[9]
Thorn fences enclose animals in the temporary residence, during dry period	[7]
Small thorns are used for internal fencing (<i>Acacia mellifera</i>), large thorns are used for defensive external fence surrounding the whole settlement (<i>Acacia tortilis</i>)	[42]
Two types of gates wide ones for livestock, and narrow ones used for people, and can be characterised as main or secondary	C, [42]

Table 24. Terms related to materials, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

Materials			
Term	Explanation	Source	Other Comments
e-munui	sediment	B	
eng-are	water	B	
	mud	A, [42]	
	wood	A, [42]	

Table 25. Concepts related to materials, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Materials	
Concept	Source
house made of dung and mud mixture	A
Wives' houses are made of a mixture of ash, cattle dung, and mud over a wooden frame	[42]

Table 26. Terms related to enclosures for animals, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Enclosures for animals			
Term	Explanation	Source	Other Comments
	Permanent enclosures – built constructions	[20]	
	Temporary livestock enclosures	[28], [20]	
Bomas*		A, C	C-cattle boma
Kraal*	*fenced enclosures for animals (Settlement surrounded by thorn bush fences)	A, B	
ormwati	thorn bush fence	[7, 28], [20]	
	Electric fences	[36]	
olopololi	Grazing field	A, C,[12]	
Olosingo*	Cattle shed	C, [8]	[8] – oloshon: largest grazing unit
	Milking shed	C	
olokeri	for sick animals or restricted area near the homestead for calves to graze [6, 39] - small family-owned pastures	A, [6, 24, 39]	
ol-girrar	where calves sleep	A	
Ol-aleli	enclosure for calves to graze	A, C, [9]	C- olale (grasses) C-olale (young cattle shed) [9] - Olale – calf pen inside house
olalili ololucoti	calf pasture reserve	A, [40]	
enkang oontare	where sheep and goats stay	A	
ol-muaate	calf pen	A, C, [9]	C-emuataa (goat shed) C- omuatata [9] – emuatata: small-stock pen
omwaiaia	Goat and sheep pen (?)	C	
m-perit	Sheep pen	A	
sum	Sheep pen	A	
em-watata	Young goat shed	C	
	Young cattle/calf shed	C	
	Chicken house /chicken coop	C	

	kennel	C	

Table 27. Concepts related to enclosures for animals, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Enclosures for animals	
Concept	Source
Temporary livestock enclosures are used during dry period - they are mainly thorn-fenced enclosures	[20]
Ormwati is a thorn bush fence created for animal protection during the wet grazing period- away from bomas, in the temporary herder residences	[28], [7, 20]
Ormwati - temporary livestock camps constructed when grazing takes place far away from bomas	[28]
Olaleli is an enclosure set aside for calves to graze. This is outside of the enk-áŋ , and is enclosed by thorn bushes. It may be 1 x 6 km or bigger	A
During evening and night the animals (in Shompole) are kept in the boma , i.e. the place where the people and livestock live . Cattle are kept within the circle of huts and sheep and goats within the inner enclosure .	[19]
Electric fences exist between Mara Game Reserve and individual croplands	[36]
Olopololis are grazing area used only by ranchers in dry period	[12]
Olokeri is a small circular grassy family-owned area, immediately outside the cattle gate, which belongs to the family as long as its members reside in the specific homestead and use it. It is grazed by calves or sick animals. Family has the exclusive temporary privilege to use it.	[6, 39]
Olokeri is a traditional private enclosures for sick animals	[24]
Olalili ololucoti is a calf pasture reserve for settlements located at the bottom of the western Rift wall. The landscape is set aside for calf grazing during the dry season	[40]

Landmarks, Vegetation, Infrastructure

Landmarks and infrastructures, mainly related to water and transportation are distinct characteristics that can provide valuable information related to land recording, and thus were incorporated into the ontological model. Trees and vegetation have also a special role as meeting places (landmarks) or boundaries, while public buildings, such as hospitals, schools or police stations, suggest special constructions which can be used as spatial reference points.

Table 28. Terms related to landmarks, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Landmarks			
Term	Explanation	Source	Other Comments
ol-polosie	Landmark (boundary)	B	
ol-joro – il-joroi en-gitokitok	fountain	B	
o-balbal en-aiposha	lake	B	
ol-balbal en-duroto	pond	B	
ol-are	watering place	B	
En-naiuroo	waterfall	B	
o-singira en-nemirishoreiki	market	B	
ol-duka	shop	B	
ol-tanki	tank	B, C	3 – the concept of tank exists also in sketches but without local term

oti	Tree – meeting point for women	C	
oltepesi	Main tree – meeting point for men	C, [42]	[42]- the tree locates usually 15 m away from the settlement
mugumo tree	Tree specie meeting place tree	C	
	Maasai Mara National Reserve	[20]	
	Talek River (perennial river - in the MMNR)	[20, 26]	
	Amboseli'S swamps	[21]	
	Tsavo National Park	[21]	
	Kilimanjaro Moutain	[12], [10]	
	Chyulu Hills	[10]	
	Amboseli National Park	[21]	
	Namelok swamp	[32]	
	Isinet swamp	[32]	
	Kimana swamp	[32]	
	Rombo perennial stream	[32]	
	Livestock Markets	[10]	

Table 29. Concepts related to landmarks, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Landmarks	
Concept	Source
Livestock Markets were vital to Maasai livelihoods	[10]

Table 30. Terms related to vegetation, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Vegetation			
Term	Explanation	Source	Other Comments
oit ekituma	Acacia forest	[9, 40]	
	forest	C	
omeserani	Baobab plants grazed all year	[40]	
markhamia lutea	plant used as boundary marker - living fence	[41]	
terminalia catappa	soil-conservation structures	[41]	
commiphora hedge	used as plant fence - secure cattle enclosure	[41]	
croton megalocarpus	used as hedge	[41]	
commiphora zimmermannii	used for permanent boundaries	[41]	
tamarindus indica	boundary marker	[41]	
grevillea robusta	for constructions	[40]	
eucalypts	for constructions	[40]	
albizia gummifera	meeting place	A	
en-guruma – in-gurman	garden	B	
ol-cjambai - il-chamba	garden	B	
en-gojit – in-gojita			
o-seyai – i-seya	grass	B	
ol-paiki	maize	B	
ol-piro	palm tree	B	

en-gurma	plantation	B	
en-gwashi	potato	B	
ol-kirataata	shrub	B	
ol-jani	tree	B	
ol-jata	tree	B	
il-gek	tree	B	
en-gurma	vineyard	B	
ol-oikilepo	willow	B	
ol-oirien	wild olive	B	
en-dabogai	vegetable	B	
en-jata			
en-dim	wood	B	
oltim, oltiki	dead tree set outside the enkang	C	
oltepesi	meeting place tree for men	C	
otiti	meeting place tree for women	C	
mugumo tree	Species of tree used as meeting place	C	
	Shady tree	C	
olaisai	<i>Sericocomopsis hildebrandtii</i>	[40]	
	Medical trees	[29]	

Table 31. Concepts related to vegetation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Vegetation	
Concept	Source
Vegetation is used for multiple purposes and plays an important role in traditional Maasai communities	[18], [5, 7, 9, 40-42], [10], [20]
Dominant Vegetation - broad leaf, dry tropical forests and woodlands, grasslands and seasonally flooded plains, riverine forests, halophytic grass and scrubland in the Amboseli Basin, and scattered Commiphora and Acacia woodlands.	[10]
Oit ekituma is Acacia forest grazed in dry period	[9, 40]
Omeserani are Baobab plants grazed all year	[40]
Markhamia lutea is a plant used as boundary marker - living fence	[41]
Acacia woodland is a dominant plant in the study area	[18], [5, 7, 10, 42], [20]
Acacia xanthoploea woodlands within Amboseli National Park collapse	[10]
The pods of Acacia tortilis are some of the most important sources of fodder for sheep and goats in the dry season	[7]
Savannah woodland can be grazed all year round	[9]
Commiphora and Acacia woodlands surrounding the park increased as a result of livestock grazing in the absence of elephants	[10]
Vegetation is used for erosion protection, spatial arrangements (define paths or land parcel boundaries), wind breaks, protection from wild animals, or landmarks (meating places, teaching areas)	[41]
Terminalia catappa is a plant used for soil-conservation structures	[41]
Commiphora hedge is a plant used as living fence in order to secure cattle enclosure	[41]
Croton megalocarpus is a plant used as hedge	[41]
Commiphora zimmermannii is a plant used for permanent boundaries	[41]
Tamarindus indica is a plant used for soil-conservation structures	[41]
Grevillea robusta is a plant used for constructions	[40]
Eucalypts is a tree used for constructions	[40]

Table 32. Terms related to constructions and infrastructure, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Constructions - Infrastructure			
Term	Explanation	Source	Other Comments
	Shop/store	C, [9]	
	Office	C	
	Car parking	C	
hospitali	Hospital	B	
	Dispensary	[9]	
	Police department	[9]	
	Governmental building	[9]	
o-sikul	School (primary school, secondary school, government school)	B, C, [9]	C - the concept of school exists also in sketches but without local term
	Primary school	C	
e'sikul eng-aji	schoolhouse	B	
	church	C, [15]	
eng-oitoi e'segenge EsekenkeiEngarriEnkima	rail road	B	
	trash pits	[42]	
eng-oitoi e-regie	Road	B, C, [12], [10]	C - the concept of road exists also in sketches but without local term
	Tarmac road	C	
	Corridor to water point /salt licks/ utilities (dips)	[36]	
	Home road	C	
	Small path	C	
	Foot path	C	
	Dust road used by neighbors	C	
e-udoto	tunnel	B	
	Infrastructure for water (dams, boreholes, wells)	[12], [10]	
ol-tanki*	Tank water reservoirs /water tank	B, C	C – Water tank for domestic use and animals
	Water base	C	
oltinga /oltinga	Borehole well – common water point for watering animals	C, [5]	
	Cattle dip	[9], [10]	
	Irrigation canals	[10]	
	Tap	C	
	Pipelines	C	
	Electricity cables	C	
	Beacon	C	
	Kitchen	C	
	Toilet /bathroom	C	

Table 33. Concepts related to constructions and infrastructure, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Constructions - Infrastructure	
Concept	Source
Herders are increasingly constrained by a fragmenting landscape of physical	[15]

and socially constructed barriers	
Dams provide the opportunity for intensive grazing	[9]
Livestock infrastructure - stock dip tanks, water points (cattle dip)	[10], [9]
Cattle dip is among the most important infrastructure - people bring their cattles from long distances	[9]
Infrastructure system seems to be still poor in the Amboseli region	[10]
Access of household to services (schools, medical facilities, markets) and infrastructure (roads, boreholes etc) differs, depending on settlement location	[10]
Trash pit (about 1x1 m) are located near the inhabited boma. Every woman's house has its own trash pit, which she uses as long as she lives in the boma	[42]
Wealthier households may be better able to afford investments that improve the quality of herding (Turner 1999a), as well as having sufficient financial reserves to purchase infrastructure or fodder that helps alleviate the effects of drought (Scoones 1992).	[17]
Land privatization has caused access limitation issues to several infrastructure	[10]

Table 34. Terms related to spatial information, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

Other words for spatial information			
Term	Explanation	Source	Other Comments
e-weji*	place / position	B	
e-weji i-wejitin	location/place	B	
en-gidanyata in-gidanyat	fracture	B	
ol-mongoite em-danyidanyata	fragment	B	
te'dokoya	front	B	
ti atwa	inner/inside	B	
ol-gerera	line	B	
en-topiz	point	B	
ol-otoni	omnipresent	B	
ti aulo	outdoors	B	
ti aulo te'ta	outside	B	
te shumata	over	B	
erisio	parallel	B	
en-gitashoto	perpendicular	B	
e-matwa	quarter	B	

Climate

The climatological conditions and the seasonality prevailing in Kenya, and consequently in the specific study region, are the dominant factor controlling human behavior related to nomadic way of living and the land use [9, 10, 17, 27, 37, 38]. Water availability is a limiting factor for the ecosystem functionality, tightly connected to the local population survival. Consequently, the concepts of **dry season** and **wet season**, as well as climatic concepts related to **drought** and **rain** were considered as critical for the ontological model.

Table 35. Terms related to climate, with the relevant explanation, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

TERMS - Climate			
Term	Explanation	Source	Other Comments
orpukel lengoloi	hot arid	[40]	

olameyu	dry season	[9]	
olari	wet season	[9]	
orpukel le-supuko	semi-arid	[40]	
osupuko	cool sub-humid	[40]	
en-deem enoguring	hail	B	
ol-odalu	summer	B	
ol-oirujuruj	winter	B	
en-jan	winter	B	
en-joro			
ol-oitokitok	spring	B	
en-gisuisui	wind	B	
ol-limwa	wind	B	
en-can	rain	B	
eng-ai	rain	B	
ol-oirag le'ngare	flood	B	
	Drought	[12]	

Table 36. Concepts related to climate, and the sources: Dictionary A (A), Dictionary B (B), sketches (C), and literature

OTHER CONCEPTS - Climate	
Concept	Source
Climatic variability significantly affects human life in the study area	[12, 37, 38], [14], [10]
Olameyu sapuk is the big drought, when land becomes very dry and water resources become scarce	[9]

Sketches

Spatial organizations			
Term	Explanation	Sketch ID	Representative sketch
Enkang*	City – area where a family resides	F4, F5	
Homestead /home area bomas*	households / small collections of huts	F8, F15, F16, F17, F18, F23, F24, F25 F2, F4, F5, F6, F11	1- Boma 
Words for homestead			
Term	Explanation	Sketch ID	Representative sketch
House /home		F3, F6, F10, F11, F16, F24, F26, F27, F28, F34, F28, F29, F31, F33	
ol-campa	ranches	F15, F16, F20	
Enkaji / enkajiji	house for wife	F4?, F20	2- ENKAJI 
olalasho	house for girls (?)	F4	
	workers'house	F35	
e-manyata – i-manyat	kraal for warriors	F6, F7, F9, F13, F16, F17, F18, F19, F23, F24	3- E-Manyata 
	Youth house	F35	
mabati	building with iron roof	F7	4- Mabati 
Components of a homestead			
Term	Explanation	Sketch ID	Representative sketch
en-gishomi in-gishomi kishomi	door, gate main-small gate	F6, F7, F9, F10, F11, F13, F15, F16, F20, F25, F26, F27, F29, F30, F31, F32, F33, F34, F35	
	Cattle gate	F27, F29, F35	
ol-gerenget – il-gerengeti en-gikatata – in-gikatata enkikarata	Fence Boundary fence – Rounding fence	F6, F7, F10, F11, F12, F14, F15, F16, F17, F18, F19, F21, F22, F23, F24, F25, F26, F27, F28, F29, F30, F31, F34, F35	
	Fireplace	F13	
	Father's bed	F13	
	Mother's bed	F13	
	Place for firewood	F13	
Enclosures For Animals			
Term	Explanation	Sketch ID	Representative sketch

olopololi	Grazing field	F2, F9, F14, F20	<i>S. Olopololi</i> 
Olosingo*	Cattle shed	F4, F6, F9, F10, F11, F17, F18, F20, F23, F24 F25, F26, F27, F30, F31, F33, F35	<i>Olosingo</i> 
	Milking shed	F35	
Ol-aleli olale	enclosure for calves to graze	F4, F6, F8, F9, F14, F15, F16, F18, F20, F24, F30	
omwaiaia	Goat and sheep pen (?)	F4, F7, F25, F26, F29, F35	
ol-muaate	calf pen		[9] - emuatata - Sheep and goats are kept outside the house in specially built pens (imuatat; sing. Emuatata)
em-watata emuatata	Young goat shed	F6, F9, F13, F17, F20, F25, F30	
	Young cattle/calf shed	F7, F9, F10, F11, F17, F18	
	Chicken house /chicken coop	F28, F29, F31, F32, F34, F35	
	kennel	F31	
Other Grazing-related Areas			
Term	Explanation	Sketch ID	Representative sketch
	pasture	F34	
Agricultural Areas			
Term	Explanation	Sketch ID	Representative sketch
Shambas	cultivated plots farming land /farm	F35 F11, F25, F34	
em-paret	field – garden		
en-kurma	garden field	F31, F33	
Land formations			
Term	Explanation	Sketch ID	Representative sketch
endonyo nadosoito	red mountain - for grazing in wet period		
en-doinyo n-dónyío	hill	F1, F5, F6, F8, F9, F15, F16, F17, F18, F23	
ol-dónyío	mountain		
ol-keju orceju	Small river, brook – river either permanent or seasonal	F3, F6, F8, F9, F11, F15, F16, F17, F18, F26	
Esilante	Swamps /marshland	F15, F17, F18	
Landmarks			
Term	Explanation	Sketch ID	Representative sketch
ol-tanki *	Tank /water tank	F15, F19, F25, F30, F31, F33, F34, F35	
	dam	F6, F15, F16, F25, F27?, F33, F35	
mugumo tree	Tree species / meeting	F25	

	place		
Constructions other than homesteads and enclosures for animals			
Term	Explanation	Sketch ID	Representative sketch
	kitchen	F10, F11, F26, F29, F30, F31, F33	
	Shop/store	F10, F11, F28, F31, F32?	
	office	F11	
	Toilet /bathroom	F18, F26, F29, F30, F31, F33, F35	
	Car parking	F33	
o-sikul	School		
enyarta	Primary school	F1, F3, F9, F11, F25	
	church	F3, F9, F11, F25	
eng-oitoi e-regie	Road	F3, F5, F8, F11, F18, F25, F31, F33, F35	
	Tarmac road	F8	
	small path foot path	F3, F8, F9, F3, F29	
	Home road	F25	
	Dust road used by neighbors	F34	
ol-tanki*	tank water reservoirs /water tank	F10, F11, F12, F19, F25, F30, F31, F34, F35	
	water base	F35	
oltinga /oltinka ontinka	borehole – also common water point for watering animals (?) well	F3, F5, F6, F8, F9, F15, F17, F18, F22, F24	
	Tap (?)	F16, F26, F27	
	pipelines	F26	
	Electricity cables	F35	
	Beacons	F1, F2, F14, F15, F22	
Vegetation			
Term	Explanation	Sketch ID	Representative sketch
	forest	F3, F14, F15, F16, F17, F18, F21, F22, F23	
	Tree / shady tree	F10, F19, F26, F29, F32	
otiti	Tree – meeting point for women	F8, F9, F18, F20	
oltepesi	Main tree – meeting point for men	F5, F8, F9, F12, F20	
mugumo tree	Species of tree used as meeting place	F25	
Oltim oltiki	dead tree set outside the enkang	F5, F7, F9, F20, F35 F4	
Ikiku inkiku	Small trees-branches kept inside enkang,	F7, F9, F20	

	used to close the main door at night		
Orkongil Entipiliwa orngosua	Medical trees	F12	
Society			
Term	Explanation	Sketch ID	Representative sketch
ol-morani moran ilmuran	warrior	F6	
<i>Olk iyioi</i>	<i>Olk iyioi</i>	F6	
Activities			
Term	Explanation	Sketch ID	Representative sketch
	Washing cattle	F11	

Ontologies

In an attempt to develop a system of land recording services, web of concepts related to the spatial features, structures, landscapes and social life of the Maasai communities, was developed. The entities and the relations between the entities of this web are described through the concept of Ontologies, with the Maasai society being the domain ontology.

For the web of ontologies, the used concepts were identified in the Maa language, literature and after direct contact with locals.

Ontologies are consisted of three main components, the Individuals (or instances), the Properties (binary relations among individuals) and the Classes (the concrete representations of concepts) [43].

A class hierarchy is developed always based on the needs of the study. Initially, were created seven main super classes (Figure 1), which were enriched as shown in the following figures.

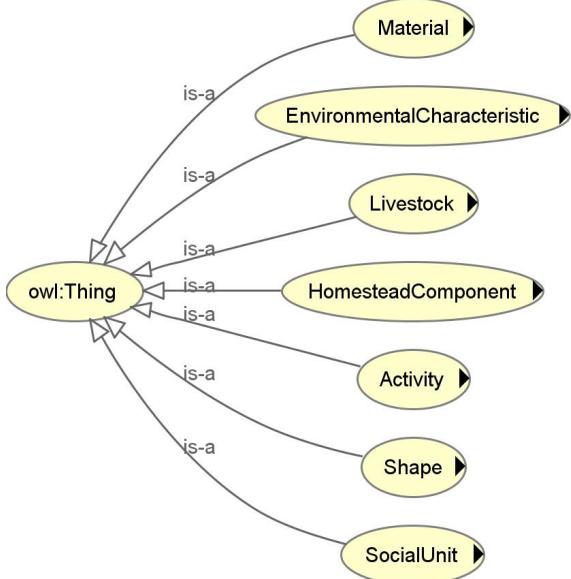


Figure 1. Initial super-classes

The class “Environmental characteristics” is subdivided in three subclasses “Climatic characteristics”, “Land characteristics” and “Vegetation characteristics” (**Figure 2**), each of which has a number of subclasses as well (**Figure 3**). The climate is an important concept since social behavior and activity of the Maasai is based on it [20]. The vegetation capital and the characteristics of the land provide significant spatial information about Maasai communities and land tenure as well.



Figure 2. Super-class “Environmental Characteristics” and its three subclasses.



Figure 3. Sub-class “Vegetation Characteristics” and its subclasses.

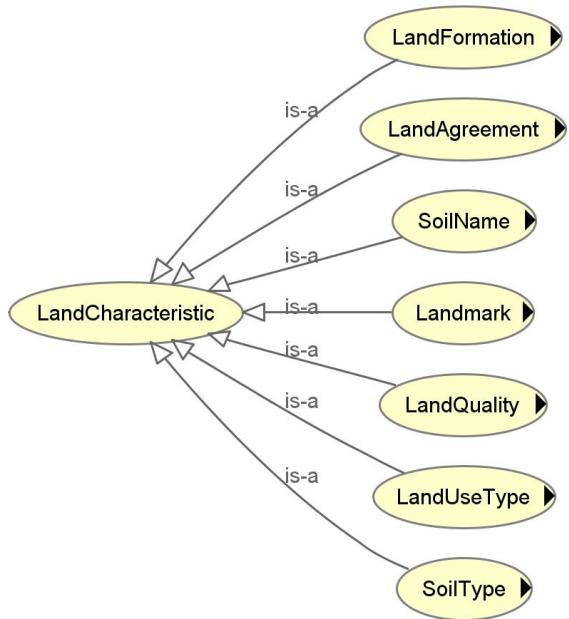


Figure 4. Sub-class “Land Characteristics” and its subclasses.

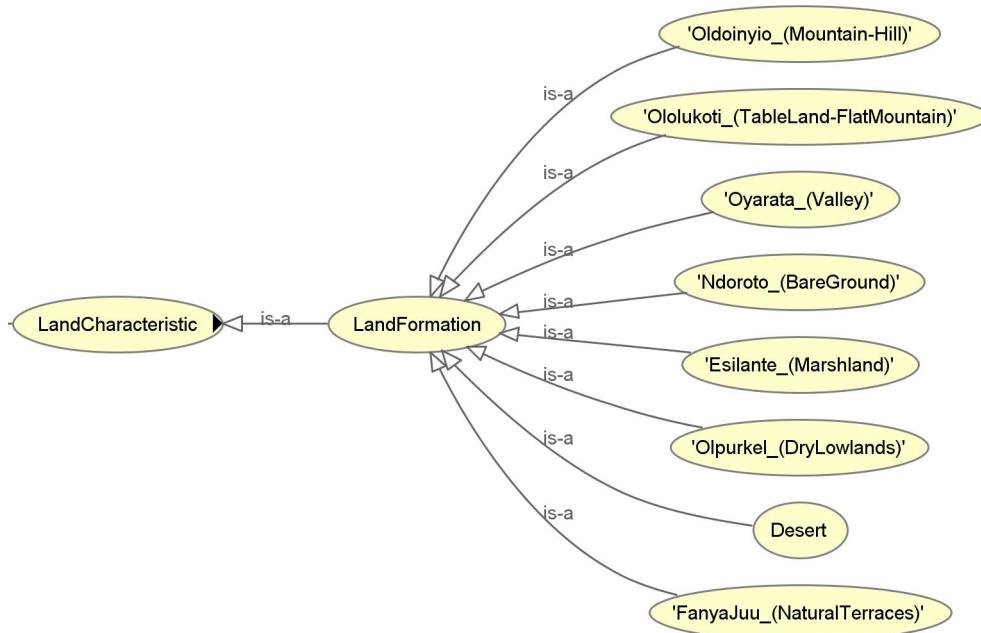
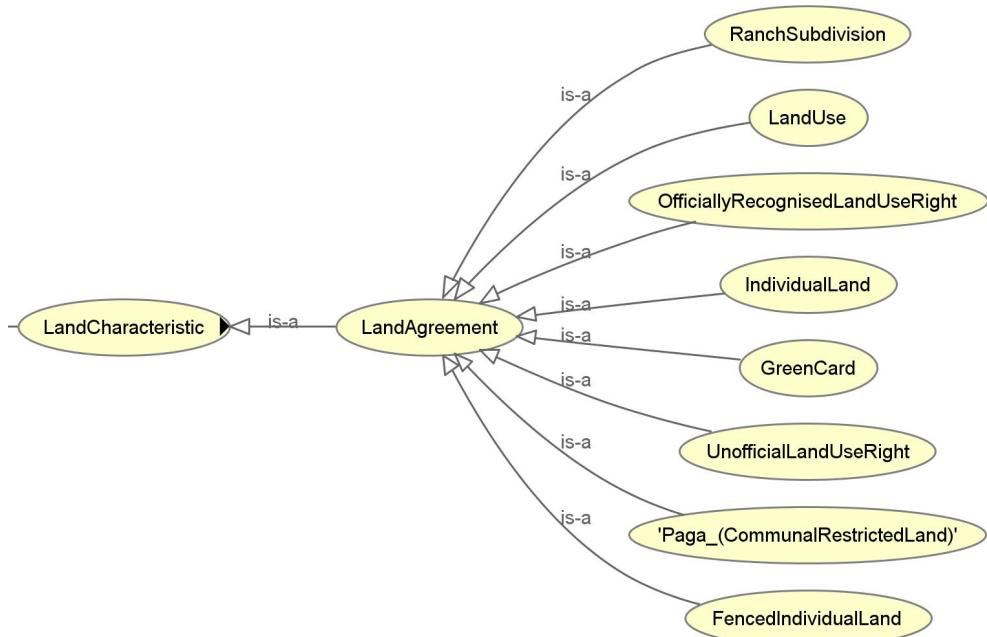


Figure 5. Sub-class “Land Formation” and its subclasses.



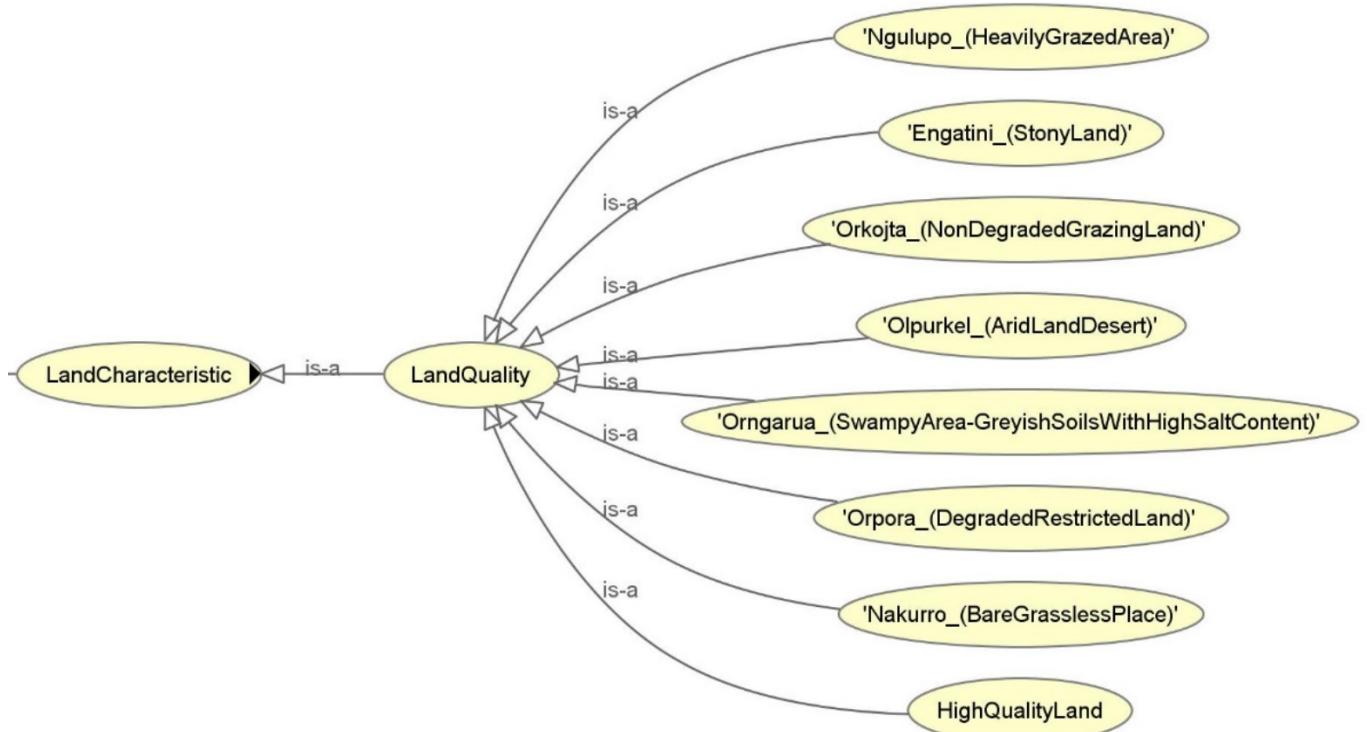


Figure 8. Sub-class “Land Quality” and its subclasses.

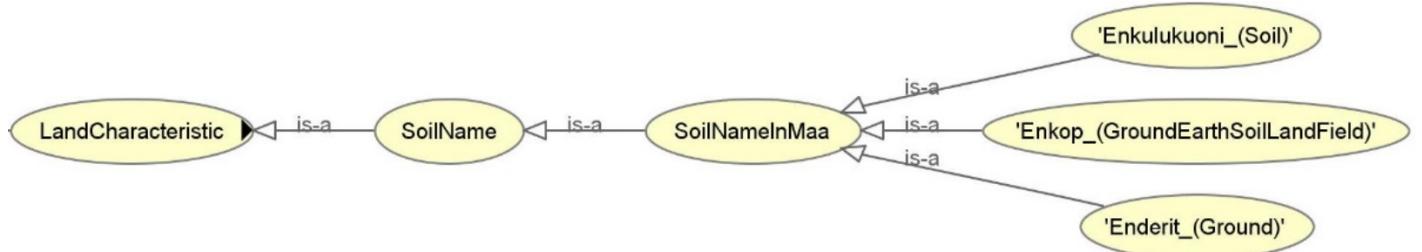


Figure 9. Sub-class “Soil Name” and its subclasses.

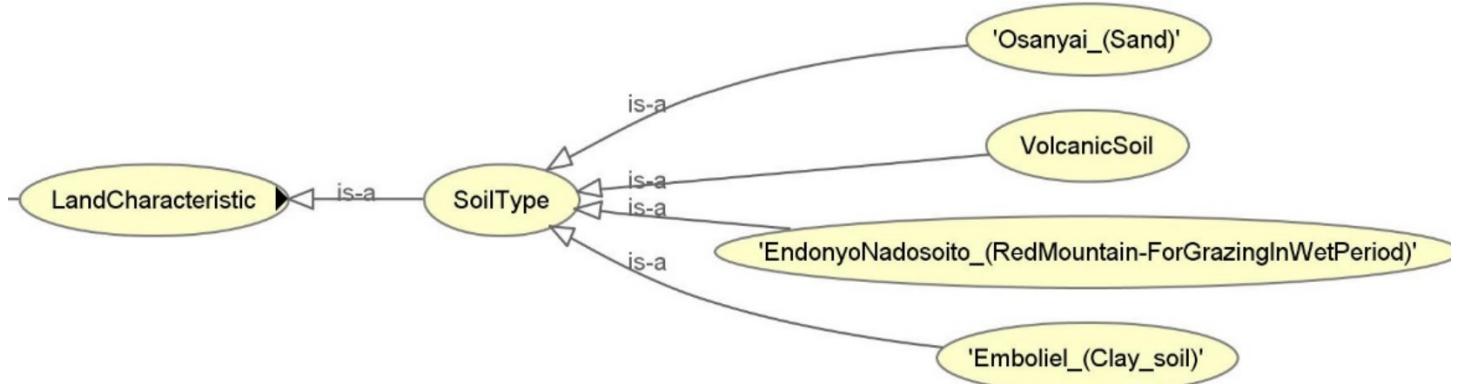


Figure 10. Sub-class “Soil Type” and its subclasses.

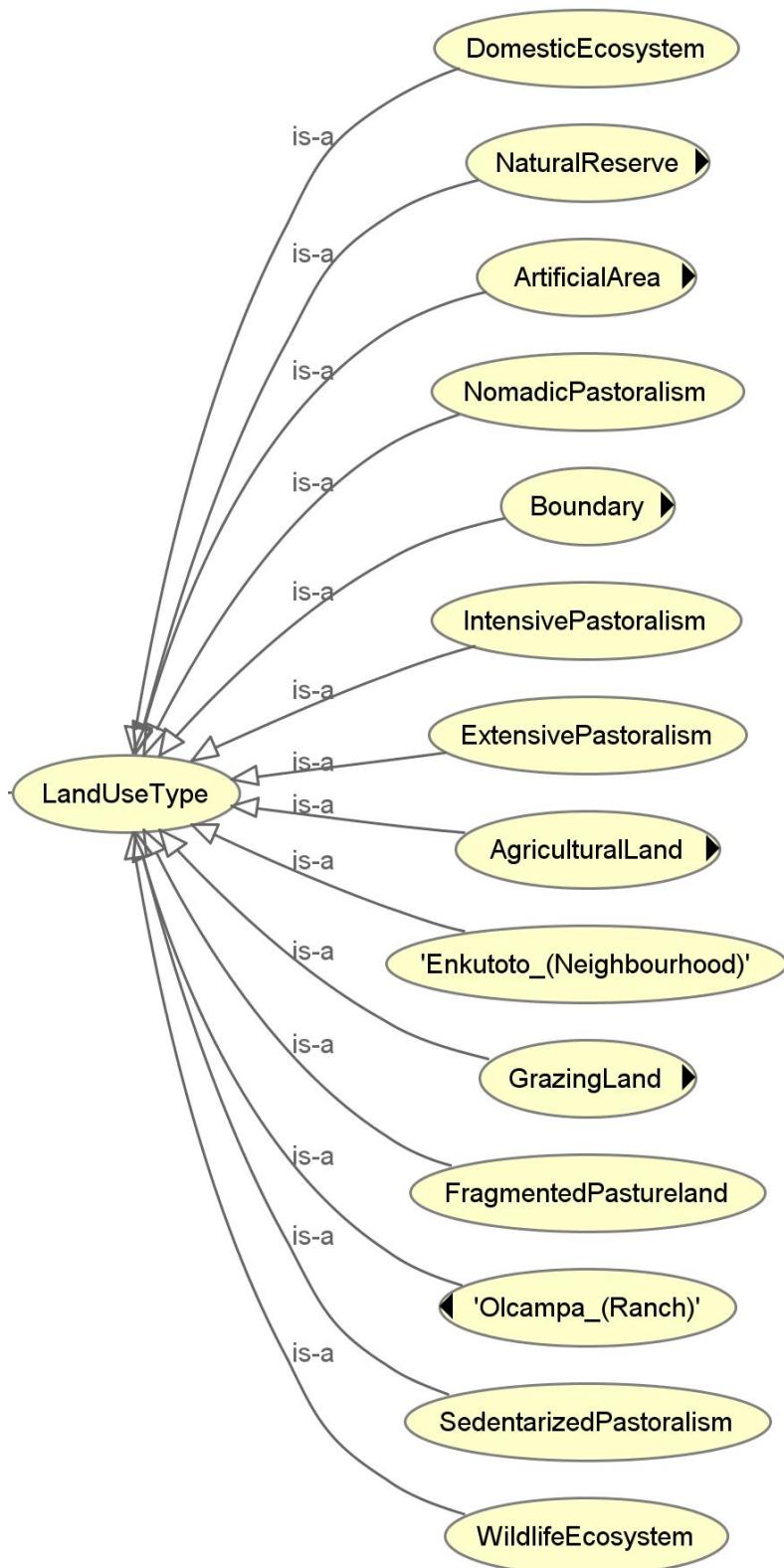


Figure 11. Sub-class “Land Use Type” and its subclasses.

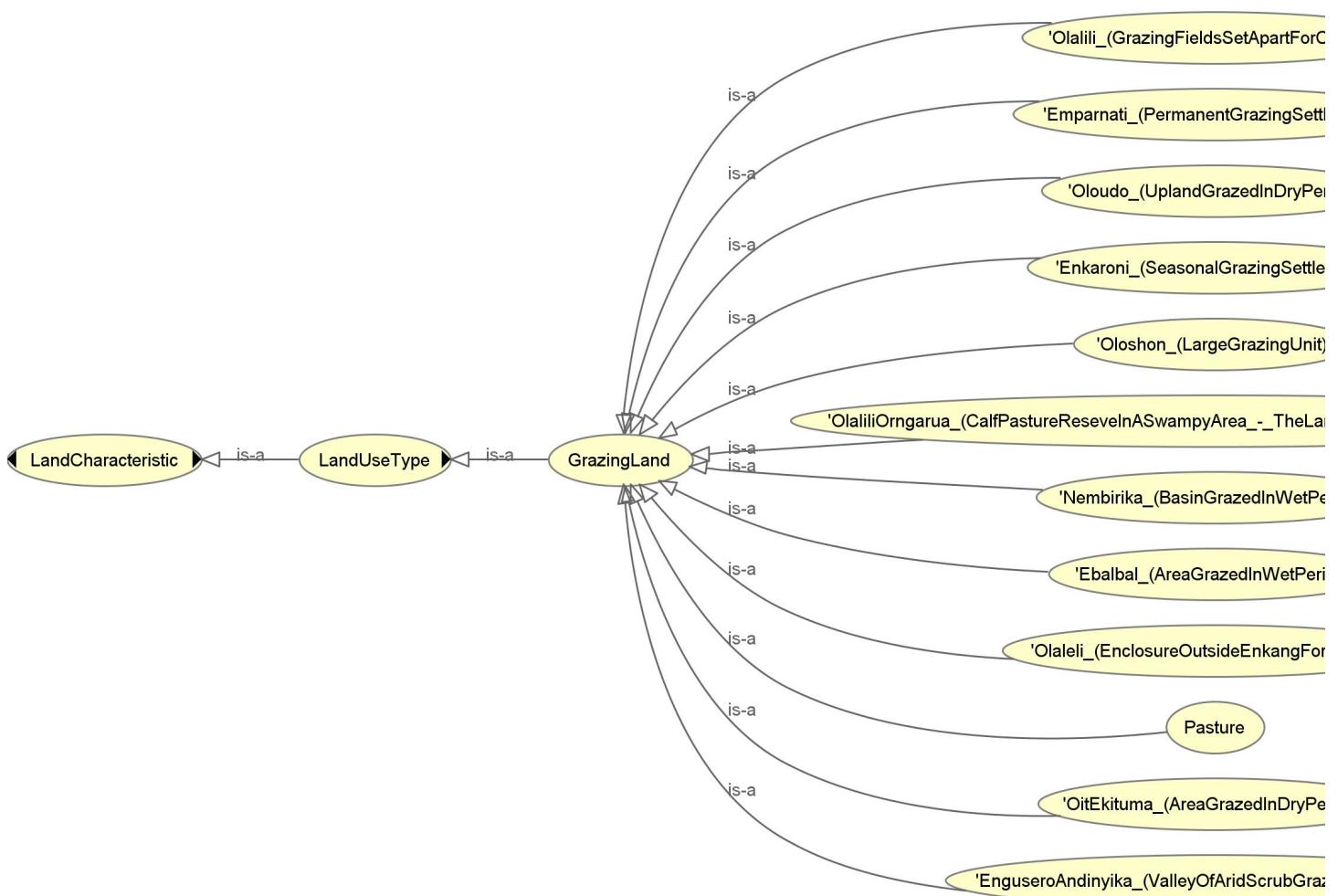
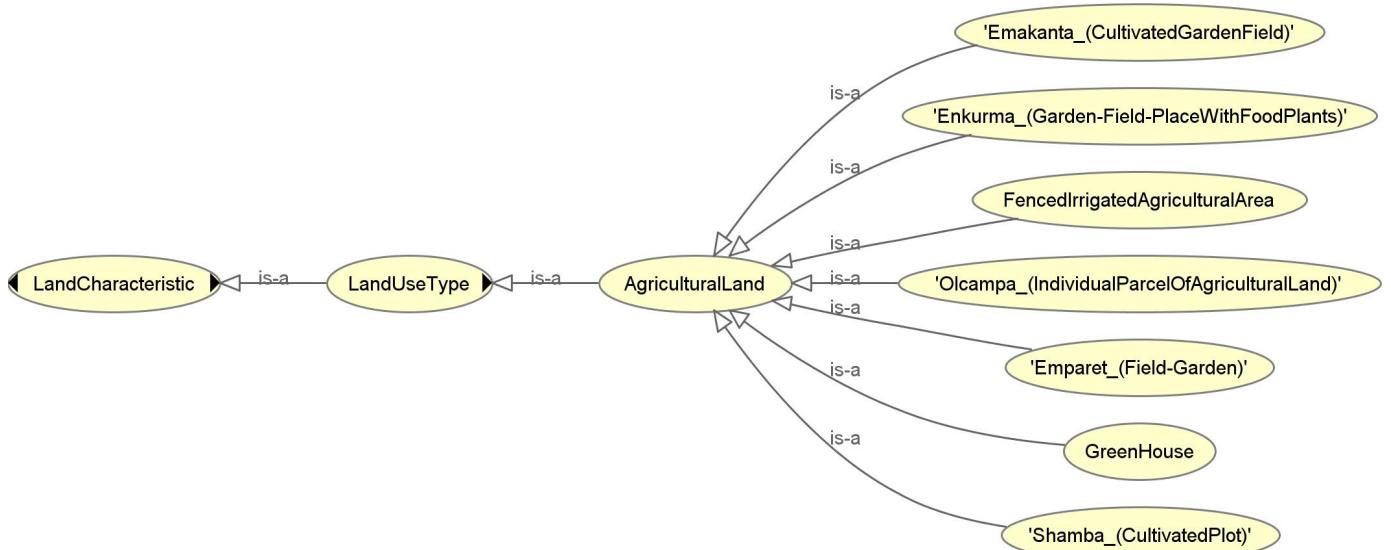


Figure 14. Sub-class “Boundary” and its subclasses.

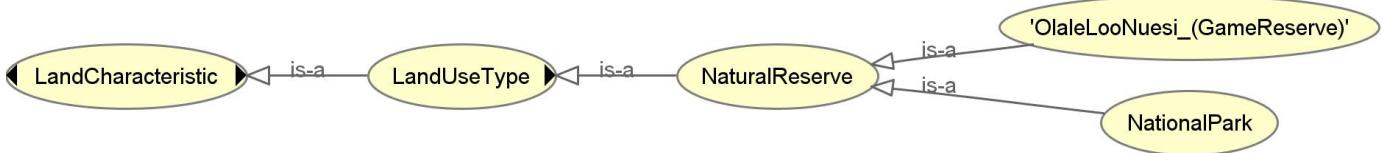


Figure 15. Sub-class “Natural Reserve” and its subclasses.

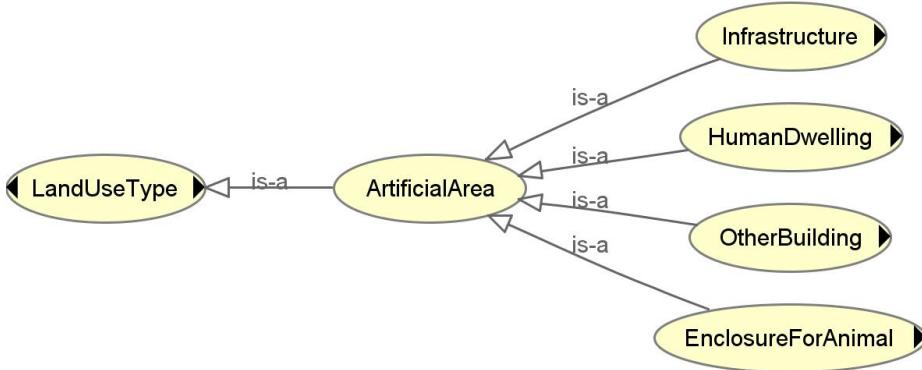


Figure 16. Sub-class “Artificial Land” and its subclasses.

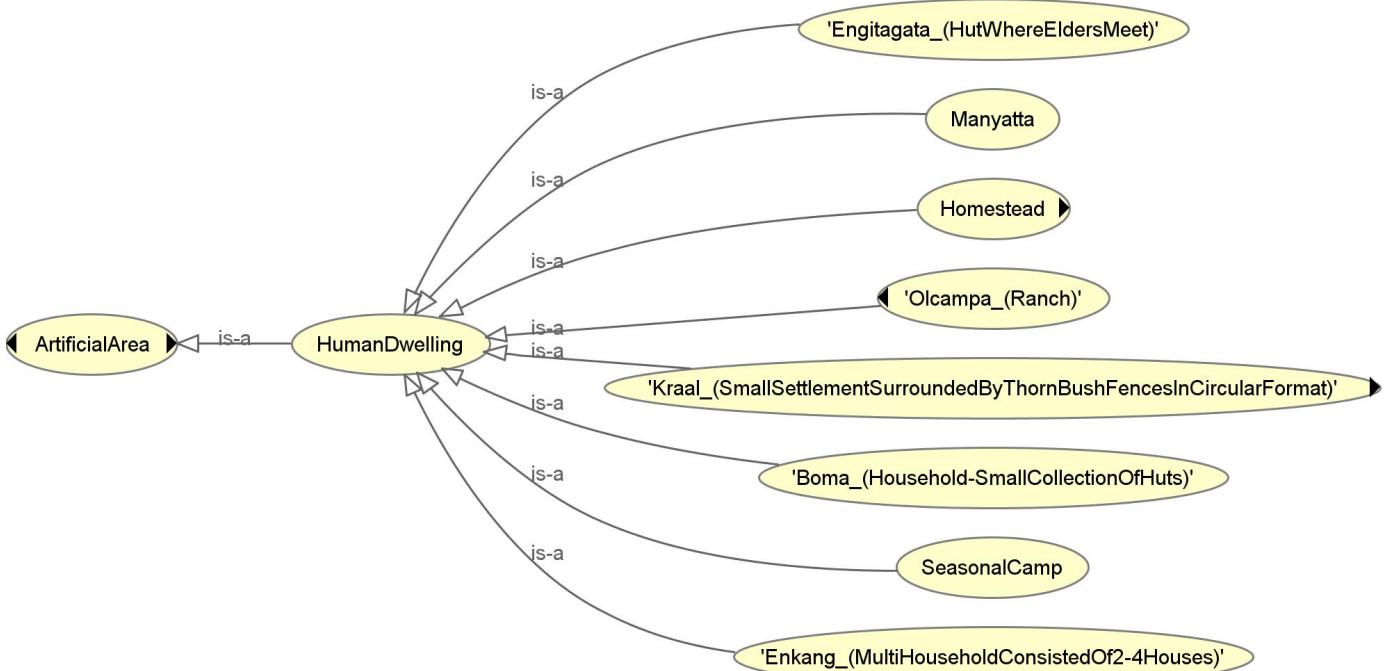


Figure 17. Sub-class “Human Dwelling” and its subclasses.

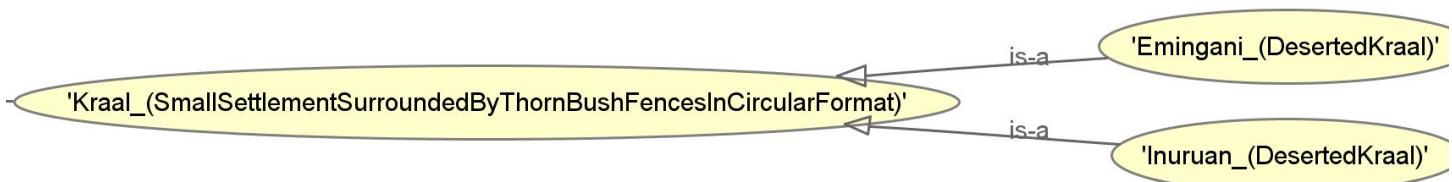


Figure 18. Sub-class “Kraal” and its subclasses.

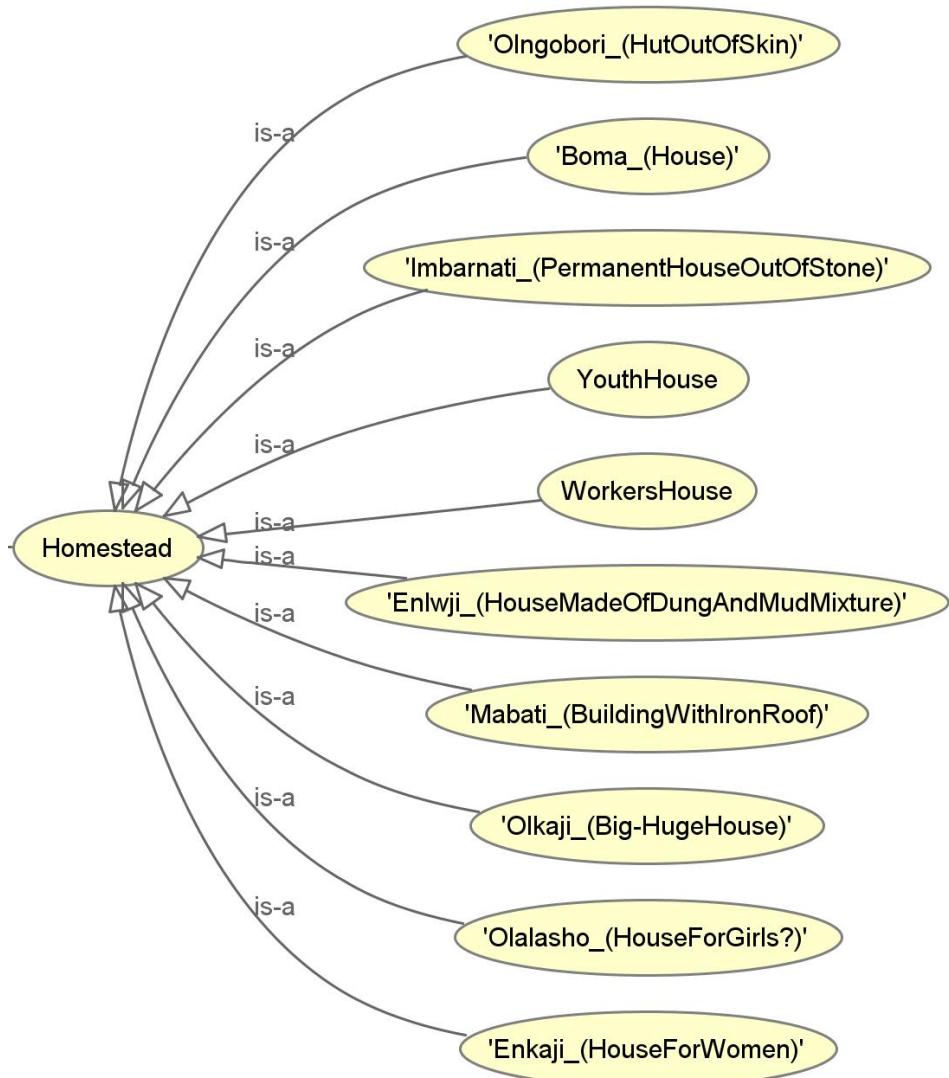


Figure 19. Sub-class “Homestead” and its subclasses.



Figure 20. Sub-class “Enclosure For Animals” and its subclasses.



Figure 21. Sub-class “Infrastructure” and its subclasses.

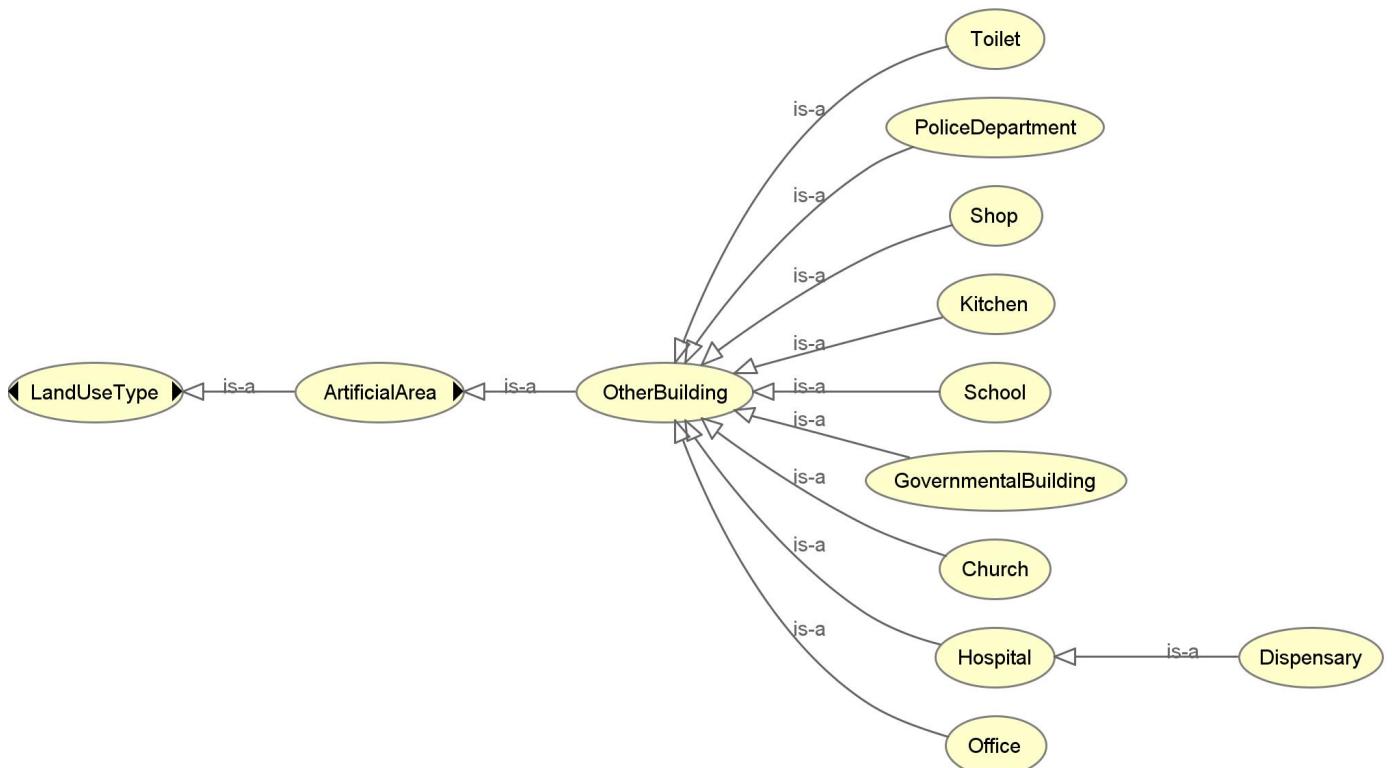


Figure 22. Sub-class “Other Building” and its subclasses.



Figure 23. Sub-class “Social Unit” and its subclasses.

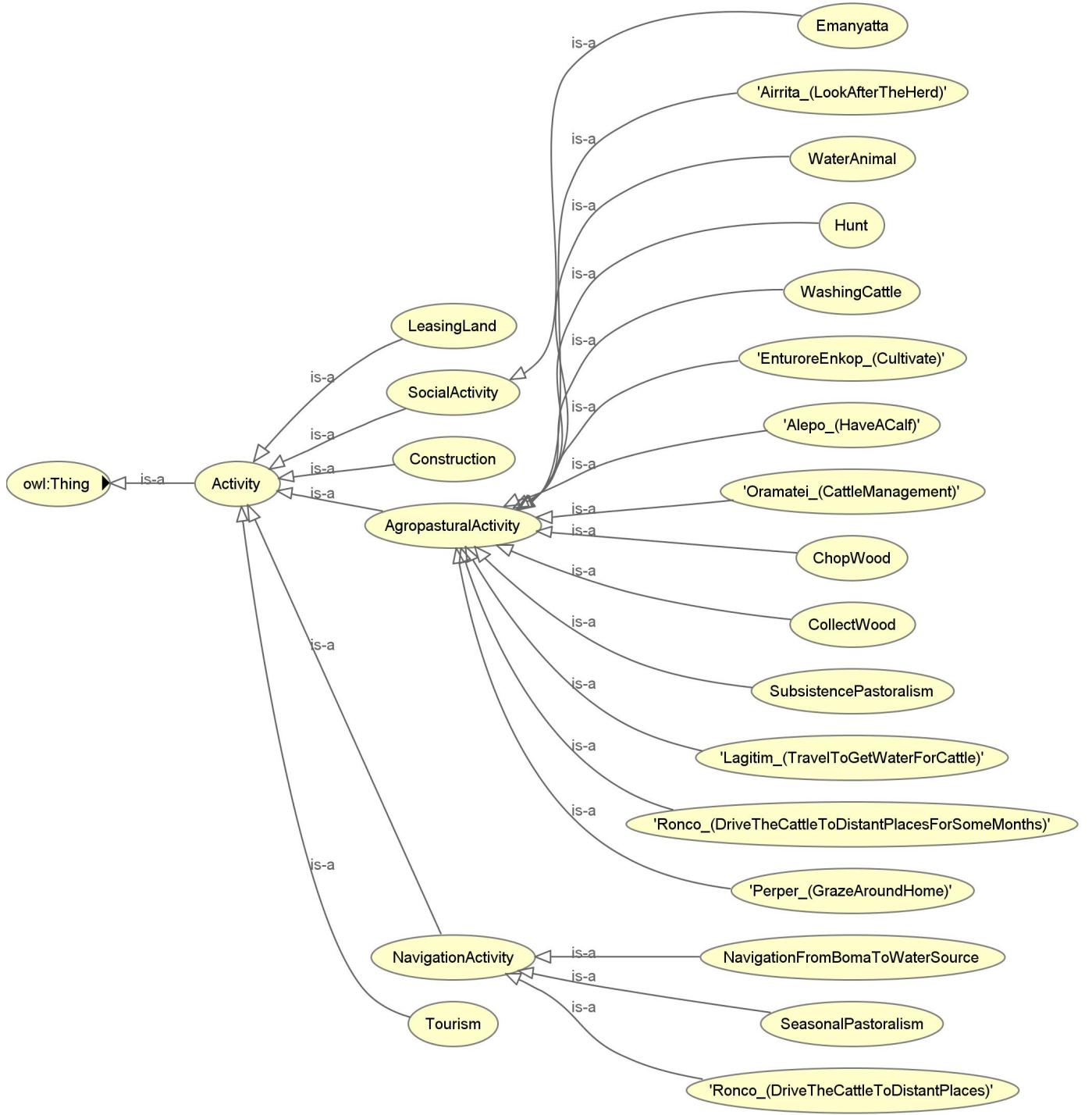


Figure 24. Sub-class “Activity” and its subclasses.



Figure 25. Sub-class “Homestead Component” and its subclasses.

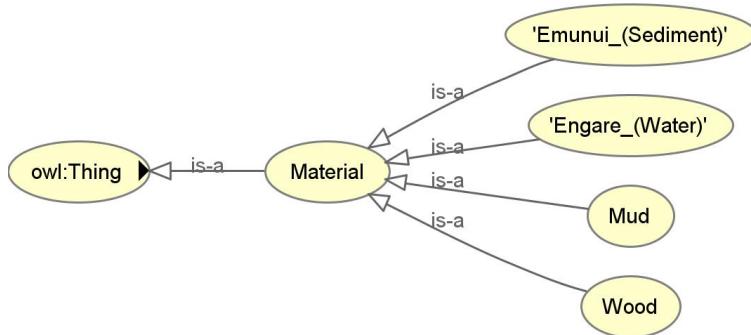


Figure 26. Sub-class “Material” and its subclasses.

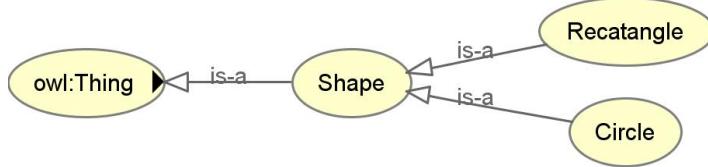


Figure 27. Sub-class “Shape” and its subclasses.

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