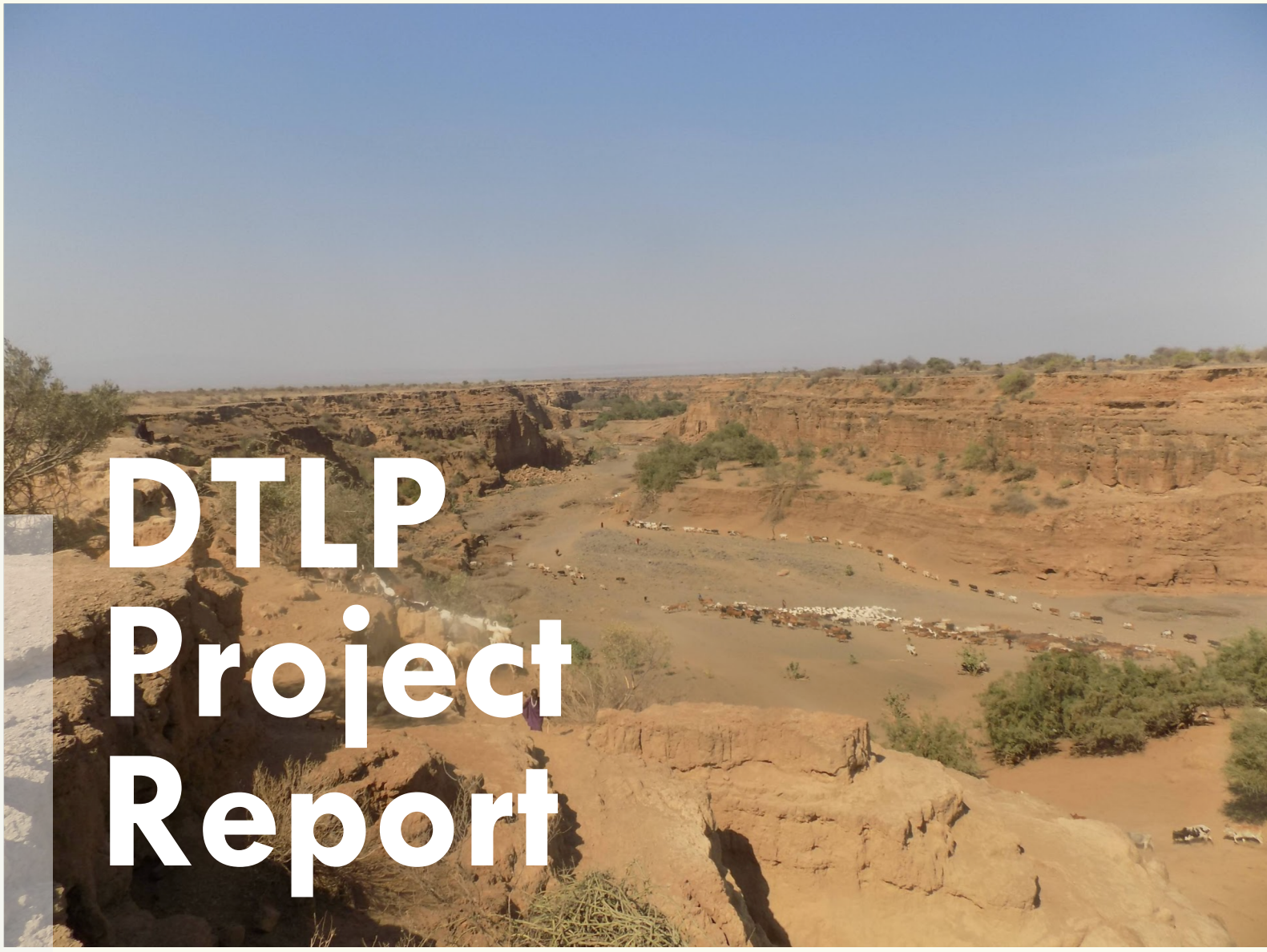

DTLP Project Report

A decision supporting tool for developing community-led land use plans (DTLP) that will allow better management of resources and improve livestock and crop production in sub-Saharan Africa

Gladness Mwanga; Divine Ekwem; Gabriel Shirima; Mizeck Chagunda

Executive summary

The concept of pastoralism is continuously changing in different parts of Sub-saharan Africa. In East Africa, for instance, there has been an increasing number of communities that are in transition between true pastoralism and agro-pastoralism. Greater richness of livestock resources in some areas compared to others create an ideal environment for movements, which is driven by a need to ensure livestock survival (e.g. grazing and watering areas). However, insufficient resource availability to support increasing livestock population numbers for countries such Tanzania, has been the biggest constraint to productivity and performance. These changes have mostly been attributed to reduced access to rangeland grazing and water particularly, in extreme weather condition such as drought. Pastoralists have been forced to adapt their migration patterns as a direct response to these challenges, to ensure livestock survival and livelihood. Hence, understanding these migration dynamics is crucial first step towards the development of a sustainable livestock system.

Currently, there is a major gap in information regarding livestock movement, availability of resources, and how their resources have been used, despite their importance to support agriculture sustainability in resource-poor settings. Therefore, this project aimed at collecting detailed information on locations and relative availability of key livestock resources (e.g. pasture and water) across seasons, and a comprehensive knowledge of livestock mobility patterns including routes. The data collected support the development community-led land use plans that will allow better management of resources by developing good strategies to support pastoralist and also prevent conflicts that arise between livestock keepers and farmers.

In this study, we used a combination of community participatory mapping and global position system (GPS) loggers to investigate seasonal livestock migration patterns and describe how the information can be used to improve livestock production. We mapped livestock resources (e.g., grazing, water and dips points) and gathered information that explain mobility patterns and migration corridors that might be associated to seasons (e.g., dry / wet season), for all villages (n=219) across four districts (Karatu, Longido, Ngorongoro and Monduli) in northern Tanzania. Additional data on fine-scale movement events were also collected using GPS collaring of selected herds, which provided an in-depth information on individual herd migration history and resource use patterns.

Our analyses suggest widespread movement events and large scale migration to specific areas (i.e. locations of early rainfall and high crop residues), which resulted in an extensive mixing of livestock and conflicts in some cases. Nonetheless, villages with locally enforceable land-use plans appear to have less conflicts. We also observed that seasonal migration patterns depend on the herd size and the level of crop production. For example, migration from permanent boma usually begins with larger herds in early wet season, and pastoralist villages that engage in crop production, return migrating herds back to the permanent boma during dry season to feed on crop residue. We demonstrate widespread movements and contacts between village livestock herds that are influenced by seasons, type of production systems and herd size. Our findings suggest location and period of greater contacts, which is an important consideration for disease control programmes and where support infrastructure could be provided to improve livestock production. For example, building more dips and water holes will reduce contacts and disease spread, and consequently improve livestock health. Our telemetry data from GPS collared herds, also identify the major pastoral migration routes between northern Tanzania southern Kenya, as well as between regions in Tanzania and locations where support infrastructures could be provided to improve livestock management.

Acknowledgements

We are grateful to the Lacuna Funds that supported this study.

We also thank the local authorities, village stakeholders and community members that participated in the mapping sessions, and those that volunteered their livestock for GPS collaring. Thanks to field assistants and coordinators that work tirelessly in the data collection and labelling activities.

We appreciate the Tanzania Commission for Science and Technology (COSTECH), and the Northern Tanzania Health Research Ethics Committee (KNCHREC) for granting the study permit and ethics clearance certificates, respectively.

Finally, thanks to Tanzania Bureau of Statistics for granting the permission to publicly share the data.

Abbreviations

CR	Cattle crush
CPM	Community participatory mapping
DP	Distribution point
GPS	Geographic positioning system
Lambo	Excavating small dams
ODK	Open data kit
QGIS	Quantum geographic information system
RG	Rest ground
UTM	Universal Transverse Mercator
WMA	Wildlife Management Area

Introduction

In sub-Saharan Africa (SSA), traditional livestock management systems relying on sharing of communal resource areas are predominant and contribute up to 90% of livestock raised (Otte and Chilonda, 2002). Greater richness of livestock resources in some areas compared to others create an ideal environment for movements, which is driven by a need to ensure livestock survival (e.g. grazing and watering areas) (Mwanga, 2018). However, insufficient resource availability to support increasing livestock population numbers for countries such Tanzania, has been the biggest constraint to productivity and performance. To a great extent, this problem has significantly impacted the livestock sector. It is estimated that by the year 2031/32, the livestock sector will have a deficit of 1.7 million tonnes of meat and 5.8 million liters of milk, if additional resources are not provided to support traditional systems (MLF, 2017). For example, the concept of pastoralism in Maasai areas of northern Tanzania is continuously changing. An increasing number of communities are in transition between true pastoralism and agro-pastoralism. It is considered locally that these changes may be due to the reduction in grazing areas caused by extreme weather conditions, allocation of rangelands to conservation, livestock losses due to absence of disease control programmes (e.g. vaccination) and drought (Ekwem, 2019). Maasai communities said, “we will not migrate, particularly to potential conflict areas, if there is available water and pastures for our livestock”.

The recurrent conflict and mass killing between agropastoralists (i.e. crop and livestock farmers) and pastoralists is another major issue arising from the low level of livestock resources. Increasing demand in livestock resources, exacerbated by increasing livestock numbers, usually result in pastoralists occupation of farmlands (Mancosu et al., 2015). In Tanzania, several cases of conflicts have been reported, which normally result in loss of life and properties. One of such cases is the continuous conflict between Sonjo (agropastoral) and Maasai (pastoral) neighbouring communities in Ngorongoro district. We gathered through engagements with community stakeholders that the lack of community- led land use plans and disagreement over land ownership were major causes of the conflicts, which are normally heightened during extreme weather conditions (e.g. extreme dry seasons or drought), when movements are highest to ensure livestock survival (Ekwem, 2019).

Therefore, detailed information on locations and relative availability of key livestock resources (e.g. pasture and water) across seasons, and a comprehensive knowledge of mobility patterns including routes would be required to develop community-led land use plans that will allow better management of resources and prevent conflicts (MLF, 2017). A community-led plan would clearly allocate areas for livestock grazing and crop cultivation, particularly for villages located at the border areas between predominantly pastoral and agropastoral communities. A comprehensive labelled data set of key livestock resource areas and movement patterns for northern Tanzania, which is currently lacking, will enable the development a land use plan and the identification of locations and periods when resources are usually low so that support infrastructure (e.g. forage banks and local dams for watering livestock) could be timely provided to mitigate conflicts and improve livestock productivity.

Scope and Approach

Focusing on locations with predominantly pastoral communities in northern Tanzania, the study integrated three related themes: (1) forage and livestock resource management in managed ecosystems such as community grazing lands and ranches, (2) issues related to pastoral migratory patterns and anticipated conflicts with crop farmers; (3) prediction of the best locations to establish forage banks and support infrastructure along livestock migratory routes. Themes were grouped into three major objectives:

Objective 1. To improve forage and livestock resource management in managed ecosystems such as community grazing lands and ranches

Objective 2. To identify issues related to pastoral migratory patterns and anticipated conflicts with crop farmers

Objective 3. To predict the best locations to establish forage banks and support infrastructure along livestock migratory routes

Data collection process

Study Areas

The data collection process was consolidated so as to address the three objectives. Data were collected from four predominantly pastoral district communities (Karatu, Longido, Ngorongoro, and Monduli) in Northern Tanzania (Figure 1), where all the villages for each district were considered. The study involved 249 villages (Karatu=82 villages, Longido=56 villages, Monduli=65 villages, and Ngorongoro= 46 villages, excluding the Ngorongoro Conservation Area). *Appendix 1* shows the list of all villages that were surveyed.

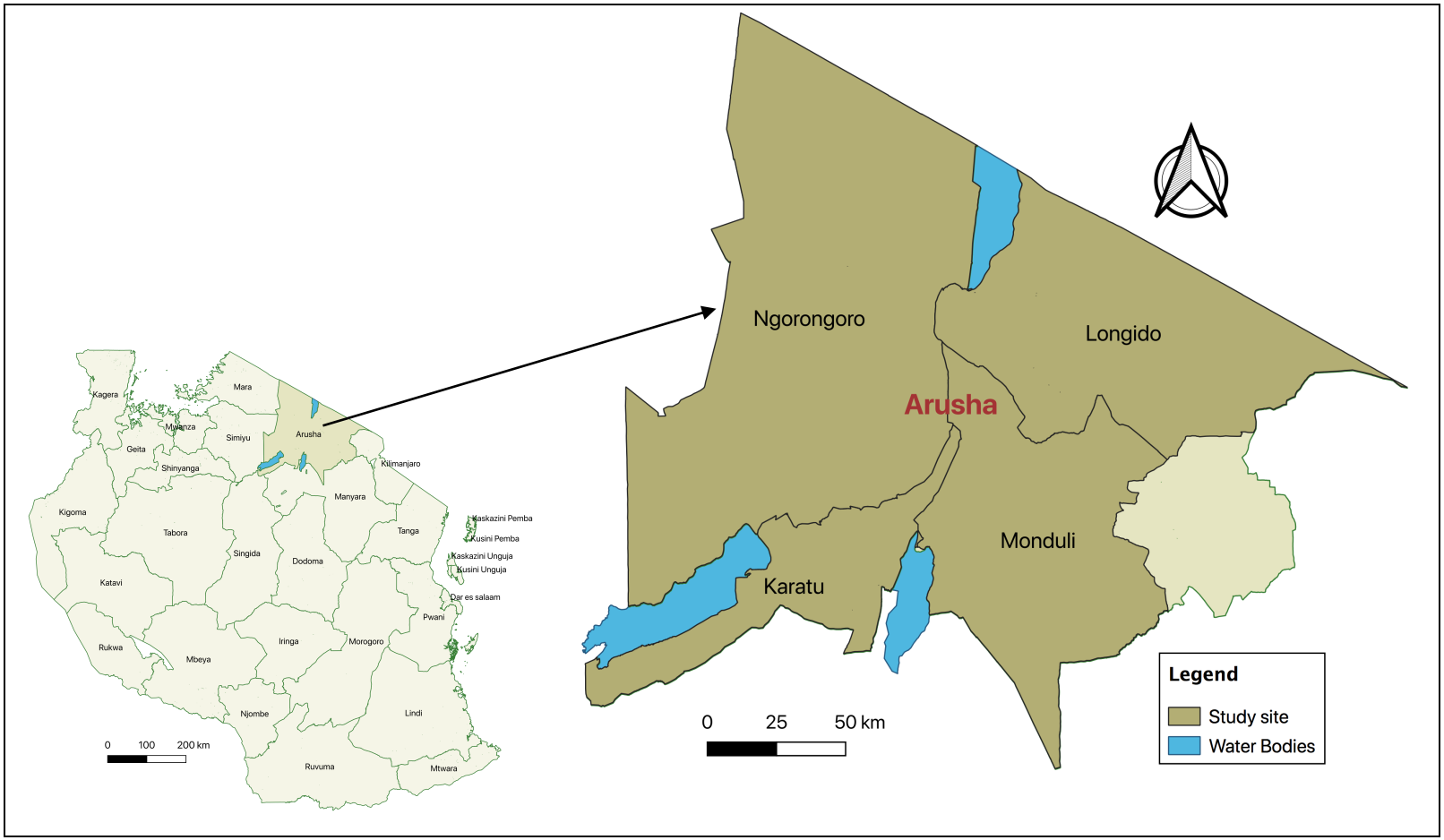

Figure 1: Location of the study districts in Arusha region, northern Tanzania .

(a) ***Karatu District*** is one of the seven Councils in Arusha Region. The District is estimated to have an area of approximately 3,300 square kilometers, with Lake Eyasi occupying about 10.6 square kilometers. Karatu District is divided into four divisions (Mbulumbulu, Eyasi, Karatu and Endabash) , 14 wards and 59 registered villages. The climate varies from one area to another in the district. The main economic activities carried in Karatu are Agriculture and livestock keeping which occupies more than 85%. (https://karatudc.go.tz/historia)

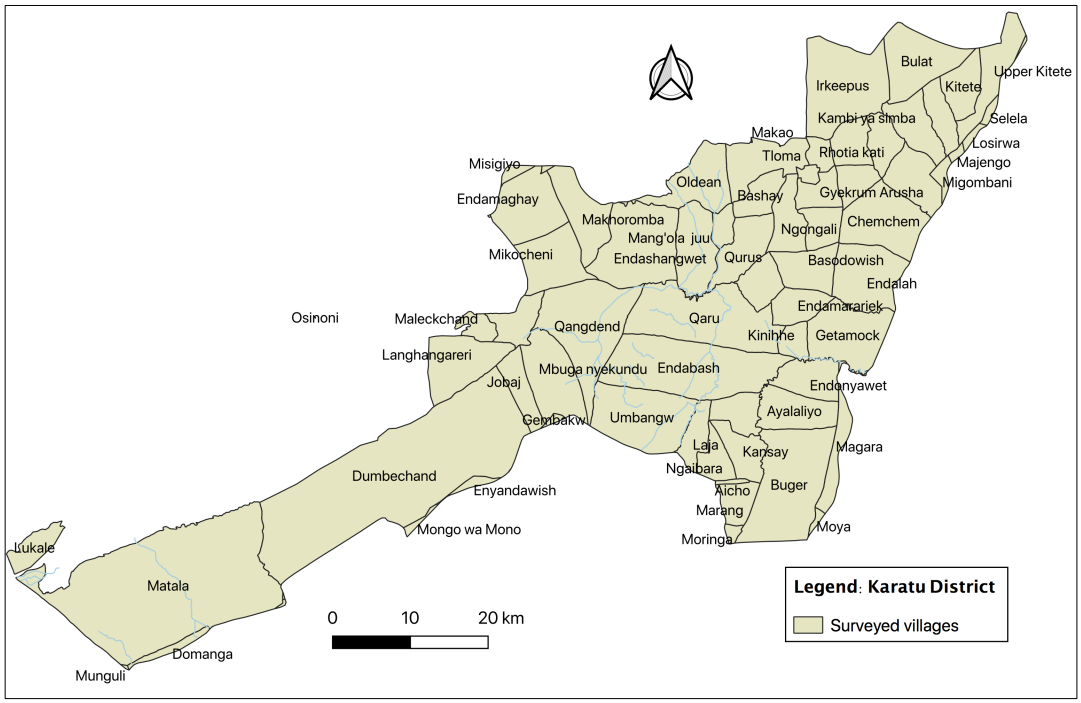

Figure 2: Shows Karatu districts with its villages

(b) ***Longido District Council*** was established in July 2007. The Council is located between 360 00’ and 370 30 East 10 00-3 0 00 east of the Green which. The Council covers an area of 7,782 Sq Km, of which Square Kilometre 9.4% is arable land, equivalent to 73,164 hectares while 6,392.35 Square Kilometres is grazing land, or 639,235 hectares, which is 82.14 %. Also 365.75 Square Kilometres of land is covered by forest and rock, or 36575 hectares which is 4.7% The District is recorded as one of the driest area in Tanzania, the temperature ranges from 20c – 35c and rainfall ranges from less than 500mm in low lands to 900mm in high elevation of West Kilimanjaro, Ketumbeine and Gelai mountains. In the North it borders Republic of Kenya (https://longidodc.go.tz/storage/app/uploads/public/59c/248/f51/59c248f51becc885839760.pdf)

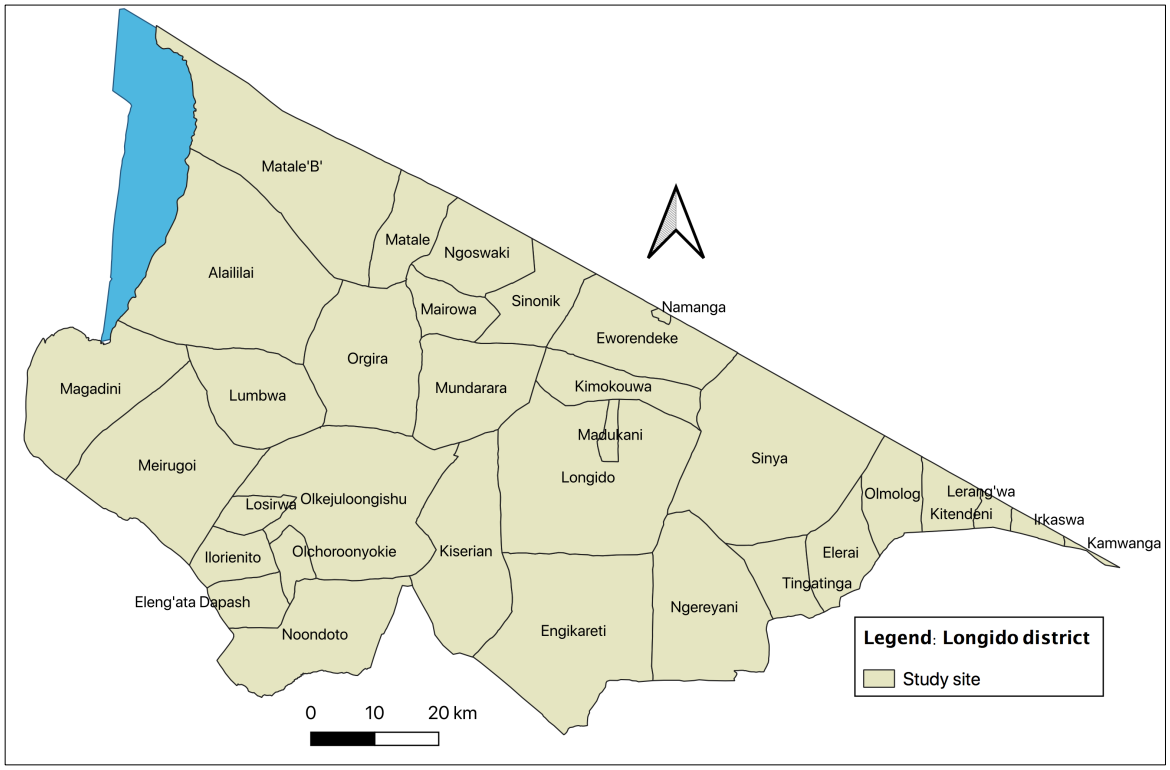

Figure 3: Shows Longido districts with its villages

(c) ***Monduli district*** established during the British Colonial Rule where the administrative area was named "Monduli Maasai District" at that time was included with the present Kiteto, Simanjiro, Ngorongoro and Longido districts. Monduli District is situated between latitudes 3.00" to 4.50' South of the Equator and Longitudes 36.50' to 36.45' East of Greenwich Meridian. The District covers an area of 6,993 km2 (2,700 sq mi) and is a home to the Maasai community (https://arusha.go.tz/monduli/historia)

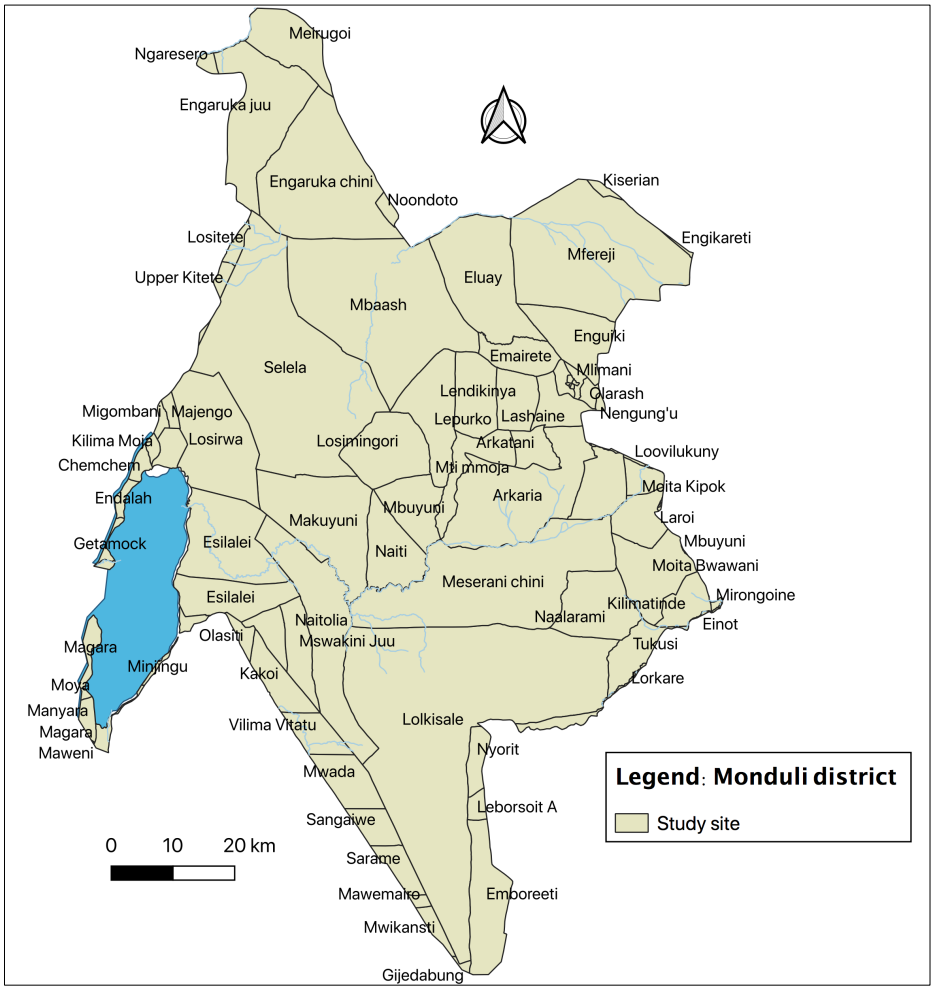

Figure 4: Shows Monduli districts with its villages

Ngorongoro district the study site in Ngorongoro district was the Loliondo Game Controlled Area (LGCA) and the Sale division, which is inhabited by lower-density Maasai and Sonjo communities with livestock production systems based on traditional pastoralism and limited crop cultivation. The district is inhabited by 175,000 people in an area of 14,036 km^2, situated between latitudes 3° 14′ 29.4″ S and longitude 35° 29′ 16.08″ E (Figure 5).

Figure 5: The map shows the Ngorongoro district with villages.

Data collection Methodologies

Data for the project were collected using a combination of methods (community participatory mapping and tracking of migratory herds using global positioning system, GPS, loggers), which allowed us to generate datasets containing fine and broad scale of movements of livestock, land use patterns and conflicts, identification of major migration routes among pastoralist herds and location and type of infrastructure that would be required to support livestock prodcution.

Community Participatory Mapping

We used Community participatory mapping (CPM) to capture information on key livestock resource areas (i.e., grazing areas, water points, dipping points). Participatory mapping through focus group discussion was performed for every village in all the four study districts. For each village, we recruit between 8-10 members of the village. The village chairman, sub-village heads, and veterinary officers were among the key stakeholders in providing information about the villages and organizing other members. A number of villages

(especially in typical pastoralist areas) had pastures committees. They are entitled to managing livestock resources including grazing areas, and water points; planning/managing resource usage per season i.e., managing grazing areas that will be used during dry and the one for wet seasons. Also, they are responsible for issuing permits to other livestock keepers from other villages who want to graze in their areas. We ensured at least two to three members from these committees were also involved in the focus group discussion.

Before the mapping sessions begins, detailed information about the project was given, then all participants were asked to sign a concert form (Figure 5). We also use this time to respond to participants' questions and clear their concerns. Before we visited each village for mapping purposes, some baseline information about grazing and watering patterns, and other livestock-keeping characteristics in each village was gathered through consulting with Other data such as the list of villages in the district were collected at the district headquarters to guide the mapping process.

Figure 5:Participants signing concert forms after the information sheet containing details of the research has been read.

a) Mapping Tools

The participatory mapping process begin with a quick exploration of the digital maps to orientate participants, and for map validation-where participants had to agreed on a clear layout of the community by combining the Google Earth images and topographic maps. Google Earth images *(Figure 6)* and gridded maps *(Figure 7)* constructed and printed out at a variety of scales (1: 2,500, 1: 5,000, and 1: 10,000) were used as data collection tools. The Google maps images were used to guide the entire mapping process. Participants were able to familiarize with their villages through Google Earth images before using the base maps (gridded maps). The image dimensions that was used was 1 metre by 1 metre at each scale, which ensured visibility and recognition of topographical features such as human settlements, hills, rivers/dams, roads, crop lands, utility centres etc. . It also helped to provide a means to locate and estimate the size of key livestock resources in the area and crop lands more precisely. All maps used was digital with a coordinate system converted to Universal Transverse Mercator (UTM).

In addition to the Google Earth maps, wider scale (1: 50,000) published topographic maps (Tanzanian 2012 Census) printed out at 1 metre by 1 metre, and was used to visualise livestock mobility corridors spanning across several villages, village borders such as hills and contours, large rivers and springs, rangelands and grass plains etc. All maps used was digital with a coordinate system converted to Universal Transverse Mercator (UTM). This allowed participants to identify the location and distances of key features that simplified the mapping process. Also it provided a means to locate and estimate the size of key livestock resources in the area and crop lands more precisely.

After signing of concerts forms the discussion with participants begins. Participants were asked to list names and identify the location of resources from the map (Google Earth and base maps) where they take their animals for watering, grazing, dipping points, crush and livestock markets, and identify major livestock routes.

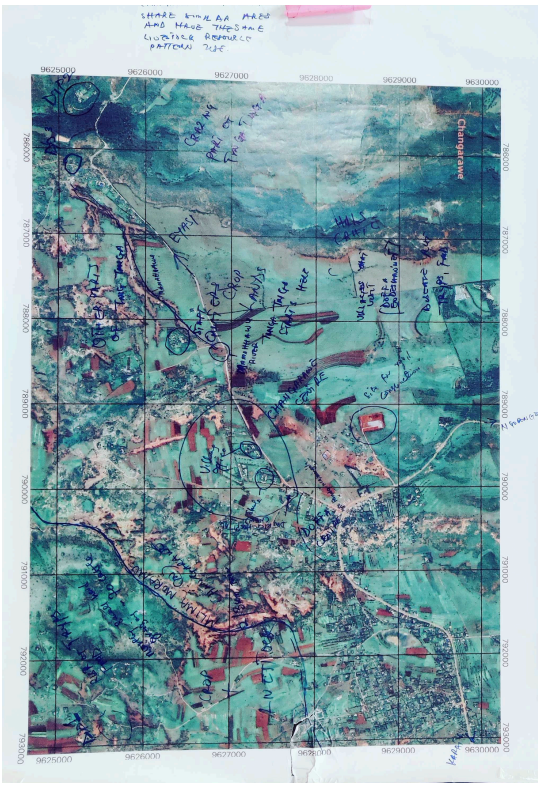

Figure 6: A sample of Google Earth maps that was used for data collection

Figure 7: A Sample of a base map that was used for data collection

b) Open Data kit (ODK)

A structured list of questions was used throughout the process to ensure consistency for all villages that were mapped. ODK was used to collect metadata information associated with each resource that was identified for each village including grazing areas, water points, minerals points, dipping points, etc. i.e., we collected information on the usage and management of these resources during wet and dry seasons and during scarcity of resources, frequency of use, ownership how the identified resources are being shared with other villages, and challenges faced to access the resources. Other information that was collected includes pastoralists' migrations patterns, the use of fodder banks, agriculture activities, and farmers to pastoralist conflicts. *Appendix 2* shows a list of all the questions that were administered for each village including the type of metadata that was captured in regard to pastoralist resources.

c) Mapping

The participatory mapping process begins with a quick exploration of the digital maps to orientate participants, by combining the Google Earth images and topographic maps (Figure

8). The questionnaire and all discussion sessions were administered in the national language (Kiswahili), however, on other occasions, the Masai language was used. After the familiarization exercise, all relevant features and key resources were identified and located on the printed maps, including other key elements that were not shown on the initial maps, for example, new croplands or dipping points. After this initial mapping session, the participants were asked to list all key livestock resources (e.g., grazing and watering points) by name, identify their locations, and hand-draw the size or extent of the area on the map. This activity was followed by broad discussions about animal movement characteristics of the village in relation to grazing and watering points, dips, resources containing minerals, livestock routes, croplands, and conflicts.

Figure 8: Participant trying to identify all key resources from the map, followed by drawing (hand-draw) the size or extent of the area on the map.

After each session, all key resource areas in the village that were identified in the discussions was visited with the assistance of the village chairman. Locations were validated and georeferenced using a hand-held geographic positioning system (GPS) device (e.g., Garmin

eTrex® 10). The discussions of the mapping exercise were recorded in a digital field book using Open Data Kit (ODK). Therefore, the final product of each livestock movement mapping process was a hand-drawn map showing all key resource areas used by the herders in the village (Figure 9) and a collection of GPS waypoints for each identified area.

Figure 9: Participant performing final cross validation to confirm if everything that was mapped is correct.

d) Data labelling

The data collection process was followed by digitized whereby for each village, all identified resource areas as indicated in the hand-drawn maps had to be digitized and validated as shown in figure 10. All the community-drawn maps were georeferenced by initially uploading the maps onto the quantum geographic information system (QGIS) via the 'Georeferenced GDAL' (a core plugin) and then manually entering coordinates on the digitized maps. Both the GPS waypoints collected during field observations and georeferenced tiff file was then overlaid on Google Earth satellite images to validate the absolute position of the hand-drawn

shapes of resource areas and qualitatively compare the biomass level as estimated by community (i.e., for grazing areas). GPS waypoints was used to validate the location of the features. After validation, shape files (e.g., polygon, lines and points) was created for each type of resource area and livestock routes. Whereby (a)Polygon was used to create grazing areas (b) lines was used to map livestock routs and rivers and (c) Points was used to indicate locations for livestock markets, water points i.e., cattle through, dipping points, crushing units and mineral salts points.

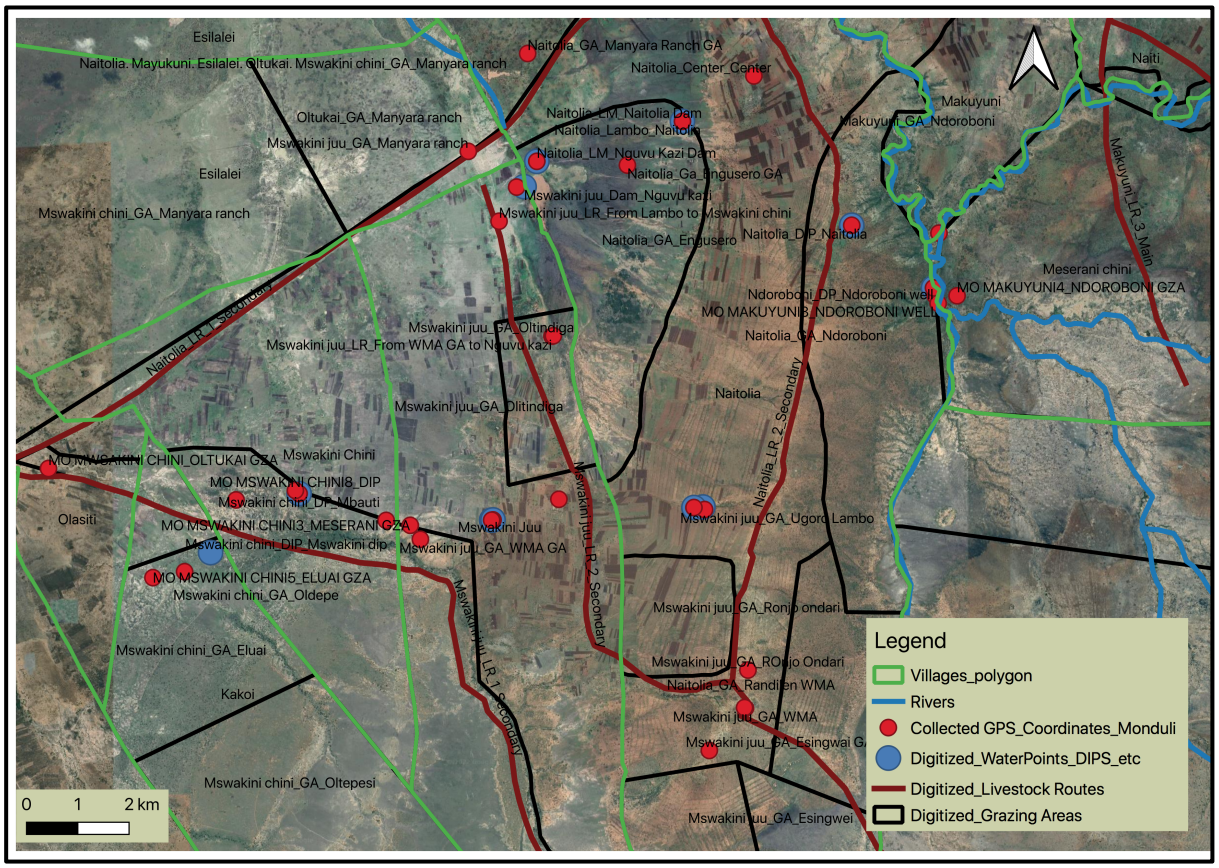

Figure 9: Sample image, showing how information from hand drawing maps was digitized in QGIS.

e) *Global Positioning System (GPS) collaring of livestock herds*

To establish the patterns of pastoral herds migration, particularly the timeline and route, selected herds from villages were collared using GPS loggers (Figure 10). The telemetry data provide additional information and further validate the livestock mobility patterns such as average distance travelled by each herd, utilisation of resources and livestock migratory routes as identified in the participatory mapping. Forty-five devices were placed on livestock-keeping households in selected

villages in Karatu, Monduli and Longido districts. We did not deploy the devices in Ngorongoro district because there was another research group that had already deployed collars in the district and agreed to collaborate on the data. Ten villages were randomly selected (without replacement) from a list of all villages in each study district. Five villages had two units and the other five had one unit deployed. (i.e., 15 units per village) between August -October 2021. The research team visited the livestock-keeping households that accepted the GPS collars on their cows every four weeks to retrieve data from the device, check for any malfunctioning and ensure that the livestock owners are happy to continue volunteering their cattle for the study. The follow up was for over a twelve-month study period to capture relevant details about livestock migratory patterns in all seasons.

Figure 10: GPS collars units that was used to track movements of individual cattle in a herd. Picture shows components of the GPS device including the complete unit in the leather collar pouch that was mounted on the cattle.

Summary of Findings

Improving forage and livestock resource management in managed ecosystems such as community grazing lands and ranches

(a) Grazing areas

(i) Access to Grazing areas

Figure 10,11 and 12 shows the digitized grazing areas we mapped that is used by pastoralist in different season. Compared to all the mapped districts, to a large extent Longido and Monduli have large grazing areas compared to the Karatu district. A number of villages in Karatu districts have very small grazing areas while other villages have no grazing areas. This is due to the fact that the majority of commnunities in the Karatu districts have fully transitioned to agro-pastoralist (i.e., crop cultivation having a greater significance to household income than livestock keeping). As a results some farmers (particularly those with small herds, <50 cattle) have adopted zero grazing and use crop residues, while those with larger herds (> 50) normally move them to nearby districts such as Monduli and Simanjiro, and return them back during the early dry season just after crop harvest to feed on residues.

(ii) Seasonal access to grazing areas

The months that correspond to seasons were slightly different among the districts. For example, the wet season for Monduli and Longido was considered to start around January to April but for Karatu it does extend to May. The dry season was considered to start from May to July/August and can extend to September. October to December was considered extreme dry seasons for the pastoral communities in Longido, Monduli and Ngorongoro. The exteme dry spells will transition to drought periods (December – February) when there is no rain between October and February.

Pastoralists mostly return to their parmanent settlement during wet season, except for Karatu district that has very few pastoral communities. Migration starts from October after all areas including reserved grazing areas have been used up. Figures (10-12) indicate the land use patterns for the study districts. Longido and Ngorongoro districts (which are very prone to drought) have more dry reserved areas compared to wet, while the reverse was the case for the less arid districts of Karatu and Monduli.

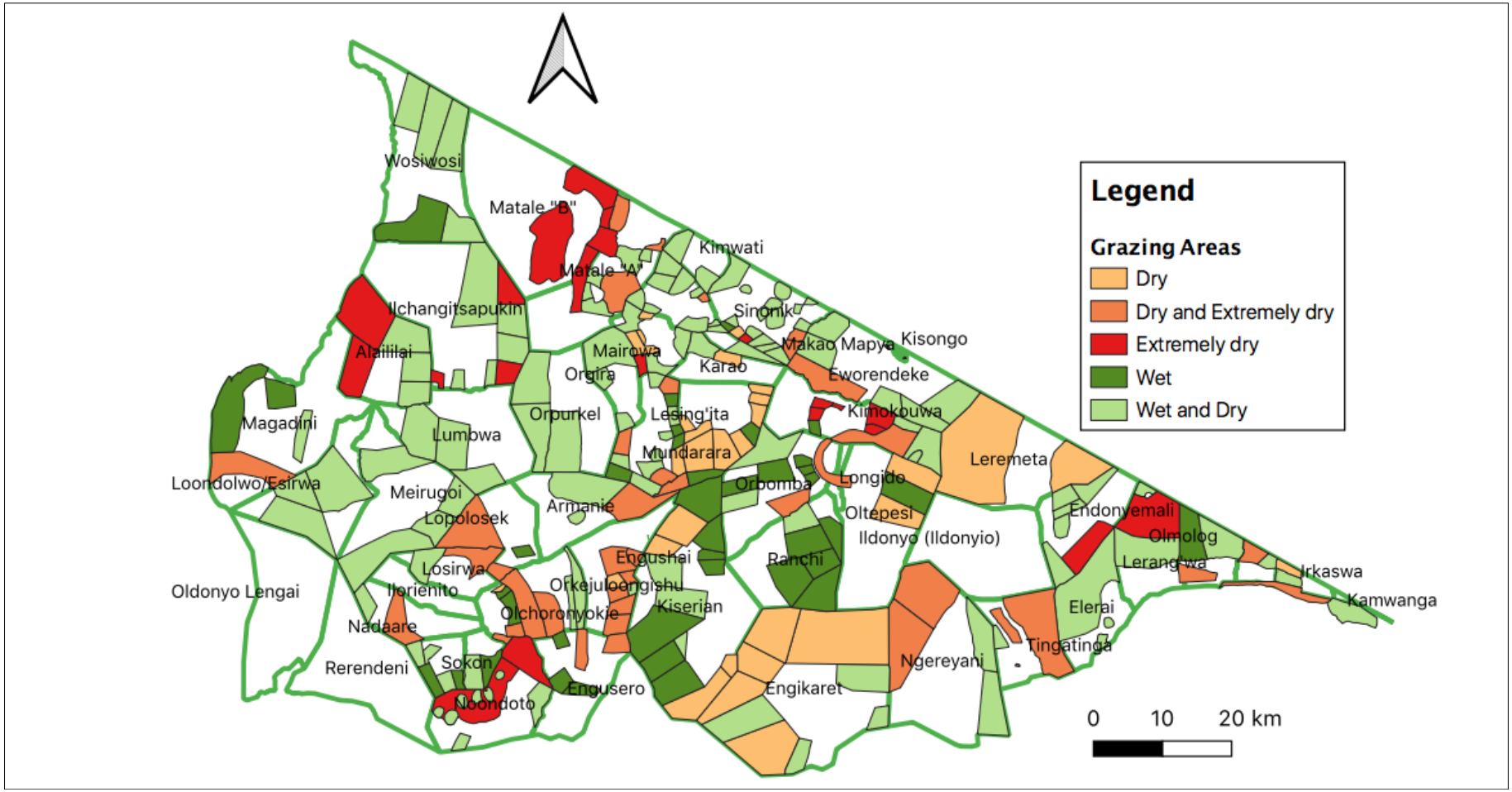

Figure 10: Shows the areas that pastoralists use to grazing per season in each village in Karatu district

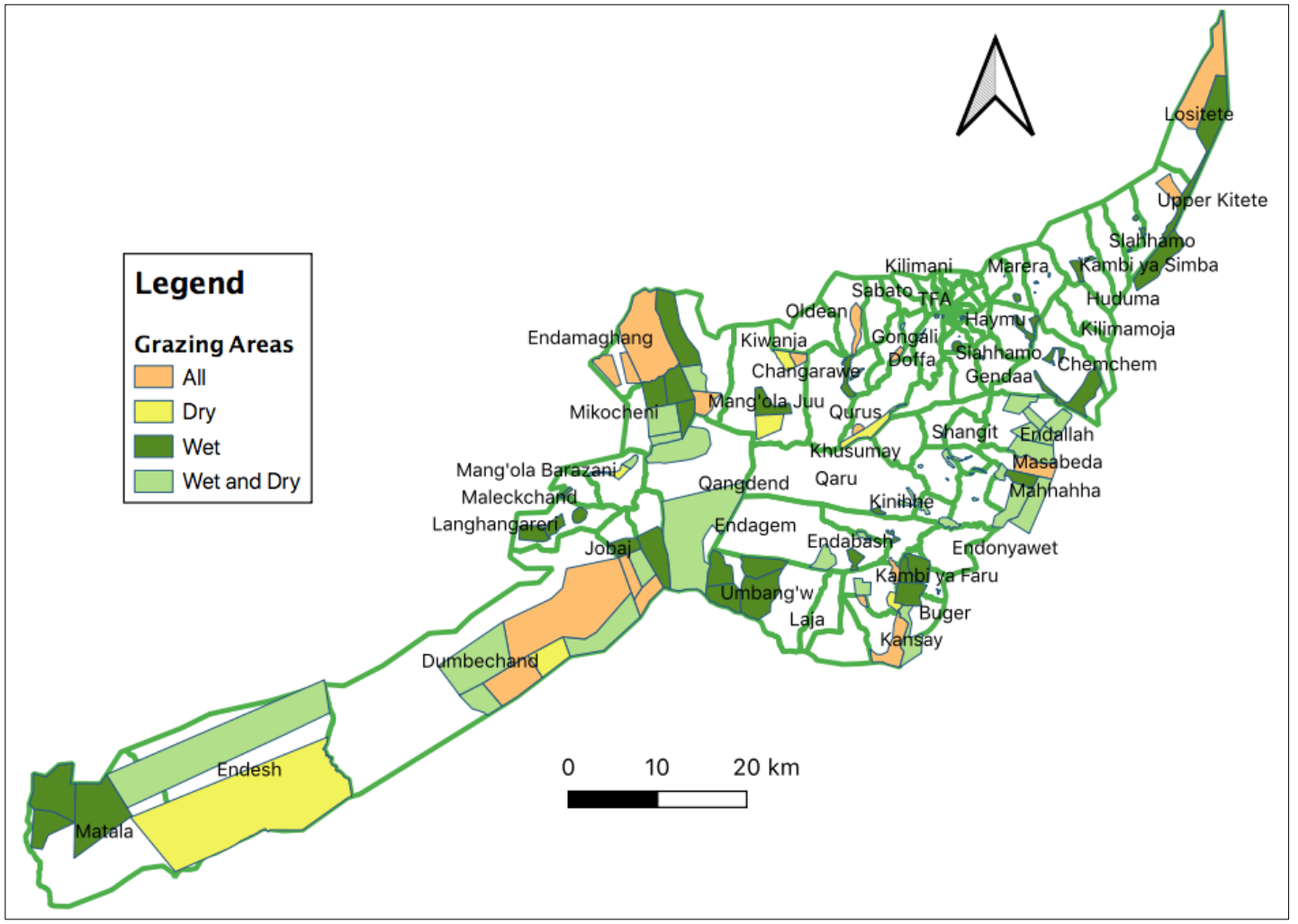

Figure 11: Shows the areas that pastoralists use to grazing per season in each village in Karatu district

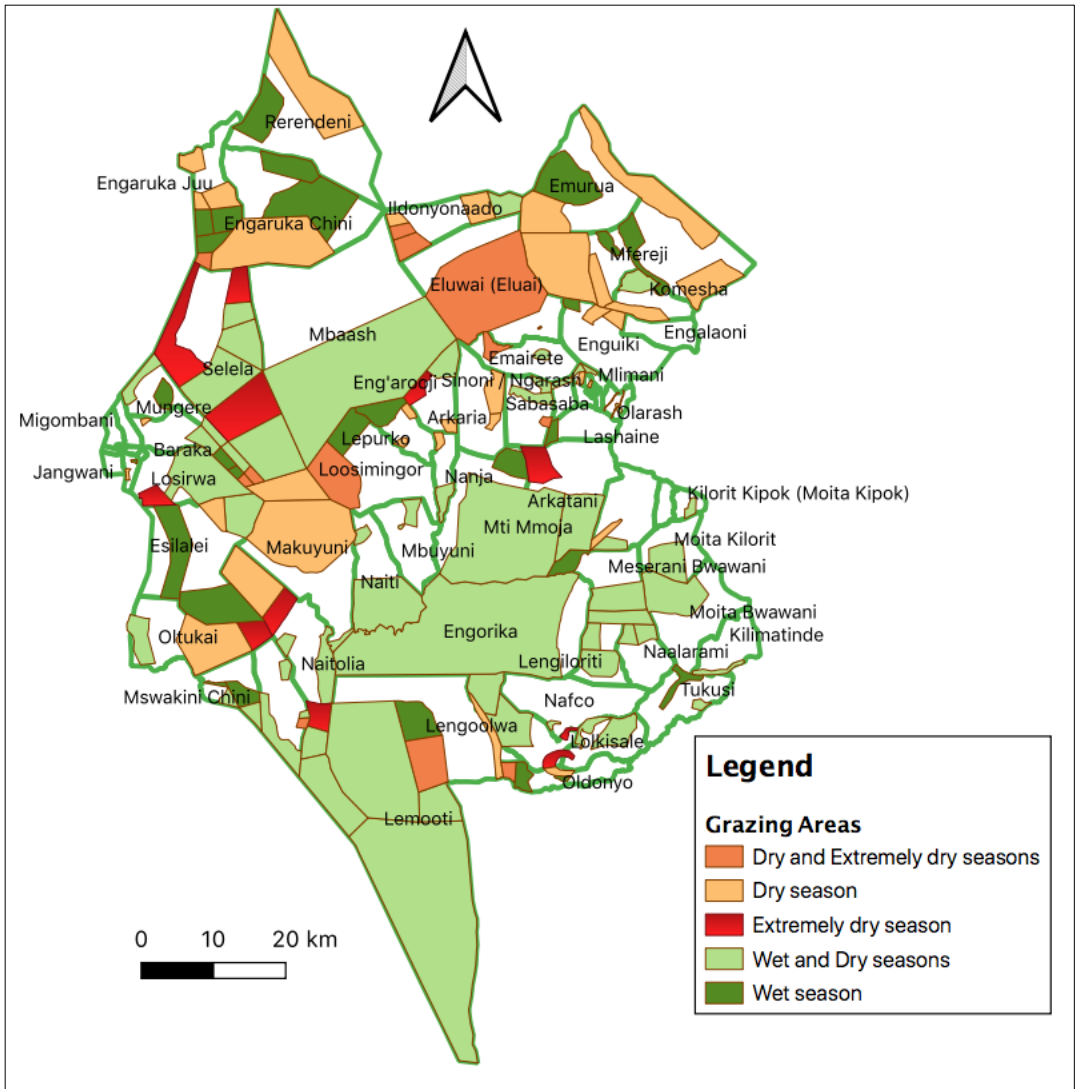

Figure 12: Shows the areas that pastoralists use to grazing per season in each village in Monduli district

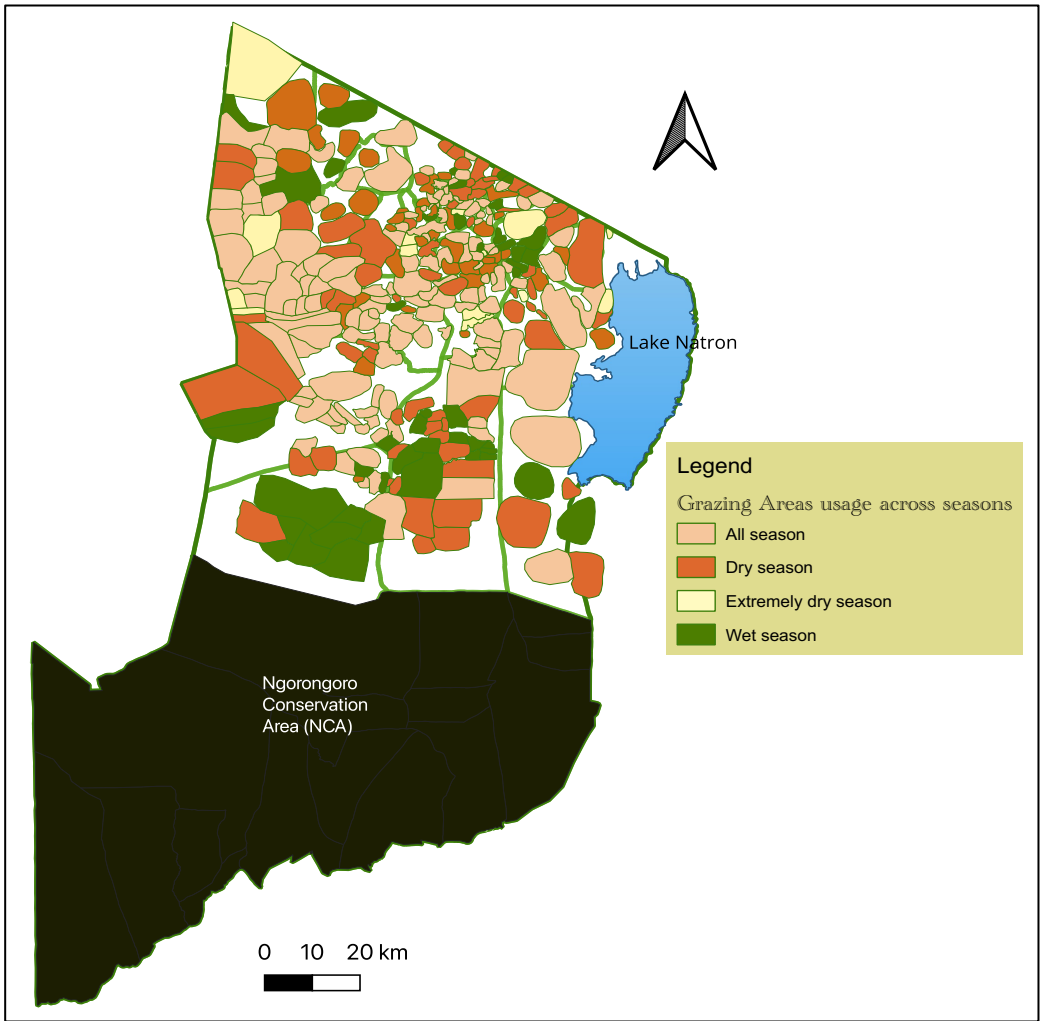

Figure 13: Land use patterns of livestock keepers in the Ngorongoro district. The Ngorongoro Conservation Area (NCA), which is restricted area, was not mapped.

(iii) Ownership and Management

For all the districts mapped, land use and ownership was mostly mediated by the community. Grazing lands are owned communally by the villages, with very few private ownership. Private ownership was mostly reported in Karatus and Monduli districts. Hence, communal herding was widely practiced (Figure 11). There were also Wildlife Management Areas (WMAs), which are areas of communal land set aside exclusively as habitat for wildlife by member villages.

Figure 11: Livestock browsing for grasses to an open space around the farm areas.

For resource management, some villages especially in the typical pastoralist areas, have formed a committee that oversees all of their livestock resources. The committee allocates grazing areas and water points to be used during wet and dry seasons and enforce the laws. The committee also provide a timetable on how the resources can be used per season, so that there is availability across seasons. They oversee and regulate the number of herders that can come from other village that do not have claims to ownership of the rangelands.

(b) Water Points and its infastructures

There are several types of water sources that are used by pastoralist, including gravity schemes (with tap stands), rivers, lakes, lambo (local dams), traditional/shallow wells and improved boreholes connected into distribution points (DP) (Figure 12; Appendices 3 - 5). The DPs were usually constructed by connecting sereval underground pipes to rivers or reservoirs that are scattered across the village. Karatu district has more DPs compared to other districts and thus has better access to clean and safe water.

(a) *A distribution point taped from improved boreholes that use a water pump. The picture was taken at Karatu district*

(b) *A distribution point supplied from a tank. The picture was taken at Longido district*

(c) *A distribution point taped from the spring water. The picture was taken at Karatu district*

(d) *A distribution point that uses water unimproved traditional/shallow wells hand-dug wells. The picture was taken at Monduli district*

Figure 12: Shows different samples of distribution points that pastoralist use to water their animals

Small dams locally referred to as Lambo (Figure 13) were also widely used in Longido and Monduli districts and were the preferred water sources by livestock farmers because it is free compared to other sources like distribution points, and can accommodate large number of cattle. Although large lambos can be permanent water sources, they are quite few compared to smaller types that usually dry up during extreme dry seasons as observed in most villages in Longido. In addition, some lambos are shared with wildlife, which increase the risks of pathogen exchange with livestock.

Figure 13: One of the excavating small dams (Lambo) used by the pastoralists community to water their livestock.

Water for livestock is a major problem for communities in Longido, where rainfall is low and ffals for a short period (January to March) every year. These areas are considered to be extremely dry and in most cases the villages have no other source of water. Therefore, pastoralists are forced to dig underground water (Figure 14), which is usually very dirt and can only accommodate few cattle and a major source of infection to livestock.

Figure 14: One of the dug wells developed by pastoralistss. The same water is used to water the animals and for household consumption

(c) Other livestock resources and Infastructures

Other important livestock resources mapped include: dipping points, mineral and salts points, cattle crush, livestock markets and resting grounds (locations where animals are rested enroute to the market). The distribution of these resources is scarce, and was observed to be insufficient to support livestock production in all the districts. For example, five to seven villages use a single dipping point (Figure 15).

Figure 15: An example of a dipping point that was used by several villages

Identifying issues related to pastoral migratory patterns and anticipated conflicts with crop farmers

Lond distance migration was observed among pastoralists herds in all districts tracked but the longest distances were observed for herds that were primary tagged in the Longido district (Figure 16). Longido is the driest district in the country, hence the migration pattern observed was expected. Herds migrated across multiple regions in Tanzania and across border to Kenya using a clear migration route (Figure 16). Few instances of conflicts were reported among the migrating herds, which were resolved by payment of compensations. The reduced number of conflicts was attributed to changes in migration patterns. Pastoralist herds now migrate in

small numbers (no more than 50-60 head of cows), which is herded by two or more people. The reduced herd size allows for better control of livestock movements and less incursion into crop lands.

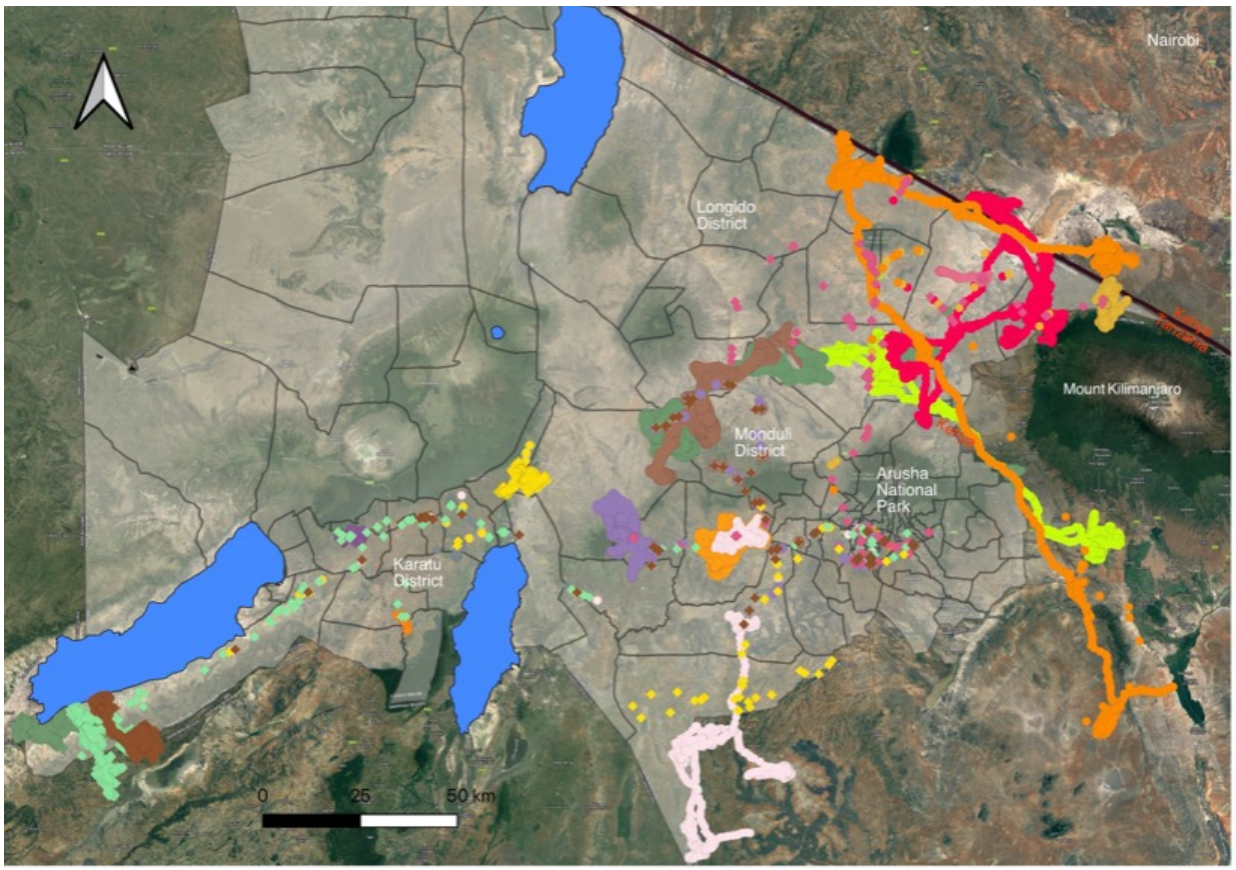

Figure 16: Migration patterns of livestock herds that were collared in Karatu, Longido and Monduli districts. The movement trajectories for each collared herd is indicated by the individua colour.

During the community participatory mapping of livestock movements, gathered from communities located along migration routes that introduction of new pathogens as a result of migration is now a major concern than crop damage because pastoralists migration are now undertaken in multiple batches with manageable number of cattle.

Migration was a direct response to scarcicity of resources driven my low precipation levels. During the cause of this studymost places around the country experienced short rains. The livestock sector reported at least 62,000 animals died in Simanjiro around January and the number increased to 92047 around March.

in just one district Simanjiro animals died due to lack of pastors and water.

Figure 17: A picture showing livestock that were lost due to drought in Simanjiro district (a neighbouring district to Monduli) as reported by local Tanzania media in January 2022.

Predict the best locations to establish forage banks and support infrastructure along livestock migratory routes

One of the questions that farmers were asked in is their preferences on livestock infrastructures. Mostly preferred to have all resources based on one location including; grazing area, watering points , dipping, crush etc. Farmers recommendation was to have these hubs at least in each Sub-village as it will serve their animals from walking a long distance and avoid conflicts with crop farmers when taking their livestock for grazing/watering.

Figure 17: Livestock farmers in this Sub-village takes their animals to graze on mountains on mountains and come down for watering and recommend if dipping points and sustainable water sources such as DPs can be implemented that will avoid their animals to walk a long distance to access the service which also assist to reduce conflicts with crops farmers.

Appendices

List of villages Surveyed

List of Villaged for Karatu District	
Ward	**Village**
Baray	Endeshi
Baray	Mbuga nyekundu
Baray	Qangdend
Baray	Dumbechand
Baray	Matala
Buger	Ayalaliyo
Buger	Buger
Buger	Endonyawet
Daa	Changarawe
Daa	Mangola juu
Daa	Makhoroba
Daa	Endashangwet
Endabash	Endabash
Endabash	Endagem
Endabash	Jobaj
Endabash	Kinihhe
Endabash	Qaru
Endamaghang	Endamaghan
Endamaghang	Mikocheni
Endamarariek	Bassodawishi
Endamarariek	Shangit
Endamarariek	Endallah
Endamarariek	Masabeda
Endamarariek	Khusumay
Endamarariek	Endamarariek
Endamarariek	Gidbasso
Endamarariek	Mahhahha
Endamarariek	Getamock
Ganako	Ganako
Ganako	Tloma
Kansay	Kansay
Kansay	Ng'aibara
Kansay	Laja
Kansay	Umbangu
Kansay	Kambi ya Faru
Karatu	Geykrum (Garusha)
Mang'ola	Laghangareri
Mang'ola	Maleckchand
Mang'ola	Barazani
Mbulumbulu	Kitete
Mbulumbulu	Upper kitete
Mbulumbulu	Kambi ya simba
Mbulumbulu	Slahamo
Mbulumbulu	Lositete
Oldeani	Oldeani

List of Villaged for Monduli District	
Ward	**Village**
Engaruka	Engaruka juu
Engaruka	Engaruka chini
Engaruka	Irerendeni
Engutoto	Olarash
Engutoto	Mlimani
Engutoto	Sinon Ngarash
Esilalei	Oltukai
Esilalei	Mungere
Esilalei	Baraka
Esilalei	Esilalei
Esilalei	Losirwa
Lemote	Oldonyo
Lemoti ward	Lemoti
Lepurko	Engaroji
Lepurko	Nanja
Lepurko	Losimingori
Lepurko	Lepurko
Lolkisale	Lolkisale
Lolkisale	Lengolwa
Lolkisale	Tukusi
Lolkisale	NAFCO
Majengo	Migombani
Majengo	Majengo
Makuyuni	Naiti
Makuyuni	Makuyuni
Makuyuni	Mbuyuni
Meserani	Meserani Juu
Meserani	Meserani chini
Mfereji	Idonyonado
Migungani	Kigongoni
Migungani	Migungani A
Migungani	Migungani B
Moita	Loolera Kipook
Moita	Morita Bwawani
Moita	Moita Kiloriti
Moita	Moita kipoki
Moita	Kilimatinde
MonduliJuu	Enguike
MonduliJuu	Emairete
MonduliJuu	Komesha
MonduliJuu	Emurua
MonduliJuu	Mfereji
MonduliJuu	Eluwai
MonduliMjini	Monduli Magharibi
MonduliMjini	Sabasaba

Oldeani	Kiwanja
Qurus	Doffa
Qurus	Gongali
Qurus	Glambo
Qurus	Qorong'aida
Qurus	Gendaa
Qurus	Qurus
Qurus	Bashay
Rhotia	Merera
Rhotia	Rotia kati
Rhotia	Kilimatembo
Rhotia	Kainam Rotia
Rhotia	Chemchem
Rhotia	Kilimamoja

MonduliMjini	Sinonik kati
MonduliMjini	Monduli mashariki
Mswakini	Mswakini chini
Mswakini	Naitolia
Mswakini	Mswakini juu
MtowaMbu	Jangwani
MtowaMbu	Barabarani
MtowaMbu	Kisutu
MtowaMbu	Magadini
Naalarami	Nalaarami
Naalarami	Engorika
Naalarami	Lengiloriti
orkeswa	Lashaine
Selela	Mbaashi
Selela	Selela
Sepeko	Lashaine
Sepeko	Arkaria
Sepeko	Arkatani
Sepeko	Mti Mmoja
Sepeko	Lendikinya

List of Villaged for Longido District

Ward	Village
Elangatadapash	Elengata edabash
Elangatadapash	Sokon
Elangatadapash	Olchoro onyikie
Engarenaibor	Mairowa
Engarenaibor	Sinoniki
Engarenaibor	Ngoswaki
Engarenaibor	Karao
Engarenaibor	Kimwati
Engikaret	Engikaret
Engikaret	Kisarian
GelaiLumbwa	Lumbwa
GelaiLumbwa	Ilchangitsapukini
GelaiLumbwa	Wosiwosi
GelaiLumbwa	Alaililai
GelaiMeirugoi	Meirugoi
GelaiMeirugoi	Loondolo
GelaiMeirugoi	Magadini
Iloirienito	Ilorienito
Iloirienito	Losirwa
Iloirienito	Nadaare
Kamwanga	Kitendeni
Kamwanga	Irkaswa
Kamwanga	Kamwanga
Kimokouwa	Kimokouwa
Kimokouwa	Kimokouwa
Kimokouwa	Ranch
Kimokouwa	Eworendeke
Kitumbeine	Olkejuloongishu
Kitumbeine	Engushai

Kitumbeine	Lopolesek
Kitumbeine	Armanie
Longido	Longido
Longido	Namanga
Matale	Matale A
Matale	Matale B
Mundarara	Mundarara
Mundarara	Lesingita
Mundarara	Orgira
Mundarara	Orpurkel
Noondoto	Noondoto
Noondoto	Engusero
Olmolog	Elerai
Olmolog	Lerang'wa
Olmolog	Olmolog
Orbomba	Ordbomba
Sinya	Oldonyo
Sinya	Leremeta
Sinya	Endonyoemali
Tingatinga	Tingatinga
Tingatinga	Ngereani

Appendix 2: A questioneer (Coded in ODK) that was administed for data collection.

S1: Registration
S1Q1: Please indicate the district
S1Q2: Please indicate the ward
S1Q3: Please indicate the village
S1Q4: What is the enumerator's name?
S2: Animals feeding and Watering
S2Q1: Do you have grazing area
S2Q2: List all grazing areas you use, starting with the one you use most ?
S2Q3: In total how many grazing areas do they have?
S2Q4: Name of ${s2_CurrSeason} grazing area?
S2Q5: Frequency of use
S2Q6: Which village is it located in
S2Q7: Type of ownership for ${s2q4_NameGrazArea} area
S2Q8: What is the size for ${s2q4_NameGrazArea} area?
S2Q9: Which seasons do you use ${s2q4_NameGrazArea}
S2Q10: Which months do you use ${s2q4_NameGrazArea} area for grazing during Wet season?
S2Q11: Which months do you use ${s2q4_NameGrazArea} area for grazing during Dry season?
S2Q12: Which months do you use ${s2q4_NameGrazArea} area for grazing during extremely Dry season?
S2Q13: Do you stay / camp there when you're using ${s2q4_NameGrazArea} ?
S2Q14: if yes, how long (months), what month do you usually arrive
S2Q15: Is ${s2q4_NameGrazArea} area permanent ?
S2Q16: is this a range rangeland (i.e. with many sublocations)

S2Q17: What are the sublocation names

S2Q18: Which area do you use most

S2Q19: Why do you like ${s2q4_NameGrazArea} area ?

S2Q20: Who else uses ${s2q4_NameGrazArea} area ?

S2Q21: If other sub-villages / villages, which ones?

S2Q22: How often do you come in contact with other villages livestock in ${s2q4_NameGrazArea} area?

S2Q23: Which months do they prefer to graze in ${s2q4_NameGrazArea} area?

S2Q24: Is the ${s2q4_NameGrazArea} area also used for agriculture activities ?

S2Q25: How far is ${s2q4_NameGrazArea} area from agriculture activities (km)?

S2Q26: GPS Location for ${s2q4_NameGrazArea} area ?

S3: Source of water

S3Q1: Do you have water sources in the village and outside the village

S3Q2: List all water sources for livestock you use, starting with the one you use most?

S3Q3: In total how many water sources do they have?

S3: Water Sources

S3: Index of Current Source

S3Q4: What is the name of the ${s3_CurrWaterSrc} source?

S3Q5: Frequency of use for ${s3q4_NameH2OSrc}

S3Q6: Which village is ${s3q4_NameH2OSrc} located in

S3Q7: Type of ownership for ${s3q4_NameH2OSrc}

S3Q8: What type of water source?

S3Q9: What is the size for ${s3_CurrWaterSrc}

S3Q10: Which seasons do you use ${s3_CurrWaterSrc}

S3Q11: Which months do you use ${s3_CurrWaterSrc} for watering during Wet season?

S3Q12: Which months do you use ${s3_CurrWaterSrc} for watering during Dry season?

S3Q13: Which months do you use ${s3_CurrWaterSrc} for watering during extremely Dry season?

S3Q14: Why do people prefer ${s3q4_NameH2OSrc} ?

S3Q15: Who else uses ${s3q4_NameH2OSrc} as water source ?

S3Q16: List the other villages that use this water source, starting from those that use it most

S3Q17: How often do these other villages use ${s3q4_NameH2OSrc} ?

S3Q18: Which months do they prefer to use ${s3q4_NameH2OSrc} ?

S3Q19: GPS Location for ${s3q4_NameH2OSrc} area ?

S4: Dipping

S4Q1: Do you have dips in your village

S4Q2: List all dips for livestock you use, starting with the one you use most

S4Q3: In total how many dips do they have?

S4: dipping Sources

S4: Index of Current Source

S4Q4: What is the name of the ${s4_CurrDip} dipping point?

S4Q5: What is the status for the ${s4_CurrDip} dipping point?

S4Q6: How many months has not being used

S4Q7: Frequency of use for ${s4q4_NameDip} Dip

S4Q8: Does ${s4q4_NameDip} depend on season?

S4Q9: Which village does ${s4q4_NameDip} located in

S4Q10: Who else uses ${s4q1_HaveDips} dip ?

S4Q11: List all other villages that use the dip, starting from those that use ${s4q4_NameDip} most.

S4Q12: How often do these other villages use ${s4q1_HaveDips} ?

S4Q13: What livestock make use of ${s4q4_NameDip} dipping points ?

S4Q14: Do you go to another village for dipping?

S4Q15: List other villages you go to for dipping

S4Q16: How often do you go to these other villages for dipping service?

S4Q17: If you don't have a dipping services, do you use hand spray?

S5: Mineral salt

S5Q1: Do you have mineral salt in your village

S5Q2: List all mineral salt for livestock you use, starting with the one you use most

S5Q3: In total how many mineral salt do they have?

S5: Mineral salt Sources

S5: Index of Current Source

S5Q4: What is the name of the ${s5_CurrMineralSalt} source?

S5Q5: Frequency of use for ${s5q4_NameminerlSlt}

S5Q6: Does ${s5q4_NameminerlSlt} depend on season?

S5Q7: Which village ${s5q4_NameminerlSlt} is it located in

S5Q8: Who else uses ${s5q4_NameminerlSlt} dip ?

S5Q9: List all other villages that use the dip, starting from those that use ${s5q4_NameminerlSlt} most.

S5Q10: How often do these other villages use ${s5q4_NameminerlSlt} ?

S5Q11: Do you go to another village for mineral salt?

S5Q12: List other villages you go to for mineral salt

S5Q13: How often do you go to these other villages for mineral salt service?

S5Q14: If you don't go to other village for mineral salt do you buy mineral salt for your animals ?

S6: Livestock movement routes

S6Q1: Do you have major livestock routes or major migration routes in your village

S6Q2: How many active livestock routes do you have ?

S6: Animals routes

S6: Index of Current Route

S6Q3: Type of the ${s6_CurrRoute} route?

S6Q4: Is route ${s6_CurrRoute} official or not official?

S6Q5: What livestock make use of these ${s6_CurrRoute} routes?

S6Q6: Who makes use of ${s6_CurrRoute} route?

S6Q7: List other villages that uses ${s6_CurrRoute} route?

S6Q8: When using ${s6_CurrRoute} route do you have to pass across crop farms ?

S6Q9: In this ${s6q3_RouteTyp} route have you ever experience conflicts with agriculture farmers ?

S6Q10: If Yes when ?

S7: Pastoralists migration patterns

S7Q1: Does your community usually migrate will all livestock?

S7Q2: Do you have some individuals in your community who only migrate with a proportion of their herd?

S7Q3: What proportions are left behind at the permanent locations?

S7Q4: Which villages does your village migrate your animals to?

S7Q5: Which months do you migrate?

S7Q6: Which months do you return?

S7Q7: Can you describe your community seasonal migration patterns wet vs dry?

S7Q8: How often do you integrate the migratory herds with those left behind?

S7Q9: Do other villages migrate their animals to your village?

S7Q10: Which villages migrate their animals to your village?

S8: Livestock population

S8Q1: Can you estimate the population of cattle in this village?

S8Q2: What is the maximum number of cattle per household?

S8Q3: Is there a limit on the number of cattle allowed to be kept in this village?

S8Q4: What do people do with remaining animals?

S8Q5: Which other villages do people keep their remaining animals?

S8Q6: Do you have relationship with these people where you keep your livestock?

S9: Crop Production and Conflicts

S9Q1: Does your community engage in crop production?

S9Q2: In average how many acres of land are used for agriculture per household

S9Q3: Which months do farmers grow their crops

S9Q4: Which months do farmers harvest their crops

S9Q5: How do you manage lands for crops and livestock especially in the wet season?

S9Q6: Do people feed their animals with crop residue after harvests

S9Q7: Around what time of the year do you use crop residues?

S9Q8: What types of conflicts do you face in your village

S9Q9: In average how many conflicts between farmers and pastrolist do you resolve per year?

S9Q10: What were damages

S9Q11: Up until now is there unresolved conflicts

S9Q12: If Yes which Area

S9Q13: What has been done now?

S9Q14: How do you resolve/manage conflicts ?

S9Q15: Do government officials intervene to prevent conflicts.

S9Q16: Are you aware of any land use plan in your village

S10: Fodder Banks

S10Q1: Do you have any reserved fodder banks or reserved grazing areas

S10Q2: If yes How many do you have

S10Q3: Who is owner for these banks or reserved grazing areas

S10Q4: How many animals can it be able to serve

S10Q5: Which months do you use these banks or reserved grazing areas

S10Q6: Who normally oversee these banks

S10Q7: Are there any disease risks that influence your community's decisions as to whether to take livestock for grazing or watering areas ?

S10Q8: If yes, what are the most important disease risks perceived by your community ?

S10Q9: More details about the village