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Participatory livestock movement routes and resource mapping in pastoral areas of Oromia and Somali Regions, southern Ethiopia

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Pastoralism is both a way of life, and a livelihood strategy for millions of people around the world and for more than four million people in Ethiopia. Better understanding of pastoralist routes allows improved delivery of services, contributing to sustainable development, and poverty reduction. Livestock routes and resource mapping was conducted from December 2019 to December 2022 using participatory mapping approaches in key pastoral areas of the Somali region and Oromia region in southern Ethiopia. In total, 96 livestock routes, 14 livestock markets, 49 animal health posts, 44 human health posts, and 142 livestock watering and salt lick points were identified and mapped by participants in the study areas. Just under 10% (n = 9) of mapped livestock routes were non-functional at the time of mapping because of poor provision of services and lack of security along the routes, limiting access to grazing resources and precipitating over-grazing in accessible rangelands. Mapping, servicing, and protecting livestock routes and resources in pastoralist areas is vital for delivering development activities tailored to the pastoral community. This research provides essential information on the location and status of livestock routes and resources for the government and other stakeholders, and the methods presented can be applied to serve other pastoralist systems.

KEYWORDS

livestock movement-routes, livestock related-resources, oromia and Somali region, participatory-mapping, southern-Ethiopia

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Introduction

A 2018 foresight exercise conducted by the Food and Agricultural Organization (FAO) warns that "business as usual" is no longer an option for a food-secure future. If food systems remain on their current path, the evidence points to a future characterized by persistent food insecurity and unsustainable economic growth (FAO, 2018a). The report concludes that high-input, resource-intensive farming systems that have caused massive deforestation, water scarcity, soil depletion, loss of biodiversity, antimicrobial resistance, and high levels of greenhouse gas (GHG) emissions cannot guarantee the sustainability of food and agricultural systems. Innovative systems are needed to increase productivity without compromising the natural resource base (FAO, 2018b). Recently, innovative, and nature-based approaches have been receiving increased attention from many stakeholders as they consider ecological concepts and principles that optimize interactions among plants, animals, humans, and the environment while taking into account the social aspects that need to be addressed for sustainable food systems. Although frequently being undervalued by outsiders, pastoralism is a time-tested alternative path to food production that provides valuable lessons for the much-needed evolution towards farming with nature, and has largely untapped potential for secure income and employment in marginal areas, and makes use of drylands and mountain areas (FAO, 2021).

Pastoralism is a livelihood strategy and a system of mobile livestock production that makes wide-ranging use of grazing lands in arid and semi-arid environments, which does not support sustainable crop cultivation. The freedom of mobility over large areas of land is indispensable to pastoralist production. The people and livestock in pastoral communities may move to avoid various natural and/or social hazards, to avert competition with others, or to seek more favorable conditions (Dong et al., 2016). Estimates of the number of people globally involved in pastoral systems and agropastoral systems exceed 180 million, living in approximately 75% of countries (Kieta et al., 2016). Pastoral livestock production systems are mostly found in Africa's vast arid and semi-arid areas, with the practice continuing in some parts of the Middle East and South Asia. All countries in the Horn of Africa host large populations of pastoral communities. In Ethiopia, arid and semi-arid pastoral

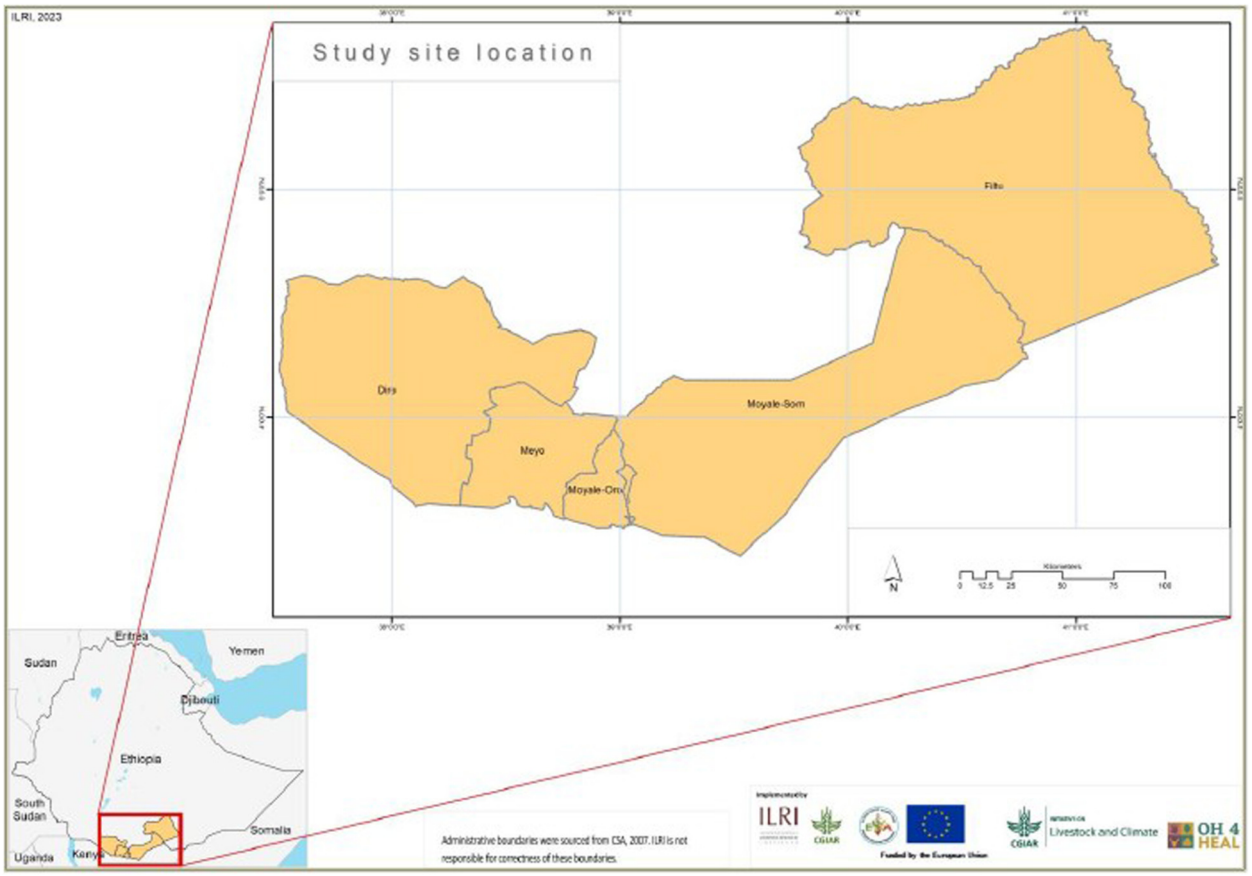

FIGURE 1
Districts included in mapping activity. Credit: Yasin Getahun (GIS expert at ILRI).

areas comprise approximately 60% of its total land area, mainly peripheral areas where no alternative production takes place. This way of life sustains the livelihood of some 14% of the population (Yohannes and Mahmmud, 2015) and contributes to Ethiopia's large livestock populations (Central Statis tical Agency, 2020).

Although it is understood that engaging with pastoralism has strong relevance to virtually all the Sustainable Development Goals (SDGs) and food security (FAO, 2013), pastoralists have remained vulnerable, poor, and marginalized from development due to conflict, inappropriate government policies, inappropriate government large-scale project planning, and climate change that exacerbates the intensity of droughts (Yohannes and Mahmmud, 2015).

Understanding the pastoral system and planning developmental activities tailored to the pastoral community is an important task needed to alleviate various problems. As pastoralism is characterized by mobility, all developmental activities should consider the routes through which the pastoralist frequently travels. Easy and safe movements are needed to access livestock markets, and to access grazing and water resources without conflict with other land users. Supporting pastoralist development also requires serviced and protected mobility routes. Therefore, mapping, servicing, and protecting livestock routes and livestock resources in pastoralist areas is key to the management and development of pastoral areas and facilitates pastoralist communities to move out of poverty (Minestry of Agriculture MoA, 2015). A team of experts who participated in an international workshop held by the Ministry of Agriculture recommended that there is a need to map livestock routes in Ethiopia to understand their location and status as a first step in supporting, servicing, and protecting them (Minestry of Agriculture MoA, 2015). The participatory mapping activities described here were conducted to produce digitized and validated maps of livestock routes, markets, watering points, facilities and human-health-related infrastructure.

Materials and methods

Description of the study areas

The mapping of livestock routes in Ethiopia was initiated and implemented by the International Livestock Research Institute (ILRI) in the pastoral areas of Oromia region (Meyo, Moyale Oromia, and Dirre districts) and Somali region (Moyale Somali and Filtu districts) (Figure 1).

Dirre, Meyo and Moyale Oromia districts are in the Borena Zone in the Oromia region of Ethiopia, bordered to the south by Kenya and are over 700 km south of Addis Ababa, the capital of Ethiopia (Borena Zone Agricultural Office, 2023). Moyale Somali district is one of the districts in the Dhawa Zone of the Somali Region of Ethiopia. The district is again bordered on the south by Kenya, and on the west by the Oromia Region (Moyale Oromia district). The southernmost point of this district is the southernmost point of Ethiopia (Moyale-Somali District Livestock and Pastoral Developmen t Office, 2023). Filtu district is one of the districts in the Liban Zone of the Somali

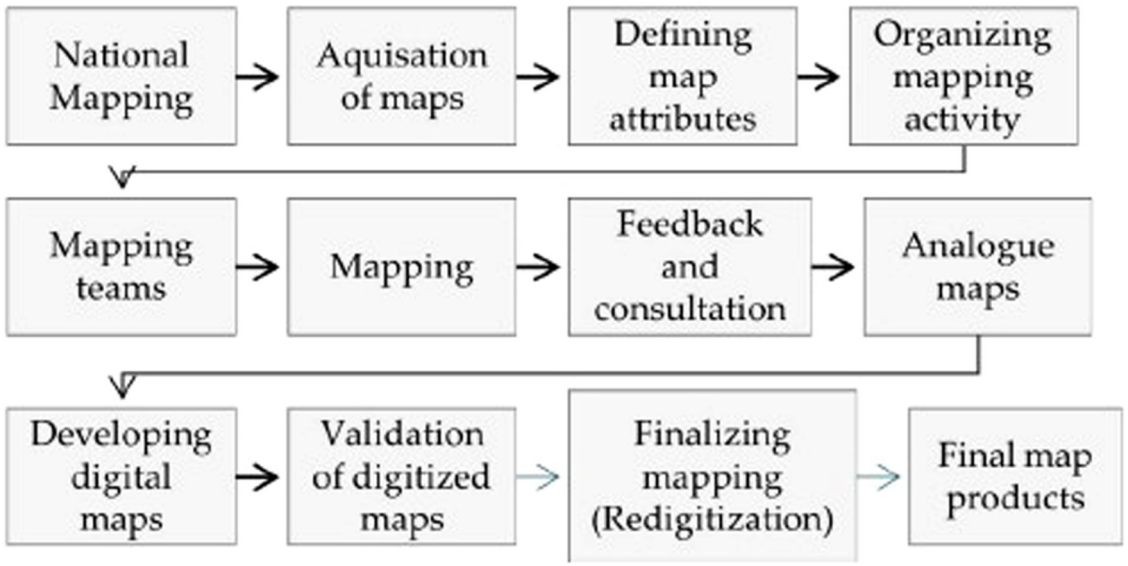

FIGURE 2
Mapping process followed in participatory mapping activity.

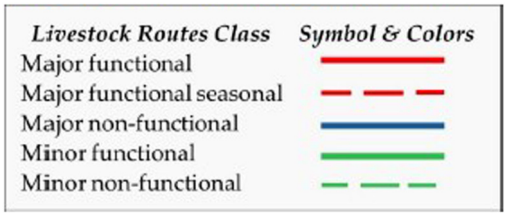

FIGURE 3
Livestock routes class and denotation.

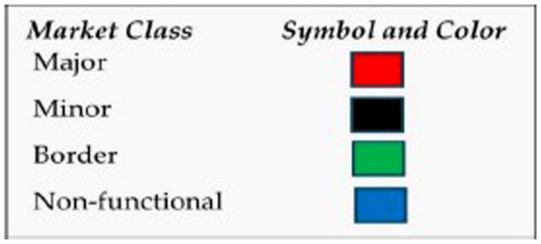

FIGURE 4
Livestock market class and denotation.

Region of Ethiopia; it borders the Oromia Region (Filtu District Livestock and Pastoral Development Office, 2023).

Study design

Generally, a mapping process tested in Tanzania to map livestock migratory routes and in Kenya to map livestock routes in Samburu County was utilized in the current activity (Figure 2) (Kifugo et al., 2015). Participatory mapping activities were conducted from December 2019 to December 2022 to map and provide basic information on the location and status of livestock routes and resources in selected districts of the Somali and Oromia regions of southern Ethiopia. The mapping activities were conducted in two phases: the primary mapping activities, which were started in December 2019, and the secondary mapping activities, which were finalized in December 2022. The primary mapping activities were conducted to produce analog maps, and after digitization was completed, the secondary mapping activities were conducted to validate the digitized maps. Participatory mapping activities were held in Mega, Moyale Somali, and Filtu towns with local stakeholders. Participants from Dirre district, Meyo district, and Moyale Oromia district were invited to the mapping activity held at Mega town. Participants from Moyale Somali district and Filtu district were invited to the mapping activity held at Moyale Somali town and Filtu town, respectively.

Primary mapping activity

For the primary mapping activity, workshops were held in Mega, Moyale-Somali, and Filtu towns to produce the analogue maps of livestock routes and resources on the provided topographic map.

For the primary mapping activity, workshops were held in Mega, Moyale Somali, and Filtu towns to produce the hand-drawn maps of livestock routes and resources on the provided topographic map. Primary mapping involves several activities: accessing official topographic maps, defining map attributes, organizing the mapping activity, developing the mapping team and map selection for each group, the mapping exercise (actual data collection), and feedback and consultation.

The official topographic map of the areas under investigation was published in 1994 and is the most recent version available and was requested and accessed from the Ethiopian Mapping Authority (EMA), Addis Ababa. The topographic map was printed on 61 sheets at a scale of 1:50,000 and arranged into three parts: the Meyo, Dirre, and Moyale Oromia parts, which covered 13 sheets of maps; the Moyale Somali parts, which covered 25 sheets; and the Filtu area, which covered 23 sheets.

The attributes to be mapped were defined at the beginning, and specific legend signs were allocated for each attribute. Accordingly, four livestock and social themes were identified and defined to be marked with different symbols and colors; livestock routes, livestock markets, water points, and livestock facilities and human health related infrastructure (Human health post: a rural healthcare facility providing primary services like immunization, maternal care, disease prevention, and health education).

Livestock route: livestock volume in the route, seasonality, and status were considered to classify the existing livestock routes in the areas. Where the volume of stock was identified as high, it qualified to be a major route; routes used by the pastoralists only during the dry season were identified as seasonal; and those working at the time of mapping were denoted as functional. Accordingly, five classes of routes were identified and denoted by different types of lines and colors (Figure 3).

Livestock markets: Three market types (minor, major, and border) were defined based on characteristics like; volume of livestock, prices, number and kinds of players (external traders, local traders, middlemen), market days per week and location. Big volumes, high prices, more external players than local, and 1 or 2 market days per week qualified for major markets. Minor markets are characterized by low volumes, low prices, local traders, and are mostly daily. Market places that are found on international borders were classified as border markets, and all market classes were denoted by small rectangles with separate colors (Figure 4).

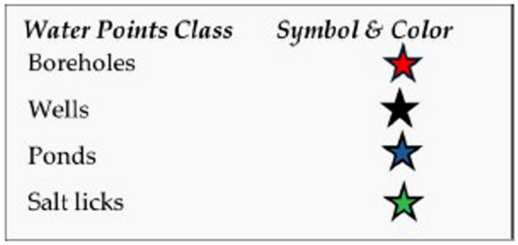

FIGURE 5
Watering points class and denotation.

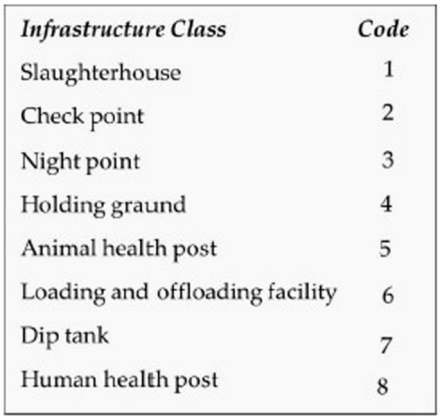

FIGURE 6
Infrastructure class and denotation.

Water points: the water resources for the pastoralists are grouped into four classes based on the intention of use, source, and mechanism of accessing the water. Deep-ground water sources accessed by machines (pumps) were classified as boreholes, while groundwater sources accessed by human power were classified as well. Surface water accumulated at one low altitude place or man-made wide superficial hole and easily accessed by animals was classified as a pond. Places or water points where animals travel for the purpose of mineral feeding were classified as salt licks. All water points are denoted by a star symbol and a separate color (Figure 5).

Livestock facilities and human health related infrastructure: Eight different infrastructures were identified and coded using unique numbers ranging from 1 to 8 (Figure 6).

The mapping activities were organized by ILRI. More than 80 (male 76 and women 4) participants were invited and participated in the participatory mapping activities, and they represented the pastoral community elders from all districts involved in the mapping activities, zonal and district level experts from the livestock resource development offices of the respective districts, and experienced livestock traders from each district. Community elders (Aba dheda) representing their communities were invited based on their experience and social status. Participants were welcomed and objectives, basic concepts, importance, and methodology of participatory mapping were explained.

TABLE 1 Proportion of livestock routes classes identified.

Route type	Proportions % (N)
Major functional	67 (64)
Major functional seasonal	20 (19)
Major non-functional	5 (5)
Minor functional	4 (4)
Minor non- functional	4 (4)
Total	100 (96)

In total eight mapping teams were formed focusing on mapping different districts according to their knowledge of the area, and different tasks were allocated to the members. Map sheets corresponding to each group were picked, allocated, and map edges joined to create a mosaic on the floor.

Each group was allowed to work on the mosaic map and track the main routes through which livestock move to water points, markets, animal health posts, and rangeland fields. In addition, livestock facilities, human health related infrastructure, waterpoints, and marketplaces were mapped alongside the routes of movement. Data related to livestock routes starting and destinations, aim of using the routes, time during which they use the routes, functional status of the routes, crossing points, relative location, type and name of livestock market, livestock and human infrastructures, and watering points were collected.

Once all groups had completed the mapping activity, edge matching was done to produce a single mosaic map, and each group was invited to present their work. All groups were engaged in discussion on the mosaic map to make information flow from one division to another, to adjust for missed points, to discuss the justification given by each group on the mapped, non-functional map features, and to make sure that all groups agreed on the produced map and justifications. Finally, the analog map produced by all groups was checked for its correctness, ratified, and collected for further digitization.

Digitization

Once the participatory mapping was completed on the field, the next step was to digitize the maps by an ILRI-GIS expert. This step involved scanning drawn topographical maps at EMA, geo-referencing, and screen digitizing the maps using Arc-GIS software at ILRI. Each of the attributes, including livestock routes, market centers, water points, and infrastructure, was coded, and a database was developed.

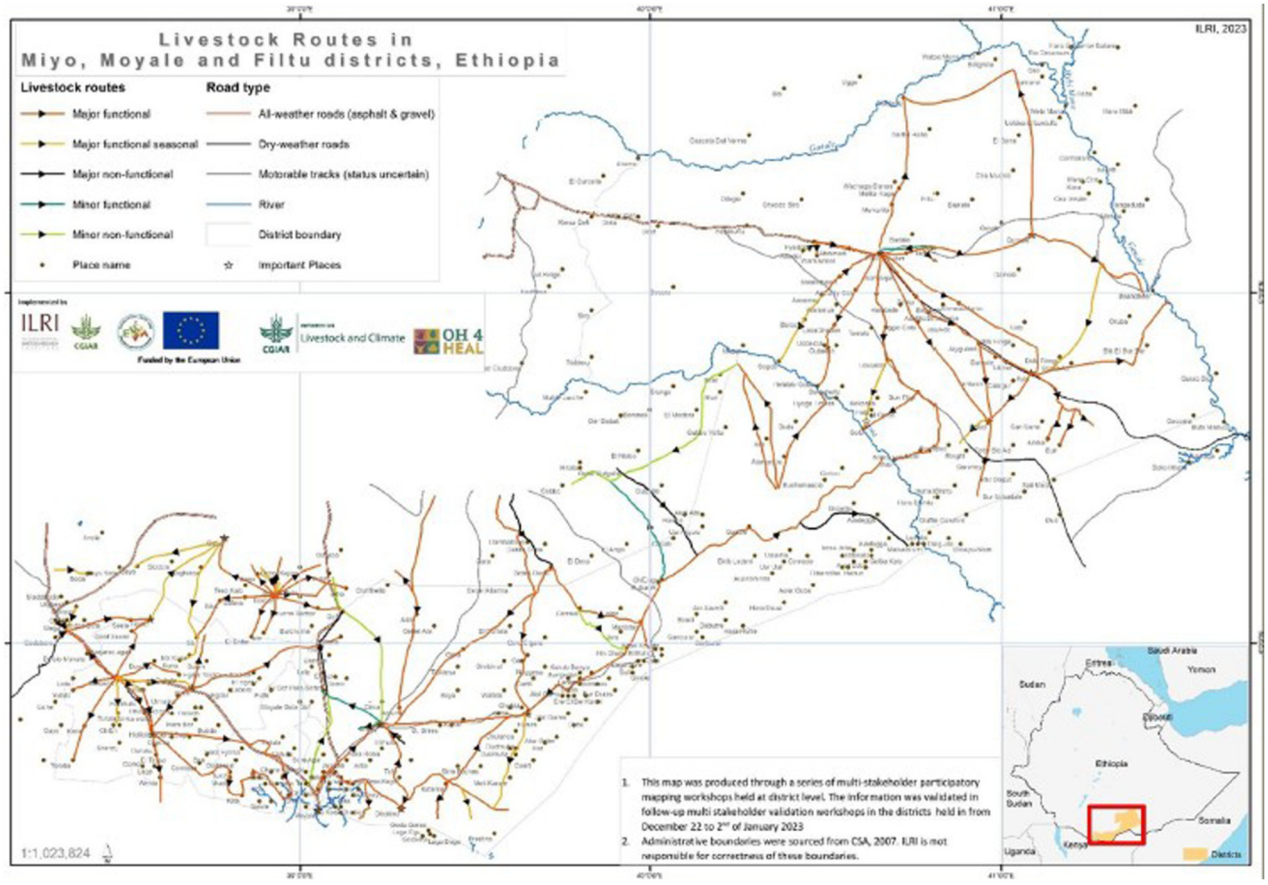

FIGURE 7
Livestock routes map. Adapted from "Livestock Livestock routes in Miyo, Moyale and Filtu districts, Ethiopia" by Yasin Getahun, licensed under CC BY 4.0.

Each of the 56 maps was edge-matched to join the map sheets, and further cleaning of the information was undertaken. After this process, the digital maps of all districts were mosaicked, and for each of the four parts (i.e., livestock and human-related infrastructure, livestock routes, markets, and water points), digital maps were produced.

Map validation activity

Like the primary mapping activity, three separate participatory map validation workshops were held in Mega, Moyale-Somali, and Filtu towns for the secondary mapping activity to make corrections (changes of names, changes of route type, length extending and completing full path information), add new information that was missed in the previous mapping exercise, and maintain rightly located features (no change). The same procedure as during the primary mapping activity was used in the validation activity. After finalizing the validation, a confirmation form was signed by each participant to confirm the mapping and validation activity was conducted by a participatory approach via active participation of the pastoral community and other stakeholders, entirely depending on their indigenous knowledge of the areas without any interference or pressure from the organizers. Finally, the validated map sheets were collected for further digitization and the map finalizing process.

TABLE 2 Proportion of livestock markets classes identified.

Market type	Proportion % (N)
Border	7 (1)
Major	14 (2)
Minor	72 (10)
Non-functional	7 (1)
Total	100 (14)

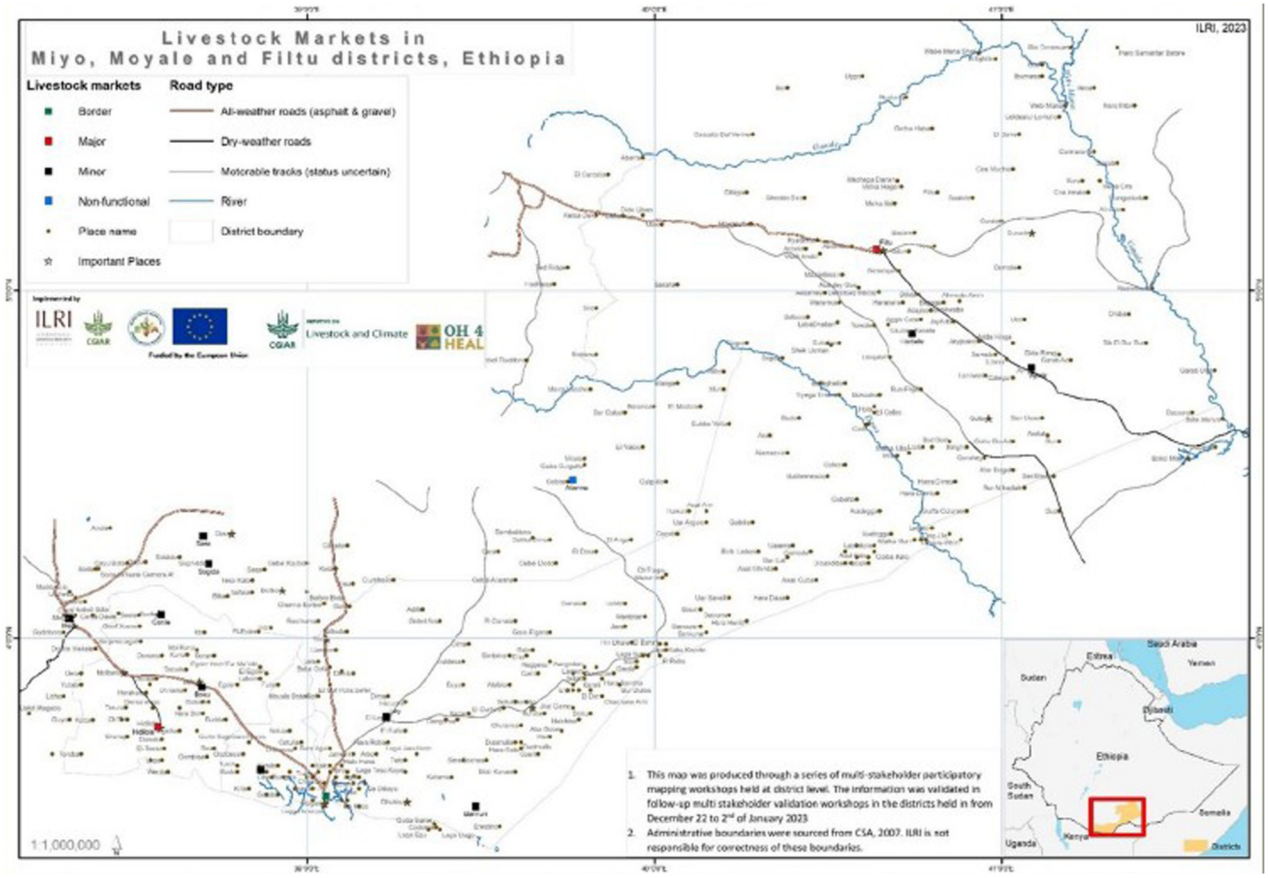

FIGURE 8
Livestock markets map. Adapted from "Livestock Market centers in Miyo, Moyale and Filtu districts, Ethipoia" by Yasin Getahun, licensed under CC BY 4.0.

TABLE 3 Proportion of livestock facilities and human health related infrastructures identified.

Livestock facilities and human health related infrastructures	Proportion % (N)
Animal health post	49 (49)
Check point	1 (1)
Holding ground	1 (1)
Loading & offloading facility	2 (2)
Slaughterhouse	3 (3)
Human health post	44 (44)
Total	100 (100)

Finalizing mapping

All validated map sheets in the field were rescanned at EMA, all corrections and newly added information were digitized, any erroneous information was deleted, and both the digital and hardcopy maps were updated by an ILRI-GIS expert on Arc-GIS software. Finally, four separate layers of digital maps and one digital map containing all layers in one were produced.

Data analysis

Geospatial data collected by the mapping activity and filled into the attribute tables of each feature were exported in a Microsoft Excel spreadsheet and analyzed using RStudio version 3.6.1 (2019-07-05). A descriptive analysis was conducted to summarize the findings of participatory mapping activities.

Results

Livestock routes map

A total of 96 livestock routes were identified and mapped by the participants in the study areas. The livestock routes mapped were grouped into five separate classes: major functional routes, major

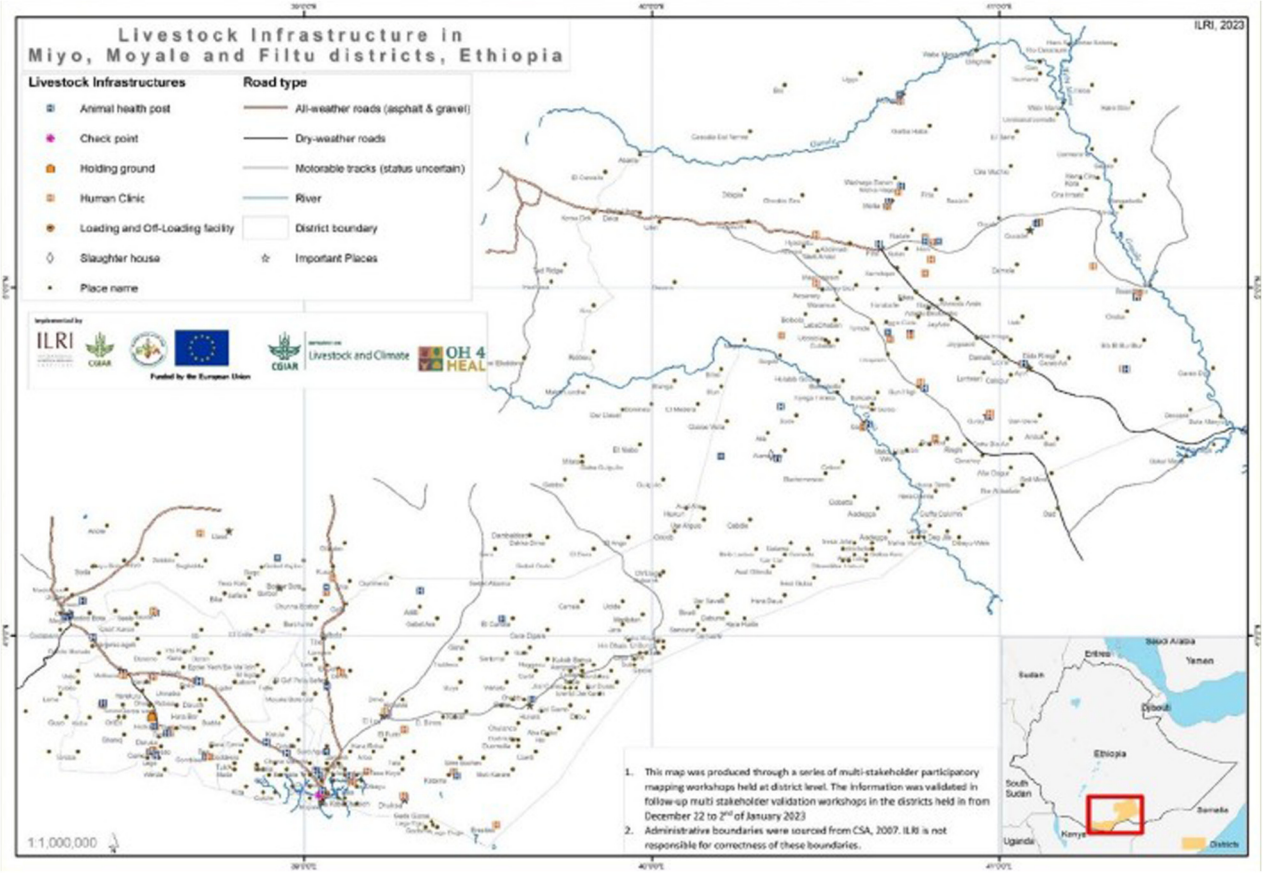

FIGURE 9
Livestock facilities and human health related infrastructure map. Adapted from "Livestock Infrastructure in Miyo, Moyale and Filtu districts, Ethipoia" by Yasin Getahun, licensed under CC BY 4.0.

TABLE 4 Proportion of water point types identified.

Water point types	Proportion % (N)
Boreholes	14.1 (20)
Ponds	64.1 (91)
Wells	15.5 (22)
Saltlicks	6.3 (9)
Total	100 (142)

functional seasonal routes, major non-functional routes, minor functional routes, and minor non-functional routes (Table 1).

From the overall mapped livestock routes, just under 10% (n = 9) were non-functional at the time of mapping for a variety of reasons: opening of alternative routes, blockage of routes because of conflicts on rangeland with neighboring districts, construction and establishment of new livestock facilities, marketplaces, and water points in the nearest locations, and depletion of livestock resources from some livestock destination points (drying of water points).

Grazing places (rangelands), watering points, salt licking points, livestock markets, and animal health posts were found to be the major destination points of the livestock routes mapped in the study areas. From the total of 96 destinations, about 90 livestock routes are used to access grazing areas, watering points, and other destination points, including marketplaces and animal health facilities, while three of them were for accessing salt licking places, and three of them for accessing marketplaces only. The final map of traditional livestock corridors (routes) from the participatory mapping is presented in Figure 7.

Livestock markets map

Location of 14 livestock markets were identified by the participants, and they are grouped into four classes: major livestock markets, minor livestock markets, border livestock markets, and non-functional livestock markets (Table 2).

The final map of the livestock market from the mapping activity is shown in Figure 8.

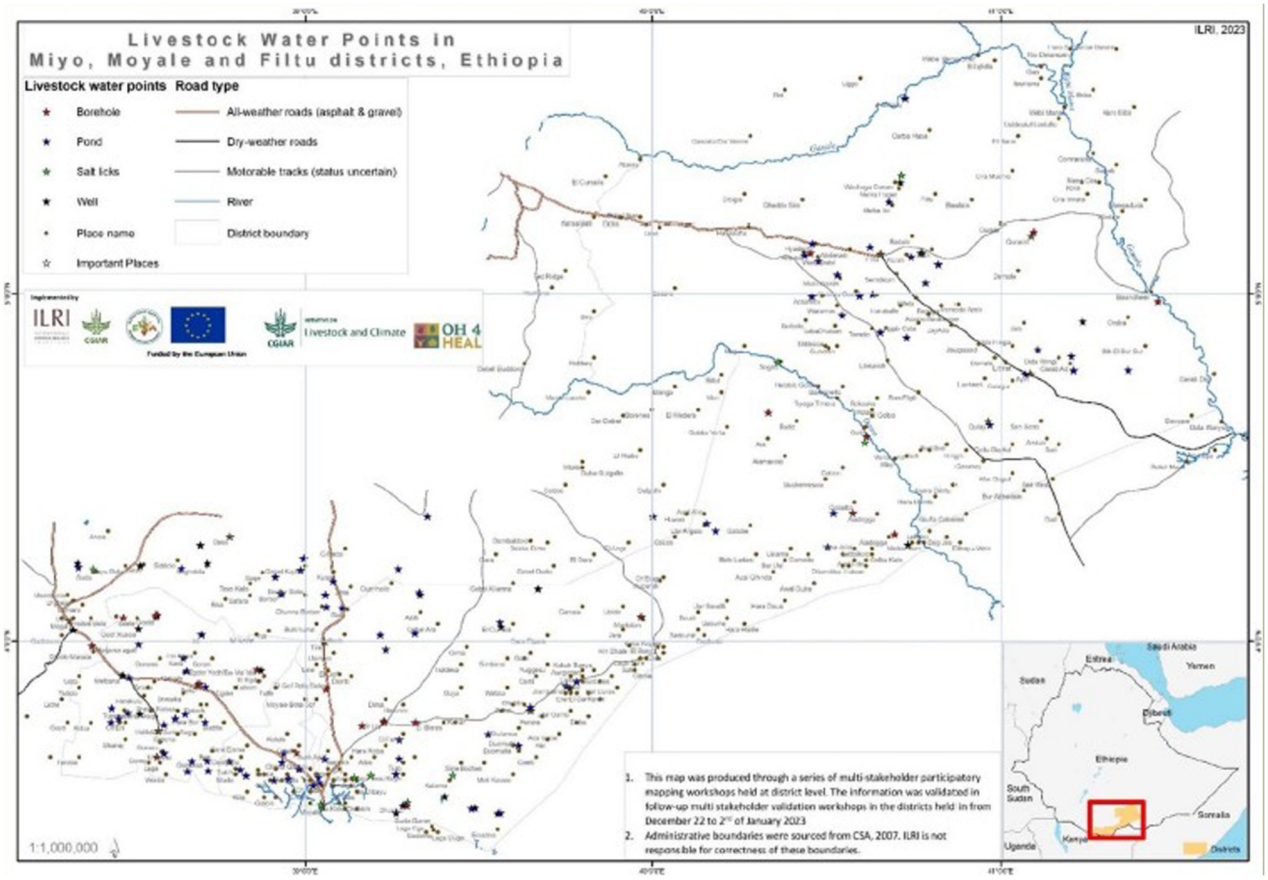

FIGURE 10
Livestock watering points and salt licks map. Adapted from "Livestock water points in Miyo, Moyale and Filtu districts, Ethipoia" by Yasin Getahun, licensed under CC BY 4.0.

Livestock facilities and human health-related infrastructure map

One hundred (100) livestock facilities and human health-related infrastructures were identified by the participants, and from these, animal health posts and human health posts account for 49% and 44%, respectively and other livestock related infrastructure accounts for 7% (Table 3).

The final map illustrating livestock facilities and human health-related infrastructure generated from the mapping activity is presented below (Figure 9).

Livestock watering points map

The participants also mapped 142 livestock watering and salt lick points. Accordingly, they pointed out boreholes, wells, and ponds as different sources of water. Ponds (64.1%) were identified as the major sources of water in the area. The proportion of water point types identified are presented in Table 4.

The final map, depicting livestock watering points and salt licks identified during the mapping activity, is presented in the following (Figure 10).

Livestock routes and resources map

All map layers produced by these mapping activities were put together in one map to indicate how the livestock routes in the study areas are serviced with livestock resources and infrastructure and to point out the distribution of human health facilities in the study areas. Figure 11 illustrates traditional livestock movement corridors, livestock, and human health facilities and infrastructure (livestock resources) map.

Discussion

Mapping, servicing, and protecting livestock routes and livestock resources in pastoralist areas is the foundation for

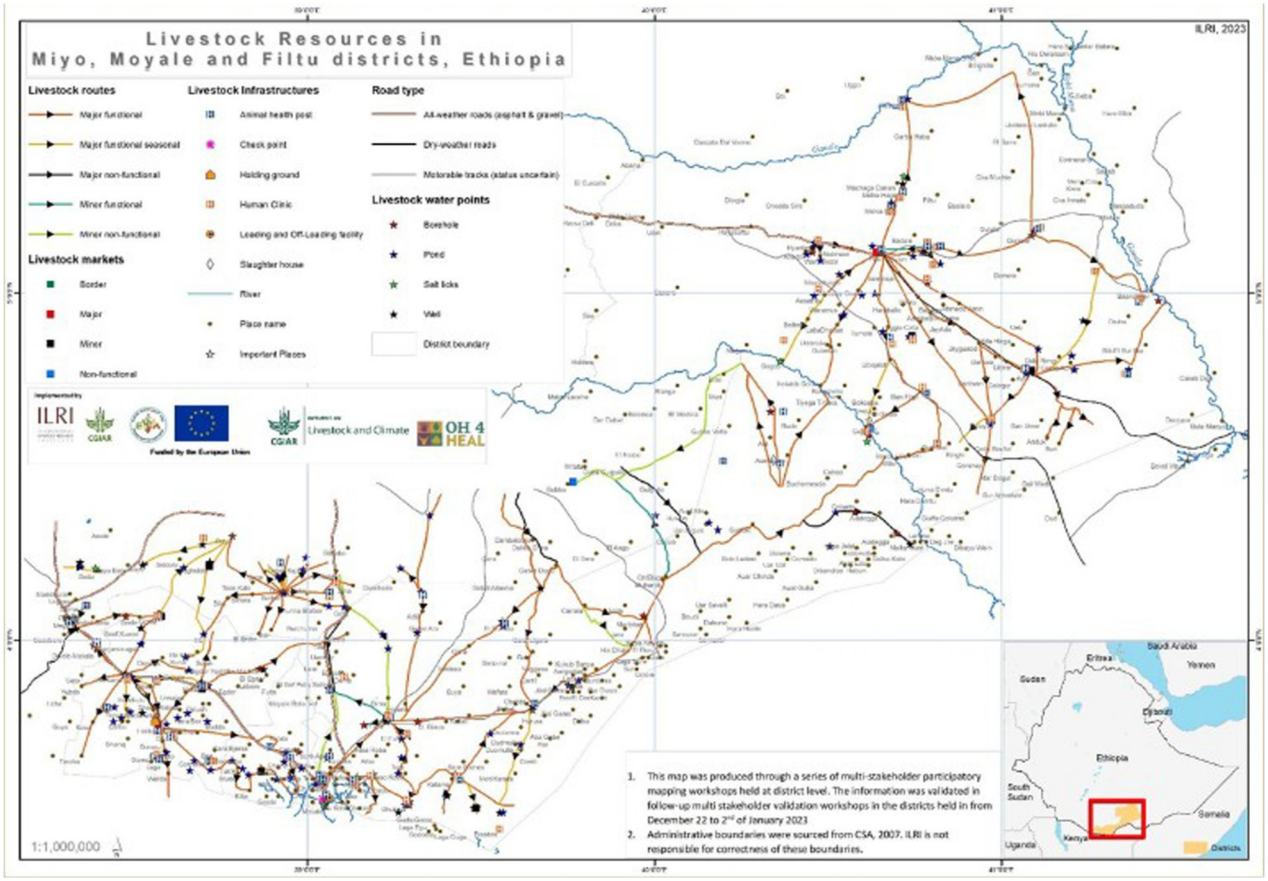

FIGURE 11
Traditional livestock movement corridors, livestock, and human health facilities and infrastructure (livestock resources) map. Adapted from "Livestock Resources in Miyo, Moyale and Filtu districts, Ethipoia" by Yasin Getahun, licensed under CC BY 4.0.

understanding the pastoral system and planning development activities tailored to meet the needs of the pastoral community. Livestock route and infrastructure mapping activities were conducted in pastoral areas of the Somali and Oromia regions. Livestock routes, livestock markets, livestock facilities and human health infrastructures, and livestock watering points were identified and mapped through employing a participatory approach. However, the mapping of livestock routes and markets did not incorporate species-specific livestock data, which constitutes a limitation of the current study.

The maps for the livestock routes in the study areas show that the majority (91.0%) of the livestock routes are functional and they are important corridors to grazing places (rangelands), watering points, salt licking points, livestock markets, and animal health posts. However, land use conflicts and other factors threaten some routes hindering access to services and resources. This finding agrees with the idea reflected on the critical review article on livestock mobility in Sub-Saharan Africa (Turner et al., 2019).

The map for watering points in the study areas indicated pond water (64.1%, n = 91) as a major water source for the pastoralist community, even if pond waters are not a clean source of water for humans and livestock. Boreholes and wells, which are relatively clean and quality water sources, are very few in number and scattered over vast rangeland areas. Ponds, wells, and boreholes are more accumulated around the residences and rod sides, and remote range lands where pastoralists used to travel found to have fewer watering points. The government and other interested developmental organizations could use watering point maps to support the pastoral community and intervene in water resource establishment and rehabilitation.

The livestock market map indicates a low density of livestock markets over vast areas, especially major livestock markets, which are very few in number. From this, one can understand that the pastoralists are expected to track their animals one foot over a long distance to sell them and buy household commodities. Livestock market maps could help the government and other interested developmental

organizations engaged in supporting the pastoral community through establishing new markets and rehabilitating the existing ones.

The maps in the study areas also clearly show the low density of animal health posts and human health posts over the vast rangeland areas, and some areas have predominantly constant major livestock routes and areas frequented through major seasonal routes. The map showing animal health posts and human health posts could help the government and other interested developmental organizations to define suitable locations for mobile or static animal health posts and human health posts establishment and where to strengthen the existing infrastructures.

In conclusion, with the current mapping activity, several livestock routes and infrastructures have been identified and mapped. Thus, the maps produced will provide basic information on the location and status of livestock routes and infrastructure to the government and other stakeholders for better decision making in supporting, servicing, and protecting them. Additionally, in times of conflict, livestock movement routes and resources maps can assist in planning safe movement of animals, and serve as a visual aid during negotiations, helping parties understand livestock movement routes and rangeland resource in the area, and support resource allocation.

Effective management of livestock routes is essential for sustainable land use planning, as it reduces conflict potential, strengthens animal disease control, enhances livelihoods' resilience to climate change, maintains ecological balance, and ensures food security within pastoral systems. In line with this objective, local, regional, and federal governments should formally recognize and protect the livestock routes and infrastructure mapped in the study areas. Moreover, the government and other stakeholders should also work towards supporting, servicing, and protecting the identified livestock routes in the study areas. As the livestock routes are continuously threatened by conflicts, the local governments and the community should strengthen conflict management systems to contain conflicts between adjacent pastoral kebeles, and the community should work towards bringing peace and harmony between neighbors to avoid livestock route obstruction and help communities make optimal use of the available livestock resources. To support this, ILRI organized a dissemination workshop involving end users, government offices at multiple levels, universities, research centers, pastoral community elders, development partners, and professional associations. The workshop aimed to promote awareness, recognition, and protection of the mapped livestock routes and associated infrastructure (Berhanu, 2024). Finally, livestock routes change over time, so does the content of the produced maps. Changes in the course of the major routes may not occur very quickly, but conflicts, natural disasters, and other emergencies may trigger the causes for change in the existing patterns. Other changes relate to ongoing or planned investments and constructions in the livestock and health sectors, which need to be considered in decision making and keeping the maps up to date. It is thus important to revalidate the current maps over time and to keep track of major changes.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The International Livestock Research Institute's (ILRI) Institutional Research Ethics Committee (IREC) has granted final approval to conduct this research. In addition, individuals who participated in the mapping activities were asked for their consent, and they approved their willingness by signing a consent form.

Author contributions

All authors contributed to the design, organization, data collection, analysis, and writing of this manuscript and have approved the final version. DB: Methodology, Software, validation, Investigation, Formal analysis, Writing original draft. YG: Methodology, Software, validation, Investigation, Writing original draft, Visualization. SG: Supervision, Reviewing and Editing. BW: Conceptualization, Funding acquisition, Project administration, Reviewing and Editing. ST: Methodology, Investigation, Reviewing and Editing. TK-J: Project administration, Supervision, Resources, Reviewing and Editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The author(s) declared that generative AI was not used in the creation of this manuscript.

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