Improving the integrated pastoral resource management of SAPARM information system using Landsat NDVI value for mobility decision making in Lege-Hidha district; Bale lowlands, Southeast Ethiopia

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IMPROVING THE INTEGRATED PASTORAL RESOURCE MANAGEMENT OF SAPARM INFORMATION SYSTEM USING LANDSAT NDVI VALUE FOR MOBILITY DECISION MAKING IN LEGE-HIDHA DISTRICT; BALE LOWLANDS, SOUTHEAST ETHIOPIA

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ACRONYMS AND ABBREVIATIONS

ACF	Action Contre la Faim
CSA	Central Statistics Agency
DPPO	Disaster Prevention and Preparedness Office
DRR	Disaster Risk Reduction
EVI	Enhanced Vegetation Index
FAO	Food and Agriculture Organization of the united nation
FGD	Focus Group Discussion
GIS	Global Information System
GPS	Global Positioning System
HHs	House Holds
HSS	Hoefsloot Spatial Solutions
IFAD	International Fund for Agricultural Development
IK	Indigenous Knowledge
LARST	Local Application of Remote Sensing Technology
LEWS	Livestock Early Warning System
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organization
NIR	Near Infra-Red
NRM	Natural Resource Management
PAs	Peasant Associations
PCDP	Pastoral Community Development Project
PCI	Project Concern International
PDSA	Pastoral Areas Development Study
RCWDO	Rift Valley Children and Women Development Organization
SAPARM	Satellite Assisted Pastoral Resource Management
TM	Thematic Mapper

ABSTRACTS

Availability of pasture and water are essential factors determine time and direction of pastorals movement. In Ethiopian pastorals mobility is a common coping strategy for dealing drought and its induced risks. Helping pastoralists more informed on decisions to manage their resource reduces response costs and livelihood losses. Matching scientific systems with traditional knowledge can lead to the successful resource managements. The aim of this study is improving the Integrated Pastoral Resource Management of SAPARM Information System using Landsat NDVI Value for Mobility Decision Making. The study was conducted on pastorals and agro-pastorals livelihood zones where livestock production is common. Data was collected in Lege-Hidha district using FGD, key informant interviews, community mapping and spatial satellite images from USGS. The spatial data was analysed using GIS/RS spatial data analysis tools. The data analysis on improving the integrated pastoral resource management (SAPARM and traditional system) using Landsat NDVI value is derived from USGS; Landsat at Path 166/167 and Row 54/55 (study area location found between 166/54, 166/55 and 167/54, 167/55) that verified and visualized using ArcGIS 10.3 and Google earth in order to compare Landsat8 NDVI values of 30m^2 resolutions with SAPARM information from Meteosat NDVI at 10km^2. Landsat8 analysis confirmed that areas where mobility is conducted have better and detailed vegetation (greenness) of enhanced reflectance than SAPARM. This was due to Landsat resolution capacity provides visible and detailed images of the invisible reflectance area on SAPARM, which improves pastoral mobility and decisions based on distances, direction, greenness, classification and allow knowing immediately specific places. Integration systems in this study attempted to apply traditional resource management with satellite assisted information using images of better resolution capacity enables to clarify and detailed reflectance. The improvement using NDVI values of Landsat ensure images with intensive areas of vegetation cover than Meteosat images of SAPARM.

Key words: Pastoral Mobility, SAPARM, NDVI, Pastoral Resource Management,

INTRODUCTION

Pastoral systems support the livelihoods of millions of people living in harsh environments where alternative land use systems are highly risky or simply not possible. Extensive pastoral production is practiced on 25% of the global land area, from the dry lands of Africa (66% of the total continent land area). It provides 10% of the world's meat production, and supports some 200 million pastoral households who raise nearly 1 billion head of camel, cattle and smaller livestock, about a third of which are found in sub-Saharan Africa (Brussels, 2012).

Ethiopia pastoral's and agro-pastoral communities inhabit 625,000 km^2 of the country's rural land mass, covering approximately 65% of the total size of the country it is characterized by an arid and semi-arid climate with low annual precipitation. Fatal combination of diminishing grazing land and both human and animal population growth has led to land degradation, a decrease in livelihood capacities, competition for pasture and water, as well as inter-ethnic and intra-ethnic conflicts (OPA, 2012).

In the pastoral production systems of arid and semi-arid rangelands, mobility strategies across different landscapes remain the main grazing management technique used by pastoralists to meet their livestock's feed requirements. With these systems experiencing increased challenges from anthropogenic and climatic pressures, there is pressing need for an in depth understanding of how pastoralists manage their grazing resources, how they determine their mobility strategies, what factors they consider when making daily and seasonal mobility decisions (Hussein, 2015).

Hence, the ability of pastoralists to migrate strategically throughout the season to access water and grazing grounds is critical to their survival. However, decisions on where to migrate are often informed by delayed and imprecise information; a wrong decision could have devastating long-term consequences, resulting in both widespread livestock death. When this occurs, pastoralists lose necessary income, and communities lose access to food.

As changes in climate become less predictable, reliable traditional methods such as indigenous knowledge and weather indicators are losing effectiveness, and these problems are becoming more prevalent (PCI, 2016). As a result of these confluences of factors is creating a growing demand for innovative solutions to address community resilience generally and climate change adaptation more specifically. Pastoralists across the continent are desperately seeking alternatives to traditional methods for finding pasture. In order to understand the demand, it's important to know current conventions and the challenges they present. Indigenous Knowledge (IK) is a dominant tool of agrarian and pastoral communities around the world for making critical decisions on planting, herd-migration, asset conservation and natural resource management (Teweldebrhan, 2017 and Jennifer Waugaman, 2016).

Each year in Africa, more than 200 million pastoralists seek available pasture for their herds using a combination of low-tech methods. Herders rely on indigenous knowledge and such as verbal exchange within their semi-nomadic communities, to tell them where there might be available grazing lands, scouts, and tips from others, Such methods have become increasingly unreliable due to climate change, leading to large scale herd mortality that erodes both income and food resources (Bonnie Maratea, 2014 and PCI, 2016).

Furthermore, the interaction between conventional science and local knowledge is not new and the history of science demonstrates the two knowledge systems have often been intertwined (Agrawal, 1995). Hence, different literatures reveal that there are also models, technologies and innovation findings that attempted to solve similar situations such as; A Pastoral Early Warning System, A near real-time, satellite-based vegetation monitoring system called LARST (Local Application of Remote Sensing Technology), A technologically advanced remote-sensing, GIS and simulation modelling system called the Livestock Early Warning System (LEWS), The vegetation productivity model uses the Enhanced Vegetation Index (EVI) and Global IMPACT (International Model for Policy Analysis of Agricultural Commodities and Trade) and SLAM (Spatial Livestock Allocation Model) (FAO, 2012).

At a time when climate change is making community IK and traditional methods of finding pasture increasingly unreliable; Satellite Assisted Pastoral Resource Management (SAPARM) fills a critical information gap for pastoralists by allowing them to monitor grazing conditions on a continuous basis. This innovation has the potential to help millions of pastoralists by improving their ability to pinpoint adequate grazing land and reducing the downward trend in livestock mortality (PCI, 2014).

Therefore this study is based on the fact that the study area lies within the pastoral and agro pastoral area, where most of households or population's income or consumption is derived from livestock production or livestock related activities and where pastoral mobility is common trend. Moreover, different development and research programs also focused the issues of pastoral resource managements as it needs a better technologies and strategies, for instance at the federal level the Ethiopian Government has established a Ministry of Federal Affairs, with the main task of addressing development programs in pastoral areas. As a consequence; the pastoral production system in general, in Ethiopia, have now officially been prioritized in the national research agenda for the following reasons of which increases in the problems of feed and water shortages, due to biotic and abiotic influences or disaster risks, as well as lack of appropriate technologies and strategies to control or remedy the situation (Amaha, 2006). In particular, this study is focused mainly on compering the effects of integrated traditional resource management and SAPARM platform derived from the Meteosat at $10km^2$ resolutions with NDVI value Landsat 8 from USGS features for a better pastoral mobility and timely decision making in the study area.

Moreover, the spatially extensive and time-varying nature of the forage resource, coupled with constraints on livestock movements created by water distributions, topography & infrastructure, necessitates this study approach assessment. The use of remote-sensing data, particularly of green vegetation biomass, has proved to be the only feasible approach. Today, there is access to vastly improved databases, GIS, remote sensing and modelling capabilities. Yet, the potential of these information sources and technologies to develop national-scale has barely been tapped (FAO, 2012).

Statement of the Problem

Ethiopia has the largest livestock inventory in Africa, including more than 49 million cattle, 47 million small ruminants, nearly 1 million camels, 4.5 million equines and 45 million chickens, with livestock ownership currently contributing to the livelihoods of an estimated 80% of the rural population (IFAD, 2016 and Malede, 2014). Moreover, according to (IFAD, 2016 report and OPA, 2012); livestock in pastoral regions accounts for an estimated 40% or so of the country's total livestock population. Despite the important contribution of the system to the national economy, pastoralists and agro-pastoralists are among the poorest and most vulnerable rural HHs and the system has been neglected in the past that national policies did not address their issues in Ethiopia. However, recent years have seen growing concern both nationally and globally for the pastoralist cause.

Hence, integrating is become valuable as local pastoralists in different study sites had knowledge of resource management assessment in their own lands. Pastoralists have many reasons for portraying their own indicators in assessments. Moreover, the pastoralists have a broad knowledge base covering materials from rangelands vegetation and animal habits to land characteristics. Therefore, matching the scientific indicators with the ones pastoralists believe in and understand can lead to the successfully control of resource managements. The involvement of pastoralist's knowledge can prove to be useful bases for sustainable utilization and conservation of natural resources. It believes that such plans based on indigenous knowledge can be easily accepted by local people (Behmanesh *et al*., 2016).

As a solution of pastorals resource management for timely decision making when and to where to migrate in reducing risks; SAPARM recently become important tool in strengthening pastoral community resiliency in Bale lowlands by integrating their existing traditional mobility system in search of pasture and water during both wet/dry season, usually at the time of drought using scouts to investigate availability of resources in their grazing routes was a difficult task that takes more than two weeks to travel long distances. This trend may results inaccuracy that cause a death for many livestock before getting pastures and water. Moreover, the ability of pastoralists to migrate strategically throughout the season to access water and grazing grounds is critical to their survival. However, decisions on where to migrate are often informed by delayed and imprecise information; a wrong decision could have devastating long-term consequences. When this occurs, pastoralists lose necessary income and communities lose access to food. As changes in climate become less predictable, reliable traditional methods such as indigenous knowledge (IK) and weather indicators are losing effectiveness, and these problems are becoming more prevalent (Bonnie Maratea, 2014 and Jennifer Waugaman, 2016). Helping pastoralists make more informed decisions on where to take their herds will not only reduce overall humanitarian response costs, but significantly reduce the livelihood losses incurred by them. Hence, using SAPARM simplified the problem recently supports the investigation by giving real time images which was mapped from the satellite in their traditional grazing routes.

Therefore; the absence of appropriate researched information systems both at national and regional levels initiated the proposed research. Despite the fact that SAPARM indicates real time images from Meteosat with $10km^2$ resolution comparing it with the NDVI value features of grazing areas with relatively better resolution effect from Landsat of $30m^2$ were valuable for the pastoral mobility and timely decision making in order to reduce risks. So that, studying integrated pastoral area resource management using NDVI values in the study area were critical in order to support the effort of community's traditional knowledge and upgrade the Meteosat SAPARM images to improve the development of predictable and reliable information.

OBJECTIVES OF THE STUDY

General Objective

The overall objective of this study is to improve or updating the integrated pastoral resource management of SAPARM information system using Landsat NDVI value for mobility decision making in Lege-Hidha district of Bale Zone lowlands, Oromia region in Southeast Ethiopia.

Specific Objectives

- To assess the integrated system of traditional pastoral resource management and SAPARM (traditional plus satellite assisted system) images in the study area.
- To update and/or analyze the improvement of SAPARM information image (originated from Meteosat) using Landsat NDVI value for mobility decision making.
- To identify the difference between improved Landsat NDVI information with SAPARM (comparing the updated Landsat NDVI information image with SAPARM)

RESEARCH METHODOLOGY

Description of the Study Area

Location**:** Bale zone falls between latitude: $5^0$30’0''- $8^0$0’0''N and longitudes: $39^0$30’0’’- $42^0$30’0’'E. It is bounded by Somalia National Regional State in East, East *Hararge* in Northeast, West *Hararge* and *Arsi* zone in North, West *Arsi* in west and *Guji* in the south. Bale zone is bounded by *Genale* River to the west and south, and *Wabe Shebele* river to the east and north directions. It covers a total area of 69,661 km^2 which accounts for about 19.2% of the total area of Oromia region; hence, is the largest zone in the region. Robe is the capital of Bale zone and located about 430 km the southeast direction far from the capital city Addis Ababa (RTA, 2010).

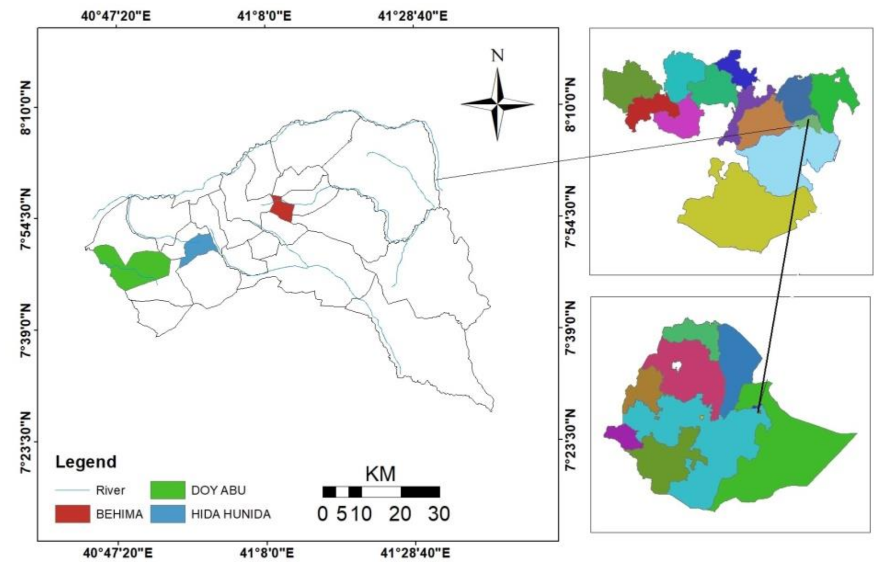

Figure 1: Location Map of the Study Area in Bale zone, Oromia Region Ethiopia

Moreover, the study is carried out in Lega-Hidha district, Bale Zone of Oromia regional state: Ethiopia. It is located between $40^0$30’0’’- $41^0$40’0’’E and 6°0’0’’- $8^0$30’0’’ and at about 678 km Southeast of Addis Ababa. It covers an area of about 6,157.15 km^2 (PDSA, 2004). It is bordered in the south by *Seweyna*, on the southwest by *Gasera* and *Gololcha*, and all other sides by the *Shebelle* River (Wikipedia, 2014).

Socio-economy and Climate: According to the 2007 CSA report, the population of Bale zone was 1,418,864. Economically, more than 85% of the population engages in agriculture and the remaining in pastoralist, trade and civil service (CSA, 2007). Likewise, pastoralism and agro-pastoralism are an integral part of the land use system in Lege-Hidha district. The 2007 national census reported that a total population of this district is 62,521 (Wikipedia, 2014). Currently the human population of the district is estimated at 70,654 (Mengistu. *et al*., 2015). Lege-Hidha has no all-weather roads, leaving *Beltu* (administrative centre of the district) 65 kilometres from the nearest all-weather road; the Socio-Economic profile for the Bale Zone describes Lege-Hidha as "***one of the remotest districts in the Zone***". About 4.7% of the total population has access to drinking water (Wikipedia, 2014).

The climate of the area is arid or semi-arid and the rainfall pattern is bimodal type. The main rainy season is from April to June while the short rainy season is from August to September. The mean annual rainfall is ranging from 500 to 800 mm. The district has an elevation ranging from 1,200 to 1,400 m.a.sl., with average temperature between 25 and 28^{o}c. The main soil types are sandy and *pellic* verity-soils (Mengistu. *et al*., 2015).

Land and Land Use Systems: According to PDSA (2004), livestock production (i.e., cattle, sheep, goats, camels, horses, mules and donkey rearing) is a common practice in the lowland areas of Bale Zone. *Teff*, maize, sorghum and wheat are the main cultivated crops for subsistence whereas livestock feed resources in the study areas included natural pasture, shrubs, tree leaves, crop residues and hay.

A survey of the land in this district shows that 16.5% is arable or cultivable (4.24% was in annual crops), 50% pasture, 28.3% forest, and the remaining 5.2% is considered swampy, mountainous or otherwise unusable. Wheat, *Teff* and corn are important crops. Although coffee is an important cash crop, less than 2,000 hectares are planted with it (Wikipedia, 2014).

Study Design and Sampling Techniques

In this study, multi-stage sampling procedure was employed. Among the 9 lowland districts of Bale Zone that used SAPARM information system, Lege-Hidha district is selected purposely due to the exposition of researcher to the area and the variation that it contains two livelihood zones. The district is stratified into pastoral and agro-pastoral livelihood *kebeles* (villages or PA) to balance the quota. Out of the total 27 *kebeles* found in the district, 16 PAs are pastoral and the rest 11 *kebeles* are agro pastoral. Hence, two from pastoral and one from agro pastoral *kebeles* were selected in simple random selection from their strata. Accordingly, Doya-Abu and Hidha-Hunda from pastoral and Behima from agro pastoral *kebeles* were selected.

The participants of the FGD were purposively selected among local government representatives, traditional pastoral and agro pastoral mobility clan leaders, elders, religious leaders, forecasters and scouts of the study area. 3 FGDs that consists an average of 10 participants were involved. Moreover, 9 key informants (3 from each *kebeles*) were participated in an in-depth interview.

Method of Data Collection

To collect data the study took 30 and 9 HHs through FGDs and in-depth interview, respectively. Primary data was collected through semi-structured in-depth interviews, FGD and field work area mapping which is digitized on GIS. The secondary data were obtained from review of organizational reports of study area; relevant government offices, NGOs like PCI, RCWDO, and monthly distributed SAPARM images beside publications of researches, journals, newsletters and common websites. FGDs and key informants interview were carried out by using checklists prepared on the themed area and other related issues. In addition to these personal observations, guide was employed to identify and facilitate field work mapping executed by selected HHs in the study area.

Instruments of Data Collection

Interview

Interview was conducted with key informants who were local government representatives, scouts, clan leaders and elders. During the interview, the interviewer (the researcher) was briefly clarified the interviewee on the purpose of the interview and attempt to make the respondents feel at ease. Information regarding the community ability to detect traditionally where to migrate and to what extent SAPARM integration supported the traditional system in or scouting information mechanisms were collected through in-depth interview with the key informants from each *Kebeles*. The key informants were also resourceful people who stayed for long period in the locality respected and considered as solution makers. The interview was made in local language. In general, 9 (3 from each *Kebele*) key informants were participated in the in-depth interview.

Focus Group Discussion

FGD was arranged with a group member of 10 participants in each *kebele* which were selected purposefully. Thus, data was collected on prioritizing major mobility systems, mobility routes, traditional mobility system reliability, and the extent to which SAPARM integration helped their traditional mobility and resource managements. The FGD were carried out by the researcher at the convenience of the participants with the help of guiding questions. Participants of the FGD were purposively selected from each *Kebele* with a mixed people with different age group, gender and economic status. FGD members and key informants were those who know the district pastoral traditional resources management systems and the challenges on these systems from long years ago to date were selected to draw or sketch community mobility routes maps.

Data Analysis Method

The qualitative data that gathered through FGD and key informant interview were transcribed, organized into themes, narrated and triangulated with field observation and digital maps. Moreover, participatory sketch map was developed and digitized in the GIS in order to locate the exact place and features of mobility places.

Similarly, Spatial Data Analysis employed for the community mobility maps that was sketched on the ground by the selected members of the community from the FGD and narrated, digitized on GIS, described and triangulated. Then the main destinations of mobility and places was indicated and described in order to triangulate with the readymade SAPARM disseminated maps for the community by the NGOs or government early warning department. In addition to this, ready-made SAPARM maps originated and based on Meteosat NDVI values at $10km^2$ was resampled and compared with Landsat NDVI values of $30m^2$ which have relatively high resolutions in order to verify the improvement and resolution change effects.

The effect of integrated pastoral resource management (SAPARM and traditional system) with the NDVI value which is derived from USGS in terms of Landsat at Path 166/167 and Row 54/55 (study area location found in 166/54, 166/55 and 167/54, 167/55) were verified and visualized using ArcGIS 10.3 and Google earth. Moreover, Landsat8 (OLI) NDVI values of $30m^2$ resolutions were determined with SAPARM ready-made images based on Meteosat of $10km^2$ resolutions using the formula which was used in similar study by Rouse et al., (1974).

Steps of Satellite Data Analysis

Step: 1 - Satellite image was downloaded from USGS Landsat 8 OLI with paths of 166 and 167 and rows of 54 and 55. This include four Scenes or extracts of images in classification with the identified the same dates of SAPARM images released. Scenes or extracts (166/54, 166/55, 167/54 and 167/55) were analysed in the next steps.

Step: 2 - Geometrically corrected Scenes or extracts were gone to district images correction and mosaic by mass to get study area shape file by GIS and extracted by mask (Raster with special analysis tools. (Spatial analysis tools- extraction- extraction by mask).

Step: 3 - Compute NDVI value in two ways of usage:

1. Special analysis tools – map Algebra – Raster Calculator and/or
2. In windows Image analysis – scientific out put options – processing – NDVI – Automatic NDVI with five classes.

And the formula indicated below was Use to get NDVI values of map Algebra

$$\mathrm{NDVI} = \frac{\mathrm{BAND\ 5} - \mathrm{BAND\ 4}}{\mathrm{BAND\ 5} + \mathrm{BAND\ 4}} \quad \text{Or} \quad \mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}}$$

Step: 4 - After getting the values of NDVI by using Raster calculator the five values were classified in two to classes-the highest and the lowest category by manually and/or by special analysis tools – Re-class – reclassify – result five classes range into two. Then the GIS put the values of ranges from 0 to 1. Finally the study area map resulted and appeared in black and white colours.

Step: 5 – Using Raster calculator classifying the NDVI values to consider values and to create maps to show more vegetation cover. And finally based on the results on the map, the values were interpreted.

The values which were resulted from steps finally give NDVI values between -1 and +1. So values which have 0 described as areas with no vegetation covers or greenness and values which have 1 described as areas with better or high vegetation covers and more greenness.

Table 1: Satellite Image Data Used

SN	Image type	Path and Raw	Date of acquisition	Resolution	Source
1	Landsat 8 (OLI)	Path 166/167 & Row 54/55	November 20, 2017	30m x 30m	USGS
2	Meteosat	N/A	November 20, 2017	10km x 10km	SAPARM

RESULTS AND DISCUSSION

The Integrated System of Traditional Pastoral Resource Management and SAPARM

SAPARM Information Maps

The definition of SAPARM according to Teweldebrhan (2017) and PCI (2016) abbreviated for Satellite Assisted Pastoral Resource Management which is an innovation well suited to respond to the needs of multiple stakeholders. During baseline for SAPARM, almost 70% of pastoralist reporting using IK for migration decision making. The potential of SAPARM to reduce or eliminate these deficiencies, without assuming unacceptable burdens, risks or costs, is inherently logical and easy to grasp by pastoralists based on the experience. The idea started with a conceptually simple solution of bringing together space technology and indigenous culture for social good. This plat-form was developed by a small Dutch company called Hoef-sloot Spatial Solutions (HSS) intrigued with PCI. However, SAPARM doesn't seek to replace the conventional approaches to migration decision-making, but works in synergy with them making them more effective.

SAPARM information maps are printed and released to communities every 10 days in the study area by the government DPPO early warning department, the district PDO range land and NRM departments or by the NGOs which operates on this activity; PCI and RCWDO. These maps was distributed for each *Kebele* administration offices (local grass root level or community based early warning committees and clan leaders) in order to announce and disseminate to the mass community. The figure below described the integrated type of readymade SAPARM image information which distributed for the community in the study area.

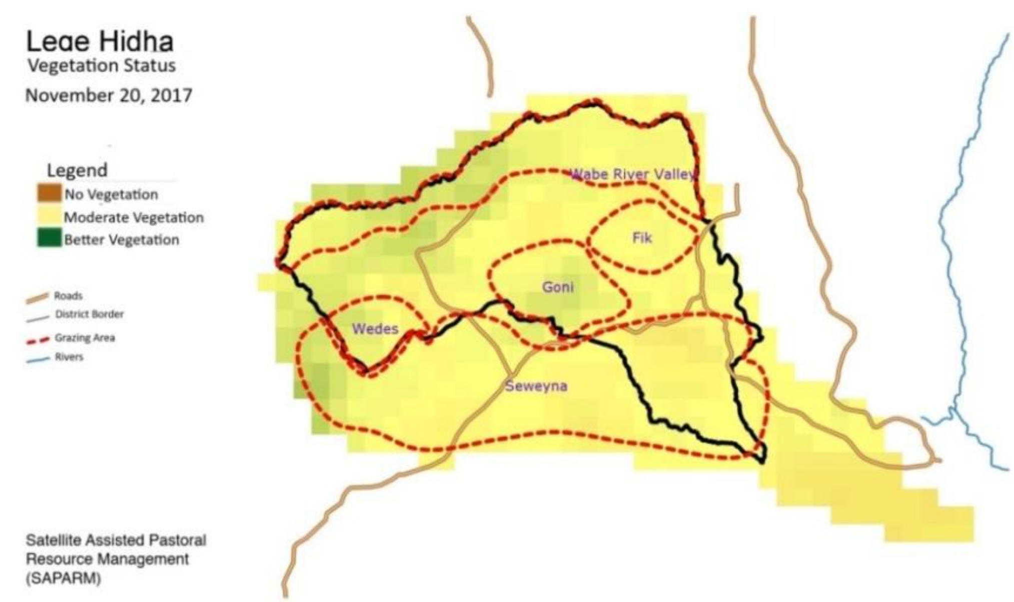

Figure 2: Ready-made SAPARM image disseminated for the community

Source: PCI, 2017 disseminated SAPARM map by PCI

This was released and disseminated for the community as information to support their routes of mobility on November 20, 2017. Based on this information the community shared with each other, discussed about, triangulated with their traditional mobility system (using IK), interpreted and utilized (migrate to the areas which have more greenness on the map). Since the time of these maps released and disseminated was during dry period, the areas that show vegetation cover (green colour) was limited. The red zones on the map describe that cluster migration areas collected from the traditional mobility systems during development of SAPARM system.

Similarly, according to PCI, (2016) report and confirmation SAPARM vegetation maps were distributed to pastoral clan leaders every ten days. The maps are based on publicly available satellite NDVI images with accuracy down to a 10 km^2 area. This uses the visible and near infrared light reflected by vegetation to measure vegetation density and greenness.

Moreover, on the FGD and key informant interviews the members revealed about the traditional (IK) and SAPARM integrated systems as "traditional mobility based on IKs is much exhaustive and challenging, needs a lot of time for journey, scouting to decide (need to scout five to six routes) even it could be not reliable after scouting these all places or routes. There is computation between clans and in a chance of missing the exact period to migrate; the grazing area might already occupied or grazed and consumed by others because every pastoral or agro-pastoral scout and investigates suitable grazing areas. However, SAPARM become relatively reliable and reduced the challenges for those clans regularly attend the information from the government and NGOs than using only traditional mobility system '***Godansa*** or ***Abura'***,"

The Improvement of SAPARM information using Landsat NDVI Value for Mobility Decision Making

Updating SAPARM Information Using Landsat NDVI Value

Teweldebrhan (2017) and PCI (2016) indicated and argued that: above pastorals sits a geostationary satellite taking high resolution photos every 15 minutes which allows one to measure NDVI. However, the challenge was how do one the get NDVI information satellite down to some of the most remote populations on earth and do it continuously because pastoralists aren't farmers they are interested in forecasts but what's happening on the ground now. Hence, the SAPARM information plat-form (solution of bringing together space technology and indigenous culture) was initiated and developed. Likely, Agrawal, (1995) also situated as the interaction between conventional science and local knowledge is not new and the history of science demonstrates the two knowledge systems have often been intertwined.

The NDVI values of Meteosat derived map (SAPARM) was already calculated and released by the concerned institution offices that means SAPARM information map disseminated and available at the *kebele* offices are readymade final image maps. While, Landsat OLI USGS derived NDVI value calculated map is the result of this study spatial data analysis.

Landsat NDVI Value Development Methodological Process

The improvement or updating of SAPARM information images with Landsat 8 OLI satellite images is after the complete analysis and development of Landsat8 NDVI value results. Landsat was analysed using downloaded satellite images of the study areas from USGS with the paths and rows of 166/54, 166/55, 167/54 and 167/55 on the same dates of acquisition that SAPARM is released for the community to compare the effects without differences of date of acquisition which was between November 15 – 20, 2017. USGSs' Landsat image was level one product that does not need topographic correction. However, the images were corrected in geometrical or district image correction after the district images correction mosaicked by mask on the study area that results the shape file by GIS and extracted by Raster in special analysis tool of Map Algebra to bring in to Raster calculation with the formula described below to get the NDVI values of Landsat study area images.

$$\mathrm{NDVI} = \frac{\mathrm{BAND\ 5 - BAND\ 4}}{\mathrm{BAND\ 5 + BAND\ 4}} \quad \text{Or} \quad \mathrm{NDVI} = \frac{\mathrm{NIR - RED}}{\mathrm{NIR + RED}}$$

Then, result of NDVI value found between: Highest: 0.185347 – 0.485636

Lowest: -0.346688 – 0.185347

Therefore, NDVI values between < 0.19 NDVI > 0.19 selected. Hence, in order to show areas of detailed or high vegetation covers selection of values that shows <0.19 to be 0 which means no greenness or less/no vegetation cover classification. And selection of values that shows >0.19 to be 1 which means better greenness or high vegetation cover. Then these classifications were calculated by Raster, values classification between the highest +1 and the lowest -1 that constitutes five categories/ classes. This classification also used in similar study by Afirah T. *et al.*, (2016) the classification to locate the vegetation cover by setting the threshold of NDVI image. The values of NDVI thresholds are shown in table below.

Table 2: NDVI values threshold

Value of NDVI	Descriptions
0.1 or less	Very low
NDVI 0.2 to 0.5	Moderate
NDVI 0.6 to 0.9	High NDVI

Source: Afirah T. *et al.,* 2016

The NDVI image based on threshold values were calculated and the pixels of image were classified. Thus, those pixels which have NDVI ratio more than 0.35 (contain moderate and high NDVI values) are assigned to the vegetation class (Afirah T. *et al.*, 2016). In the same method of classification used by the above NDVI threshold values, this study is also classified values selection in which values that shows <0.19 to be 0 that means no greenness or less/no (very low) vegetation cover classification. And selection of values that shows >0.19 to be 1 which means better greenness or detailed and high vegetation covers (High NDVI value).

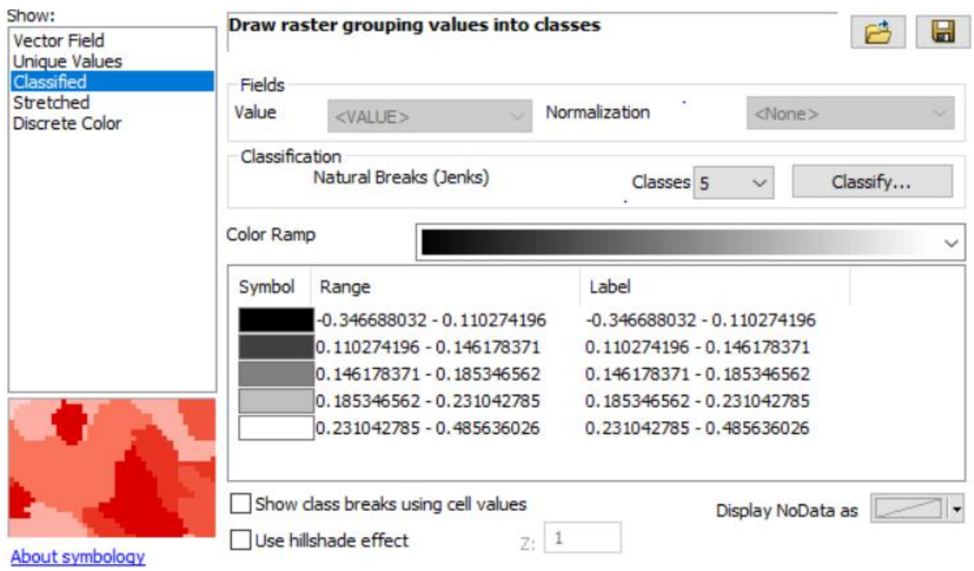

Figure 3: Landsat image classifications (into five classes)

Therefore, according to two figures described above and below, by breaking these Landsat image classifications of five classes into two manually between values of - 0.35 and 0.19 (the first range) and from 0.19 to 1 (the second range). In similar ways, Igor E. *et al.*, (2016) reclassified values and suggested this results NDVI with the values below 0.2 generally corresponds to non-vegetated surfaces, whereas green vegetation canopies have NDVI greater than 0.3.

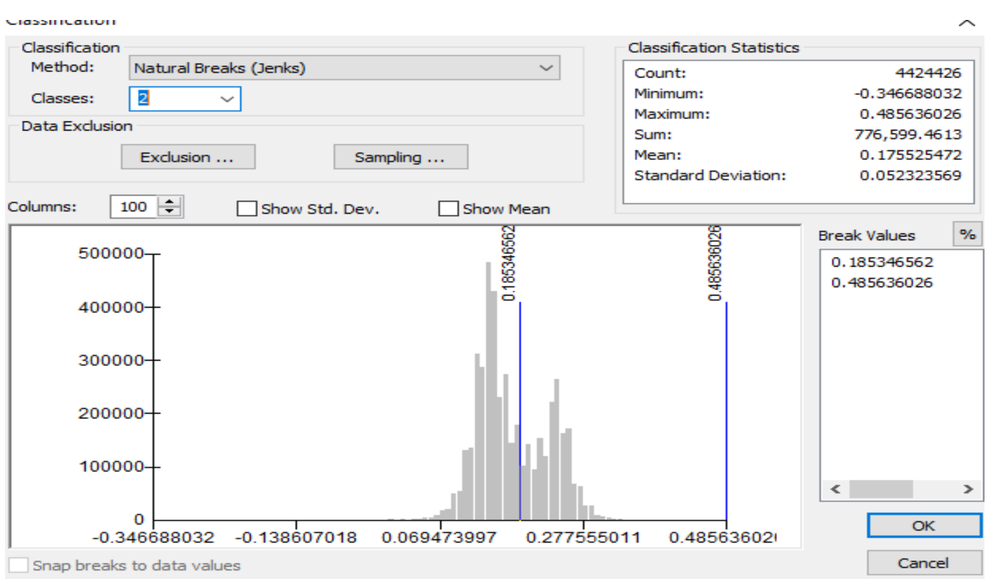

Figure 4: Landsat image value classifying in to two by raster

Landsat image value classified into two by raster were mosaicked in ranges; then after mosaicked the ranges between NDVI values which result the black and white colour in the study area map or it can be presented in colour image map as shown on the figure below that indicates the interpretation of white colour is areas with high vegetation covers and black colour is areas with no and/or less vegetation covers.

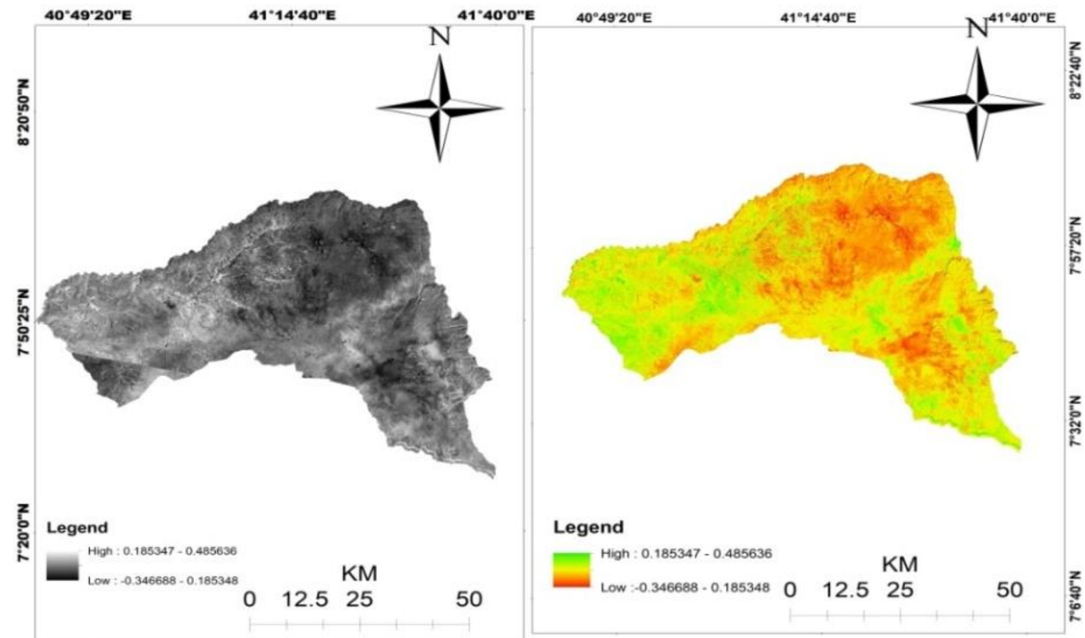

Figure 5: Landsat Images value of two classes (black & white) and color

Comparing the Difference between Updated Landsat NDVI Information with SAPARM

After Landsat NDVI value Images of two classes (black & white) and coloured identified using Raster calculator and classifying the NDVI values to consider values <0 NDVI >0.19 to create map that demonstrate high and low vegetation coverage on the final map was updated as shown in the figure below which is this study attempted to compare with SAPARM.

In similar study by Jensen (2007) and Liang (2005) resulted the combination of remotely-sensed spectral bands can reveal valuable information such as vegetation structure, state of vegetation cover, photosynthetic capacity, leaf density and distribution, water content in leaves, mineral deficiencies and evidence of parasitic shocks or attacks. Likewise, the final NDVI class values of this study supported as; the range of values obtained is between −1 and +1. Only positive values correspond to vegetated zones; the higher the index, the greater the chlorophyll content of the target. Similarly, the article on (Genesis. *et al.*, 2014) also inveterate that NDVI is most useful tools for detecting and investing drought effects on the vegetation cover.

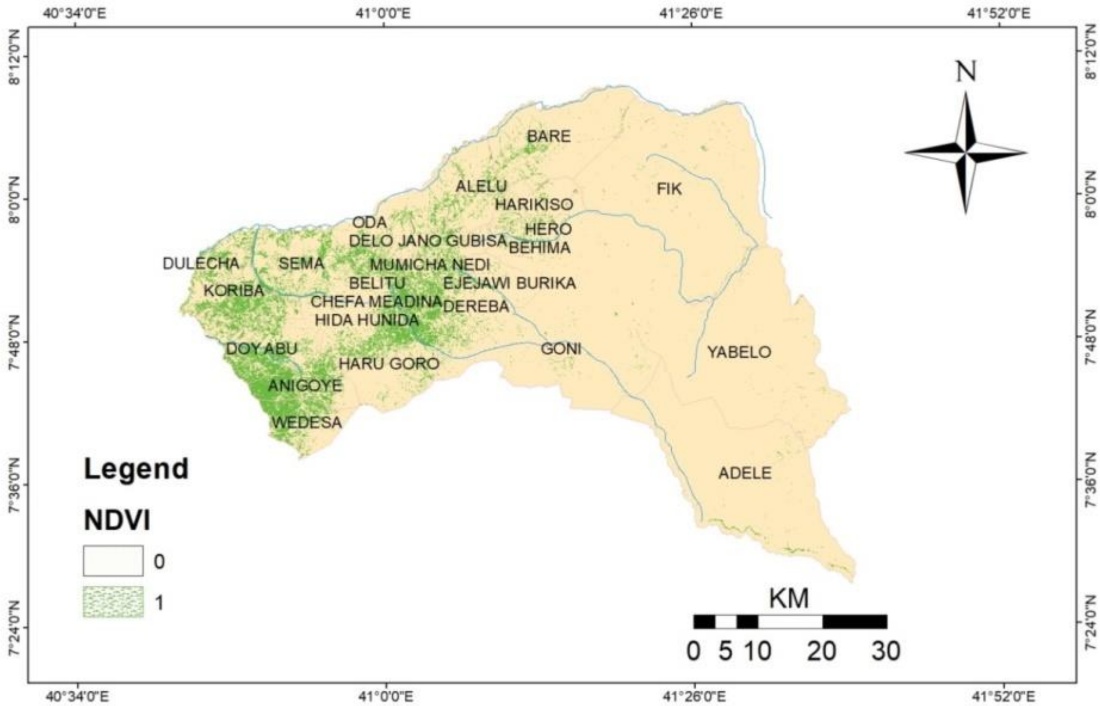

Figure 6: Updated or Improved Landsat Image Map for Comparison

This final analysis finding of Landsat 8 OLI updated the study area vegetation coverage which included all the specific area of community's mobility places is considered in order to compare the improved differences with SAPARM (the integrated system of traditional pastoral resource management with Meteosat NDVI value). Accordingly the green values are areas that used to the migration places for the communities in the study area (specific places identified on FGD). Therefore, around the areas with no vegetation expresses it could not be areas for the migration which is also confirmed by the FGD results. These areas having more greenness means high vegetation to migrate in respect to identified specific places of migrations. As a result, majority of the places identified on FGD and in-depth interview were also found in this satellite updated image (Landsat 8) of the analysis result.

Similarly, on the article available by (Townshend *et al.*, 2012) mentioned that Strittholt and Steininger, (2007) also reason out Landsat 8 results and concluded as Landsat NDVI value has a relatively fine resolution for land use change studies and wave bands extending across the visible, near-infrared, shortwave infrared spectrum. Moreover, for finer resolution resulted in vegetation species distribution or high-quality forest change monitoring; Mapping and monitoring using moderate resolution sensors such as Landsat with spatial resolutions from 15 to 60m that provide enough spatial and spectral detail to discriminate between individual trees and, in some cases, species (Townshend *et al.*, 2012), whereas the comparison of this study find out that resampled SAPARM information image of NDVI value from Meteosat at $10km^2$ resolution do not provide enough spatial and spectral detail to identify individual objects which further discussed and compared below.

Updated Landsat and SAPARM Comparison Methodological Process

The figure below shows the difference and comparison of the updated or improved using Landsat NDVI value analysis result and SAPARM Images;

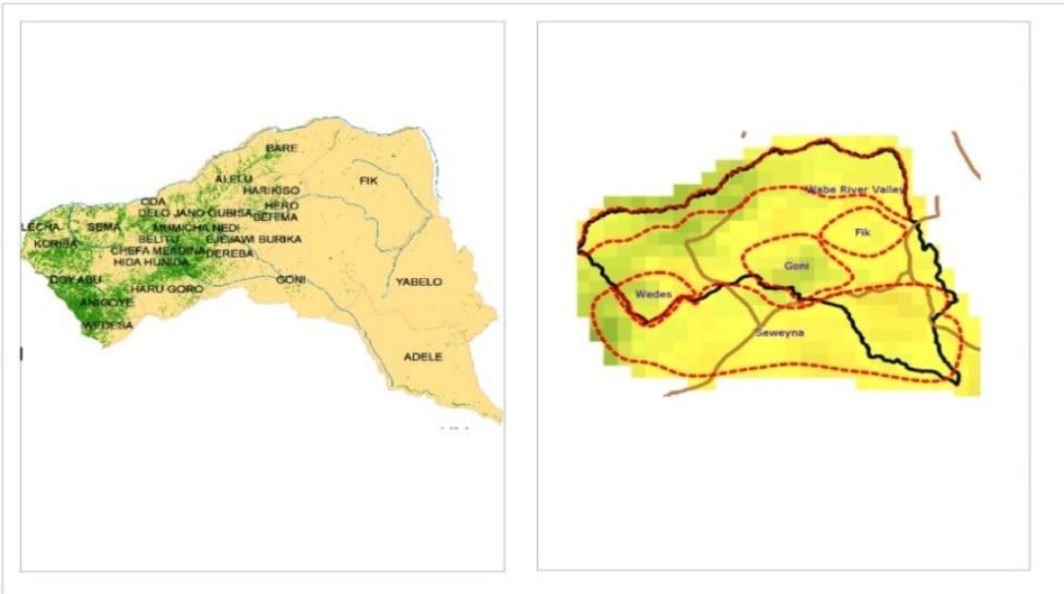

Figure 7: Landsat and SAPARM Images comparison based on scales

Source: GIS analysis, 2018 and PCI 2017

In order to make comparisons and find out the differences of the two result images, the step resampling either in the same scale or the same resolution capacity is critical. Accordingly, the above figure shows the resampled satellite SAPARM images of the study area image which was released from Meteosat as information with the resolution capacity $10km^2$ presented at map scale of 1:12,813. Likewise the study result map which derived from Landsat resolution of $30m^2$ presented at map scale of 1:8,952 exported final image scale. Therefore, the step resampling the size of these two scales was included in making the result image into equal scales and resampled or rescaled into the map scales of (1:8,952) both in equal size.

On the other hand it is important to compare the two images based on the size of resolution capacity level of satellite features, accordingly the figure below shows SAPARM image which was released from Meteosat as information map for the community in the resolution capacity of $10km^2$ and the updated image using Landsat resolution of $30m^2$ in relatively better resolution. Both images were acquired in the same date of SAPARM released and Landsat downloaded on November 20, 2017.

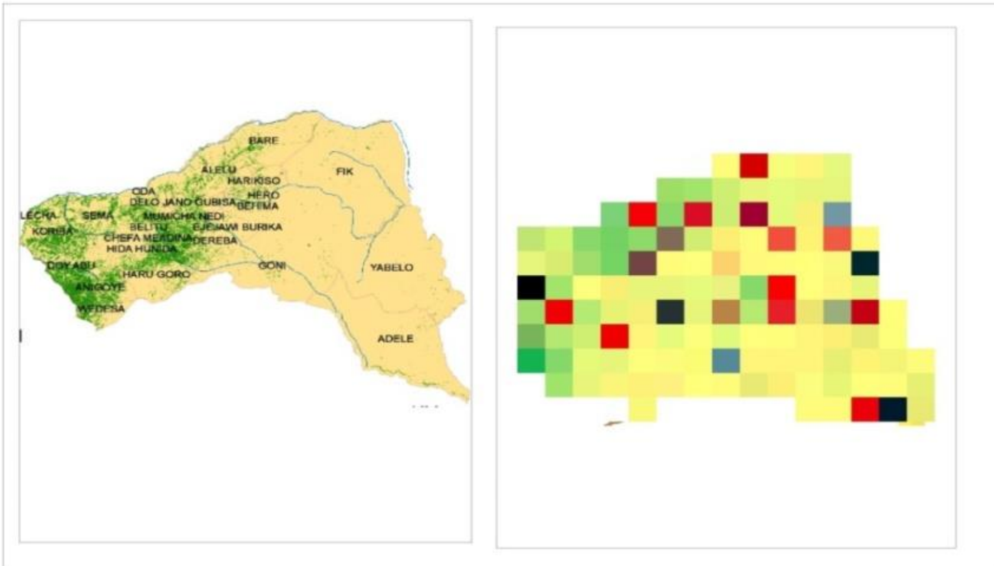

Figure 8: Updated Landsat and SAPARM Images comparison based on Resolution

Source: GIS analysis, 2018 and PCI, 2017

The differences are according to the above figure; in this study findings to the areas of most of the communities migrate have better greenness and detailed spectral. This implies since the study used Landsat NDVI value final images, the result were enlarged and included invisible (by heighten) areas with a better vegetation cover because of Landsat8 have better resolution capacity, enough spatial and detail spectral at 30m x 30m. Also this study result included the classifications of boundaries of PAs that enables to know the communities where the vegetation coverage found and in which *kebele* easily.

Further, this comparison supported by Anderson, M.C., *et al.,* (2012) in study of comparing resolutions of Landsat with Meteosat for monitoring rainfall and moisture. The comparison discussed as resolutions exceeding 10km do not function well in areas of dense cover. Vegetation index is a slow response variable. In contrast, moderate-resolution imagery from Landsat has the potential to provide valuable early warning regarding soil moisture deficits and canopy stress at scales required for operational management. Hence, it implies that spectral index of vegetation NDVI provides the most direct quantification of the fraction of photo synthetically active radiation that is absorbed by vegetation.

Likewise, the aim of this study finding is to disseminate updated and/or improved quality and visible satellite assisted information of early warning in order to make the community alert on their mobility systems and manage the pastoral resources properly by integrating their IK with a better resolution capacity of Landsat product that provides better visible and detailed vegetation areas including *kebele* classifications in addition to SAPARM modification that was mostly demanded by FGD respondents, hence the figure shown below describe the updated satellite image resulted using Landsat 8 for comparison with SAPARM by including all the necessary FGD respondents request;

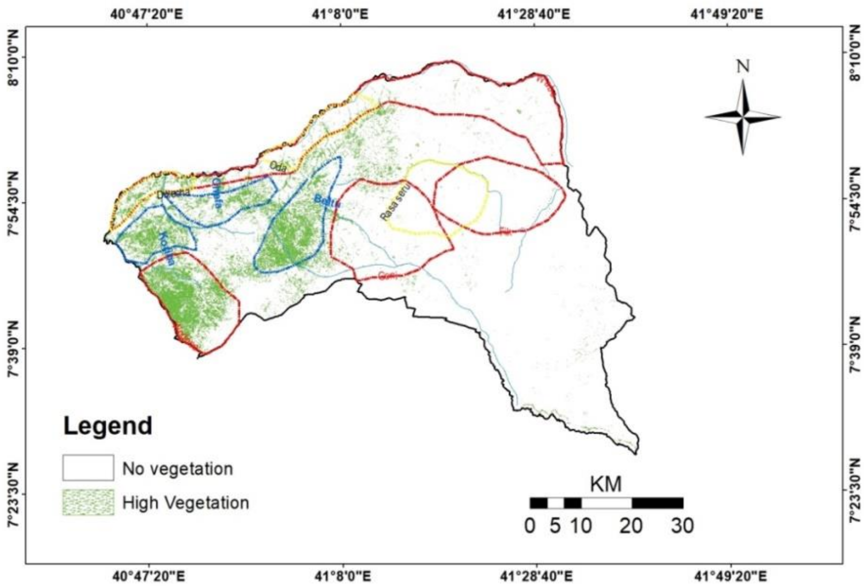

Figure 9: Overlay digitized community grazing routes map

Accordingly, the figure above shows the result of this study analysis modified by overlaid digitizing the location of pastoral and agro-pastoral communities migrate in search of pasture and water including and layering the community participatory grazing routes sketch map using their IKs on the ground in to GIS. The differences between this digitized participatory map and SAPARM is presented in the figure below;

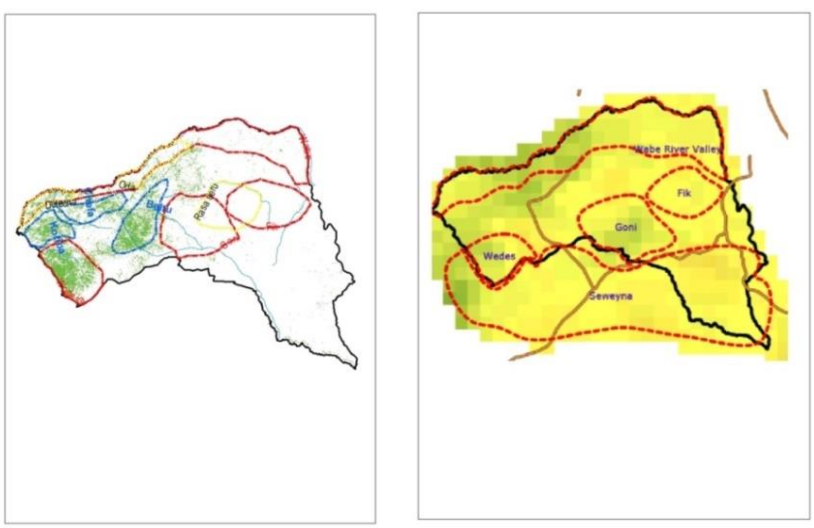

Figure 10: Comparing overlay digitized community map and ready-made SAPARM

***Source**: GIS Analysis (2018) and PCI (2017)*

According to the figure shown above when it compared the differences were clearly detailed. Even though both maps were produced using the existing community traditional mobility routes of participatory sketches; SAPARM did not included some of specific places of mobility, water or streams and the routes were digitized in cluster composites that FGD respondents complained. Accordingly, the boundaries digitized in blue colour of this study result shows omitted and lost specific mobility places because of the limited resolution capacity of Meteosat on SAPARM (Vegetation index is a slow response variable) whereas it is improved and become detailed and visible as a result of Landsat 8 OLI which is also confirmed by (Townshend et al., (2012) “for finer resolution resulted in vegetation species distribution or high-quality forest change monitoring; mapping and monitoring using moderate resolution sensors such as Landsat with spatial resolutions from 15 to 60m that provide enough spatial and spectral detail to discriminate between individual trees and, in some cases, species”. Moreover, the boundaries digitized and shaded in yellow colour shows omitted specific mobility places because of cluster composites employed on SAPARM whereas, boundaries that were digitized and shaded in red colour on both maps shows the wide areas and places where the community sketched on the participatory map that assumed to be mobility resource area coverage.

Therefore, based on the results shown above, SAPARM were omitted and lost mobility specific places and mixed them in cluster and the resolution capacity of Meteosat were not enabled to make visible and detailed the places, lacks water/ stream and PAs indications, and needs modification. Even though SAPARM has average or relative integration with traditional pastoral resource management system integrated with satellite assisted pastoral resource management (the NDVI values of Meteosat derived map); it is confirmed through FGD, informant interviews and participatory sketch maps, that SAPARM (the integrated system of traditional pastoral resource management with Meteosat NDVI) was relatively reliable and decreased the challenges of much exhaustive traditional mobility for those regularly attend the information. Hence, SAPARM was not only strengthened traditional mobility systems but also introduced the traditional information system to follow or integrate the modern technologies.

CONCLUSSION AND RECOMMENDATIONS

Conclusions

The main purpose of this study is improving the integrated traditional pastoral resource management system with satellite assisted (SAPARM) Information System using Landsat NDVI value for mobility decision making with updated information specifically by assessing the integrated system of traditional pastoral resource management with SAPARM (traditional and Satellite assisted) images; analysing the improvement of SAPARM information (originated from Meteosat) using Landsat NDVI value and identifying the difference between improved Landsat NDVI information with SAPARM for mobility decision making. Hence, based on the findings of this study the following conclusions were made:

To address the above main purposes of the study; literature review, primary and secondary data collection were employed. The primary data was collected from in-depth interview and FGDs whereas for spatial data was collected from USGS Landsat8 OLI and GIS analysis. Further to analyse the NDVI values Raster extraction calculation and Map Algebra were employed.

The study revealed that, sever and imprecise or less reliable information gathering result failure to know better areas where and/or when resources (pasture, feed and water) were available, time taking and exhaustive scouts investigation for medium to total losses of livelihoods

With respect to current information management the communities in the study area understood technologies integrated to their knowledge for the mobility found as reliable relatively to their traditional systems (‘***Abura’*** or ‘***Godansa’***), while using and interpreting SAPARM. Hence, before SAPARM knowledge of resource area, times when or where to migrate were limited but now improved and it was not only strengthened traditional mobility but also their traditional information system to align with modern technologies but needs to be updated or modified including all necessary findings of this study.

The need for tentative traditional scouting was because of the underline causes of erratic rain fall and uncertainty to predict it. Due to this scouts gather unreliable information about areas that results reliability of traditional mobility systems unpredictable and less trustworthy. So, during the time of high demands to reliable information and prediction SAPARM relatively helped through integrating indigenous knowledge (IKs) and forecasting indicators with spatial images.

The study compared result of Landsat by updating and correcting the study area map images having detailed resolution capacity of $30m^2$ with SAPARM. Using Landsat NDVI value vegetation covered areas become wide and focused where mobility conducted in which Landsat resolution enabled observable those invisible reflectance on that of SAPARM. Therefore, spatial analysis of Landsat identified SAPARM information image should be modified and shall use Landsat resolutions which are free of charge from USGS.

The study concluded that; if the information disseminated for pastoral resource management and mobility uses the study result of updated Landsat information it enable to allow to identify easily mobility places in order of priorities on distances, nearby, coherent, more vegetation cover and understood immediately specific areas of pastoral resources and empower confidence of mobility decision making which is identified both through the analysis results, FGD and key informant.

Recommendations

Based on the research findings, the researchers addressed and recommend the following options in order to use alternative update information and to overcome the problems;

- The study informed that the study area is the most remote place with poor infrastructures and less attention from the local authority so, the government focus the infrastructure development as well as donors and NGOs should start programs on these areas and support researches, academic programs, involve and implement with Universities.
- Interviewed individuals revealed the challenges during scouting, movements and staying around mobility areas. Therefore, the local authority should focus on establishments of mobile veterinary services, food and shelter delivery, timely information dissemination systems improvement and strengthening of traditional resource management.
- SAPARM information should be presented with easy and understandable early warning systems tools. Hence the local authority should pay attention to inform, investigate more information, and seek alternative up-to-dated information tools through supporting the linkages, updates, strengthening early warning systems in integrated means of action (IK and improved technologies) to make the community alert.

- The study find out using Landsat NDVI value where pastoral mobility is conducted; vegetation covered areas become extensive, focused and detailed because Landsat resolution enabled observable those invisible reflectance on that of SAPARM. Therefore, spatial analysis of Landsat identified SAPARM information image should be modified and shall use Landsat NDVI values from USGS than from Meteosat at 10km2 resolution that do not provide sufficient spatial and spectral details to identify individual objects.
- In order to improve the information dissemination system addressable and efficient for successful pastoral mobility decision making: establishing community radio services (Mass-media) since most of pastorals have radios; mobile texting in local languages in order to address all type of mobile phone users; establishing school clubs on DRR, SAPARM information, early warning and environmental clubs and through these clubs, teachers will take the responsibilities of familiarization, announce and coach about every information; then students disseminate the information to their families effectively.
- Based on the study, researchers also should develop and find out grazing land suitability first and other researchable factors; then satellite assisted mobility should be addressed both in Landsat and SAPARM for better resource management and decision making.

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Figures

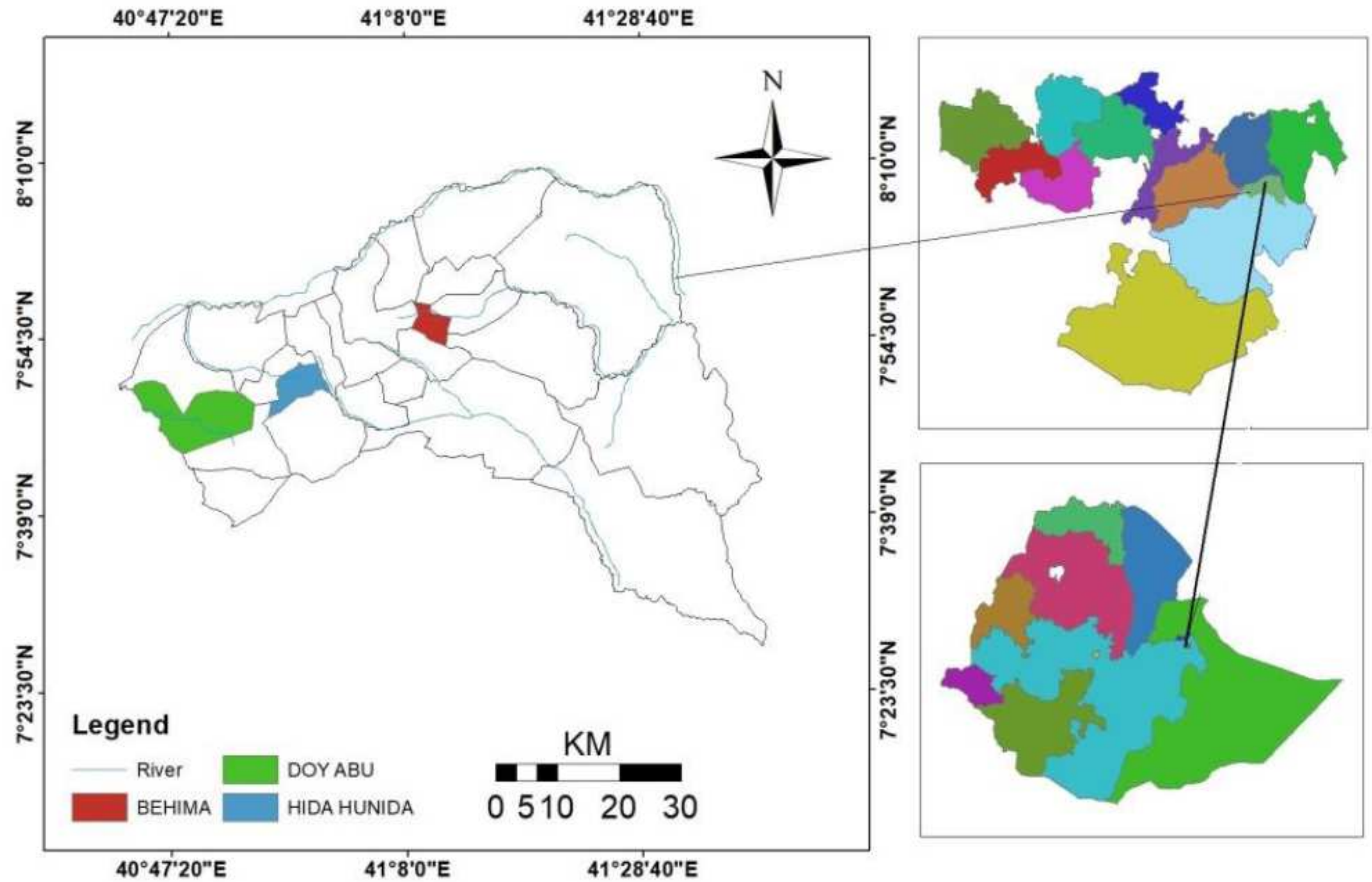

Figure 1

Location Map of the Study Area in Bale zone, Oromia Region Ethiopia

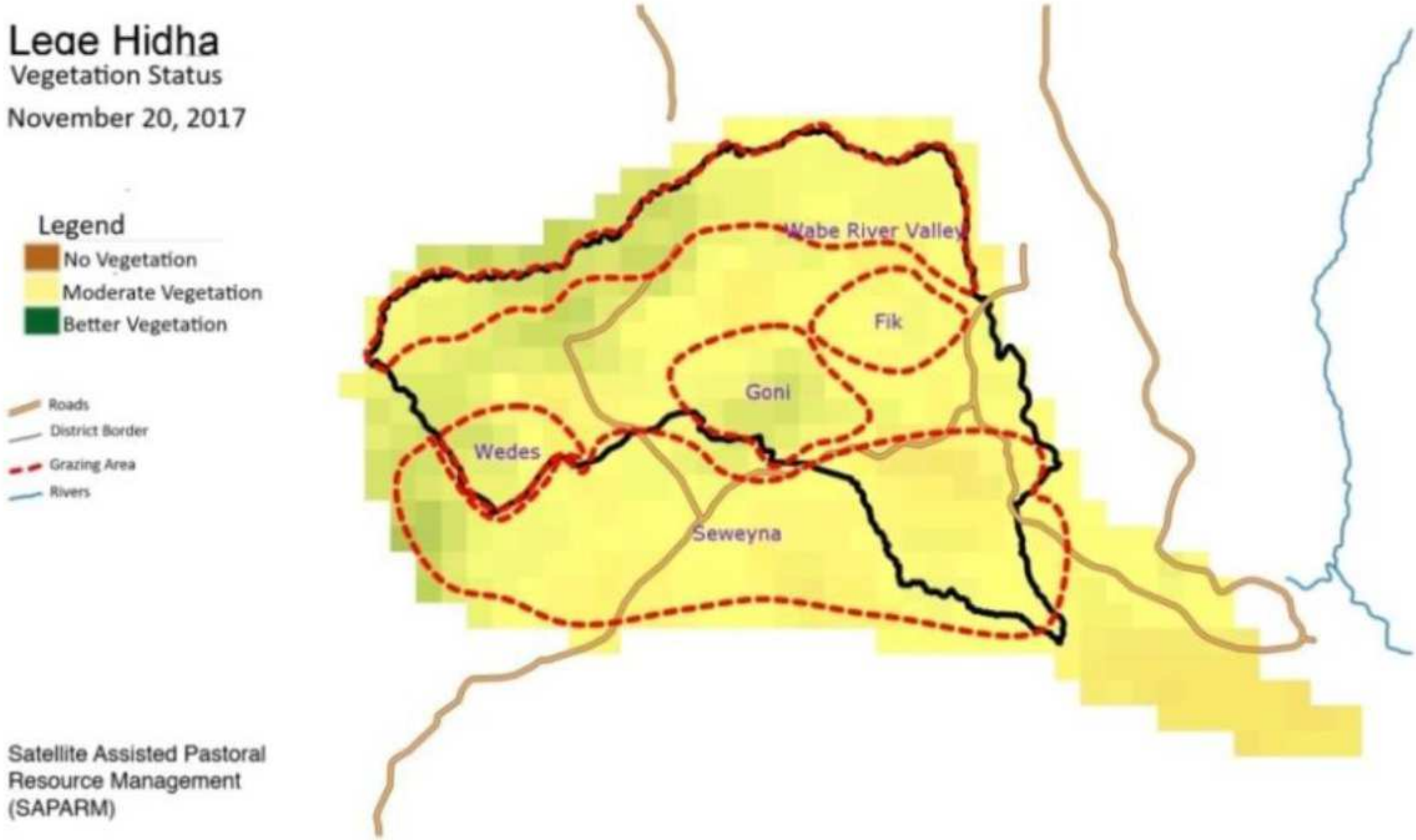

Figure 2

Ready-made SAPARM image disseminated for the community Source: PCI, 2017 disseminated SAPARM map by PCI

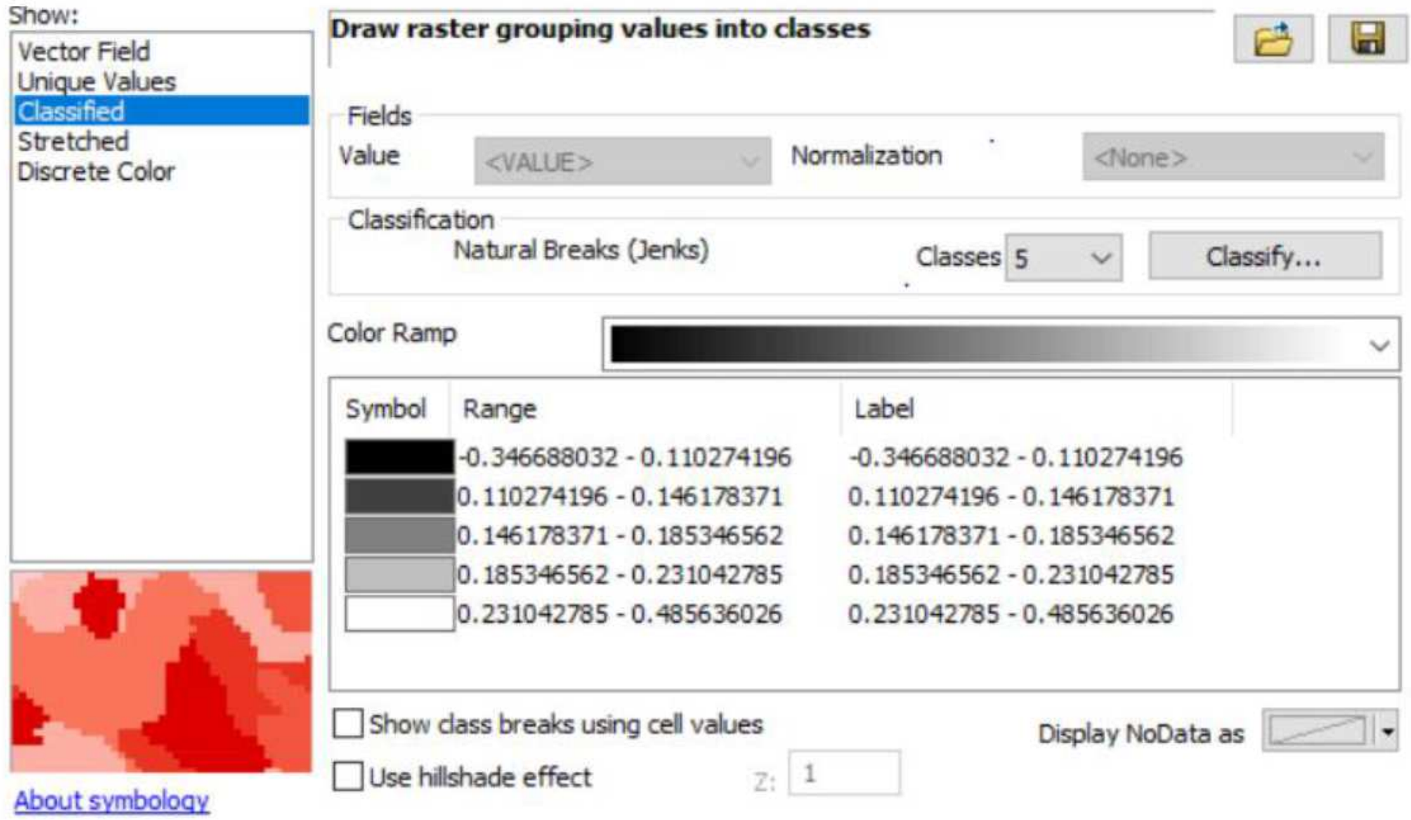

Figure 3

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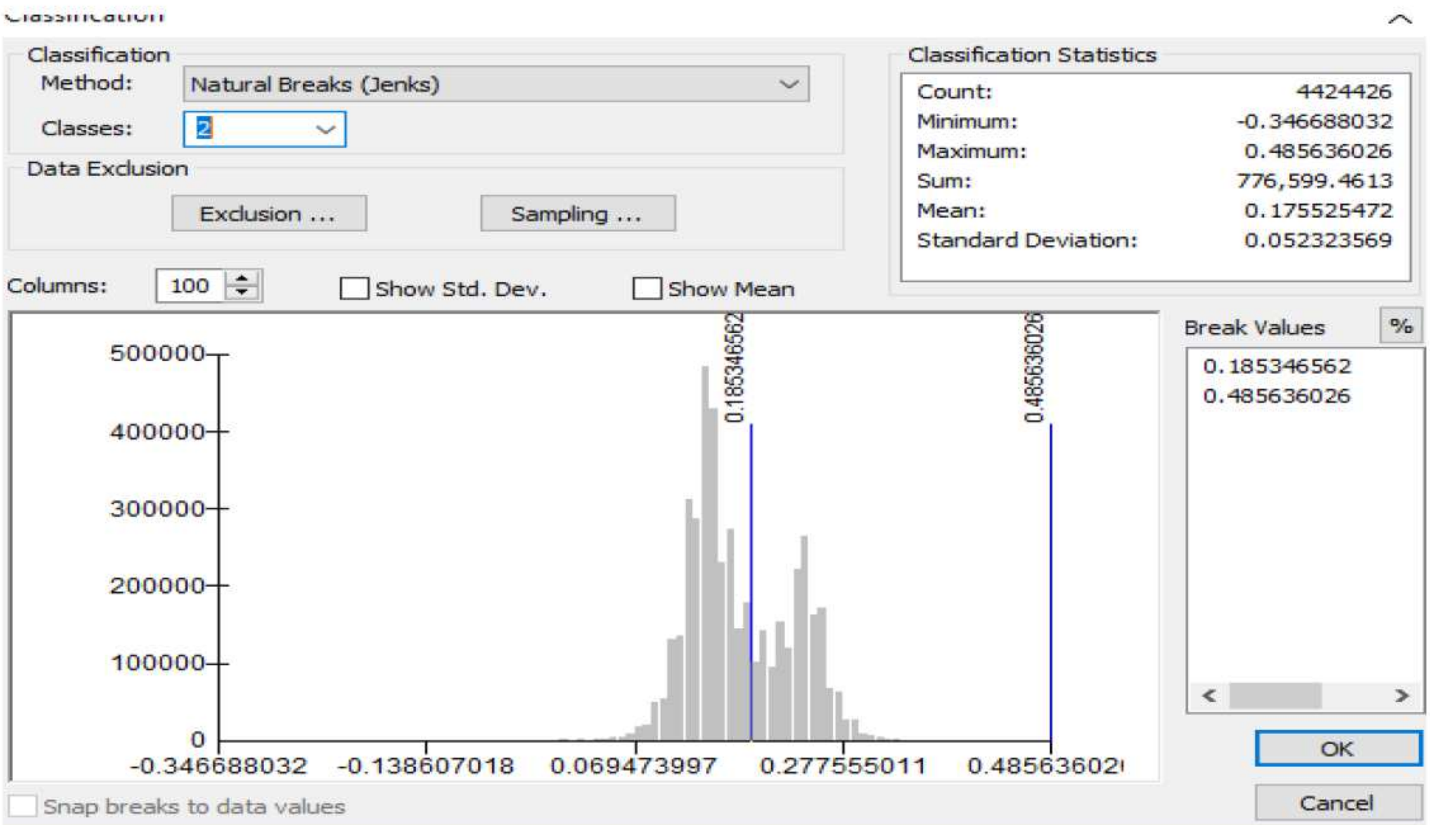

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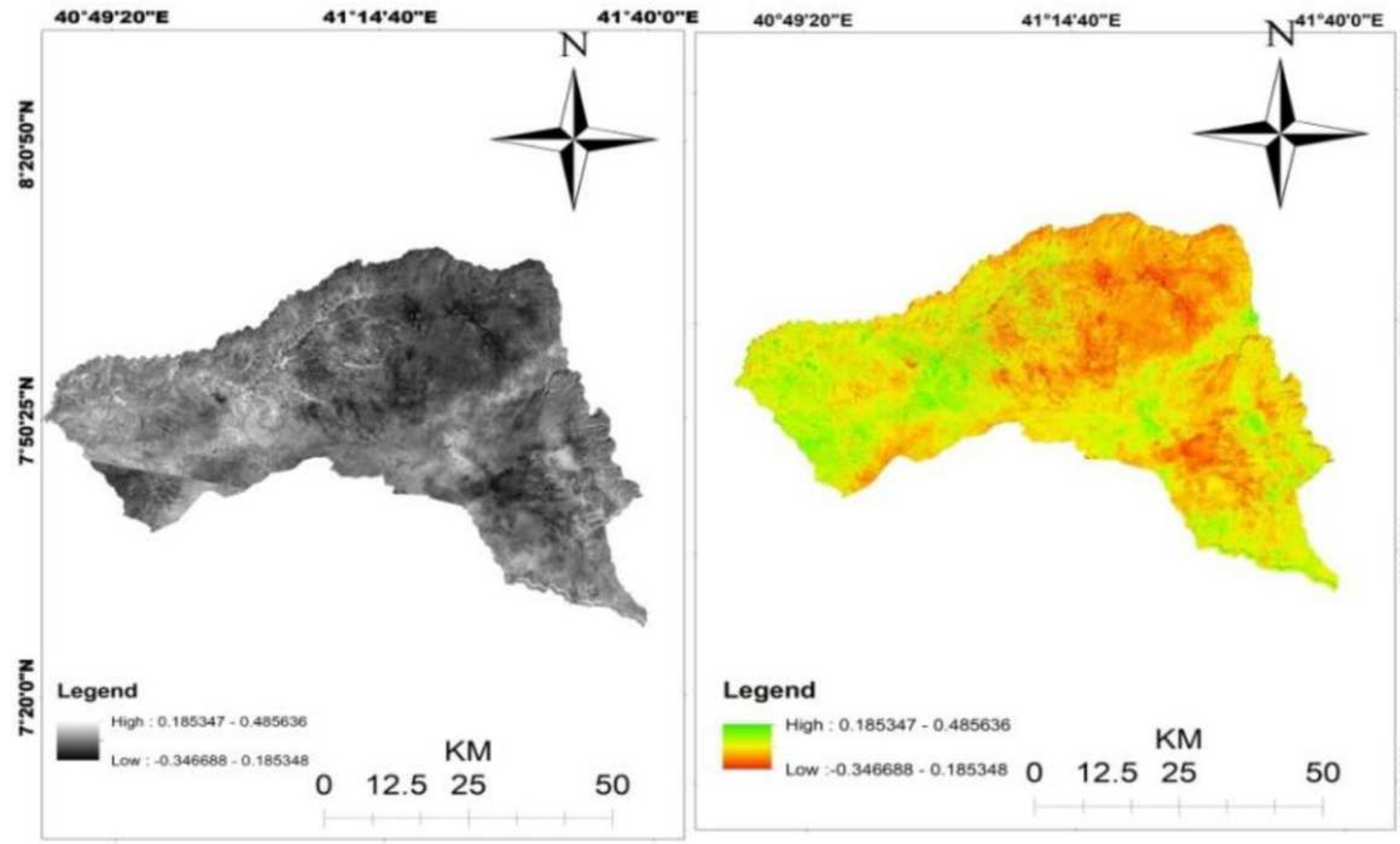

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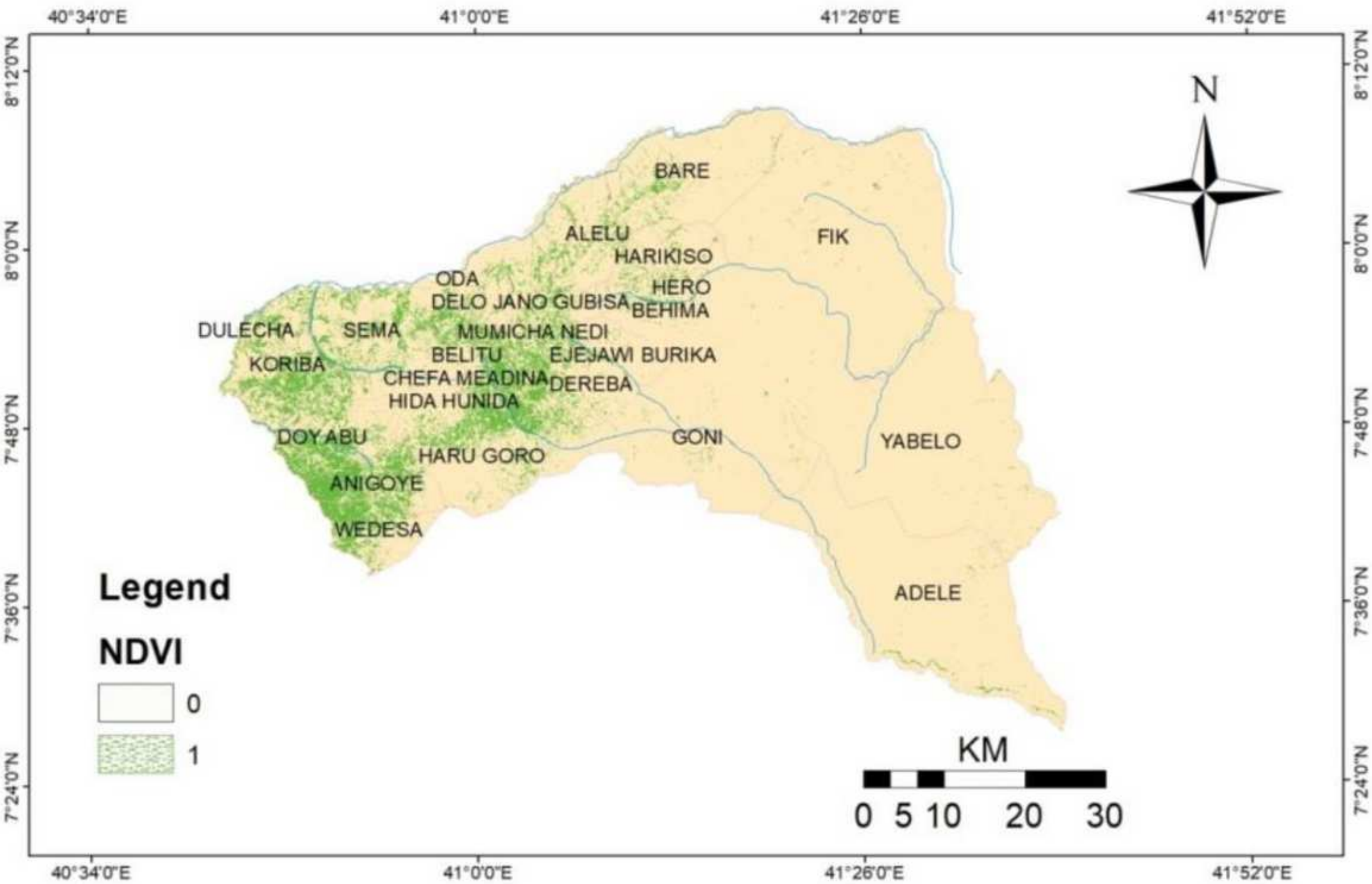

Figure 6

Updated or Improved Landsat Image Map for Comparison

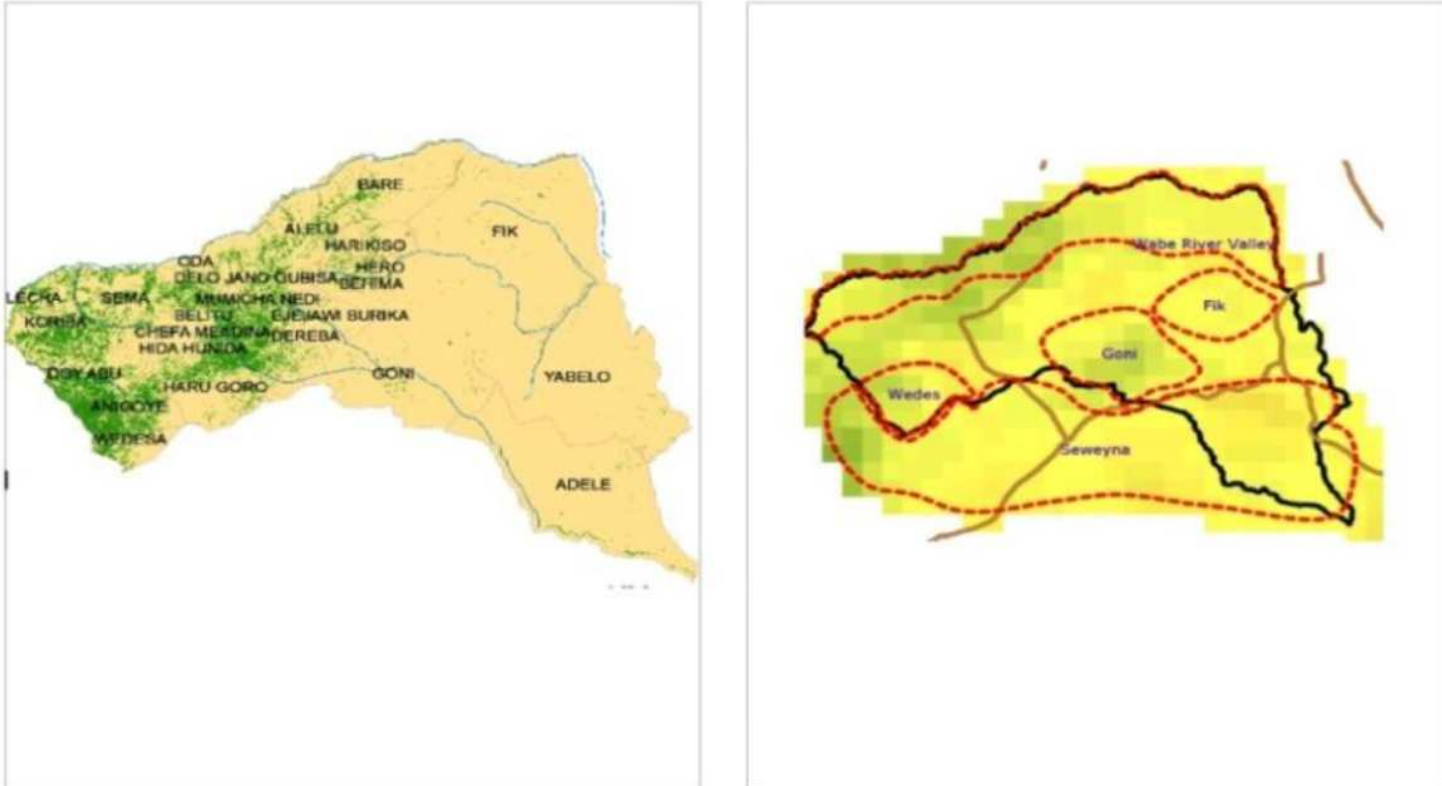

Figure 7

Landsat and SAPARM Images comparison based on scales Source: GIS analysis, 2018 and PCI 2017

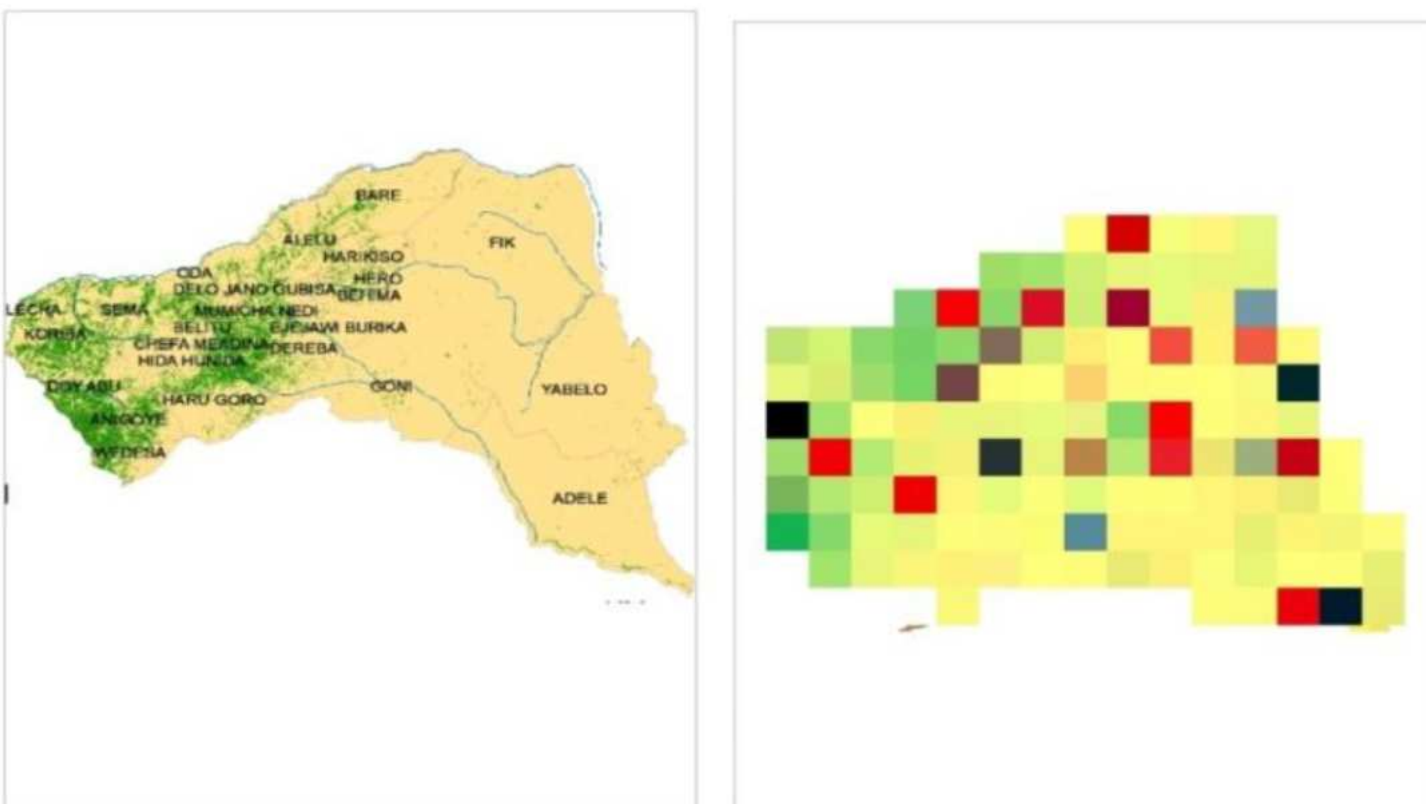

Figure 8

Updated Landsat and SAPARM Images comparison based on Resolution Source: GIS analysis, 2018 and PCI, 2017

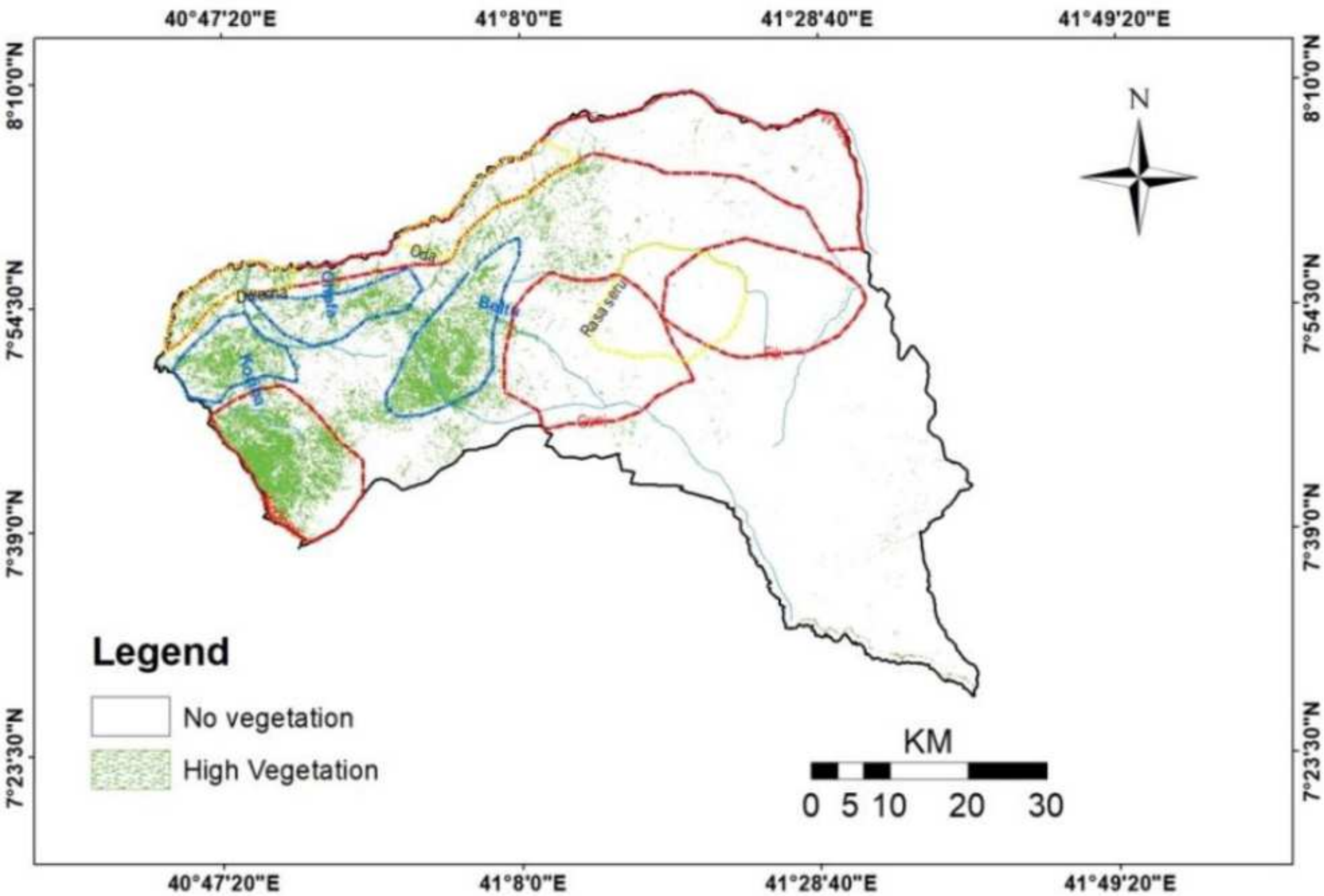

Figure 9

Overlay digitized community grazing routes map

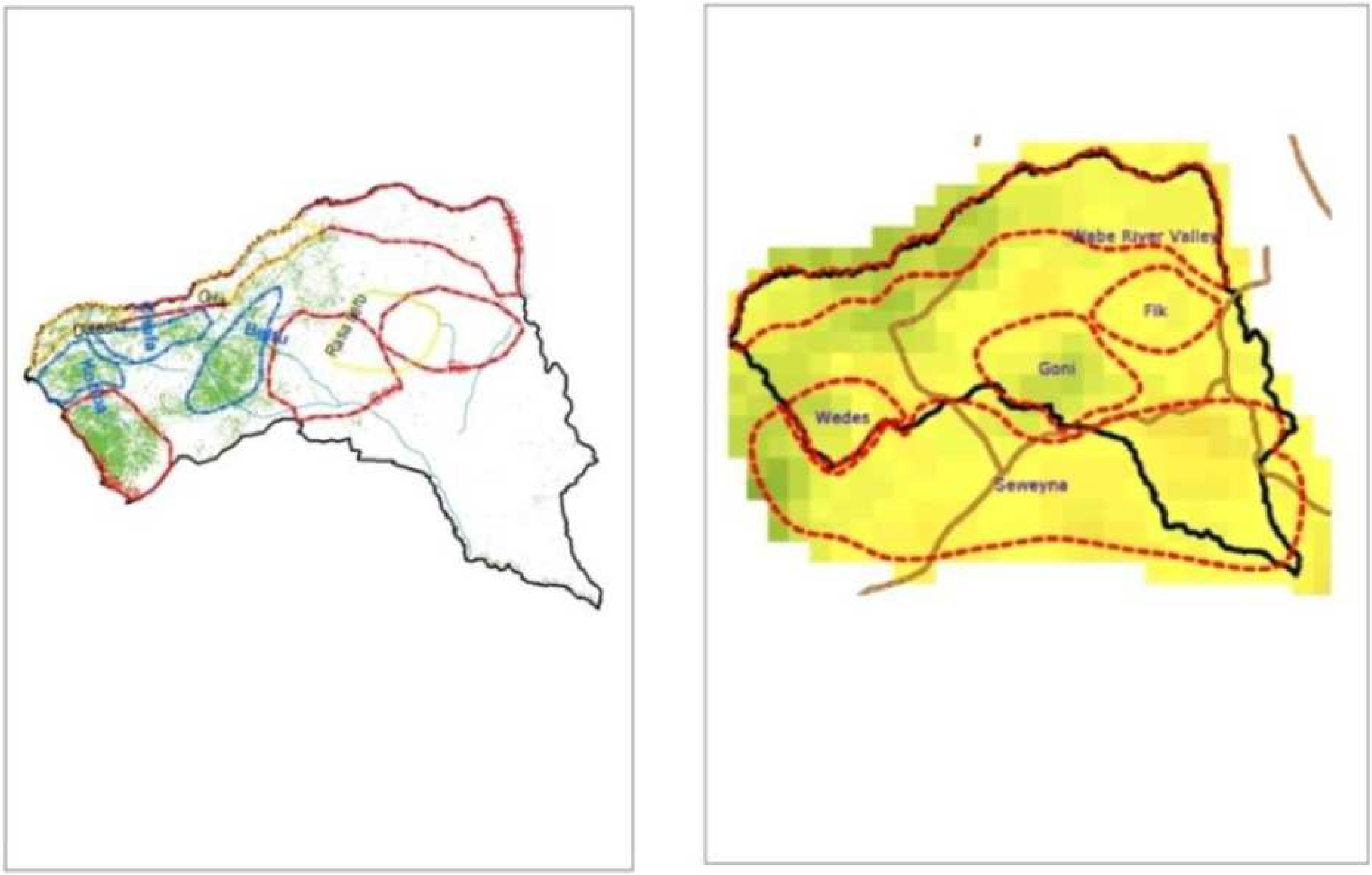

Figure 10

Comparing overlay digitized community map and ready-made SAPARM Source: GIS Analysis (2018) and PCI (2017)