PUNTLAND INFORMATION
MANAGEMENT CENTER FOR
WATER & LAND RESOURCES (IMC)

Food and Agriculture
Organization of the
United Nations

JIBAGALLE AREA
GAROWE DISTRICT
PUNTLAND, SOMALIA

JIBAGALLE

LAND COVER ASSESSMENT & MAPPING REPORT

2026

A comprehensive assessment of land cover,
land use and environmental conditions

Strengthening evidence-based decision making
for sustainable land and water resources management.

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EXECUTIVE SUMMARY

The Jibagalle Land Cover Mapping utilizes the FAO Land Cover Classification System (LCCS3) to systematically assess and categorize land cover in the settlement.

The study aims to conduct a detailed land cover assessment in the Jibagalle area using the Standard Land Cover Classification System Version 3 (LCCS3). It seeks to systematically map various land cover types, evaluate the extent of land degradation, and establish a reliable pilot assessment that can inform future land cover mapping efforts. Furthermore, the study focuses on improving mapping accuracy through ground truthing and delivering well-informed recommendations for Nature-Based Solutions to promote sustainable land management.

The land cover mapping study encompassed an extensive area of 219.38 km² within the Jibagalle Settlement. Notably, this study represents the first-ever application of the LCCS3 system in Somalia, introducing an advanced and standardized approach to land cover classification. This innovative methodology enhances the accuracy and consistency of land cover assessments, setting a foundation for future studies and sustainable land management initiatives.

The study found 17 distinct land cover classes using the LCCS system with the dominant land cover type of Sparse Shrubs covering 8,300.8 Ha (hectares), followed by Herbaceous Savanna (SAV) at 4,976.3 Ha (hectares), and Bare Soil (BSO) at 3,398.5 Ha (hectares).

The study utilizes Geographic Information System (GIS) tool alongside Very High-Resolution satellite imagery with further aided ground truthing to validate the mapping process, ensuring accuracy. Additionally, field surveys, guided by structured questionnaires and preselected sample sites, collect firsthand data and integrate local knowledge, providing valuable insights into land cover classes. The land cover classes are digitized using the Land Cover Classification System (LCCS3), which standardizes the mapping process and allows for precise visual adjustments and finally, Field verification has been dine further enhances the reliability of the satellite-based analysis by validating land cover classifications and refining the resulting maps.

The Study concludes with a comprehensive report that compiles the collected data, analysis, and findings. This report not only highlights the existing land cover types but also offers recommendations for sustainable land management practices to prevent future degradation expansion. The insights gained will support policymakers, researchers, and stakeholders in making informed decisions about land cover types, land use and possible conservation efforts in Jibagalle.

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Our sincere appreciation goes to **FAO-SWALIM (Somali Water and Land Information Management) under the Food and Agriculture Organization of the United Nations (FAO)** for their financial support and technical assistance. Their cooperation, guidance, and resources played a crucial role in making this assessment possible.

Many thanks to the dedicated field team, including IMC female Interns Ilham Jama(Land resources Intern), Ifrah Hussein (Water resources Intern), Nusaymo Abdirashid (GIS&RS Intern), and Maryam Abdirahman(Information Management intern) and IMC Line Ministries staff Ahmed Bushale, from the ministry of Environment and climate change for their diligence in conducting the surveys, and capturing the essential data, We also extend our sincere appreciation to the FAO staff: Ismail khalif(GIS & RS Data Analyst), Abdullahi Ali (Land Resources Specialist), Benard Onyango (GIS Developer), and Okumu Nakitari (Project Coordinator) .

We of course extend our gratitude to the farmers, pastoralists and residents of Jibagalle for lending us their time and providing us with critical insight.

Finally, our sincere appreciation goes to the SWALIM Technical advisor (Ugo leonard) for the support and guidance through the study, which made this assessment possible.

Key Words: Data Acquisition, data integration, GIS & Remote Sensing, Land cover, Land Use, Land degradation, Land cover classification System, Satellite, Soil, and Topography

ACRONYMS

ASL	Above sea level
$CaCO_3$	Calcium Carbonate
FAO	Food and Agriculture Organization
FEWS NET	Famine Early Warning Systems Network
FMNR	Farmer Managed Natural Regeneration
GIS	Geographic Information Systems
Ha	Hector
IDPs	Internally Displaced Persons
IMC	Puntland Information Management Center for Water and Land Resources
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
ITCZ	Inter-Tropical Convergence Zone
LADA	Land Degradation Assessment in Drylands
LCML	Land Cover Meta Language
LCHS	Land Characterization System
LCCS3	Land Cover Classification System Version 3
LCLU	Land Cover and Land Use
LULC	Land Use and Land Cover
MOERCC	Ministry of Environment, Range, and Climate Change
RS	Remote Sensing
SWALIM	Somali Water and Land Information Management
UTM	Universal Transverse Mercator
VHR	Very High Resolution
WGS	World Geodetic System

1. INTRODUCTION

1.1. Background

Amid the escalating impacts of climate change, understanding how humans interact with and transform the land has never been more critical. One method for understanding this interaction involves mapping the areas where humans use the land and classifying how they're using it; the collected data is then used to understand the degree of influence human activities have on land and the quality and type of land around them.

This method is referred to as land cover and land use mapping. Cover describes the land's physical features, such as the topography, water bodies, or flora present on the upper layer of land. It refers to the direct interaction these features have with humans, like agricultural or urban areas describing what humans do in that area.

Mapping LULC highlights significant information regarding the land, this information is often a method of change monitoring which is particularly helpful in the fight against climate change. Once a LULC map is created a duplicate map can be created sometime later, and the two maps can be compared, and change can be measured. For example, suppose an area is suffering from soil erosion the duplicated LULC map highlighted that the soil erosion is worsening, and now ministries and local governments have the necessary information to warn, mitigate, and intervene.

Although the Terms "Cover" and "use" are used separately, it is important to understand the interlinks between cover and use. Land cover can determine how the land is used if an area's soil is rich in nutrients, it is likely to see agricultural land uses in the area and the opposite is true, a degraded and harsh environment is unlikely to have urban settlements. How the land is used has a significant effect on the cover of the land, one example is the overharvesting of the natural vegetation by pastoralists which can transform the land from Shrubland or Grazelands to degraded and bare soil. Understanding the interlinks between land cover and land use helps create a more comprehensive and accurate assessment of the land, which in turn, helps ministries, local governments, AIDS groups, and so on, in their plan to fight climate change and its corresponding disasters.

These LULC maps and subsequent assessments are invaluable to various stakeholders, with one of the most significant beneficiaries being early warning systems. By analyzing changes in the land, these systems can pinpoint areas of risk and vulnerability, as a result, the accuracy of the data is a priority to stakeholders.

Technological advancement has eased the process of creating LULC maps as well as enhancing the accuracy of the collected data, Geographical information systems, and remote sensing are tools that aid the LULC mapping and assessment process, by providing high-resolution photos and analytical tools.

Land cover mapping is a method designed to comprehensively understand the various types of surface coverage within a study area. It provides valuable insights into both natural and human-made features, helping to establish patterns that support sustainable development. This process also facilitates environmental monitoring and the effective management of resources, ensuring a balanced and informed approach to land use and resources conservation.

With this in mind, Jibagalle was chosen as a focal area due to its diverse land cover types, which include vegetation, water body, rangelands, scattered settlements, agricultural fields, livestock rearing and other land use types present. The objective is to apply the Land Cover Classification System Version 3 (LCCS3), making it the first area in Somalia to be implemented the newly developed land cover classification system comprehensively and accurately. This approach aims to set a precedent for land cover mapping in the area while ensuring a detailed and standardized analysis of the landscape.

Although Somalia's land cover faces various environmental challenges, both natural and human-induced, there is a growing body of detailed information on the subject. Researchers and experts from diverse fields have contributed valuable insights, documenting these issues through various approaches and perspectives. They have defined the landcover through various ways, each taking a unique perspective and addressing the issue from a specific angle. This diverse approach provides a comprehensive understanding of the complexities surrounding land cover and its dynamics.

Recently, the topic of Land Use and Land Cover (LULC) changes has garnered significant attention from researchers with diverse interests. Some focus on modeling the spatial and temporal dynamics of land conversion, while others aim to investigate its underlying drivers, impacts, and broader implications (Verburg et al., 1999; Brown et al., 2000; Theobald, 2001).

Land cover is the observed (bio)physical cover on the earth's surface including vegetation, bare soil, water, and artificial structures." Anderson et al. (1976). Anderson's classification system formed the basis for land cover mapping standards.

Land cover is the biophysical state of the earth’s surface differences so that they are used properly in studies of land and immediate subsurface (Turner et al. 1995).

It describes the physical state of the land surface; e.g., cropland, mountains or forests (Meyer, 1995 in Moser, 1996).

Land cover deals with the quantity and type of surface vegetation, water, and earth materials (Meyer and Turner, 1994). i.e. man-made constructions (buildings etc.), the type of material used in housing structure (Parveen, 2017).

The term land cover originally referred to the type of vegetation that covered the land surface, but has broadened subsequently to include other aspects of the physical environment also, such as soils, biodiversity and surfaces and groundwater (Moser, 1996).

According to the Intergovernmental Panel on Climate Change. (n.d.). Land cover and land use defined, the observed physical and biological cover of the earths land as vegetation or manmade features whereas land Use defined the total of arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions). The social and economic purposes for which land is managed (e.g., grazing, timber extraction, conservation).

A segmentation is crucial in land cover mapping the goal of segmentation is to divide an image into separate, non-overlapping portions that differ based on particular attributes, including texture, color, shape, size, and intensity levels (Lucchese and Mitray, 2001).

1.2. Objectives of the Study

1.2.1. General objectives

The General objective of this study is to collect data on LCLU Using ISO Standard Land cover Classification system of Somalia, Additionally, the study aims to examine, the actual land cover, use systems and land degradation in the area.

1.2.2. Specific Objectives

The specific objectives of study are:

I. To map all the land cover types, present in the Jibagalle area using Standard Land cover classification System Version 3 (LCCS3).
II. To Assess the extent land degradation occurring in the area.
III. To develop a robust and comprehensive pilot land cover assessment that serves as a model for future land cover mapping initiatives.
IV. To perform ground truthing to enhance accuracy of the mapped land cover types.
V. To bring comprehensive Recommendations for Nature Based Solutions.

The Puntland Information Management Center for water and Land resources (IMC) aims to leverage Very High-Resolution (VHR) imagery to precisely map the existing land cover types and usage patterns within the study area. The resulting data will serve as a life-saving resource for future environmental intervention, enabling evidence-based decision-making grounded in accurate and high-quality information. Furthermore, this study will play a crucial role in advancing environmental planning efforts in Jibagalle, promoting sustainable development that benefits both the local community and their livestock.

1.3. Recommended Specific objectives

- To classify and map the land cover types in Jibagalle using the FAO Land Cover Classification System (LCCS3) and high-resolution satellite imagery.
- To quantify the spatial distribution and extent of different land cover classes within the study area.
- To validate the land cover classification using ground truthing and community-based verification to ensure accuracy and reliability of the mapping results.
- To develop high-quality land cover maps and spatial datasets that can be used by policymakers, researchers, and planners for sustainable land management and decision-making.
- To provide recommendations for land use planning, natural resource management, and conservation efforts based on the findings of the study.

1.4. Climate Characteristics

1.4.1 Rainfall

Puntland shares its climate characteristics with the rest of Somalia; however, its landscape is predominantly characterized by arid and semi-arid terrain and its climate is shaped by various factors, including the Inter-Tropical Convergence Zone (ITCZ), monsoonal winds, ocean currents, the Jetstream, easterly waves, tropical cyclones, and the Indian Ocean and Red Sea. (World Bank Group. (n.d.). *Somalia climate data).*

1.4.2. Temperature

Jibagalle is an arid to semi-arid, with two seasonal rainfall periods and an average annual temperature near 30°C. Temperatures peak from April to June, with the hottest months in the north occurring from June to September, while December to March are the warmest in the south. (World Bank Group. (n.d.). *Somalia climate data).*

According to the time series data for the Jibagalle shows a rising trend in average temperatures over the last thirty years. Annual temperature indicates a constant increase, with averages rising by about 1.18 degrees Celsius since early 1991 in addition to the last five years temperature increases yearly by year(https://power.larc.nasa.gov/data-access-viewer).

1.4.3 Soil of Jibagalle

The soil of the study area is characterized by Haplic Calcisols, Haplic Solonchaks, and Lithic Leptosols containing calcium carbonate ($CaCO_3$) are primarily found in the area. Each soil type affects the areas agricultural potential characteristics like texture, calcium levels, salinity, and depth, shaping their suitability for various land uses within the Jibagalle settlement. (FAO,2020).

1.4.4 Topography

The topography of Jibagalle is a low-lying terrain with flat to gently sloping. The highest point within the area reaches only 16 meters above sea level(asl), emphasizing its generally flat in nature. This low terrain characteristic is significant for activities such as agriculture, water resource management, and flood risk assessment, as it affects drainage patterns and land use suitability.

1.3.5 land form and drainage system

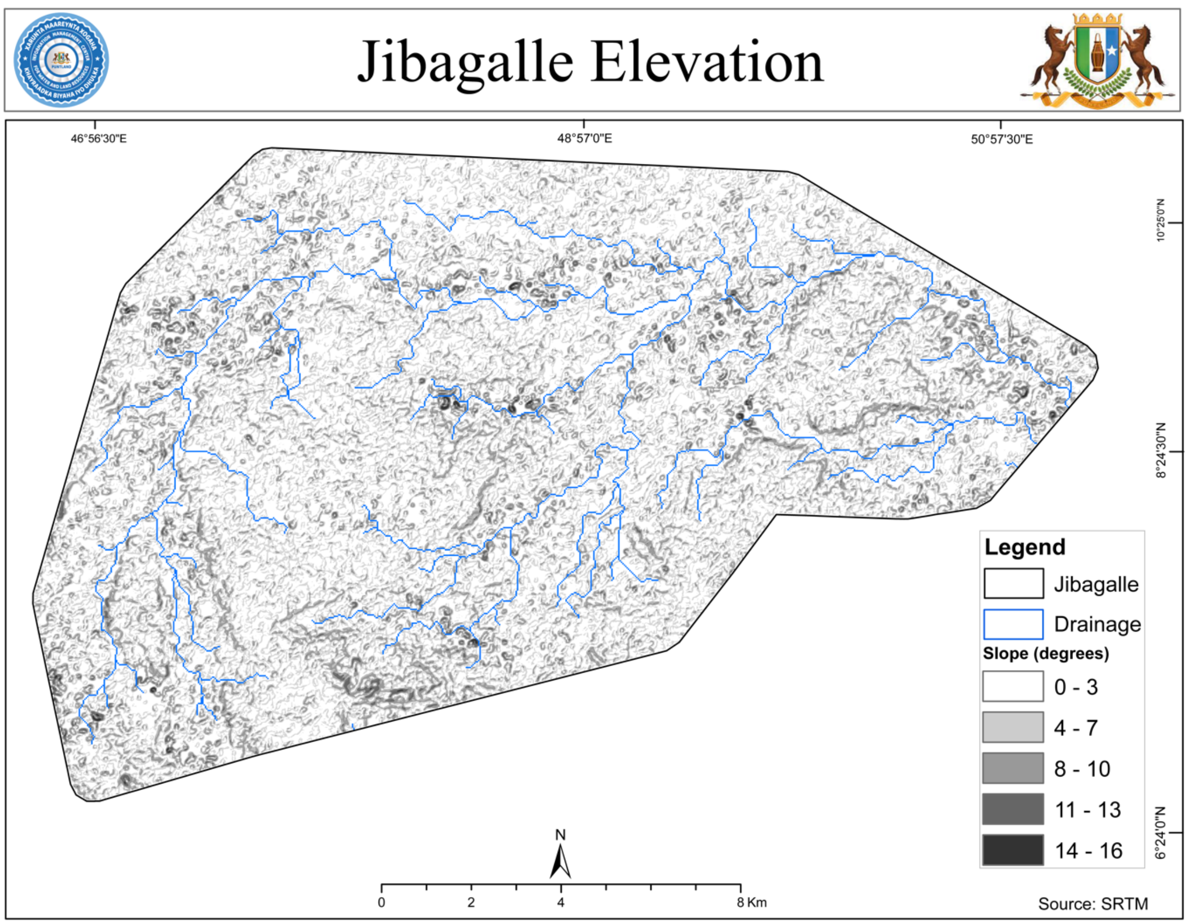


Figure 1: Jibagalle Elevation

2. MATERIALS AND METHODOLOGY

2.1. Description of the Study Area

Jibagalle locates to the east of Garowe district, starting from the eastern edge of the town, covering an area of 219.38 (Km). it lies, at Latitude of 8°30'21.30"N and Longitude of 48° 36' 5.08"E along a key road connecting Garowe to the commercial city of Bossaso.

The site was selected due to its significance, some oasis farms dotting the landscape which contributes a lot in terms of the household's income and livelihoods in this area and contains diverse land cover classes, including shrubs, trees, and herbaceous vegetation. Additionally, the area features various crop fields, rangelands, waterbodies, and residential structures, which added unique importance during the selection process.

Methodology followed for land cover Mapping in Jibagalle

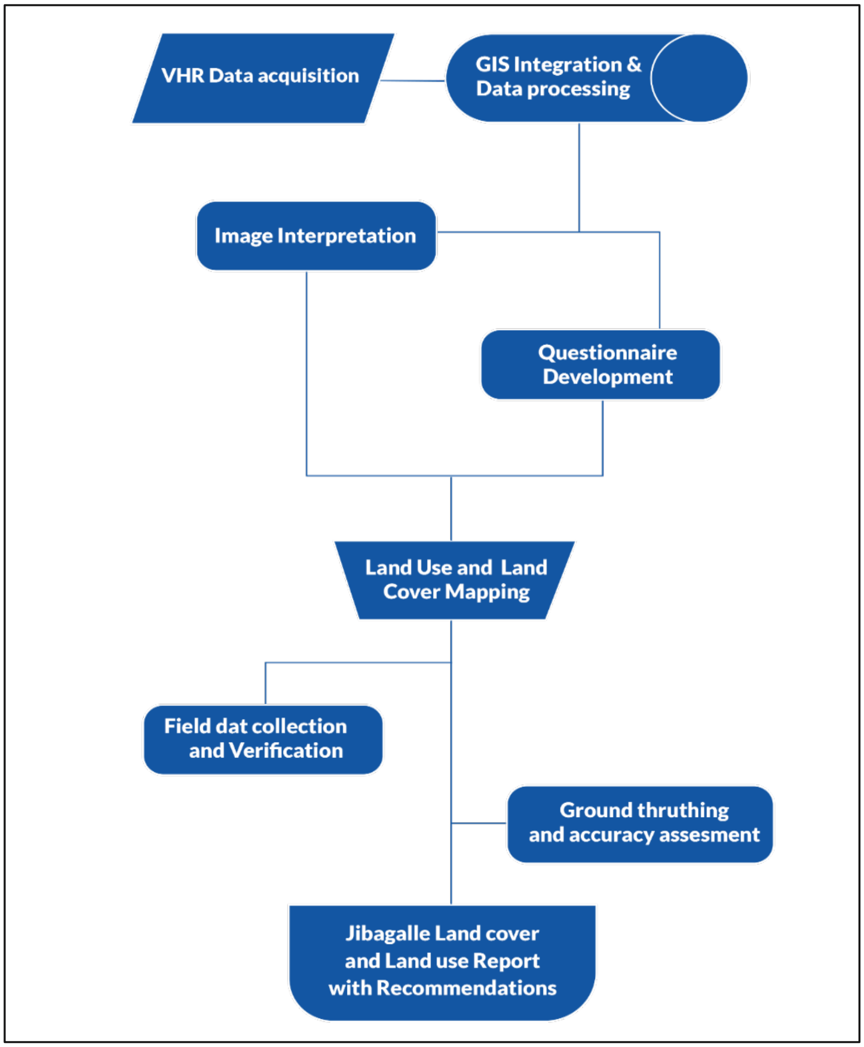


Figure 2: Methodology for Lanad cover mapping in jibagalle

2.2. Desk Review

Figure 2 Flow chart presenting the steps involved in the process, accompanied by the implementation of the 8-step land cover mapping methodology. Techniques employed to attain the ultimate LULC mapping activity in Jibagalle study area.

An activity work plan was developed for the first time, outlining a detailed step-by-step approach for the Jibagalle mapping process. The plan systematically assigned tasks to IMC team to optimize workflow efficiency. Subsequently, a comprehensive desk review was conducted to collect and analyze relevant literature essential to the study. Key Literature on land cover and land use in Somalia and Puntland were utilized, supplemented by additional data sourced from IMC archives to ensure a robust foundation for the study.

2.3. Very Hight resolution Data Acquisition (VHR).

A comprehensive dataset purchased from Airbus sources was used to support an in-depth land cover analysis. The land cover of Jibagalle were identified utilizing Very High-Resolution (VHR) satellite imagery captured in August 2023.

Satellite Images were acquired: a panchromatic image with a resolution of 0.5 m and a multispectral image with a resolution of 2 m. Pan sharpening was applied to merge the resolutions, and image enhancement was performed to improve visual quality, ensuring effective mapping activity.

Table 1: Datasets Used and their Sources

#	Satellite	Date	Source	Resolution
1	Airbus	August 2023	Maxer Technology	0.5 m
2	Maxer/Airbus	July 2024	Google Earth Pro	0.5 m

Table 1: Datasets used and their sources

2.4. GIS Integration and Processing

The study utilized advanced GIS tools, including Arc GIS 10.4.1, ArcGIS Pro and QGIS 3.28 to map the study area with precision. GIS tools are powerful and globally recognized for their key role in achieving accurate mapping, particularly in relation to land cover and land use analysis. These tools enable the integration, visualization, and analysis of spatial data, ensuring high-quality outputs and informed decision-making.

Before initiating the mapping process, all the images used were standardized to the same spatial projection by applying reprojection. The WGS 1984 UTM Zone 38N coordinate system was used to ensure consistency and comparability in data analysis. This step ensures that all images are aligned within a unified spatial reference system, facilitating precise spatial analysis and seamless data integration within the context of Somalia.

2.5. Image Classification

The image classification process in Jibagalle's land cover assessment involved categorizing pixels in satellite imagery into distinct land cover classes based on their spectral, spatial, and structural characteristics. This was achieved using Very High-Resolution (VHR) satellite imagery combined with advanced GIS techniques. The primary objective of this study was to systematically assess, classify, and analyze the land cover characteristics of the study area with a high degree of accuracy. This was achieved through the application of the Land Cover Classification System version 3 (LCCS3), a standardized and internationally recognized methodology developed by FAO. The use of LCCS3 enabled a detailed and hierarchical categorization of diverse land cover types, ensuring consistency, comparability, and reproducibility of the classification process. Furthermore, the approach facilitated the precise differentiation of vegetation, water bodies, built-up areas, and other land surface features, contributing to a comprehensive understanding of the spatial distribution and ecological significance of each category.

The accurate identification of land cover features such as vegetation cover, settlement areas, water bodies, gullies, and crop fields from satellite imagery presents a significant challenge due to spectral similarities, spatial resolution constraints, and environmental variability. To enhance the efficiency and accuracy of land cover classification, the team adopted a structured workflow by dividing the workload among five specialized groups, each responsible for analyzing an equal portion of the study area. This division facilitated a more systematic and coordinated classification process, ensuring comprehensive coverage while reducing individual workload disparities.

To further improve classification precision, an image segmentation technique was applied prior to classification. This approach involved partitioning the satellite imagery into homogeneous regions based on spectral and spatial properties, enabling the identification of distinct land cover features with greater clarity. By segmenting the imagery into meaningful objects rather than relying solely on pixel-based classification, the methodology enhanced classification accuracy, minimized spectral confusion, and improved the delineation of complex landscape patterns. This segmentation-based workflow proved instrumental in optimizing the mapping process, ensuring a more efficient, reliable, and high-resolution representation of the land cover distribution within the study area.

2.6. Land Cover Classification System 3 (LCCS3)

The Land Cover Classification System 3 (LCCS3), developed by the Food and Agriculture Organization of the United Nations (FAO), was employed as a core component of the methodological framework for land cover assessment in Jibagalle, Somalia. LCCS3 is a standardized, adaptable, and hierarchical system designed to classify land cover based on a well-defined set of parameters. By incorporating a structured classification approach, this system ensures consistency, comparability, and accuracy in land cover mapping, facilitating both national and international interoperability.

To establish harmonized, globally comparable land cover datasets, Somalia must adhere to internationally recognized classification frameworks. The FAO recommends the adoption of advanced methodologies such as the Land Cover Meta Language (LCML), which provides a semantic foundation for classifying land cover, and the implementation of LCCS3 alongside the Land Characterization System (LCHS). These classification systems have been scientifically validated to enhance the standardization, precision, and reproducibility of land cover data analysis, ensuring that national datasets align with global environmental and resource monitoring initiatives.

Within the Somali context, a total of 36 distinct land cover classes were defined, structured into five major thematic categories that represent the country's diverse landscapes. These include:

1. Natural and Semi-natural Vegetation – encompassing forests, shrublands, grasslands, and other natural ecosystems.
2. Agriculture – covering croplands, orchards, and managed agricultural landscapes.
3. Natural Surfaces – including barren lands, rocky outcrops, and other non-vegetated terrains.
4. Water Bodies – representing inland and coastal aquatic ecosystems, such as lakes, rivers, and wetlands.
5. Settlements – comprising urban, peri-urban, and rural built environments.

The implementation of this scientific classification system is instrumental in facilitating collaboration among governmental agencies, research institutions, and domain experts, fostering a multidisciplinary approach to land cover mapping. By integrating local knowledge with internationally recognized classification standards, Somalia can enhance environmental monitoring, inform sustainable land management strategies, and support evidence-based policy decisions tailored to its specific ecological and socio-economic context.

2.7. Sampling Techniques

Sample data is essential for the accuracy and effectiveness of classification processes. This study employed purposive sampling techniques to ensure accurate representation of the study area. A total of 33 sample sites were selected based on their ability to effectively represent the diversity land cover within the study area. The samples were chosen considering the variability in land cover types, their spatial distribution, areas with complex land cover and the different land cover classes present across the study area.

Field Sites	Description	Coordinate	
S1	Degradation	8.494282	48.65112
S2	Land Cover	8.490295	48.65729
S3	Land Cover	8.483189	48.70237
S4	Land Cover	8.468082	48.69806
S5	Land Cover	8.480287	48.71457
S6	LC/LU	8.500746	48.64452
S7	LC/LU	8.503322	48.62854
S8	Land Cover	8.510405	48.61792
S9	Land Cover	8.49537	48.58779
S10	Land Cover	8.516689	48.56744
S11	Land Cover	8.463241	48.63306
S12	Land Cover	8.428481	48.63307
S13	Land Cover	8.429498	48.62488
S14	Land Cover	8.516867	48.63953
S15	Degradation	8.496904	48.54753
S16	LC/LU	8.491812	48.62086
S17	LC/LU	8.492335	48.62781
S18	Degradation	8.451797	48.64813
S19	Land Cover	8.490948	48.68275
S20	LC/LU	8.470422	48.6089
S21	Dumpsite	8.431033	48.52444
S22	Land Cover	8.428704	48.53584
S23	Land Cover	8.469818	48.58085
S24	Degradation	8.494866	48.60658
S25	Degradation	8.454052	48.60688
S26	Land Cover	8.49528	48.53171
S27	Land Cover	8.47419	48.51856
S28	Land Cover	8.472591	48.51757
S29	Land Cover	8.429025	48.56203
S30	Water Catchment	8.434167	48.56461
S31	Land Cover	8.43428	48.56903
S32	Land Cover	8.501012	48.68328
S33	Land Cover	8.487695	48.70432

Table 2: Sample Sites

2.8. Field Survey Questionnaires

The IMC developed comprehensive and systematically designed questionnaires to facilitate the collection of detailed data on land cover and land use within the Jibagalle study area. These accurately structured instruments were prepared for field deployment to acquire primary data, focusing on capturing insights into diverse land cover, gully and land use patterns across the study area. Additionally, the questionnaires aimed to engage the Jibagalle community, leveraging their experiential knowledge and observations to enrich the dataset and enhance the precision of the land cover assessment.

2.9. Field data collection and Verification

Eight days field data collection and verification were undertaken as integral components of the land cover mapping process, serving to enhance the precision and reliability of the resulting data. An extensive and systematic survey was conducted to acquire detailed insights into land cover, land use, and gully erosion, within the designated study area. This endeavor encompassed the evaluation and ground-truthing of 37 strategically pre-selected sample sites, ensuring robust and contextually accurate data for analysis.

For the field data collection process, the teams were equipped with all the necessary tools to ensure they could effectively reach and gather data from the designated locations. Each team was provided with GPS devices to guide their navigation. Additionally, laminated sheets in A3 and A4 sizes were supplied for recording spatial, directional data onsite and Additionally, the teams were trained in land cover mapping, keeping in mind the principles and guidelines of Land cover classification system.

The data collection was further streamlined through the use of Kobo Collect forms, which were preloaded onto the team's devices. These forms facilitated the systematic recording of information at each pre-selected site. Once the data was collected, it underwent a quality enhancement process before being transmitted to a designated server for centralized storage.

Finally, a thorough data cleaning process was conducted to ensure accuracy and consistency. This step was essential to prepare the data for subsequent analysis, providing reliable insights derived from the information collected in the field.

2.10. Accuracy Assessment and Ground Truthing

In the context of remote sensing for land cover classification, accuracy assessment is crucial as it involves evaluating the agreement between the reference system and the classified image to identify errors. This can be performed either qualitatively, through visual interpretation, or quantitatively, using statistical methods. Typically, the error matrix method is widely employed for this purpose.

To ensure data accuracy in the study, 33 sites were visited as ground truthing to determine the actual land cover in each location. These sites were selected to represent the various types of land cover present in the area, ensuring that each type was adequately sampled. The Visual Accuracy assessment method was applied in the assessment together will visual interpretation.

3. DISCUSSION AND RESULTS

3.1 Land Cover

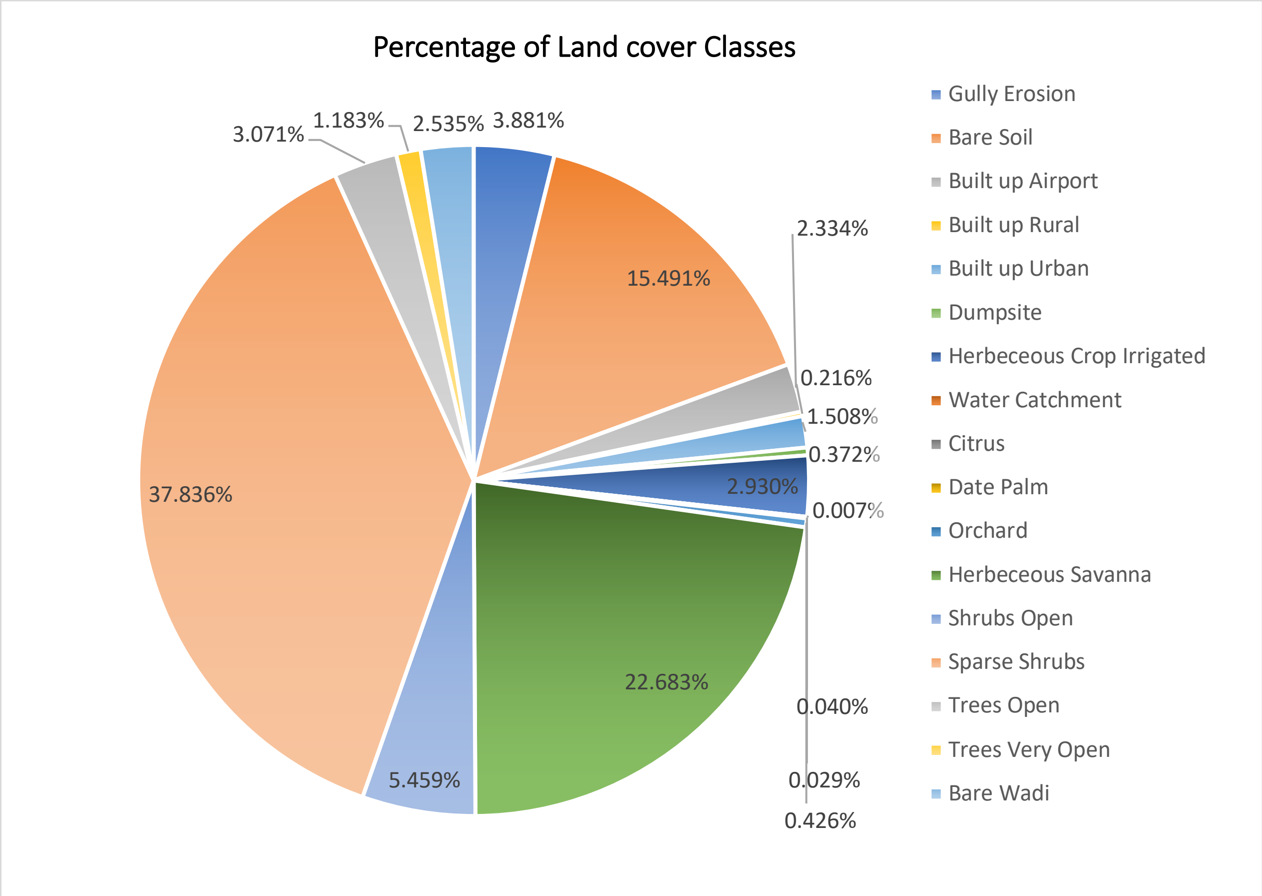


Figure 3: percentage of landcover classes

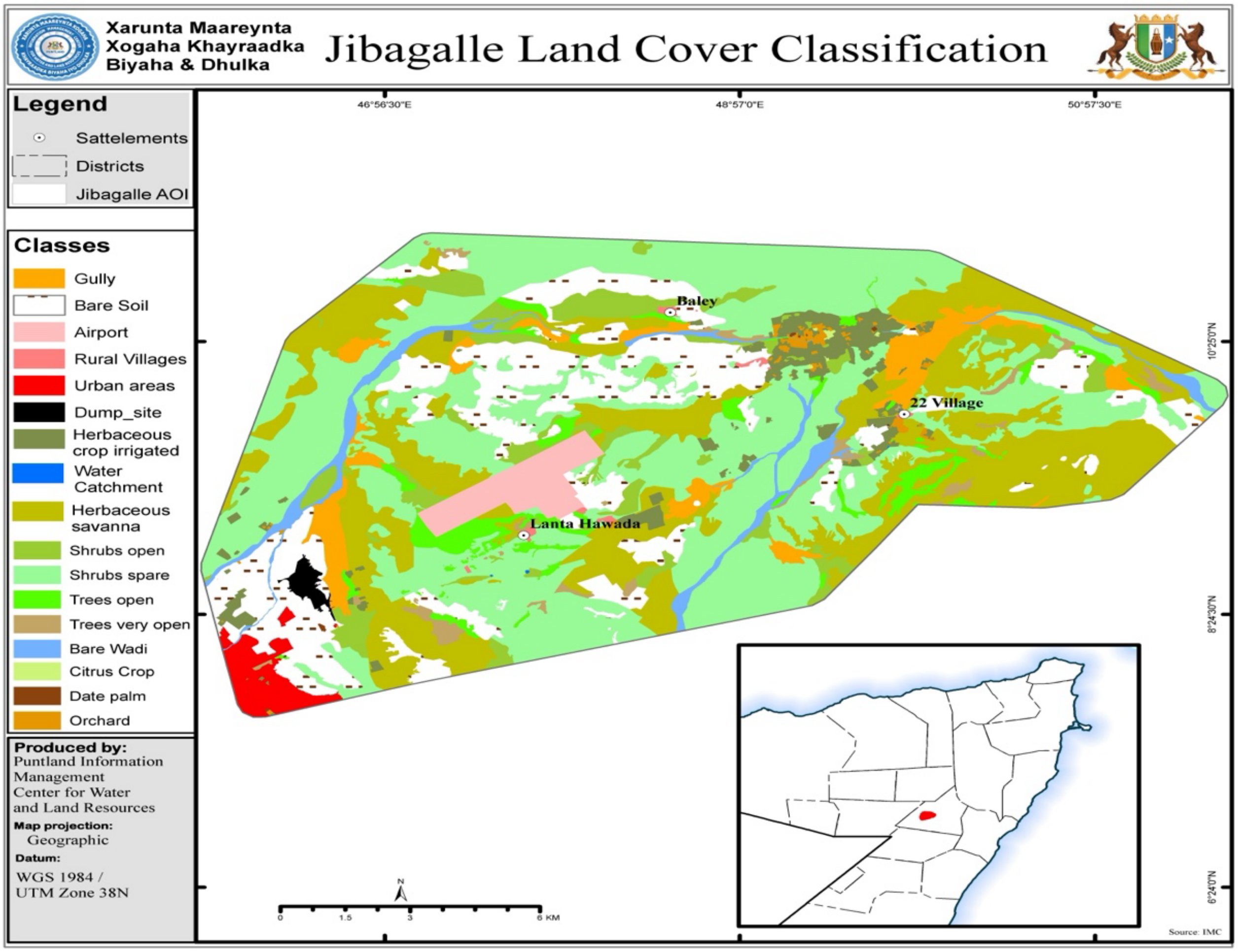
The land cover map of Jibagalle represents the presence of 17 different classes within the area, which have been generated using the LCCS3 system. Each class signifies a specific category of land cover with its unique spatial distribution and characteristics.

The dominant land cover class is **Sparse Shrubs (SSP)**, which constitutes 37.8%, **Herbaceous Savanna (SAV)**, accounting for 22.68%, **Bare Soil (BSO)**, representing 15.5%, **Open Shrubs (SOP)**, which cover 5.5 %, **Herbaceous Crop Irrigated** (**HCI**) occupies 2.9%, meaning areas where herbaceous crops are cultivated under irrigation. **Gully erosion** (BGU) 3.9% of the area, reflecting land degradation due to the erosion.

Built-Up Airport (BUA) covers 2.3%, representative areas dominated by airport infrastructure and related facilities. **Tree Very Open** (**TVO**), comprising areas with widely scattered tree cover, accounts for 1.2%. Built-Up Urban (**BUU**), characterized by dense urban infrastructure, constitutes 1.5%, **Bare Wadi** (**WBW**), referring to dry riverbeds or ephemeral streams with exposed substrates, occupies 2.5%.

Tree Open (**TOP**), representing open-canopy woodlands, accounts for 3.1%, while Orchard (**ORC**), indicative of cultivated fruit-bearing trees, covers 0.43%. Dump Site, representing areas designated for waste disposal, constitutes 0.37%. Built-Up Rural (**BUR**), comprising rural settlements, spans 0.22%.

Citrus (**OCI**), representing intensively cultivated citrus plantations, accounts for 0.04%, while Date Palm (**OPA**), areas with date palm cultivation, occupies 0.03%. Lastly the least covered is Water Catchment (**IWWC**), including water catchment areas, covers 0.01%. This classification provides insights into the spatial distribution of various land cover types and their implications for land management and environmental planning.



Map 1: Jibagalle Land cover Classification

The study area is characterized by deciduous vegetation type, with most of the vegetation species consisting of needle leaf phenology. The dominant woody types present included: Acacia tortilis, Boscia Minimifolia, Prosopis juliflora (Garanwaa), Boswellia neglecta (Dhirindhir), Acacia stuhlmanii (Qaydar), Euphorbia cuneata, Commiphora Spp (Qaroon) Acacia seyal (Jeerin) Caesalpinia erianthera (Jirme), Zygophyllum Hildebrandti (Aftaxole), cadaba somalensis (Qalaanqal), and Taraxo While the Herbaceous species of Xanthium strumarium, Daran, Dousperma Eromoophilum , Indigofera Espinosa(Xajiin), and Rako are present in the area.

Table 2: Land cover Statistics

Classes	Frequency	Sum_Area_Ha	Percentage
Gully Erosion (BGU)	14	851.5	3.881%
Bare Soil (BSO)	51	3398.5	15.5%
Built- Up Airport (BUA)	1	511.9	2.33%
Built-Up Rural (BUR)	8	47.4	0.22%
Built-Up Urban (BUU)	1	330.8	1.51%
Dump site	1	81.5	0.37%
Herbaceous Crop Irrigated (HCI)	71	642.8	2.93%
Water Catchment (IWWC)	5	1.4	0.01%
Citrus (OCI)	5	8.7	0.04%
Date Palm (OPA)	6	6.3	0.03%
Orchard (ORC)	55	93.5	0.43%
Herbaceous Savanna (SAV)	33	4976.3	22.68%
Shrubs Open (SOP)	52	1197.5	5.46%
Sparse Shrubs (SSP)	45	8300.8	37.84%
Trees Open (TOP)	75	673.8	3.07%
Trees Very Open (TVO)	26	259.4	1.18%
Bare Wadi (WBW)	9	556.1	2.53%
Total	**458**	**21938.2**	**100%**

Table 3: Land cover statistics

3.2 Land Use

The predominant land use in Jibagalle is nomadic pastoralism, which accounts for 78% of the area. The second most common type of land use is Semi-sedentary (agro-pastoralism) where animal husbandry is coupled with agricultural activities comprising 14% of the land use. Additionally, irrigated farming and small rural and urban settlements collectively make of 8% of the land use within the study area.

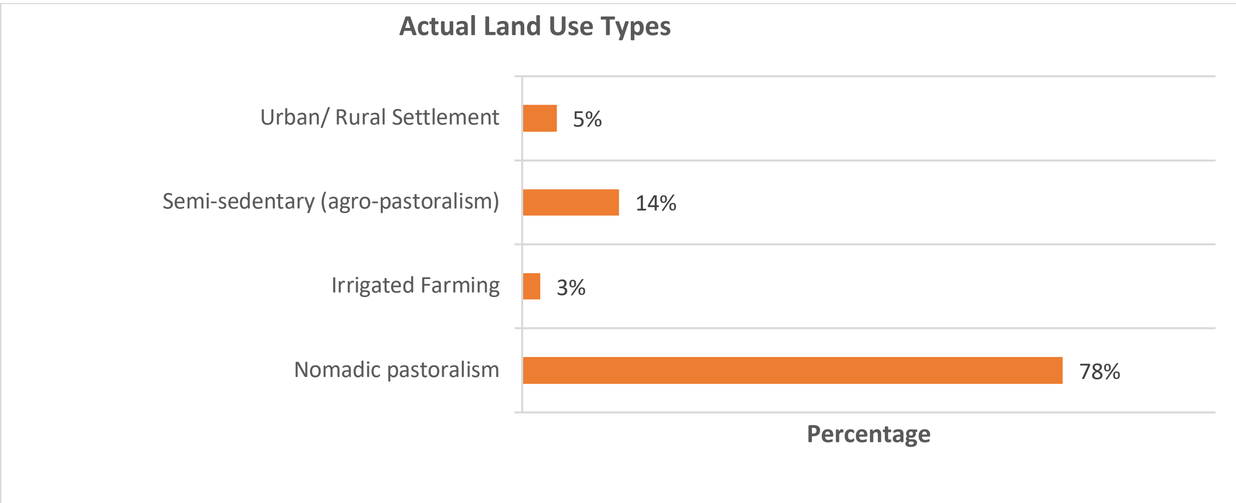


Figure 4: Actual Land Use Types

Crop cultivation is also practiced in the area, with the primary crops including orchards, citrus fruits, date palms, and green vegetables of (Okra, Coriander, Tomato, Onion and hot Pepper). A number of farmers also grows maize. The study also found that farmers are facing challenges, including crop failures caused by water scarcity in the area. Additionally, there are crop pests and diseases affecting the crops being cultivated, which has led to some crops, such as tomatoes, being abandoned altogether.

The primary objective of crop production in the area is commercial, driven by market demand which is 46.1%, Subsistence farming is practiced to 38.5%, while the remaining a portion of 15.3% for livestock fodder.

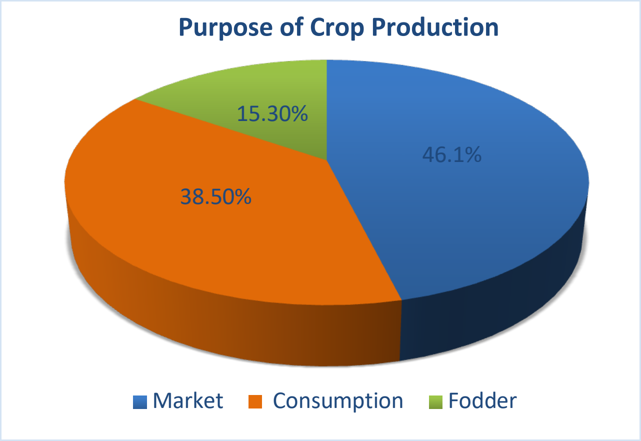


Figure 5: Purpose of crop production

Farmers in Jibagalle also engage with land management practices, such as farm fencing and the establishment of windbreak plantations, to protect and sustain their fields.

The community is actively involved in livestock husbandry, primarily focusing on the rearing of four main types of livestock: goats, cattle, sheep and camels, this diverse livestock system plays a vital role in the local economy and livelihoods.

3.3 Land Degradation

Environmental degradation is a concerning phenomenon, mostly in arid and semi-arid areas particularly northeastern part of Puntland, Somalia. The degradation is primarily driven by recurrent droughts caused by climate change and reduced rainfall amounts.

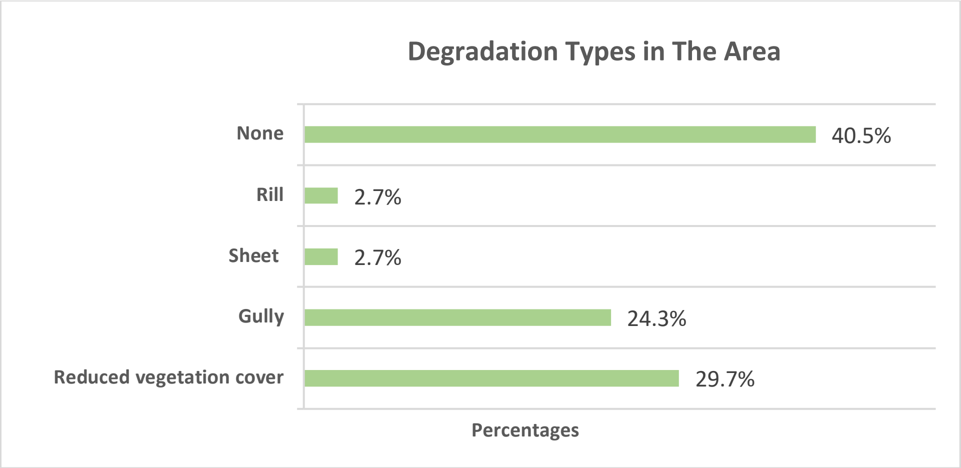


Figure 6: Degradation types in the area

land degradation refers to a negative change in land condition over time, driven by direct or indirect human activities, including climate change caused by human influence. This is characterized by a sustained reduction or loss in one or more of the following: biological productivity, ecological integrity, or value to human well-being (Montanarella et al., 2018).

Land degradation Assessment in drylands (LADA) defined degradation as reduction of the capacity of land to perform ecosystem functions and services (including those of agro-ecosystems and urban systems) which support society and development.

Alternative Definition of Land degradation is the reduction in the capability of the land to produce benefits from a particular land use under a specified form of land management (FAO, 1999).

Furthermore, A decline in biological productivity, ecological integrity, or value to humans can be considered degradation. However, any one of these changes on its own does not necessarily constitute degradation. (Olsson et al., 2019).

According to the information provided by respondents from 33 locations visited, 22 sites equivalent to 59.4% revealed the presence of land degradation features. Of this, 29.7% was attributed to reduced vegetation cover, while 24.3% resulted from gully erosion, which poses significant impacts to both crop fields and rangelands. Additionally, 5.4% of the degradation was caused by rill and sheet erosions, which are currently progressing into gullies. In contrast, the remaining 15 sites (40.5%) showed no visible signs of land degradation.

4. CONCLUSION AND RECOMMENDATIONS

4.1. Field Challenges

1. Despite the challenges in the field, the mission coincided with a dry period when most participants, especially livestock herders, were busy migrating their animals in search of better pasture.
2. There was also sand that covered some of the roads, making it difficult for vehicles to access the sample sites.
3. the sample located inside the airport become in accessible due to restrictions preventing public entry into the area.

4.2. Conclusion

This study successfully collected and analyzed land cover and land use (LCLU) data for Jibagalle using the ISO Standard Land Cover Classification System of Somalia. By leveraging high-resolution satellite imagery and GIS techniques, the study classified and mapped the spatial distribution of various land cover types, providing a comprehensive understanding of the area's land use dynamics.

Field validation and community engagement enhanced the accuracy of the classification, ensuring that the mapped data reflects actual land cover conditions. The analysis also identified key land use systems and highlighted areas affected by land degradation, offering insights into environmental changes and their potential impact on local livelihoods.

The findings of this study serve as a crucial resource for land management, policy development, and conservation planning. The results emphasize the need for sustainable land use strategies, particularly in areas experiencing degradation and land use conflicts.

In conclusion, this assessment provides valuable spatial data that can inform decision-making processes for natural resource management, agricultural planning, and environmental conservation. Future studies should consider periodic updates to monitor land cover changes over time and assess the effectiveness of land management interventions.

This study identified areas prone to land degradations including gully erosions, change in land cover, control of Invasive species, crop pests and diseases and making proper land management practices for nature-based solutions, sustainable agricultural practices, and training farmers for pests and disease control.

4.3. Recommendations

Based on the findings of the study, following recommendations can be made to address the challenges of Land cover assessment in Jibagalle area.

- Implementing techniques to control erosion, such as terracing, bunds, and land zoning, to reduce flooding and gully erosion and utilizing modern methods to rehabilitate degraded lands.
- Finding a solution for the Prosopis tree or other invasive species, which is widespread in the study area and poses a threat to the surrounding crop fields and vegetation cover.
- Providing Training to the Farmers of Jibagalle for Pest Management and Control mechanisms as they face numerous crop failures as results of crop pests and diseases.
- Implementation of land management practices to control erosion this includes Soil bunds, Gabions, Farmer Managed Natural Regeneration (FMNR), afforestation and Half-moons.
- Foster community participation for land management efforts while ensuring local practices and knowledge are considered in nature-based solutions.
- Developing and enforcing land uses policies for the monitoring of overgrazing and deforestations.
- Continuous Monitoring of change in order to monitor the in alteration of land use system's and vegetation cover with the study area.

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6. ANNEXES

6.1 Selected Field Photos

Figure 12: testing the form application

Figure 10: Team in field mission

Figure 11: Herbaceous Savvana(SAV)

Figure 7: Field work

Figure 13: Date Palm (OPO)

Figure 9: Bare soil (BSO)

Figure 8: Cultivated area

Figure 14: Prosopis Juliflora invaded area.

6.2 Field Questionnaires

Land Cover Field Form

SURVEY QUESTIONNAIRE	RESPONSES	
Site No		
Location		
Observer		
Date		
Coordinates of the Area	LAT [North]	
	LONG [East]	
Field Photography		
On Spot	☐ North	☐ South
	☐ East	☐ West
Take photo		
General Land Form		
Slope	☐ Flat to Gently Sloping Terrain (0-7 %)	
	☐Gently Sloping to Moderately Sloping (8-13%)	
	☐ Sloping to Moderately Steep, Undulating to Rolling terrain (14-20 %)	
	☐ Steep to Very steep, Rolling to Hilly Terrain (21-55 %)	
	☐Extremely Steep Terrain, Steeply Dissected Hilly and Mountainous Terrain (56 -140 %)	
General Land Cover Information		
General land cover type present in the site	☐ Natural vegetation	
	☐ Agricultural	
	☐Built Up	

	☐Water body ☐ Natural Surface	
Specific land cover type		
What is the Major land cover aspect?	Natural / Semi-Natural	**Cover Percentage**
	☐ Trees Closed (TCL)	☐ Trees 70-100 (%) ☐ Shrubs 10-50 (%) ☐ Herbaceous (10-100%)
	Remarks	
	☐ Trees Open (TOP)	☐ Trees (20-70%) ☐ Shrubs (10-60 %) ☐ Herbaceous (10-100%)
	Remarks	
	☐ Trees very Open (TVO)	☐ Trees (10-20 %) ☐ Shrubs (5-40 %) ☐ Herbaceous (10-100%)
	Remarks	
	☐ Shrubs Closed (SCL)	☐ Shrubs (70-100 %) ☐ Trees (1-10 %) ☐ Herbaceous (10-100%)
	Remarks	

	☐ Tiger Bush (**TBU**)	☐ Shrubs (10-40 %) ☐ Herbaceous (10-60%) ☐ Trees (5-40 %) ☐ Bare soil
	Remarks	
	☐ Riverine Gallery Forest (**RGF**)	☐ Trees (20-100 %) ☐ Herbaceous (10-100%) ☐ Water body
	Remarks	
	☐ Herbaceous Permanently Flooded (**HFL**)	☐ Herbaceous (60-100%) ☐ Water body (months)
	Remarks	
	☐ Trees Seasonally Flooded (**TSF**)	☐ Herbaceous (60-100%) ☐ Water body (months)
	Remarks	
	☐ Woody Mangroves (**WMA**)	☐ Woody growth form (40-100%) ☐ Water body (Brackish)
	Remarks	

	☐ Shrubs Open (**SOP**)	☐ Shrubs (10-70 %)
		☐ Herbaceous (5-40 %)
		☐ Soil deposit
		☐ Trees (1-10 %)
	Remarks	
	☐ Shrubs Sparse (**SSP**)	☐ shrubs (1-10 %)
		☐ Herbaceous
		☐ Soil deposit surface
	Remarks	
	☐ Trees and shrubs Savanna (**TSS**)	☐ Herbaceous growth form (20-60 %)
		☐ Soil deposit surface
		☐ Shrubs (2-10%)
		☐ Trees (3-20%)
	Remarks	
	☐ Herbaceous Savanna (**SAV**)	☐ Herbaceous growth form (20-100 %)
		☐ Soil deposit surface
		☐ shrubs (2-10 %)
		☐ Trees (2-10 %)
	Remarks	

	Agricultural	**Dominance**
	☐Orchard (**ORC**)	☐ Trees
	☐Herbaceous Crop Rainfed (**HCR**)	☐ Herbaceous growth form
		☐ Rainfed
	☐Herbaceous Crop Irrigated (**HCI**)	☐ Herbaceous growth form
		☐ Irrigation
	☐Banana Crop (**OBA**)	☐ Trees
		☐ Irrigation
	☐Citrus Crop (**OCI**)	☐ Trees
		☐ Irrigation
	☐Maize Crop (**HMA**)	☐ Herbaceous growth form
		☐ growing length 1-120
	☐Date Palm (**OPA**)	☐ Trees
		☐ Irrigation
	☐Herbaceous Crop Post Flooded (**HPF**)	☐ Herbaceous growth form
		☐ Flooding
	Remarks	

Life form of Natural vegetation											
		Trees	level	cover	Height	Leaf type			Leave Phenology	
						Broad	Needle	Aphyllous	Evergreen	Deciduous
			☐1	☐	☐	☐	☐	☐	☐	☐
			☐2	☐	☐	☐	☐	☐	☐	☐
			☐3	☐	☐	☐	☐	☐	☐	☐

		Shrubs	☐1	☐	☐	☐	☐	☐	☐	☐
			☐2	☐	☐	☐	☐	☐	☐	☐
		Herbs	☐1	☐	☐	☐	☐	☐	☐	☐
			☐2	☐	☐	☐	☐	☐	☐	☐
		Graminoids	☐	☐	☐	☐	☐	☐	☐	☐
		Forbs	☐	☐	☐	☐	☐	☐	☐	☐
	Cover estimation of vegetation		☐ Visual		☐ Instrumental		☐ Others			

Agriculture

Purpose of crop production

Crop Type	Crop Use			
	Market	Consumption	Fodder	Other
☐Orchard				
☐Herbaceous Crop Rainfed (**HCR**)				
☐Herbaceous Crop Irrigated (**HCI**)				
☐Banana Crop (**OBA**)				
☐Date palm				
☐Citrus Crop (**OCI**)				
☐Maize Crop (**HMA**)				
☐Herbaceous Crop Post Flooded (**HPF**)				

Crop Phenological Stage

	Name of Crop:		**Start**	**Growing**	**Flowering**	**Fruiting**	**Fallow**
		Orchard	☐	☐	☐	☐	☐
		Herbaceous Crop Rainfed (**HCR**)	☐	☐	☐	☐	☐
		Herbaceous Crop Irrigated (**HCI**)	☐	☐	☐	☐	☐
		Banana Crop (**OBA**)	☐	☐	☐	☐	☐

Water Bodies		
	Permanent water bodies	☐ Rivers ☐Seasonal rivers
	Temporary Water bodies	☐Dams
		☐Berkads
		☐Water catchments
	Permanent water bodies	☐ Rivers
		☐Seasonal rivers
	Wadis	☐vegetated wadi
		☐Bare wadi
Built up areas		
	Built Up non-linear	☐ IDPS ☐ Port ☐ Airports ☐ Sport Facilities ☐ Dumpsite ☐ Urban Area ☐ Rural Village's
	Built up linear	☐ Roads
	Land Degradation	
	Is there any evidence of land degradation?	☐ Yes
		☐ No
	If yes, What type of degradation?	☐Gully
		☐Rill
		☐Sheet
		☐ Reduced vegetation cover
		☐ Salination

	Is there soil and water conservation structures	☐ Yes
		☐ No
	If yes, what is the structures?	☐ Contour bund
		☐ Semi-circular bunds
		☐ Firebreak
		☐ Trenches
		☐ Rock dam
		☐ Hedge (Sand dune stabilisation)
		☐ Palisades (Sand dune stabilisation)
		☐ Gabion
		☐ Stone bunds
		☐ Rock dikes
		☐ Planting pits
		☐ Grass strips
		☐ Other

Livestock		
Do you own any livestock	☐ Yes	
	☐ No	
If yes, what type of livestock do you own?	☐ Camel	
	☐ Goat	
	☐ Sheep	
	☐ Cattle	
Number per species		
Estimate the Number of the livestock you own?	**Species**	**Approx. Number**
	Camel	
	Goat	
	Sheep	
	Cattle	
Land Use Type		
What's the actual land use type?	☐ Nomadic pastoralism	
	☐ Transhumance pastoralism	
	☐ Semi-sedentary (agro-pastoralism)	
	☐ Rainfed Agriculture	
	☐ Irrigated Farming	
	☐ Transhumance Pastoralism	
	☐ Urban Settlement	
	☐ Rural Settlement	
	☐ Barreland	
	☐ Nomadic Pastoralism	
	☐ Other	

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