**"Preventing Forest Loss, Promoting Restoration, and Integrating Sustainability into Ethiopia's Coffee Value Chains and Food Systems"**

# Institutional Capacity Baseline Assessment on Geospatial-Based Integrated Land Use Planning

## Part I: Baseline Assessment Report on the Capacity of Federal Institutions

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**Abbreviations and Acronyms**

| | |
|---|---|
| CRGE | Climate Resilient Green Economy |
| CSPro | Census and Survey Processing System |
| EBI | Ethiopian Biodiversity Institute |
| ECTA | Ethiopian Coffee and Tea Authority |
| EFD | Ethiopian Forest Development |
| ENVI | Environment for Visualizing Imagery |
| EEPA | Ethiopian Environmental Protection Authority |
| ERDAS | Earth Resource Data Analysis System |
| FAO | Food and Agricultural Organizations |
| FOLUR | Food Systems, Land Use and Restoration |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| ILUP | Integrated Land Use Planning |
| LULC | land use and land cover |
| ML | Machine Learning |
| MoA | Ministry of Agriculture, |
| MoARD | Ministry of Agriculture and Rural Development |
| MoP | Ministry of Peace, |
| MoPD | Ministry of Planning and Development |
| MoUI | Ministry of Urban and Infrastructure |
| MoTL | Ministry of Transport and Logistics |
| MoWE | Ministry of Water and Energy |
| QGIS | Quantum Geographic Information System |
| SLM | Sustainable Land Management |
| SPSS | Statistical Packages for Social Scientists |
| SSGI | Space Science and Geospatial Institute |
| UNCCD | United Nations Conventions to Combat Desertification |

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**Executive Summary**

Ethiopia, situated in the Horn of Africa, has diverse land use and cover types, influenced by factors like topography, climate change, socio-economic activities, deforestation and land degradation, overutilization of land resources population growth, and governmental policies. The absence of sustainable land use plans and management implementation leads to environmental resource dwindling, affecting food and water systems, enhancing water scarcity, food insecurity and poverty traps in the country. Ethiopia's agricultural sector, including coffee farming, is facing significant challenges due to land degradation, impacting food and water supply systems in the country. Implementing modern technology and agronomic management practices, including geospatial-based integrated land use planning (ILUP), is crucial for improving agricultural production and productivity. ILUP involves identifying stakeholders, setting objectives, and describing land tracts for a certain use. However, to implement ILUP efficiently, Ethiopia faces challenges from the perspective of institutional arrangements, technical and resource constraints, and social and political difficulties. Currently, the government is attempting to realize sustainable land management strategies through “Preventing Forest Loss, Promoting Restoration (FOLUR) and Integrating Sustainability into Ethiopia’s Coffee Value Chains and Food Systems" project initiative. This institutional capacity survey aimed to analyze the state of geospatial-based ILUP capacity building initiatives at different Ethiopian Federal organizations focusing on capacity building initiatives, skill gaps, infrastructure, technology, data access, and institutional systems frameworks.

A mixed-methods approach was used to analyze the data, revealing that the implementation of ILUP in Ethiopia requires a diverse range of skills, expertise, strong institutional systems, and technological capacities. The study found gaps in the implementation, including unclear mandates, conflict of interests, lack of legal and policy frameworks, lack of coordination and collaboration among government institutions, and limited opportunities for professional development and capacity building. A human capacity development gap analysis revealed a significant lack of specialized knowledge and skills for implementing ILUP, particularly in ILUP, GIS, and remote sensing. However, there is a significant pool of experienced professionals who can contribute their knowledge and skills to ILUP initiatives. The main reasons for this skill mismatch include lack of skilled manpower, brain drain, inadequate remuneration and incentives, and lack of career development opportunities. The findings also asserted that geospatial advancements have revolutionized land use planning in Ethiopia, making the implementation of geospatial-based ILUP crucial. However, most federal institutions lack the necessary technological capacities to effectively implement ILUP, relying on low-capacity computers and basic software. This results in limited access to advanced technologies used for realizing ILUP such as data infrastructure, management, digital literacy, and skills. A baseline survey assessment revealed a lack of skilled manpower, strong institutional system capacity, and advanced geospatial technologies for ILUP implementation.

Urgent action is needed to improve sustainable land use and environmental conservation. This includes formulating land use policies, legal frameworks, guidelines, and land laws, strengthening leadership commitment, and institutional restructuring. Similarly, investing in geospatial-based ILUP training and capacity building program is highly recommended to develop a skilled workforce capable of addressing complex challenges in land use planning and management. This includes providing training and capacity-development opportunities for government officials, technical experts and community members. Accordingly, the baseline survey results prioritize three training packages: *i) Advanced GIS*

*and Remote Sensing Trainings* with ArcGIS Pro, QGIS, ERDAS, and Google Earth Engine software; *ii) Python Programming and its Applications*, and iii) *R Programming* and its Applications.

**Keywords:** Land Degradation, Human Capacity, Technological Capacity, Institutional Systems, Capacity, Geospatial, Integrated Land Use Planning, Federal Organizations, Ethiopia.

# 1. Introduction

## 1.1 Background of the Study

Ethiopia's total land area amounts to 1.13 million square kilometers, characterized by diverse land use and land cover (LULC) conditions. Various factors including geography, topography, climate and socio-economic activities are known to govern land use and land cover (LULC) conditions in the country (Gessesse et al., 2015; Bezuayehu and Sterk, 2008; Woldeamlak, 2002). Cropland is the dominant land use type in the highlands, with cereal crops like teff, wheat, barely, coffee and maize being extensively cultivated (Gete and Hurni 2001). On the other hand, land cover types such as grasslands and shrublands land cover types are primarily used for grazing for livestock are very common in the eastern and southern low land regions. Besides, Ethiopia has significant forest cover, mainly in the different highland regions of the country (Bezuayehu and Sterk, 2008; Woldeamlak, 2002). These forests are vital for biodiversity and carbon storage. Similarly, urbanization is another emergingly observed land use system in Ethiopia. In addition, Ethiopia has several important wetlands and lakes, such as Lake Tana and other lakes found the main Ethiopian rift systems (Getaneh et al., 2022) and wetlands play a crucial role in water supply, biodiversity and local livelihoods.

The Ethiopian economy is mainly reliant on rain-fed agriculture and the sector provides raw materials for the national industrial sector. Nearly, based on World Bank estimation 77% of Ethiopians are farmers, primarily living in rural areas (World Bank, 2023)[5] and smallholder farmers produce over 90% of cultivated products and export earnings. However, the agricultural sector in Ethiopia is characterized by low production and productivity (MoARD, 2007) due to inappropriate land use, low technological input applications, harvesting lose and pest management techniques. Biophysical conditions such as soil types, climate and topography are also factors negatively affecting the productivity of agriculture in the country.

Over the years, forest degradation and deforestation has increased due to agricultural land use expansion, logging and urbanization that threatening biodiversity and contributing to soil erosion. Over 75% of the total land area in Ethiopia is considered prone to soil degradation (MoARD, 2007). Land degradation in the form of soil erosion, vegetation and forest degradation loss of biodiversity, hydrological degradation, land use alienation and climate change and variability are increasingly affecting crops and pasture, adding pressure on depleting forest resources that safeguard freshwater supplies (Gessesse et al., 2015; Bezuayehu and Sterk, 2008; Kebrom and Hedlund 2000).

Rapid urban growth, especially in cities like Addis Ababa and other major cities, is leading to increased forest land conversion for residential, commercial and industrial uses. Expansion of roads and infrastructure is altering forest land use patterns significantly in most parts of Ethiopia. The rapid growth of urban landscapes in Ethiopia changed much of the urban peripheral agricultural and forestlands. Ethiopia has experienced one of the fastest urbanization rates in Africa. Cities like Addis Ababa are expanding quickly due to unprecedented population pressure. Besides, as of recent estimates, about 20% of Ethiopia's population lives in urban areas and this figure is expected to rise (Teller et al, 2007) and the urban population is projected to continue growing, leading to increased demand for housing and services. This leads to the shrinking of the most fertile and even prime

[5] https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=ET

agricultural and forest land use types. On the other hand, the urban population places burden on the surrounding rural area for the supply of basic daily needs. This leads to excessive exploitation of the peri-urban land, which makes more susceptible to land degradation as well as pollution.

Land degradation and lack of full-scale sustainable land management practice implementation are negatively affecting food and water systems as well as enhancing water scarcity, food insecurity and poverty rates in the country. These problems in turn exacerbate land degradation and the loop continues unless sustainable land management measures are put in place.

While the impacts of land degradation evident and the competition for land is increasing, comprehensive and integrated land use planning remains to be a critical instrument for sustainable land management. The uses of appropriate agronomic management practices using modern technology including developing and implementing pertinent geospatial based integrated land use planning (ILUP) have a paramount importance to improve agricultural production and productivity in a sustainable way with minimum environmental impacts. It also requires transformational and technological revolution to manage site specific biophysical and agronomic management practices to enhance agricultural production and productivity.

Drawing on the insights of GIZ (2011) and Admasu and Jenberu (2020), the major challenges in implementing ILUP in Ethiopia can be categorized into policy and institutional framework challenges, technical and resource challenges and social and political challenges. Policy and institutional framework challenges such as absence of clear integrated land use policy as well as weak institutional capacity including a shortage of skilled personnel, limited technical expertise and weak organizational structures lead to and can hinder effective planning, implementation and monitoring of ILUP at both federal and regional levels. On the other hand, technical and resource challenges including limited technological capacity, insufficient financial resources and shortage of skilled professionals can impede the implementation of ILUP. Similarly, social and political challenges such as land tenure insecurity, lack of public participation and political interference in land use decisions can undermine the processes and outcomes of land use planning.

In recognition of the consequences associated with absence of a robust land use plan and the multidimensional benefits of integrated land-use planning, the Ministry of Planning and Development (MoPD), through the GEF-funded FOLUR Ethiopia initiative, is carrying out all the necessary preparations to establish integrated land use planning and management systems in Ethiopia. One of those preparatory actions is documenting the existing knowledge on level of institutional capacity and such intent has necessitated conducting a baseline capacity assessment.

### 1.2 Objectives

The overall objective of this baseline assessment was to generate knowledge on overall capacity of key stakeholder institutions on the status of integrated land use planning, thereby informing decisions relevant to capacity building and establishment of comprehensive land use planning and management systems at national, regional and local levels. The specific objectives of the assessment were to:

- assess the past and existing institutional set-up systems, human and technological capacities in the areas of geospatial based ILUP and
- assess the level of awareness and understanding of geospatial technologies and their applications in ILUP;

- evaluate the existence and effectiveness of current capacity building programs;
- Identifying specific geospatial based skill gaps and training requirements from policy, human power, technical and institutional systems perspectives;
- assess the availability and adequacy of geospatial infrastructure and technology;
- evaluating data accessibility, sharing practices, and data quality; and
- assess the enabling policy and institutional environment for geospatial-based ILUP.

Accordingly, the MoPD has partnered with the Ethiopian Space Science and Geospatial Institute (SSGI) to undertake the baseline study. The objectives of doing the baseline institutional capacity assessment, the methodology employed, the key findings, conclusions and recommendations are presented in the following sections.

# 2. Methods

### 2.1 Scope and target population of the survey

This report covers the geospatial-based ILUP capacity building need assessment survey at Federal Institutions level. The capacity survey focused on institutional systems capacities (consists of the availability and sufficiency of polices, guidelines and standard operating procedures), human capacity (addressing knowledge, skill and attitudes of employees required to effectively and efficiently perform defined sets of responsibilities) and technological systems capacities (focused on the availability, sufficiency, operation of technologies such as information communication, hardware, software and equipment supporting forest management, agricultural production and marketing).

Specifically, the survey focused on assessing the capacities related to land use-planning practices, institutional systems challenges for formulating and implementing geospatial based ILUP and the availability of required technologies for realizing LUP in the project sites. Finally, the findings of this assessment could provide valuable insights to dig out the existing institutional system capacity, human capacity and technological gaps and requirements necessary to support sustainable land use practices and effectively integrate these technologies into land use directive, guideline, land use policy and land use plan development.

## 2.1 Data sources

We collected primary data directly from participants through an online questionnaire survey, key-informant interview and observation check lists. On the other hand, the secondary data were gathered from existing reports, publications and other relevant sources. Primary and secondary datasets were collected and used to evaluate the current status of geospatial based ILUP capacity building program at different Federal organizations in Ethiopia. The data collection aimed to evaluate the current state of geospatial-based ILUP capacity building programs at Ethiopian Federal organizations. Specifically, data collected were used for assessing the level of knowledge about geospatial technologies, the effectiveness of these programs, geospatial based ILUP skill gaps, the availability of geospatial infrastructure, data accessibility and sharing practices and the policy and institutional environment for geospatial-based ILUP. Data collection was made at Federal level through gathering quantitative and qualitative data from both primary and secondary sources.

The Federal Organizations covered during the online based questionnaire survey were Ministry of Agriculture, Ministry of Water and Energy, Ministry of Planning and Development, Ministry of Transport and Logistics, Ministry of Urban and Construction, Ministry of Peace, Ethiopian Biodiversity Institute, Ethiopian Forest Institute and Ethiopian Environment Protection Authority. We purposively selected and collected data from these federal organizations because their mandates are in line with land related issues. In general, primary datasets were acquired from these Federal organizations' leaders, center directors, coordinators and experts. Social survey data collection tools such as questionnaire survey, key informant interview and observational checklists were used to derive background information of respondents about the status, challenges and opportunities of geospatial based ILIP formulation and implementation. Questionnaires were used as one of the primary data collections tools and initially, we aimed to survey 130 respondents from 13 Federal Organizations. However, we were able to administer questionnaires to 94 respondents from 10 institutions (Table 2.1).

Table 2. 1 Target group of respondents from the Federal Government Organizations.

| Sr. No. | Organization | Questionnaire | Key Informant Interview |
|---|---|---|---|
| 1 | Ministry of Agriculture, | 10 | 4 |
| 2 | Ministry of Planning and Development | 14 | 4 |
| 3 | Ministry of Transport and Logistics | 1 | 1 |
| 4 | Ministry of Urban and Construction, | 16 | 2 |
| 5 | Ministry of Peace, | 3 | 4 |
| 6 | Ethiopian Biodiversity Institute | 12 | 1 |
| 7 | Ethiopian Forest Development | 15 | 2 |
| 8 | Ethiopian Environment Protection Authority | 5 | 1 |
| 9 | Ethiopian Coffee and Tea Authority | 15 | 1 |
| 10 | Space Science and Geospatial Institute | 3 | 3 |
| | Total collected questionnaires | 94 | 23 |

**2.3 Data collection**

Both quantitative and qualitative data sets were collected from the above-mentioned sources. We used structured questionnaire to conduct quantitative data collection through the Kobo Toolbox (online platform) while key informant interviews for qualitative data collection. Four senior researchers from the Ethiopia Space Science and Geospatial Institute (SSGI) were involved in data collection through online questionnaires survey, in person key informant interviews and physical observational approaches using checklists. On the other hand, secondary data were collected from numerous documents including strategies, policies, office reports, research outputs, guidelines, published materials and statistical abstracts. The targeted group consulted during the questionnaire survey comprised of officials, department heads, experts, organization heads, professionals, agricultural and forestry experts. The selection criteria of respondents were mainly based on their involvement in planning and implementing of LUP sectors.

**2.3 Data analysis**

A mixed-methods approach was employed, combining quantitative and qualitative analysis techniques to analyze the data collected from different sources. Descriptive statistics such as calculating measures of central tendency and dispersion were used for numerical data analysis. Python libraries including geopandas were employed as data analysis tools. Besides, we used frequency analysis for determining the frequency of occurrence of different categories or responses and cross-tabulation for analyzing the relationship between two or more categorical variables. On the other hand, we used qualitative analysis including thematic and content analysis.

# 3. Assessment Results

## 3.1 Institutional systems capacity

### 3.1.1 Key stakeholders and their mandates

ILUP is a critical tool for sustainable development, particularly in resource-rich but vulnerable countries like Ethiopia. In this regard, Ethiopia has been trying to develop and implement ILUP. Various institutions at Federal level have been established and are working on the establishment of an ILUP framework. The key institutions involved include the MoA, EEPA, MoPD, MoUI and MoWE, each of them having their own roles regarding the development of ILUP framework. For example, the MoA plays a pivotal role in agricultural land use planning and management, the MoUI is responsible for urban and regional planning while the MoWE is responsible for water resource management in a sustainable way through basin-based plan. On the other hand, the EEPA is responsible for environmental conservation and sustainable land use practices. In this regard, various institutions at the Federal level have direct and indirect mandates for executing and implementing ILUP. However, the Key-informant interview result shows that there is a lack of clear mandate, institutional set up and structures challenges, mandate overlapping and conflict of interest among the key stakeholder Federal institutions.

According to Key-Informant Interview from MoP, “while our Ministry's primary focus may not be directly on ILUPs, we recognize the significant impact that clear and effective land use policies, strategies and guidelines can have on preventing and resolving mandate boundary conflicts. These conflicts often arise from ambiguity and inconsistency in land use regulations, leading to disputes between regions, zones and even districts. To address these challenges, a comprehensive review and revision of existing policies and guidelines is essential. By updating these frameworks to reflect current needs and priorities, we can create a more equitable and sustainable landscape, reducing the potential for conflict and promoting harmonious development.”

### 3.1.2 Legal and policy framework for ILUP in Ethiopia

Ethiopia has been trying to establish a legal and policy framework for integrated land use planning during the past couples of decades. The legal and policy framework for integrated land use planning in country is a complex interplay of Federal and regional laws, policies, and regulations. While the Federal Democratic Republic of Ethiopia Constitution provides a framework for land administration and use, specific provisions for integrated land use planning are still under development.

Land administration in rural areas is governed by a combination of national and regional-level policies and regulations. At the national level, the Rural Land Administration Declaration provides the overarching framework for land governance. However, regions have the authority to enact their own specific regulations, which can vary significantly in terms of content and enforcement mechanisms. Additionally, national-level policies, such as the Agriculture and Rural Development Policy and the ‘Land Use Plan Manual’, provide broader guidance on land use planning and management. To ensure a more integrated and coordinated approach to LUP, participatory processes are employed at various levels, involving stakeholders from communities, local governments and relevant government agencies. Nevertheless, the existing land use proclamation frameworks lack a holistic approach, and a clear, nationally approved land use policy is still absent.

The Federal Land Use Proclamation, enacted in 2007, establishes the general principles for land use and administration, but lacks detailed provisions for exercising and implementing integrated land use planning. In addition, legal and policy framework that guide land use practices in Ethiopia includes Federal Land Use Proclamation, Regional Land Use Plans, Sectoral Policies and Strategies, National Growth and Transformation Plan (NGTP) and Climate Resilient Green Economy Strategies (CRGE) as well as Ethiopia's 10-year development plan (2021-2030), known as "Ethiopia 2030: The pathway to Prosperity.

The Federal Land Use Proclamation provides the overarching legal framework for land administration and use in Ethiopia. It outlines principles for sustainable land use including the need for integrated planning. However, it primarily focused on land tenure and administration rather than specific land use planning guidelines. On the other hand, Regional Land Use Plans **r**ecognizing the diverse ecological and socio-economic conditions across the country, regional governments have the authority to develop their own land use plans. These plans often incorporate specific land use zoning, conservation areas and development guidelines. Besides, various sectoral policies related to agriculture, forestry, and urban development highly influences land use decisions. While these policies provide guidance for specific sectors, their integration into a comprehensive land use planning framework are challenging. In addition, NGTP sets out strategic objectives for Ethiopia's economic and social development. It includes provisions for sustainable land use practices and resource management. Similarly, CRGE emphasizes the importance of sustainable land use practices for mitigating climate change and promoting green economic growth. It outlines specific actions for land use planning and management to address climate challenges.

While efforts are underway to develop national land use and management policies, the current reliance on participatory processes at different levels presents challenges in ensuring consistency and coordination, and in terms of implementation and enforcement. As such, several challenges hinder the effective implementation of integrated land use planning in Ethiopia which includes:

**(i)** **Lack of clear guidelines:** while the Federal Land Use Proclamation provides a foundation, more specific guidelines and standards are required for integrated land use planning, particularly at the regional and local levels.

**(ii)** **Weak institutional coordination:** Effective coordination among different government agencies involved in land use planning is important. However, institutional silos and overlapping mandates hinders integrated approaches.

**(iii)** **Limited Technical Capacity:** reliable and up-to-date data on land use, soil quality, water resources and other relevant factors is essential for informed decision-making. However, data gaps and inconsistencies remain challenging.

Therefore, despite the availability of land use policies, guidelines and proclamation at Federal and regional levels, significant implementation gaps persist. A lack of coordination and integration among different sectors, each with their own fragmented directives, regulations, and policies, has hindered the development and implementation of comprehensive land use plans. The absence of clear and authorized mandates governing integrated land use planning at the national level has further limited the ability to enforce and implement these plans. Institutional barriers and a lack of collaboration among relevant agencies have exacerbated these challenges, making it difficult to achieve a coordinated and effective approach to land use management.

Despite the development of a Land Use Policy and its submission to the Prime Minister's Office in 2012, it remains unratified. This lack of clear national direction, coupled with limited financial support and institutional commitment, further exacerbates the challenges. The absence of a ratified national land use policy creates a vacuum, hindering the development of a coherent and integrated approach to land use planning and management. Without a clear policy framework, it becomes difficult to establish priorities, allocate resources, and coordinate efforts among different stakeholders. Moreover, the lack of financial support limits the ability to invest in essential infrastructure, technology, and human capacity building. This, in turn, hinders the implementation of effective land use planning and monitoring systems. Additionally, the lack of institutional commitment and political will can lead to delays, bureaucratic hurdles, and a lack of ownership, further hindering the progress of ILUP implementation.

For example, according to a key-informant interview from the Ministry of Peace, the absence of a comprehensive ILUP is a significant factor contributing to border conflicts. While ILUPs have the potential to mitigate such disputes, existing plans often fall short in providing the necessary clarity, consistency and coordination. This lack of a unified framework can lead to overlapping claims, ambiguous boundaries, and conflicting land use practices, exacerbating tensions and hindering sustainable development. A well-crafted ILUP can help address these issues by establishing clear land use designations, resolving boundary disputes and promoting equitable access to resources. However, the effectiveness of ILUPs depends on their implementation and enforcement, which often face challenges due to institutional capacity, political will, and social factors.

Therefore, the study result recognizes the need for a more comprehensive and integrated approach to land use planning like National Integrated Land Use Policy, which provide a clear framework for integrated land use planning, promote sustainable land use practices, and ensure equitable access to land resources. The development of this policy is a significant step towards strengthening the legal and policy framework for ILUP in Ethiopia.

### 3.1.3 Capacity assessment for ILUP legal frameworks and standard operational procedures

The questioner analysis results suggest that while a significant portion of respondents (38%) perceive the institution's capacity to set legal frameworks and standard operational procedures (SOPs) for ILUP management as moderate, a substantial number (47%) believe it to be limited or optimal. This indicates a clear need for improvement in this area (Figure 3.1).

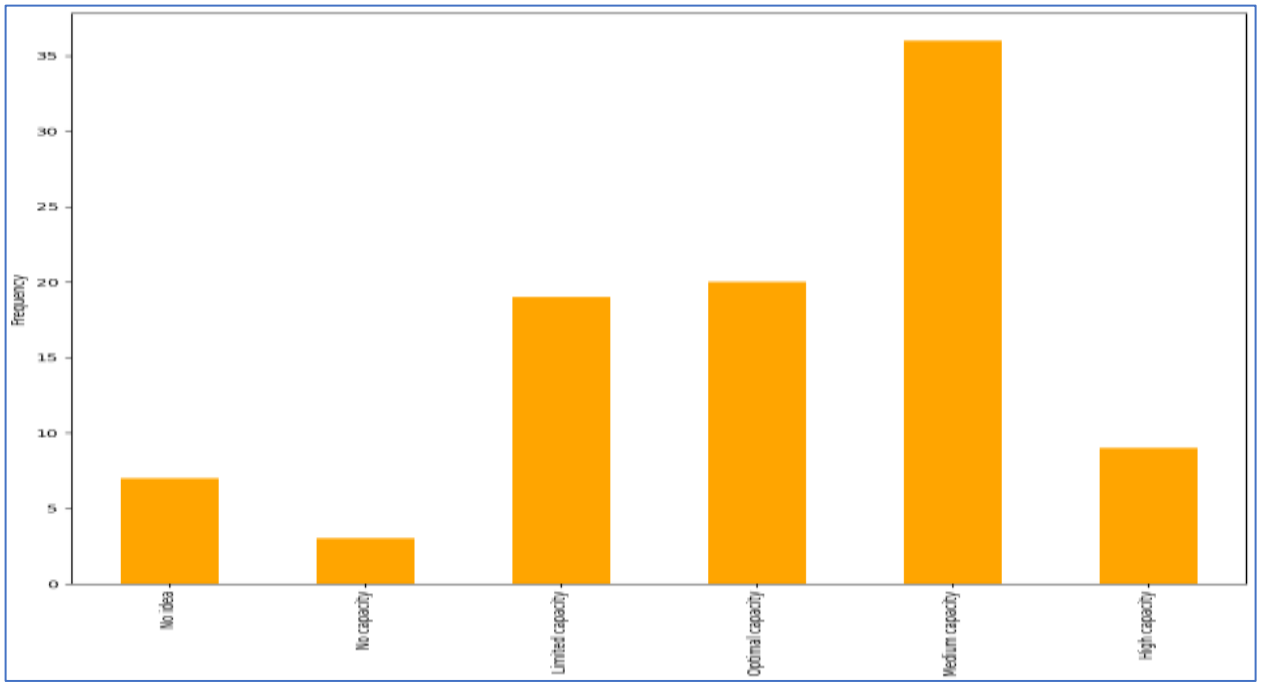


Figure 3. 1: The institutions' current capacity in legal frameworks and standard operating procedures for ILUP and management.

Accordingly, to enhance the institutions capacity in this domain, they can significantly improve their capacity to set robust legal frameworks and SOPs for ILUP management, ultimately enhancing the overall quality and effectiveness of its ILUP programs.

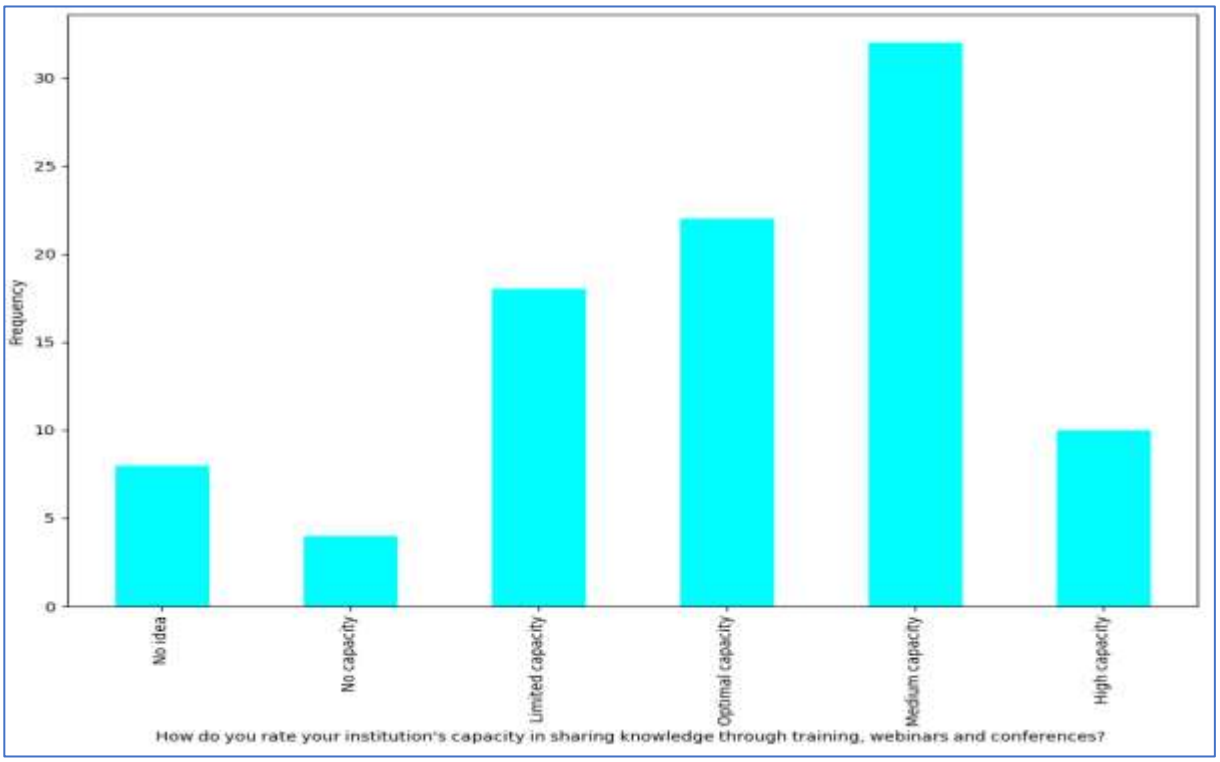
### 3.1.4 Knowledge sharing capacity assessment

The interview response result shows a mixed picture of the institution's capacity for knowledge sharing through training, webinars and conferences. While a significant portion (34%) perceives the capacity as moderate, a substantial number (45%) believe it to be limited, optimal, or non-existent (Figure 3.2). This indicates a need for improvement in the institution's knowledge-sharing practices. A closer look at the data reveals that a significant proportion of respondents (45%) believe the institution's capacity for knowledge sharing is either limited, optimal, or non-existent. Lack of a clear knowledge-sharing strategy, insufficient resources and resistance to change are some of the factors contribute to this limited knowledge sharing mechanisms through various outlets. However, some institutions are still struggling to effectively disseminate knowledge and expertise among its staff and stakeholders.

Strengthening knowledge management systems, enhancing training and development programs, promoting a culture of information, skill and knowledge sharing and improving communication skills are some of the strategies that could be implemented to address these challenges and enhance the institution's capacity in knowledge sharing. Therefore, by implementing these strategies, the organizations can significantly improve their capacity to share knowledge through training, webinars and conferences, ultimately enhancing its overall performance and impact. In addition, the study result recognizes the need for a more comprehensive and integrated approach to LUP with National Integrated Land Use Policy, which provide a clear framework for ILUP, promote sustainable land use practices and ensure equitable access to land resources. The development of this policy would be considered as a significant step towards strengthening the legal and policy framework for integrated land use planning in Ethiopia.

Figure 3. 2: Frequency of respondents to rate institutions' capacity in sharing knowledge through training, webinars and conferences

### 3.2 Human capacity




Ethiopia possesses a pool of skilled professionals in various fields relevant to land use planning, which includes urban planner, agricultural engineers, environmental scientists, geospatial experts, foresters, and water resources engineers. However, challenges remain regarding capacity building, data availability and accessibility, and technological infrastructure. While there are institutions providing training and capacity building, a consistent and comprehensive approach is required to address the diverse needs of professionals at different levels.

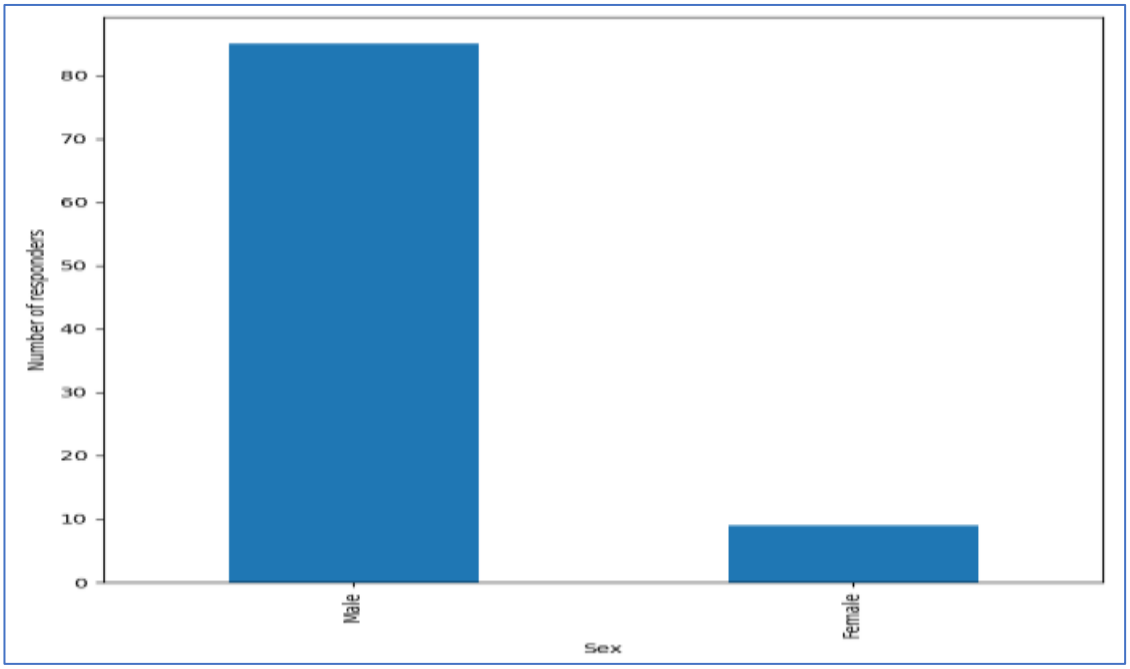
#### 3.2 1 Respondents demographic and academic background characteristics

A survey of 94 respondents from 10 Ethiopian Federal Institutions were collected and assessed the human capacity status for implementing geospatial based ILUP in the country.

**Gender and age:** The majority of respondents were male (85%) and over 30 years old (Figure 3.3). This suggests a potential gender gap in land use planning expertise and a need for targeted efforts to engage and empower women in this field. Additionally, the age distribution indicates a significant pool of experienced professionals who can contribute their knowledge to ILUP initiatives.

Figure 3. 3: Demographic characteristics of the respondents

**Respondents' academic qualifications relevant to ILUP:** A smaller proportion of respondents, less than




15% (14 of the 94 respondents), were experts in land use and related fields (Figure 3.4). The majority held MSc (50) or BSc (26) degrees (Figure 3.5), indicating a solid foundation in relevant academic disciplines. However, the relatively low number of experts suggests a need for further capacity building and knowledge enhancement in this area. Additionally, a smaller number of respondents held MA, PhD, or BA degrees, showcasing a diverse range of educational backgrounds and potential areas of expertise that could be useful for implementing geospatial based ILUP program in the future.

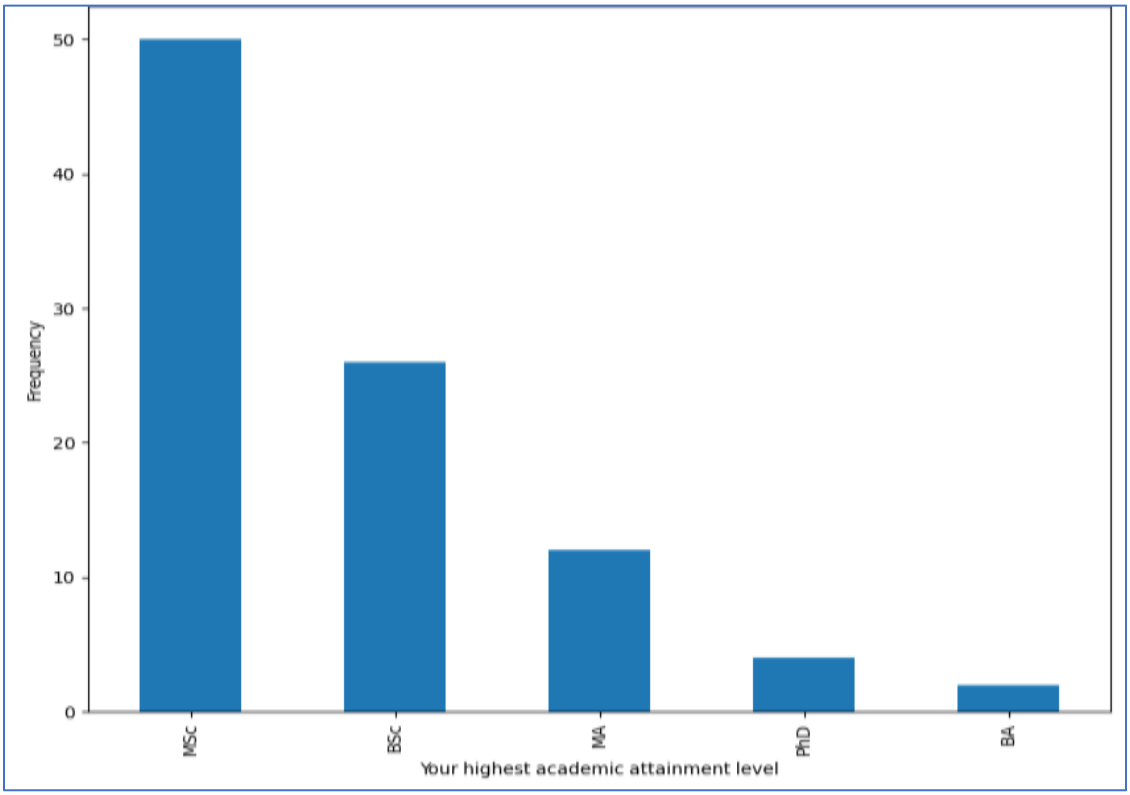



*Figure 3. 4: Highest academic level attained by the respondents*

The result also showed that no institution had more than four employees qualified in ILUP (Figure 4). This limited capacity highlights the need for strategic investments in human resource development and capacity building initiatives to strengthen the institutional capability for ILUP. By investing in training programs, workshops, and mentorship opportunities, institutions can develop a skilled workforce capable of effectively addressing the complexities of land use planning.

This result is consistent with the key-informant interview results. For example, according to a key-informant interview to the Ministry of Agriculture, Ethiopia's land use planning and administration sector is severely understaffed, with only 30 individuals currently employed in this critical field. Moreover, the majority of these individuals lack the necessary expertise in modern land use planning techniques. This shortage is particularly acute at the regional level, where the demand for skilled professionals far exceeds the available supply.

A 2015 study underscored the urgent need to address this human capacity gap, highlighting the significant shortfall in both the number and quality of skilled professionals required for effective land use planning. While efforts have been made to improve the quality of ILUP training through collaborations with universities and the implementation of short-term and long-term training programs, structural challenges persist, hindering the development of a skilled workforce capable of meeting the complex challenges of land use planning and management. These challenges include inadequate compensation packages, limited career advancement opportunities, and a lack of supportive institutional frameworks. As a result, many qualified professionals are opting for alternative career paths, further exacerbating the human capacity crisis in the sector. Skilled manpower scarcity is also the main challenges in the Ministry of Urban Infrastructure and Development where trained and

skilled expertise are leaving the institution when they feel they are developed the necessary skilled in their fields of studies. This could be due to low salary and absence of incentives.

Similarly, according to a key-informant interview from the Ministry of Peace, “the MoP faces significant challenges in addressing land use planning, which is key driving factors for conflict in the country, due to a critical shortage of trained human resources. We lack qualified ILUP experts, particularly those skilled in GIS and geographic analysis. While our staff primarily consists of Peace and Security Experts, their expertise does not directly align with the technical requirements of ILUP implementation and conflict mapping. This lack of specialized knowledge hinders our ability to effectively analyze land use patterns, identify potential conflicts, and develop evidence-based solutions. As a result, we are unable to fully leverage the potential of ILUP to address land-related challenges and promote sustainable development. Land-related disputes are a major driver of conflict in our country. To effectively address these issues, we require a skilled workforce with expertise in Integrated Land Use Planning (ILUP) to interpret geospatial data and identify potential conflict zones. Additionally, developing clear and effective land use policies, guidelines, and strategies is crucial. By improving the accessibility and utilization of geospatial technologies, we can enhance land use planning and decision-making, ultimately contributing to conflict prevention and resolution”.

**Work experience:** Regarding relevant work experience, fourteen respondents had over 17 years of experience, while others ranged from 5 to 33 years (Figure 3.5). This indicates a wide range of experience levels, from seasoned professionals to early-career individuals. The presence of both experienced and less experienced individuals can be beneficial for knowledge sharing and capacity building within the institutions. However, it is important to ensure that there is a sufficient number of experienced professionals to guide and mentor the younger staff members.

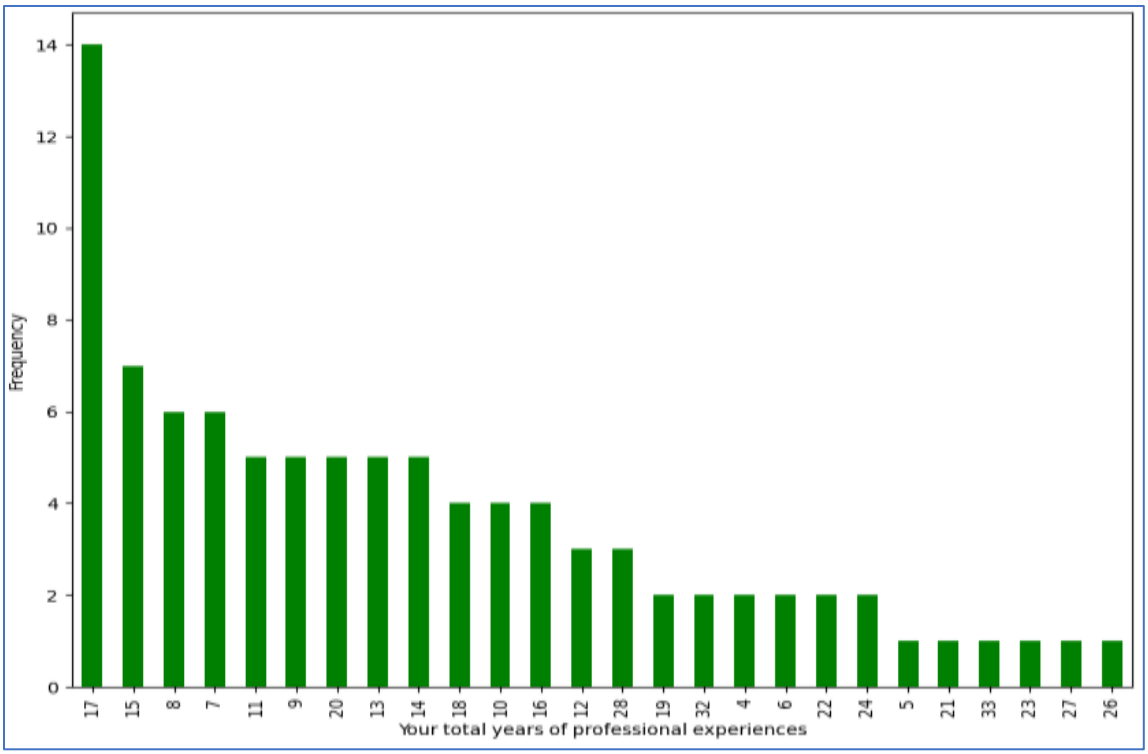



*Figure 3. 5:* Total years of professional experiences gained by the respondents

### 3.2.2 Respondents level of knowledge and skills in geospatial based ILUP, tools and techniques

The questionnaire-based survey also assessed respondents' knowledge considering 14 key geospatial technology and data processing themes relevant to ILUP, including GIS, remote sensing, conflict management and various software tools such as ArcGIS, QGIS and Python (Table 3.1 and Figure 7a). The level of knowledge was assessed considering six categorical parameters including *No Understanding (0), Below average (1), Fair (2), Good (3), Very good (4) and Excellent (5).* We operationally defined these six parameters of level of knowledge as follows. *No Understanding (0) means c*ompletely unfamiliar with geospatial based ILUP application and *Below average* (1) refers to having limited knowledge and understanding on geospatial based ILUP application. Conversely, *Fair (2) and Good (3)* parameters are characterized by a basic comprehension of the subject matter and the ability to apply knowledge to novel situations to carry out basic mapping tasks with minimal assistance, respectively. However, the *Very Good (4)* category denotes having a thorough understanding of the application of geospatial techniques on ILUP subject and being able to complete intermediate packages of mapping and statistical technologies without outside assistance, whereas the *Excellent (5)* category considers advanced professional knowledge and skills, mastery of the subject matter, the ability to create training materials, and the ability to provide precise and thorough explanations in response to questions.

Table 3. 1: Respondent's level of knowledge in Geospatial based ILUP, tools, and Techniques.

| | Respondents level of knowledge in Geospatial technologies and data processing tools for ILUP | | | | | | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No understanding | | Below average | | Fair | | Good | | Very good | | Excellent | | | |
| Selected Geospatial Technologies | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % |
| Fundamentals of GIS & RS | 5 | 5.32 | 23 | 24.47 | 17 | 18.09 | 21 | 22.34 | 14 | 14.89 | 14 | 14.89 | 94 | 100 |
| Advanced GIS & RS | 10 | 10.64 | 28 | 29.79 | 13 | 13.83 | 19 | 20.21 | 11 | 11.7 | 13 | 5.32 | 94 | 100 |
| Conflict management in ILUP | 16 | 17.02 | 20 | 21.28 | 22 | 23.4 | 20 | 21.28 | 11 | 11.7 | 5 | 13.83 | 94 | 100 |
| ArcGIS | 13 | 13.83 | 23 | 24.47 | 19 | 20.21 | 14 | 14.89 | 12 | 12.77 | 13 | 3.19 | 94 | 100 |
| QGIS | 13 | 13.83 | 29 | 30.85 | 15 | 15.96 | 16 | 17.02 | 18 | 19.15 | 3 | 13.83 | 94 | 100 |
| Google Earth Engine | 13 | 13.83 | 29 | 30.85 | 17 | 18.09 | 17 | 18.09 | 9 | 9.57 | 9 | 9.57 | 94 | 100 |
| ArcGIS Pro (online) | 20 | 21.28 | 30 | 31.91 | 17 | 18.09 | 13 | 13.83 | 6 | 6.38 | 8 | 8.51 | 94 | 100 |
| ERDAS Imagine | 23 | 24.47 | 31 | 32.98 | 13 | 13.83 | 12 | 12.77 | 7 | 7.45 | 8 | 8.51 | 94 | 100 |
| R-programming | 30 | 31.91 | 23 | 24.47 | 12 | 12.77 | 17 | 18.09 | 9 | 9.57 | 3 | 3.19 | 94 | 100 |
| Python | 42 | 44.68 | 23 | 24.47 | 14 | 14.89 | 5 | 5.32 | 6 | 6.38 | 4 | 4.26 | 94 | 100 |
| ENVI | 44 | 46.81 | 23 | 24.47 | 12 | 12.77 | 4 | 4.26 | 2 | 2.13 | 9 | 9.57 | 94 | 100 |
| Global Mapper | 35 | 37.23 | 27 | 28.72 | 16 | 17.02 | 5 | 5.32 | 2 | 2.13 | 9 | 9.57 | 94 | 100 |
| Machine Learning | 43 | 45.74 | 23 | 24.47 | 12 | 12.77 | 8 | 8.51 | 7 | 7.45 | 1 | 1.06 | 94 | 100 |
| GPS | 7 | 7.45 | 20 | 21.28 | 19 | 20.21 | 22 | 23.4 | 15 | 15.96 | 11 | 11.7 | 94 | 100 |
| Mean Average | | 23.86 | | 26.75 | | 16.57 | | 14.67 | | 9.80 | | 8.36 | | |

As clearly indicated with Table 3.1 and Figure 7a, the mean percentage values of respondents indicated that a significant number of defendants responded like they have "no understanding"(23.86%), "below average" (26.75%) or "fair" (16.57%) level of knowledge in the areas of GIS, remote sensing, programming and machine learning tools and techniques to realize geospatial based ILUP. On the other hand, 32.83% of the respondent's response fall under the categories of "Good" and above level of knowledge and skill categories in terms of geospatial technologies and data processing tools to integrate them with ILUP. This suggests that majority of respondents reported "no understanding" or "below average" knowledge of geospatial-based ILUP-related tools and procedures to apply them in Ethiopia at Federal level. Thus, this shows that there is a considerable lack of technical expertise needed for efficient Geospatial based ILUP in the country.

To address this gap, targeted capacity-building initiatives are required to equip professionals with the necessary skills to effectively utilize these tools and techniques. This could involve training programs,

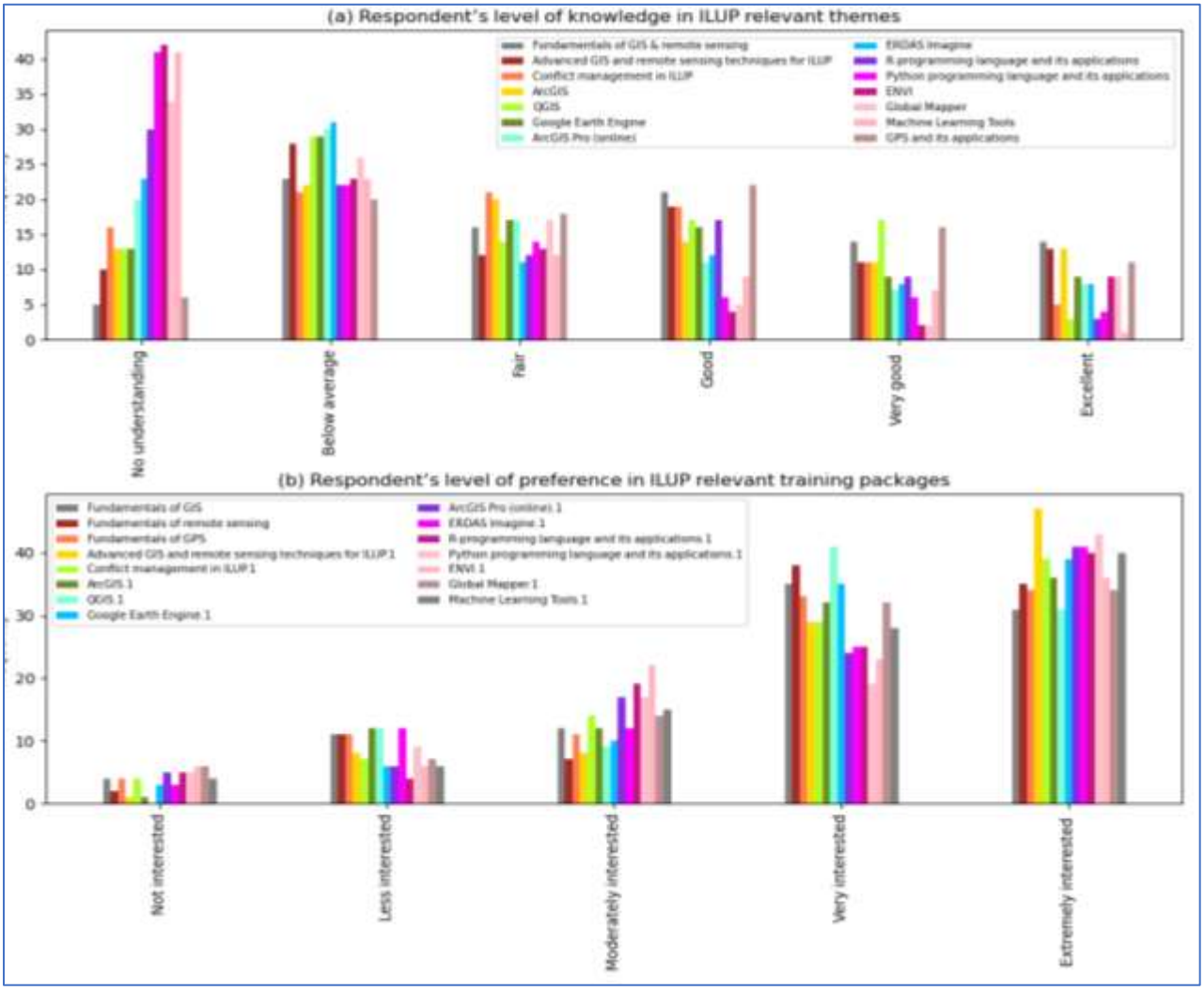
workshops and online courses that focus on both foundational and advanced topics. Additionally, fostering collaboration between institutions and experts can help to share knowledge and best practices, promoting a more robust and informed approach to land use planning.

The lack of knowledge in Python and R programming languages is also particularly concern for respondents. These tools are essential for advanced spatial data analyses, data processing and modeling, which are crucial for informed decision-making in land use planning. To address this specific weakness, targeted training programs and workshops should be developed to focus on these tools and their applications in the context of ILUP. Additionally, online resources and tutorials can be made available to provide self-paced learning opportunities for professionals who may not have access to formal training programs.

Similarly, the rapidly evolving field of GIS and remote sensing requires continuous learning and adaptation. To stay up-to-date with the latest advancements and best practices, professionals in the field should actively seek out opportunities for professional development. This could involve attending conferences, workshops, and webinars, as well as participating in online forums and communities of practice. Additionally, institutions can encourage a culture of learning and innovation by providing resources and support for staff to attend training programs and conferences.

By addressing these knowledge gaps and fostering a culture of continuous learning, institutions can enhance their capacity to effectively utilize GIS, remote sensing, and other relevant tools and techniques in support of ILUP. This will ultimately lead to more informed and sustainable land use planning decisions.

Figure 3. 6: Respondent's level of knowledge and preferences in ILUP relevant training packages




Finally, the lack of knowledge in Python, R, and Global Mapper programming languages is particularly concerning (Figure 3.6a) and Table 3.2). These tools are essential for advanced spatial analysis, data processing, and modeling, which are crucial for informed decision-making in land use planning. To address these knowledge gaps, targeted capacity-building initiatives are required to equip professionals with the necessary skills to effectively utilize these tools and techniques. This could involve training programs, workshops, and online courses that focus on both foundational and advanced topics. Additionally, fostering collaboration between institutions and experts can help to share knowledge and best practices, promoting a more robust and informed approach to land use planning.

### 3.2.3 Respondents level of preference on relevant training packages

Based on analysis of respondents on level of preferences in ILUP relevant training packages, fourteen relevant training package that includes Fundamentals of GIS, Fundamentals of GPS, Remote sensing, Advanced GIS and remote sensing techniques for ILUP, Conflict management in ILUP, ArcGIS, QGIS, Google Earth Engine, ArcGIS Pro (online), ERDAS Imagine, R-programming language and its applications, Python programming language and its applications, ENVI, Global Mapper and Machine Learning Tools are given to evaluate whether the respondents are interested or not (Figure 3.6b) and Table 3.2).

Table 3. 2 Respondents' level of preference in ILUP relevant training packages.

| # | Domain | Respondents' level of preference | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 1 | Fundamentals of GIS & remote sensing | - | - | - | 35 | |
| 2 | Advanced GIS and remote sensing for ILUP | - | - | - | 37 | |
| 3 | ArcGIS | - | - | - | | 34 |
| 4 | QGIS | - | - | - | | 37 |
| 5 | Google Earth Engine | - | - | - | 42 | |
| 6 | ArcGIS Pro (online) | - | - | - | 41 | |
| 7 | ERDAS Imagine | - | - | - | 42 | |
| 8 | R-programming | - | - | - | | 40 |
| 9 | Python programming | - | - | - | | 41 |
| 10 | ENVI | - | - | - | | 36 |
| 11 | Global Mapper | - | - | - | 34 | |
| 12 | Machine Learning Tools | - | - | - | | 40 |
| 13 | GPS and its applications | - | - | - | | |

NB: 1= No Not interested, 2= Less interested, 3= Moderately interested (3): 4= Very interested and 5= Extremely interested

Most of the respondents are extremely interested in almost all of the relevant packages proposed. Accordingly, 48 respondents are extremely interested in Advanced GIS and remote sensing techniques for ILUP, 43 respondents are extremely interested in the training of Python-programming language and its applications, 42 respondents each extremely interested in ArcGIS Pro, QGIS and ERDAS for GIS and remote sensing data analysis and interpretation, 41 respondents are extremely interested in Google Earth Engine and 40 respondents each are Extremely interested in R-programming language and its applications and Machine Learning tools. This shows that most of the respondents recognized the importance of training in Advanced GIS using ArcGIS Pro and QGIS packages and remote sensing techniques with ERDAS Imagine software, Python programming, and Google Earth Engine using machine learning tools to enhance their competence in ILUP and Management systems.

The high level of interest in the proposed training packages is a strong indicator of the need for advanced skills in GIS, remote sensing and programming for effective ILUP. To start with, the overwhelming interest in Advanced GIS and Remote Sensing techniques for ILUP highlights the need for specialized training to address complex land use planning challenges. Besides, GIS and remote sensing software proficiency including ArcGIS Pro, QGIS, ERDAS and Google Earth Engine suggests a desire to master industry-standard GIS software for spatial analysis and visualization. In general, the findings of the need assessment survey indicated that experts have strong demand and interest to

enhance their skills in the areas of Advanced GIS (with ArcGIS Pro, QGIS software packages), Remote Sensing (ERDAS Imagine Software package), Python and R Programming and Machine Learning (Google Earth Engine cloud computing) Tools. Therefore, based on the survey results, the following training packages are prioritizing:

1. Advanced GIS (with ArcGIS Pro and QGIS Software) and Remote Sensing (with ERDAS Imagine Software and Google Earth Engine) Techniques for ILUP: This should be a core training packages that cover topics like image classification, object-based image analysis, change detection, and spatial modeling.
2. Python Programming and its applications in GIS and Remote Sensing: This package should focus on data analysis, visualization, and automation using libraries like NumPy, Pandas, Matplotlib, and GeoPandas.
3. R Programming and Its Applications in GIS and Remote Sensing: This package should cover statistical analysis, spatial modeling, and machine learning using R packages like raster, sf, and caret, and
4. Machine Learning for ILUP: This package should introduce concepts like supervised and unsupervised learning, deep learning, and their applications in land use classification, prediction, and scenario analysis.

Hence, by addressing the training needs identified in the survey, the institution can empower individuals to tackle complex ILUP challenges and contribute to sustainable land use planning and management.

### 3.2.4 Organizations capacity building plan

To assess the institutions' human capacity plan for enhancing human knowledge in ILUP implementation, monitoring and learning, respondents were asked about their existing plans. The responses revealed a range of capacities, from very limited to optimal level planning strategy. A significant proportion of respondents (30 out of 94) indicated that their institutions have very limited capacity for enhancing human knowledge in ILUP (Figure 8). This suggests a need for substantial investments in capacity building initiatives to address knowledge and skill gaps.

Approximately 28 respondents assessed their institutions' capacity as medium (Figure 3.7). While this indicates a moderate level of capacity, it also highlights the need for continued efforts to improve knowledge and skills, particularly in areas where gaps exist, such as advanced data analysis techniques and strategic planning while a smaller number of respondents (18) reported optimal capacity (Figure 8). These institutions may be well-positioned to lead and support ILUP initiatives, but ongoing efforts are still necessary to maintain and enhance their capacity, especially in light of emerging trends and technological advancements in the field of land use planning. Meanwhile, a small number of respondents indicated that their institutions have no capacity or no idea about their capacity for human knowledge enhancement. This underscores the importance of conducting thorough assessments to identify capacity gaps and develop targeted strategies to address them.

To address the identified capacity gaps and enhance the implementation, monitoring, and learning of ILUP, the following recommendations are proposed: develop and implement tailored training programs and workshops to address specific knowledge and skill gaps; establish mentorship and coaching programs to facilitate knowledge transfer and skill development among staff; foster collaboration between institutions and experts to promote knowledge sharing and best practices; invest in modern

technology and software tools to support data analysis, modeling, and decision-making; develop long-term human resource development plans to ensure a sustainable pipeline of skilled professionals; regularly monitor and evaluate the effectiveness of capacity building initiatives to identify areas for improvement. By addressing these recommendations, institutions can strengthen their human capacity, enhance their ability to implement ILUP effectively, and contribute to sustainable land use planning and management.

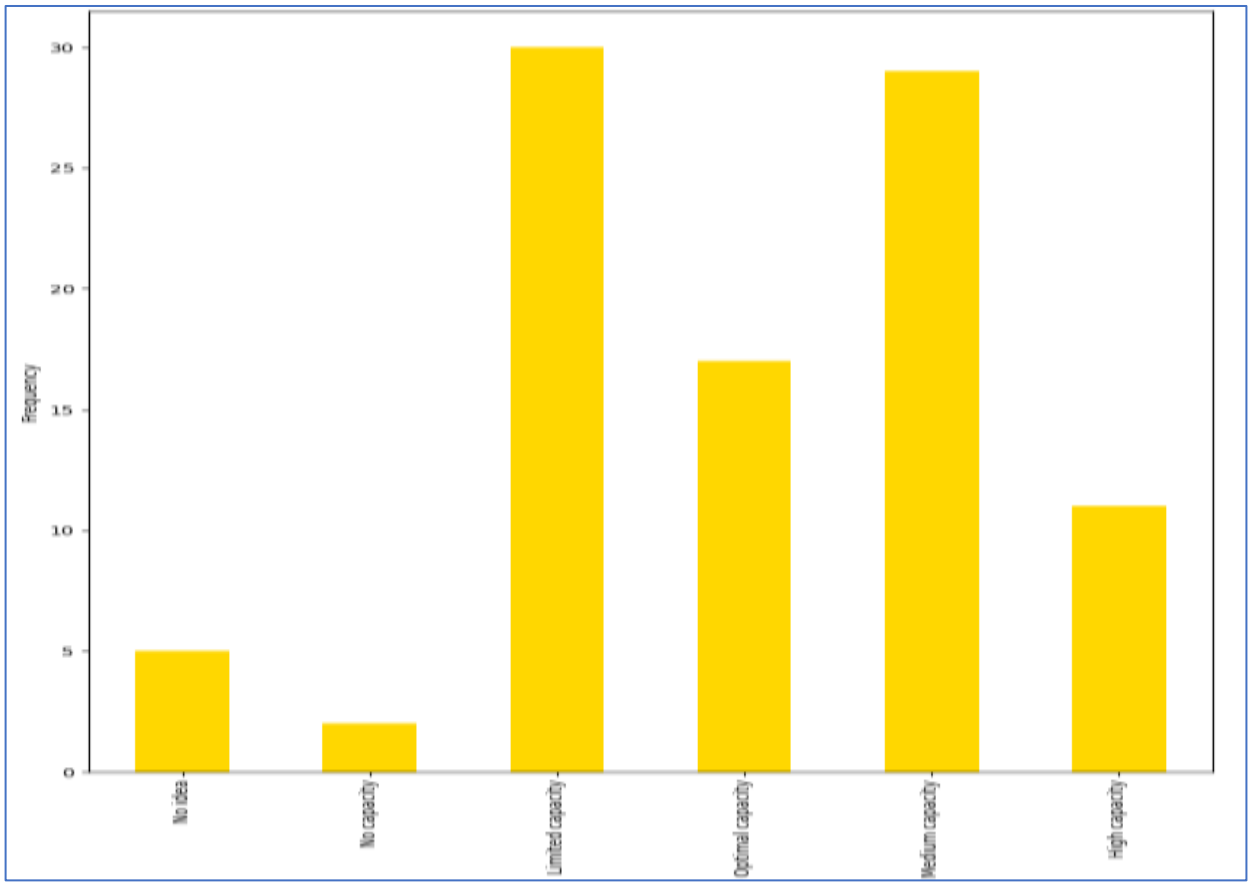



Figure 3. 7: Respondents' answers to institutions' human knowledge enhancement plan to improve ILUP, implementation, monitoring and learning

### 3.3 Technological capacity

The study evaluated Ethiopian federal institutions' technological capacity in ILUP using checklists to assess their availability of essential geospatial tools and resources. This included hardware such as computers, servers, and storage devices, data recording instruments like GPS receivers and drones, software like GIS and statistical analysis, and knowledge products like geospatial databases and maps for decision-making in ILUP. These resources are crucial for effective ILUP implementation, as they enable the collection, analysis, and dissemination of accurate and up-to-date geospatial information. Accordingly, the assessment results, visualized in Tables 3 to 6 with blue indicating 'yes' and red indicating 'no,' revealed a predominance of red cells. This suggests that these institutions are in the early stages of developing the technological capabilities and resource base necessary for effective ILUP implementation. Key informant interviews corroborated these findings.

According to one Federal Institution's key-informant interview response, the institute's infrastructure limitations hinder the adoption of modern technologies, restricting access to essential tools like software, land parcels, and satellite imagery. This prevents real-time land use monitoring and hampers effective ILUP implementation. For example, the lack of reliable and up-to-date geospatial data makes it difficult to accurately assess land use patterns, identify potential conflicts, and monitor changes over time. Additionally, the absence of advanced GIS software limits our ability to perform complex spatial analyses and generate high-quality maps and visualizations.

The prevalence of red cells in the Tables 3 to 6 highlights the need for significant investments in technology and capacity building to strengthen the technological foundation of these institutions. This includes acquiring and maintaining state-of-the-art hardware and software, training staff in geospatial technologies, and developing robust data management systems. Therefore, by addressing these technological gaps, Ethiopian federal institutions can enhance their ability to collect, analyze, and utilize geospatial data to support informed decision-making in ILUP and other related initiatives.

### 3.3.1 Availability of hardware for geospatial data storage, processing and access

A checklist was used to evaluate the availability of essential hardware for geospatial data storage, processing, and access in federal institutions involved in ILUP, including high-performance desktop computers, laptop computers, plotters, scanners, workstations, data servers, and cloud computing and web-based mapping solutions for land use information accessibility. The assessment revealed that cloud computing and web-based mapping solutions were largely unavailable across most institutions. Additionally, the Ministry of Transport and Logistics was found to lack any hardware relevant to ILUP. As shown in Table 3.3, only a limited number of the listed hardware items are available in the remaining federal institutions.

Table 3. 3: Assessment of Hardware Capacity for Geospatial Data Management in Ethiopian Federal Institutions.

| | Hardware Availability Observational Report from each Organization | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Items | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 |
| High Performance Desktop PC | No | Yes | No | No | No | No | No | No | No | No |
| High-Performance Laptop PC | Yes | Yes | No | No | Yes | No | No | Yes | Yes | Yes |
| High-Capacity Plotter | Yes | Yes | No | No | No | No | No | No | No | No |
| High-Capacity Scanner | Yes | Yes | No | No | No | No | No | No | No | No |
| Workstations | Yes | No | Yes | No | No | No | No | Yes | Yes | Yes |
| Data Server for geospatial and land use data storage | Yes | No | Yes | No | Yes | No | No | No | No | No |
| Cloud computing and web-based mapping solutions for land use information accessibility | No | No | No | No | No | No | No | No | No | No |

NB: 01= Ministry of Urban and Infrastructure, 02= Ministry of Agriculture, 03= Ethiopian Tea and Coffee Authority,04= Ministry of Transport and logistics,05= Ethiopian Forestry Development, 06= Ministry of Peace, 07= Ministry of Plan and Development and 08= Biodiversity Institute, 09= Ministry of Water and energy, 10= Ethiopian Environment Protection Authority

### 3.3.2 Availability of geospatial data acquisition instruments

Similar to this, a checklist was used to determine whether the following items were present in order to evaluate the availability of geospatial data recording equipment: GPS units, smartphones, tablets, drones, groundwater detectors, augmented reality devices, and tents. According to the assessment, only a small number of organizations, mostly the Ministry of Urban and Infrastructure Development, own and make use of some of these tools, including drones, cellphones, tablets, and GPS units (Table 3.4). The data logging capabilities required for successful ILUP adoption are absent from other universities. All federal entities participating in ILUP must immediately focus on and invest in acquiring and implementing the necessary instruments in order to close this substantial gap in data collection capabilities

Table 3. 4: Assessment of Data Collection Tools and Equipment in Ethiopian Federal Institutions

| | Target Organizations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Items | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 |
| GPS | Yes | No | No | No | Yes | No | No | Yes | No | Yes |
| Smart phones | Yes | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes |
| Tablets | Yes | No | No | No | Yes | No | No | Yes | No | Yes |
| Drones | Yes | No | No | No | No | No | No | No | No | No |
| Ground water detector | No | No | No | No | No | No | No | No | Yes | No |
| Auger | No | No | No | No | No | No | No | No | No | No |
| Tent | No | No | No | No | No | No | No | No | No | No |

NB: 01= Ministry of Urban and Infrastructure,02= Ministry of Agriculture,03= Tea & Coffee Authority,04= Ministry of Transport and logistics,05= Forestry Development,06= Ministry of Peace,07= Ministry of Plan & Dev't and 08= Biodiversity Institute, 09= Ministry of Water and energy, 10= Environment Protection Authority

#### 3.3.3 Availability of software for geospatial data processing and statistical analysis

To evaluate the availability of software for geospatial data processing, statistical analysis and presentation, a checklist was utilized to assess the presence of the following software namely ArcGIS, ArcGIS Pro, QGIS, ERDAS Imagine, ENVI, Google Earth Engine (GEE), R Packages, Python, SPSS, STATS, SAS, CSPRO, RCM, Machine Learning (ML) tools, Other (specify).With the exception of the Ministry of Urban and Infrastructure Development and the Ministry of Agriculture (Table 3.6), nearly all institutions assessed lacked one or more of these crucial ILUP-relevant software tools. The red-shaded cells in Table 5 highlight the significant absence of technologically essential software across most institutions. This indicates that either these institutions are not actively engaged in technologically advanced ILUP activities due to a shortage of skilled personnel or they rely on external software solutions through

rental or borrowing arrangements. This situation is concerning and requires immediate attention from the federal government and relevant stakeholders to address the urgent need for software investment and capacity building.

Table 3. 5: Assessment of Software Tools for Geospatial Data Management and Analysis in Ethiopian Federal Institutions

| | Target Organizations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Items | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 |
| ArcGIS | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | Yes |
| ArcGIS-Pro | Yes | Yes | No | No | Yes | No | No | No | No | No |
| QGIS | Yes | Yes | No | No | Yes | No | No | Yes | Yes | Yes |
| ERDAS Imagine | Yes | No | No | No | Yes | No | No | Yes | No | Yes |
| ENVI | Yes | No | No | No | Yes | No | No | Yes | No | Yes |
| GEE | No | No | No | No | Yes | No | No | No | No | Yes |
| R-Packages | No | No | No | No | No | No | No | No | No | No |
| Python | Yes | No | No | No | No | No | No | No | No | No |
| SPSS | Yes | Yes | No | No | Yes | No | No | Yes | Yes | Yes |
| STATA | Yes | Yes | No | No | No | No | No | No | Yes | Yes |
| SAS | Yes | Yes | No | No | No | No | No | No | No | No |
| CSPRO | No | No | No | No | No | No | No | No | No | No |
| RCM | No | No | No | No | No | No | No | No | No | No |
| Machine Learning (ML) tools | No | No | No | No | No | No | No | No | No | No |
| Other (mention) | Yes | No | No | No | No | No | No | No | No | No |

NB: 01= Ministry of Urban and Infrastructure,02= Ministry of Agriculture,03= Tea & Coffee Authority,04= Ministry of Transport and logistics,05= Forestry Development,06= Ministry of Peace,07= Ministry of Plan and Development and 08= Biodiversity Institute, 09= Ministry of Water and energy, 10= Environment Protection Authority

### 3.3.4 Availability of technological and knowledge products

Additionally, checklists were used to assess the availability of technological products, including Remote sensing satellite imagery, topographic maps and aerial photographs, Geospatial and land use-based published reports, proceedings, catalogs, journals, magazines and newspapers. As shown in Table 3.6, except for the Ministry of Urban and Infrastructure, nearly all federal institutions lack access to these essential ILUP-relevant technological and knowledge products.

Table 3. 6: Assessment of Geospatial Data Products and Knowledge Base in Ethiopian Federal Institutions

| Items | Target Organizations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 |
| Remote sensing satellite imagery | Yes | No | No | No | Yes | No | No | Yes | No | Yes |
| Topographic maps and aerial photos | Yes | No | No | No | Yes | No | No | No | Yes | Yes |
| Geospatial and land use based published reports, proceedings, catalogs, journals, magazines, news papers | Yes | No | No | No | Yes | No | Yes | Yes | Yes | Yes |

NB: 01= Ministry of Urban and Infrastructure,02= Ministry of Agriculture,03= Tea & Coffee Authority,04= Ministry of Transport and logistics,05= Forestry Development,06= Ministry of Peace,07= Ministry of Plan and Development and 08= Biodiversity Institute, 09= Ministry of Water and energy, 10= Environment Protection Authority.

This reliance on traditional methods of information gathering, such as mobile phone photos and visual inspections, instead of up-to-date technological products like satellite imagery and topographic maps, is a critical indicator of inadequate knowledge and technological skills within federal institutions to effectively execute ILUP activities.

# 4. Conclusions and Recommendations

## 4.1 Conclusions

The implementation of geospatial based integrated land use planning (ILUP) in Ethiopia requires a diverse range of skills and expertise, strong institutional system and technological capacities. In this regard, this baseline survey results show that there are gaps in the Federal organizations of Ethiopia in the implementation of ILUP. Accordingly, the major gaps identified in the institutional system capacity includes unclear mandates or mandate overlapping, conflict of interests, lack of legal and policy framework, lack of coordination among government institution, lack of well-structured dedicated offices to land use planning, and limited opportunities for professional development and capacity building for staff working in land use planning (insufficient training and development opportunities). The result also showed that while a significant portion of respondents (38%) perceive the institution's capacity to set legal frameworks and Standard Operational Procedures (SOPs) for ILUP management as moderate, a substantial number (47%) believe it to be limited or optimal. This indicates a clear need for improvement in developing and enforcing land use policy in the country.

Similarly, human capacity gap analysis results showed that specialized knowledge and skills relevant for implementing ILUP are limited in Ethiopia. For instance, specialized expertise like ILUP, GIS and remote sensing, and land use and policy are lacking or limited in most Federal institutes. In addition, a significant portion of respondents indicated having "no understanding" or "below average" knowledge of most geospatial based ILUP-related tools and techniques. This suggests a significant gap in the technical skills required for effective land use planning. On the other hand, the majority of experts were male (85%) and over 30 years old. This suggests a potential gender gap in land use planning expertise and a need for targeted efforts to engage and empower women in this field. Additionally, the age distribution indicates a significant pool of experienced professionals who can contribute their knowledge and skills to ILUP initiatives. Furthermore, there exists skill mismatch for the existing expertise in each Federal institution, and the land use planning related experts lack practical skills in that their theoretical knowledge and practical skill in applying ILUP principles and techniques are lacking. In addition, they have limited field experience, insufficient experience in conducting field surveys, data collection, and participatory planning processes. Generally, there is limited skilled manpower both in number and qualification to implement ILUP in Ethiopia. The main reasons for the lack of skilled manpower include brain drain (skilled professionals migrating to other countries or sectors), inadequate remuneration and incentives for professionals, and lack of career development opportunities.

Geospatial based technological advancements have significantly transformed the field of land use planning. Hence, the effective implementation of geospatial-based ILUP in Ethiopia relies heavily on the availability and accessibility of advanced technologies. However, this baseline survey result, obtained from key informant interview, questioner and observational check list results obtained from various Federal institutions, showed that almost all the assessed Federal institutions lack geospatial based technological capacities to implement ILUP in Ethiopia. The various Federal institution responded that they have only computers with low computing capacity like Laptops and Desktop Computers, and basic geospatial software like ArcGIS to do basic activities. However, most institutions lack advanced technologies like high computing computers, servers, and workstation. Therefore, the result shows almost all the assessed Federal institutions have limited access to advanced technologies,

data infrastructure and management, digital literacy and skills to execute and implement ILUP in Ethiopia.

Generally, this baseline survey showed that Ethiopia lacks skilled and experienced manpower, strong and well structure institutional system capacity and the-state-of-the-art geospatial based technologies for implementing ILUP. Therefore, addressing and filling these capacity gaps are highly required to significantly improve its ability to implement effective integrated land use planning, leading to sustainable land use and environmental conservation.

## 4.2 Recommendations

To address these issues and create a sustainable future for land use planning and management in Ethiopia, we recommend the following:

***Formulating and Ratification of the Land Use Policy:*** The immediate ratification of the proposed Land Use Policy is essential to provide a clear national framework for land use planning and management. This policy should indicate clear guidelines, standards, and procedures for land use planning, allocation and management. During the formulation of Ethiopia's land use policy, the policy document shall also clearly outline the roles and responsibilities of different stakeholders, including government entities, local communities and the private sector.

***Strengthening Leadership Commitment, Institutional Restructuring and Establishment of an Independent Land Use Office:*** As clearly indicated in the institutional systems capacity assessment analysis of this document, strong leadership commitment and institutional restructuring are crucial for the success of geospatial based ILUP implementation. The government should prioritize land use planning and management and allocate the necessary resources and personnel to support these efforts. Institutional restructuring may be necessary to streamline decision-making processes, improve coordination, and enhance accountability. Besides, an independent Land Use Office should be established to oversee the implementation of the Land Use Policy. This office should have the authority to coordinate and integrate land use planning efforts across different sectors and levels of government. It should also be responsible for monitoring land use changes, resolving land disputes and enforcing land use regulations.

***Budget Allocation:*** Adequate funding is essential to support the implementation of geospatial based ILUP initiatives. This includes funding for infrastructure development, technology acquisition, human capacity development and operational costs. The government should allocate sufficient funds to the Land Use Office and other relevant institutions to ensure that they have the resources they need to carry out their responsibilities.

***Strengthening Training and Capacity Development:*** Investing on geospatial based ILUP training and capacity building is essential to develop a skilled workforce capable of addressing the complex challenges of land use planning and management. This includes providing training and capacity-building opportunities for government officials, technical experts and community members. It is also important to recruit and retain qualified professionals in the field of land use planning and management. By implementing these recommendations, Ethiopia can create a more sustainable and equitable future for its land resources. In addition, the evolving nature of land use challenges like urbanization, climate change, and population growth requires continuous review and adaptation of the legal and policy framework to ensure its relevance and effectiveness. Therefore, addressing the

challenges of implementing ILUP requires a determined effort and strong political commitment to strengthen institutional capacity, develop clear guidelines, and promote inter-sectoral collaboration. By enhancing the legal and policy framework and investing in technical expertise, Ethiopia can improve its ability to implement effective integrated land use planning and ensure sustainable land use practices. Strengthen education and training by incorporating geospatial based ILUP courses into relevant academic programs, organize short-term training programs and workshops could be very pertinent to enhance the skills of professionals in GIS, remote sensing, land use and policy, and implement targeted capacity building programs for government officials, community leaders, and other stakeholders. Accordingly, based on the survey results, the training packages are prioritized as follows

I. *Advanced GIS and Remote Sensing Trainings with ArcGIS Pro, QGIS, ERDAS, and Google Earth Engine software:* This should be a core offering, covering topics like land use mapping, base map preparation for land use planning, image classification, object-based image analysis, change detection and spatial modeling.

II. *Python Programming and Its Applications in GIS and Remote Sensing:* This package should focus on data analysis, visualization, and automation using libraries like NumPy, Pandas, Matplotlib, and GeoPandas and

III. *R Programming and Its Applications in GIS and Remote Sensing:* This package should cover statistical analysis, spatial modeling, and machine learning using R packages like raster, sf, and caret.

***Enhancing Efforts to address technological capacity gaps:*** establish well-equipped GIS and remote sensing laboratories in the Federal institutes including Universities, research institutions, and other government agencies. In addition, invest in high-performance computing infrastructure to support complex data analysis and modelling, and develop secure and reliable data centers to store and manage large datasets. Besides, establishing clear data standards and metadata guidelines to ensure data quality and consistency should be an additional activity in the future. In addition, developing online platforms for sharing and accessing geospatial data, and promoting the use of open standards and formats to facilitate data exchange and integration are crucial to solve technological gaps for implementing ILUP in Ethiopia. On top of these, investing in Geospatial technology and infrastructure by providing access to modern GIS and remote sensing software and hardware, and provide robust data management systems could be essential to facilitate data sharing and analysis.

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