GUIDELINES FOR PARTICIPATORY NATURAL ASSETS MAPPING

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CETRAD
Centre for Training and Integrated Research in ASAL Development

SAVE THE ELEPHANTS

NRT
NORTHERN RANGELANDS TRUST

Foreword

The development of these guidelines couldn't have come at a better time than this when the Country is struggling with land reforms implementation processes and actions. The National Land Commission is empowered under Section 10 of the Land ACt 2012 with the responsibility of developing guidelines for sound management of public land. Natural resources, including the dryland natural assets, are part of the broader public land; that are under the direct administration and management of the Commission in line with Article 67 as read with Article 62 of the Constitution. In this case, the dryland natural assets include wetlands, rivers, lagas, minerals, springs, rock catchments, wildlife corridors and concentration areas, areas with critical biodiversity and genetic resources, and forests. They are of great value and significance to the dryland areas, landscapes and local communities; contributing to the well-being and resilience of the people and the landscapes. Their sustainable management and use are of great interest to, and priority of the Commission, as the guardian of all public land in Kenya.

Despite these critical legal underpinnings and requirements, natural assets, especially those in the drylands, are severely threatened by both human-induced and natural factors such as inappropriate and unsustainable land use practices, pollution, landscape degradation, land fragmentation and subdivision, encroachment into wildlife and biodiversity areas and corridors, defective and unresponsive policies, along with climatic changes. The rush for land in the new frontiers, mainly the drylands, and the on-going community land registration processes, compound these challenges further and are likely to jeopardize the integrity of these critical assets that provide immense benefits to the local people and contribute to the general economy.

Urgent actions by local communities, government and non-government agencies are required to halt and reverse the degradative actions; and foster sustainable and resilient landscapes through protection of natural assets. A critical step to this is to appreciate the true worth of the natural capital via accurate and elaborate inventories and establishment of databases for informed planning and decision regarding the protection, sustainable use and conservation of the vital natural assets. Consequently, these guidelines, meant to support both the duty-bearers: practitioners and technical officers as well as the rights holders - local community, with a step-by step process of undertaking a comprehensive natural asset mapping in drylands through an inclusive and participatory means, is critical in strengthening governance and sustainable management of the resources. I welcome everyone interested in mapping and inventorying natural assets to engage and utilise this framework, that is robust and easy to understand.

Dr. Abdillahi Saggaf Alawy
Chairman, National Land Commission

Acknowledgments

This guideline was developed to support communities, practitioners, and decision-makers in identifying, documenting, and protecting natural assets in dryland areas. It draws from practical experiences in Northern Kenya and provides step-by-step guidance for conducting inclusive, participatory and community-centered natural asset mapping. The aim is to promote informed planning, equitable resource governance, and sustainable land management.

The development of this guideline was made possible through the contributions of multiple stakeholders. We are grateful to the communities of Laikipia, Isiolo, and Samburu counties, whose local knowledge and lived experiences provided valuable insights that shaped the content and approach of this guideline. We also appreciate the county governments and national agencies for their policy input and technical support in ensuring the guideline aligns with broader planning and land governance frameworks.

We extend our sincere thanks to the Wyss Academy for Nature for its financial and technical support in the co-creation of this resource. Their commitment to participatory approaches and sustainable development has been instrumental.

Special recognition goes to the technical teams from the National Land Commission, led by Benard Opaa, and partners for their dedication in compiling this practical, community-centered tool. We also thank CETRAD and all others who contributed to its development—planners, researchers, editors, and administrative teams.

This guideline is intended to be a living resource—adaptable across contexts and useful to all those working to strengthen land and resource governance in drylands.

Kabale Tache Arero, MBS
Secretary/Chief Executive Officer
National Land Commission

Production Teams

The National Land Commission

1. Benard Opaa
2. Esterina Dokhe

WYSS Academy For Nature

1. Dr. Benson Okita
2. Antony Wandera
3. Richard Kiaka
4. Dickens Odeny

Centre for Training and Integrated Research in ASAL Development (CETRAD)

1. Dr. Boniface Kiteme
2. Grace Wambugu
3. Lee Muthuri

Save The Elephants (STE)

1. Benjamin Loloju

Northern Rangelands Trust

2. Kasaine Letiktik

State Department for Lands & Physical Planning

1. Peter Naibei

Kenyatta University

1. Dr. Ben Osukuku

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List Of Abbreviations

CBD	Convention on Biological Diversity
CBOs	Community Based Organizations
CETRAD	Centre for Training and integrated Research in ASAL Development
CP	Control Point
CSO	Civil Society Organizations
CSV	Comma- Separated Values
DEM	Digital Elevation Model
DSA	Data Sharing Agreement
EbA	Ecosystem-based Adaptation.
EMCA	Environmental Management and Coordination Act
ESRI	Environmental Systems, Research Institute
FGD	Focus Group Discussion
FPIC	Free, Prior and Informed Consent
GIS	Geographic Information Systems
GPS	Global Positioning Systems.
KIIs	Key Informant Interviews
KML	Keyhole Markup Language
NbS	Nature- based Solutions
NGOs	Nongovernmental organizations
NLC	National Lands Commission
OECD	Organization for Economic Cooperation and Development
PGIS	Participatory Geographic Information Systems.
PRA	Participatory Rural Appraisal
QGIS	Quantum Geographic Information Systems.
SDGs	Sustainable Development Goals
STE	Save The Elephants
SWAT	Soil and Water Assessment Tool.

1.0 INTRODUCTION

1.1. Background and Rationale

In many countries across the Global South, the true value and potential of natural assets remain underexplored and undocumented. As a result, there is limited tangible evidence to inform policy development, sustainable management, and sound decision-making (Reed et al., 2014; Stringer et al., 2017). These assets face increasing threats due to the ongoing monetization of natural resources, large-scale infrastructure projects, and rapid population growth (Lambin et al., 2014). Additionally, recent shifts in land tenure systems—particularly privatization—have weakened State protection of these critical resources (Meinzen-Dick & Mwangi, 2009; Schoneveld & Zoomers, 2015; Wily, 2011). In contexts of weak land laws, poor enforcement, and widespread land corruption, powerful individuals—including political and economic elites—often exploit the system to illegally acquire these assets (Barbier, 2012). Such land grabbing frequently results in the exclusion of local and Indigenous communities from important natural assets that support their livelihoods and essential ecological functions (Cotula, 2013; Willy, 2013).

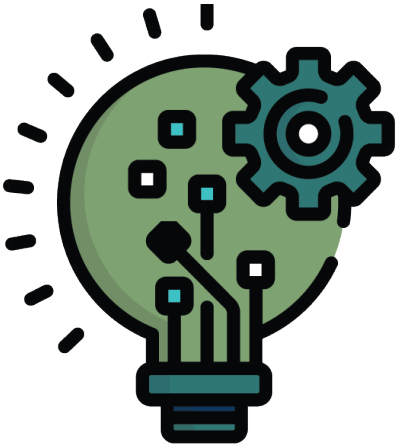
Mapping and inventorying natural assets is therefore essential. It offers a foundation for strengthening State protection—such as integrating these assets into national and local land cadastres—and ensures their preservation for continued ecological and socio-economic benefits. This Guideline offers a step-by-step approach for national and local governments to carry out natural asset mapping, with the overarching goal of securing their protection through policy, planning, and legal frameworks.

1.2.
Purpose of the Guidelines

The guideline aims to equip national and local governments, as well stakeholders with a step-by-step methodology for identifying, documenting, and mapping dryland natural assets, using participatory and evidence-based approaches.

The guideline promotes the inclusion of natural assets in land cadastres and planning tools, ensuring their recognition and sustainable use while protecting the rights and access of local and Indigenous communities.

The guideline aims to equip national and local governments, as well stakeholders with a step-by-step methodology for identifying, documenting, and mapping dryland natural assets, using participatory and evidence-based approaches.



The guideline serves as a capacity-building tool for government officials, planners, community leaders, and civil society actors, raising awareness on the value of natural assets and the urgency of their protection in the face of development pressures and tenure shifts.

1.3. Scope and Applicability

This guideline applies to organizations, researchers, government agencies, and community groups involved in mapping of natural resources in Kenya. It is designed to guide processes that are community-cantered, inclusive, and ethically sound, especially in contexts where land and resource rights are contested, shared, or held communally. The guidelines draws on lessons and insights from a pilot community-catered natural asset mapping that was undertaken the National Lands Commission (NLC) with support from her partners (Wyss Academy for Nature and CETRAD) for three counties in the northern rangelands of Kenya namely, Laikipia, Isiolo and Samburu.

This guideline is particularly relevant for:

- Local governments facilitating participatory land use planning processes.
- NGOs and CSOs supporting land and resource governance.
- Research institutions engaging in field-based land use mapping exercises.
- Development partners seeking to empower communities in decision-making related to natural resources.

1.4. Guiding Principles

Participatory natural asset mapping exercise should follow at least the following key principles as presented in Table 3:

Key Principles to guide Participatory Mapping Process

Principle	Description
Social Inclusivity	The participatory mapping process should ensure: • Full inclusion of community members and other important stakeholders in mapping of the assets, especially those that are historically marginalized, including women, youth, persons with disabilities and indigenous groups. • Transparency, accountability, gender sensitivity, and openness in terms of information disclosure.
Commitment to Community Control and Ownership	• The process and outputs should be clear to local communities and other stakeholders that the process was community driven. As such, mapping teams should seek Free, Prior and Informed Consent with the communities before the mapping process begins. • Communities should not only own the process but also the output.
Empowerment	• Natural asset mapping process will have meaning to the local communities if it seeks to address their existing socioecological, economic, and political challenges. Therefore, the process should recognize that the data collected, and outputs will be used to improve governance, access, and quality of those resources that local communities depend on.
Knowledge co-creation	• The entire participatory mapping process should provide an opportunity for collaborative learning for both the local communities and experts through crosspollination of ideas. It should promote the integration of indigenous with scientific knowledges.
Spatial specificity	• With the aid of technology, the participatory mapping process involves picking specific location coordinates of various natural assets with guidance from locals.
Multi-sourcing	• The entire exercise should involve various expert and community teams in identification if their assets as it presents opportunities cross-checking and alternative validations
Technology Integration	• The mapping initiative should leverage on existing appropriate technologies to capture data on all the identified assets.
The Storytelling Approach	• Storytelling should be adopted to help tease out how communities interact with natural assets in ways beyond visual representation and spatial data.

2.0 Overview of Natural Assets

2.1. What are natural assets?

Natural assets, as defined by the Organisation for Economic Co-operation and Development (OECD), comprise the biophysical components of the environment, including biological resources, land and water ecosystems, subsoil resources, and the atmosphere (OECD, 2008).

This definition captures the tangible, ecological dimensions of natural systems that support human and non-human life. However, natural resources become assets when people have rights to access their benefits (Boyce, 2001).

Considering decolonial critique, natural assets are understood not merely as biophysical resources with economic value, but as relational entities embedded within indigenous and local worldviews, cosmologies, and territorial rights (Escobar, 2020). This perspective challenges the colonial and anthropocentric conception of a natural asset as a repository of resources to be owned, extracted, and monetized. When viewed through a cultural lens, however, natural assets embody meanings that go beyond their physical or economic utility. They encompass ecological entities and landscapes—such as land, wetlands, water, biodiversity, forests and minerals —that are valued not merely for their instrumental function, but for their cultural, spiritual, historical, and relational significance, as articulated within indigenous and local knowledge systems (Whyte, 2018). In this context, a natural asset is understood as something that holds value due to its role in sustaining community livelihoods, knowledge systems, cultural identity, and collective wellbeing (Green, 2015; McPherson et al., 2020).

The boundaries between natural resources and culture are often indistinct. Scholars have emphasized that natural and cultural heritage are inextricably linked, co-producing landscapes and meanings that foster a shared sense of place (Cheng et al., 2003; King & Willow, 2011; Speed et al., 2012). Lockwood and colleagues go further to argue that the interdependence of cultural and natural dimensions is so profound that they are best managed as a unified whole (Lockwood et al., 2006). Doing so not only reflects the dynamic interplay between people and their environments but also enhances the efficacy and sustainability of development interventions (Hossen, 2016; Mere-Roncal et al., 2021).

Categorisation of natural assets in participatory approaches often mirrors the cultural landscapes and socioecological realities of the communities involved. In northern Kenya, for instance, participatory mapping exercises conducted with pastoral communities revealed classifications of natural assets that closely reflected the intimate local pastoralist practices and wildlife conservation, and embodied their knowledge systems, mobility patterns, and livelihood strategies (Table 1).

Table 1: Categories of natural assets identified in Northern Kenya

Assets Category	Natural asset elements
 Water Resources	• Rivers • Drainage valleys (lagas) • Ponds • Rock catchments • Sand dams • Springs • Wetlands (Swamps/ Marshes)
 Vegetation	• Dryland Forests (islands of dense vegetation) • Grasslands
 Wildlife	• Movement corridors • Dispersal areas • Wildlife concentration areas
 Livestock Resources	• Dry season grazing areas • Livestock Routes
 Minerals	• Salt licks areas and other minerals

2.2. What is natural asset mapping?

In this guide, **asset mapping** refers to a place-based approach that involves the systematic identification, documentation, classification, and analysis of natural assets within a specific area that hold social, ecological, cultural, or economic value (Chaplin-Kramer et al., 2022).

These assets may include land-based natural resources, and local knowledge systems, along with the networks, connections, and patterns of usage that give them meaning and utility. The insights generated from asset mapping are often used to inform planning and decision-making—guiding the development of certain assets or emphasizing those that require protection or improved management for sustainability (Bateman & Mace, 2020; Hinson et al., 2022).

Traditionally, mapping efforts have prioritized tangible and geographically locatable features of the landscape—such as forests, water bodies, and other land-bases resources (Currie & Correa, 2022). However, such an approach risks overlooking intangible dimensions that are deeply valued by communities, including spiritual significance, historical memory, or symbolic meaning (Taylor, 2013).

Asset mapping can also be constrained by the challenge of accounting for the different ways natural assets are valued—specifically, the distinction between their instrumental value, which relates to human use, and their intrinsic value, which exists independently of human benefit (Himes et al., 2024). Intrinsic values, while ethically significant, are inherently difficult to capture in conventional planning frameworks due to their intangible and subjective (Raymond et al., 2009).

Brown (2005) critiques the dominant emphasis in landscape planning on physical features, arguing that it systematically marginalizes perceptual and affective attributes such as sense of place, cultural identity, and emotional attachment (Brown, 2004). Yet these qualities are fundamental to how communities relate to their environments and should be integral to management strategies.

In light of these considerations, it is essential to adopt mapping approaches that recognize both tangible and intangible assets, visible and less apparent resources, as well as the full spectrum of values—ranging from instrumental, anthropocentric benefits to intrinsic, eco-centric worth. Such integrative methodologies more accurately reflect the complex and dynamic ways in which communities engage with their environments. By adopting this comprehensive perspective, planners and policymakers can design conservation and development strategies that are not only ecologically sound but also culturally resonant and socially inclusive. Crucially, these approaches must be participatory in nature, ensuring that local knowledge systems and the nuanced, place-based uses of natural resources by communities are acknowledged, respected, and meaningfully integrated into planning and decision-making processes. In addition, such approaches should actively engage all relevant stakeholders—including policymakers, development planners, and practitioners—to foster shared understanding, enhance coordination, and support coherent, context-sensitive interventions that affect natural assets.

2.1. What is participatory natural asset mapping?

Drawing on early works on participatory research methods (Chambers, 1994b, 1994a), **participatory asset** mapping is a collaborative process that engages local communities in the collection, analysis, and interpretation of information from their territories to generate a comprehensive map of natural assets, including their ecological, socioeconomic, and cultural significance.

This approach is inherently holistic and consultative, and serves as a form of collective learning that benefits both communities and area managers (Stoll-Kleemann & Welp, 2008). Increasingly, participatory methods are being recognized as essential components of planning within biosphere reserves and other conservation landscapes (Brown et al., 2017; Martin et al., 2012) and to engage marginalised groups (Burdon et al., 2022; Mosavel et al., 2018).

While various tools—such as existing maps, online databases, and satellite imagery—can aid in identifying natural assets, they often fall short in capturing the nuanced, place-based understanding and locally ascribed significance of these resources (Reid & Sieber, 2022). One of the most effective approaches is to engage community members who possess deep, experiential knowledge of the landscape (Briggs et al., 2020; Tripathi & Bhattarya, 2004) Consulting local communities not only surfaces information on well-known and previously undocumented assets, but also reveals the personal experiences, values, and meanings that people associate with them. This helps to reveal why certain assets matter and the roles they play in daily life and local ecological resilience.

Beyond identifying community-perceived strengths, participatory mapping can uncover gaps in resource protection. The process also fosters social cohesion and encourages active community participation in environmental governance (Brown et al., 2017; Norris, 2014). Indeed, "It is vital to take account of [the] interests and knowledge [of local communities] and to involve them in managing and protecting the environment. It is better to discuss an issue without reaching a decision than to reach a decision without discussion (Chalker, 1998:92)."

The shift toward participatory approaches in asset management planning is rooted in growing recognition that such involvement enhances the likelihood of successful implementation (Muchunguzi, 2023). When communities feel a sense of shared ownership over decisions and plans, they are more likely to support and sustain them (Renn et al., 1995).

2.2. Why natural assets mapping?

Asset mapping is a valuable tool for planning and managing natural resources, as well as for strengthening community resilience and improving wellbeing. It involves identifying the natural assets present in a particular area—such as forests, wetlands, rivers, rangelands, and biodiversity—and understanding their ecological value and importance to local livelihoods.

The process may also uncover overlooked or under-recognized assets, particularly those that are informally managed, communally held, weakly protected by law, and therefore vulnerable to degradation.

Once these assets are identified, it becomes easier to develop strategies for their sustainable use, protection, and restoration. Asset mapping enables planners, resource managers and policy makers to:

1. Comprehensively identify natural resources;
2. Support the legal recognition and protection of natural assets through integration into land-use plans, the land cadastres, conservation policies, and environmental as well as land laws;
3. Recognize gaps, risks, and opportunities for improved management;
4. Design interventions to prevent degradation and enhance ecological function; and
5. Enhance access and use of the assets by various local communities among other stakeholders.

Through this process, communities are better positioned to advocate for the recognition of their environmental priorities, assert custodianship rights over their land-based natural resources, and participate meaningfully in resource governance frameworks—both locally and globally—through alignment with international instruments such as the Convention on Biological Diversity (CBD), the Nagoya Protocol on Access and Benefit Sharing, and other mechanisms that uphold Indigenous and community rights.

3.0 Stakeholder Identification and Engagement

3.1. Community Identification and Inclusion Criteria

- Define the community or communities to be involved, with attention to ethnic, geographic, and livelihood diversity.
- Include marginalized and vulnerable groups (e.g., pastoralists, Indigenous peoples, women, youth, persons with disabilities).
- Ensure adherence to principles of Free, Prior and Informed Consent (FPIC) during identification.

Stakeholder Mapping Identify all actors who may influence or be affected by natural resource mapping. These include:

a. Community-level Stakeholders

- Traditional leaders and elders
- Women's groups and youth representatives
- Local resource user associations (e.g., water user associations, grazing committees, conservancies, community forest associations, beach management units, county mining associations)
- Community-based organizations (CBOs)
- Other opinion shapers

b. Civil Society and Technical Partners

- NGOs and community development organizations
- Academic and research institutions
- Local mapping facilitators and technology providers

c. State Agencies and Government Institutions

These should be national and local government departments and agencies in charge of:

- Water resources
- Land adjudication
- Physical planning
- Wildlife resources
- Forest resources
- Minerals
- Environmental quality
- Security and local administration

4.0 Participatory Mapping Preparation

Effective participatory natural asset mapping begins with deliberate preparation. This phase sets the foundation for meaningful engagement, accurate data collection, and locally relevant outcomes. It involves clarifying the purpose of the mapping exercise, selecting tools and techniques that are contextually appropriate, and building shared understanding among facilitators and community participants. Proper preparation ensures that the process is inclusive, technically sound, and aligned with the priorities of both the community and supporting institutions.

4.1. Defining Mapping Objectives

Clearly defining the objectives of the mapping exercise is a critical first step. Objectives should be co-developed with community members and other stakeholders to reflect local priorities, knowledge, and intended uses of the data. These could include identifying critical natural resources with a view of enhancing their protection, planning sustainable land use, supporting advocacy efforts, documenting traditional ecological knowledge, or resolving land and resource conflicts. Establishing clear and shared objectives helps frame the scope of the exercise, determine who should be involved, and guide the selection of mapping methods and outputs.

4.2. Selecting Appropriate Mapping Tools and Methods

Participatory mapping must balance technical accuracy with accessibility for non-experts. Tools and methods should be chosen based on the community's familiarity with mapping, literacy levels, cultural norms, and the complexity of the landscape. Options range from hand-drawn sketch maps, geo-referenced community maps using GPS, satellite imagery interpretation, to digital participatory GIS platforms. The mapping approach should also consider inclusivity—ensuring that women, youth, elders, and marginalized groups can meaningfully participate and contribute their knowledge. Training and preparatory sessions may be necessary to build confidence and common understanding around the tools being used.

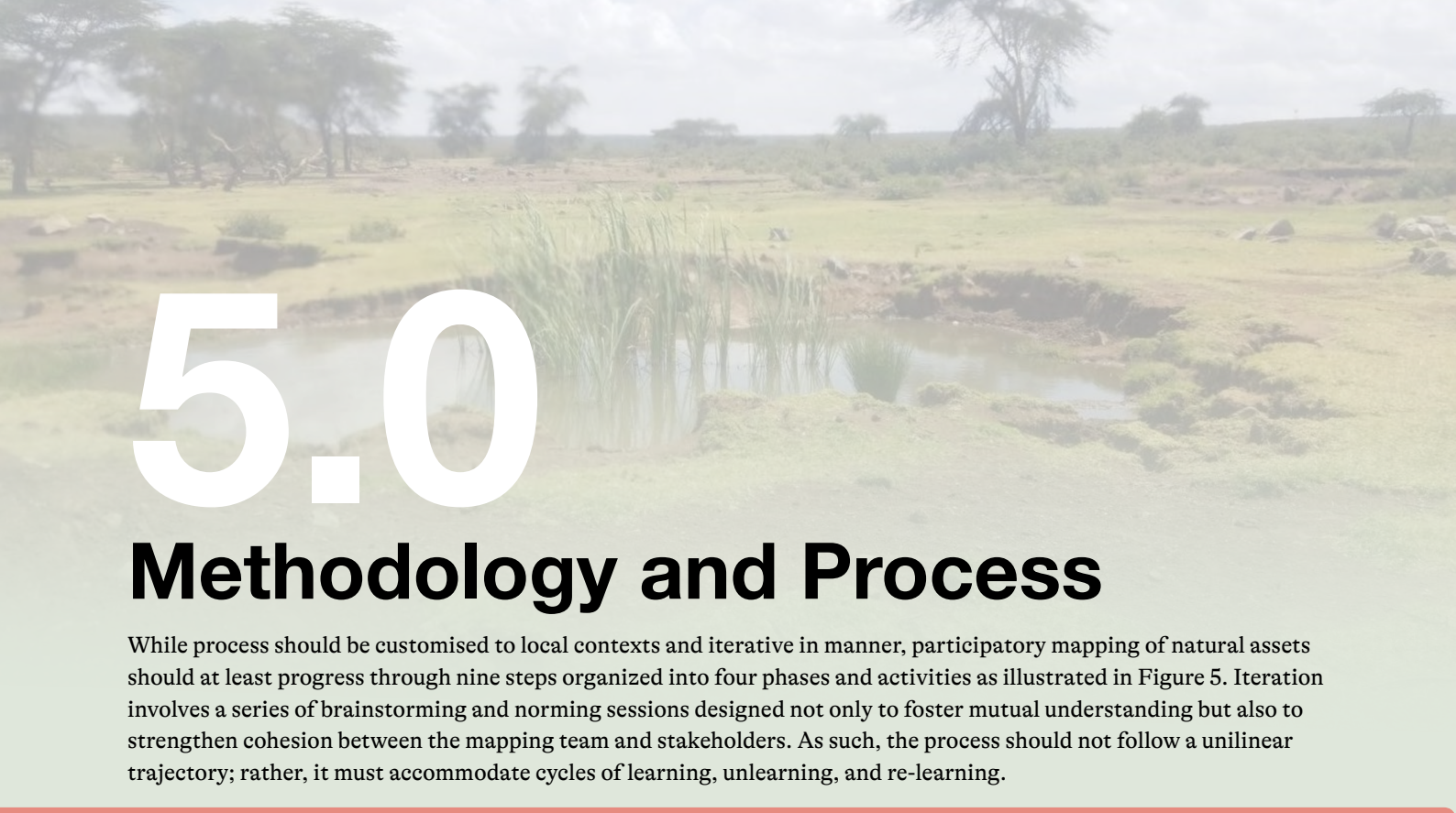
4.3. Agreeing on unit of focus (location/ward/county)

While data collection is conducted within the localities of various communities, it is essential to report findings and outputs at the lowest political-administrative unit and subsequently consolidate them at the sub-national level, where policy-making processes begin. This approach aligns with the broader objective of influencing policy across multiple governance scales. In the pilot case study conducted in northern Kenya, data collection was carried out at the Ward level—the smallest political unit in the country. However, analysis and reporting were undertaken at the County level, which represents the lowest formal stage in Kenya's policy development framework.

4.4. Developing a Mapping Work Plan and Timeline

A well-structured work plan and realistic timeline are essential for guiding the participatory mapping process from preparation to completion. The work plan should outline key activities, responsible persons or teams, expected outputs, and resource requirements at each stage. It should also incorporate time for community mobilization, training, data validation, and feedback sessions. In developing the timeline, consider agricultural calendars, community events, and seasonal accessibility of sites to ensure maximum participation and minimize disruption to local livelihoods.

The time plan should also remain flexible to accommodate unforeseen eventualities such as natural disasters, sudden weather changes, or culturally significant events such as funerals, rituals, or community ceremonies, which may take precedence over planned activities. Respecting these realities reinforces cultural sensitivity and supports sustained community trust and participation.



5.0 Methodology and Process

While process should be customised to local contexts and iterative in manner, participatory mapping of natural assets should at least progress through nine steps organized into four phases and activities as illustrated in Figure 5. Iteration involves a series of brainstorming and norming sessions designed not only to foster mutual understanding but also to strengthen cohesion between the mapping team and stakeholders. As such, the process should not follow a unilinear trajectory; rather, it must accommodate cycles of learning, unlearning, and re-learning.

Figure 1: Step-by-Step Methodology for Natural Asset Mapping

Phase 1: Initiation

Step 1: Consultations
Step 2: Preliminary Assets Identification:
Step 3: Developing digital surveys
Step 4: Recruitment and Training of Data Collection Assistants

Phase 2: Data Collection

Step 5: Sampling
Step 6: Field Survey

Phase 3: Data Mining and Interpretation

Step 7: Data Verification
Step 8: Data Analysis and Interpretations

Phase 4: Validation of the Report

Step 9: Stakeholders Validation
National Government Agencies/Policy makers
Local Government Agencies
Landowners
Local Politicians

5.1. Inception Phase

Step 1: Initial consultations

In this initial step, the planning team establishes entry into the community where the mapping exercise will take place. This can be achieved through courtesy visits and consultative meetings with local government administrators, community leaders, and leaders of indigenous groups. These meetings should aim to clearly communicate the purpose of the exercise and seek the support and endorsement of these key stakeholders. Securing the buy-in of local leaders and administrators—and their facilitation of the process—helps lay a clear foundation for the mapping activities and sets the stage for subsequent phases. The layers of consultation should be tailored to align with the local political, administrative, and cultural contexts.

Step 2: Conduct preliminary assets identification

To gain initial insights into the natural assets within a community, it is important to develop a map that reflects the resources considered vital by community members—particularly those essential for their livelihoods. This process can begin by utilizing simple Google Earth imagery to assemble preliminary maps.

The technical team should prepare Google Maps in advance and print them in A0 format, using high-resolution satellite imagery where possible. To assist participants in orienting themselves, additional geographic information should be overlaid onto the maps. This may include major roads, settlements, administrative boundaries, drainage features such as rivers and laggas, and notable hills. Integrating these elements enhances the clarity and accuracy of the mapping process, enabling participants to more easily identify and locate key geographic features within the study area.

While Google Earth is useful for orientation and allows participants to navigate and cross-reference key resources using satellite imagery, it should not serve as the primary mapping tool. Instead, the mapping process should be grounded in the deep, lived knowledge of local community members and key opinion leaders.

Mapping should take place in a safe and inclusive space, involving representatives from various groups within the community, including women, youth, and elders. To minimize power dynamics and hierarchies, these groups should initially work separately. This allows for more open and equitable contributions. Once provided with the Google map, participants break into workgroups to identify their community area and mark natural assets based on their local knowledge, lived experience, and the significance of these assets to their livelihoods and social life. Using the asset categories provided by the technical team, participants record the identified features along with their local names and preliminary status. Within each group, discussions are held to reconcile differing views and ensure a shared understanding of the assets, importance, and names of their locations. The groups can then reconvene in a plenary session to validate and consolidate their respective maps.

Once validated, the maps from each group are amalgamated into a single, composite map representing the entire community. This final map forms the basis for developing a preliminary checklist of all natural assets present in the area.

Picture 1: Preliminary Community Assets Tracing and Identification from google aerial imagery in Laikipia, Northern Kenya. (Source NLC)

Step 3: Design a survey

Using the preliminary asset identification checklist and relevant secondary sources, develop a data collection platform tailored to the target area. Leveraging digital survey tools such as ArcGIS Survey123 Connect can significantly accelerate data collection and improve data management. The specific data and information to be collected will vary depending on the ecological conditions of each site and the priorities of the local communities. Key data fields may include asset type, administrative location, GPS coordinates, local name of the asset, asset size, governance institutions, land tenure status, land use, and the general condition of the asset. In summary, the data should include: Assets metadata; high resolution photos, and location coordinates.

Step 4: Recruit and train of data enumerators

Recruiting data enumerators from local communities is highly recommended. In many cases, individuals with prior experience in data collection and the necessary qualifications can be found within the community. Drawing on this local expertise not only strengthens the credibility of the process but also reinforces a sense of local ownership and participation. Local enumerators often possess deep, contextual knowledge of community assets and a personal connection to them.

However, in line with justice-oriented approaches in citizen science, it is essential to ensure that enumerators are fairly compensated for their work.

Enumerator training should emphasize a clear understanding of the survey objectives, the operation of digital tools such as ArcGIS Survey123 (or any other relevant platform), and adherence to research ethics and safety protocols. Sufficient time should be allocated for training to ensure enumerators develop both technical proficiency and confidence in using the tools effectively. See Box 1 for example from northern Kenya.

Box 1: Example of use of technology in asset mapping in northern Kenya.

The mobile application in participatory mapping in Kenya

The mobile field data collection application was developed using ESRI Survey 123 technology, tailored to the list of assets and corresponding information requirements. The tool underwent multiple iterations of testing under real-life conditions and subsequent refinement. Mobile devices were set up to automatically transmit records to the central database hosted at the University of Bern. Research assistants participated in a two-day training program, followed by sessions to discuss feedback on the application's usability and any encountered issues before commencing field surveys. This approach ensured that the data collection process was efficient, accurate, and in line with the project's objectives.

5.2. Phase 2: Data Collection and field Mapping

Step 6: Field Survey:

Using the preliminary asset identification checklist and printed satellite imagery, the mapping team should proceed to conduct fieldwork. As a minimum requirement, the data collection team should comprise data enumerators, community opinion leaders, key resource persons, local government administrators, and members of the technical team. Table 2 below outlines stakeholders involved in data collection in a participatory asset mapping exercise in Northern Kenya.

Table 2: Stakeholders involved in data collection in Northern Kenya and their roles

Team member	Role	Example from northern Kenya
Data enumerators	Data collection and entry into the digital mapping survey tool e.g. ArcGIS Survey 123.	They were recruited from the local communities by the technical team having met set criteria.
Community opinion leaders	• Asset identification and verification. • Guides the mapping team through the community.	• Village elders • Clan leaders • Chiefs • Village headmen
Key resource persons	• Provide information on the specific assets within their areas of jurisdiction. • Asset identification and verification	• Religious leaders • Local government administrators e.g. Chiefs, Village elders • Clan elders
Local government administrators	• Asserts government's presence and stake in the process. • Asserts legitimacy of the exercise. • Clarify the administrative and political boundaries of the assets to avert territorial conflicts. • Ensures security of the teams in areas prone to conflicts and insecurity.	• Area Chiefs • Village Headmen

Technical team	• Provide technical guidance on the methodology and data collection and capacity building of the data enumerators. • Data analysis, interpretation and production of the final outputs. • Ensures quality assurance role.	• GIS experts • Socioeconomic development experts • Policy and legal experts • Ecologists

Sampling: Since the mapping focuses on assets that the community identifies as essential to their livelihoods, a purposive sampling approach is most appropriate. This approach draws on the community's intrinsic knowledge and understanding of the assets within their localities. In addition, stratifying the sample—preferably along administrative boundaries—can help ensure broader representation. Rigid sampling designs should be avoided to allow for flexibility in the field, ensuring that the data collection process remains responsive to community priorities and retains its relevance from the community's perspective. See Box 2 for an example from northern Kenya.

Box 2: Example of sampling procedure from asset mapping in northern Kenya.

Sampling design in Laikipia County, Kenya

The sampling procedure adopted was both stratified and purposive. The stratification was executed at the wards, locations, sub locations, up to the village level. On the other hand, purposive sampling was based on the community's intrinsic knowledge and understanding about the available assets in their localities where they deliberately took the mapping team to pick points and capture data. Further, additional data was also collected through observations to provide a better understanding on the nature and state of these assets including any threats. The data collection team equally compiled field notes describing what was observed based on an observation matrix. Photography was deployed to capture the key phenomenon of interest.

5.3. Phase 3: Data processing & Analysis

Step 7: Verification of Facts and Data from the Field:

Daily verification and cleaning of data is essential to ensure accuracy and consistency. The technical team should carry out data verification at the end of each day. Common challenges to monitor include:

- Failure by digital gargets to capture geo-locations due to poor weather or physical obstructions, including areas of poor network coverage.
- Teams falling short of daily data collection targets.
- Survey questions requiring revision, addition, or removal.
- Inconsistencies in the understanding or interpretation of key terms—such as asset categories.
- The need to reshuffle or reconstitute teams for better dynamics.
- Logistical constraints such as power shortages for digital devices, difficult terrain, or inadequate transport.
- Community resistance or reluctance to participate.

Daily debriefing sessions are essential—before transmitting data to the digital database—as they provide an opportunity to collaboratively identify and resolve emerging issues. This ensures that the data collection process remains adaptive, efficient, and responsive to field conditions. Once the team is satisfied with the quality and completeness of the data, it should then be submitted to an online server for secure storage and future use. SeeBox 1 for examples from Northern Kenya.

Box 3 Example of a challenges encountered during asset mapping in northern Kenya:

Practical Challenges Encountered During Natural Resource Mapping in Northern Kenya

One of the most significant challenges encountered during the natural asset mapping process—particularly at the data collection stage—was the vastness and rugged topography of the project areas. These landscapes, characterized by poor or non-existent road infrastructure, made accessibility extremely difficult and considerably slowed the pace of data collection by field assistants.

The terrain in northern Kenya is not only expansive but also harsh and uneven, posing logistical constraints. In one instance, a data enumerator and his team ran out of fuel and were stranded in a remote location for several hours, with limited mobile network coverage making it difficult to contact them for support.

To address this challenge, the project procured four-wheel-drive (4WD) vehicles capable of handling the rough terrain with greater ease and reliability. Additionally, the deployment of motorbikes enabled data assistants to reach remote and otherwise inaccessible areas, significantly enhancing manoeuvrability. Most importantly, involving local community members in the data collection process proved invaluable. Their intimate knowledge of the landscape allowed for more efficient navigation and the avoidance of hazardous routes, making their participation a key asset to the project.

Another notable challenge was the failure to geolocate some of the mapped asset locations accurately. This was primarily a technical issue linked to the use of inadequately calibrated data collection devices, such as personal smartphones, which often lacked the GPS precision required for reliable spatial data. In response, the project transitioned entirely to using calibrated tablets that had been pre-tested for accuracy. This shift significantly improved the quality and reliability of geospatial data. The experience underscored the importance of prior calibration and equipment testing before field deployment to ensure the accuracy of GPS readings and overall data integrity.

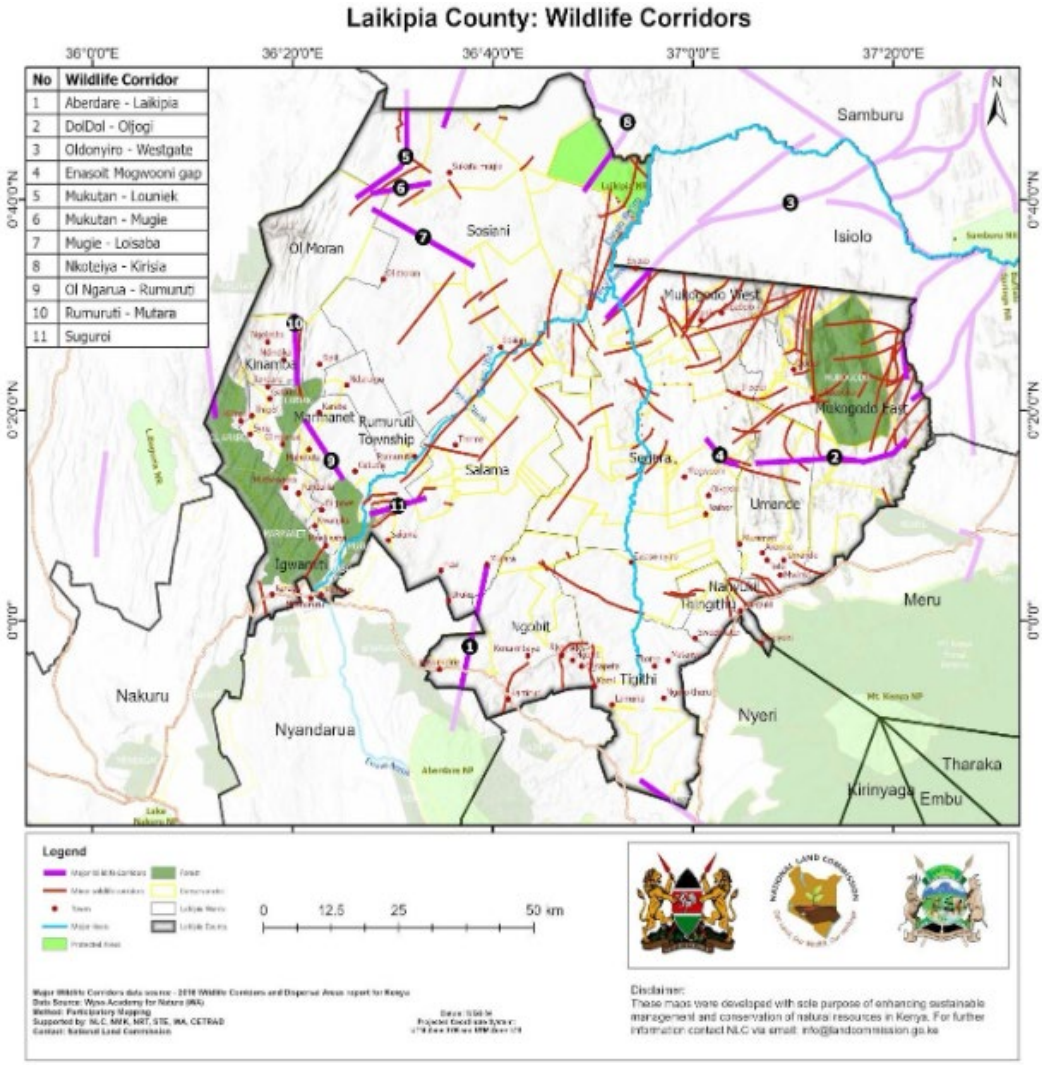
Step 8: Data Analysis and Interpretation

Once the data collection exercise is complete, the data can be exported from the attribute shapefile into CSV (Comma-Separated Values) format for further analysis. Spatial data is then processed using appropriate software that is both technically suitable and financially accessible for the team. ArcGIS is among the most widely used tools for this purpose. The results are visualized through maps that display the location of assets and associated threat levels.

The types of maps to be produced should be determined by the specific objectives of the mapping exercise and the nature of information that is most meaningful to the community. For example, if the objective is to protect and secure natural assets through formalization of land rights—or by transitioning ownership to the state—it is essential that the maps clearly depict the existing land tenure regimes in the areas where these assets are located. The maps should be high-resolution to ensure clear visibility and should avoid excessive detail that could compromise ease of interpretation.

For example, mapping exercise from Northern Kenya, revealed wildlife corridors (Figure 2) as well as seasonal availability of water resources in Laikipia County (Figure 3)

Figure 2: Major and Minor Wildlife Corridors in Laikipia County, Kenya.



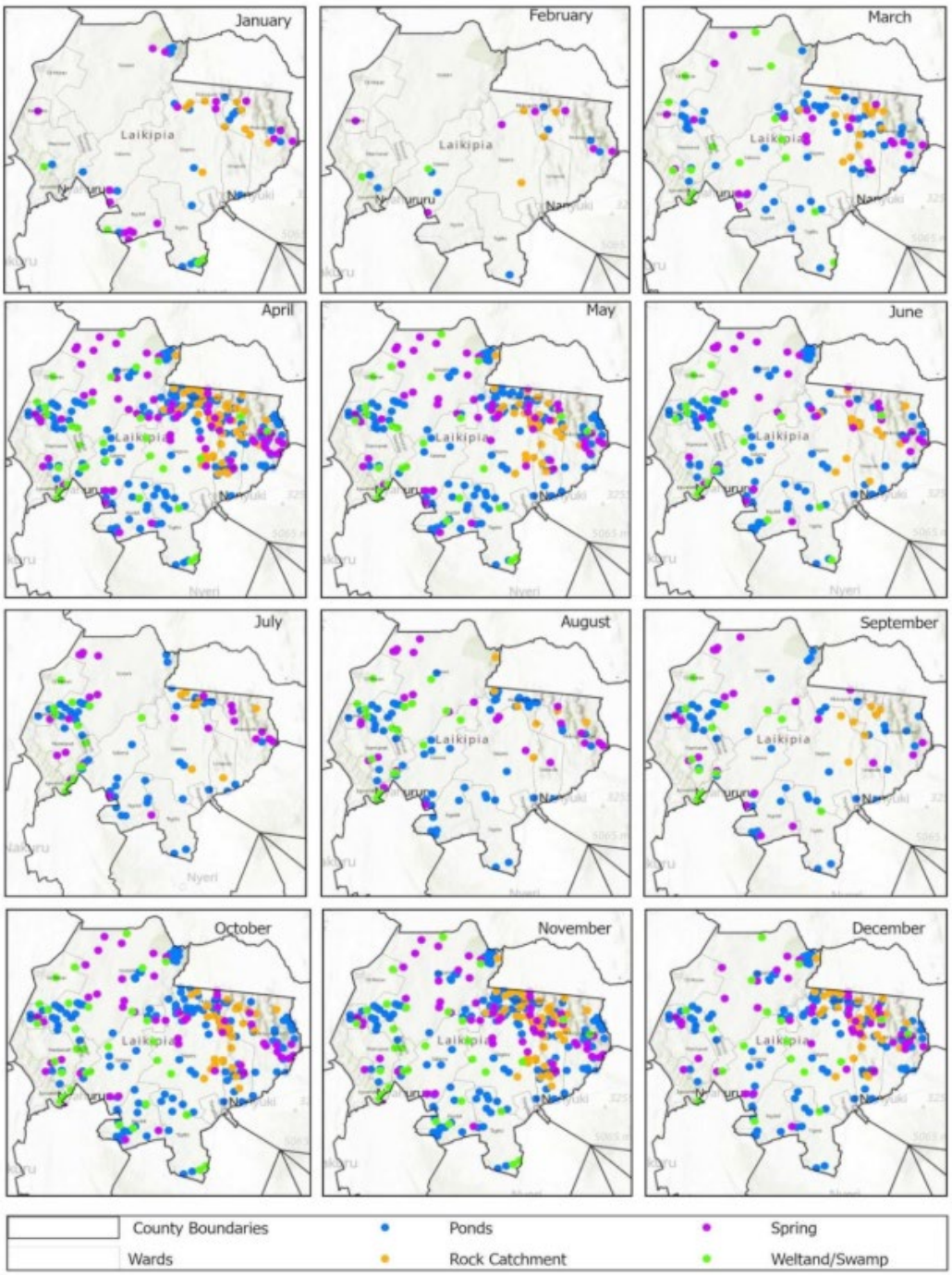


Figure 3: Seasonal Water Availability in Laikipia County, Kenya.

Non-spatial data extracted in CSV format can be processed using Microsoft Excel to generate charts, frequency distribution tables, and other forms of quantitative data visualization. In addition to the quantitative data, the integration of qualitative data, especially those relating to indigenous knowledge is key. A practical example from a case study in northern Kenya is the description provided by communities on the use of salt licks not only for livestock production and wildlife, but also for the detoxification of the human body and cleansing the human gut. The integration of indigenous knowledge not only captures the nuanced ways in which communities interact with natural assets, but also reinforces community confidence in the mapping outputs, as they are able to see their own experiences, values, and worldviews reflected in the maps.

5.4. Phase 4: Validation of assets mapping outputs

Validation is a critical step in ensuring the legitimacy, ownership, and alignment of the mapping process with democratic principles—particularly those that uphold public participation in governance. It also provides an important opportunity to build the capacity and awareness of stakeholders, allowing them to critically review and provide feedback on the mapping outcomes. Furthermore, the validation process helps to build community confidence, reassuring them of the transparency and positive intent behind the initiative. Structured validation sessions should be conducted with a range of stakeholders and interested parties, including community representatives. Key stakeholder categories to be considered in the validation process may include:

- National government agencies
- Local government departments
- Local politicians
- Local administrators
- Clan leaders
- Development organizations working in the area

Gender considerations in stakeholder selection are essential but should be approached with sensitivity to the specific socio-cultural context.

Picture 2: Participatory natural asset mapping validation session with the Isiolo Members of County Assembly in northern Kenya

Engagement and validation sessions should be sufficiently robust to accommodate diverse inputs, including concerns raised by various stakeholders. These sessions offer a vital platform for the technical team to clarify issues arising from the mapping findings, legal frameworks, and relevant facts. Where appropriate, participants should be referred to the relevant government or state agencies for additional support, guidance, or advice.

Stakeholder feedback should be documented in a structured format—preferably in a table—to record the specific comments raised, the corresponding responses from the technical team, and any actions proposed. All feedback should be treated with seriousness and responded to in clear and detailed terms to prevent misunderstandings or disputes regarding the final outputs. In instances where the technical team determines that no action is necessary, a well-reasoned explanation should still be provided and recorded in the table.

6.0 Data Management, Ethics and Security

Data generated through natural asset mapping must be managed in an ethical, secure, and legally compliant manner that respects community values. This requires adherence to clear principles and procedures, particularly regarding data ownership, access rights, ethical use, protection against misuse, and long-term storage. Given the sensitive nature of spatial and socio-ecological information, robust data governance mechanisms are essential to safeguard the rights of individuals, communities, and ecosystems.

6.1. Data Ownership and Access Rights

Natural asset data should be co-owned by the community from which it originates, in recognition of their longstanding relationship with the land and ecosystems. External actors (e.g., researchers, government, NGOs) must respect this ownership and seek Free, Prior and Informed Consent (FPIC) before accessing, using, or disseminating such data. Access rights should be clearly documented in participatory agreements, specifying levels of access for different stakeholders (e.g., public access, restricted access, internal-only datasets) and purposes (e.g., conservation, planning, advocacy).

6.2. Community Data Governance Protocols

Communities participating in asset mapping should be supported to develop and adopt data governance protocols that reflect their cultural values, knowledge systems, and decision-making processes. These protocols define who speaks for the data, who authorizes its use, how it should be stored or shared, and under what conditions it may be withdrawn or withheld. These protocols should be recognized by partners and aligned with the county's legal framework on data protection, customary rights, data sovereignty, and indigenous knowledge protection.

6.3. Ethical Considerations and Anonymity

Ethical conduct in data collection, analysis, and dissemination is paramount. Where individual perspectives, household information, or sensitive cultural or ecological knowledge is collected, steps must be taken to protect anonymity and prevent unintended harm. Participants must be informed of the purpose of data use and given the opportunity to opt out or restrict certain uses. Local committees and government agencies should be consulted, especially when working in areas with historically marginalized or vulnerable groups.

6.4. Data Storage, Protection, and Use (aligning with national data protection laws)

All data must be securely stored using systems that prevent unauthorized access, tampering, or loss. Physical and digital storage protocols should comply with the county's data protection laws and related laws. This includes encrypting sensitive data, ensuring secure backups, and designating a data custodian responsible for managing access requests and ensuring proper use. Use of data for commercial purposes without explicit community approval is prohibited. Long-term stewardship arrangements should also ensure that data remains accessible and useful for future community planning, advocacy, and resilience-building.

7.0 Use of Mapping Outputs

Natural asset mapping provides spatial and qualitative data on the location, extent, value, and use of natural resources. These outputs—including maps, inventories, community knowledge, and geospatial layers—can be applied in multiple policy and planning processes.

7.1. Advocacy and Policy Influence

Asset mapping outputs can be powerful tools for evidence-based advocacy by communities, civil society, and local governments. By visually and quantitatively demonstrating the location and socio-ecological value of natural assets, the outputs help make visible what is often overlooked in policy-making. Stakeholders can use the data to:

- Advocate for formal recognition of community-managed resources in national and local-level policies.
- Push for stronger legal protection or inclusion of mapped assets in gazetted conservation areas, communally used lands, public land registries, or development control zones.
- Expose and challenge cases of illegal or irregular acquisition of natural assets by private individuals or entities, especially where these acquisitions contravene land laws or deny local communities access to key resources. Mapping outputs can support public interest litigation, calls for restitution, or administrative review of contested land allocations.
- Support campaigns to reclaim natural assets that have been privatized without due process, and demand their reclassification as public or community-held resources.
- Engage legislators, policymakers, and planners with compelling visual evidence that supports equitable and sustainable resource governance

7.2. Resource Conflict Resolution

In contexts where natural assets are contested—due to overlapping claims, unclear boundaries, or competing land uses—asset mapping outputs can help clarify and mediate disputes. The outputs provide:

- Verified information on the spatial extent and traditional use of resources, which can support negotiations between communities, government agencies, and private actors.
- A neutral basis for conflict mediation, especially where customary and statutory claims intersect.
- Documentation that can be submitted in land tribunals or during public participation processes to assert historical and community rights.

7.3. Land Use Planning and Development

Asset mapping enhances participatory and sustainable land use planning by ensuring that ecologically and culturally important areas are identified before development decisions are made. Planners and development agencies can use the outputs to:

- Integrate natural assets into county spatial plans, national land information systems, and development control frameworks.
- Assess the environmental and social trade-offs of proposed infrastructure or agricultural projects.
- Ensure that zoning plans account for conservation priorities, ecosystem services, and community resource access.

7.4. Conservation and Climate Resilience Planning

Natural asset mapping provides baseline information that is essential for conservation and climate resilience strategies. Conservationists, environmental agencies, and climate actors can use the data to:

- Prioritize ecologically sensitive or threatened areas for protection or restoration.
- Identify landscape-level connectivity (e.g., wildlife corridors, water catchments) and integrate them into climate adaptation and biodiversity action plans.
- Support ecosystem-based adaptation (EbA) and nature-based solutions by highlighting where natural assets buffer communities against climate shocks such as droughts, floods, or land degradation.

Table 3 below presents the policy and legislative actions proposed as a result of participatory natural asset mapping conducted in Laikipia County, northern Kenya. It illustrates how the outputs of natural asset mapping can inform and guide policy development and legislative decision-making.

Table 3: Proposed Gazettement of Critical and Vulnerable Assets for Public Use

Priority Resource/Site	Issues/Threats	Proposed Conservation Measures
Oldonyiro-Westgate corridor	It forms part of a larger north-south connectivity system crucial for wildlife movement between the Laikipia plateau, Samburu, and further north into the Mathews Range.	• Inter county dialogues • Inter-county physical and land use planning • Inter-county natural resource committee tasked with setting grazing plans alongside other attendant regulations. • Gazettement in accordance with the Wildlife Act, 2013
Mukutan-Luoniek corridor	This corridor provides a critical westward outlet for wildlife moving from the Laikipia Plateau across the Great Rift Valley escarpment toward Baringo lowlands and beyond. It is one of the few remaining relatively open routes across Laikipia's western edge.	
The Mugie–Loisaba corridor	This corridor is essential for north-south wildlife movement between Laikipia's northern ranches and community conservancies linking Laikipia's private and community conservation landscapes into a larger functional ecosystem	
Nkoteiya–Kirisia corridor	A vital ecological linkage in Samburu County, connecting Nkoteiya (a dryland community area near Westgate Conservancy and northern Laikipia) to the Kirisia Forest (a large montane forest block providing permanent water and refuge for wildlife).	
Mugie –Luoniek-Mukutan Conservancy Corridor	• Habitat fragmentation and blockage of wildlife movement • Land use change and subdivision • Human Wildlife Conflicts • Insecurity and resource conflicts	
Parcel LR No. 1091, Luoniek Location	• Public land reserved from Luoniek settlement as a wildlife corridor. • The corridor is part of the broader Laikipia–Samburu–Isiolo rangeland system, linking: Laikipia Conservancies (e.g., Ol Jogi, Mpala, Loisaba), Community lands and group ranches in Mukogodo and Il Ngwesi, Samburu National Reserve and surrounding landscapes. • The parcel also functions as a dry-season refuge and grazing passage and an important for gene flow and maintaining ecosystem connectivity between fragmented conservation lands.	• Reserve as public land under section 15 of Land Act, 2012 • Gazettement as a corridor in accordance with the Wildlife Act, 2013

Ewaso Narok and Pesi Wetlands	Human encroachments	• Wetland rehabilitation and protection • Enforce wetlands regulations • Community participation in the protection of these wetlands • Development control and enforcement
Parcel No. LR No. 1092 in Luoniek Location (public land)	• Vital water catchment area for locals. • The parcel is rich in Mtamayo and Acacia tree species and play a critical role as a grazing areas for both livestock and wildlife • Faces significant threats including the ongoing inter-tribal violence over pasture and water access, mainly involving Pokot and neighbouring groups as well as severe charcoal burning.	• Reserve as public land under section 15 of Land Act, 2012 • Gazettement in accordance with the Water Act, 2016
Ewaso Narok and Ewaso Nyiro rivers riparian reserves	Human encroachments	• Demarcation of riparian reserves. • Riparian buffering preferably with native trees • Development control and enforcement
Salt licks protection at PND scheme	Access and user rights by communities	Invoke conservation easement as per EMCA

8.0 Reporting and Dissemination

Effective reporting and dissemination are critical to ensuring that the results of natural asset mapping are credible, accessible, and actionable. Proper documentation and targeted sharing of outputs can build transparency, support community ownership, and strengthen the influence of the mapping exercise in shaping policy, planning, and resource governance. This section outlines how to document the process and share the outcomes in formats appropriate for various audiences.

8.1. Documentation of Process and Outcomes

Thorough documentation provides a permanent record of how the mapping was conducted and the insights generated. It ensures that the methods, data sources, and community inputs are transparent and replicable. Documentation should include:

- A narrative report detailing the objectives, methodology, tools used, stakeholder engagement, challenges faced, and lessons learned.
- Geospatial outputs such as maps (in printable and digital formats), shapefiles, and associated metadata.
- A community-friendly summary of findings, using infographics, photos, and translated materials where appropriate.
- A log of validation steps taken, including community feedback, consensus-building meetings, and verification processes.
- A record of any agreements or declarations made by stakeholders, particularly around access, ownership, or use of mapped assets.

This documentation serves as both an internal learning resource and an external communication product to support policy engagement.

8.2. Dissemination to Stakeholders and Policy Forums

To maximize the influence of the mapping outputs, strategic dissemination is essential. Different audiences require different formats and engagement strategies. Key dissemination actions include:

- Sharing with local stakeholders, including community leaders, user groups, and county-level departments, through barazas, workshops, or community exhibitions.
- Engaging national and local government departments responsible for land, environment, planning, wildlife, and development to ensure the outputs inform policy and planning processes.
- Presenting at policy forums and technical working groups such as land use planning committees, ecosystem management platforms, or climate adaptation working groups.
- Using the media and civil society networks to raise public awareness and amplify advocacy messages.
- Publishing the results online, where appropriate, through open data portals, institutional websites, or geospatial data platforms, with appropriate data protection measures in place.

Tailoring the format and messaging to each audience—whether policymakers, technical experts, or community members—enhances the usability and uptake of the mapping outcomes.

9.0 Sustainability and Follow-Up

To ensure that natural asset mapping efforts remain relevant, credible, and impactful over time, it is essential to embed sustainability and long-term planning into the process. Mapping should not be treated as a one-off exercise, but rather as part of an ongoing system of monitoring, review, and policy integration. Sustainability depends on continued stakeholder engagement, institutional ownership, and integration into broader governance and development frameworks. This section outlines two key pillars for sustaining the value of natural asset mapping: regular updates and strategic policy linkage.

9.1. Periodic Map Updates and Reviews

Natural assets are dynamic—they may change in extent, condition, and use over time due to factors such as land use conversion, climate impacts, population growth, or restoration efforts. To maintain accuracy and relevance, periodic reviews and updates of the mapping outputs are critical.

Key actions include:

- **Establishing update intervals** (e.g., every 3–5 years) as part of local government planning cycles or environmental monitoring programs.
- **Involving community members and local institutions** in regular verification and documentation of changes in land use, access patterns, and ecological health.
- **Using remote sensing technologies, participatory mapping, and field surveys** to capture updates and compare with baseline data.
- **Institutionalizing map review protocols** within relevant departments (e.g., land, environment, planning) to ensure continuity despite staff turnover or political changes.
- **Archiving and disseminating revised maps and inventories** to stakeholders, including community organizations, county assemblies, and national agencies.
- Consistent updates allow for adaptive planning and timely responses to emerging threats or opportunities affecting natural assets.

9.2. Linking Mapping to Broader Governance and Planning Mechanisms

To have lasting policy and developmental impact, natural asset mapping must be embedded in formal governance and planning systems. When treated as a complementary input to statutory plans, mapping outputs can significantly enhance the quality, inclusivity, and sustainability of local decision-making.

Opportunities for linkage include:

- **Local Government Spatial Plans:** Mapping outputs can be integrated into County Spatial Plans and Local Physical Development Plans to inform zoning decisions, identify ecological buffers, and safeguard community access to critical resources.
- **Ecosystem Management Plans:** The data can support integrated watershed management, rangeland management, and forest restoration programs by providing spatial clarity on resource distribution and degradation hotspots.
- **Human-Wildlife Coexistence Strategies:** Asset maps help identify shared spaces (e.g., water points, migration corridors) and support proactive planning to reduce conflict and promote coexistence.
- **Community Cohesion and Peacebuilding Programs:** In areas with resource-based conflict, mapping provides a neutral evidence base for dialogue and collaboration between communities, and between communities and the State.
- **Climate Change Adaptation Plans:** Natural asset inventories can inform Ecosystem-based Adaptation (EbA) and Nature-based Solutions (NbS) in national and sub-national climate strategies.

Institutionalizing the use of asset mapping within these mechanisms ensures that natural assets are not only protected but also contribute directly to broader goals of sustainable development, conflict prevention, and environmental justice.

10.0. Lessons learnt

1. *Natural assets are often overlooked in formal planning*

   One of the most striking lessons is how many critical natural assets—such as seasonal wetlands, livestock and wildlife movement corridors, forest patches, drainage valleys, and sacred sites—are excluded from formal land use plans and policy frameworks. Mapping brings visibility to these resources and emphasizes their ecological, cultural, and economic significance.

2. *Local and Indigenous Knowledge is indispensable*

   Community knowledge often provides accurate, context-rich, and historical understanding of natural assets. Engaging local and indigenous communities in the mapping process ensures relevance, legitimacy, and richer data. It also empowers these groups to assert their rights and priorities.

3. *Participatory mapping strengthens local ownership and governance*

   When communities are involved in the mapping process—from design to validation—it increases their ownership and stewardship of natural assets. This participatory approach also fosters accountability, transparency, and social cohesion, especially in areas with overlapping or contested resource claims.

4. *Asset mapping can surface conflicts and hidden inequities*

   Mapping often reveals competing claims over land and natural resources, including historical injustices, elite capture, and gender or generational inequalities in access. These insights are important for designing inclusive governance responses and conflict resolution mechanisms.

5. *Institutional coordination is crucial*

   The success of asset mapping depends on coordination between various government departments (e.g., land, environment, wildlife, planning), NGOs, and community institutions. Fragmented governance limits the ability to translate mapping outputs into policy action.

6. *Visual evidence is a powerful advocacy tool*

   Maps and geospatial outputs can transform advocacy by providing clear, visual evidence that resonates with policymakers, media, and the public. They can help communities and civil society make strong cases for protecting or reclaiming natural assets.

7. *Legal and policy integration is essential for impact*

   Unless mapping outputs are formally recognized and integrated into legal and policy instruments (e.g., spatial plans, registries, Environmental Impact Assessment Processes), they may have limited protective value. Legal follow-up is critical to ensure lasting influence.

8. *Data maintenance and updates are often overlooked*

   A common challenge is the lack of mechanisms for updating and maintaining the mapping data over time. Without this, maps can become outdated and lose their utility for planning and advocacy.

9. *Technology must be matched with local capacity*

   While GIS and remote sensing tools are valuable, their use must be aligned with local technical capacity and access to technology. Capacity building and simplified tools increase sustainability and local usability.

10. *Asset mapping supports broader sustainability and resilience goals*

    Mapping exercises can contribute to broader objectives such as biodiversity conservation, climate resilience, land restoration, and poverty reduction—especially when aligned with national development plans and global frameworks like the SDGs and the Global Biodiversity Framework.

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11.0. Annexes

A. Sample FPIC Consent Form

Free, Prior and Informed Consent (FPIC) Form for Participatory Natural Asset Mapping

1. Project Title

Participatory Natural Asset Mapping in [Insert Community Name]

2. Implementing Organization(s)/Institutions

- Name of lead organization/Institutions: _____
- Partner organizations/Institutions (if any): _____

3. Purpose of the Mapping Exercise

This mapping exercise aims to document and map natural assets such as forests, grazing areas, water sources, sacred sites, and other ecologically and culturally important features in [Insert Community Name]. The outcomes will support [e.g., natural asset protection, land use planning, conservation, resource conflict resolution, advocacy, community development].

4. What Participation Involves

- Community members will be invited to share their knowledge of the landscape.
- The mapping will use tools such as sketch mapping, GPS, photography, and storytelling.
- Information shared may include locations of natural resources, traditional knowledge, and land uses.
- The process will include group discussions, workshops, and verification meetings.

5. Voluntary Participation

Your participation is completely voluntary. You have the right to:

- Ask questions at any time
- Decline to participate in any part of the activity
- Withdraw your consent at any point without any negative consequences

6. Data Ownership and Use

- The data and maps created will remain the **collective property of the community**.
- No data will be used for commercial purposes.
- Information will be stored securely and used only for the purposes agreed upon.
- Any sharing of information with third parties will require separate community approval.

7. Confidentiality and Anonymity

- If individual perspectives or sensitive information are collected, efforts will be made to keep this anonymous.
- No names or identifying details will be published without your explicit consent.

8. Risks and Benefits

Risks: Minimal risk is anticipated. However, disclosing resource locations may lead to external interest or exploitation. All measures will be taken to avoid such risks.

Benefits: Community members may benefit from improved recognition of their knowledge and resources, strengthened land and resource claims, and improved planning and advocacy.

9. Contact Information

For questions or concerns, please contact:

- Project Lead Name: _____
- Phone: _____ Email: _____
- Community Focal Person (if any): _____

10. Consent Declaration

I, the undersigned, have read (or have had this form read to me in a language I understand), and I understand the purpose, procedures, and implications of this mapping exercise. I have had the opportunity to ask questions and have received satisfactory answers.

☐ I voluntarily consent to participate in the participatory natural asset mapping exercise.

☐ I understand that I can withdraw at any time.

☐ I consent to the information I provide being used as outlined above.

Name of Participant: _____

Signature/Thumbprint: _____

Date: _____

Name of Witness (if participant is illiterate): _____

Signature of Witness: _____

Name of Facilitator: _____

Signature of Facilitator: _____

Date: _____

B. Protocols for collecting local data and oral histories

Protocol for Collecting Local Data and Oral Histories

For Participatory Natural Asset Mapping Exercises

1. Objectives

- To collect, document, and validate local knowledge of natural assets, ecological changes, land use practices, and culturally significant sites.
- To record oral histories and lived experiences that provide historical and intergenerational context to resource use and governance.
- To ensure community voices inform mapping outputs and land/resource planning processes.

2. Preparation and Planning

2.1. Community Entry and Consent

- Hold initial meetings with local leadership and community institutions (elders, women's groups, youth leaders) to explain the purpose and approach.
- Obtain **Free, Prior and Informed Consent (FPIC)** from participants (use written or verbal FPIC forms as appropriate).
- Clearly explain the voluntary nature of participation and how data will be used, stored, and protected.

2.2. Identify Participants

- Use purposive and snowball sampling to select knowledgeable community members, ensuring diversity in age, gender, livelihood (e.g., herders, farmers), and clan/sub-group.
- Aim for representation across different ecological zones and social groups.

2.3. Develop Tools

- Prepare semi-structured interview guides and focus group discussion (FGD) checklists.
- Include prompts for stories, memory mapping, and timelines (e.g., droughts, migration, land cover change).
- Prepare sketch maps or blank base maps for annotating during interviews or group sessions.
- Equip teams with GPS devices, notebooks, audio recorders, and consent forms.

3. Data Collection Methods

3.1. Key Informant Interviews (KIIs)

- Conduct one-on-one interviews with elders, traditional knowledge holders, local leaders, and resource users.
- Ask about changes in land use, species presence, sacred sites, natural disasters, conflict zones, and governance systems.
- Where appropriate, record interviews with consent.

3.2. Oral Histories

- Invite participants to share stories about landscape change, migration routes, land conflicts, and traditional land management practices.
- Use open-ended storytelling prompts: "Tell us what this land was like when you were young…"
- Situate stories in time (e.g., by historical events, age milestones) to create chronological understanding.

3.3. Participatory Mapping Sessions

- Organize small group sessions to draw maps or annotate satellite images or topographic maps.
- Identify and discuss areas with ecological, economic, or cultural significance.
- Capture different perceptions—e.g., women may map water sources and collection routes; herders may map grazing patterns.

3.4. Transect Walks and Ground-Truthing

- Walk across selected landscapes with local guides while observing and recording landscape features, GPS coordinates, and oral commentaries.
- Use mobile GIS or paper forms to record key landmarks, boundaries, and natural assets.

4. Ethical and Cultural Considerations

- Respect sacred knowledge and do not record or map sites that community members deem confidential.
- Avoid extractive interviews; ensure dialogues are reciprocal and participatory.
- Use local language(s) with trained facilitators and interpreters.
- Allow participants to decline questions or topics they are not comfortable discussing.
- Compensate for participants' time where appropriate (e.g., through refreshments, transport refund, or small tokens).

5. Documentation and Data Management

- Maintain secure records of all consent forms, audio recordings, and notes.
- Transcribe and translate oral histories while preserving original expressions and meanings.
- Digitize hand-drawn maps and geo-reference them as needed.
- Store data in line with national data protection laws and community governance protocols.
- Return mapped outputs and synthesized findings to the community for feedback and validation.

6. Use and Dissemination of Findings

- Ensure that collected oral histories and local data inform mapping outputs, planning tools, and policy dialogues.
- Attribute knowledge respectfully and, where applicable, collectively.
- Share accessible summaries and maps with communities in formats they can understand and use (e.g., printed maps, community meetings, posters, radio segments).

C. Mapping Tools and Equipment Checklist

Participatory Natural Asset Mapping Tools and Checklist

I. Mapping Tools

Tool Name	Purpose	When to Use	Notes
Sketch Maps (Paper-based)	Allow communities to draw their local landscapes, assets, and boundaries	Early stages; to gather perceptions	Use large paper sheets, pens, and symbols familiar to the community
Satellite Imagery Printouts	Provide spatial reference and anchor for local knowledge	Map validation or guided group mapping	Print high-resolution imagery of the area, preferably labeled
GPS Devices/ Smartphones	Geo-tag assets and verify spatial accuracy	During transect walks or ground-truthing	Ensure participants are trained on use
Participatory GIS (PGIS)	Combine local knowledge with digital mapping platforms	Intermediate/ advanced communities or post-field	Can use QGIS or other open-source platforms
Transect Walk Forms	Record observations during walks across ecological or livelihood zones	Data collection phase	Include space for GPS coordinates, asset type, issues, comments
Photo/Video Documentation	Visually record key sites, natural features, and oral explanations	Throughout mapping process	Always obtain consent before photographing people or sacred sites
Voice Recorders/ Smartphones	Record oral histories and in-depth explanations	During interviews and storytelling sessions	Backup recordings and transcribe with community guidance
Local Symbols & Icons Sheet	Ensure consistent use of community-relevant icons in maps	While creating sketch maps	Co-develop symbols with participants where possible
Flipcharts or Whiteboards	Facilitate group discussions and clustering of knowledge	During group sessions or mapping workshops	Useful for organizing themes or resource categories
Map Legend Template	Standardize meaning of colors, symbols, and map annotations	At the end of each map-making session	Create with participants for transparency and shared understanding

II. Mapping Field Checklist

A. Pre-Field Logistics

☐ Confirm community entry approvals and FPIC procedures
☐ Assemble field team with local translators/guides
☐ Print base maps or satellite imagery of mapping area
☐ Prepare sketch map materials (large papers, markers, pencils, erasers)
☐ Check and charge GPS units, smartphones, or tablets
☐ Pack voice recorders, cameras, and power banks
☐ Print consent forms and briefing materials
☐ Prepare snacks, water, and allowances for participants (if applicable)

B. During Mapping

☐ Conduct a community briefing to explain purpose and activities
☐ Facilitate group mapping sessions (women, elders, youth separately if needed)
☐ Support participants to draw, annotate, and explain features
☐ Use satellite imagery or base maps to validate sketch maps
☐ Conduct transect walks to ground-truth key sites and features
☐ Record GPS coordinates and take photos (with consent)
☐ Conduct interviews or storytelling sessions for oral histories
☐ Build or review map legends and categories together
☐ Document challenges, conflicts, or disputes encountered

C. Post-Mapping

☐ Digitize maps using GIS software (QGIS, Google Earth Pro, etc.)
☐ Cross-check field data with digital maps
☐ Store raw data securely (photos, notes, audio, GPS files)
☐ Translate and transcribe oral history recordings
☐ Return to the community for map validation and feedback
☐ Integrate local corrections or additions into final outputs
☐ Share printed or digital versions of validated maps with the community
☐ Submit final data and mapping report to project team/data curator

III. Optional Supplementary Tools

- Participatory 3D Models – For tactile and visual understanding in remote or hilly terrain
- Drone Imagery – For high-resolution visuals, only with proper approvals
- Community Scorecards – To evaluate the condition and governance of assets
- Conflict Maps – If mapping overlaps with disputed resources or boundary issues

D. Risk Assessment and Mitigation Measures

Risk Assessment and Mitigation Measures for Participatory Natural Asset Mapping

This matrix is only a suggestion, based on common risks encountered. It should be adapted to contexts.

Risk Category	Specific Risk	Potential Impact	Likelihood	Severity	Mitigation Measures	Responsible Actor(s)
Community Participation	Low turnout or lack of community engagement	Poor representation and data gaps	Medium	High	Conduct early and inclusive community mobilization; Use culturally appropriate communication; Schedule activities around local calendars	Facilitators, Community Liaison
Cultural Sensitivity	Disclosure of sacred or taboo sites	Offending cultural norms, loss of trust	Low	High	Respect community protocols; Allow anonymous sharing; Exclude or generalize sensitive locations in public maps	Mapping Team, Community Elders
Informed Consent and Ethics	Misunderstanding of consent or misuse of data	Breach of trust, reputational damage	Medium	High	Use FPIC with clear, simple language; Provide ongoing clarification; Clearly explain data use and rights	Facilitators, Project Lead
Data Security and Ownership	Unauthorized access or misuse of data	Loss of control over community knowledge	Medium	High	Store data securely; Restrict access per community protocols; Assign data custodian role	Data Manager, Community Representative
Power Imbalances	Dominance of elites or certain groups in mapping process	Marginalization of women, youth, minorities	Medium	Medium	Facilitate small inclusive group discussions; Use separate focus groups when needed; Engage local facilitators from diverse groups	Facilitators, Gender Inclusion Advisor
Environmental Hazards	Poor weather or difficult terrain during mapping	Physical risk to participants, incomplete data	High (seasonal)	Medium	Check weather forecasts; Use remote tools when needed; Plan buffer days in schedule	Field Coordinator
Political or Land Conflicts	Mapping triggers tensions over land/resource boundaries	Conflict or resistance from stakeholders	Medium	High	Engage all relevant stakeholders; Use neutral language in maps; Facilitate joint boundary dialogue where needed	Local Leaders, Peace Committees

Logistical Challenges	Delays in travel, materials, or facilitation	Disrupted timelines, budget overruns	Medium	Medium	Develop contingency budget; Identify backup resources; Maintain regular check-ins	Project Logistics Lead
Natural Disasters or Emergencies	Floods, droughts, disease outbreaks	Delays or cancellations	Low	High	Build flexibility into timeline; Prioritize safety and rescheduling; Liaise with local disaster response structures	Project Coordinator, Community Liaison

Notes:

- Likelihood: Low, Medium, High
- Severity: Low (minor disruption), Medium (moderate impact), High (major consequences)
- This matrix should be updated during each phase (planning, implementation, reporting).

E. Data Sharing Agreement Template

Data Sharing Agreement (DSA) Template for Participatory Natural Asset Mapping Exercise

1. Agreement Overview

This Data Sharing Agreement (hereafter referred to as "Agreement") is entered into on this ___ day of _____, 20___, by and between:

Community/Local Authority Name: _____

Mapping Implementing Organization: _____

Partner Organization(s) (if any): _____

Hereinafter collectively referred to as "the Parties".

2. Purpose of the Agreement

2.1. This Agreement outlines the terms and conditions for accessing, sharing, and using data collected through the Participatory Natural Asset Mapping exercise conducted in the area of _____.

2.2. The objective is to ensure that all parties respect data ownership, protect community rights, and promote ethical and transparent use of shared data.

3. Types of Data Covered

- This Agreement applies to the following categories of data
- Hand-drawn and digital natural asset map
- GPS coordinates of natural and cultural feature
- Oral histories and narrative
- Photographs, video, and audio recording
- Transcripts and field note
- Spatial data files (e.g., shapefiles, KML, GeoTIFFs)
- Any metadata or reports derived from the above

4. Ownership and Custodianship

4.1. All data generated through the mapping process remains the collective intellectual property of the community and the implementing organizations/ institutions

4.2. The implementing organization is designated as the data custodian, responsible for secure storage and managing requests for access.

5. Data Access and Use Conditions

5.1. Data may only be used for the purposes defined in this Agreement:

[Tick applicable]

☐ Community land use planning

☐ Environmental conservation

☐ Advocacy and policy engagement

☐ Academic research (with ethics approval)

☐ Conflict resolution and mediation

☐ Legislation and policy enhancement (e.g., informing bylaws, land tenure reform, natural resource governance), with prior consultation and agreement from the community

☐ Other (specify): _____

5.2. Any commercial use of the data is strictly prohibited.

5.3. Any derivative products (e.g., publications, maps, reports) must acknowledge the data origin and community contribution.

6. Confidentiality and Sensitivity

6.1. Sensitive or sacred data (e.g., locations of shrines, burial grounds, or medicinal sites) will not be published or shared outside the community without written approval.

6.2. Names or personal identifiers of individuals will be anonymized unless explicit consent is obtained.

7. Data Sharing Mechanism

7.1. Requests for access to the data must be submitted in writing to the data custodian.

7.2. The request must state:

a) Purpose of access

b) Type of data needed

c) Duration of use

d) Safeguards to protect data privacy and integrity

7.3. A Data Access Committee, composed of community representatives and mapping team members, will review requests.

8. Duration and Termination

8.1. This Agreement is valid from the date of signing and shall remain in effect for a period of ____ years.

8.2. Any party may terminate the Agreement with written notice and justification. Upon termination, shared data must be returned or destroyed, unless otherwise agreed.

9. Dispute Resolution

9.1. Disputes arising from this Agreement will first be addressed through dialogue and mediation involving community elders or appointed representatives.

9.2. If unresolved, matters may be escalated to a mutually agreed third-party mediator.

10. Signatures

By signing below, the parties agree to abide by the terms of this Data Sharing Agreement:

Community Representative(s):

Name: _____

Position/Role: _____

Signature: _____ Date: _____

Mapping Organization Representative:

Name: _____

Organization: _____

Signature: _____ Date: _____

Witness (optional):

Name: _____

Signature: _____ Date: _____

F. Protocol for Participatory Natural Asset Mapping in northern Kenya

Rationales for the mapping

Mapping all these features is crucial for protection, sustainability, and government policies for several reasons:

1. **Informed Decision-Making:** Comprehensive mapping provides accurate and up-to-date information on the location, distribution, and status of natural assets. This data enables government agencies, policymakers, and stakeholders to make informed decisions regarding land-use planning, resource management, and conservation efforts.
2. **Sustainable Resource Management:** Understanding the spatial distribution and characteristics of these features helps identify areas where sustainable practices can be implemented. This aids in balancing the needs of human development and ecological preservation, ensuring resources are utilized in a manner that meets the needs of current and future generations.
3. **Identification of Critical Areas:** Mapping these features allows for the identification of ecologically sensitive or critical areas requiring immediate protection or restoration. Early identification of such areas helps prioritize and allocate resources for conservation and management efforts.
4. **Conflict Mitigation:** Spatial data on these features can assist in addressing and mitigating potential conflicts between different land-use practices or stakeholder interests, such as agriculture, urban development, and conservation. By identifying shared resources and areas of potential conflict, policies can be developed to encourage collaboration and equitable resource distribution.
5. **Monitoring and Evaluation:** Mapping serves as a baseline for monitoring and evaluating the effectiveness of existing protection measures, management practices, and government policies. It enables the tracking of changes over time, the assessment of policy impacts, and the identification of areas where interventions may be required.
6. **Climate Change Adaptation and Resilience:** Comprehensive mapping of these features contributes to the understanding of climate change vulnerabilities and helps identify areas requiring adaptation measures. This data supports the development of policies and strategies that enhance the resilience of ecosystems and communities to climate change impacts.
7. **Research and Conservation Planning:** Accurate spatial data on these features facilitates research on ecological processes, biodiversity, and human-environment interactions. This information can inform the development of targeted conservation strategies, management plans, and policies.

In summary, mapping these features plays a critical role in promoting protection, sustainability, and evidence-based government policies. By providing detailed spatial data, mapping supports informed decision-making, sustainable resource management, conflict mitigation, climate change adaptation, and conservation planning.

Approach for Mapping Drylands Natural Assets

Definition of the research objectives

The initiation of the Drylands Natural Assets mapping project was carried out through a collaborative multistakeholder process, spearheaded by the National Land Commission and bolstered technically and financially by the Wyss Academy for Nature and CETRAD. A series of workshops took place in Laikipia, engaging crucial national agencies, non-governmental organizations, and research institutions (refer to Annex XX for a comprehensive list). Collectively, these stakeholders established the following research objectives:

> *Building a robust spatial and open access database on key fragile ecological assets in the arid and semi-arid lands of Kenya to support evidence-based just and sustainable management, planning and policies.*

List of assets and their attributes

Through this collaboration mechanism, the list of priority assets to be included in the study was finalized based on a consensus between participant experts. The final list includes two types of location data: 1) precise and well-defined location that can be mapped using geographic coordinates collected with GPS devices in the field, 2) area data that are not physically observable in the field, and that require expert knowledge to map.

Salt licks

Salt licks, also known as mineral licks, are natural deposits of essential minerals and salts that are vital for the overall health and well-being of wildlife. They play a particularly important role in the arid and semi-arid regions of Kenya, where access to these crucial nutrients may be limited due to the harsh environmental conditions. The significance of salt licks in these areas can be outlined as follows:

- **Nutrients Provision:** Salt licks provide essential minerals such as sodium, calcium, magnesium, and phosphorus, which are required for the proper growth, development, and maintenance of bodily functions in animals. In arid regions, where the availability of these nutrients in the food chain may be scarce, salt licks serve as a critical nutritional resource for wildlife.
- **Wildlife Attraction:** Salt licks act as natural congregation points for various species of wildlife, including herbivores, omnivores, and even carnivores. This attracts a diverse range of animals to a specific area, enhancing the overall biodiversity and contributing to the ecological balance of the region.
- **Ecotourism Opportunities:** The unique wildlife gathering around salt licks presents an exceptional opportunity for ecotourism. Tourists are drawn to these sites to witness the fascinating interactions between different animal species. This, in turn, generates revenue for the local communities and promotes conservation efforts.
- **Research and Monitoring:** Salt licks are valuable for researchers and conservationists as they provide an opportunity to study and monitor the health, behavior, and population dynamics of various wildlife species. This information is essential for devising appropriate conservation strategies and managing the delicate ecosystems in arid and semi-arid regions of Kenya.

In the arid and semi-arid regions of Kenya, salt licks are typically found in smaller sizes due to the harsh environmental conditions and limited water availability. However, the size of each salt lick is subject to change over time, as erosion, weathering, and other natural processes may alter its dimensions.

Swamps and Wetlands

Swamps and wetlands are unique ecosystems characterized by their saturated soil conditions and the presence of water-adapted vegetation. They play a vital role in the ecology of both arid and semi-arid regions of Kenya, providing essential habitats and resources for a variety of flora and fauna. The importance of swamps and wetlands in these areas can be outlined as follows:

- **Water Filtration and Storage:** Swamps and wetlands act as natural filters, removing pollutants and sediments from the water that flows through them. This improves water

quality and helps maintain the health of downstream ecosystems. Additionally, they serve as vital water storage areas, particularly in arid regions where water scarcity is common.

- **Habitat Provision:** Swamps and wetlands provide essential habitats for a diverse range of plant and animal species, including many that are specially adapted to these unique environments. This contributes to the overall biodiversity and ecological balance of the region.
- **Flood Mitigation:** These ecosystems play a crucial role in flood mitigation by absorbing and storing excess water during heavy rainfall events. This reduces the risk of flooding in surrounding areas and helps to protect both human settlements and valuable agricultural lands.
- **Ecotourism Opportunities:** Swamps and wetlands are rich in biodiversity and offer unique opportunities for ecotourism, attracting visitors who wish to observe the fascinating array of plant and animal life found in these environments. This, in turn, generates revenue for local communities and promotes conservation efforts.

Research and Monitoring: Swamps and wetlands serve as invaluable resources for researchers and conservationists, providing opportunities to study and monitor the health, behavior, and population dynamics of various plant and animal species. This information is essential for developing effective conservation strategies and managing the delicate ecosystems in arid and semi-arid regions of Kenya.

Rock catchments

Rock catchments are natural or engineered formations that facilitate the collection, storage, and management of rainwater in areas with limited water resources. They play a particularly important role in the arid and semi-arid regions of Kenya, where water scarcity is a pressing concern. The significance of rock catchments in these areas can be outlined as follows:

- **Water Harvesting:** Rock catchments enable the effective capture and storage of rainwater, providing a valuable water source in arid regions with scarce surface water and unreliable rainfall patterns. This harvested water can be used for various purposes, including drinking, irrigation, and livestock watering.
- **Erosion Control:** By capturing rainwater and reducing surface runoff, rock catchments help to minimize soil erosion, preserving the fertility of the land and preventing the degradation of vital ecosystems in arid and semi-arid regions.
- **Groundwater Recharge:** Rock catchments contribute to groundwater recharge by allowing water to infiltrate the soil and replenish underground aquifers. This is particularly important in arid areas, where groundwater resources may be limited and overexploited.
- **Ecotourism Opportunities:** Some rock catchments, particularly those with unique geological features or in scenic locations, can attract tourists who are interested in the natural beauty of these formations. This, in turn, generates revenue for local communities and promotes conservation efforts.
- **Research and Monitoring:** Rock catchments provide valuable opportunities for researchers and conservationists to study the hydrological processes, water quality, and ecological interactions associated with these unique water collection systems. This information is essential for devising effective water management strategies and maintaining the ecological balance in arid and semi-arid regions of Kenya.

Springs

Springs are natural sources of water that emerge from the ground, typically as a result of groundwater being discharged at the Earth's surface. They play a significant role in the ecology of arid and semi-arid regions of Kenya, providing essential water resources in areas where water scarcity is a persistent challenge. The importance of springs in these areas can be outlined as follows:

- **Water Supply:** Springs serve as a reliable source of fresh water for drinking, irrigation, and livestock watering in arid regions, where surface water resources are often scarce and subject to seasonal fluctuations.

» **Habitat Provision:** Springs create unique microhabitats that support a diverse range of plant and animal species, including many that are specifically adapted to these environments. This contributes to the overall biodiversity and ecological balance of the region.

» **Groundwater Discharge:** Springs act as natural outlets for groundwater discharge, maintaining the hydrological balance between recharge and discharge processes in the aquifer system. This is particularly important in arid areas, where groundwater resources may be limited and subject to overexploitation.

» **Research and Monitoring:** Springs serve as valuable resources for researchers and conservationists, providing opportunities to study the hydrogeology, water quality, and ecological interactions associated with these unique water sources. This information is essential for developing effective water management strategies and maintaining the ecological balance in arid and semi-arid regions of Kenya.

Laggas

Lagas, also known as laggas or wadis, are ephemeral riverbeds or channels that only carry water during periods of heavy rainfall. They are common features in arid and semi-arid regions, including Kenya, where they play a crucial role in the ecology and hydrology of the landscape. The significance of lagas in these areas can be outlined as follows:

1. **Water Flow and Drainage:** Lagas facilitate the flow of water during heavy rainfall events, acting as natural drainage systems that prevent flooding in the surrounding areas. This helps to protect local communities, infrastructure, and agricultural lands from the adverse effects of flash floods.
2. **Groundwater Recharge:** As water flows through lagas, it infiltrates the soil, recharging underground aquifers and contributing to the overall groundwater resources in arid and semi-arid regions. This process is particularly important in areas where groundwater resources are limited and heavily relied upon for various purposes.
3. **Habitat Provision:** During periods of water flow, lagas support a range of plant and animal species that are specifically adapted to these ephemeral environments. This contributes to the overall biodiversity and ecological balance of the region.
4. **Soil Fertility and Erosion Control:** The sediment carried by water flow in lagas can help to replenish soil fertility in the surrounding areas. Additionally, the presence of vegetation in and around lagas aids erosion control by stabilizing the soil and reducing surface runoff.
5. **Grazing:** During wet periods, laggas can support the growth of vegetation, providing important grazing areas for livestock. This helps local communities maintain their livestock and support their livelihoods.
6. **Cultural Significance:** Laggas may hold cultural and historical significance for local communities, as they have shaped the landscape over time and influenced traditional practices, beliefs, and local knowledge. These ephemeral watercourses can also serve as natural boundaries, navigation aids, or locations for communal gatherings.
7. **Ecotourism Opportunities:** The unique landscape features and biodiversity found in lagas can attract tourists interested in exploring these distinctive ecosystems. This, in turn, generates revenue for local communities and promotes conservation efforts.
8. **Research and Monitoring:** Lagas provide valuable opportunities for researchers and conservationists to study hydrological processes, ecological interactions, and the response of these unique systems to climate change and human activities. This information is essential for developing effective water management and conservation strategies in arid and semi-arid regions of Kenya.

Dry season grazing areas

Dry season grazing areas, also known as dry season pastures, are designated regions with relatively better forage availability during the dry season, when the overall vegetation cover and water resources are limited in arid and semi-arid regions. These areas are crucial for the survival of livestock and the livelihoods of local communities in arid areas of Kenya. The importance of dry season grazing areas can be outlined as follows:

1. **Livestock Survival:** Dry season grazing areas provide essential forage resources for livestock during the dry season when other areas may have limited or no vegetation. This helps to ensure the survival and health of animals, which are vital to the livelihoods of pastoralist communities in arid regions.
2. **Pasture Management:** By designating specific areas for dry season grazing, communities can practice more sustainable pasture management, reducing the risk of overgrazing and land degradation. This ensures that the rangelands remain productive and can support livestock throughout the year.
3. **Reduced Conflict:** Competition for grazing resources can lead to conflicts between pastoralist communities. Dry season grazing areas help to alleviate such tensions by providing designated zones where communities can share resources, thus promoting peaceful coexistence and cooperation.
4. **Diversified Livelihoods:** Dry season grazing areas can also support other livelihood activities, such as beekeeping and the collection of non-timber forest products, which can provide additional income sources for local communities during the dry season.
5. **Biodiversity Conservation:** By promoting sustainable land use practices, dry season grazing areas can help to conserve local biodiversity, protecting the ecosystems that support both human livelihoods and wildlife populations.
6. **Cultural Significance:** Dry season grazing areas often have cultural and historical significance for local communities, as they have been traditionally used by pastoralists for generations. Preserving these areas helps maintain cultural heritage and traditional knowledge of sustainable land management practices.

Livestock corridors

Livestock routes, also known as pastoral corridors or transhumance pathways, are traditional pathways used by pastoralist communities to move their herds between different grazing areas throughout the year. These routes are crucial for the survival of livestock and the livelihoods of local communities in arid and semi-arid regions, such as Kenya. The importance of livestock routes can be outlined as follows:

1. **Seasonal Resource Access:** Livestock routes facilitate the movement of herds between wet and dry season grazing areas, enabling pastoralists to access vital water and pasture resources throughout the year. This helps ensure the survival and health of livestock, which are critical to the livelihoods of pastoralist communities.
2. **Land Use Efficiency:** By utilizing livestock routes, pastoralists can practice rotational grazing and avoid overgrazing in specific areas. This promotes sustainable land use and helps maintain the productivity and biodiversity of rangelands.
3. **Conflict Mitigation:** Livestock routes enable pastoralist communities to share resources and avoid conflicts over water and pasture access. By defining specific routes for livestock movement, communities can minimize competition and promote peaceful coexistence.
4. **Traditional Knowledge Preservation:** Livestock routes have been established and maintained by pastoralist communities over generations, reflecting a wealth of traditional knowledge related to animal husbandry, navigation, and resource management. Preserving these routes helps maintain cultural heritage and pass on traditional knowledge to future generations.

5. **Disease Control:** The movement of livestock along designated routes can help control the spread of diseases by minimizing contact between herds from different areas. This is particularly important in regions where livestock diseases can have significant impacts on the health and productivity of herds.
6. **Climate Change Resilience:** As climate change affects the availability and distribution of water and pasture resources, livestock routes allow pastoralists to adapt their movements to changing conditions. This flexibility helps pastoral communities maintain their livelihoods in the face of environmental uncertainties.

Livestock routes play an essential role in the ecology and socio-economic well-being of pastoralist communities in arid and semi-arid regions, such as Kenya. These routes provide access to seasonal resources, promote sustainable land use, mitigate conflicts, preserve traditional knowledge, facilitate disease control, and enhance climate change resilience for local communities.

Wildlife concentration areas

Wildlife concentration areas are specific regions where wildlife populations tend to congregate due to the presence of essential resources such as water, food, or suitable habitats. These areas play a crucial role in the ecology and conservation of wildlife in arid and semi-arid regions, such as Kenya. The importance of wildlife concentration areas can be outlined as follows:

1. **Resource Availability:** Wildlife concentration areas provide critical resources, such as water, food, and shelter, for various species during different seasons. This is particularly important in arid and semi-arid regions, where resources are often scarce and unevenly distributed.
2. **Biodiversity Conservation:** By supporting a high density of wildlife populations, wildlife concentration areas contribute to the overall biodiversity and ecological balance of the region. This is essential for maintaining healthy ecosystems and ensuring the long-term survival of different species.
3. **Breeding and Nursery Grounds:** Wildlife concentration areas often serve as breeding and nursery grounds for various species, providing a safe environment for mating, nesting, and raising offspring. This is crucial for maintaining healthy populations and ensuring the continued survival of species in arid and semi-arid regions.
4. **Research and Monitoring:** Wildlife concentration areas provide valuable opportunities for researchers and conservationists to study and monitor the health, behavior, and population dynamics of various wildlife species. This information is essential for devising appropriate conservation strategies and managing the delicate ecosystems in arid and semi-arid regions.
5. **Ecotourism Opportunities:** The high density of wildlife in concentration areas attracts tourists who are interested in observing and learning about the region's unique flora and fauna. This, in turn, generates revenue for local communities and promotes conservation efforts through the sustainable use of natural resources.
6. **Cultural Significance:** Wildlife concentration areas may hold cultural and historical significance for local communities, as they have shaped the landscape over time and influenced traditional practices, beliefs, and local knowledge.

Wildlife concentration areas play a vital role in the ecology and conservation of arid and semi-arid regions, such as Kenya. They provide essential resources, support biodiversity, serve as breeding and nursery grounds, offer opportunities for research and ecotourism, and preserve cultural heritage. The protection and management of these areas are essential for the long-term survival of wildlife populations and the well-being of local communities.

Sand Dams

Sand dams are structures built across seasonal riverbeds to capture and store water within sand deposits. They play a significant role in arid and semi-arid regions, where water scarcity is a common challenge. The importance of sand dams can be outlined as follows:

- Water Storage and Supply: Sand dams provide a reliable source of water for local communities, livestock, and agriculture by capturing and storing water from seasonal rivers.
- Groundwater Recharge: By storing water within sand deposits, sand dams contribute to groundwater recharge and help maintain aquifer levels.
- Erosion Control and Riverbank Stabilization: Sand dams mitigate soil erosion and help stabilize riverbanks, protecting surrounding ecosystems and agricultural lands.
- Support for Agriculture and Irrigation: Sand dams enable communities to practice agriculture and irrigation in arid regions by ensuring a consistent water supply.
- Enhanced Biodiversity: By creating water access points for wildlife, sand dams contribute to enhancing biodiversity in arid regions.
- Climate Change Adaptation and Resilience: Sand dams offer a sustainable solution to water scarcity, helping communities adapt to climate change and build resilience against drought.

Wildlife Corridors:

Wildlife corridors are natural or man-made routes that connect fragmented habitats, allowing wildlife to move freely between them. They are essential for maintaining ecological connectivity in arid and semi-arid regions. The importance of wildlife corridors can be outlined as follows:

- Facilitating Animal Movement and Genetic Exchange: Wildlife corridors enable animals to move between isolated habitats, promoting genetic exchange and preventing inbreeding within populations.
- Reducing Human-Wildlife Conflicts: By providing dedicated routes for animal movement, wildlife corridors can help reduce human-wildlife conflicts, such as crop damage and livestock predation.
- Enhancing Biodiversity and Ecological Resilience: Wildlife corridors contribute to preserving and enhancing biodiversity by enabling species to access and recolonize habitats.
- Mitigating Habitat Fragmentation and Climate Change Effects: Wildlife corridors help mitigate the impacts of habitat fragmentation and climate change by connecting habitats and allowing species to adapt to changing conditions.
- Research and Conservation Planning: Wildlife corridors provide valuable opportunities for researchers and conservationists to study animal movement patterns and devise conservation strategies.
- Supporting Ecotourism: Healthy and connected wildlife populations in protected areas can attract tourists and generate revenue for local communities, promoting conservation efforts.

Ponds:

Ponds are small, shallow bodies of water that provide crucial resources for both human and wildlife populations in arid and semi-arid regions. The importance of ponds can be outlined as follows:

- **Water Storage:** Ponds serve as water storage facilities for local communities, agriculture, and livestock, especially during dry seasons when water is scarce.
- **Biodiversity and Habitat Provision:** Ponds provide habitats for various aquatic, amphibious, and terrestrial species, contributing to biodiversity conservation in arid regions.
- **Breeding and Nursery Grounds:** Ponds serve as breeding and nursery grounds for aquatic and amphibious species, helping maintain healthy populations.
- **Flood Control and Sediment Capture:** Ponds can help regulate water flow and reduce flooding while capturing sediment, thus minimizing erosion.
- **Recreational and Ecotourism Opportunities:** Ponds can offer recreational and ecotourism opportunities for local communities and tourists, generating income and promoting conservation efforts.

Shallow Wells

Shallow wells are small-scale, usually hand-dug, groundwater extraction points used for domestic or agricultural purposes in arid and semi-arid regions. The importance of shallow wells can be outlined as follows:

- **Providing a Reliable Water Source:** Shallow wells offer a reliable source of water for local communities and livestock, helping to sustain their livelihoods in arid regions.
- **Supporting Small-scale Agriculture and Irrigation:** Shallow wells provide water for small-scale agriculture and irrigation, enabling communities to grow food and maintain livestock even in arid conditions.
- **Enhancing Community Resilience:** Access to reliable water sources, such as shallow wells, can enhance the resilience of communities in the face of drought and climate change.
- **Reducing Pressure on Surface Water Resources**: By tapping into groundwater resources, shallow wells help alleviate the pressure on surface water resources, promoting more sustainable water management practices.

Mining Sites:

Mining sites are areas where minerals and other resources are extracted from the earth. While mining can have negative environmental impacts, responsible mining practices can contribute to local economies and development in arid and semi-arid regions. The importance of mining sites can be outlined as follows:

- **Economic Growth and Employment Opportunities:** Mining activities can create jobs and stimulate economic growth, improving the livelihoods of local communities in arid regions.
- **Infrastructure Development and Improved Access to Resources:** Mining projects often involve the construction of roads, bridges, and other infrastructure, which can facilitate access to resources and services for local communities.
- **Responsible and Sustainable Resource Extraction:** With proper planning, regulation, and enforcement, mining can be conducted responsibly and sustainably, minimizing negative environmental impacts and maximizing benefits for local communities.
- **Research and Monitoring:** Mining sites can provide valuable opportunities for researchers to study the environmental impacts of resource extraction, monitor ecosystem changes, and develop strategies for ecological restoration and remediation.

Summary of assets and their importance

Feature	Importance	Collection method
Salt Licks	- Nutrient provision for wildlife- Wildlife attraction - Ecotourism opportunities - Research and monitoring	GPS
Swamps and Wetlands	- Water storage and purification - Flood control - Biodiversity and habitat provision - Carbon sequestration - Livelihood support (fishing, farming, etc.) - Ecotourism opportunities	GPS
Rock Catchments	- Rainwater harvesting - Groundwater recharge - Erosion control - Wildlife habitat - Ecotourism opportunities - Research and monitoring	GPS
Springs	- Freshwater source - Irrigation and agriculture support - Biodiversity and habitat provision - Cultural and historical significance - Ecotourism opportunities - Research and monitoring	GPS
Lagas (Laggas)	- Water flow and drainage - Groundwater recharge - Habitat provision - Soil fertility and erosion control - Ecotourism opportunities - Research and monitoring	GPS + satellite
Dry Season Grazing Areas	- Livestock survival - Pasture management - Reduced conflict - Diversified livelihoods - Biodiversity conservation - Cultural significance	Participatory mapping
Livestock Routes	- Seasonal resource access - Land use efficiency - Conflict mitigation - Traditional knowledge preservation - Disease control - Climate change resilience	Participatory mapping
Wildlife Concentration Areas	- Resource availability - Biodiversity conservation - Breeding and nursery grounds - Research and monitoring - Ecotourism opportunities - Cultural significance	Participatory mapping
Sand Dams	- Water storage and supply - Groundwater recharge - Erosion control - Support for agriculture and irrigation - Enhanced biodiversity - Climate change adaptation and resilience	GPS
Wildlife Corridors	Facilitating animal movement and genetic exchange - Reducing human-wildlife conflicts - Enhancing biodiversity and ecological resilience - Mitigating habitat fragmentation and climate change effects - Research and conservation planning - Supporting ecotourism	Participatory mapping
Ponds	Water storage for communities, agriculture, and livestock - Biodiversity and habitat provision - Breeding and nursery grounds - Flood control and sediment capture - Recreational and ecotourism opportunities	GPS + Satellite
Shallow Wells	Reliable water source for communities and livestock - Small-scale agriculture and irrigation support - Enhancing resilience to drought and climate change - Reducing pressure on surface water resources	GPS
Mining Sites	- Economic growth and employment opportunities - Infrastructure development and improved access to resources - Responsible and sustainable resource extraction - Research and monitoring of environmental impacts and remediation efforts	GPS

Attribute data

For each category of asset, a comprehensive list of additional information was formulated to optimize the utility and potential applications of the database. With the assistance of local experts, data collection focused on aspects such as property rights, resource usage, seasonality and long-term trends, user conflicts, local names, and any surrounding protection or management infrastructure. For assets gathered in the field using the mobile application, multiple photographs were captured to provide visual documentation. This approach ensures that the database is both comprehensive and relevant to the various stakeholders and use cases in the context of the Kenyan government's objectives.

Modelling drainage system

A Digital Elevation Model (DEM) with a 30m resolution was utilized to generate a model for the drainage system across the county landscapes. The drainage system modeling was carried out using the watershed function in the Soil and Water Assessment Tool (SWAT), combined with the ArcSWAT plugin in ArcGIS (version 10.8). A resolution of 100 hectares was employed to generate the drainage features, aiming to produce a higher-resolution drainage network distribution. However, the drainage model faced an inherent issue of channel simplification at a 100-hectare scale, leading to a misalignment between the drainage model and the channels observed in higher-resolution satellite images and Google Earth. Consequently, manual alignment was conducted to ensure that the drainage model corresponded with the channel shapes observed in satellite images and Google Earth.

The mobile application

The mobile field data collection application was developed using ESRI Survey 123 technology, tailored to the list of assets and corresponding information requirements. The tool underwent multiple iterations of testing under real-life conditions and subsequent refinement. Mobile devices were set up to automatically transmit records to the central database hosted at the University of Bern. Research assistants participated in a two-day training program, followed by sessions to discuss feedback on the application's usability and any encountered issues before commencing field surveys. This approach ensured that the data collection process was efficient, accurate, and in line with the project's objectives.

Preparation of Participatory Field Maps (Desktop)

For the participatory mapping exercise, maps were prepared and printed in A0 format beforehand. High-resolution satellite imagery served as the background, with additional geographic information overlaid to assist participants in orienting themselves on the maps. This supplementary information included main roads, settlements, administrative boundaries, and drainage features (rivers and laggas). The integration of these elements facilitated a more effective and accurate mapping process, enabling participants to efficiently identify and locate pertinent geographic features within the study area.

Field data collection (Participatory Field Maps)

At each site, the project team leader engaged with local authorities to facilitate a gathering with a group of knowledgeable residents. This initial meeting served as a formal introduction to the project and was followed by a participatory mapping exercise.

In order to acclimate participants to the process, the first step involved orientation using the A0 printed maps, allowing participants to pinpoint their locations. They were then guided to identify and annotate the primary rivers and laggas, providing names and documenting key characteristics.

Subsequently, the mapping exercise extended to assets that couldn't be pinpointed using GPS coordinates. These included wildlife concentration areas and corridors, livestock routes and grazing areas, and regions of dense vegetation. Capturing this information is essential for its later inclusion in the broader mapping project.

The third step of the process was not intended to contribute directly to the final database. Instead, the preliminary mapping of the other assets' locations on the printed map served as a planning tool to organize fieldwork. It assisted in distributing specific areas among various teams for field data collection and ground truthing.

These participatory exercises have proven to be highly effective, not only in generating the necessary data, but also in engaging resource persons productively within the project's scope.

Field data collection (mobile application)

The fieldwork phase involved researchers, assisted by local resource persons, visiting each individual asset in the study area. The ESRI Survey 123 mobile application was instrumental in this process, serving as the primary tool for data collection.

Each asset was geolocated using the application's GPS functionality, ensuring precise and accurate geographical information. In addition to this, pictures of each asset were captured using the mobile devices, providing a visual record that supplements the collected data.

Moreover, the application facilitated the documentation of other relevant information about each asset. This included details such as the asset's physical characteristics, its usage, seasonal variations, potential conflicts, and any associated traditional or local names. The mobile devices were set up to automatically transmit this collected data to a central database hosted at the University of Bern.

This methodology, combining technology and local knowledge, ensured a comprehensive, accurate, and efficient data collection process, ultimately contributing to the robustness of the final database.

Digitizing Participatory Field Maps

Mounting and Scanning

Participatory Field Maps were generated and satellite images clipped to the extent of the administrative location boundaries. These maps were printed based on the administrative location boundaries and used for guiding local communities in identifying and sketching on the map wildlife and livestock resources. These resources include wetlands, springs and other water point features, drainage channels, salt licks, wildlife and livestock routes, wildlife concentration areas, breeding sites for selected wildlife species. These Participatory Field Maps were set and mounted on a wallboard one at a time for scanning. Each of the maps were scanned using smartphone; while perpendicular position was maintained throughout the scanning process in order to minimize distortion of images and ensuring quality on digitized layer. All the scanned copies were transferred to the project directory in computer external drives where they were sorted out into administrative location boundaries that was used for clipping satellite image.

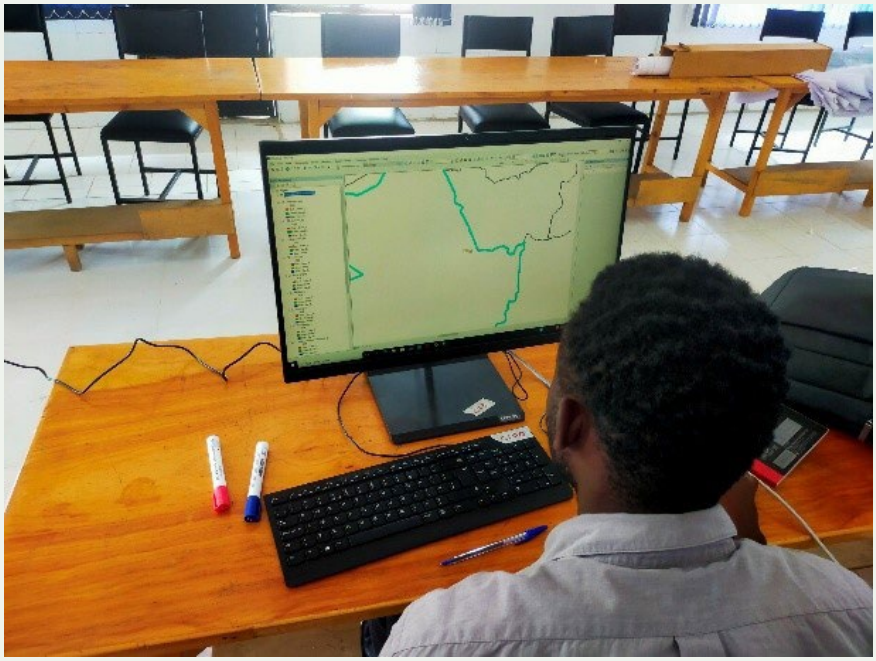
Georeferencing and digitization

Georeferencing

Georeferencing was performed in ArcMap/Pro environment. Scanned maps were added into the viewer extent in ArcMap/Pro one at a time together with the Kenya Location Layer. Since the scanned layer is not georeferenced, the image does not overlay on the Kenya Location layer which already have spatial reference. In order to begin georeferencing, scanned image was inspected by zooming into at least four angle points that defines the extent of the administrative boundaries. Georeferencing tool was activated in ArcGIS for preparation for georeferencing. Warping technique was used for georeferencing; this is where defining angle point in the scanned image was zoomed into and control point (CP) added. The technique works by acquiring coordinates for adding into the CP from the administrative location boundary with spatial reference. Thus, same angle point was zoomed into on Kenya Location Layer and the defining angle point clicked to acquire coordinated for georeferencing. Image rectification was used in order to generate new georeferenced layer while preserving the scanned images for future use. The process was repeated for the other remaining angle points in the same scanned map, and for the whole scanned images in the directory. From this process, all the scanned images were georeferenced and overlaid exactly on the Kenya Location Layer in ArcMap/Pro.

Digitization

All information that was sketched by the local communities in the paper maps and later scanned and georeferenced was acquired into vector format by digitization process. The sketched features were converted into points, polyline or polygon features were necessary. First, digitization layer was created in ArcCatalogue for each thematic feature.



Building attributes for drainage system

Field data collection and validation contributed to information for building attributes for the drainage features. These included information such as local names of the drainage channels (river or lagga), seasonality, precipitation etc. Field and desktop generated data was transferred to drainage layer using spatial join with distance intersection in order to include point data that were not occurring exactly on the drainage channels.

Geodatabase and geoportal

Following the field data collection, the subsequent phase involved data cleaning, verification, and integration into the geodatabase and geoportal. This process ensured the accuracy and usability of the collected data, thus enhancing the quality of the final output. Here's how each step was conducted:

1. Data Cleaning: This step involved the removal of any irrelevant, duplicate, or erroneous entries from the collected data. This could include inaccuracies in GPS coordinates, inconsistencies in asset descriptions, or any anomalies in the data that may have occurred during the collection process. Data cleaning ensured that the database was concise, accurate, and free from any misleading information.
2. Verification: After cleaning the data, it underwent a process of verification. This involved cross-checking the cleaned data with the original field notes, images, and other sources of information to ensure its accuracy and authenticity. Any discrepancies identified during this stage were resolved by referring back to the original data sources or conducting additional field visits if necessary.
3. Integration into the Geodatabase: Once cleaned and verified, the data was integrated into the geodatabase. This process involved organizing and structuring the data in a way that allowed for efficient storage, retrieval, and analysis of geographic information. The integration process also ensured that the data was compatible with the geodatabase's existing structure and formats.
4. Geoportal Update: Finally, the cleaned, verified, and integrated data was uploaded to the geoportal. This step involved ensuring that the data was correctly displayed and was easily accessible for users of the portal. It also involved updating any associated metadata to reflect the new data additions.

By following these steps, the field data collected using the mobile application was transformed into a reliable and user-friendly resource that could be effectively used for planning, policy-making, and asset management in the arid and semi-arid regions of Kenya.

Sharing of the content on the geoportal

Once the data was cleaned, verified, and integrated into the geodatabase, it was made accessible through the geoportal via a metadata catalogue. This catalogue is a structured resource that provides detailed information about each data set, including its source, collection methods, time of collection, geographic coverage, and other relevant details. To facilitate user-friendly access to this vast data repository, the metadata catalogue is equipped with advanced search functionalities. These functionalities allow users to search for data based on various parameters, offering a streamlined and efficient data discovery process.

In addition to the metadata catalogue, the geoportal features a suite of interactive data visualization and mapping tools. These tools allow users to explore the data visually, helping them understand complex data sets and geographic relationships more intuitively. Data visualization tools can transform raw data into informative charts, graphs, and maps, thereby simplifying the data analysis process.

Moreover, these interactive tools play a crucial role in communicating insights derived from the data effectively. By providing clear, visual representations of the data, these tools help users interpret and understand the implications of the data, aiding in the formulation of informed decisions.

Ultimately, the geoportal aims to transform the collected data into actionable decision-support tools. By offering easy access to the data, along with powerful visualization and mapping tools, the geoportal empowers policy-makers, planners, and managers to leverage the data effectively for sustainable management and planning in the arid and semi-arid regions of Kenya.