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RESEARCH ARTICLE

Blending Spatial Information Management Technologies and Participatory Approaches to Develop Land Use Plans for Community-Based Natural Resources Management: A Case of Keiyo and Marakwet Districts, Kenya

J. G. Muchemi
ERMIS Africa, P. O. Box 11349, Nairobi, Kenya,
julius@ermisafrica.org

E. K. Ucakuwun
ucakuwun@gmail.com

Wangu Mungai

H. Greijn
hgreijn@snvworld.org

Abstract

This paper describes how 'Modern Spatial Information Technologies' has been blended with Participatory Approaches to yield 'Participatory-GIS as a tool, process and practice for use in facilitating the preparation of participatory land use planning at local levels in Kenya. The resulting plans have been used to guide community-based natural resource management among rural-based communities in Keiyo and Marakwet Districts in the Rift Valley Region. While GIS and Remote Sensing techniques provided scientific methodologies for generating reliable land use planning data, participatory approaches enhances consultation and participation of local communities that leads to broad community support for the development agenda, plans and actions. If well applied, Participatory-GIS can become an indispensible practice for empowering local communities to actively participate in social, economic and political that configures how development resources are allocate, accessed and utilized.. Given that participatory-GIS was a new tool and practice to guide participatory land use planning among local community and government staff, its introduction was systematically organized to not only demonstrate the ease of applying it but also to explicitly show its value-addition to the traditional land use planning approaches while enhancing enthusiasm among the development practitioners to catalyze its adoption in similar and other development initiatives. The technical part of the planning process consisted of three steps. The first step included the use of participatory rural appraisal (PRA) approaches and tools to inventory natural resources, document seasonal calendar the availability of the resources and required gender differentiated labor, and establishing of multi-temporal resources use trend. The second step entailed the use of Participatory-GIS approach and technologies in mapping out the resource. This included: sourcing for aerial photographs of 1991 and conducting an aerial photography to acquire images of year 2000; delineating the land cover types from the aerial photos, and a combination of visual and GIS-supported interpretation and analysis of land cover types and land cover changes over the ten years (1991 - 2000) of land use. The third step involved the use of the derived spatial data and information products to develop land use plans. This entailed further consultations with the communities to document their community based natural resource management needs; validation of their past and current land uses and trends as depicted from the aerial photograph interpretation and GIS analysis, documenting any social, cultural, economic and political impacts resulting from the 10 years of land use, and developing plans address any issues arising from the ten-years of land use. Results show that communities are able to use devolved remotes sensing and GIS technologies such as aerial photo-enlargements to generate crucial data and information for guiding land use planning process. In addition, Participatory-GIS proved a vital tool and practice of narrowing the gap between development technocrats and local community as it provides a commonly understood pictorial, graphical and illustrative language thus improving consultation and participation. Conversely, if not well planned and facilitated, participatory-GIS like other traditional approaches can fail to reach out to minority community groups who might already be structurally marginalized and discriminated by the dominant society and the state decision making mechanisms. The communities are able to participate in the formulation and implementation of a better land use policy and guidelines, making projections on the utility of land and natural resources, identify future development pressure points and areas, and implement effective land use plans for effective regional development.

Key Words: Participatory-GIS, Participatory Land Use Planning, Remote Sensing, Aerial Photography, Traditional Ecological Knowledge

Introduction

Land Use Planning Concept

Optimal return from investment in land use, whether public, communal or private, is determined by the extent to which planning of its use is informed. Land use planning is designed to match different land uses with the areas that yield the greatest benefits at the least cost receiving the greatest investment (FAO/UNEP, 1999).

In making such an intricate decision on communal land, communities must make several considerations. These include: determine their current and future livelihood needs, the land uses that would meet these needs, available land holdings that can accommodate the desired land uses, and the limitations facing the various land uses.

Land use plans, apart from their role in optimizing returns from investment in land, are crucial to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss habitats. Land use data are needed in the analysis of environmental processes and problems that must be understood if livelihood and environmental conservation are to be improved. One of the prime prerequisites for better use of land is information on existing patterns and changes in land use through time.

Role of Local Community in Land Use Planning Process

Land use planning at community level is mainly determined by traditional land use practices and the relevance of externally introduced land management practice. Traditional ecological knowledge and perceptions held by community are crucial in determining adoption of environmental conservation approaches and technologies. Local communities accumulate a wide body of knowledge for over generations through systematic observation of ecosystem processes and changes that are associated with certain land use patterns and climatic variability. In an attempt to mitigate adverse environment impacts from certain land use patterns, communities develop a culture of resource use, conservation and protection. In addition, the social norms, values and cultural practices are embedded on the landscape through an intricate association of spiritual, human and natural worldviews. Ecosystem can thus be conserved to meet livelihood and spiritual needs.

Study Area

Marakwet district is administratively situated in the Rift Valley Province of Kenya. It lies between latitude 0^o 51’ N and 1^o 19’ N and longitudes 35^o 29’ E and 35^o 43’ W (Figure 1). It has a total area of 1707 km^2. The district was curved out on 4^{th} August 1994 from the Elgeiyo–Marakwet -created in the colonial era to form one of the 18 districts in Rift Valley Province (DDP, 2000). The district borders West Pokot to the north, Trans Nzoia to the north east, Uasin Gishu to the south west, Koibatek to the south, and Baringo to the west. The western extent of the district is marked by Kerio River, which flows northwards into Lake Turkana (Chebet & Dietz, 2000; Jeatzold & Schmidt, 1983).

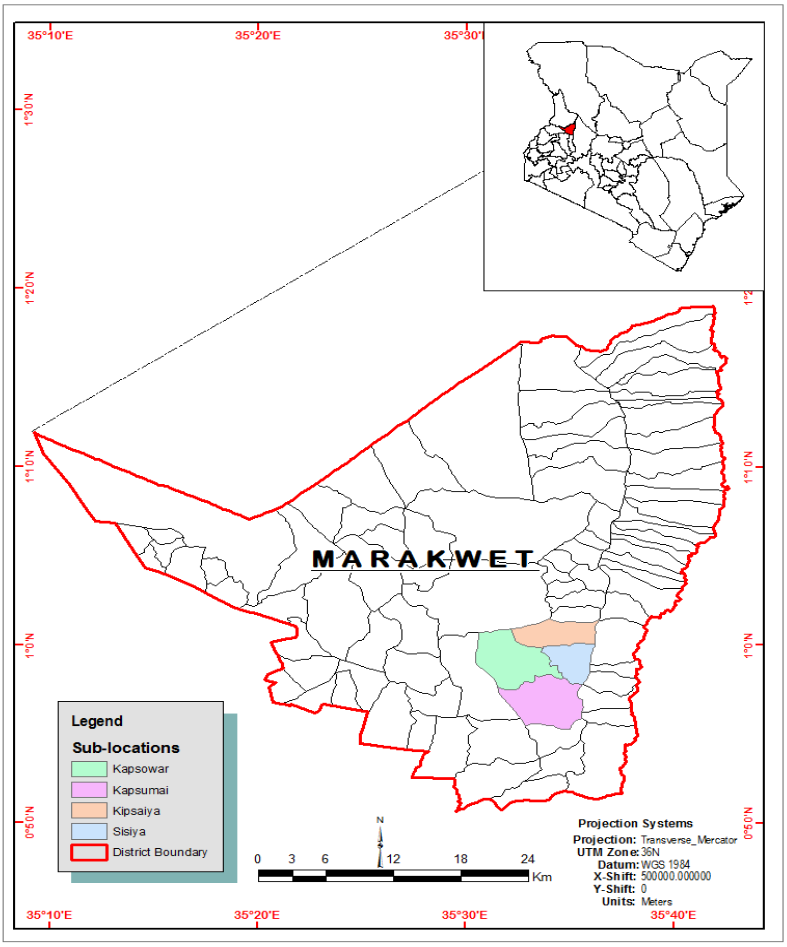

Figure 1. Study Area

The district has diverse climatic characteristics which are influenced by three geographic zones. These include the humid highlands –locally referred to as *Mosop* which is located at an altitude of about 2400 m, the semi-arid escarpment -locally referred to as *Lagam*, and the Kerio valley –locally referred to as *Keu* located at an altitude of 1000 m. The north-southerly valley, locally known as Kerio Valley consists of a steep mountainous slopes with shallow rocky and boulder soils with sediment deposits.

The southern half of Kerio Valley consists of volcanic rocks, while the northern part is dominated by metamorphic rocks (MALDM, 1994).

The Research Problem

The study area is faced with three land use planning dilemmas. This include: a national land use planning process that is incongruent with local realities; accelerated socio-economic and political activities within the district; and scarcity of quality data and information for facilitating meaningful local land use plans.

National Land Use Planning Context

In Kenya, development planning process has been characterized by top-down planning process where community views are required to conform to the national development agenda and plans. Communities are usually required to implement the national plans as the only basis for receiving extension support and development funding from the relevant ministerial budgetary allocations. The national plans mostly focus at the regional context without paying much attention to the micro-context where communities define the access, use and control of natural resources. Usually the national interventions and support from the extension staff is short lived, lasting only over the period the government is able to provided development funds which apparently dwindles as the financing duration progress.

Accelerated Socio-Economic and Political Activities

The management of natural resource in Marakwet District is threatened by increased basic human needs, energy demand, static farming technologies, increased standard of living, lack of employment, and recurrent droughts like many other parts in Kenya. In addition, there is currently a drastic socio-economic change within the district since it was upgraded into a distinct district. The move has led to an increased establishment of social amenities and services to upgrade and enhance the provision of services to the resided. In addition, business investment opportunities are emerging to meet the increases demand for goods and services required by the new institutions and the influx of human population. These dynamics have resulted in an increased demand for construction materials, energy for households and institutions, food and standard of living. Consequently, there is an increased encroachment into the forest, destruction of water catchments to increase farmland, and accelerated soil erosion along the steep sloppy areas. This has in turn threatened the integrity of the natural resources base within the areas (Muchemi, 2002).

Yves and Peter (1997) observed that although issues such as pressure on land and natural resources are world trends, the situation is most critical in sub-Saharan Africa where the economy is dependent on natural resources. Marakwet District falls within the semi-arid parts of Kenya which are socio-economically and politically marginalized. The proportion of development resources allocated to the district is not only low but has also been on the decline compared with other districts in Kenya. The resource allocation declined from 26% in the fiscal year 1996/97 to 16% in the fiscal year 1999/2000 and, worse still, over 80% was spent on administrative overheads (IEA, 1998).

Given that the district is heavily dependent on land-based resources, the area needs a development agenda that focuses on Sustainable Land Management (SLM). This study has recommended the use of participatory-GIS as a tool and practice from facilitating the development of participatory land use planning (PLUP). The practice has proved beneficial in aiding development practitioners and local communities to engage in consultative and participative process as well as utilized scientifically generated data and information together with local knowledge to inform the planning process.

Development activities in the area, before the adoption of participatory land use planning were confined and limited to the mandate and the capacity of single core government ministry. This led to not only the exclusion of local communities in the planning process but also failed to benefit from the synergistic sector-wide approach to solving a development problem as well as the complementary capacities of the diverse relevant ministries and other development practitioners. The planning process was thus functionally disjointed and administratively uncoordinated. The development plans initiated at the meso-level (district or province) lacked focus on the local community context and were thus subjective leading to a lack of grass-root support. This resulted in poor adoption of land management approaches and technologies introduced by government agencies. As a result natural resources degradation continued unabated resulting to scarcity of resources and the eminent escalation of conflict over the access, use and control of the natural resources across the three topographic zone.

Scarcity for Spatial Data and Information Appropriate for local Land Use Planning

Spatial data and information appropriate for local land use planning is immensely scarce. Considering the rural context of the study area, with the dominant land use being forestry and crop production, pastoralism, urban set-up at the two districts headquarters, varied datasets were required to guide the land use planning. In addition, the area has variable terrain from gentle to steep slope and climatic conditions from humid to semi-arid thus increasing the intensity of data required for the land use planning. The data considered critical in land use planning within the study area included: the estimated area for each land use type, water resources, human population, slope, climatic factors such as rainfall and temperature. These were considered important in determining the pressure exerted on the natural resources and hence the intensity of degradation of the resources.

Realizing this local planning inertia, this study designed at participatory land use planning approach that benefited from ecological context, local community’s views and knowledge, scientific information management technologies, and government planning framework.

Research Questions

The designing of a participatory land use planning approach was guided by the following question:

1. What is best methodological framework for combining participatory approaches to planning and Spatial Information Technologies towards guiding participatory land use planning process at local levels?
2. What would be the most appropriate institutionalization framework of a GIS-supported participatory land use planning for guiding rural development within the study area?
3. What are spatial datasets and information that a GIS-supported framework would generate for guiding participatory land use planning?
4. What would the most appropriate presentation formats of the resultant participatory land use plans for use by local community?

Participatory land use planning (PLUP) approach developed by combining participatory improved grass-root ownership of GIS and remote sensing the dialogue negotiation between the government and the community (Muchemi, 2002) national planning hierarchy expected to influence national policies on natural resource management.

Conceptual Framework

Figure 2 presents the conceptual framework of the study. The framework represent components, tools and processes required to facilitate a Participatory-GIS aided Land use Planning. These include 4 components; Land use planning levels, Institutional arrangements, Participatory-GIS devolving process; and spatial data and information requirements.

Two planning levels are identified as local and national level. While the local level offers a increased opportunity for communities to participate in the planning process, National level is often too general as it brings together all the communities into a national planning agenda. Nevertheless, the two planning levels need to be linked in such a way that the local plans from each local community planning context should be aggregated to build-up National land use plans.

Noting that sustainable land use management requires varied expertise which cannot be provided by a single institution, the conceptual framework has indicated the three categories of institutions required to provide various the services. The four categories of institutions include: state, non-state, and community members. These provide the various fundamental services and inputs required in develop participatory land use plan. The state and non-state institutions, who include government ministries, civil society organizations and research, provide social, natural resources management, and data and information services. The local community members provide critical data and information configured into traditional ecological knowledge about the natural and cultural landscape.

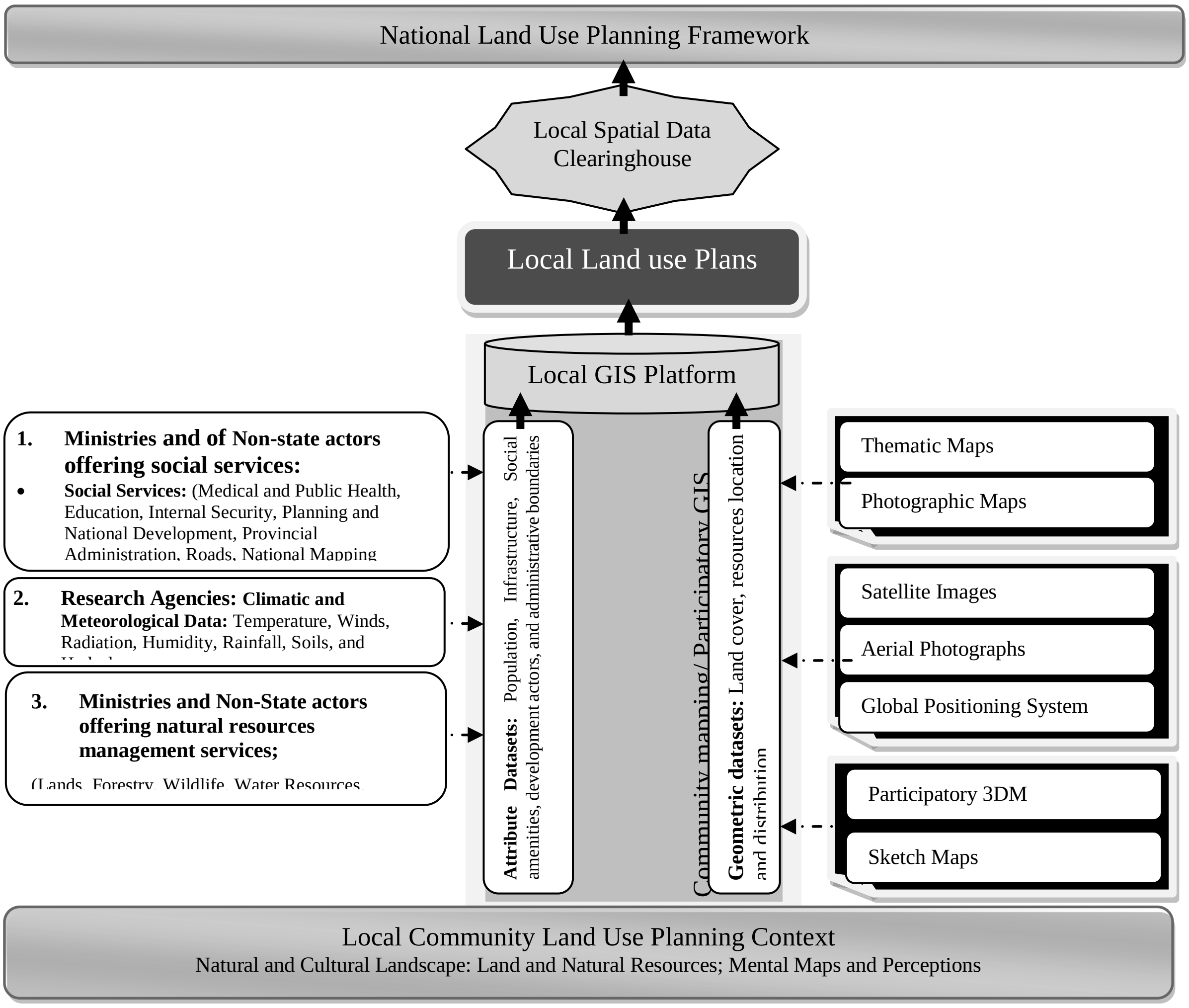

Figure 2. Conceptual Framework of Components, Tools and Process for a Participatory-GIS aided PLUP

The devolution mechanism of GIS and remote sensing into the Participatory-GIS practice that guided this study requires both interactions of all the actors through a participatory learning and action processes. A crucial ingredient into the process spatial data and information generated in isolation such space-borne and ground-based technologies or collaboratively using participatory process such as PRA and RRA methodologies. The data and information are taken through a GIS where processing of land and natural resources data is combined with actors perceptions about land use management options to develop land use plans.The development of a national land use plans can be best developed by designed a spatial data infrastructure as a clearinghouse where all the various local land use planning datasets and plans can be aggregated. The spatial data infrastructure would offer a framework of all the required spatial data, metadata, user and tools that are interactively connected in order to use spatial data for decision making in a efficient and flexible way (Kuhn, 2005).

Materials and Methods

The study designed and utilized a participatory planning process of delineating the land use planning units and forming community-based land use planning institutions. In addition materials and methods for gathering and analyzing datasets and presentation of land use plans were developed in consultation with the local community.

Delineation of Land Use Planning Units

The study facilitated the formation of community institutions to guide the participatory land use planning process and project management requirements.

A "Transect Approach" to development was used to guide the development of participatory land use planning process and management of respective projects (SARDEP, 2000). Vertically aligned transects were formed as the planning units. The transects ran across the landscape from the humid highland to the semi-arid lowlands.

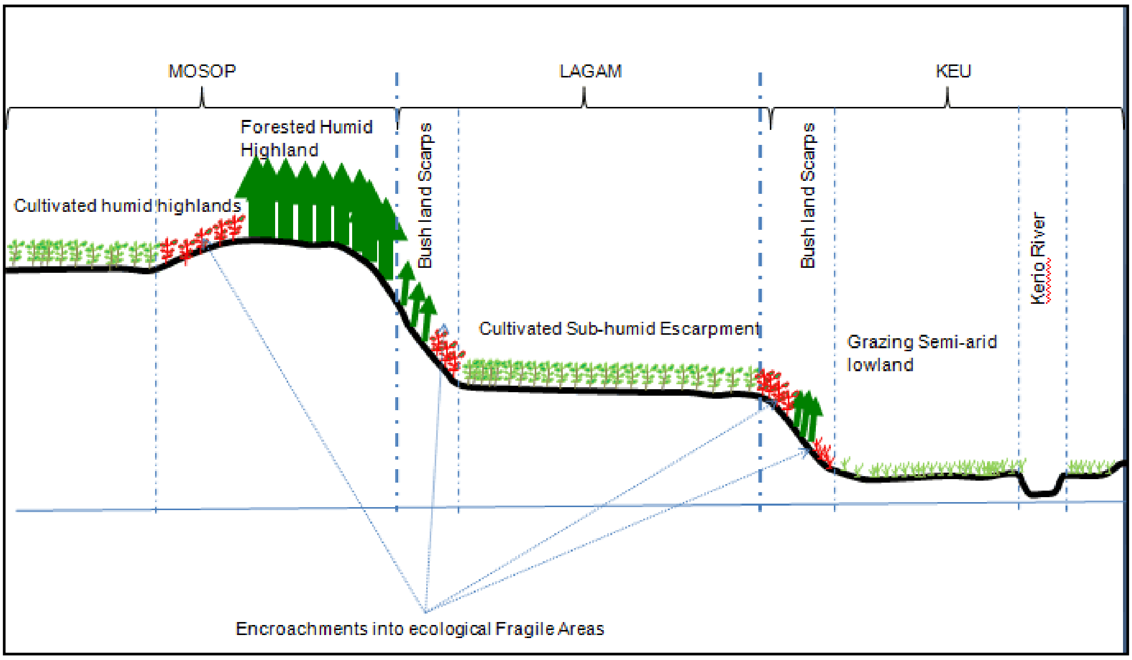

Figure 3. Transect Layout in Keiyo Marakwet District

The Transects were designed by delineating geographic concentration areas, using a set of criteria that was jointly developed by community members and government extension staff. The criteria outlined vertically aligned land transects with a distinct concentration of natural resources, socially defined households, and administrative units. Each transect was designed to cut across the three geographical zones; the highlands (*Mosop*), the escarpment (*Lagam*), and the valley (*Keu*) as illustrated in Figure 3. The Transect formed the basis for community capacity building, development of transect areas plan, and channeling and concentrating development resources within locally defined development contexts within the district. The reasoning behind the "Transect Area Approach" was that people living in a Transect shared natural resources and it was therefore important for them to utilize these resources in consultation with each other. Previously, the people living in one area would not consider the needs of others, for instance, farmers on the escarpment would not consider the needs of those in the valley. Through the 'Transect Area Approach' it was hoped that communities together would find solutions to their problems, without marginalizing any area.

Formation of Community Planning Institutions

Local community planning institutions were designed at the larger Transect Level and at localized project levels. At the Transect Level, the communities formed a 'Transect Area Committee' with the mandate of overseeing planning and management of development projects within the Transect Area. The communities within each transect were facilitated to form community groups which would focus on development needs to address environmental problems experienced by a given number of households within a specific ecological niche. The development interventions could, for example, be rehabilitation and protection of water resources, reducing soil erosion on the fragile steep slopes by introducing zero-grazing to reducing grazing pressure, or afforestation and reforestation of deforested or degraded forest.

Each of the identified community project would then be managed by a Project Management Committee (PMC). The TAC would bring all the (TAC) for the purposes of coordination of the interventions across the whole transect. The two institutions TACs and PMCs were charged with the mandate of awareness creation, developing the PLUP, implementing, and impacts monitoring and eventual project evaluation within respect to the envisaged impacts at household and ecosystems levels. The technical expertise for formation and capacity-building of community governance structure as well as planning and management of development initiatives would be drawn from the Ministry of Social Services for expertise on formation and formalization of community groups, Agriculture and Livestock Development for farming systems interventions, Ministry of Water for expertise in water catchment rehabilitation and development, Ministry of Health for public health issues and nutritional issues at the household, and Ministry of Cooperative Development for purposes of capacity building in income generating activities.

Materials and Methods for Land Use Planning

The materials for use in the facilitating participatory approaches and Spatial Information Analysis were carefully selected to ensure the semi-literature communities took a lead in land use planning process. Materials and methods used enabled the community to identify the environmental issues, determine the corrective intervention, inventory the available resources necessary in undertaking the corrective initiative, and instituting the relevant local governance system that would effectively manage the resultant community projects by ensuring they were aimed at improvement of natural resources management and livelihoods.

Spatial Information Technology was considered as the most efficient and effective method of generating scientifically validated data and information for guiding the PLUP process. A Geographic Information Systems (GIS) was designed to aid in analyzing the resulting data from aerial photo interpretation and GPS survey process. The GIS was located within the premises of the Ministry of Arid Land which was responsible for undertaking development projects within the semi-arid areas of Keiyo and Marakwet districts among other areas. In addition, it was linked to the District Statistics Office which served as the custodian of data and information for guiding development planning processes within the district. Further, the facility was linked to the District Information Center of the District Development Office which served as the repository for reference information products for guiding development projects within the district. The GIS included Digitizing Tablet, Software (Arcview 3.2, and Map Info, ERDAS Imagine), aerial photographs, topographic map sheets, thematic maps and district development plans.

Considering the need for enhanced ownership of resultant land use plans by local communities, the study chose participatory approaches that have a high potential of utilizing local knowledge and empowering the local communities in taking a lead in the PLUP process. The participatory approaches chosen to guide the PLUP process included Participatory Rapid Appraisal (PRA) and Participatory Learning Approaches (PLA). The process utilized such tools as sketch maps, seasonal calendars, historical trend lines, transect-walk, social venn-diagrams, and information matrices.

Acquisition of Aerial Photographs

Aerial photographs are a suitable tool and source of spatial datasets for local planning. The ability to display pictorial qualities of an infinite number of ground features as pointed out by Lillesand and Kiefer (1994) makes it possible for the community members to recognize and identify natural features and social infrastructure necessary for guiding land use planning process. Combined with GPS survey for purposes of geo-referencing the datasets, aerial photography provided a seamless platform for dialogues and a mechanism for navigating over impassable landscape through visual transect explorations across pictorial depiction of landscape features.

The study facilitated the assessment of environmental issues resulting from 10 years of land use in Keiyo and Marakwet districts. The assessment utilized aerial photography of 1991 as a base year and 2000 as the year of assessment. The Aerial photographs of 1991, produced through a survey of "Kenya Forest Plantation Inventory Project (KFPIP) sponsored by Food Agriculture Organization (FAO) were used to depict the past situation. The photographs were at a scale of 1:25,000 with a format of 23 cm x 23 cm.

Aerial photography was conducted in 2000 to aid in the assessment of land cover changes that had taken place over the 10 years of land use. The aerial photography mission was done using 4 topographic map sheets numbers 76/1, 76/3, 90/1, and 90/4, respectively, of the Survey of Kenya (SoK, years..). Flight lines were constructed on the topographic sheets running in a north-southerly direction. This made it easy for the aircraft to navigate the study area through few but long flight-runs which reduces the aircraft turns and hence the cost of jet fuel and hence the cost of photography. Further, the orientation aided the pilot to take advantage of north-southerly facing major roads to guide the flight paths which produced aerial photographs with road features running laterally to provide suitable control points for geo-rectifying the aerial photographs.

Remote sensing missions are highly dependent on weather conditions. The aerial photography survey of year 2000 was done in two missions due to variability in daily weather conditions. The humid highlands are often cloudy in the early morning and late afternoons thus leaving a narrow time period for aerial photography missions. The semi-arid valley often has dry weather conditions and less cloud cover giving a wider period for aerial photography missions. As a result, the first mission was conducted along the valley as scheduled within the month of August 2000. The second was conducted in September 2000 taking opportunity of narrow week-long dry spell without clouds to cover the upper scarps of the escarpments. The aerial photography mission produced 213 aerial photographs at a scale 1:25,000 and with a format of 23 cm x 23 cm.

Acquisition of Secondary Datasets

Successful utilization of primary spatial datasets such as aerial photographs requires reference datasets which are regarded as secondary spatial data sources. The study utilized topographic map sheets and thematic maps published by the Survey of Kenya (SoK), administrative boundary maps acquired from Department of Physical Planning, forest maps acquired from KIFCON project, soil maps from, land cover maps acquired from Department of Resource Surveys and Remote Sensing (DRSRS), and geological maps from Department of Geology and Mines.

The topographic map sheets covering the area included numbers 76/1, 76/3, 90/1, 90/3, and 90/4, produced from aerial photographs of 1956 and 1967 and drawn to a scale of 1:50,000. Thematic maps utilized were derived from 1:50,000 topographic maps prepared by abstracting contour lines, land cover details while retaining rivers, administrative boundaries of districts, divisions, locations and sub-locations, and local authority boundaries of Town Council and County Council.

Review of existing district development plans and national development agenda, and literature that discuss land use planning in other similar context were used to generate supplementary data.

Field Survey

Noting that adoption of environmental conservation approaches and technologies depends upon the social norms and values that a community attaches to either the entire ecosystem or some of its components, field surveys were conducted to gather local knowledge and perceptions considered crucial in sustainable land management.

The field surveys were conducted through visits along the geographic transects. They were organized into common interests groups (CIG) to discuss the availability, status, and trends in natural resource use. The discussions were guided by scheduled interview list and open ended question. The data collected included a list of: (i) stakeholders participating in local development agenda with the study area, (ii) available natural resources and their use, and (iii) land use while remote sensing and GIS generated land cover classes, land use types and respective areas and trends in land cover and land use.

Materials and Methods of Data Analysis

GPS was used to locate control points for use in referencing the aerial photographs. Topographic map sheets were also used to guide the field location of the ground control points.

To aid in the photo-interpretation a land use classification criterion was devised and constructed based upon the ease with which a given category is recognized and delineated from examination of the aerial photography. To aid in interpretation the following collateral information, equipment and materials were used; light tables, Mylar drafting film/transparency, pens, pencils, papers, stereoscope, and a desktop computer with Cartalinx and MapInfo softwares.

A guiding land-cover classification outline was developed, as proposed by Anderson *et al*. (1976) to help in the structuring of the classification. Further, a field reconnaissance was conducted before commencing the interpretation of aerial photographs, with a view of familiarizing with the physical features and land uses. A list of the land cover categories present on the photography was compiled by carefully inspecting the photographs and their respective sizes estimated. A standard size for the smallest parcels to be shown was set at 2.54 mm on a side (about 6.5 $mm^{2)}$ as recommended by Anderson *et al.* (1976), to enable the tracing process.

The results of the application of the classification and anticipated problems in identifying or delineating the categories were established during this stage. A revised list of categories was compiled for further discussions with the community members, project implementers, planners, donor agency and policy makers for standardizing the land use maps and the resulting plans.

The classification system was then applied to the photograph by overlying it with a transparency and then tracing the boundaries between categories as they occur on the photograph. The separate land cover parcels were identified with a symbol corresponding to categories in the classification system while ensuring consistency, clarity and legibility. The land covers were extracted by mapping the aerial photographs in sequence to ensure the boundaries and labels of adjacent areas matched at the edges of the sheets. Groundtruthing was conducted to verify certain interpretations and to confirm the consistency of interpretation.

Map overlays of the various land covers were produced from the aerial photographs by tracing on a transparency. Digital map overlays were used to compose the final maps, which were generated by digitizing in vector format, the photograph overlays to offer an accurate planimetric base free of positional errors.

Two sets of land use maps, one for the period ending in year 1991 and the other for the period ending in year 2000, were composed using the same scale, details, accuracy and classification.

A final field observation was done before the final maps were printed to help detect and resolve any overlooked mapping details.

Analysis of Spatial–Temporal Land Use Changes

The spatial-temporal land-use change analysis utilized the multi-date land use maps of the years 1991 and 2000. The areas experiencing spatial-temporal land use changes were noted by superimposing the two land use maps of 1991 and 2000 and the changes recorded on a third land use change map.

Groundtruthing surveys were conducted in the areas that recorded land use change to investigate and document the changes and any evidence of natural resources degradation. The groundtruthing survey utilized a devised land use change criterion with the following attributes: land use category, land use change indicators, and means of quantifying the land use change as indicated in Table 2.1.

Table 2.1. Criteria for participatory assessment of land use change

Land Use	Indicators
Forested Area	Position of forest boundary
	Forested area
	Texture of forest canopy
	Presence of roads and footpaths
	Presence of houses or buildings within the forest reserves
	Pattern of edge of forest
	Existence of farm plots in the forest reserves
Rangeland	Position of rangeland boundary
	Rangeland area
	Texture of the rangeland vegetation
	Presence of houses or buildings within the rangeland
	Pattern of edge of rangeland
	Presence of bare ground within the rangeland
	Presence of farm plots around the water sources
Water catchments	Texture of the riparian vegetation
	Presence of farm plots around the water resources
	Presence of bare ground around the water sources

Impacts of Land Use Change in Natural Resources Base

The assessment of impacts of land use changes on natural resources was based on the premise that most rural areas experience unidirectional land use changes, which is from primary land use to secondary and tertiary land use. The change usually entails the disruption of the natural form of land resources such as soils, water, and biodiversity thereby resulting in natural resources degradation. The indicators used to assess impacts of land use change on natural resources are summarized in Table 2.2.

Table 2.2. Criteria for Land Use Change Impacts on the Natural Resource Base

Natural Resources	Indicators
Soil	Gully erosion, Landslides, decreasing crop yield
Water	Decreasing water discharge, presence of silt in water, reported incidences of water borne diseases.

Participatory Land Use Mapping and Planning

The integration of the scientific mapping routines into community land use planning processes involved a careful translation of relevant GIS and Remote Sensing techniques into easily understandable and workable procedures by community to generate the desired data for land use plans (Table 2.3).

Table 2.3. Comparison of Community Land Use Planning Routine with Adopted GIS and Remote Sensing Techniques in Participatory Land Use Planning

Community Land Use planning routines	Adopted GIS and Remote Sensing techniques in participatory land use planning
1. Delineation of planning area	1. Delineation of the project area
The community draws a sketch map of the planning area	The extent of the project area (transects) was determined using topographic map sheets to know the area to be photographed and the costs. The process was guided by the community by the natural and artificial features marking the boundaries.
2. Community land use planning data acquisition techniques.	2. Spatial planning data acquisition techniques (primary and collateral sources of spatial data).
Community assemblies are convened to generate planning data. The process involves the use of community key-informants who are well versed with the planning area and the natural resource use trends over time. The key informants include village elders, retirees, chiefs and councilors. The community generates data through reporting of issues they can remember with the assumption that only data often year period can be remembered.	The primary data comprised aerial photographs of 1991 depicting the past situation and 2000 for the current situation. The aerial photography of 2000 was conducted in consultation with the community by informing them of the extent of the mission as derived in step 1 above. The aerial photograph was enlarged to six times the original size of 23 cm x 23 cm so that the community members would be able to identify the ground features from their locality on the photographs.
3. Community discussion for generation of land use planning data	3. Interpretation of the aerial photographs
i. Gathering spatial data for the base map The community lists basic spatial data in existence on their planning area. The data includes description of basic infrastructure (roads, schools, churches), administrative boundaries (transect, sub-locations, and villages)	*i. Gathering spatial data for the base map* The community members were assisted to clearly identify the ground features on the enlarged aerial photographs. The identified features included basic infrastructure, and administrative boundaries (transects, sub-locations and villages).
ii. Gathering spatial data on the natural resource in the area. The community lists natural resources in existence in their specific area	*ii. Gathering spatial data on the natural resources in the area* The community identified the land covers in existence in 1991 and 2000 to reveal the natural resources in the area
	iii. Gathering spatial data on land cover/use change to reveal natural resource use trend The community compared the main land uses seen on the aerial photographs from 1991 and those of 2000/2001. The differences between the two years were noted and marked using erasable coloured pencils and used to generate natural resources use trends.
	iv. Gathering data on degradation of natural resource Participatory groundtruthing was done in the areas of land cover changes for further revealing and verification of natural resource degradation.
Composing of community maps for data display and presentation in the land use plans.	*v. Composing maps for data display and presentation in the land use plans* The resulting spatial data were input into the GIS and maps of the past,

present and land cover change composed. Further spatial data analysis was done to quantify the results of participatory aerial photography analysis.

The spatial data were given to the planning community groups who developed intervention plans against the identified and ranked environmental plans.

Maps of the area experiencing environmental problems and appropriate interventions were composed and integrated into the land use plan reports.

Results and Discussion

Institutionalization of the GIS-Supported Land Use Planning

Land Cover Classification

The Analysis of 1991 aerial photographs revealed five land cover classes while that of 2000 produced six land cover classes as shown by Figure 4.1 and Figure 4.2. The land cover classes of 1991 were primary natural forest, cultivation, rangeland, built–up environment and secondary natural forest. The number of land cover classes of year 2000 was the same for 1991 except for the disappearance of riparian vegetation and establishment of a land cover of bare ground. The land covers of 1991 and 2000 and their respective areas and percentages are summarized in Table 3.1 and Figures 4 and 5.

Table 3.1. Land cover/Land Use within the Study Area between 1991 and 2000

Land Cover area for 1991 and 2000				
	1991[*1]		2000[*2]	
Land use /Land cover	Area km^2	% Area	Area km^2	% Area
Natural Forest Land	33.22	42.86	36.08	39.42
Cultivated Land	21.10	27.23	35.88	39.20
Rangeland	19.80	25.55	17.31	18.91
Riparian Vegetation	2.80	3.61	[*1]?	---
Built up Land	0.28	0.36	1.03	1.23
Secondary Natural Forest	0.55	0.71	1.20	1.31
Bare Land	[*2]	---	0.03	0.03
Total Area	77.75	100	91.53	100

*1 The data is based on the 84.9% of the study area covered by 1991 aerial photography
*2 The data is based on the whole study area as it was covered by 2000 aerial photography

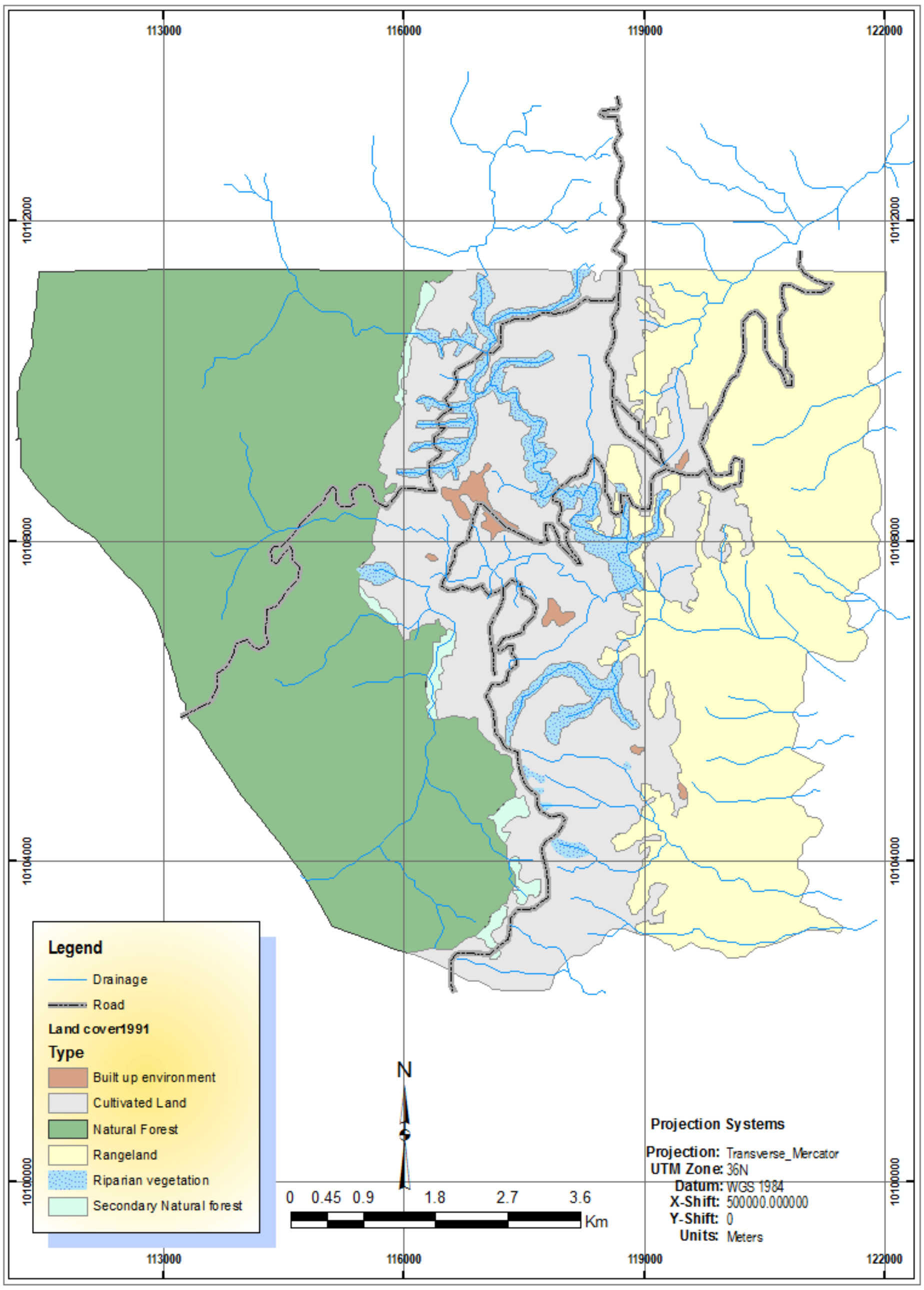

Figure 4. Land Cover and Land Use, 1991

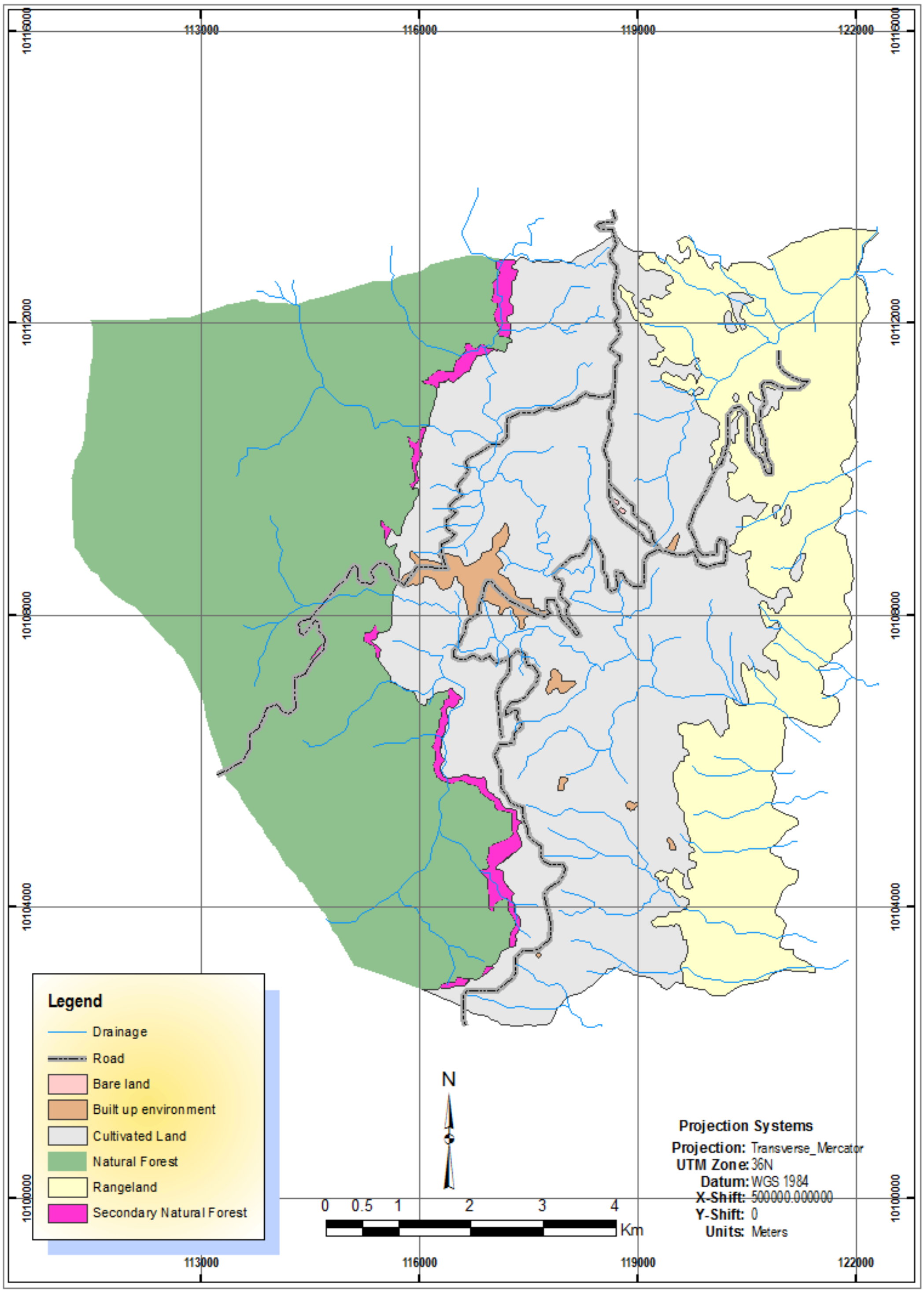

Figure 5. Land Cover and Land Use of 2000

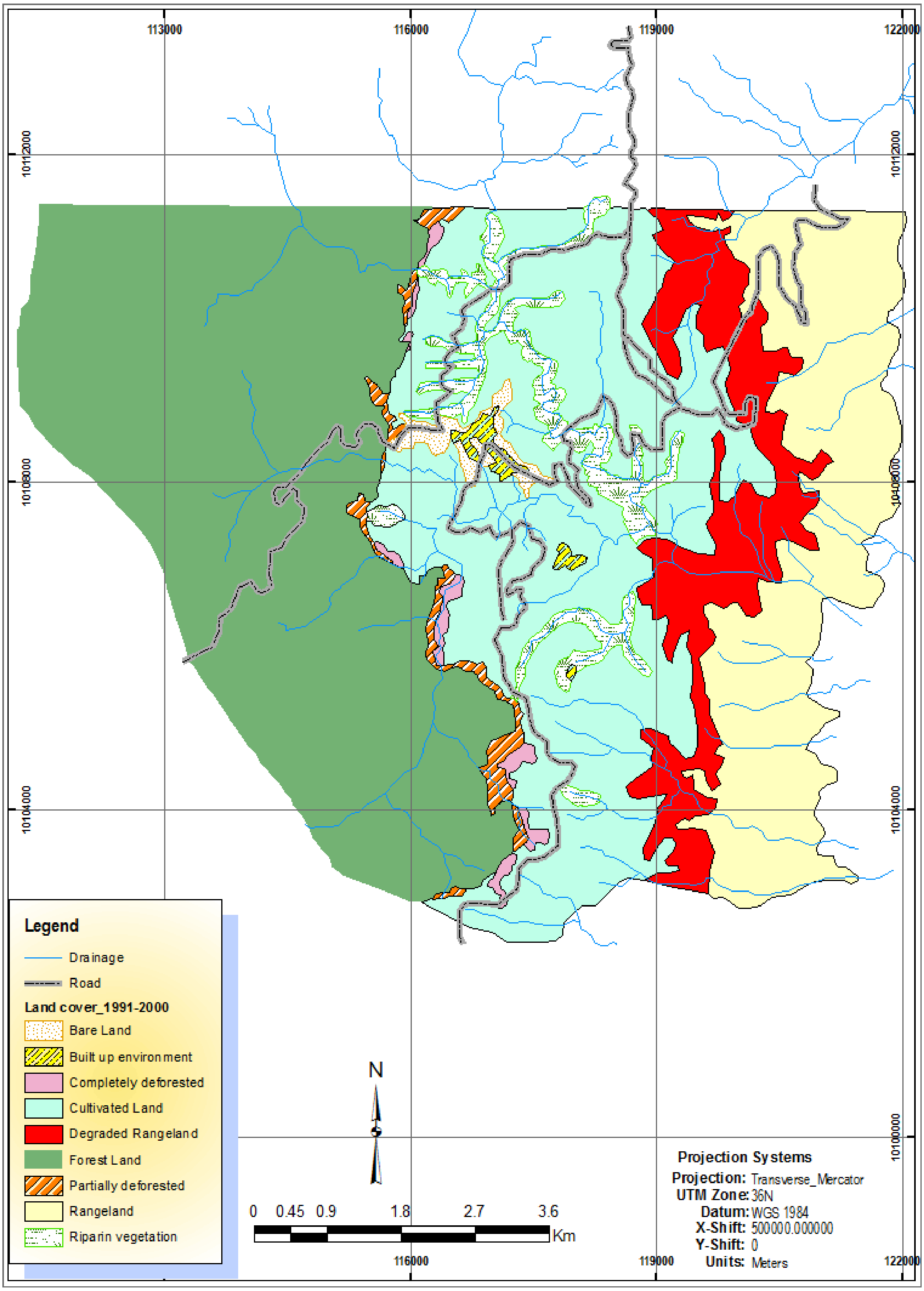

Figure 6. Land Cover and Land Use Change between 1991 and 2000

Discussion

The major land cover types in the study area are forest (39.42%), which is primary or secondary (a mixture of bushes and trees), cultivated land (39.20%), rangeland (18.91%), built-up environment (1.23%) and bare land (0.03%). The study area is dominated by an extensive rangeland of marginal productivity. The rangeland is located on the scarps of the Rift Valley. The scarps have thin soil cover that is poorly developed with the basement rock exposed in most parts. This area receives limited rainfall, about 7500 mm per annum due to the low altitude and high temperature that drives the hot and wet air up the highlands. The soils are therefore poorly developed, infertile due to the high erosion incidences that carry the rich soil down the valley and into Kerio River. About twenty per cent (18.91%) of the study area is semi arid, characterized by scarce and erratic rains, which cannot support arable farming. The implication of such a high percentage of aridity is limited cultivable land that can support the population.

The two options available for increasing land productivity are either to increase the cultivable land or intensify the existing farming systems. The exploitation of each option depends in its flexibility. The opportunities for increasing cultivable land are minimal due to need for forest conservation on the upper side and ecological limitation on the lower end of the cultivated land, respectively.

The community has to contend with both forest protection laws to the west and ecological limitations to the east to increase the cultivatable land. Intensive farming systems demand that the community be well endowed with appropriate technologies and finances to bring them into realization.

Rural communities, especially in arid and semi-arid areas, are economically weak and often lack the appropriate technologies for the intensification of farming due to low income and adoption of technologies meant for high potential areas. The only opportunity left is for farmers to encroach upon the forest reserves to expand cultivable land. The farmers, in the study area, seriously encroached upon the forestland due to weak legal framework that governs forest management. The main issues identified were policy contradictions between the forest act and ministry of land. The communities noted that the forest act CAP 385 does not recognize their role in the management of forest property. The act bestows the management of forest purely to the Government a hierarchical and bureaucratic top-down decision-making arrangements from the ‘Ministry’ though the ‘Forest Conservator’. This is purely central government framework that does not involve the local community in arising views on how to meaningfully participate in the Forest Management. In addition, being colonial in design, enactment and implementation, the Forest Act CAP 385 undermines the community’s historical customary attachments to forest land and resources there in which formed part of their ancestral territories. The communities viewed the Act as having propagated the breakdown of their traditional natural resource governance structure and processes.

It was further noted that the perception that the act lead to dispossession and expropriation of community’s ancestral land and draconian restricted of their access to forest resources in master and servant arrangements has led to the community atrocities in utilizing the forest without consulting the government.

Land Cover Change

The analysis of Land use changes between the two mapping years, 1991 and 2000 (Figure 6), revealed -8.79% change in forest land, +35.55% change in cultivated land, -14.14% change in rangeland, +210.71% change in built-up environment, and +72.73% change in secondary forest as shown in Table 3.2, Figure 4, and Figure 5. Further, there was an emergent land cover of bare land that accounted for 0.03% and disappearance of riparian cover through reduction to an immapable scale in year 2000.

Table 3.2. Estimates of Land Use Changes within the Study Area Covered by the 1991 and 2000 Aerial Photography

Land cover class	1991 (km^2)	2000 (km^2)	% Change
Primary natural forest	33.22	30.30	-8.79
Cultivated land	21.10	28.60	+35.55
Rangeland	19.80	17.00	-14.14
Riparian vegetation	2.80	*1	-100
Built up environment	0.28	0.87	+210.71
Secondary natural forest	0.55	0.95	+72.73
Bare ground	*2	0.03	
Total Area	77.75	77.75	

*1 The riparian vegetation cover was mappable in 1991 but in 2000 it was immapable at the same scale.

*2 The bare land cover was non-existent? in 1991 but in 2000 it had formed from quarrying work to get murram for construction of roads in the area, especially due to the elevation of Kapsowar town to the district headquarters

Participatory Land Use Plans

The number of community members and members of sites for community assemblies during the focused participatory land use planning is summarized in Table 3.3.

Table 3.3. Criteria for Land Use Change Impacts on the Natural Resource Base

Sub-location	Community members	Sites of community assembly
Kapsowar	65	7
Kapsumai	23	3
Kipsaiya	36	4
Sisiya	105	3

The proposed interventions against the identified environmental threats include: interventions against deforestation, declining water resources, and soil fertility. The interventions were limited to suggestions given by the community in the focused participatory planning meetings. A summary of planned interventions by the community for Sisiya sub-location is illustrated in Figure 7.

Plans to Safeguard the Forest

In all the sub-locations; Kapsowar, Kipsaiya and Kapsumia, plans to safeguard the forest were established. Sisiya has no forest cover and therefore the community focused on interventions against rangeland degradation. As a remedy to the already deforested areas the community suggested the establishment of tree nurseries for afforestation, re-forestation, enrichment of the existing forest, and agro-forestry. Further, realignment of forest boundaries by the Forestry Department was suggested to facilitate the forest rehabilitation program. The community further suggested to be trained by the Forest Department on forest management.

Plans to Safeguard the Water Resources

All the three sub-locations had degraded water resources. The interventions suggested by the community included: protection of water resources through planting of trees around the sources, construction of conservation structures on the upper parts of the water catchments, fencing around the springs, development of the springs by construction of water collection tanks, to relocate the water collection points from the delicate spring sources and livestock watering troughs away from the water source to avoid water pollution. To ensure sustainability of water projects the community suggested training on gravity water flow projects operation and maintenance.

Plans to Safeguard the Rangeland

The community of Sisiya, Kipsaiya and Kapsumai sub-location developed plans to safeguard the rangeland, which included: controlling overgrazing through destocking and initiation of reseeding program.

Plans to Safeguard Soils

Interventions against soil erosion and water resource degradation are interrelated. The community suggested establishment of soil and water conservation measures such as terraces, trees, grass strips, contour farming, controlled grazing, and construction of water harvesting structures. To involve the entire community soil and water conservation awareness creation campaigns were suggested. To ensure very sound protection of the environment the community suggested the formulation and institutionalization of community-based environment by-laws that should be adopted from the country's environmental law.

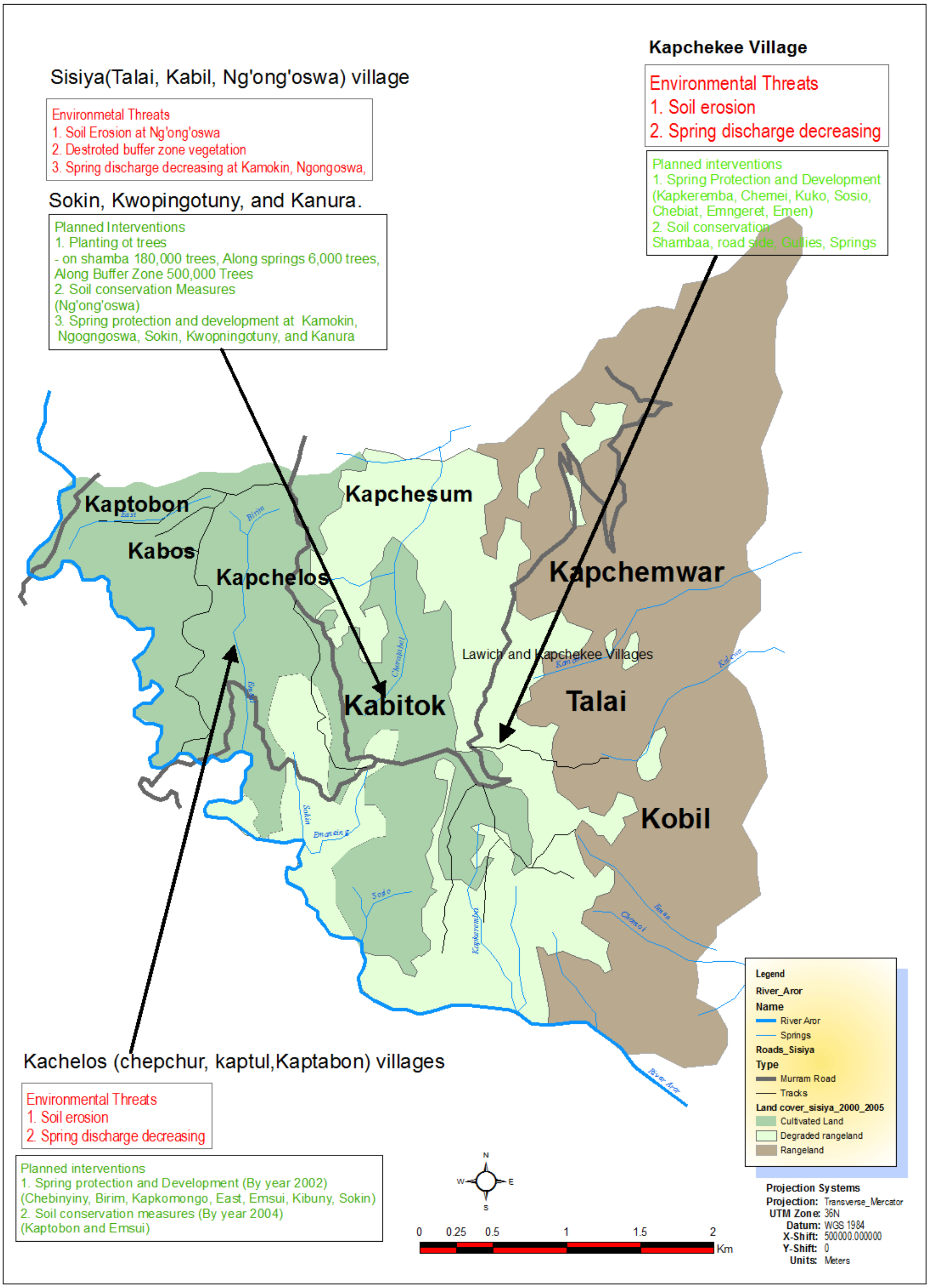

Figure 7. Sisiya Sub-Location Land Use Plans

Conclusion

The participatory land use planning (PLUP) approach can be developed by combining participatory approaches and spatial information systems and technologies (SIST). The validity of scientifically generated datasets and information has the potential of enhancing the objectivity of land use plans (Green, 1992; Reid *et al.*, 1994; Sunder and Eugene, 1990).

In addition, validated datasets generated through the use of SIST improved the planning process by encouraging dialogue and negotiation between the government and the community to develop participatory development plans based on local community context with enrichment by local views and government planning framework. The process was underscored as potentially able to link local planning context with national development planning context through meso-level (district) development plans (Muchemi, 2002). Participatory land use planning approach was perceived as potentially capable of mainstreaming community action plans across the national planning hierarchy thus expected to influence national policies of natural resource management.

National land use plans can best be develop by aggregating participatory land use planning at various community levels across the countries to cultivate a broad support for national-wide community based natural resource management. This requires involvement of all the relevant institutions, devolution of spatial information technologies, and well coordination up-scaling of datasets and information generated at eth local level using a spatial data infrastructure and a clearinghouse, and political goodwill.

Participatory Land use planning can enhance sustainable land use management by facilitating consultations across resource flow and use gradient. This can reduce conflicts among the various common interest groups across the gradient.

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