Spatial planning: Making space for livestock and wildlife

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September 2011

Abbreviations

ACC	African Conservation Centre
ADDS	Africa Data Dissemination Centre
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AWF	African Wildlife Foundation
CBS	Central Bureau of Statistics
DRSRS	Department of Resource Surveys and Remote Sensing
FAO	Food and Agriculture Organization
FEWSNET	Famine Early Warning System Network
GTZ	Gesellschaft für Technische Zusammenarbeit
ILRI	International Livestock Research Institute
IFPRI	International Food Policy Research Institute
IUCN	International Union for Conservation of Nature
KMD	Kenya Metrological Department
KNBS	Kenya National Bureau of Statistics
KSS	Kenya Soils Survey
KWS	Kenya Wildlife Services
LAPSSET	Lamu Port – Southern Sudan - Ethiopia Transport
MOLD	Ministry of Livestock Development
MRC	Mpala Research Centre
NRT	Northern Rangelands Trust
SoK	Survey of Kenya
SRTM	Shuttle Radar Topography Mission
WRI	World Resource Institute

Making space for livestock and wildlife with spatial planning

Introduction

Ecosystem-based planning seeks to identify and understand the important ecological characteristics of a landscape or region, and then use this information to design plans that guide the development of ecologically-responsible human activities. The integration of ecosystem services into decisions relies on access to good scientific information showing where ecosystem services are provided and how they will be affected by alternative plans and policies.

The Arid and Semi-Arid Lands (ASALs) cover 80% of Kenya's land area, and cut across 39 districts, mainly in Rift Valley, Eastern, Northeastern and Coast Provinces (World Bank 2010). The ASALs account for almost 30 percent of Kenya' population and host about 70% of the national livestock population with an estimated value of Ksh 70 billion (World Bank 2010).

A vast majority (74%) of ASAL constituents were poor in 2005/06; poverty rates in the ASALs have increased from 65% in 1994 (KIHBS 2005/6 cited in MDNKOAL 2008), which contrasts with the rest of Kenya -- national poverty rates fell from 52% to 46% in the decade 1996-2006. Similar stark inequalities between the ASALs and other areas of Kenya are found in health and education as well as infrastructure development and services provisioning (MDNKOAL 2010).

The ASALs need special attention in order to achieve sustainable economic development (World Bank 2010) and after decades of neglect, the government is committed to close the development gap between the ASALs and the rest of Kenya. The Government of Kenya (GoK) increasingly acknowledges the special attention the ASALs need in order to achieve poverty reduction and economic growth (World Bank 2010). To do so, it charged the Ministry of State for

Development of Northern Kenya and other Arid Lands (MDNKOAL) to develop policies and interventions addressing the challenges specific to ASAL, mostly regarding their climate, pastoral and agro-pastoral livelihood strategies and low infrastructure, financial, and human capitals (MDNKOAL 2008).

Unlike line ministries with sectoral development planning, MDNKOAL has a cross-sectoral mandate, which requires a holistic approach to development, weighing trade-offs and promoting synergies between sectoral objectives. To achieve this mandate, MDNKOAL and other government ministries require up-to-date spatial information that can be analyzed to inform evidence-based planning and decision-making.

Constraints for land use planning

At present, there are a number of constraints facing government institutions tasked with land use planning, including limitations in institutional capacity, data access, and tool availability.

1) **Institutional** – A number of government organizations are tasked with developing spatial plans based on analysis of socio-economic and environmental data. However, there is a lack of capacity within these institutions to undertake such analysis. Fortunately, a number of non-governmental organizations have the requisite expertise, and several ministries are building their in-house analytical capacity to meet increasing demands for evidence-based planning.

2) **Data** – Land use planning requires cross-sectoral datasets. In Kenya, as in many developing nations, socio-economic and environmental data are gathered by various institutions across the government. Since there is no national policy on data sharing, many institutions find it difficult to release their data in an organized and legal manner. There is therefore an urgent need for the government to develop a coherent data sharing policy that will facilitate access to the information necessary for effective land use planning in Kenya.

3) Recently the Government launched open data source to encourage the sharing and promotion of development through use of information. Open data initiatives are being promoted by actors within and outside the government to

ensure these data are available for research, education and planning purposes.

4) **Tools** – A number of tools are available to facilitate land use planning, such as Geographic Information Systems, Statistical software, and Modeling tools. Unfortunately, many government institutions lack some of the basic tools required to conduct spatial analysis, making it difficult to take advantage of spatial data in the planning process.

Mandate of livestock and wildlife agencies in Kenya

A) Livestock

The goal of the Ministry of Livestock Development (MOLD) is to improve the livelihoods of Kenyans through sustainable livestock development. To achieve this MOLD has identified five strategic objectives namely:

- Develop appropriate policy and legal environment
- Increase livestock productivity through provision of widely accessible inputs and services to farmers and pastoralists
- Enhance investment in the livestock sector
- Increase market access of livestock and livestock produce
- Enhance institutional efficiency and effectiveness in service delivery

B) Wildlife

A number of Ministries (including Wildlife and Mines, Tourism, Local Government and Environment) are tasked to ensure the sustenance of wildlife in Kenya. These ministries are tasked to:

- Promote an integrated approach to planning for biodiversity.
- Identify habitat designated wildlife sites make provisions for their protection and enhancement.

- Identify opportunities to create new habitats and networks in the plan areas and support their restoration or creation through appropriate policies.

- Recognise the impact development could have on biodiversity and its capacity to adapt.

All these objectives need data and spatial planning and monitoring to realize the goals of the various tasks mandated to the various government agencies.

How can spatial planning help?

Integrated Geo-Database for spatial planning

To meet these mandates, government institutions need accurate, up-to-date spatial data that is accessible in an easy to use database. The International Livestock Research Institute (ILRI), together with the World Resources Institute (WRI) and other partners, organized series of meetings and workshops with the Ministry of State for Development of Northern Kenya and Other Arid Lands (MDNKOAL) to discuss the minimum data that would be required to undertake and conduct Mapping of Ecosystem Services for the Ewaso N'giro and also demonstrate the usage of data in spatial planning for livestock and wildlife development. A list of datasets was identified.

The next step was to assemble a geo-database, document the datasets and use them to address planning questions of relevant to the MDNKOAL.

The first exercise was to map the ecosystem services in the Ewaso Ng'iro basin and later value some of these services to demonstrate the importance of natural capital in supporting the development of the ASALs (see separate report of Erickson et al., (2011) Mapping and valuing ecosystem services in the Ewaso Ng'iro Watershed).

The second exercise was to demonstrate the use of the data in spatial planning, which is the subject of this report.

Policy and Planning

Reviewing the draft Wildlife Bill, Land use policy and Kenya Vision 2030 all call for better plans on conservation areas, protection of the environment and increase in tourism revenue and involvement of local communities in the development of conservancies. Yet, all this will require up to date data covering a number of thematic areas such wildlife and livestock counts, land use and cover,

infrastructure (roads, river and water points), climate (rainfall and temperature), forage availability and variability, distance markets, etc.,.

In this project we assembled these data sets from various partners such as DRSRS, KNBS, ILRI, WRI, MOLD, GTZ, FAO, Texas A&M, KMD, IUCN, KWS, Rural Focus, IFPRI, KSS, ACC, AWF, NRT and WFP (Appendix 1 shows the list of data compiled and archived). We used these data sets to demonstrate the usage in spatial planning for livestock and wildlife management.

Case Studies

In this report we highlight the use of spatial data in planning in five case studies.

We adapted the first case study from the Range Management Handbook (Thurow and Herlocker 1993). This case highlights the great potential for using the range data, which were previously only available in printed form, to plan for a new borehole in the county of Samburu.

The second case study undertakes a spatial analysis of wildlife and livestock populations at the landscape level in the Mara Ecosystem. This case demonstrates the application of long-term population datasets in analyzing wildlife and livestock trends (both temporal and spatial), at the landscape level. Further, evaluating the trends and its implication to policy making.

The third case study was conducted at water basin level. We mapped the distribution of key wildlife species in the Ewaso Ng'iro basin. The maps were used to identify important wildlife areas that need to be integrated in the current land use plans for the Ewaso Ng'iro basin..

The fourth case study combines data gathered from aerial censuses with data from radio collared elephants to map elephant densities and migratory corridors in Ewaso Ng'iro basin. Overlaying these data with a map of land cover will allow planners to delineate the key habitats and migratory corridors for the elephants.

The fifth case study uses national datasets to conduct a strategic environmental assessment of infrastructure development in Northern Kenya (Looijen and Voinov 2011). This case illustrates the application of a spatial multi-criteria evaluation (SMCE) tool to help identify and rank possible risks and proposed solutions to guide the routing of the Lamu Port-Southern Sudan-Ethiopia Transport (LAPSSET) Corridor project.

The examples here show the application of the database in planning at the landscape, basin and national level. Although these case studies clearly demonstrate the importance of spatial data for evidence-based land use planning, they also reveal the need to keep updating the geo-database. Also it points out the need build on the socio-economic geo-database at all levels, from national to county level and if possible even at landscape level.

Source of Information

Erickson, P., Said, M., de Leeuw, J., Silvestri, S., Zaibet, L., Kifugo, S., Sijmons, K., Kinoti, J., Ng'ang'a, L., Landsberg, F., Stickler, M. (2011) Mapping and valuing ecosystem services in the Ewaso Ng'iro watershed. Nairobi, Kenya, International Livestock Research Institute (ILRI).

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MDNKOAL 2010. *Getting to the Hardest to Reach: A strategy to provide education to nomadic communities in Kenya through distance learning*, Minister of State for Development of Northern Kenya and Other Arid Lands (Office of the Prime Minister) and Education for Nomads programme, Nairobi. http://pubs.iied.org/G02742.html

Thurow, T. L., and Herlocker, D.J. 1993 User Guide for the Range Management Handbook of Kenya, Range Management Handbook of Kenya Volume III, 5. Republic of Kenya, Ministry of Agriculture, Livestock Development and Marketing.

World Bank 2010 Project Information Document (PID) Concept Stage. World Bank.

Spatial planning for livestock water points at county level – Samburu County

EXAMPLES OF HOW TO ORGANIZE THE INFORMATION IN THE RANGE MANAGEMENT HANDBOOK TO HELP MAKE PLANNING DECISIONS

The Range Management Handbook (RMH) contains a lots of information that is important to consider when devising range management plans. However, the sheer volume of information on the maps and in the accompanying text may initially bewilder the user, thereby limiting use of the RMH in an integrated, organized and logical fashion.

The best way to approach a problem is to ask two questions regarding the criteria for success of the proposed activity:

What are factors that will make success of the proposed activity likely?

What are factors that will prevent the proposed activity from being successful?

This RMH Users Guide will raise the reader's awareness of the different components of the environment that might influence a particular task. Write out a list of factors you must consider to fully address these two questions. The simplest way to proceed is to compose the list as a series of questions that you can answer with a simple yes (acceptable) or no (unacceptable).

Once you have made a list of the pertinent factors that can influence success of the proposed activity, begin to check the information in the RMH to determine whether a particular site is a suitable location for the activity. To avoid confusion use one map at a time to check the factors that will allow or prohibit success of the activity. As you proceed through the RMH information you may find that the site is not compatible with the proposed activity (i.e. you get a no (unacceptable) answer to one of the questions you asked). In such a situation you will either have to select a new location, alter the proposed activity, or abandon the idea. Of course, even if it appears that the proposed activity is acceptable, given the information in the RMH, a field visit should be made to assess the situation on the ground.

Remember that the decisions being made by using

the information in the RMH are "technical" (not political). It is understood that many development activities are based largely on non--technical/political reasons. However, the technical officer (i.e. the professional charged with managing range, forest, agriculture, water, etc.) should always be prepared to provide the technical reasons for or against a proposed activity.

There have been a variety of examples presented in the districts Rangeland Management Handbooks the text regarding how to use a particular map or particular series of maps. The following text provides additional examples of how the wide variety of information included in the RMH can be applied to address the planning needs of a proposed activity.

For example, consider an agency wishing to install a new borehole in your district for the primary purpose of increasing water to enhance livestock production in the region. A proposal is made to install the borehole at a particular site. Is this site a good location at which to install the borehole?

What are factors that will make it likely that the proposed activity will be successful?

What are factors that will prevent the proposed activity from being successful?

1. Is an additional water source needed in the area? YES or NO

2. Is the vegetation of the area likely to be able to support increased livestock use? YES or NO

3. Will the livestock have reasonable access to the borehole? YES or NO

4. Will the site be accessible to the drilling rig and maintenance personnel? YES or NO

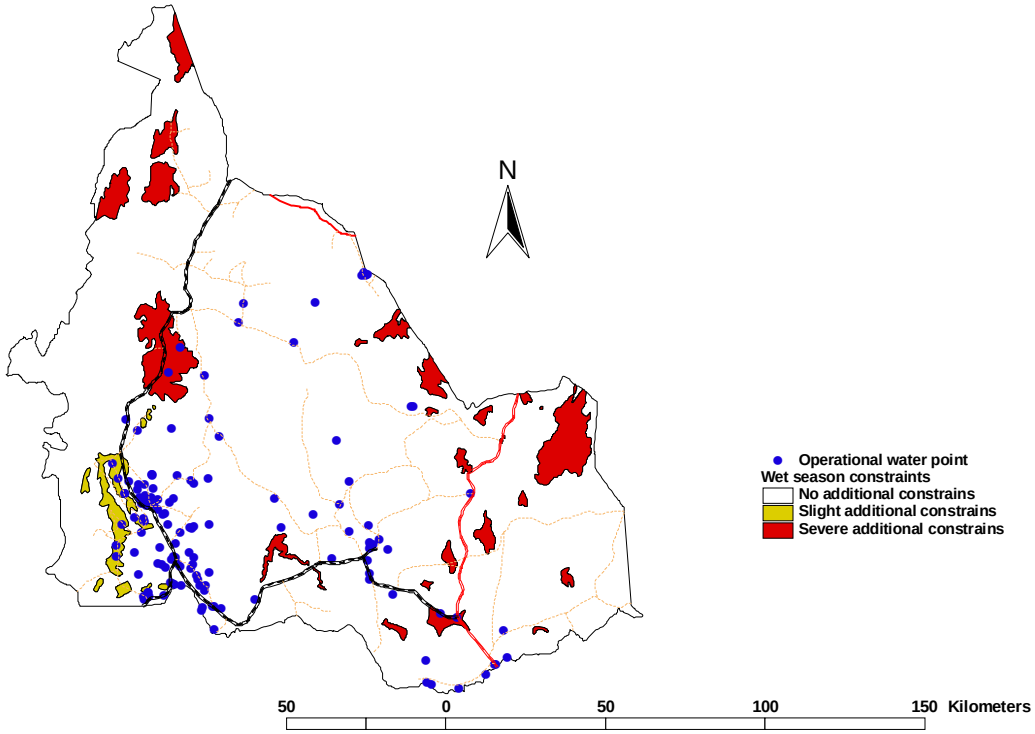
Next, proceed to the RMH maps and text to answer each of these questions.

1. Is an additional water source needed in the area? YES or NO

Check the maps and text information regarding the type, location, volume/output and water quality of

the existing water sources near the proposed activity, If your answer to the question is NO, there is no need to check other information. You should suggest that the well site would be better located elsewhere in a place that it is needed. If your answer is YES, the site is short of water and you can proceed to your next question.

Map 1.1 shows a big in Samburu county is not well covered by boreholes and that they may be a need to add more boreholes. Next is to analyse do we have areas with sufficient forage to support livestock production based on numbers gathered from DRSRS and also based on the livestock distribution.



Map 1.1: Distribution of water points in Samburu district showing high concentration of water points near the main road (Source of Information: Rural Focus)

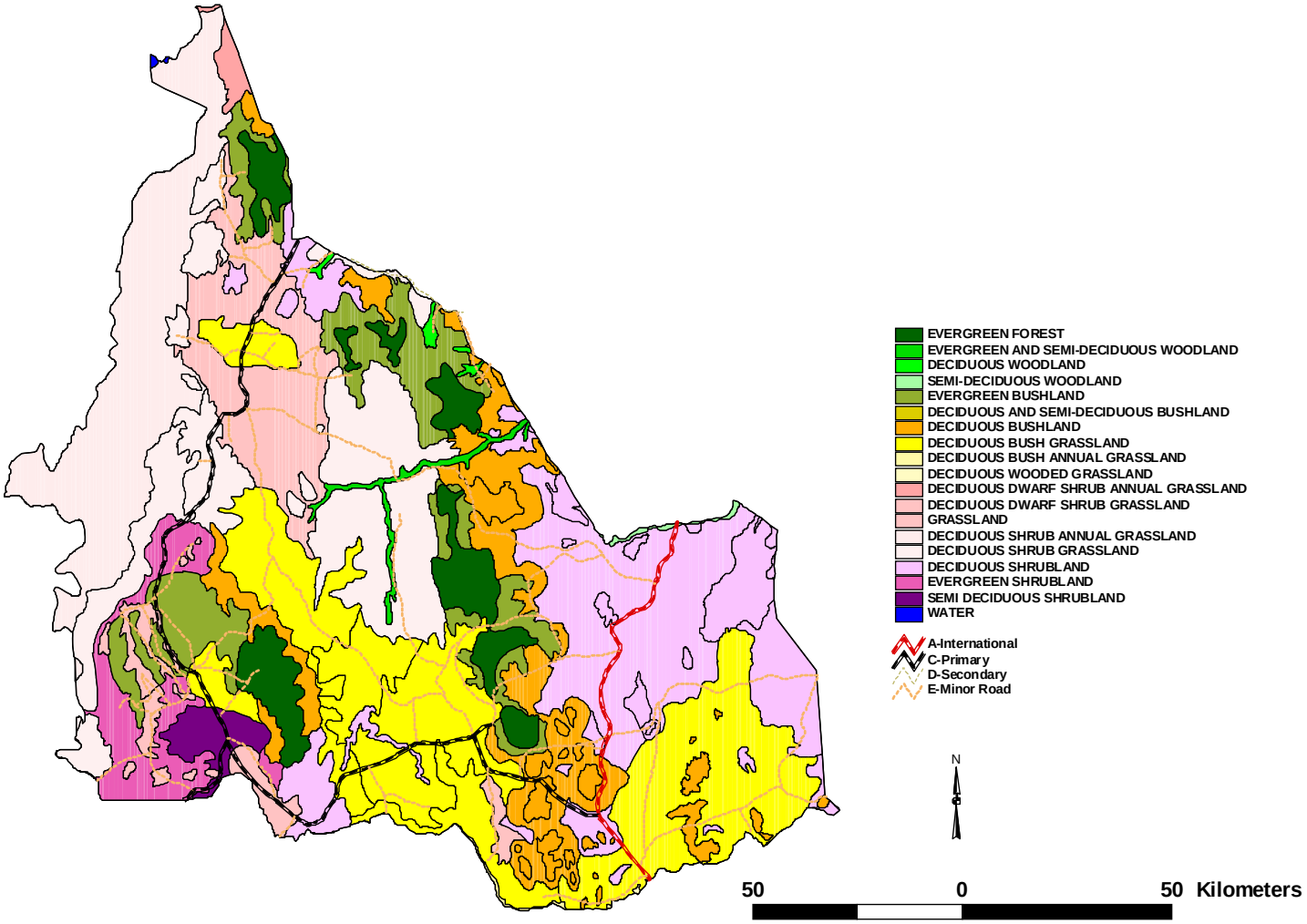
2. Is the vegetation of the area likely to be able to support increased livestock use? YES or NO

If the vegetation is forest, dense bushland or shrubland, annual grassland, or barren land the forage base is usually unsuitable for long-term use by livestock. Therefore the answer to the question is NO; there is little reason for a new borehole because the surrounding vegetation cannot support the increase in livestock use that the borehole would enable.

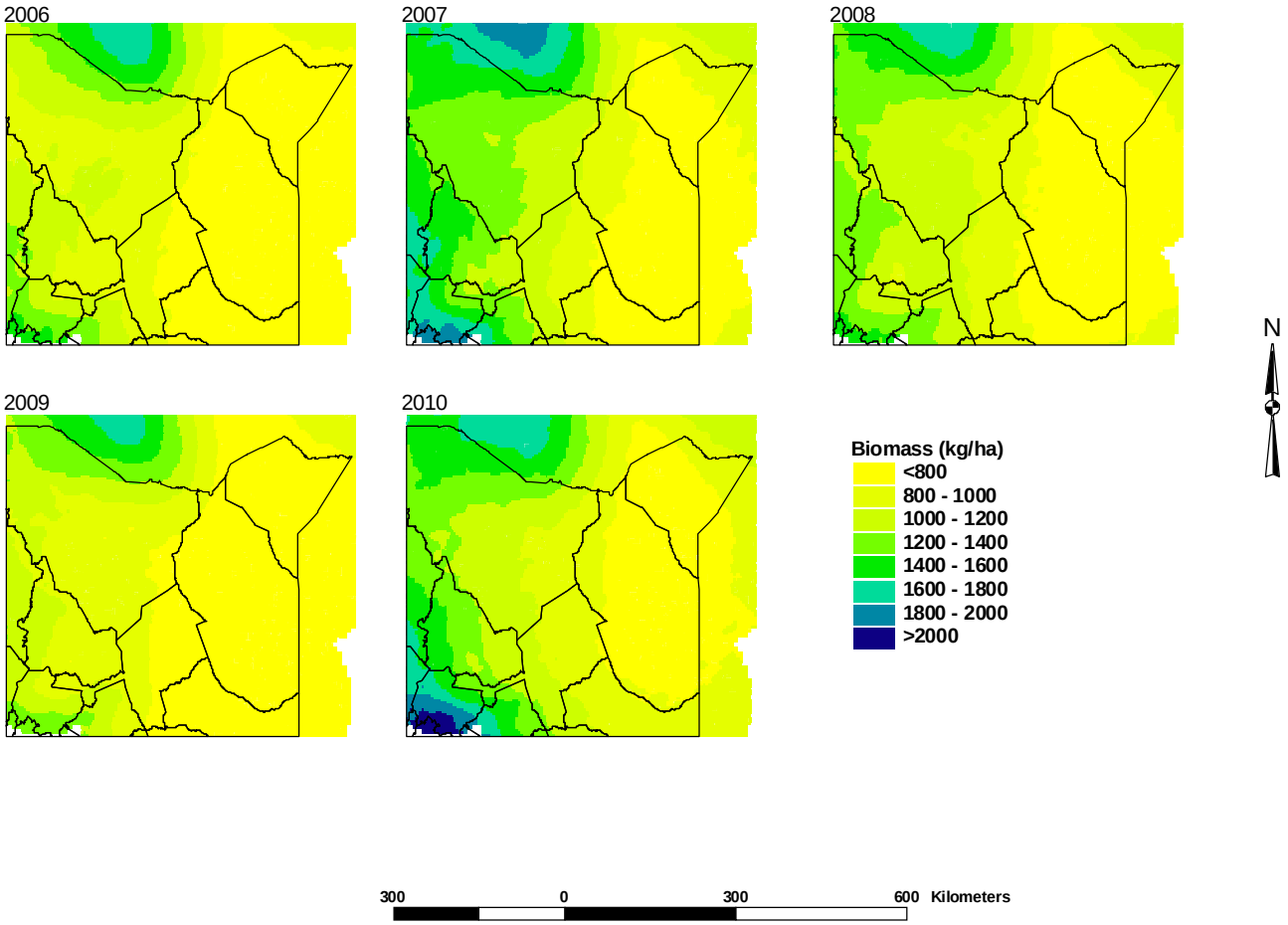
Check the map on VEGETATION TYPES and the accompanying information in the RMH text regarding the vegetation types and range unit inventory. If the vegetation is relatively open shrubland or bushland, dwarf shrubland, or grassland there is a chance that the area will provide a good forage base for livestock. But is the range site producing near its potential or is it degraded? Check the map on range condition. If the site is in poor or very poor condition the area is too degraded to support the increased use that would follow placement of a new borehole. Therefore the answer to the question is NO and there is no need to pursue further consideration of the site. If the answer is YES, the site has a forage base sufficient for livestock use and you can proceed to your next question.

In this exercise we mapped the vegetation type (see Map 1.2) and also forage map of the region (Map 1.3). The vegetation map shows Samburu has a variety of vegetation type and also open grasslands which are both important for livestock and wildlife. The forage maps show a large variability of forage from one year to another.

This variation is important in terms of ensuring that there is mobility for the livestock. The planning of the area needs to take this into account and water points should be widely distributed to minimize land degradation. To move the next stage of planning where to put the boreholes we need to assess the accessibility of the place in terms of terrain and roads.



Map 1.2: Distribution of vegetation in Samburu district and surrounding areas (Source of Information: GTZ Samburu Rangeland Management Handbook)



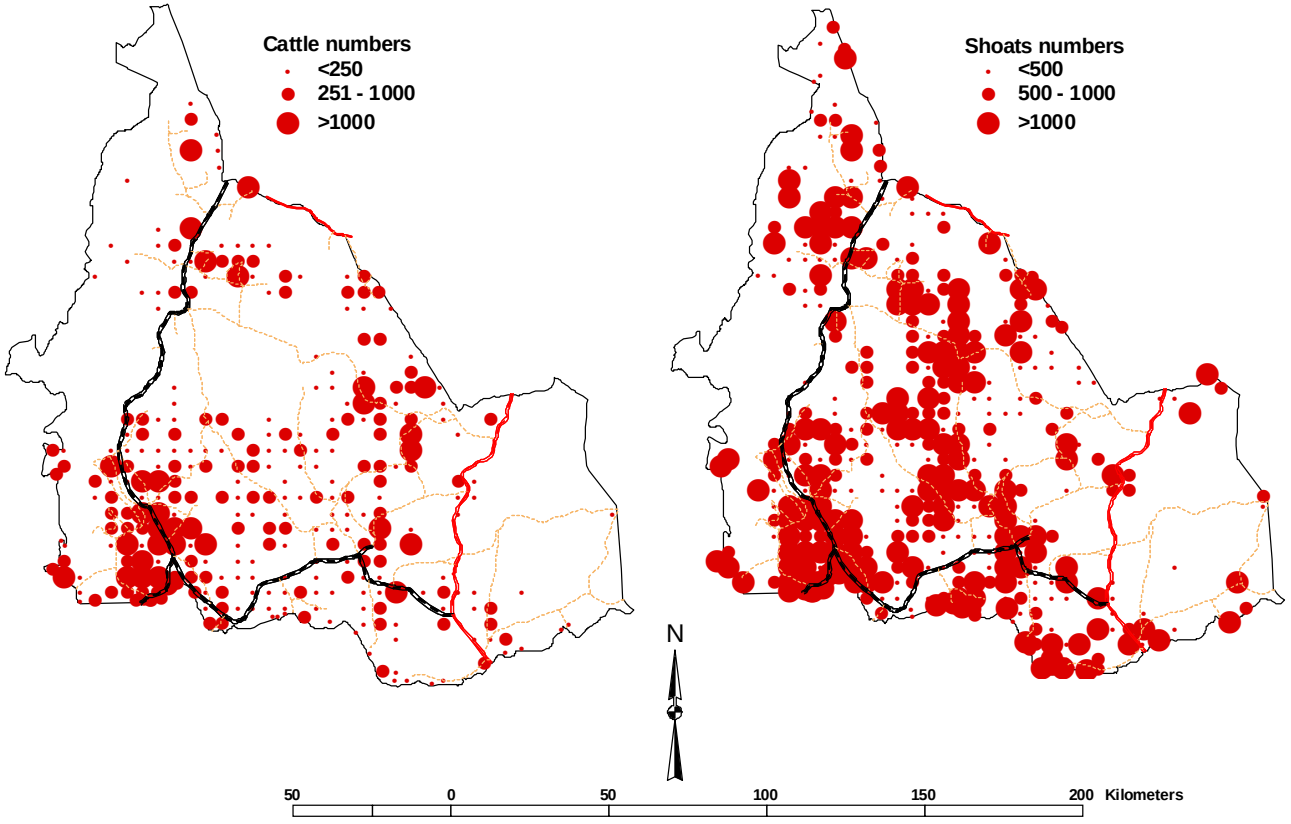
Map 1.3: Distribution of forage in Ewaso Ng'iro showing Samburu as an important grazing area. The importance of the regional map is that livestock move long distance in search for forage and water (Source of Information: Texas A&M, Erickson et al., 2011)

3. Will the site be accessible to the drilling rig and maintenance personnel? YES or NO

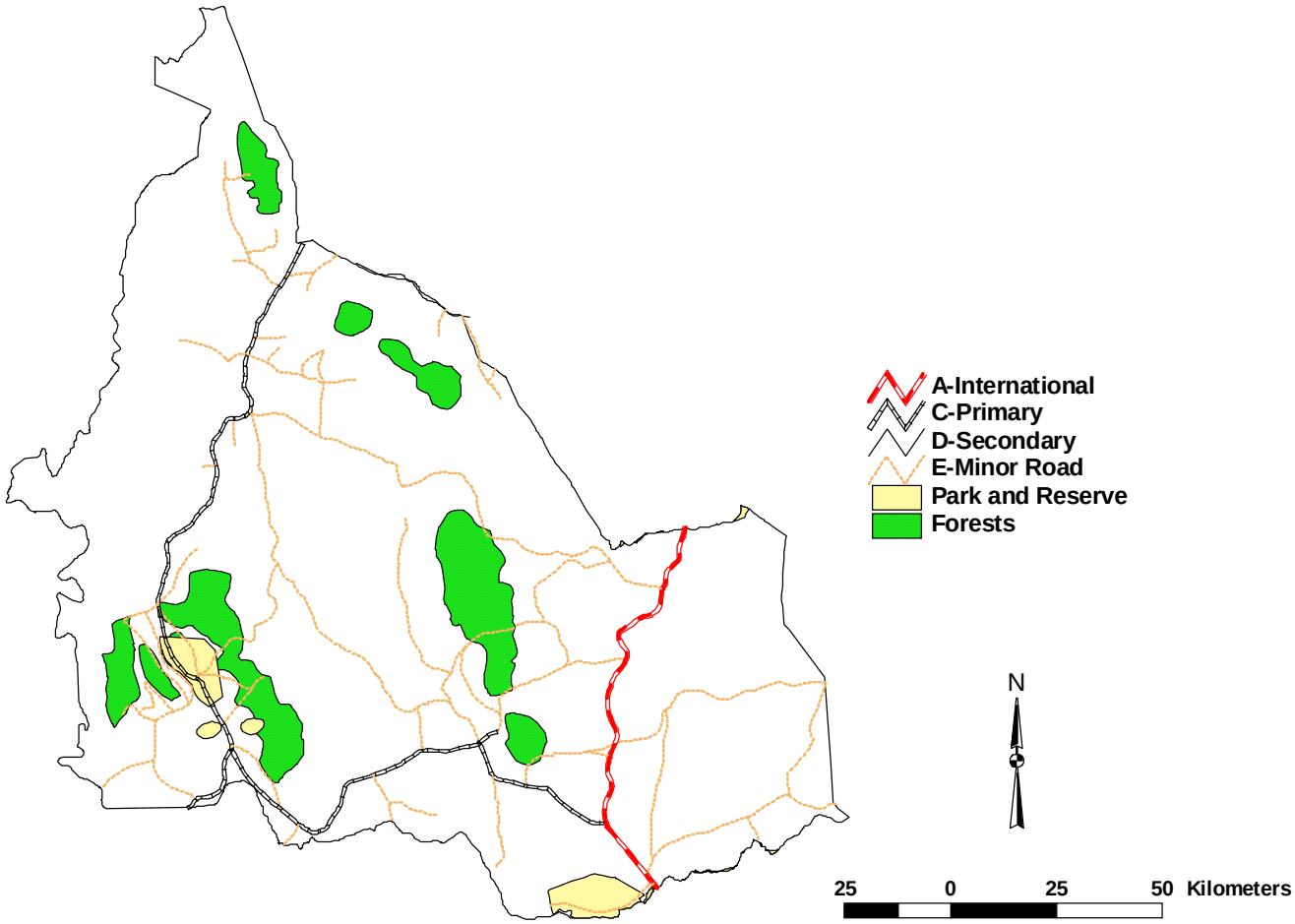
If there is no road near the site it will be difficult, if not impossible, to get the drilling rig to the site and it will be difficult to maintain the well. Unless the project includes funds for road construction to the borehole, the answer is NO and the site should not be chosen. If the roads are simply graded soil, access to the site may be limited to only certain times of the year. Check the information on the nature of the soil and the rainy season restrictions on livestock use. If livestock are going to have a difficult time accessing the area, vehicles and heavy machinery will also have difficulties. This may pose serious problems in the drilling and long-term maintenance of the borehole and pump.

However, if there are over drilling in a site this will promote land degradation. Therefore, it will be wise to choose a site and spread the water points. In case of Samburu this is not the case the water points are poorly planned as indicated in this analysis (see the maps of water points and distribution of livestock). There certain areas that you have large population of shoats yet you have little provision of water.

The example here shows clearly if you have data on livestock (Map 1.4), roads, and constraints (Map 1.5), population centres you can come up with better plans that takes into consideration on the environment, travel distance to markets and also ensuring sustainable production of livestock and livestock products through proper management of the rangeland.



Map 1.4: Distribution of livestock in Samburu district and surrounding areas based on 1995 to 2010 DRSRS aerial counts (Source of Information: DRSRS).



Map 1.5: Accessibility - roads and protected areas (parks, reserve and forests) in Samburu district and surrounding areas (Source of Information: Samburu Range Management Handbook; Survey of Kenya).

4. Will the livestock have reasonable access to the borehole? YES or NO

Check the maps (Map 1.4 and 1.5) and text information pertinent to indicating whether there will be year round access for livestock. If access is poor or very poor, then the answer is NO. There is no need to pursue further consideration of the site because livestock use of the area will be seriously constrained. If it is important that livestock have access to the borehole during the wet season but the RMH text and maps indicate that the nature of the soils prevent use of the area when wet, then the site would not be a good place for a borehole and the answer is NO; there is no need to pursue further consideration of the site. If the site does allow moderate or good access by livestock to the borehole whenever access is needed, the answer is YES and you can proceed on where to dig the borehole.

All the process should be done between the range managers, local communities, planners and water engineers to ensure the success of the project.

Source of Information

Erickson, P., Said, M., de Leeuw, J., Silvestri, S., Zaibet, L., Kifugo, S., Sijmons, K., Kinoti, J., Ng'ang'a, L., Landsberg, F., Stickler, M. (2011) Mapping and valuing ecosystem services in the Ewaso Ng'iro watershed. Nairobi, Kenya, International Livestock Research Institute (ILRI).

Thurow, T. L., and Herlocker, D.J. 1993 User Guide for the Range Management Handbook of Kenya, Range Management Handbook of Kenya Volume III, 5. Republic of Kenya, Ministry of Agriculture, Livestock Development and Marketing.

Spatial planning of wildlife at landscape level – The Mara Ecosystem

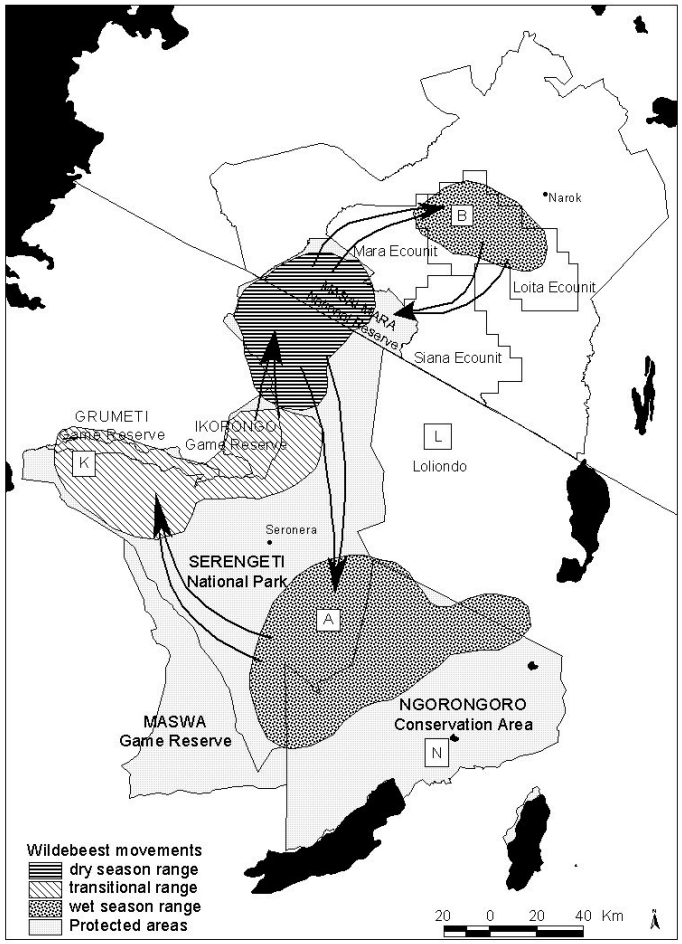
Introduction

The Serengeti-Mara Ecosystem (SME) is renowned for its abundant and diverse assemblage of wild ungulates (Sinclair 1995). The SME covers 25,000 km^2 and the core area comprises the Serengeti National Park (SNP) and Masai Mara National Reserve (MMNR). The Serengeti-Mara Ecosystem (SME) is most famous for the migration of 1.3 million wildebeest, *Connochaetes taurinus*, and 0.6 million zebra, *Equus Burchelli*, and gazelle, *Gazella thomsoni* (see Map 2.1; Sinclair 1995).

The MMNR is bordered to the north by group ranches. The group ranches are communal land used by the community to graze their livestock, but also home to wildlife. Some of the group ranches have since privatized their land to individual holding (Norton-Griffiths et al. 2008). The privatization of land started in the outer group ranches areas of high rainfall and high agricultural potential (Norton-Griffiths et al., 2007; Serneels et al., 2001), but now privatization is taking place in the inner group ranches next to the MMNR. Therefore, the management of the reserve and land outside the reserve are important in the conservation and management of wildlife in this rich wildlife and livestock area

The Mara Ecosystem faces threats from land use changes, poaching and also the uncoordinated or overall lack of land use planning (Ogutu et al. 2011; Norton-Griffiths et al., 2008). This case study analysed trends (both temporal and spatial) of livestock and wildlife populations in the SME to demonstrate the use of spatial in planning and conservation

Photo courtesy: Susanne Serneels



Map 2.1: Migration of wildebeest in the Serengeti-Mara Ecosystem. The arrow shows the migration routes or movements of wildebeest between Serengeti National Park in Tanzania and the Mara in Kenya (Source of information: Serneels at al., 2001).

Data Source

The Department of Resource Surveys and Remote Sensing has been collecting information on wildlife and livestock numbers since in 1977. The data has been collected systematically using high-winged aircrafts (Norton-Griffiths 1978). Data collected include more than 30 wildlife species, livestock (cattle, sheep and goats, donkeys and camel). Other information collected includes settlements, crops presence and condition, erosion status and vegetation types and cover. This information is transcribed and later entered into a Geographical Information System for storage and usage.

Use of spatial data for land use planning within an ecosystem

This exercise first analyses population trends for three species, namely the wildebeest, Thomson's gazelle and shoats (sheep and goats). Long-term population trends for the 3 species were evaluated based on regression analysis of DRSRS population data. Longitudinal analysis was based on more than 50 surveys conducted in the Mara (both wet and dry season surveys). The surveys were done in the Mara to capture wildlife before, during and after the wildebeest migration. DRSRS has conducted similar surveys for other ecosystems at

longer intervals that would nonetheless allow for this type of analysis.

Next, the entire MMNR area was divided into 5 regions - the reserve edges, reserve core, reserve, inner ranches and outer ranches - to facilitate spatial analysis of the distribution of livestock and wildlife populations over time and across the SME landscape. This analysis can reveal whether wildlife may have declined more in the ranches where there are more people, livestock and settlements or on the reserve edges, which are used by more livestock than the interior of the reserve. Population estimates for each species were averaged across all years with data in each decade to minimize the effect of random noise on the estimated percentage change in population size between decades.

Figure 2.1 shows decline in wildebeest population up to 2002, but the population slightly increased between 2002 and 2009. The Thomson's gazelle population has continually declined in the last 33 years. Whereas, the population of shoats (sheep and Goats) has increased in the Mara since the late 1980s. However, using only population numbers, it is not possible to identify where in the landscape these populations have increased or decreased.

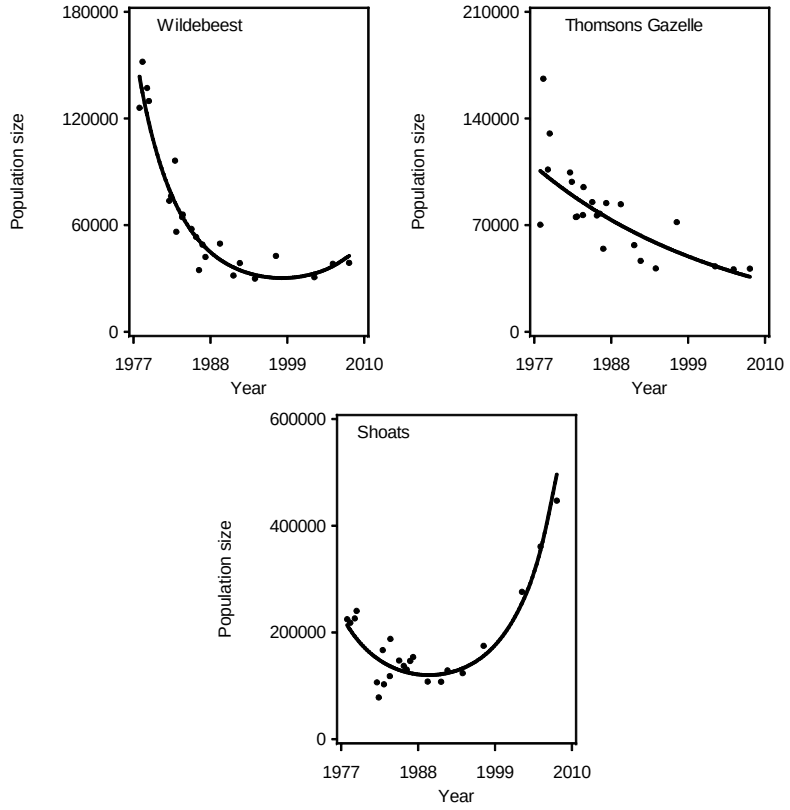
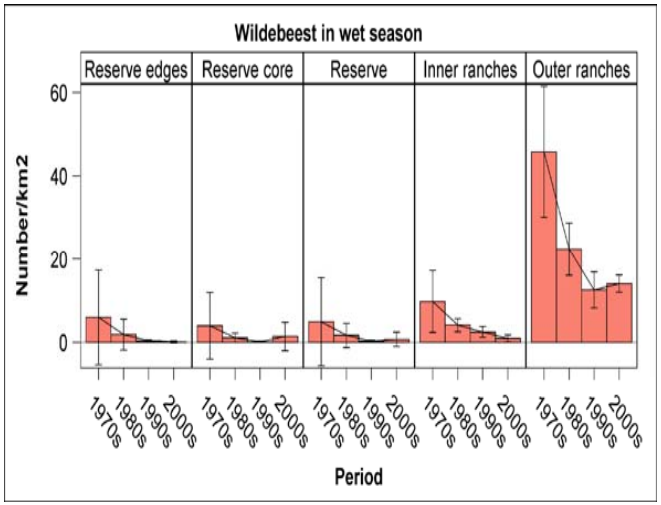


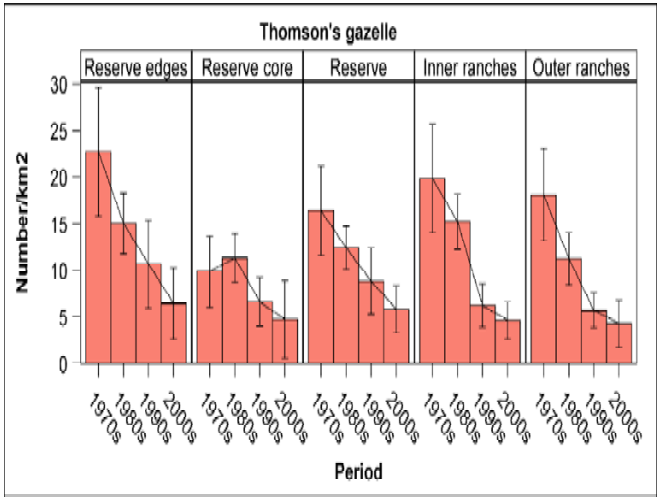
Figure 2.1: Trends of wildebeest, Thomson's gazelle and shoats (sheep and goats), Source of Information: DRSRS.

Therefore, spatial analysis can be used to pinpoint where certain populations are declining or increasing. Overlaying this analysis with a land use map can help identify areas where there may

be opportunities for planning new conservation areas to target specific species and what efforts might be required to address drivers of population decline within the ecosystem.

As seen in Figure 2.2, spatial analysis of the wildebeest population indicates that the highest density is found in the outer ranches. We observe from the analysis that there has been some slight increase in wildebeest population in the outer ranches, the reserve core and the reserve itself. The increase in the outer ranches is mainly due to abandonment of wheat farms in the Loita (Serneels et al. 2001, Ogutu et al., 2011, Ottichilo et al., 2001)





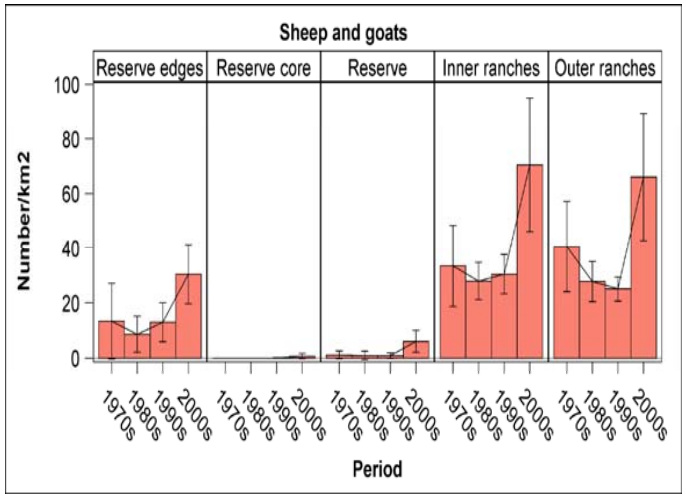


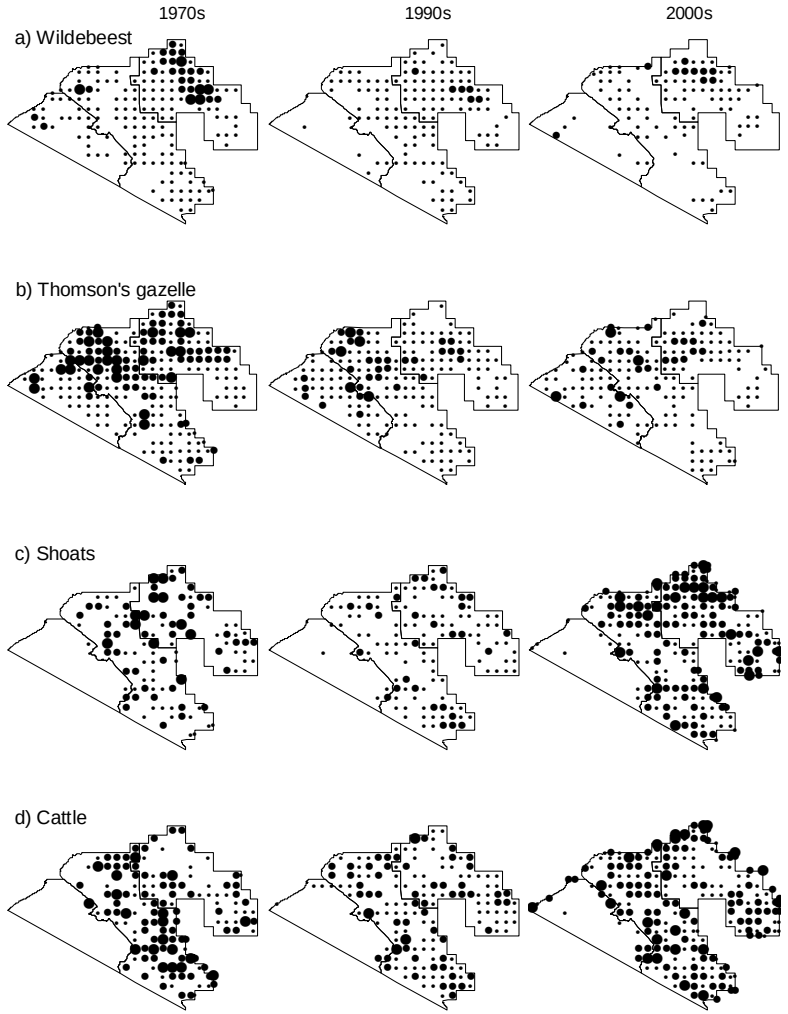
Figure 2.2: Trends of wildebeest, Thomson's gazelle and shoats (sheep and goats) by reserve edges, reserve core, reserve, inner ranches and outer ranches (Ogutu at al., 2011)

The highest densities of Thomson's gazelle were also found in lands outside protected areas. We observe steeper declines in gazelle populations in the outer and inner group ranches and the edges of the reserve compared to the core protected areas.

This analysis indicates that maintaining connectivity between protected areas and the areas outside them is crucial to ensure the continued existence of wildlife.

The population trend of shoats shows an increasing number of animals both in the ranches but also in the park. A large increase in the shoat's population will likely compete with wildlife species, such as impala and other mixed feeders.

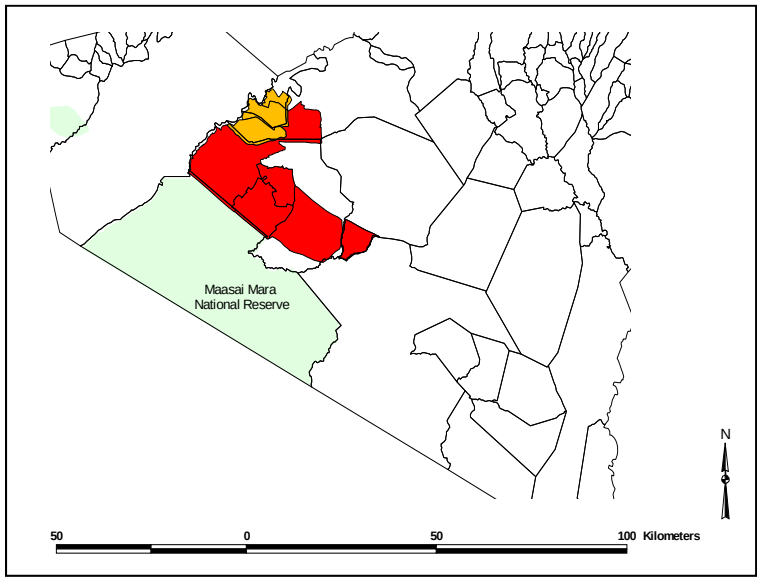
Map 2.2 shows the spatial distribution of wildebeest, Thomson's gazelle, shoats and cattle in the 1970s, 1990s, and 2000s. Such maps help us to see clearly where in the landscape these changes are taking place and also potential areas for locating conservancies. Communities have realized this potential and have established a number of conservancies that protect wildlife but also that they benefit from revenues collected from tourism.



Map 2.2: Distribution of wildebeest, Thomson's gazelle, shoats and cattle in the Mara Ecosystem (Source of information: DRSRS)

Response from Community

The communities living around the MMNR and private entrepreneurs have established a number of conservancies along the park boundary (Map 2.3). A total of 8 conservancies covering an area of about 92,000 ha have been developed, which is more than half the area of Maasai Mara National Reserve (150,000 ha).



Map 2.3: Map showing the location of conservancies in the Mara Ecosystem. Most of the conservancies fall under the Koiyaki, Lemek, Ol Kinyei and Ol Chorro group ranches.

The rules of land use within conservancies vary, with some conservancies allowing pastoralists to graze their livestock in the conservancy and others not. While there is evidence that livestock and wildlife can successfully co-exist, integrated land use planning will be essential to ensure that wildlife conservation goals are attained.

Key Messages

1. The DRSRS has been monitoring livestock and wildlife for over 30 years, and these databases are key for analyzing population trends that can be applied in land use planning.

These datasets can also be used to assess the impacts of key policies such as the drafted Wildlife Bill that calls for measures for the protection of wildlife species and their habitats and ecosystems particularly in using ecosystem-based conservation plans to achieve land use compatibility which includes;

(a) Developing norms and standards for ecosystem-based conservation plans;
(b) facilitating community-based natural resources management practices in wildlife conservation, management and enforcement;
(c) prioritizing areas for wildlife conservation

and projections on increasing designated wildlife conservation areas in form of national parks, national reserves, wildlife conservancies and sanctuaries;

(d) developing innovative schemes, measures and incentives to be applied in securing identified critical wildlife migratory routes, corridors and dispersal areas for sustainable wildlife conservation and management;

2. As in this case study we looked at the spatial distribution of livestock and wildlife inside and outside the MMNR. We observed decline of wildlife populations both inside and outside the park at alarming rates.

3. Long-term population data give a picture of the general trends, while spatial analysis helps discern specific patterns across the landscape.

4. By including additional information on tourist hotels, camps and other facilities, and migration corridors, these maps can be used in the development of management plans, new conservation sites and infrastructure development.

5. This type of analysis can help governments and other stakeholders take remedial actions to address the drivers of declines in wildlife populations and can also target specific areas using spatial data. This type of information can be used to target new conservation areas but also monitor their success.

6. We need to extend such analysis to other important ecosystems, such as in Amboseli, Tsavo, Laikipia-Samburu, Marsabit and Tana Delta, amongst others.

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Spatial planning for wildlife corridors in Ewaso Ng'iro basin

Introduction

The greater Ewaso Ng'iro is a human-dominated landscape comprised of private wildlife conservancies and cattle ranches managed by both commercial enterprises and pastoralist communities. Although the landscape has few parks and protected areas, it is home to the greatest diversity and density of wild ungulates in East Africa outside of the Serengeti-Mara park system (Georgiadis et al. 2007).

It has more than twenty indigenous large mammals with several endangered species. There are more than 4,000 elephants, the largest remaining population of Grevy's zebra and Jackson's hartebeest, as well as the largest national population of rhinoceros and reticulated giraffe existing outside protected areas (Ojwang et al. 2010, Georgiadis et al. 2007).

However, the Ewaso Ng'iro basin faces enormous challenges - all related to increasing human pressure, unsustainable land use practices, and declining wildlife ranges. Land-use changes in the Ewaso landscape have occurred primarily as a result of once-nomadic pastoralists being forced into sedentary lifestyles which have resulted in enormous increases in stocking densities, fencing, habitat fragmentation, and depletion of grass, browse and water - all of which have negative implications for wildlife management (Ojwang et al. 2010).

Assessing the tradeoffs between these different land uses and the degree to which they can be pursued together are critical in Ewaso Ng'iro basin at the moment (Ojwang et al. 2010).

In the first case study, we demonstrate how to map the critical wildlife areas. In the second case we pick one species, the elephant and map its distribution and movement patterns in relation to land use and also demarcate its possible migratory corridors.

Mapping critical wildlife areas

1) We mapped the critical wildlife areas using aerial survey data collected by the Department of Resource Surveys and Remote Sensing (DRSRS) and Mpala Research Centre.
2) The 2 institutions have jointly been conducting aerial surveys for livestock and wildlife in Laikipia since 1995. The surveys are done after every 2 years thereby forming one of the richest surveyed areas in northern Kenya.

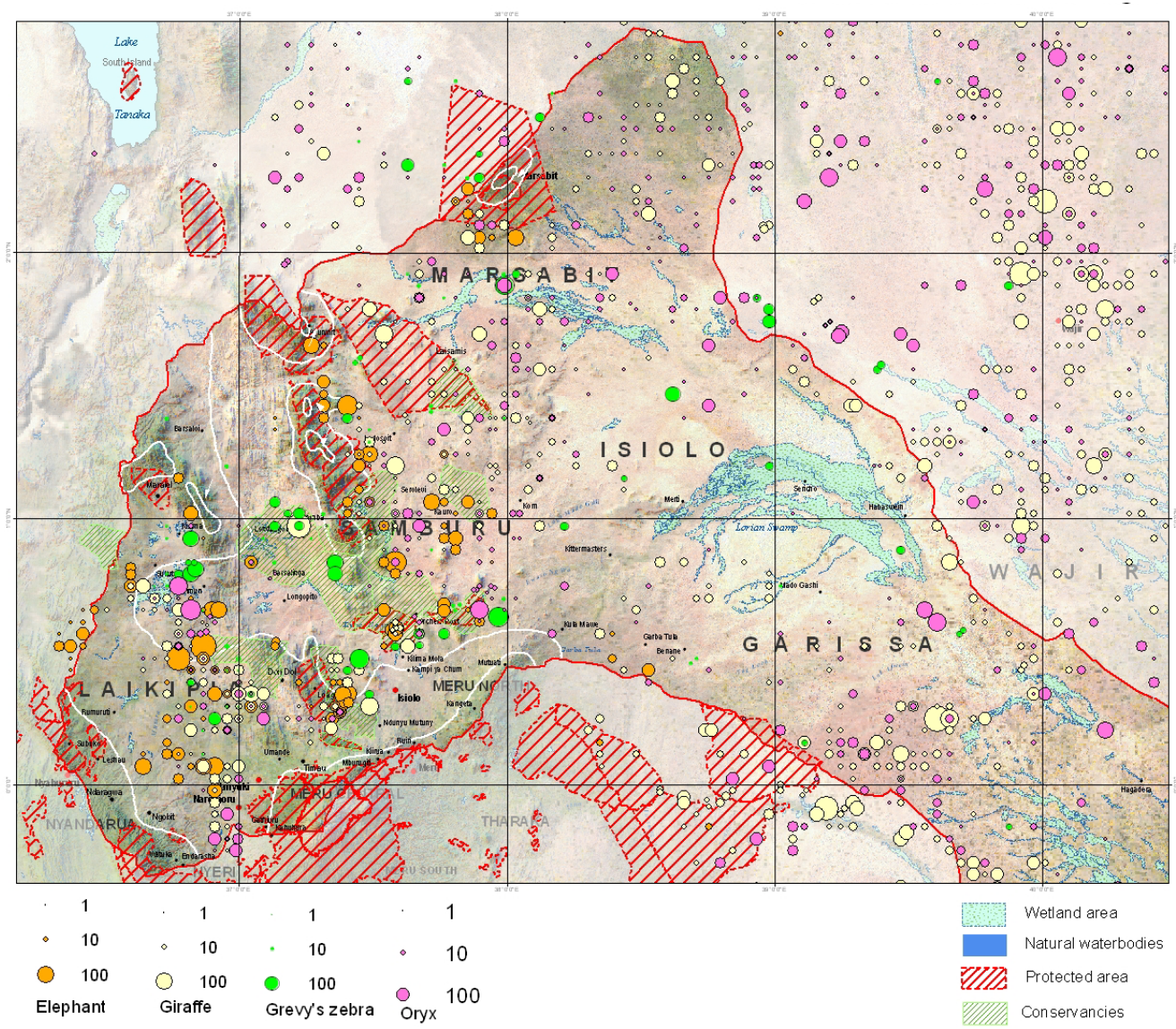
3) In this analysis we merged data from Laikipia, Marsabit, Samburu, Isiolo and Garissa. The data came from the recent surveys conducted between 2000 and 2010.
4) We chose five species and mapped these species on a single map using the spatial overlay function. This spatial overlay function allowed us to overlap the distribution of different species. We used circles to denote the densities of the species. This type of analysis allows us to display spatial patterns and distribution in one single map.
5) Finally, we overlaid these maps with those of land cover, protected areas and also with conservancies to see the relationship among these landscapes.

Where are the critical wildlife areas in the Ewaso Ng'iro?

The analysis has shown the importance of planning at a level higher than the landscape. The importance of land use planning at the basin level is clearly highlighted. We observed 2 clear patterns of wildlife (Map 1). We have Laikipia, Samburu and Marsabit as one of the key important landscapes for wildlife, where we see a diversity of species, such as Grevy's zebra, oryx, reticulated giraffe, and elephants. The presence of oryx, giraffe and a few occurrences of Grevy's zebra are seen on the eastern side of the study site. (See the map of wildlife distribution in Ewaso Ng'iro)

Grevy's zebra is listed as endangered and occurs mostly in the Ewaso Ng'iro basin. The success of its recovery is therefore dependent on the management of this landscape. Recent analysis on wildlife trends and distribution highlighted the threats (refer Georgiadis et al. 2007 and Ojwang and Wargute 2009).

A number of organizations, led by Kenya Wildlife Service, group ranches, conservancies and Northern Rangelands Trust have been involved in ensuring the zebra's survival in the basin and have worked with communities and ranches in Laikipia, Samburu, Garissa and Wajir to manage the species.



Map 3.1: Distribution of elephant, giraffe, Grevy's zebra and oryx in the Ewaso Ng'iro (Sources of information: Erickson et al. 2011)

Such analysis and information can be used to target other species in terms of developing strategic plans for the individual species as has been done for Grevy's zebra and Hunters Hartebeest, Hirola (refer example of management plans - Conservation and Management Strategy for Grevy's Zebra in Kenya (2007 – 2011); Independent Evaluation of Hirola Antelope *Beatragus Hunteri* Conservation Status and Conservation Action in Kenya).

Mapping elephant corridors

Elephants are a key stone species in the Ewaso Ng'iro basin. They move long distances among districts and also between the different landscape (from the mountains to the low lands and back) (Map 2).

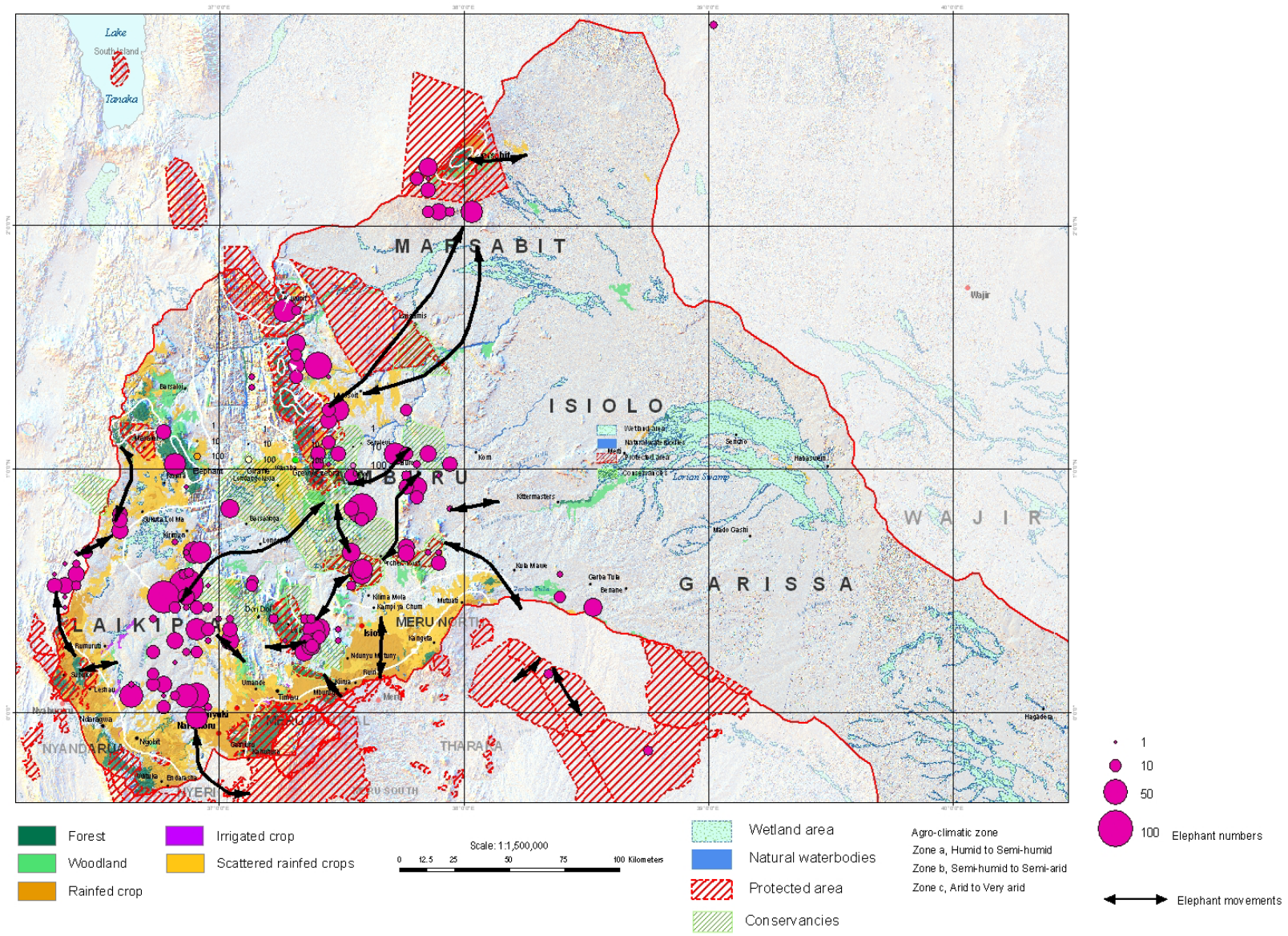
The steps used in mapping elephant corridors within the basin included

1) Mapping elephant distribution --- we mapped elephant distribution from the DRSRS data. The data were not sufficient enough to indicate movement of the elephants, the time and season.
2) Mapping elephant movements --- we mapped elephant routes using data generated by Save the Elephants and Kenya Wildlife Services. Save the Elephants has collared a number of elephants with global positioning system (GPS) units. Based on the GPS recordings they mapped the elephant corridors.
3) Mapping land use – we generated the land cover map from Africover (FAO 2000). We further generalized the classes from 26 to 11 to reduce the complexity of the maps.
4) Protected areas and terrain – the last step was to include the protected areas (parks and conservancies. The data were gathered from Kenya Wildlife Services, Northern Rangeland Trust, African Wildlife Conservation and African Conservation Centre). The purpose was to see if the protected areas were important habitats for the elephants.

Importance of elephant corridors

1) During the wet season the elephants utilize the lowlands and during the dry season the forests. They also move between protected areas and private or communally-owned lands.
2) This analysis shows that we need to have connectivity between the various landscapes. The elephants utilize the forested area and the plains during different seasons.

3) In Kenya wildlife corridors are not protected by law though the proposed Wildlife Bill proposes innovative schemes, measures and incentives to be applied in securing identified critical wildlife migratory routes, corridors and dispersal areas for sustainable wildlife conservation and management;
4) In this exercise we show that by combining the data that is gathered from aerial census and the ones gathered through GPS, you can map corridors and critical wildlife areas.
5) This information can be an input in the mapping of land use and also allocating land for corridors.



Map 4.1: Elephant movements in the Ewaso Ng'iro (Source of Information: Erickson et al. 2011).

Key Messages

1. Analysis of critical wildlife areas and wildlife corridors need to be conducted at higher spatial levels such as the ecosystem or water basin level.

2. In the Ewaso Ng'iro basin the wildlife utilize natural resources quite widely and the distribution of species is based on landscapes, rainfall distribution, seasonality and heterogeneity of the landscapes. These conditions are what make Ewaso Ng'iro rich and diverse in wildlife.

3. As demonstrated in the analysis most of the wildlife is found outside protected areas in northern Kenya and management of these landscapes are crucial for the existence of the wildlife.

4. We have also demonstrated using the aerial counts and GPS data that we can map both the distribution and also corridors of elephants. This type of mapping is helpful and can be used in assigning land use, assessing the threats to wildlife movements and also in prioritizing areas for future conservation.
5. Communities in Laikipia, Samburu and Marsabit are developing conservancies to coincide with areas with wildlife but also to ensure the continuity of these landscapes so that wildlife will be able to move from one place to the other.

Source of Information

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Resource Surveys and Remote Sensing, Nairobi,
Kenya.

Strategic environmental assessment of infrastructure development in Northern Kenya

Introduction

This case study demonstrates the use of mostly national data for strategic assessment of regional development and environment planning.

The case study demonstrates the potential of geographical information in support of spatial planning and Environmental Impact Assessment (EIA) of the Lamu Port-Southern Sudan-Ethiopia Transport (LAPSSET) Corridor project. Environmental impact assessment in Kenya is regulated by legal notice number 101 "The Environmental (impact assessment and audit) regulations 2003", which was amended in 2009 by the Environmental (Impact, Audit and Strategic Assessment) regulations. An EIA is prerequisite for any development in Kenya.

The LAPSSET Corridor will stretch across Kenya to connect southern Sudan and its oil-rich areas to a planned port in Lamu, carrying the promise of increased economic development. It also has a branch from Isiolo to Moyale at the border with Ethiopia and a southern link with Nairobi (see Map 1). If well designed, the LAPSSET corridor can strengthen the competitive advantage of counties in Kenya's Arid and Semi-Arid Lands and enhance livelihoods and economic opportunities for its population.

So far, most of the focus has been on the positive economic outcomes at national level, which may not fully incorporate some of the local processes and consequences of this project. Possible social and ecological impacts include:

- Disturbance of traditional pastoral livelihoods and cultures;
- Fragmentation of ecologically and socially sensitive areas;
- Water scarcity and pollution
- Population relocation, unplanned urbanization, and new migration patterns.
- Hazardous events, such as oil spills.

In this exercise we used spatial data to conduct a multi-criteria analysis.

Spatial decision support tools

Spatial Decision Support tools like spatial multi-criteria evaluation (SMCE) can help to identify and structure the problem(s), to find possible solutions, to evaluate the proposed solutions, and to monitor and evaluate the development.

The input for the application is a number of raster maps of a certain area (so-called 'criteria'), and a criteria tree that contains the way criteria are grouped, standardized and weighed. The output is one or more maps (so-called 'composite index' or suitability maps) indicating the extent to which criteria are met (or not).

The user can easily compare criteria and criteria trees with each other to determine differences and discover what exactly are the reasons that result to a significantly different suitability map, which may lead to a different decision. They can also assess why the suitability is high or low at a certain location.

Finally, the composite index maps can be sliced or classified, and Shape Indices and Connectivity Indices can be calculated.

ITC has developed a Spatial Multi-Criteria Evaluation (SMCE) module in their ILWIS software, which is open source. The advantage of this SMCE extension is that most of the analysis steps are built in. This makes it easy for stakeholders to go step-by-step through the process in a transparent and interactive way.

SMCE is particularly useful to design and locate alternatives for a proposed plan, programme or project activity**,** taking into account a wide range of evaluation criteria derived from policy objectives and stakeholder views and values. SMCE is used to assess different development scenarios in terms of how they affect the vulnerability of the receiving environment. In such an approach highly vulnerable and risky areas can be avoided and the beneficial aspects of the proposed development enhanced.

Another positive effect of such an interactive modelling process is that stakeholders can actively be involved in the planning and decision-making process. Within a couple of minutes valuation criteria and weights can be changed and a new suitability map produced. This makes the whole assessment process more transparent and easy to visually illustrate the implications of spatial decisions.

Evaluation on potential impacts on biodiversity

Here we demonstrate the potential ecological impacts of the proposed infrastructure development. The data used was national livestock and wildlife data, data on towns and major cities,

wetlands, key endangered wildlife species such as Hunter's hartebeest (hirola) and Grevy's zebra, and elephant corridors. Three major steps were taken to develop the analysis. These included:

- Identification of key economic, social, and ecological issues regarding the LAPSSET corridor
- Draft a list of key issues, associated objectives and indicators with stakeholders
- Get feedback from participants on these key issues, objectives and indicators and their quantification

In this exercise we demonstrate how to set the criteria for ecological indicators. The table below was constructed through discussion with key stakeholders. The table shown in this exercise was developed with Kenya Wildlife Service (Figure 5.1). Their main objective was to minimise loss and disturbance of areas with high biodiversity (protected areas, internationally recognised biodiversity areas, and habitat of red listed species). Each of the indicators was given weight and spatial maps derived based on the functions created based on the weighted indicators (Figure 5.2). The data used in this exercise were derived from a number of organizations. National parks and reserves (KWS), important bird areas (Nature Kenya), wildlife and livestock density (DRSRS), elephant corridors (Save the Elephant and KWS), and wetlands (Africover – FAO 2002).

Map 5.1 shows the proposed LAPSSET development and location of town and market centres. Most of the towns and markets centres are located in central and southern Kenya. Map 5.2 shows the distribution of livestock and the proposed development will open many of the areas in northern Kenya. However, we see that also within these areas the development will cut across key wildlife areas in Tana River famous for Hirola and in Laikipia, Samburu and Garissa for its Grevy's zebra (see Map 5.3). Suitability of the proposed development based on ecological criteria is therefore low (see Map 5.4).

This assessment indicates we need to pay attention on biodiversity issues and plans need to be put in place to ensure minimum disturbance. However, you need also to analyse the socio and economic (see Map 5.5) indicators to assess the various options based on the trade-offs.

Key issues	Objective	Spatial indicators	Indicators (parametrization)		Prioritization of indicators
What are the foreseeable key impacts by the LAPPSET corridor (both positive and negative)?	*What can be done about these issues?*	*What should the corridor routing take into consideration to achieve these objectives?*	*The corridor needs to be*	*Possible buffer zone - distance from source (m)*	*How important is this indicator compared to the others?*
Loss of biodiversity	Minimise loss and disturbance of areas with high biodiversity (protected areas, internationally recognized areas, habitat of red listed species, etc)	National parks and reserves (NPR)	The further away from NPR boundaries, the better	min: max:	
		Important bird areas	The further away from important bird area boundaries, the better	min: max:	
		Wildlife density areas	The further away from high density and moderately dense wildlife areas,	min: max:	
		Elephant corridor areas	The further away from existing or proposed elephant corridor areas, the	min: max:	
		Wetlands (Ramsar sites)	The further away from wetlands/Ramsar sites, the better	min: max:	

Figure 5.1: Identification of the key issues, objectives, spatial indicators, parameters and weight for biodiversity considerations

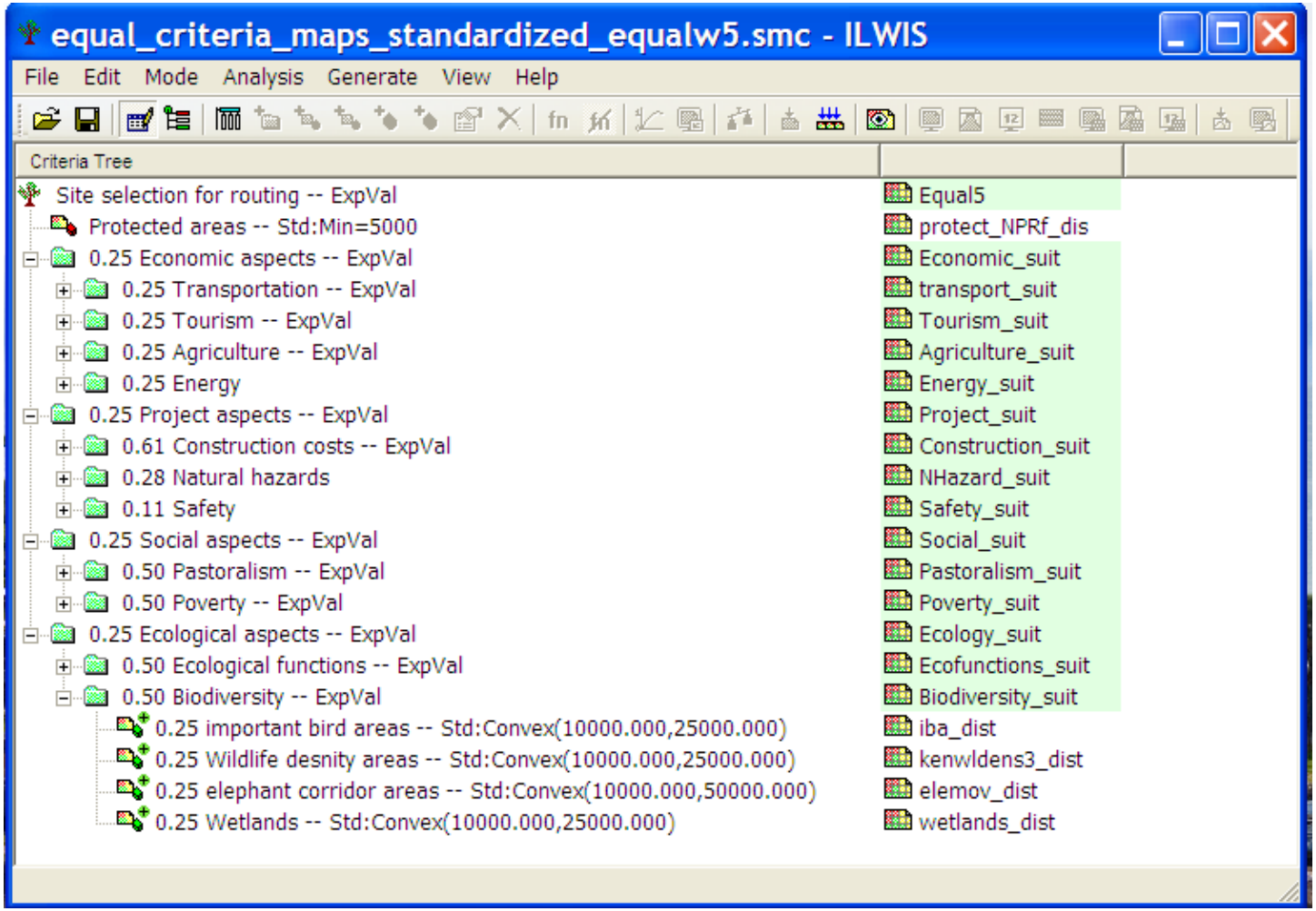
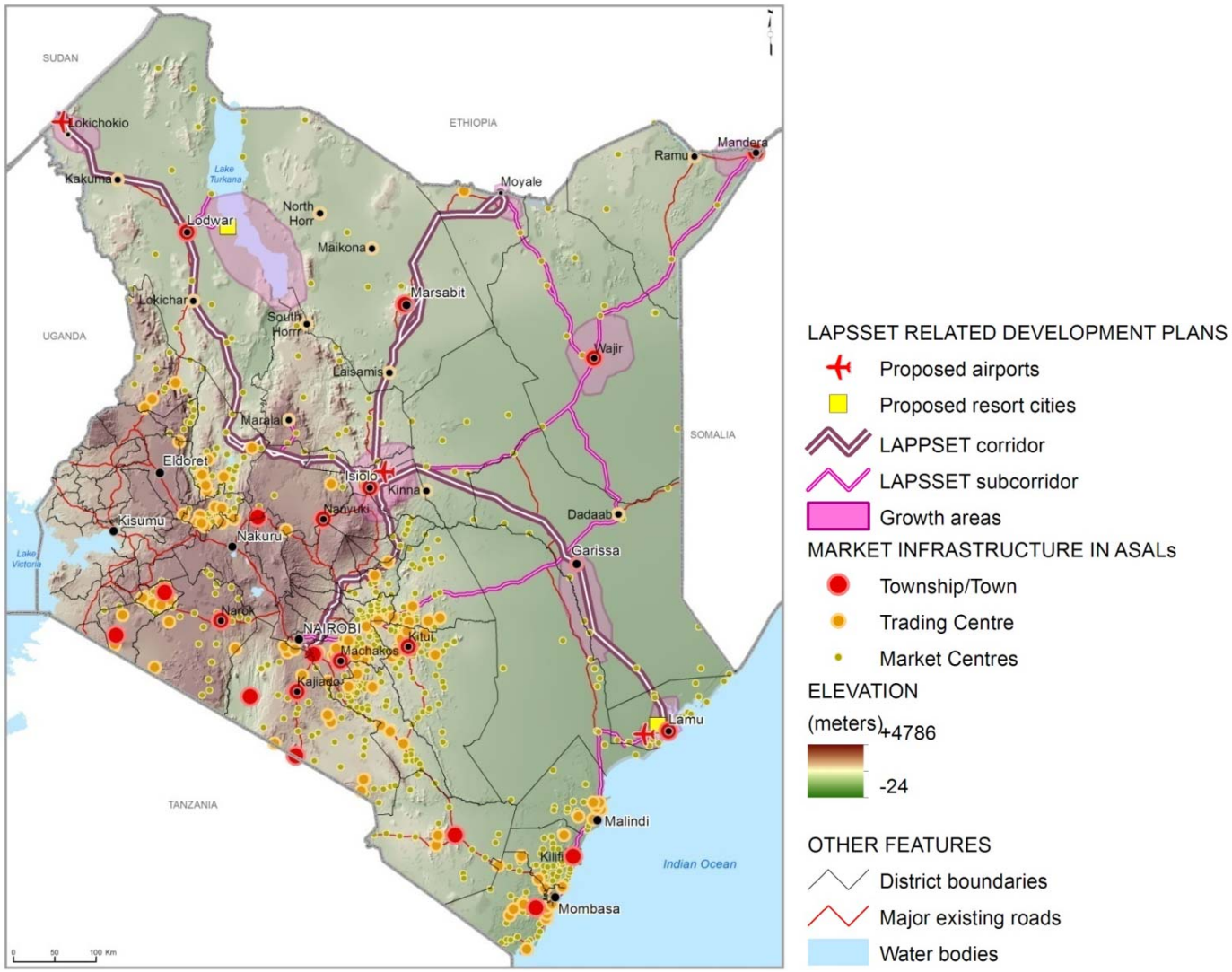
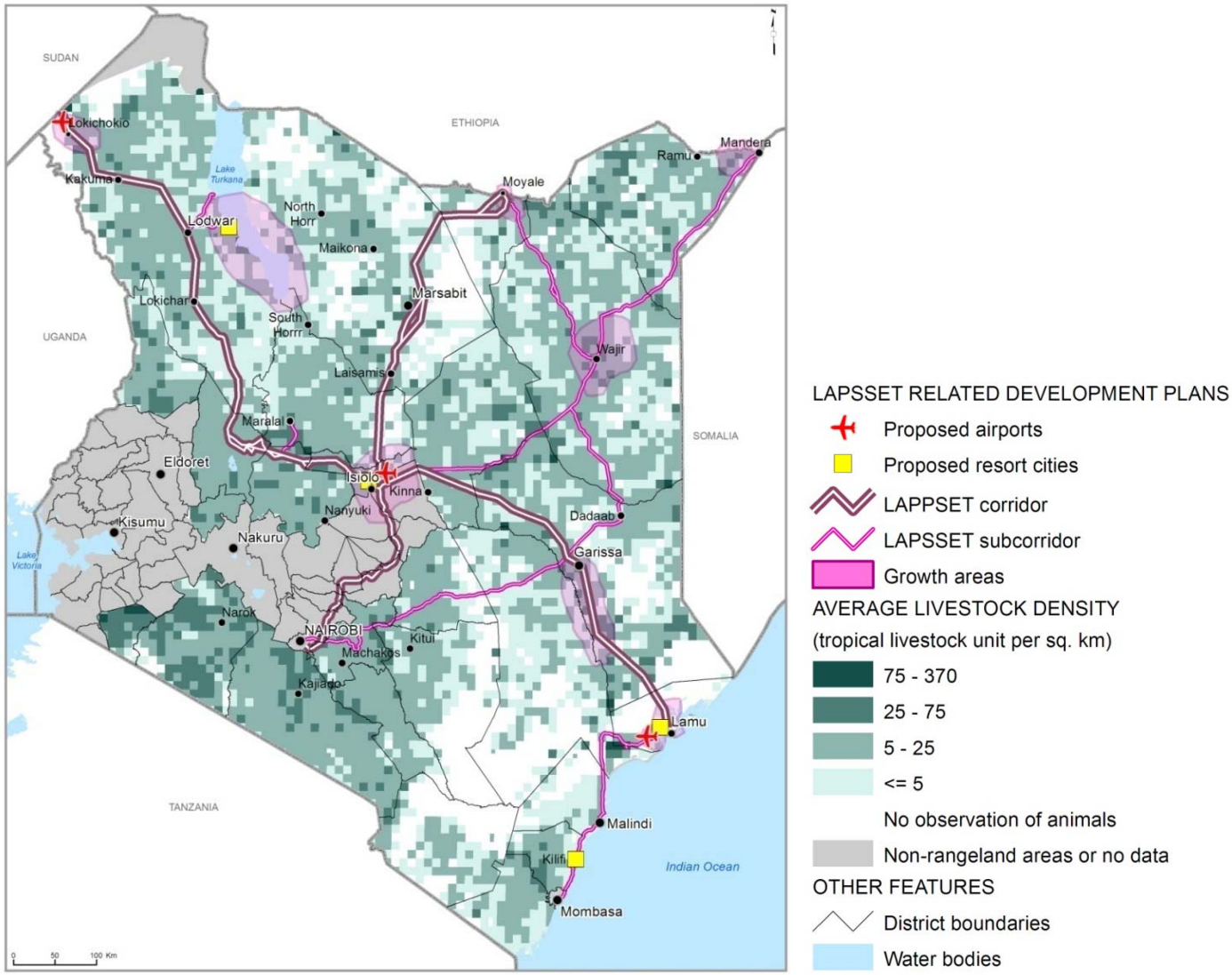


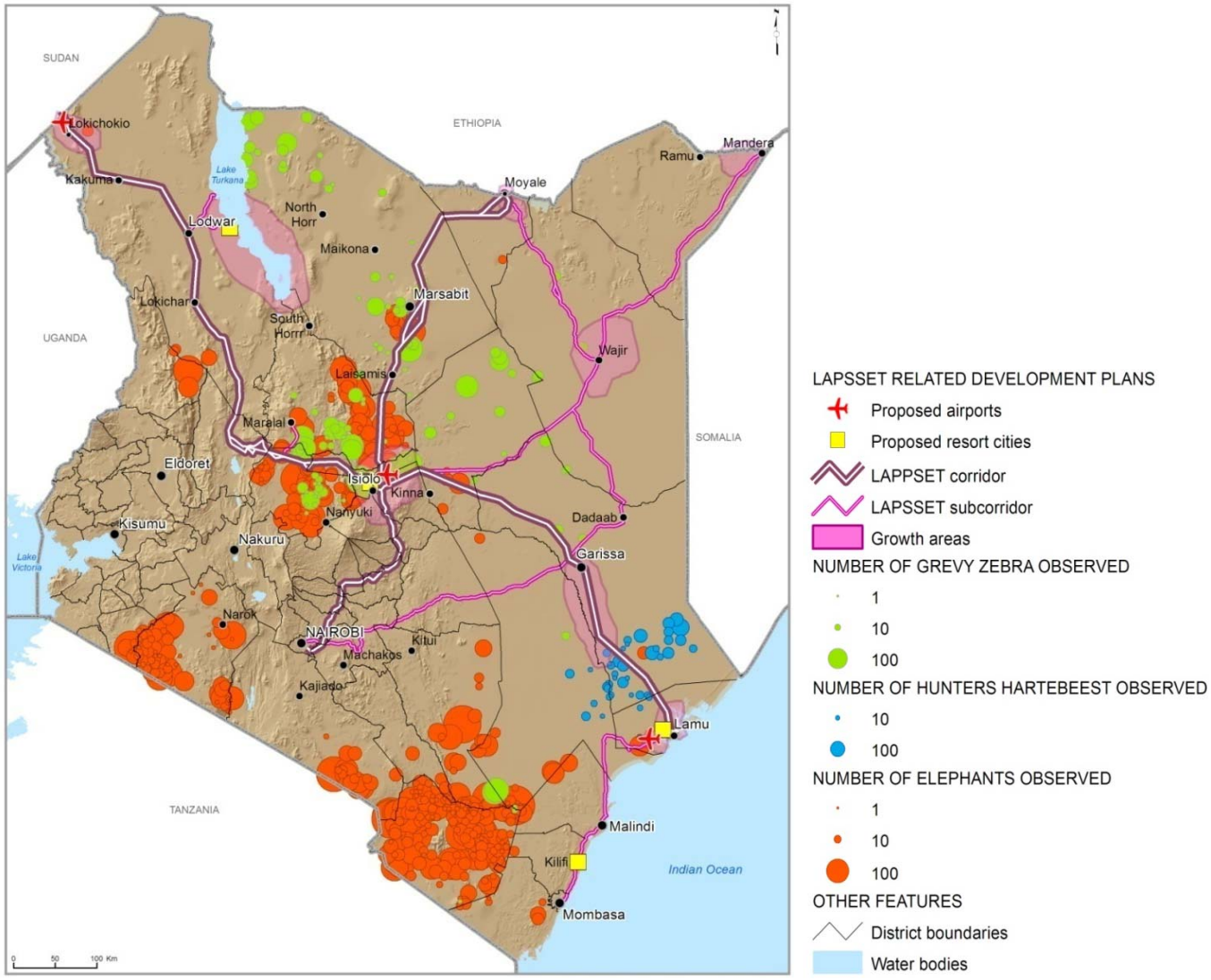
Figure 5.2: ILWIS decision tree for an vision where economic, project. social and ecological aspects are equally weighted.



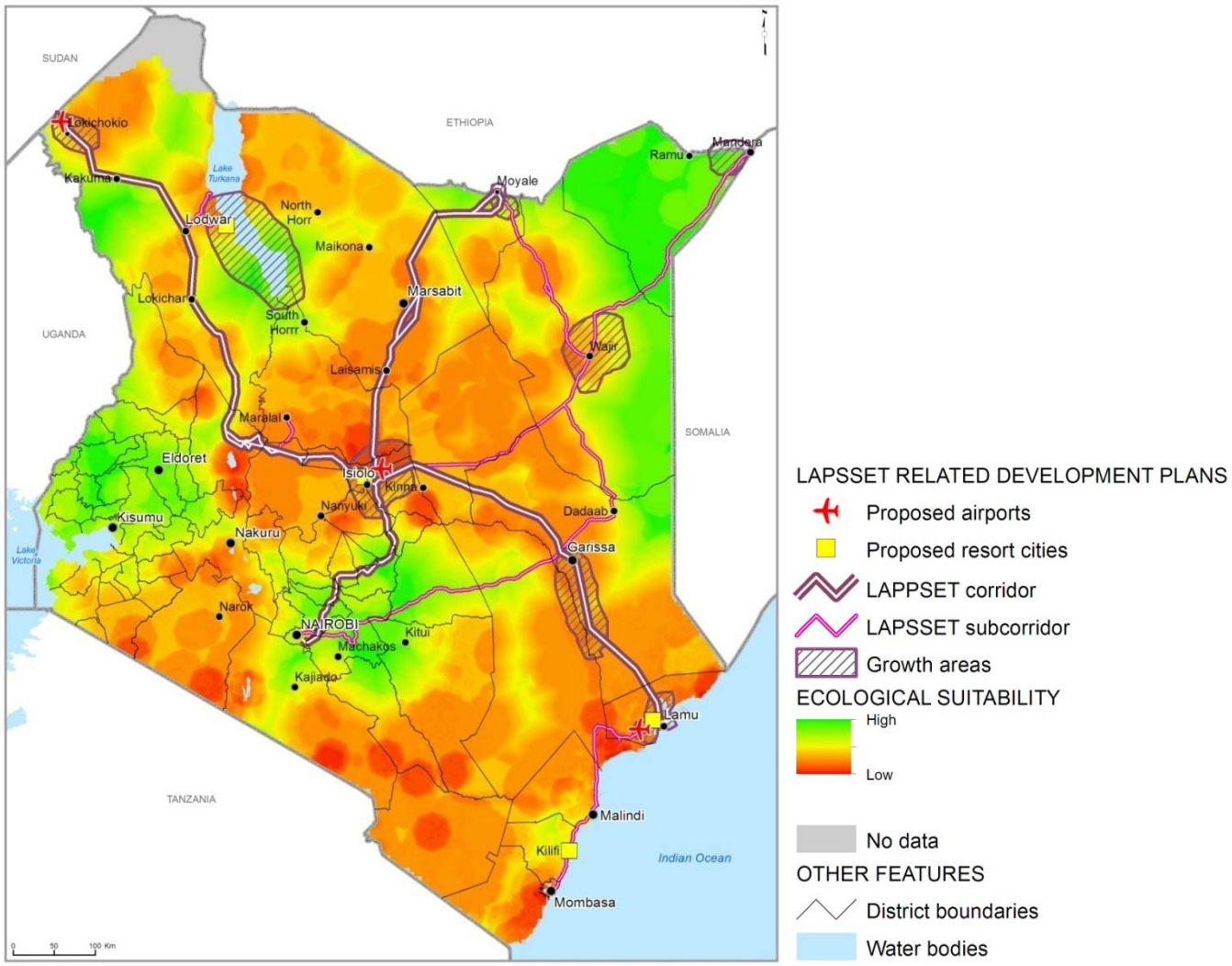
Map 5.1: Proposed LAPSSET development plans with major towns, trading centres and market centres (Sources of information: SoK and ILRI 2000, FAO 2000, CBS 2003, WFP 2009 and Japan Port Consultants Ltd. October 2010).



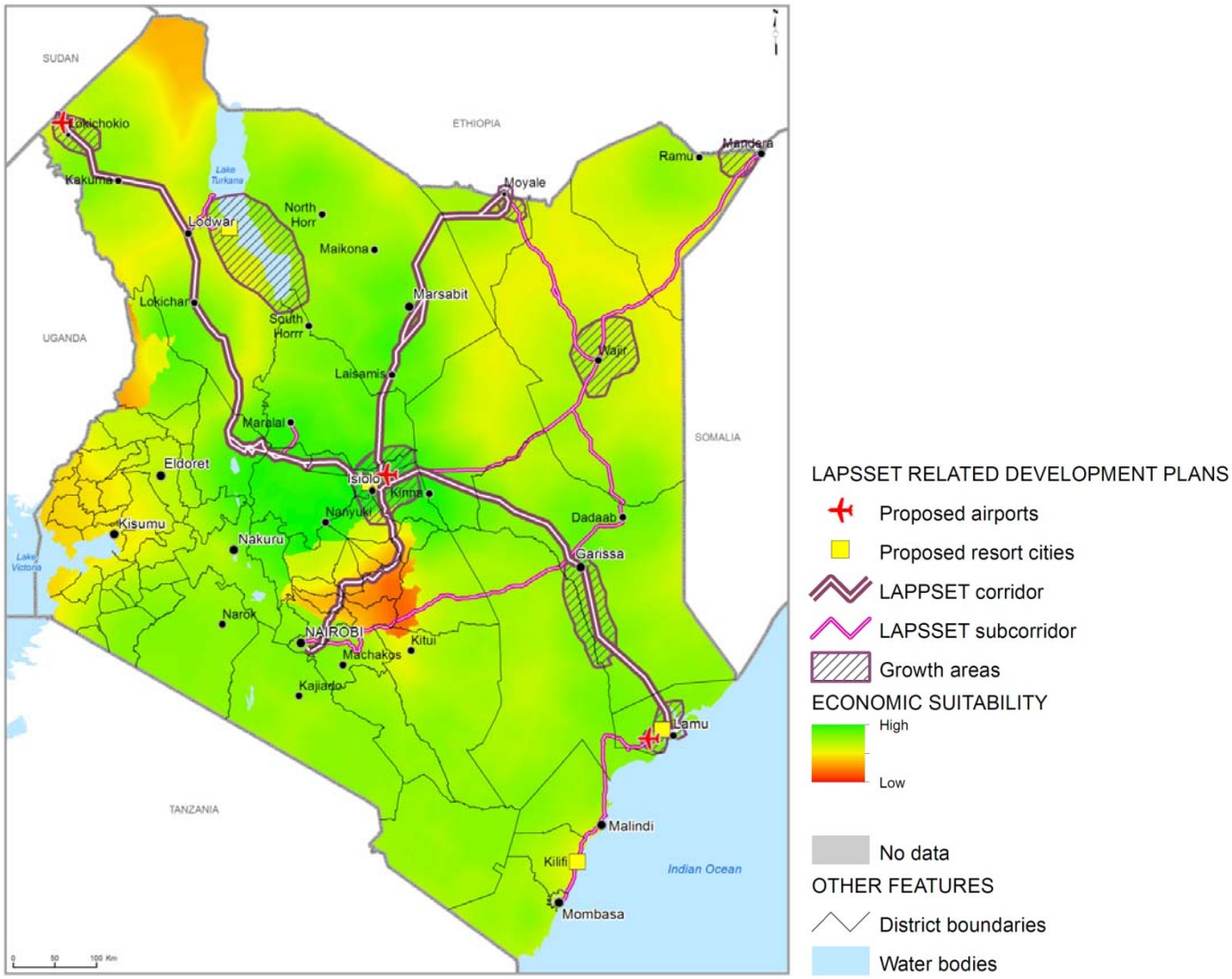
Map 5.2: Average livestock density (1977-2010) in the Kenya rangelands (Source of Information: DRSRS, SoK and ILRI 2000, FAO 2000, CBS 2003 and Japan Port Consultants Ltd. October 2010)


SUDAN
ETHIOPIA
UGANDA
SOMALIA
TANZANIA
Indian Ocean
Lake Turkana
Lake Victoria
Lokichokio
Kakuma
Lodwar
North Horr
Maikona
Moyale
Ramu
Mandera
Lokichar
South Horr
Marsabit
Wajir
Laisamis
Maralal
Eldoret
Isiolo
Kinna
Nanyuki
Kisumu
Nakuru
Dadaab
Garissa
Narok
NAIROBI
Kitui
Machakos
Kajiado
Lamu
Malindi
Kilifi
Mombasa
0 50 100 Km
LAPSSET RELATED DEVELOPMENT PLANS
Proposed airports
Proposed resort cities
LAPPSET corridor
LAPSSET subcorridor
Growth areas
NUMBER OF GREVY ZEBRA OBSERVED
1
10
100
NUMBER OF HUNTERS HARTEBEEST OBSERVED
10
100
NUMBER OF ELEPHANTS OBSERVED
1
10
100
OTHER FEATURES
District boundaries
Water bodies

Map 5.3: Distribution of key and endangered wildlife species in Kenya – the Grevy's zebra, Hunter's hartebeest and elephant based on data collected between 1995 and 2010 (Source of Information: DRSRS, SoK and ILRI 2000, FAO 2000, CBS 2003 and Japan Port Consultants Ltd. October 2010).



Map 5.4: Ecological suitability map, which indicates the extent to which the ecological criteria are met (Source of information: Looijen, J and Voinov 2011, SoK and ILRI 2000, FAO 2000, CBS 2003 and Japan Port Consultants Ltd. October 2010).



Map 5.5: Economic suitability map, which indicates the extent to which the economic criteria are met (Source of information: Looijen, J and Voinov 2011, SoK and ILRI 2000, FAO 2000, CBS 2003 and Japan Port Consultants Ltd. October 2010).

Source of Information

Looijen, J and Voinov, A. 2011. Formulation and evaluation of transport routing alternatives in impact assessment: the LAPSSET corridor demonstration case. University of Twente, World Resource Institute and International Livestock Research Institute. UT-ITC, The Netherlands.

Appendix

List of datasets for Ewaso Ng’iro Basin

1. Bio-physical

Theme	Source
Land cover (2000)	FAO, DSRSR
Land cover (2008)	FAO, DRSRS, and WRI
Agriculture survey by DRSRS (1977-2010)	DRSRS
Distribution of wildlife (1977-2010)	DRSRS
Distribution of livestock (1977-2010)	DRSRS
Rangeland degradation (1997-2010)	DRSRS
Monthly forage maps (2001-2010)	Texas A& M
Annual forage deviation maps (2001 – 2010)	Texas A& M
Normalized Difference Vegetation Index (NDVI) – 1982 - 2009	ADDS
Rainfall, temperature, evapotranspiration	KMD
Slope and DEM (90 meter resolution)	SRTM
Slope and DEM (30 meter resolution)	ASTER
Rivers and open water bodies	Rural Focus
Projected rainfall, temperature and evapo-transpiration under climate scenario (2000 and 2050)	ILRI
Protected areas and conservancies	KWS, IUCN, WCMC, NRT, ACC, AWF
Aquifer extent and recharge rates	Kenya Food Security Steering Group – on-going
Water abstraction in high-lands	Kenya Food Security Steering Group – on-going
Ground water potential	Rural focus
Grazing patterns	Rural focus

2. <u>Administrative boundaries</u>

Theme	Source
County boundaries (2009)	ILRI 2011
District and sublocation boundaries (1979)	CBS, SoK
District and sublocation boundaries (1989)	CBS, SoK
District and sublocation boundaries (1999)	CBS, SoK

3. Range condition

Theme	Source
Roads	GTZ and MOLD
Principal towns, villages	GTZ and MOLD
Rivers - seasonal	GTZ and MOLD
Land elevation contours	GTZ and MOLD
Cliffs and craters	GTZ and MOLD
Special surfaces	GTZ and MOLD
March – seasonal rainfall?	GTZ and MOLD
Dense bush	GTZ and MOLD
Forest area	GTZ and MOLD
Boundary of National Parks and Forest	GTZ and MOLD
Median annual rainfall	GTZ and MOLD
Median rainfall of the first rainy season (long rains)	GTZ and MOLD
Median rainfall of the second rainy season (short rains)	GTZ and MOLD
66% reliability of rainfall of the first rainy season during the growing period of pastures (in millimeters of rainfall)	GTZ and MOLD
66% reliability of rainfall of the second rainy season during the growing period of pastures (in millimeters of rainfall)	GTZ and MOLD
66% reliability of rainfall of the first rainy season during the growing period of pastures (in decades)	GTZ and MOLD
66% reliability of rainfall of the second rainy season during the growing period of pastures (in decades)	GTZ and MOLD
Landform and soil	GTZ and MOLD
Wet season restriction in accessibility for livestock	GTZ and MOLD
Vegetation	GTZ and MOLD
Range condition – is rated as good, fair, poor or non-rangeland based on pasture accessibility, type of vegetation, terrain and if the place is a flooded or non-flooding area	GTZ and MOLD
Range units - areas of uniform ecological potential for their use as pastures, i.e. rangelands which are roughly similar with regard to altitude, precipitation, soils and vegetation	GTZ and MOLD
Distance to permanent and season water points	GTZ and MOLD
Livestock diseases	GTZ and MOLD

Note: The digital database is available for 8 districts namely Baringo (1994), West Pokot (1994), Turkana (1994), Marsabit (1991), Samburu (1991), Isiolo (1993), Wajir-Mandera (1992).

4. Livestock and wildlife

Theme	Source
Distribution of wildlife (1977-2010)	DRSRS
Distribution of livestock (1977-2010)	DRSRS
Distribution of wildlife (1970s)	DRSRS
Distribution of livestock (1970s)	DRSRS
Distribution of wildlife (1990s)	DRSRS
Distribution of livestock (1990s)	DRSRS
Distribution of wildlife (2000s)	DRSRS
Distribution of livestock (200s)	DRSRS

5. Economic

Theme	Source and years
LAPSSET corridor	Japan Port Consultants Ltd. 2010
Roads	WFP?
Railway	Have
Agro-climatic zones	KSS, Sombroek et al. 1982
Crop production	Source?
Cash income source	Source?
Markets (functionality, type of transactions)	Source?
Livestock and poultry ownership	Source?
Veterinary services	Source?
Constraints to economic activities	Source?
Energy sources	Source?
Time travel to distance to markets	IFPRI, Nelson 2008

6. Social

Theme	Status
Human population (1962, 1969, 1979, 1989, 2009)	CBS, KNBS
Poverty rates, density and gaps (1989)	CBS
Settlements (1979-2010)	Have
Water sources (boreholes, wells, dams and pans)	Rural focus
Health centers	Rural focus
Schools	Rural focus
Access to sanitation	Kenya Food Security Steering Group
Conflicts	Kenya Food Security Steering Group
Food security	Kenya Food Security Steering Group
Land tenure (land parcel)	Mpala (Laikipia)
Cultural sites	Source?
Health status (nutrition levels, disease incidence)	Food Security Steering Group