Better Understanding Livelihood Strategies and Poverty through the Mapping of Livelihood Assets: A Pilot Study in Kenya

An ILRI-FIVIMS Collaborative Project
Final Report to FAO-FIVIMS

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i. Background

Under the FAO-Netherlands Partnership Programme's (FNPP) Food Security Component, support has been granted to the "Food Insecurity and Vulnerability Information and Mapping Systems" (FIVIMS) initiative. FIVIMS is a direct follow-up of the World Food Summit of 1996, and monitors the number of hungry people in the world. In addition, FIVIMS also supports ongoing national information system activities relevant to food insecurity and vulnerability to improve the quality of information available in the decision-making process by promoting data sharing among partners and conduct of integrated analysis.

Under the Food Security component of the FAO-Netherlands Partnership Programme the project entitled "Integrating FIVIMS into the UNDAF/CCA Process," the UN Development Group and the FIVIMS Inter-Agency Working Group (IAWG) Secretariat have agreed to use FIVIMS methods and tools to strengthen the "Common Country Assessment" (CCA) and the "UN Development Assistance Framework" (UNDAF) at country level, with a pilot approach to be developed in Bangladesh and Kenya. ILRI is responsible for leading the Kenya pilot study aimed at developing and testing new methodologies for identifying and characterizing the most food insecure and vulnerable groups and better understanding the livelihood assets upon which their livelihood strategies depend.

Kenya was chosen as a pilot country since it is in the start-up phase of developing a national Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS) and this project will provide critical information to it. ILRI, in partnership with several other Future Harvest/CGIAR centers, has many ongoing research activities in Kenya with multiple local partners focusing on gaining a better understanding of the livelihood strategies of poor households and the role of livestock in poverty alleviation.

ii. Acknowledgments

We would like to thank John Owuor, Rene Verduijn, Maarten Immink, and Jenny Riches of FIVIMS for their support for this collaborative research effort, and David Wilcock for initiating it. The ILRI research team greatly appreciates the assistance and contributions of a large number of individuals and organisations that assisted during the mapping exercise. In particular, we are grateful to the Netherlands Development Organisation (SNV), particularly Jackson Wandera and Steve Osingo, for providing logistical support and sharing with us important tips on Participatory Landuse Planning and Mapping, and to the Community Area Development Committee (CADC) members and community-based organisations (CBOs) for assisting in workshop preparations and coordination. The research team is also grateful to representatives from various GOK Ministries, particularly the participating representatives of the health, livestock, agriculture, social services, livestock, water, education and environment ministries. Finally, the study would not have been complete without the enthusiasm and participation from members of the community who provided vital information on the status of various facilities in their sublocations. We'd also like to thank the following individuals for helpful technical advice and contributions to the analyses: Frank Place, Brent Swallow, Norbert Henninger, Janet Nackoney, Nick Schlaepfer, Russ Kruska, Mario Herrero and Jeannette van de Steeg.

1. Introduction

1.1 Poverty and livelihoods assets

Poverty is a multi-dimensional and complex phenomenon. It is common to find large spatial variability in poverty incidence in developing countries for a variety of reasons, including differences in geography, history and ethnicity, access to markets, public services and infrastructure, and other aspects of public policy (see de Janvry and Sadoulet*, 1997*). With advances in remote sensing technologies and GIS tools, there are now more opportunities to gather poverty information at a level of disaggregation sufficient to analyze this spatial variation and better understand the factors behind these differential levels of poverty at both community and household levels.

A whole range of methods and indicators have been developed to study the spatial distribution of wealth and poverty, generally referred to as 'poverty maps' (see Henninger and Snel, 2002, for a review of these methods and applications). This study makes use of new, sub-District poverty maps for Kenya (CBS and ILRI, 2003) to examine in detail the spatial variation in poverty incidence and the factors influencing differential poverty levels for a semi-arid, agro-pastoral district of Kenya, Kajiado district.

In particular, we are interested in the role that livelihood assets play in determining and explaining poverty incidence. The concept of sustainable livelihood strategies and assets provides a way of exploring more deeply the role of environmental resources in the livelihoods of the poor (Ashley and Carney, 1999). A core feature of the sustainable livelihoods framework is an analysis of the five different types of assets upon which individuals draw to build their livelihoods. These are natural, social, human, physical and financial capital (see Ashley and Carney, 1999 for more details on this approach).

Natural capital refers to the natural resource stock from which resource flows useful for livelihoods are derived, and includes: land, forests, water, air, wildlife, biodiversity and other environmental resources. Social capital includes the social resources that people draw upon in pursuit of livelihoods, such as group membership, networks, and access to institutions and influential people. Examples of human capital are the skills, knowledge (including indigenous), labour availability and good health necessary for people to be able to make a reasonable living. Physical capital represents the basic infrastructure and production equipment that enable people to pursue their livelihoods, e.g. transport, shelter, water, energy and communications). Financial capital can be in the form of cash, credit, savings or remittances (Carney, 1998, Figure 1.1).

Figure 1.1. The 5 livelihood capital asset types

Natural capital: The natural resource stock from which resource flows useful for livelihoods are derived (e.g., land, water, wildlife, bio-diversity, and environmental resources)
Social capital: The social resources (networks, memberships of groups, relationships of trust, access to wider institutions of society) upon which people draw in pursuit of livelihoods
Human capital: The skills, knowledge, ability to labour and good health important to the ability to purse different livelihood strategies
Physical capital: The basic infrastructure (transport, shelter, water, energy and communications) and the production equipment and means that enable people to pursue their livelihoods
Financial capital: The financial resources available to people (whether savings, supplies of credit or regular remittances or pensions), providing them with different livelihood options
Source: Carney (1998, p.7)

This study began by asking the question "which of these livelihood assets can be mapped'? The next question that followed was "of the 'map-able' livelihood assets, which are the most useful, for whom, when and why?' To answer these questions, several conceptual challenges had to be overcome. First, how and what to actually map for each of the 5 asset categories needed to be addressed. Second, a participatory community-level approach was taken in order to explore what types of decision-makers, at various levels (sublocation to District), could use the resulting information and maps, and how and what were they using the information for? In other words, we also needed to explore the hypothesis that detailed sub-District level livelihood asset maps provide useful information to a variety of policy/decision-makers[1].

1.2 Study objectives

Specific objectives of this study included:

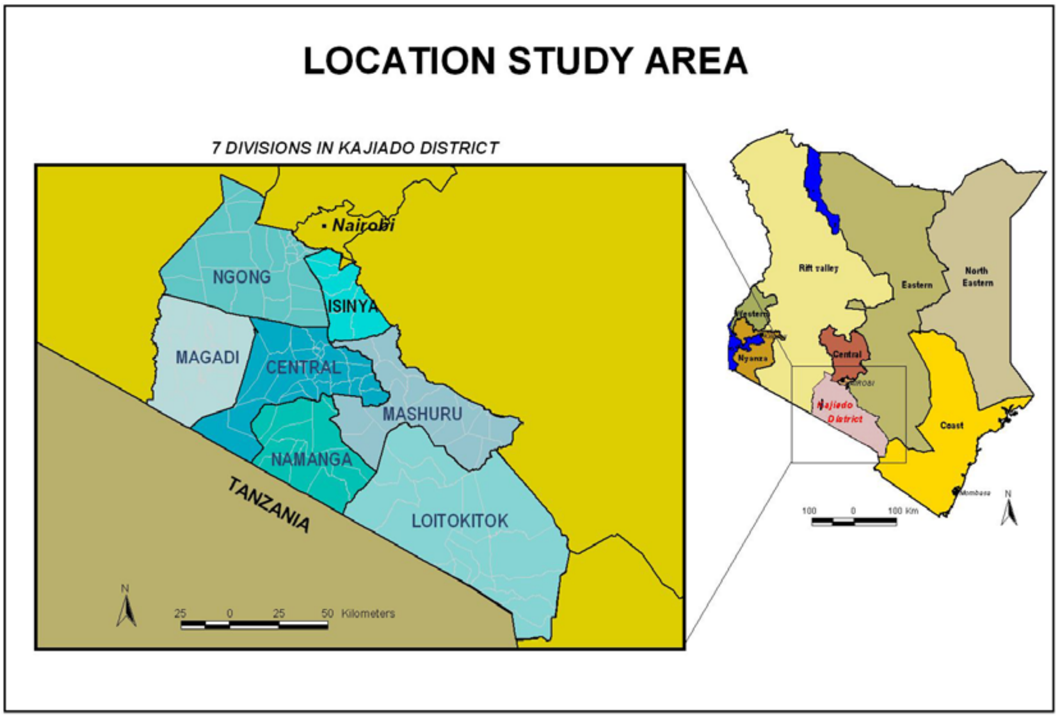
1. Taking a pilot study approach, test approaches, data requirements and field surveys needed to contribute to the development of a food security and poverty information systems for Kenya, as a solid input into the preparation of a Common Country Assessment.
2. Develop livelihood maps for one pilot district in Kenya (Kajiado district, see Figure 1.2 and Figure 1.3)
3. Review approach, results and lessons learned from the pilot study with all relevant partners
4. Based on livelihoods mapping results in the pilot district, assist with validating and applying the approach in two additional districts that represent different livelihood systems
5. Make recommendations on possibilities for a more broad application of this approach based on lessons learned re: costs versus benefits of this pilot study

Figure 1.2 The pilot district: Kajiado

Kajiado district is found in southern Rift Valley Province. It is bordered by Tanzania to the south-west, Taita Taveta district to the south east, Machakos to the east, Nairobi to the north and Narok district to the west. It is an expansive and thinly populated area with an uneven distribution of social and economic infrastructure. It is subdivided into 7 divisions and 120 sublocations. The general topography of the district is characterised by plains and a few volcanic hills and valleys. The land rises in altitude from about 500 metres around Lake Magadi to about 2,500 metres in the Ngong Hills area. Most of district's area of 21,903 km^2 is classified as Arid or Semi-Arid. The total population of the district, mainly Maasai people, was 406,054 according to the 1999 census, which implies an average population density of19 people/km^2. The Maasai's livelihoods have traditionally revolved around livestock – primarily cattle, sheep and goats. Increasingly, they are seeking to diversify their livelihoods.

[1] Note that a second hypothesis, namely that local policy/decision-makers will make better informed decisions if they have access to these detailed livelihood asset maps is much more difficult to ascertain and requires a longer timeframe than this year-long project allowed, but should be followed up over the next few years.

Figure 1.3 Location Study Area

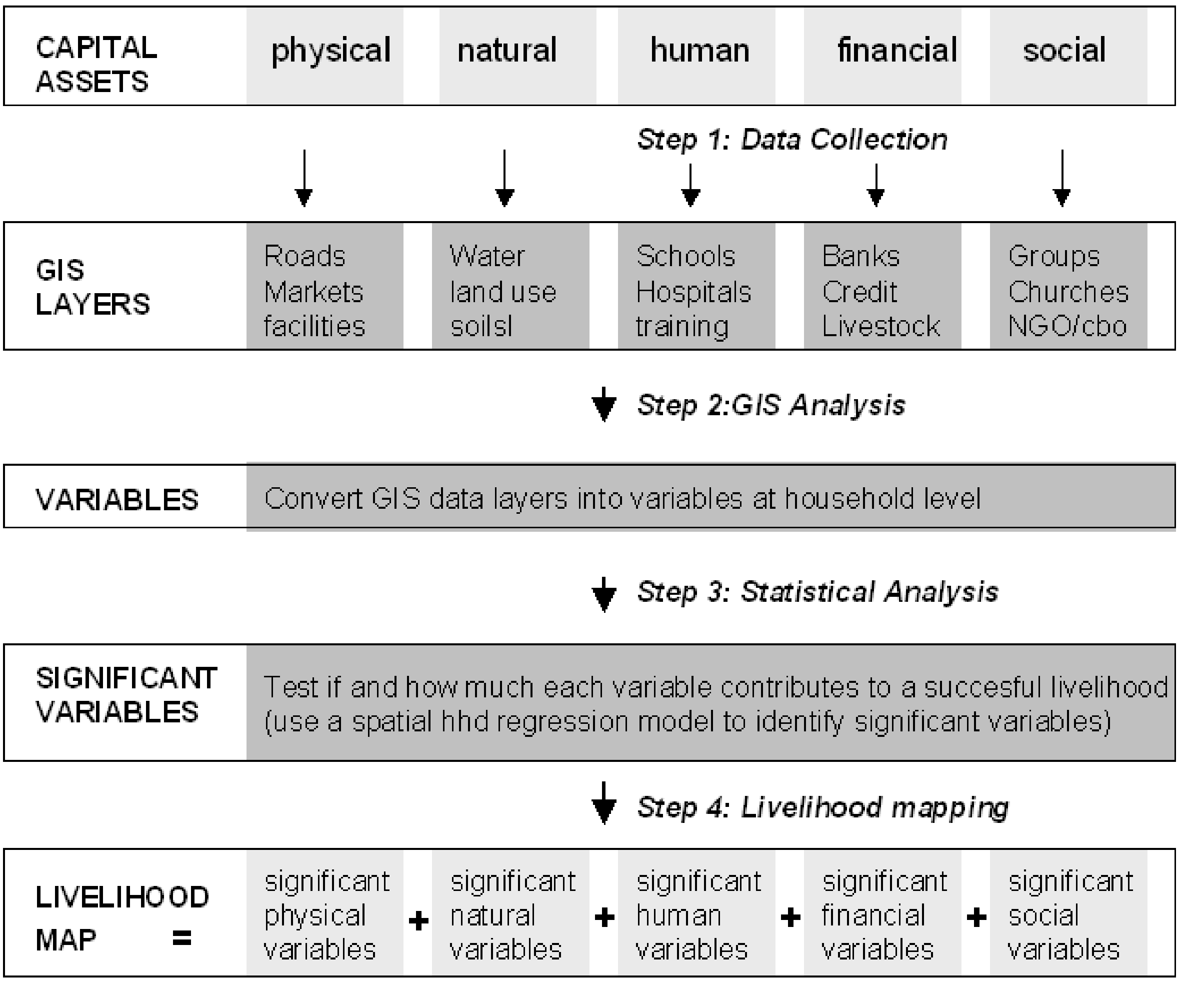


2. Methods

2.1 Overview of the approach

To develop livelihood maps based on the livelihoods framework, a number of steps were needed (see Figure 2.1). The first step involved translating the five capital assets into physical and 'map-able' variables that could then be assembled in a GIS environment. This set of GIS layers formed the basis for the analysis in this project and at the same time provided valuable information and maps for many different stakeholders.

Figure 2.1 Data inputs and process for the production of livelihood maps



In the second step, the available datasets were converted into more specific variables: information about type and distances of roads were translated into variables such as the average distance in travel time to reach the nearest town, permanent water source or health facility within the sublocation, for example.

The third step involved statistical analyses at the sublocation level aimed at better understanding which livelihood asset variables have statistically significant explanatory power vis-a-vis variations in poverty levels. At the sublocation level, the dependent variable was the proportion of the population falling below the rural poverty line. The following hypotheses were explored:

1. Community-level poverty levels can be explained to a large extent by access to the five livelihood capital assets, since these largely define peoples' livelihood options
2. Not all types of capital assets are significant factors influencing relative poverty levels
3. Some capital asset variables will explain more of the variation in poverty levels than others

We had no a priori hypotheses, however, about which of the five types of livelihood assets would be more important than others in explaining relative sublocation poverty levels. This was an open question to be explored in the analyses.

The final step involved combining the variables found to be significant and thus important factors affecting poverty in different ways to create livelihood maps for Kajiado district. Asset scores and probability mapping were two of the methods that were explored.

The first two steps, and the final step, relied heavily on the participation of multiple stakeholders in Kajiado district. First, community members and decision-makers helped in choosing which variables were appropriate and potentially useful indicators of each of the five asset types. Next, participants from each sublocation in the district took part in a participatory landuse mapping and subsequent verification exercise (described more fully in Appendix 2). Lastly, the information and maps generated were presented to community members and the uses, and usefulness, of the various products were explored. SNV, a NGO-based in Kajiado district, proved to be an indispensable partner in allowing us to take such a participatory approach.

2.2 Mapping capital assets (step 1)

2.2.1 Which indicators of the five types of capital assets can be mapped?

The process of filling in the five capital asset groups with actual map-able features turned out to be quite challenging. Where assets like natural capital and physical infrastructure are by definition geographically defined, and as such, have a long mapping history, resources such as social networks and financial capital do not necessarily have a physical location. How to capture and map networks of trust, membership of groups, savings and remittances, for example, has been extremely challenging. Besides consulting the literature, a workshop with stakeholders and technical/government experts was held in Kajiado, resulting in a first "wish-list" of variables that were thought to cover all aspects of the 5 types of livelihood capital adequately (see Appendix 1 for the initial list of assets to be mapped for each sublocation). It was during this workshop that community members stressed that it would be necessary to map these variables for all 120 sublocations (i.e. that people from each sublocation would be best placed to verify the location of the variables chosen).

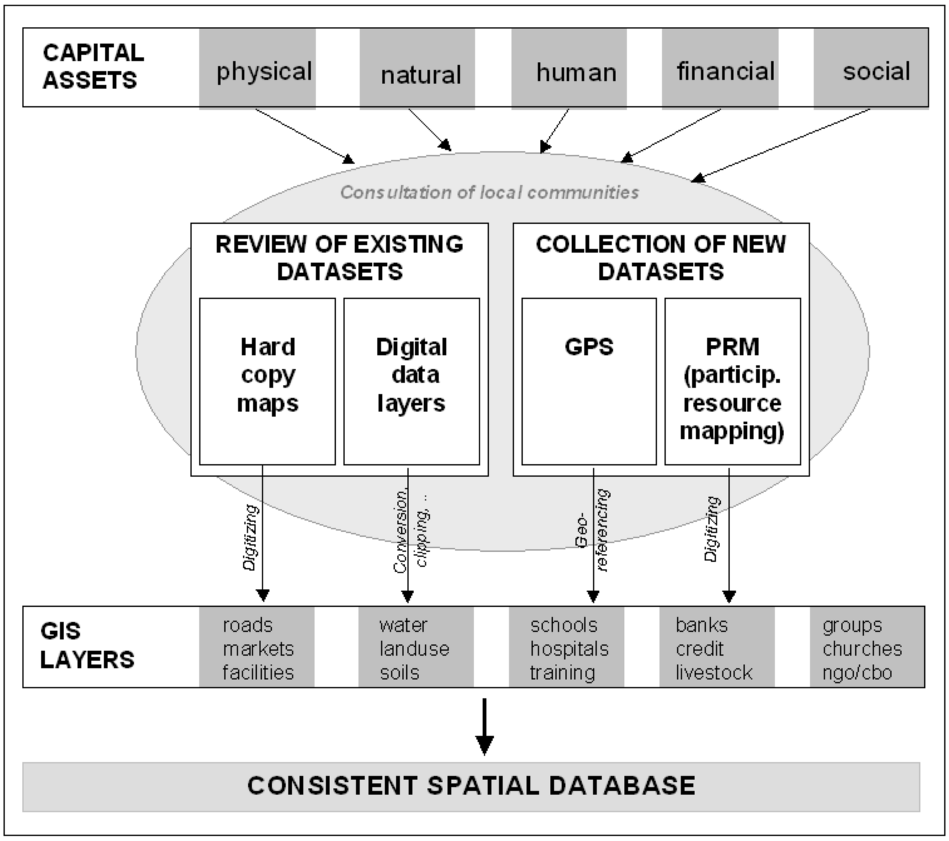
This was a one-day workshop; in hindsight, it would have been useful to perhaps extend it to two days and on the second day prioritise the indicators suggested by participants.

2.2.2 Collecting GIS layers

Although creating a comprehensive list of layers that could be mapped was an important first step, much of the data still had to actually be mapped. The steps involved in this process are shown in Figure 2.2. Most of the layers that were listed as potentially important information sources were not yet available in digital GIS format. So, apart from pulling together existing GIS layers, a large part of the project has involved collecting and creating new datasets. Both means are described below.

A workshop was undertaken in collaboration with the Netherlands Development Organization, SNV (previously SARDEP)[2], in Kajiado District in Dec. 2002. SNV operates throughout Kajiado District (with a particular emphasis on 3 divisions) and has built up an impressive network of local decision makers, government officials, and through its impressive track record of involving community members in projects that have had positive impact has garnered a high level of trust from community members.

Figure 2.2 From Assets to GIS Layers



[2] See www.snvworld.org

Review of existing datasets

Use was made of a whole range of different sources during collection and review of existing spatial data for Kajiado District. All sources were scanned for their most recent, their most detailed as well as their most complete datasets. Particularly useful sources included:

- ILRI GIS database
- Africover
- Kenya Wildlife Service
- Ministry of Land Reclamation, Regional and Water Development
- DRSRS and CBS

Some datasets were already in digital format, while some needed to be converted to ArcView, and some needed to be clipped for the region of interest, while still others could be used directly. Some very useful data on a range of possible water sources in the district was available in the form of hard copy maps. These maps were digitized and converted into ArcView shapefiles.

Unfortunately, geometric distortions occurred in the different source maps. There was a need to align all the datasets. The administrative boundaries as found in Africover were used as a reference. Existing datasets have been rubbersheeted towards the same. Rubbersheeting is a GIS functionality used to correct flaws through the geometric adjustment of coordinates. During rubbersheeting, the surface is literally stretched, using a piecewise transformation that preserves straight lines. This process was used to align the different existing datasets.

All in all, collecting existing datasets was time consuming (taking at least 6 months), but well worth the effort. All existing sets could be used as a reference for others during the data collection exercises later on in the field. In particular, the very comprehensive and relatively recent (1995) dataset from the Ministry on water sources and water development proved a valuable (reference) dataset.

2.2.3 Creation of GIS-layers

Participatory Resource Mapping

In order to fill in the missing data gaps, a participatory resource mapping exercise was undertaken in collaboration with SNV for the entire district (see Appendix 2 for a detailed description).

The main objectives of the exercise were to:

1. Collect baseline data for livelihood mapping, e.g. locating schools and other service facilities, water sources and job opportunities throughout the district;
2. Increase the capacity of communities and other stakeholders such as various Ministry representatives in Kajiado and to make local communities and government representatives aware of the natural resources that exist within their immediate surroundings; and
3. Develop a method and tools that are useful for asking the same stakeholders feedback on our products and analysis outputs and involving them in the process of using the final outputs.

In their three focus Divisions, SNV had previously undertaken several Participatory Land-Use Planning (PLUP) exercises with local communities. They are currently in the process of expanding their operations to cover the remaining Divisions and thus ILRI and this study assisted in completing this process.

GPS exercise

Much to the profit of the study, SNV (then SARDEP) had recently invested in obtaining baseline data at community and household levels. Almost 2,000 community members were surveyed in three divisions (Loitokitok, Central and Magadi Divisions) in 2001 (benchmark year 2000) on topics ranging from socio-economic characteristics to agriculture and livestock to domestic water supply and education. None of the households were, however, geographically located (GPS'd) at that time for lack of resources. Thus it was decided to revisit the same households that were originally surveyed and get a proper geo-reference, which would allow us to map not only these households, but also the SARDEP/SNV-funded projects and additional development projects at the same time.

The process involved two major steps. The first was conducting extensive GPS training in the field. Three separate training sessions were organized at the division-level headquarters. During the training sessions, ILRI provided the technical know-how, while SNV provided matching funds and logistical support. The sessions entailed training of former enumerators, officials of the community area development committees (CADC) and various government officers (also known as RAFT members) on the use of GPS units. One enumerator involved in SNV's extensive household-level survey was included from each sublocation, along with one government officer per Division. A total of 120 enumerators and 17 government officers took part in the training. All of these participants verified the lists of households, institutions and groups interviewed during the baseline survey as well as the lists of SARDEP-funded community projects per sublocation. The actual geo-referencing of households and projects took place over a three months' period from September - December 2002. Under supervision of researchers from ILRI, the exercise depended largely on the previous survey experience of the trained enumerators, government officials and community members. Where the surveyors knew how to find almost all of the households visited two years earlier, the government participants/RAFT members mustered their knowledge on both the location as well as the history of the SARDEP-funded community projects. It was important to involve both groups, not just for their knowledge of household and project locations, but also because they would later on become the avenues through which the delivery of the outputs would be extended, as per SNV's policy.

2.3 Creating variables to characterize capital assets (step 2)

While compiling a dataset with sufficient information to cover all livelihood assets is a challenge, so is converting these layers into useful information. Of course, some of the GIS layers collected can be used as they are, such as simple rainfall patterns and the slope of the terrain, but most layers have to be translated into some kind of accessibility measure (e.g. how far are people or communities away from the resources that provide different livelihood options). The location of schools, for instance, is not that informative in itself, but can be very revealing if transformed into a measure of distance to a primary school, or presence of good quality schools within a sublocation.

Some of the accessibility measures make use of the existing road network, e.g. access to markets and facilities is defined by the presence and the quality of the existing road network. Other measures, such as access to schools and water facilities, do not depend on the road network but simply on passable terrain by foot. For these latter cases, a simple distance surface was calculated. Alternatively, natural barriers like hills or rough terrain were incorporated in the form of a cost-surface, which allows the calculation of a least-cost-distance surface.

For each of the five livelihood asset types, a number of variables were extracted. Two sets of variables were created, one at the household level and another one where data was aggregated up to sublocation level (typically by deriving the mean value for the sublocation, e.g. the average PPE (precipitation over potential evapotranspiration) for the sublocation. For a detailed description of the extracted variables and how the hypotheses of how they may be expected to contribute to the poverty at the sublocation-level, see Appendix 3.

2.4 Factors explaining livelihoods at the sublocation-level (step 3)

SNV carried out participatory poverty assessment in 2000 that led to a poverty reduction strategy paper for Kajiado District. It contains a comprehensive list of at least 15 causes of poverty, including a range of spatial factors such as insufficient water supply and poor infrastructure, land problems, frequent droughts and poor access to health and educational services. The World Food Programme defined 'Livelihood Zones' for Kenya, and for Kajiado District they describe four zones (pastoralist, irrigated agriculture, agro-pastoral and urban zones) (Haan et al., 2001). Neither of these approaches were able to address questions about the relative importance of the different spatial factors, or livelihood assets, underlying the different livelihood strategies, as their analyses were conducted at a very coarse resolution (i.e. division-level at best).

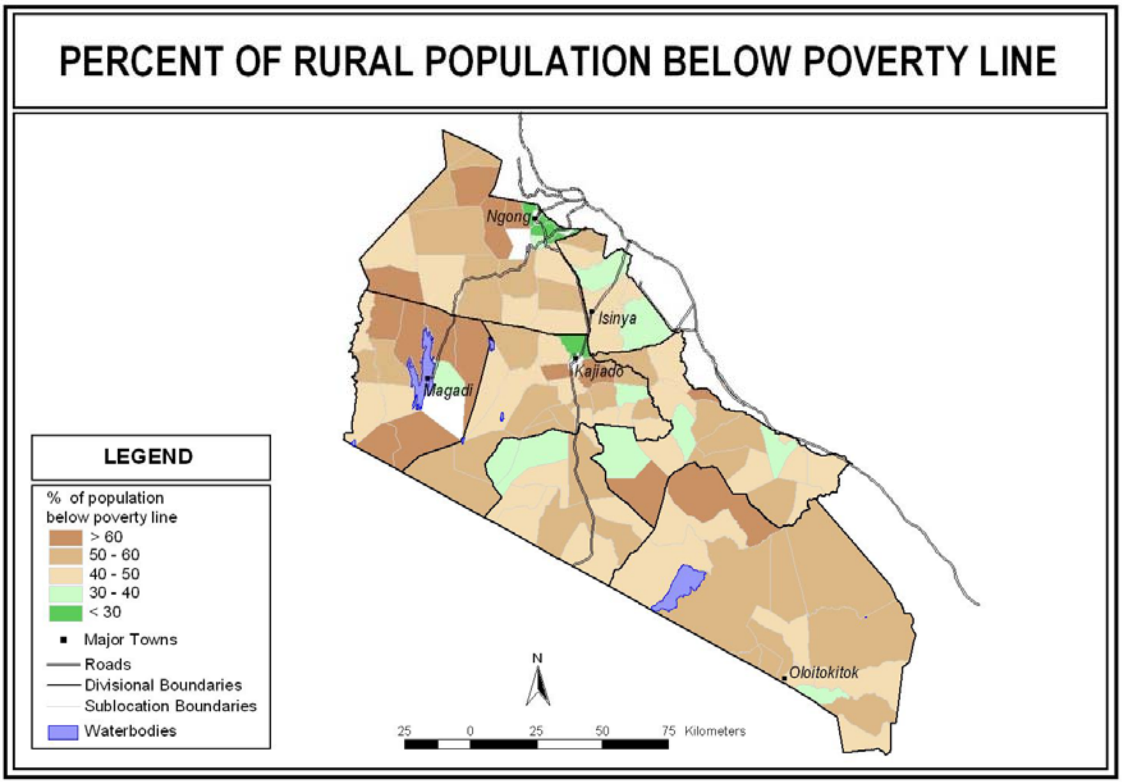
At the sublocation-level (the level at which the new poverty data allows us to analyze the factors behind differential poverty rates), explaining the causal factors behind poverty levels is tricky. Certain variables will be exogenous to poverty processes. For example, the level of rainfall is certainly a cause, and not caused by, relative community- or sublocation-level poverty levels. Other factors may be endogenous, and not as easily determined as being cause or effect variables. For example, relatively wealthy communities may influence the construction of health or education facilities. So whether relatively wealthier sublocations influence access to health or education, or access to education or health influence relative poverty levels across communities is very difficult to determine.

In Kajiado district, sublocation poverty levels vary from 11 to 93 percent *(*CBS and ILRI, 2003) (Figure 2.3)[3]. We do not attempt to explain factors *causing* these widely different poverty rates in this analysis. Rather, we attempt to tease out which factors appear to have an important and statistically significant relationship, and the relative importance of the five livelihood capital asset-related variables, in helping to explain different poverty levels across sublocations.

For example, which of the five livelihood asset category variables are the most important in helping to explain poverty? Is being close to a school more important than being close to a hospital? Is it true that roads and infrastructure matter much in a district where walking is paramount? How do we weigh the importance of each variable? These are questions that are important to answer before trying to create livelihood maps — i.e., should each asset have a similar weight, or should the livelihood maps give different weights to each of the livelihood asset categories? Moreover, should some variables be left out of the equation entirely because they do not appear to contribute significantly to livelihood options/choices?

[3] The poverty measure used at the sublocation level is the proportion of the population falling below the poverty line in 1999. This poverty line is based on the estimated expenditures required to purchase a food basket that allows minimum nutritional requirements to be met, plus the costs of meeting basic non-food needs (GoK, 2000). In rural Kenya the 1999 poverty line was estimated to be KShs 1,239/adult/month (roughly $.55/adult/day).

Figure 2.4 Proportion of population falling below the rural poverty line in Kajiado District, at the sublocation level



Source: CBS and ILRI, 2003.

2.4.1 Analytical Approach

In this analysis, we took an model selection approach (rather than a more traditional null hypothesis testing approach) based on information and likelihood theory (Burnham and Anderson, 2002). We chose a loglinear Poisson functional form for a regression relating the number of poor people in each sublocation to the set of predictor, or explanatory variables, and used the total population size in each sublocation as an offset variable, i.e. the dependent variable was the *number of poor people divided by the total population size in each sublocation.* More details on this approach can be found in Kristjanson et al., forthcoming.

The regression model can be specified as:

$\log(Y_i) = \log(N_i) + \log(\beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots\ldots + \beta_n x_{ni})$

Where: Y_i = Number of poor people in each sublocation

N_i = Total population in each sublocation

X_i = Explanatory variables

A list of possible explanatory variables for inclusion in the econometric analyses is shown in Figure 2.5. This list was narrowed down from a larger one (generated via community-level discussions) through discussions with seminar participants along with testing and elimination of variables that were highly correlated. Since we wanted to know which of these variables are related to poverty incidence, our challenge was essentially one of selecting the 'best' model, or sets of models, that explain the variation in poverty incidence across sublocations.

We used a maximum likelihood model selection approach using SAS, and calculated the relative likelihood of each model (starting with the model with all 16 variables included), or Akaike weight, and the evidence ratios between the best approximating model and all the other models included in the set of candidate models. Akaike weights can be interpreted as the probability that the selected model is the best if all the candidate models were to be fitted to multiple data sets. The evidence ratios provide the evidence against a model as being the best compared to another model, e.g. the best model in the set of candidate models. The larger the evidence ratio, the stronger is the evidence against a model relative to the reference model in the pair under consideration (Burnham and Anderson, 2002).

Figure 2.5 Sublocation Level Analysis: Description of Independent/Explanatory Variables

NATURAL CAPITAL	
P/PE (Precipitation/ Potential Evapotranspiration)	An index that combines average rainfall, altitude, and sun radiation and a likely indicator of agricultural potential or available rainwater. A long-term average average for each sublocation was calculated
Wildlife density	Wildlife density calculations were based on aerial animal counts done by DRSRS during the wet seasons in 1977, 1978, 1980, 1981, 1982, 1986, 1990, 1991, 1992, 1994, 1998 and 2000. Wildlife includes eland, elephant, giraffe, grant's gazelle, greater kudu, gerenuk, impala, kongoni, lesser kudu, ostrich, oryx, rhino, thomson's gazelle, waterbuck, warthog, wildebeest and zebra. The total number of animals were converted to an average annual TLU per km^2.
Soil fertility index	On the basis of soiltype, soils were classified according to suitability for agriculture. The percentage of area with highly suitable soil types for agriculture was calculated for each sublocation
Access to water[4]	Percent of area within 1 hr walking distance of a permanent water source (boreholes, tanks, wells, springs, pans, dams, rain catchment and permanent rivers). Other water access measures used were per capita water access, i.e. number of permanent water sources per 1000 people, and presence of wetlands, i.e. percentage area of a sub location within 1 hr walking distance from wetlands
NDVI (Normalised Differential Vegetation Index)	NDVI is an indicator of the presence and condition of green vegetation (grazing/pasture potential). In areas where livelihoods depend so much on livestock, the potential for pasture is extremely important. We used a 2002 average NDVI, which was an average year for precipitation
Likelihood of having tick and tick-borne disease problems	Likelihood of having tick problems, i.e. the probability of finding ticks is between 0.25-0.75 (this is the range where tick-related problems are most likely to occur; lower than 0.25 and the probability of finding ticks very low; higher than 0.75 and the cattle are likely to build resistance). The percentage of area within the sublocation that is within the 0.25-0.75 range was calculated
FINANCIAL CAPITAL	
Livestock Density	TLU/km^2, or total livestock units per km^2 were used to measure livestock density. Average livestock density for each sublocation was calculated
PHYSICAL CAPITAL	
Road Density	A measure of accessibility/availability of road infrastructure within a sublocation, this was calculated as total kms of all kinds of road per km2 of each sublocation
Distance to nearest major town	Distance from the shopping center in each sublocation to the nearest major town by road, in kms
Distance to Nairobi	Distance from the shopping center in each sublocation to Nairobi by road in kms
Irrigated area	Percent of the irrigated area within a 5km radius
HUMAN CAPITAL	
Access to education	Access to education facilities (primary, secondary schools and training centers) was defined as the number of facilities per 1000 people within each sublocation
Access to health services/facilities	Defined as the number of health facilities in the sublocation per 1000 people. Another health access measure used was the percentage of area within 1 hr walking distance to a health facility
Access to security	Percent of area within 1 hr walking distance to a chief's office or a police post. Another security access measure used was the number of chiefs or police posts per 1000 people
SOCIAL CAPITAL	
Population density[5]	Number of persons per square km; average for each sublocation
Density of churches and nursery schools[6]	Number of churches or nursery schools per 1000 people for each sublocation
Density of active community groups	Number of active community groups per 1000 people for each sublocation

[4] Since some water points are man-made, this variable is a combination of natural and physical capital.

[5] Human population density was highly correlated with livestock density, so it was dropped from the analysis.

[6] Church and nursery school locations were highly correlated to the location of education facilities so this variable was dropped.

3. Results

3.1 Data collected and maps produced (results step 1)

On the basis of consultations of the local communities and decision-makers, a large number of resources were mapped (see Appendix 1, and Figure 3.1). These included the following.

Physical Capital:

- agricultural and livestock inputs
- location of chief's offices
- location of dips
- irrigated land areas
- location of market centers
- location of mining sites
- location of police posts
- roads, by type
- location of veterinarians

Natural Capital:

- Rainfall and PPE
- Lakes
- Landcover classes
- Rivers
- Type of soils
- Tick and tsetse distribution
- Water points, by type
- National parks
- Wildlife density

Human Capital:

- Location of hospitals and health clinics
- Location of schools, by type

Social Capital:

- Membership and location of active groups
- Location of churches
- Population density

Financial Capital:

- Livestock density

Others:

- Location of surveyed households

- Administrative boundaries
- Poverty incidence, by sublocation

The data collected covers the whole district of Kajiado.
All data is projected in UTM - zone 37S.
All layers are stored in ArcView format, and are available upon request to ILRI.

3.2 Maps

From the collected data thematic maps were produced. Different themes (i.e. natural resources, livestock inputs, social amenities and socio-economic features) are all represented on Division-level maps, following requests from local communities regarding the kind of maps that would be the most helpful for them. The maps have been printed out in the form of a District Atlas and will be distributed widely around the District. Forty-nine copies of this atlas will be distributed, 7 per Division, to the various Ministry heads. Copies will also be distributed to project collaborators, including SNV, FIVIMS, etc., who will in turn make them available to community members and various international community/ agency partners. Along with making the data available on CD to various organizations and individuals in Kajiado District, a GIS training course was carried out together with SNV to enable a number computer-literate people within the District to do their own mapping and analysis using the data. SNV will also be using this data as the basis of their community information system, which they will maintain and update regularly.

Further analysis was also undertaken to produce accessibility maps using some of the natural, financial, physical, social and human capital indicators (see Figure 3.1). For example, this allows a delineation of areas within 5 km of a permanent water source can be compared to areas greater than 5 or 10 km from a permanent water source. The density of roads within a sublocation can also be mapped, or the number of churches within a sublocation.

Figure 3.1 Livelihood asset variables included in econometric analysis

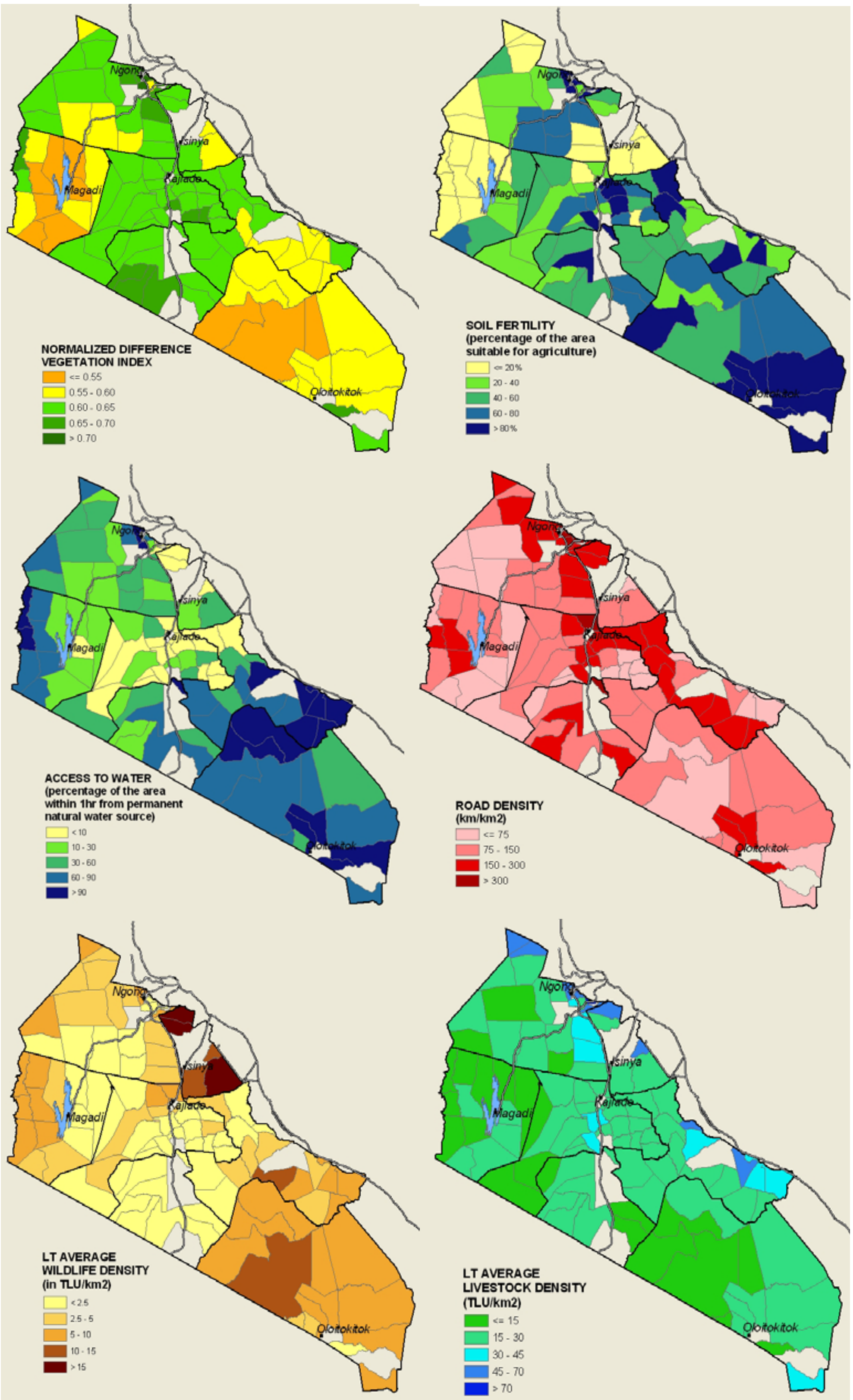


Figure 3.1, cont'd Livelihood asset variables included in econometric analysis

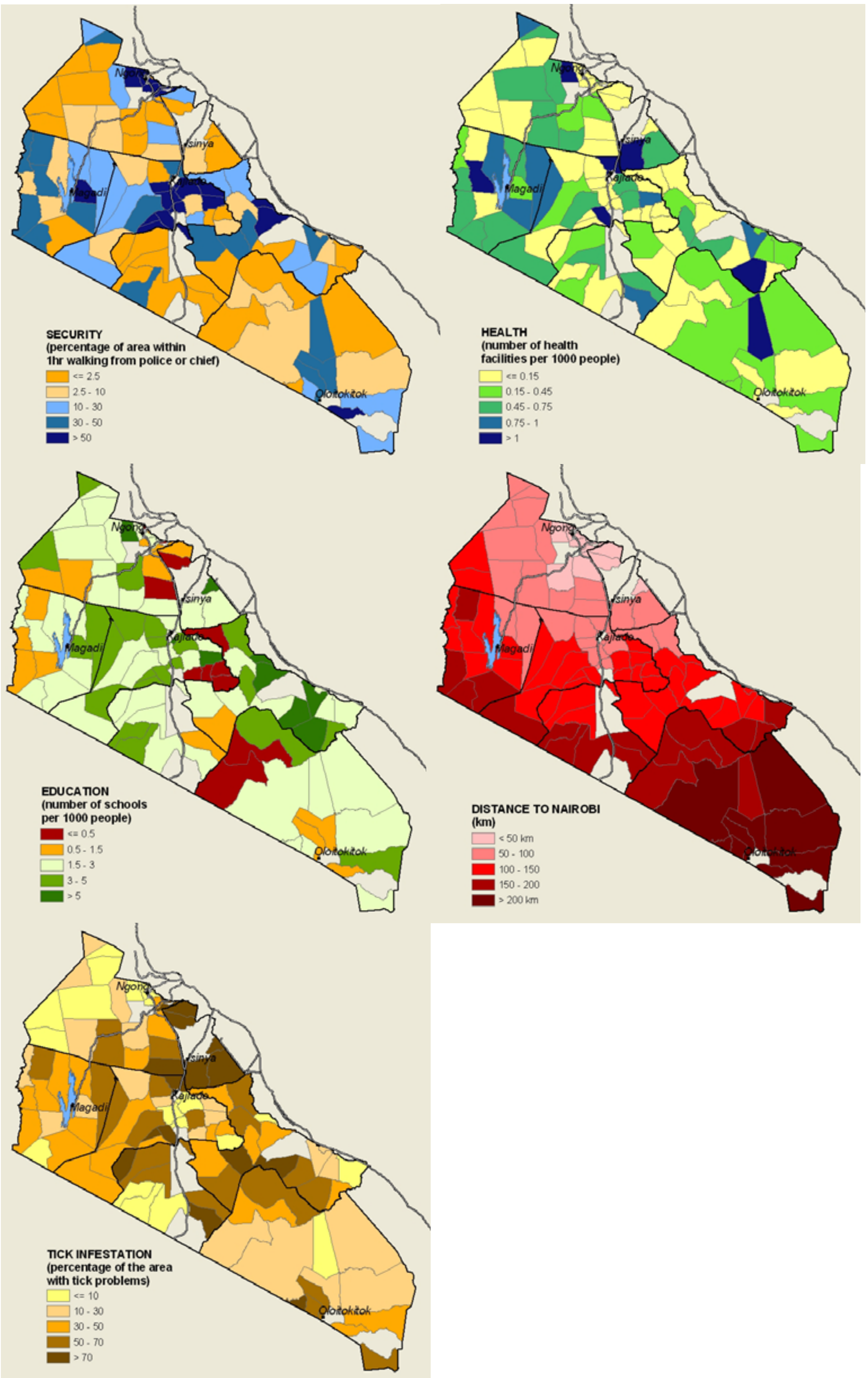
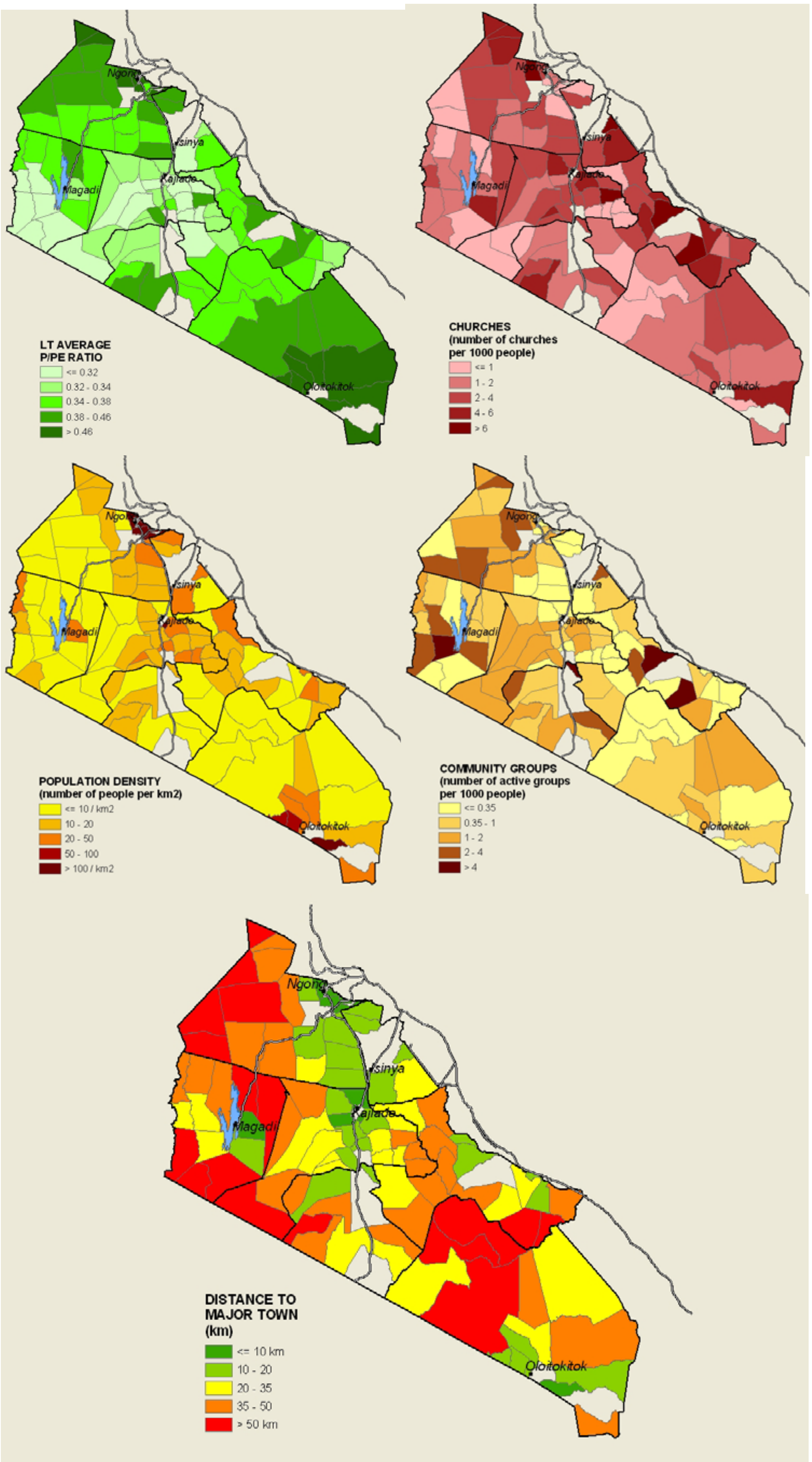


Figure 3.1, cont'd Livelihood asset variables included in econometric analysis



3.3 Results of econometric analysis

The sublocation analysis attempted to answer the following questions:

- What is the relative contribution of each of the livelihood asset variables (i.e. natural, physical, financial, social, human) in explaining variability in poverty incidence across Kajiado District?
- Within each livelihood asset category, which particular variables are key correlates of poverty?
- Can we map the probability of a sublocation or household being poor based on the parameter estimates of GIS-derived livelihood asset variables?

The model selection approach used resulted in a selection of a set of three 'best models'. A 96% confidence set encompassed the three models, implying that if we were to make inferences based on these three models, we would be correct 96% of the time. By dropping the variables included in models other than the final three, we suffered no loss of explanatory power. Thus there are lessons to be learned from which variables dropped out, and which variables remained in the final 3 models.

Explanatory variables that dropped out included:

- Density of active community groups (social capital)
- Access to health facilities (human capital)
- Distance to Nairobi (physical capital)
- Likelihood of having tick and tick-borne disease problems (human capital)
- Wildlife density (natural capital)
- Access to a permanent water source (natural capital)

Explanatory variables that stayed in the final set of models, i.e. that appear to be strong correlates of sublocation poverty rates, are:

Natural capital -

- Soil resources (percentage of area suitable for cropping)
- P/PE (rainfall and climate)
- NDVI (a measure of presence of green vegetation and proxy for pasture potential)

Financial capital -

- Livestock density

Physical capital -

- Distance to a major town/market centre
- Road density within the sublocation

Human capital -

- Access to education (number of schools per 1000 people)
- Access to security (percentage of area within 1 hour walk to a police/chief's station)

Thus at least one variable from four of the asset categories, with the exception of social capital, showed up in the set of models that were best able to explain the variation in poverty levels across the District. This does not necessarily imply that social capital is unimportant vis-à-vis poverty incidence, but could reflect the difficulty in capturing this concept through the use of a proxy such as density of active community groups. We also faced the problem that our social capital variables were strongly correlated to other variables (e.g. the location of important gathering places such as churches and nursery schools tend to be in the same locations as schools, and human population density is highly correlated to livestock density).

Within the natural capital assets, NDVI was significant and negative, so sublocations with a lower presence of green vegetation have higher poverty rates (or sublocations with higher poverty rates tend to be less 'green' with lower pasture potential, since we don't know for sure which way the relationship goes).

Livestock density, an indicator of financial capital assets (our only indicator of financial capital, since household surveys in this area indicate that very few have access to any formal credit or a bank account, and mapping access to informal credit was not feasible), was included in the final set of models and has a negative sign, implying that in general, sublocations with lower livestock densities have higher poverty rates. This result could be expected in this district where so many livelihood strategies still rely heavily on livestock. It will be interesting to monitor this over time, however, with observed trends of intensification of livestock systems and diversification in livelihood/income sources starting to take place in certain areas.

Road density, an indicator of physical capital assets, was a selected variable with a negative sign, suggesting road infrastructure is a correlate of poverty and sublocations with less road infrastructure are poorer.

Access to education facilities and security, both indicators of human capital assets, remained in the final set of models. Access to education, with a positive sign, suggests that in sublocations with better/greater access to education facilities, poverty rates are higher, a somewhat non-intuitive finding. This suggests that perhaps education facilities do exist in the poorer areas, but have not been there for a sufficient length of time to have had an influence on poverty levels. Not surprisingly in this district where livestock theft and banditry still occurs, access to security was an important variable, with a negative sign, implying that sublocations with poor access to security are poorer.

From a starting point of 14 livelihood asset indicators (down from an original list of over 40), this analysis further narrowed the list of critical variables, with respect to helping to explain sublocation-level poverty incidence, to eight. Lessons learned from this study will help better target particular indicators in future applications of this approach to other regions, and will provide important baseline information for policymakers and planners in Kajiado district as they monitor progress towards poverty reduction goals.

These results suggest that investment strategies focusing on increasing security and improving roads have a high potential for impact on poverty levels in Kajiado District. Areas with higher potential soiltypes for cropping appear to be fairing better, demonstrating the importance of the shift towards cropping in this traditionally livestock-only area. Thus improving access to information and appropriate agricultural inputs are policy implications arising from these results. On the other hand, livestock density is still strongly correlated with poverty levels, so investments in improving the productivity and marketing of livestock is another pro-poor investment possibility.

3.4 Next steps

3.4.1 Development of an assessment, monitoring and evaluation tool

It would be extremely useful to develop a software tool to make the above livelihood and vulnerability information easily accessible for non-GIS specialists. Users would be able to monitor and assess specific locations in terms of the different assets/resources available. The tool would also include the possibility of setting thresholds for different assets in order to be able to develop specific user-defined zones (for targeting purposes) – e.g. mapping all areas within 10 km of a permanent water source. Finally it will enable the end-users to evaluate interventions based on objectively verifiable indicators – e.g. how many poor people are being reached with a particular intervention. Funding for the development of such a tool is being sought.

3.4.2 Expanding to other regions

Applying this method to other districts would enable us to answer the question: Is this approach viable and useful in districts with very different livelihood strategies than those found in Kajiado (e.g. intensive smallholder mixed crop-livestock systems in the highlands), or are major refinements to the method needed to accommodate different physical environments? The lessons learned in this pilot study (e.g. which are the critical variables to map) will enable us to carry out similar assessments in other districts much faster and at lower cost. Again, local partnerships are key, thus we will be working closely with local governments and NGO's and seeking funding with them in order to undertake such efforts in other livestock systems and countries.

3.4.3 Exploring the use of other proxies for human and social capital

In the technical and feedback workshops, it was suggested that better indicators for human capital might include teacher:student ratios for each sublocation, ratio of doctors: patients, average amount of time spent by outpatients, or some indicator of availability of medicine in the health facilities rather than density or distance measures such as those that we used. It was suggested that many of these facilities have been built in poor areas (e.g. by NGO's), but that quality of health care or education still varied significantly and thus it would be very interesting to try to capture this aspect. One of the results of the final feedback session was that several of the technical officers from the District offered to get this information to add to the database and thus future analyses will be able to test the relationship of such variables to poverty incidence.

4. Conclusions and lessons learned

The results of the analysis, along with community training and stakeholder feedback sessions allow us to draw some lessons learned throughout the process that will help us in determining future directions of this research and making sure that it influences pro-poor policy decisions.

1. We were able to answer the question 'Which of the five livelihood asset indicators can we map'? , although it turned out to be quite an intensive, lengthy exercise, due to the time it takes when numerous stakeholders are involved in every step of the process. However, the benefits from this approach far outweigh the costs, as it is the only approach that will ensure that our outputs are useful and used; and in fact, we have already made a lasting impression on the community (in terms of awareness of links between landuse, poverty and livelihoods, for example) and individuals that have received training (in participatory landuse mapping, for example).

2. We have not yet completed all the steps necessary to answer the next question we tackled, 'of the map-able livelihood assets, which are the most useful, for whom, when and why?' There is a lag between the time that information is disseminated and when its usefulness can be evaluated, and it was not possible to complete the evaluations our project timeframe (i.e. a complete 'ex post' assessment). Initial stakeholder feedback sessions that were held, along with the distribution of the atlases, data and GIS training, indicated the following:
   - There is widespread appreciation for our broad dissemination of the information we collected and there were many different ways in which the data and maps will be useful to various people

- This is information that will help in targeting investments and interventions by the District Planning Officer and Division-level technical officers (agriculture, health, education, etc)
- The training of a group of people within the District in simple GIS analysis and mapping and the use of GPS instruments was particularly appreciated, with requests for additional 'follow-up' session

3. The econometric analysis attempted to answer the very complex question 'which of all the identified 'map-able' livelihood assets appear to be the most important in helping to explain poverty?' The results of the sublocation analysis have allowed us to identify some key variables that help explain agro-pastoralists' livelihood strategies and varying poverty levels, and the degree to which their underlying livelihood assets determine their choice of strategies and in turn influences relative poverty levels. These key variables include: soil resources (percentage of area suitable for cropping), P/PE (rainfall and climate), NDVI (pasture potential), livestock density, distance to a major town/market centre, road density within the sublocation, access to education (number of schools per 1000 people), and access to security (percentage of area within 1 hour walk to a police/chief's station).

4. The results of our analysis suggest that investment/development strategies aimed at increasing security and improving roads in Kajiado district should have an appreciable impact on poverty levels. Areas with higher potential soiltypes for cropping appear to be fairing better, demonstrating the importance of the shift towards cropping in what up until recently has been primarily a pastoral area. Thus improving access to information and appropriate agricultural inputs are policy implications arising from these results. With livestock density strongly correlated with poverty levels, high priority should be place on investing in pro-poor research and strategies aimed at improving the productivity and marketing of livestock.

5. There may be better proxies for human and social assets than those tested in this analysis. In the technical and feedback workshops, it was suggested that better indicators for human capital might include teacher:student ratios for each sublocation; doctors: patients ratios; average amount of time spent by outpatients; or some indicator of availability of medicine in the health facilities rather than density or distance measures. It was suggested that many of these facilities have been built in poor areas (e.g. by NGO's), but that quality of health care or education still varied significantly and thus it may be important to try to capture this aspect. One of the results of the final feedback session was that several of the technical officers from the District offered to get this information to add to the database and thus future analyses will be able to test the relationship of such variables to poverty incidence.

6. The process we followed resulted in a reduction from over 40 potentially important livelihood asset variables (to map and analyze) to less than 10, so the next time this method is applied (e.g. in other Districts), we will collect information on fewer variables (i.e. the lessons learned in this analysis will pay off in terms of faster, more targeted data collection in the future). The results also provide information that several donors have indicated is of very high importance to them, namely, ideas as to investment priorities and evidence towards what the major correlates of poverty are for a given area/agricultural system/landuse choice/livelihood strategy.

7. Participants in the final feedback session[7] indicated that the maps and analysis were of considerable interest to many of them, and had already been used to:
    - Identify areas where horticultural crops were being grown and explore marketing opportunities by linking the horticultural farmers to the fresh produce exporters based on accessibility (distance to roads and local

[7] Participants in the feedback workshop included representatives from various government ministries/departments, CBOs and project at the district and divisional levels. These included the District Veterinary Officer, District Agricultural Officer, District Water Development Officer, District Social Services Officer, Arid Lands Management Project Officer, Divisional Agricultural Extension Officers, representatives from Kenya Wildlife Service, Kenya Red Cross Society, and officials from local NGOs (OLKODO) and NIA (Neighbours Initiative Alliance).

market centres) by the Ministry of Agriculture in support of a horticultural market development program

- The Ministry of Lands and Water was very happy to have an updated map to assist their department in targeting sublocations for water projects/investments more transparently than has been done in the past, and they were sharing the information with a new water resources association in neighboring Machakos District that would like to undertake a similar exercise
- The Department of Social Services told us the participatory landuse mapping exercise had helped them get more closely involved with communities, and would like to refine the database with respect to information on groups from their registries
- The Agriculture Ministry defines focal areas in which to work closely with communities for 1-2 years before moving on to the next areas, and they suggested the information provided through this study would help them prioritize and choose these focal areas
- The Arid Lands Management Project (ALMP) is using the information to identify non-functional boreholes for rehabilitation as per their mandate
- AMREF (African Medical Research Foundation) was using the information for targeting areas of intervention.
- GTZ is using the information re:location of schools for targeting the FGM (Female Genital Mutilation) projects. FGM is likely to be high in areas with less access to education, infrastructure and communication facilities

8. In future applications of this method, we will start with much more detailed base layers/maps. One of the lessons from the participatory landuse mapping exercise was that people need more reference points to orient themselves on the landscape and locate things more accurately. Having said that, we also learned that the Maasai know their environment intimately (i.e. they can locate the sublocation boundaries, waterpoints, etc very accurately and precisely), and this exercise will not be easier in other districts where perhaps communities are not so intimately linked with their environments and each other.

9. In future applications, it is suggested that fieldworkers go with laptops and hard copies of the maps, and work with several sublocations at a time (compared to our approach, where we started at District-level, this approach would 'build up' from the sublocations to the District). 'On the spot' verifications will save time returning to many areas to ground-truth the data generated in a participatory fashion.

10. Strong local partners such as SNV are critical, due to their knowledge of the communities' needs, their ability to mobilize key individuals, but also in making sure that the information generated is made widely available locally, and the database maintained and updated.

11. Applying this method to other Districts in Kenya, where livelihood strategies are considerably different than those found in semi-arid, agropastoral and pastoral Kajiado District, would allow us to further refine this research method to make it more 'generic' and widely applicable. It would also greatly strengthen our findings regarding determinants of poverty and their policy implications.

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Appendix 1: List of resources to be mapped in each sublocation

Services and facilities

ITEM	ATTRIBUTES	PRESENT?
1. schools	* name * nursery/primary/secondary/ training centre * performance	If not in sublocation describe where children go to school instead
2. hospitals	* no. of beds * private or government * trained doctors present?	If not in sublocation describe where people get treated instead
3. dispensaries	* trained nurses present? * drugs present?	If not in sublocation, describe where people get drugs instead
4. churches	* name * activities (community support?)	
5. vets	* private or government * qualified or no degree * operating from home, clinic or government office?	If not in sublocation describe how animals get treated instead
6. dips	* function/non-functioning	
7. livestock inputs	* chemists, drugstores * feedstores * cooperatives * slaughterhouses	If not in sublocation describe where people get animal drugs and feeds instead
8. livestock markets	* name * size (no. of cattle sold) * charge for marketing animal	If not in sublocation, describe where people market their animals instead
9. Agricultural inputs	* where do people buy seeds * where do people buy fertilizer * where do people get information	If not in sublocation, describe alternative locations
10. Shopping centres (small)	* number of shops or duka's	If not in sublocation, where do people get basic foodstuffs
11. police posts	* functioning? * area covered	If not present, where do people go for help?
12. chiefs office		
13. projects	* type (mills, iron roofs, water, conservation, crops etc) * funded by whom? (NGO/community)	
14. CBO's	* type of business * important as employment opportunity?	If not present, do people work at CBO's outside the sublocation?
15. Mining sites	* product (sand, quarry etc)	
16. Income generating activities	* type of activities (tourism, honey, charcoal, craftmaking etc)	
17. waterpoints	* watersources other than rivers: pan, dam, borehole, well, spring	

Resource areas

RESOURCE	ATTRIBUTES
1. Tick infested areas	
2. Tse-tse infested areas	
3. Secure/insecure areas	* reason of (in)security
4. areas with conflicts over water use (people/animals)	
5. communal land areas	* have all ranches been subdivided or are there still communal areas where everybody can let their animals graze?
6. medicinal sites	* which plants are harvested/used
7. woodlots	* used for what purpose (building, firewood etc)
8. irrigated areas	* irrigated how? * accessible to whom?
9. areas with mobile reception	

Other resources

1. List the NGOs that are active in your sublocation: please list their names and main activities in the area
2. List the number of active community groups in your sublocation: how many of these groups are involved in income generating activities?
3. List the five main sources of income for men and women in your sublocation

APPENDIX 2: PARTICIPATORY RESOURCE MAPPING AND GIS

I. OBJECTIVES

A participatory resource mapping exercise was set up in the entire district, involving at least two community representatives from each sublocation and covering all data needs at the same time.

The main objectives of the exercise were to:

4. Collect baseline data for livelihood mapping: locating schools and other service facilities, water sources and job opportunities throughout the district;
5. Increase the capacity of communities and other stakeholders such as various Ministry representatives in Kajiado and to make local communities and government representatives aware of the natural resources that exist within their immediate surroundings;
6. Develop a method and tools that are useful for asking the same stakeholders feedback on our products and analysis outputs and involving them in the process of using the final outputs.

II. METHODOLOGY

This exercise was conducted in close cooperation with SNV. In their three focus Divisions, SNV had previously undertaken several Participatory Land-Use Planning (PLUP) exercises with local communities. They are currently in the process of expanding their operations to cover the remaining Divisions and thus ILRI assisted in this.

II.1 Workshop 1: Participatory Landuse Mapping

Workshops were organised in each of the 7 divisions: Isinya, Mashuru, Loitokitok, Magadi, Central, Namanga and Ngon'g. The participatory mapping exercise was conducted at the sublocation level with at least 2 representatives from each sublocation.

Two community members (male and female) were selected from each of the 120 sublocations, along with the chiefs and heads of community-based organizations (CBOs), to assist with the landuse mapping exercise for their sublocation.

Criteria for selection of community members:

1. Good knowledge of the resource base in the community. These are people who were either born or have lived and worked in the area for a considerable number of years.
2. It was also recommended to send a male and a female representative from each sublocation

Also included were government officers, i.e. representatives from various government ministries (health, livestock, agriculture, social services, livestock, water, education and environment). The community members were useful in this case because they knew the exact locations of features while the government had a clear understanding of the projects in each sector and their history. Combined they had a wide knowledge of the social, economic, political and ecological conditions of the area. The group was also diverse and comprising of people of different ages, gender and ethnicity, thus allowing for regular cross-checks and feedback from all the different sources.

Division	**Government Officers**	**Community Male**	**Community Female**	**TOTAL**
Isinya	5	9	3	17
Loitokitok	3	13	9	25
Magadi	4	21	7	32
Central	5	40	6	51
Mashuru	7	25	8	40
Namanga	8	15	5	28
Ngong	10	37	21	68
				261

Table 1: number of participants in the participatory landuse mapping exercise

The mapping exercise was carried out in a rigorous series of steps, resulting in sublocational landuse maps:

1. Explanation of the team's <u>data needs</u>. All community members were taken through the list of resources that were to be mapped that day (appendix 1b).
2. Short discussion of the <u>list of resources</u>, trying to make sure that everybody understood each of the resource items in the same way and check whether the team's list was exhaustive, and whether the requested attributes were feasible or useful.

3. Come up with a naming convention that was understood by everyone in the group. This involved adoption of codes to be used in the mapping exercise and symbols for use in representing land use types.
4. Agreement on attribute information: participants were asked to note all the attribute information of the facilities they indicated on the map in a separate notebook. In the case of a school, for instance, they were asked to comment on staffing, number of teachers present, performance and number of students.
5. Spending some time getting a feel for spatial drawing and referencing: all representatives were split into groups by sublocation and were asked to draw their sublocation off the top of their head: including boundaries, roads and rivers and some major natural resources areas. This was an important step, since it not only helped them focus on thinking spatially but it also brought out the various perceptions of the communities' environment and the quality of their resources.
6. Comparing community maps with official sublocation boundaries, with remarkably good results in most cases (see figure 1).
7. The actual mapping: participants were then given new A3 papers with their sublocation boundaries, and any prominent spatial markers that could be offered from existing datasets. These included town centres, rivers, roads and names of households or projects that were mapped earlier on for a spatial reference of the household model (see chapter 8). They were then asked to draw in all resources from the list in relation to all other markers available and write down the additional attribute information requested.

During the entire process, four or five ILRI team members walked around to observe and facilitate the process, checking whether all topics were covered exhaustively, asking for cross references, and making sure that for all resources that were not present in that particular sublocation, people at least noted down where community members went to find these resources/services.

Figure 1: participatory landuse map showing features of Pakase sublocation (Magadi division). (available on request, not included due to filesize)

II.3 In the office: input in the GIS database

The resulting resource maps were then scanned and geo-referenced, using the sublocation boundaries that were used in creating the original maps. A total of 105 sublocation maps were scanned and geo-referenced. On-screen digitizing was used to convert these paper maps to digital GIS-layers. This was done for each livelihood asset in order to come up with measures of access to each of the various livelihood assets (services, markets, water, etc).

II.4 Workshop 2: Updating through Participatory GIS

In a last step, the processed data was brought back to the local community in a participatory GIS exercise. This is a widely used tool that allows for rapid correction and collection of data through on-screen digitizing and immediate storage of the same within the GIS Database. This process is a very useful tool when you need to quickly add supplementary information into the GIS. In this project it was used to fill in the data gaps (spatial and descriptive) discovered when assembling the GIS database on basis of the results from first workshop, e.g. are the water points really operational, where are the mining sites, etc?

A total of 7 workshops were organized in 7 different divisional headquarters, which were easily accessible to the surrounding sublocations. Each of these workshops took between 1 to 3 days.

Division	**Government Officers**	**Community Male**	**Community Female**	**TOTAL**
Isinya	5	8	3	16
Loitokitok	5	17	8	30
Magadi	5	23	8	36
Central	7	32	7	46
Mashuru	11	25	6	42
Namanga	5	11	3	19
Ngong	7	29	20	56
				245

Table 2: number of participants in the participatory GIS exercise

The feedback workshops with the stakeholders helped clarify misunderstandings, misconceptions and distortions of information. It also gave them a sense of ownership of the information and process, hence reduced conflicts. Data generated from the P-GIS exercise supplemented the existing spatial information and identified errors at the local level.

III. RESULTS

The Participatory Resource Mapping and GIS resulted in:

- A very rich database, comprising of livelihood assets that are acceptable and convincing to both scientists and local communities;
- A framework for further discussions and avenues for disseminating the project's outputs;
- Increased awareness of the local communities of the resources available and hence of the potential for development.

IV. RECOMMENDATIONS

- Capacity building for Government officers and local groups to empower the local communities in gathering, storing, analyzing, and using the GIS data. This should enable them to have a common understanding of the database as a prerequisite for using it to plan and manage their natural resources.
- In order to validate the findings and the maps produced, we should set up mechanisms for updating and maintaining the data at the local level. A temporal component to monitoring changing livelihoods should be included in this process and a way of scaling up such information to wider areas with the same environmental and socio-economic setup.

APPENDIX 3: EXTRACTED VARIABLES FOR ECONOMETRIC ANALYSIS AT SUBLOCATION LEVEL

***Dependent variable*:**

Percentage of population living below the poverty line within each sublocation (from the recent high resolution poverty maps, CBS and ILRI, 2003).

***Independent variables*:**

A large number of spatial variables were derived in this exploration of factors correlated to poverty. Access to resources can be defined in several ways. For example, access to water within a sublocation can be defined as distance to natural water sources, man-made water sources, or wetlands; it can also be defined as the percentage of the area of a sublocation within, say, 10 km of a particular type of watersource. With very little a priori information as to which may be the 'best' variables, we made an effort to define each in several ways and explore, using an econometric analysis, which appeared to have the strongest relationship with our dependent variable.

In the following pages, all the independent variables extracted and fed into the statistical models during the study are named and described. The reasons for including each variable are included. Since many of these factors may be endogenous, i.e. the direction of causality unclear (e.g. do areas of high poverty attract low infrastructural investments, or does lack of investment in infrastructure cause high poverty?), we attempt to indicate those variables where this may be the case. From a policy perspective, there are also variables which can be modified in a relatively short-term (e.g. roads), and those that cannot (e.g. level of rainfall). We indicate the former as 'modifiable' and the latter as 'non-modifiable'.

Independent/Explanatory GIS variables:

NATURAL CAPITAL

Variable name	Description	Expected Use	*Modifiable? (yes/no)*	*Endogenous or Exogenous*
NANNPPE	PPE Ratio – precipitation/potential evapotranspiration, i.e. an index that combines average effects of rainfall, altitude, and sun radiation. A long-term average for each sublocation was calculated.	In an arid to semi-arid area like Kajiado the amount of rainfall is critical , particularly for forage. Taking into account the evapotranspiration might give a more accurate indication for available rainwater and agric. potential.	No	Exogenous
NWLDDENS	Density of wildlife expressed in TLU/km2. Wildlife density calculations were based on aerial animal counts done by DRSRS during the wet seasons in 1977, 1978, 1980, 1981, 1982, 1986, 1990, 1991, 1992, 1994, 1998 and 2000 (5X5 km resolution). Wildlife includes eland, elephant, giraffe, grant's gazelle, greater kudu, gerenuk, impala, kongoni, lesser kudu, ostrich, oryx, rhino, thomson's gazelle, waterbuck, warthog, wildebeest and zebra. The total number of animals were converted to an av. annual TLU/km^2	Because of numerous human-wildlife conflicts a high wildlife density will probably have a negative impact on livelihoods; on top of that wildlife is a competitor for cattle grazing; on the other hand there are eco-tourism initiatives where wildlife is considered to be a positive asset.	No	Exogenous
NWLPOP	Wildlife numbers divided by population, i.e. TLU per person		No	Exogenous
NSOILFER	Index of soil fertility. On the basis of soiltype, soils were classified according to suitability for agriculture. The percentage of area with highly suitable soil types for agriculture was calculated for each sublocation	To capture soil fertility, fodder or agricultural potential.	Yes	Endogenous
NTOTWAT	Availability of water coming from any permanent water source (borehole, tank, well, spring, pan, dam, rain catchment), permanent river. %of area within 1 hour walking of these permanent water sources (without wetlands)	A measure for accessibility to water for domestic / livestock use	No	Exogenous

NATURAL CAPITAL, CONT'D

NTOTWATPO	Percentage of the area within 1 hour walking from a permanent watersource (without wetlands) divided by the population and multiplied by 1000.		No	Exogenous
NTOTWAT2	Percentage of the area within 1 hour walking from a permanent water source (INCLUSIVE of wetlands).		No	Exogenous
NTOWA2PO	Percentage of the area within 1 hour walking from a permanent water source (INCLUSIVE of wetlands) divided by the population and multiplied by 1000.		No	Exogenous
NNUMWAT	Number of water sources per 1000 people.		No	Exogenous
NNUMWAT2	Number of water sources (INCLUSIVE of wetlands) per 1000 people.		No	Exogenous
NWET	Percentage of the area within 1 hour walking from wetlands.	Wetland might not only be important because of water, but also as saltlicks/conservation/etc.	No	Exogenous
NWETPOP	Percentage of the area within 1 hour walking from wetlands divided by the population and multiplied by 1000.		No	Exogenous
NNATWAT	Percentage of the area within 1 hour walking from a natural permanent watersource (without wetlands).		No	Exogenous
NNATWATPO	Percentage of the area within 1 hour walking from a natural permanent watersource (without wetlands) divided by the population and multiplied by 1000.		No	Exogenous
NNATWAT2	Percentage of the area within 1 hour walking from a natural permanent watersource (incl. wetlands).		No	Exogenous
NNAWA2PO	Percentage of the area within 1 hour walking from a natural permanent watersource (incl. wetlands) divided by the population and multiplied by 1000.		No	Exogenous

NATURAL CAPITAL, CONT'D

Variable name	Description	Expected Use	*Modifiable? (yes/no)*	*Endogenous or Exogenous*
NTREE	Percentage of the area where trees can be found		Yes	Endogenous
NTREE1HR	Percentage of the area within 1 hour from trees		Yes	Endogenous
NTR1HRPO	Percentage of the area within 1 hour from trees divided by the population and multiplied by 1000			
NFOREST	Percentage of the area where forest patches can be found	Forest areas are a valuable resource (providing forage, fuel wood, medicinal plants, etc.) The shorter the distance, or the more of it, the better.	Yes	Endogenous Poverty may cause deforestation or vice versa
NFOR1HR	Percentage of the area within 1 hour from forest patches		Yes	Endogenous
NFOR1HRPO	Percentage of the area within 1 hour from forest patches divided by the population and multiplied by 1000		Yes	Endogenous
NNDVI	% Greenness Extract biomass value based on NDVI NDVI is an indicator of the presence and condition of green vegetation (grazing/pasture potential). We used a 2002 average NDVI, which was an average year for precipitation	In areas where livelihoods depend so much on livestock, the potential for pasture is extremely important.	Yes? Maybe only in longer run?	Endogenous Poverty may cause practices leading to land degradation or vice versa.
NTICKPRO	Predicted probability of tick infestation, defined as the likelihood of having tick problems, i.e. the probability of finding ticks is between 0.25-0.75. The percentage of area within the sublocation that is within the 0.25-0.75 range was calculated	Ticks and tsetse pose an important disease risk in Kajiado. For the latter we do not have reliable data but the probability of ticks being a problem has been modelled by ILRI. This is the range where tick-related problems are most likely to occur; < 0.25 and the probability of finding ticks is very low; > 0.75 and the cattle are likely to build resistance	Yes	Endogenous Poverty may result in practices that increase tick risk (e.g. less management) or vice versa

NATURAL CAPITAL, CONT'D

Variable name	**Description**	**Expected Use**	***Modifiable? (yes/no)***	***Endogenous or Exogenous***
NCROPS	Percentage of the area within 5 km from cropped land.	Competitor with forage and grazing, plus livelihoods diversification options	Yes	Endogenous
NCROPSPO	Percentage of the area within 5 km from cropped land divided by the population and multiplied by 1000.		Yes	Endogenous

FINANCIAL CAPITAL

Variable name	**Description**	**Expected Use**	***Modifiable? (yes/no)***	***Endogenous or Exogenous***
FLIVDENS	Density of livestock expressed in TLU/km2	With little or no access to formal credit in this district, this variable is a proxy for this, as livestock can act as a bank account . Higher density of livestock may lead to high pressure on the environment OR maybe it will be an indication of where there are ample resources so that livestock concentrates in these areas.	Yes	Endogenous Poverty leads to smaller herd sizes, vice versa
FLDENPO	Livestock numbers per 1000 people, i.e. livestock density divided by the population and multiplied by 1000.		Yes	Endogenous

PHYSICAL CAPITAL

Variable name	Description	Expected Use	*Modifiable? (yes/no)*	*Endogenous or Exogenous*
PROADLENG	Total length of roads in the sublocation		Yes	Endogenous
PROADDENS	Road density within sublocation, Km road/km2, i.e. length of the roads in a sublocationdivided by the area of the sublocation	Measure of availability of roads within the sublocation; remoteness.	Yes	Endogenous Poverty causes low road investment or vice versa
PTOWNKM	Distance from the shopping centre in each sublocation to the nearest major market/town by road, in kms	Measure of accessibility/remoteness of the area. Used distance by road + distance to nearest road.	Yes	Endogenous
PNBIKM	Distance from the shopping centre in each sublocation to Nairobi by road in kms	Distance to Nairobi would capture access to services/jobs/administration/etc.	Yes	Endogenous
PLSERVNM	Number of livestock service providers in each sublocation per 1000 people.	Access to livestock services	Yes	Endogenous
PLSERV10	Number of livestock services in 10km buffers, surfaced and averaged by sublocation		Yes	Endogenous
PMANWT	Availability of permanent man-made water sources. Percentage of the area within 1 hour walking	In combination with natural sources of water (see natural capital indicators), makes up total access to water	Yes	Endogenous
PMWATPOP	Percentage of the area within 1 hour walking from a permanent man-made water source divided by the population and multiplied by 1000.		Yes	Endogenous

PHYSICAL CAPITAL, CONT'D

Variable name	**Description**	**Expected Use**	***Modifiable? (yes/no)***	***Endogenous or Exogenous***
P_ELECMOB	Presence of electricity or mobile reception in the sublocation (yes/no) OR number of centres with electricity or mobile reception in the sublocation OR the percentage of the area of the sublocation within an x km radius of centres with electricity or mobile reception.	Measure of access to opportunities for jua-kali for instance or marketing; also a proxy for transactions costs of doing business (less access; higher costs)	Yes	Endogenous
PIRRIG5K	Percentage of the area with irrigation within a 5km radius	The irrigated areas are "islands of food production"; households living in irrigated areas pay less for agricultural products and may earn income by selling crops	Yes	Endogenous

HUMAN CAPITAL

Variable name	Description	Expected Use	*Modifiable? (yes/no)*	*Endogenous or Exogenous*
HPRIMNRM	Number of primary schools per 1000 people	Indicator of physical access to education opportunities for kids.	Yes	Endogenous; Poverty resulting in few schools built or vice versa
HPRIMSEC	All education and training facilities. Number of education and training facilities in a sublocation,	Accessibility of training, teachers	Yes	Endogenous; Poverty resulting in few training centres built or vice versa
HRPSECPOP	Number of education and training facilities in a sublocation, per 1000 people		Yes	Endogenous
HHEALTNRM	Number of health centre/clinics or dispensaries in the sublocation per 1000 people	Accessibility of health services	2.4.1 Yes	Endogenous; Few health facilities, higher poverty or vice versa
HSECURITY	percentage of area within 1 hours walking time to a police station or chiefs office	Proxy for degree of security; sublocations with less access to police and chiefs may have more security problems	Yes	Endogenous; Poverty resulting in few security posts built or vice versa
HSECNRM	Number of police stations and chiefs offices per 1000 people		Yes	Endogenous

SOCIAL CAPITAL

Variable name	Description	Expected Use	*Modifiable? (yes/no)*	*Endogenous or Exogenous*
SNURSNRM	Number of nurseries in the sublocation per 1000 people	Use as indicator of access to social networks since nurseries are 75% community/parent managed and sponsored	Yes	Endogenous Poverty causes low investment in nurseries or vice versa
SCHURCHNRM	Number of churches in the sublocation per 1000 people	As indicator of access to potential social network/social meeting place, use the presence of churches since distance to churches might correlate with distance to nearest shopping center/ nearest road.	Yes	Endogenous Poverty causes low (or high) investment in churches or vice versa
SGRPNRM	Number of active community groups in each sublocation per 1000 people	Indication of "social power" in different areas, potential to develop groups to make a positive change.	Yes	Endogenous