TERMS OF REFERENCE

LAND DEGRADABILITY ANALYSIS OF SURVEY BLOCKS IN WESTERN KENYA

WESTERN KENYA INTEGRATED ECOSYSTEM

MANAGEMENT PROJECT

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1 Rationale

Following the ground surveys, there is a need to understand the extent and degree of degraded and degradable lands in Western Kenya for designing and targeting the interventions for counteracting current and future degradation. This will be achieved by combining remote sensing and GIS information, which will eventually lead to a mapping of the survey block areas on their susceptibility to degradation, hence their vulnerability.

Four main classes will be formed dividing the land into areas of no, low, moderate and high vulnerability, out of which the last three classes will be subdivided into potentially recoverable through appropriate interventions of low cost (reversible) and recoverable only at high expense (irreversible).

This approach has been first developed for the Lower Nyando block and designed under the notion of having to respond to the degrees of data and fund scarcity and is meant to serve as a practicable scheme that can be applied to the remaining blocks.

2 Information to be used

2.1 Land cover

The principal information layer for this exercise will be land cover, which is classified as follows:

- Bare soil
- Natural vegetation:
    - Forest
    - Woodland / shrubland
    - Grassland
- Cropland:
    - Perennial crops
    - Annual crops

While water bodies and urban areas were excluded from the classification using readily available GIS layers. This classification scheme allows for identifying potential high risk areas (bare soil) and areas which qualify for agroforestry interventions such as croplands and grasslands.

2.2   Methods

2.2.1   Unsupervised classification

Responding to financial constraints and for reasons of practical applicability to other areas of interest, medium-resolution remote sensing data will be used. Due to the current short-comings of Landsat imagery, a readily available Aster (Advanced Spaceborne Thermal Emission and Reflection Radiometer) scene (0 - 60 US$ per scene) from November 19, 2007 has been chosen for the classification.

Using the 4 VNIR (very near infrared) bands of an Aster level 1A image at a spatial resolution of 15 m, these images require to be georeferenced to a reference system such as topographical maps, a GoogleEarth image or a GIS layer, with which the classification will eventually have to correspond. Based on these corresponding GIS layers, urban areas and water bodies can now be masked out of the image to be excluded from the subsequent classification.

For the unsupervised classification, a subset of the preprocessed Aster image will be used that will be slightly larger, i.e. about 15 x 15 km, than the block in order to compensate for classes that are potentially underrepresented within the boundaries of the block. In total, 20 different land cover classes will be obtained using all four VNIR bands using the K-means option with 10 iterations and without any change threshold.

All satellite image processing will be performed with the ENVI 4.4 software package.

2.2.2   Supervision vs. ground-truthing

Twenty classes derived from the unsupervised classification commonly represent the maximum of reliably distinguishable, yet rather abstract, classes based on the given input data. For those classes to correspond to the six desired land cover classes they need to be identified and aggregated. This will occur through a supervision process and/or ground-truthing data.

For the Lower Nyando block a high resolution (0.6 m) Quickbird image from April 04, 2008, (1800 – 2800 US$ per 100 km^2 block) is available and provides about 60 % coverage of the block, including all the main classes from the unsupervised classification. Using this high resolution image, the classes will be identified for aggregation in a reverse process. All uniform land use will be marked as separate regions of interest (ROI) in the Quickbird image which will be referenced onto the Aster image. Transferring these ROIs eventually allows for assigning different classes from the unsupervised classification to these relevant land cover classes obtained from the reference image.

Where such high resolution image is not available or does not provide explicit decision support or where distinct differences due to seasonal vegetation patterns or cloud cover are critical, other forms for verification of the unsupervised classification must be sought. A first source for such data will be the biophysical baseline database of recorded land cover on each of the 160 recording plots per block, which can be used for the identification of land cover classes due to their thorough description and georeferencing. Classes which are not covered by these points must be visited and identified by a field team as ground-truthing activity.

2.3   Slope and elevation

As slope is one of the main destabilizing factors for soil, it will be used as an additional input variable. Slope will be derived from an available digital elevation model (DEM) based on the SRTM mission data of 90 m resolution. Elevation can similarly be obtained from the DEM, providing an additional GIS layer if stark relief contrasts exist within a block.

2.4   Precipitation

In regions where large gradients in precipitation exist, rainfall data such as the annual rainfall or the rainfall of the wettest month can be used as an additional proxy for soil instability, given the access to reliable data with sufficient resolution.

2.5   Soil

Soil stability depends largely on its mineral composition and its particle size distribution. Thus, information on particle size distribution is likely to substantially enhance the prediction of soil stability. As interpolation of soil analyses from the individual plots would most likely produce only vague maps, while small scale maps are unavailable, slope is rather considered as a proxy for soil stability upon absence of soil maps.

An exception are sodic soils which occur frequently in the sampled catchments and are apparently independent of slope effects, i.e. large gullies also develop in plain terrain. Maps are partly available and will be sought for identifying areas of such sodic soils for pre stratifying them as especially vulnerable.

3 Synopsis

The different parameters described above (for the Lower Nyando block this has been restricted to land cover, slope and mapped sodic soils) can be translated into GIS layers using ArcView 3.4. Queries of the existing information layers according to the decision tree below allowed for classifying each grid cell into the vulnerability classes:

The distribution of sodic soils was recognized prior to the queries from existing soil maps where these regions received special focus due to their high erodability irrespective of slope effects. As information layers increase, the decision tree is capable of refining to reflect the input data and allow for even finer tuning of the criteria for each vulnerability class. This can also result in a higher fragmentation of the regional map in terms of vulnerability.

Land Use	Slope (deg)	Vulnerability	
Bare	0-10	C2	
	10-30	D2	
	> 30	D2	
Forest	0-10	A1	
	10-30	A1	
	> 30	B1	
Woodland	0-10	A1	
	10-30	B1	
	> 30	C1	
Grassland	0-10	C1	
	10-30	C2	
	> 30	D1	
Perennial crops	0-10	B1	
	10-30	B1	
	> 30	C1	
Annual crops	0-10	B1	
	10-30	C1	
	> 30	D1	

Vulnerability	none	low	moderate	high
reversible				
irreversible				

Figure 1. *Hierarchical decision scheme for assigning criteria of land use and slope to the vulnerability classes indicated below (no presence of sodic soils is assumed in this scheme as these would have been identified prior to the application of this decision scheme).*

4 Output

Using input data from at least visible satellite imagery and slope/elevation data, this exercise will produce comprehensive maps of the survey blocks in Western Kenya with a spatial resolution of 30 m or better, explicitly dividing the region into the following seven vulnerability classes (Fig. 1):

- No vulnerability

- Low vulnerability   – reversible

                           – irreversible

- Moderate vulnerability – reversible

                           – irreversible

- High vulnerability   – reversible

                           – irreversible

where the four principal classes will be correspond to no, low, moderate, and high vulnerability, out of which the last three classes will be subdivided into potentially recoverable through appropriate interventions of low cost (reversible) and recoverable only at high expense (irreversible).