Using Farmer Field Schools Approaches to Overcome Land Degradation in Agro-Pastoral Areas of Kenya

Land degradation assessment – Baseline survey on spatial analysis of land cover / degradation trends and Toolkit Development.

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1. Introduction

Desertification – land degradation in drylands – is one of the most serious environmental and development challenges. Land degradation threatens the natural resource base and also strongly interacts with other environmental problems such as biodiversity loss, water shortages, flooding and climate change. Because of these strong interactions it is becoming increasingly recognized that integrated approaches to tackling these problems are not only needed but can bring about multiple benefits.

The lack of adequate ground data has led to most studies utilizing the growing archives of satellite data for mapping vegetation changes and land degradation. In this study time series data of vegetation was taken from two different satellite based sources. Vegetation for the period 1981 to 2006 is calculated from 8 km resolution Normalized Difference Vegetation Index (NDVI) data obtained from the Advanced Very High Resolution Radiometer (AVHRR) sensor flown on a series of satellites operated by the National Oceanic Atmospheric Administration (NOAA) of the United States of America (USA). The AVHRR sensor was not designed for vegetation mapping, and NDVI is hampered by several shortcomings. To overcome the influence of soil signals at low vegetation densities affecting NDVI we applied a previously published soil adjustment factor. For the period 2000 to 2006 more high resolution, and better quality vegetation data was calculated from 250 m resolution Enhanced Vegetation Index (EVI) data from MODIS (Moderate Resolution Image Spectrometer) flown on TERRA and AQUA, also operated by NASA. EVI is a better index than NDVI, but can not be calculated from the AVHRR sensor.

Changes in vegetation properties occur from transitions such as from rangeland to agriculture, and through tree-planting. To overcome artificial trends in vegetation data we developed an algorithm (vegetation increment index) for calculating annual vegetation growth. It is hypothesized that this index neutralizes artificial differences in satellite derived vegetation indexes between different ecosystems such as rangelands, croplands and woodlands. The vegetation increment index calculates the vegetation increments in 10-day (NDVI) and 16-day (EVI) intervals over an annual cycle. This algorithm was applied to both the MODIS EVI data and the soil adjusted AVHRR NDVI data. In this way we should theoretically be able to better capture the vegetation growth in both rangelands (where intermittent grazing leads to less standing biomass than in croplands) and tree interspersed agriculture (where woody biomass distorts the satellite derived vegetation estimates).

Publicly available rainfall records for Kenya going back to around 1900 were assembled. Attempts to interpolate this data to rainfall fields did not succeed, as the spatial variation (e.g. in and around the Rift Valley) is too large. For the period 1995 to 2006 rainfall maps produced by the Famine

Early Warning System (FEWS) and created by a combination of rainfall station and satellite imagery were used. Lack of consistent rainfall records prior to 1995 prevented the full evaluation of rainfall versus NDVI from the AVHRR sensor. For the EVI the annual vegetation growth was compared with annual rainfall for the period 2000-2006 to derive an annual index of Rain Use Efficiency (RUE). The RUE disentangles the temporal and spatial variation in vegetation due to rainfall variation from other factors, and can hence be used as a proxy for screening studies identifying areas with potential land degradation.

Trend analysis of changes in annual vegetation growth and RUE were done for detecting land degradation risk domains. A compounded index of vegetation change was constructed seeking out areas where all vegetation indexes shows negative trends, and then averaging the trends of vegetation and RUE change. From this compounded index land degradation hotspots were identified.

2. Objectives

This report presents a study of vegetation changes in Kenya (1981-2006), with detailed studies covering the districts of Mbeere, Mwingi and Narok (2000-2006). The aim of the study was to develop a comprehensive GIS (Geographical Information System) database with relevant data for identifying land degradation in Kenya, focusing on three selected districts (Mbeere, Mwingi and Narok); and to develop a synoptic screening method to identify areas with anomalous vegetation degradation or recovery patterns.

The report includes a training module designed to help national partners and students recreate the analyses done in this study. The training module uses a freeware GIS package, a step-by-step introduction to GIS, the source data and map products, and a video-presentation of key findings. It is hoped that the module will additionally provide an educational resource for universities and training institutes. All datasets, web-pages presenting the data and a local xml database over all included datasets are available on the project CD together with the training module.

3. Datasets

For this project a comprehensive database containing framework data (basic administrative data, infrastructure, hydrography) and data on geology, land cover and population etc was assembled. Time series data on vegetation and rainfall was constructed at two spatial resolutions; 8 km resolution for the whole of Kenya, and 250 m resolution for the included districts. All data was reprojected to geographical positions (longitude-latitude), and cut to fit the study areas. All datasets are available on the project CD and can be viewed as quicklook maps in a web-browser. An xml database is included that describes all the datasets and data layers. The xml database can be intrepreted with the html file that follows it. The tags (“<this is a tag>”) used in the xml file are self-explanatory.

3.1 Framework datasets

The framework datasets can be viewed using a web-browser or an ArcView project (.apr) file included on the Project CD. The framework datasets were compiled from open data source available over the internet (url links to the internet sites holding the datasets are included on the project CD). Additional data for the three districts was compiled by the GIS unit at ICRAF (Meshak, 2007).

3.2 Rainfall time series data 1995-2006

Rainfall grid maps at 8 by 8 km resolution, representing (10-day) rainfall from June 1995 until December 2006, were taken from the Famine Early Warning System (FEWS) web site (see project CD for url link) (Herman et al., 1997). For the detailed studies of the districts of Mbeere, Mwingi and Narok the rainfall data was resampled to 250 m resolution and then an average filter was applied to smooth the derived rainfall surfaces. This was done to avoid having artificially abrupt changes in the analysis of Rain Use Efficiency.

3.3. Vegetation time series data 1981-2006

3.3.1 NOAA-AVHRR NDVIg data 1981-2006

The longest consistent time series of satellite-derived vegetation data available is from the Advanced Very High Resolution Radiometer (AVHRR) instrument. In this project we used version "g" of the AVHRR NDVI data, processed to eliminate errors stemming from both sensor problems and atmospheric disturbances (Fensholt et al, 2006). NDVI was one of the first vegetation indexes that were developed. NDVI has several shortcomings, including sensitivity to soil color, atmospheric effects, and illumination and observation geometry. In this study a linear NDVI correction process following Maselli et al. (2000) was adopted for adjusting the NDVI data. The correction assumes that the soil influence decreases as vegetation increases, and becomes negligible at full vegetation coverage.

3.3.2 MODIS EVI data 2000-2006

The MODIS sensor carried on board the TERRA and AQUA satellites was developed for better estimation of vegetation (Huete et al., 2002). Supported by other on board sensors the MODIS vegetation data can be calculated using a more advanced algorithm – the Enhanced Vegetation Index (EVI). For this project we downloaded EVI data recorded with 16-day intervals (23 datasets per year) for the period March 2000 to December 2006. The MODIS EVI data used in this study is version 4 (MOD13q1v004) in 250 m resolution.

3.3.3 Vegetation data processing

The NDVI and EVI data was recalculated to annual indexes of vegetation growth: 1) annual average vegetation, 2) annual maximum vegetation and, 3) annual increments in vegetation. As the main dry season in Kenya occurs in September – October in Kenya the annual indexes were calculated using the period October to September the following year. This was done in order to capture the annual growing cycle rather than the calendar year annual vegetation.

In this study we adopted a theoretically neutral annual vegetation index, defined as the summed annual increment in NDVI/EVI between each of the individual observations (i.e. difference in vegetation between current and previous observation if positive). The starting of each annual vegetation cycle was set to September-October. By summing the increments we hypothesize that our index better captures the productivity of rangelands, and neutralizes the differences between rangelands, croplands and woodlands. It further has the advantage of neutralizing initial background effects (e.g. soil moisture conditions, influence of woody biomass) at the start of an annual growing cycle. The developed index should hence be more suitable when comparing vegetation in landscapes with transient temporal and spatial changes, compared to either annual average or maximum vegetation used in most other studies.

3.4 Rain Use Efficiency

To overcome the shortcomings of using annual vegetation indices for tracking land degradation, the concept of Rain Use Efficiency (RUE), which combines rainfall and vegetation information, was developed for arid and semi-arid regions. It is an attractive index in regions where growth is limited by rainfall, and where there is a linear relation between rainfall and vegetation. As RUE is calculated using seasonal or annual time-steps it is also hypothesized to bridge short-term fluctuations in vegetation dynamics. In parts of Kenya (including parts of the district of Narok) rainfall is most likely not limiting vegetation growth, and RUE will not be less ideal to use for identifying land degradation. In this study RUE was calculated using MODIS EVI data and rainfall data resampled to fit the EVI data spatial and temporal resolution. RUE was calculated with annual time steps going from October to September the following year.

4. Analysis and results

4.1 Kenya vegetation 1981-2006

The vegetation development in Kenya was analyzed from AVHRR NDVIg data for the period September 1981 to October 2006 (Fig. 1). The trend in annual average vegetation growth for this period was calculated using Ordinary Least Square (OLS) regression (Fig. 1). This, and other vegetation indexes for Kenya are available on the project CD.

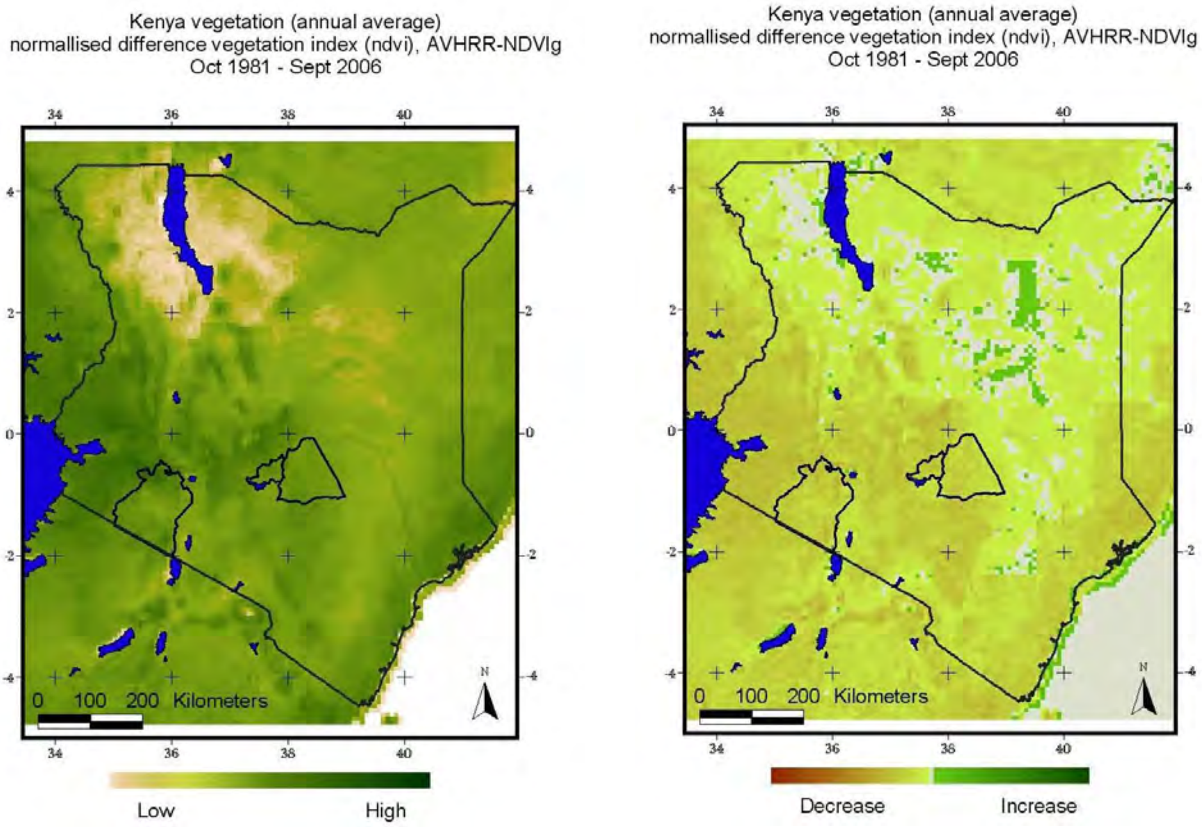

Fig. 1. Kenya vegetation data (AVHRR NDVIg 8 km for each 10 days 1981-2006) calculated as average annual vegetation cover for years going from 1 October – 30 September, left: overall average; right: trend. Large-scale topographic effects (e.g. Mount Kenya and Mount Kilimanjaro) are clearly seen. The greening effect along the coast is an artifact stemming from uncertain georeferencing of the satellite images used in the analysis. Note that the symbolizing of this map and the following are different and the color schemes can not be directly compared.

4.2 Mbeere and Mwingi vegetation 2000-2006

The vegetation development in Mbeere and Mwingi districts was analyzed for the period September 2000 to October 2006 using MODIS EVI data in 250 m resolution. Three annual indexes were calculated: average EVI (Fig. 2), maximum EVI (Fig. 3) and increments in EVI (Fig. 4). All indexes were calculated over an annual growing cycle (October to September the following year). For each annual index the trend in vegetation growth was calculated using Ordinary Least Square (OLS) regression. The data is available as GIS data layers on the project CD (separate datasets for Mbeere and Mwingi).

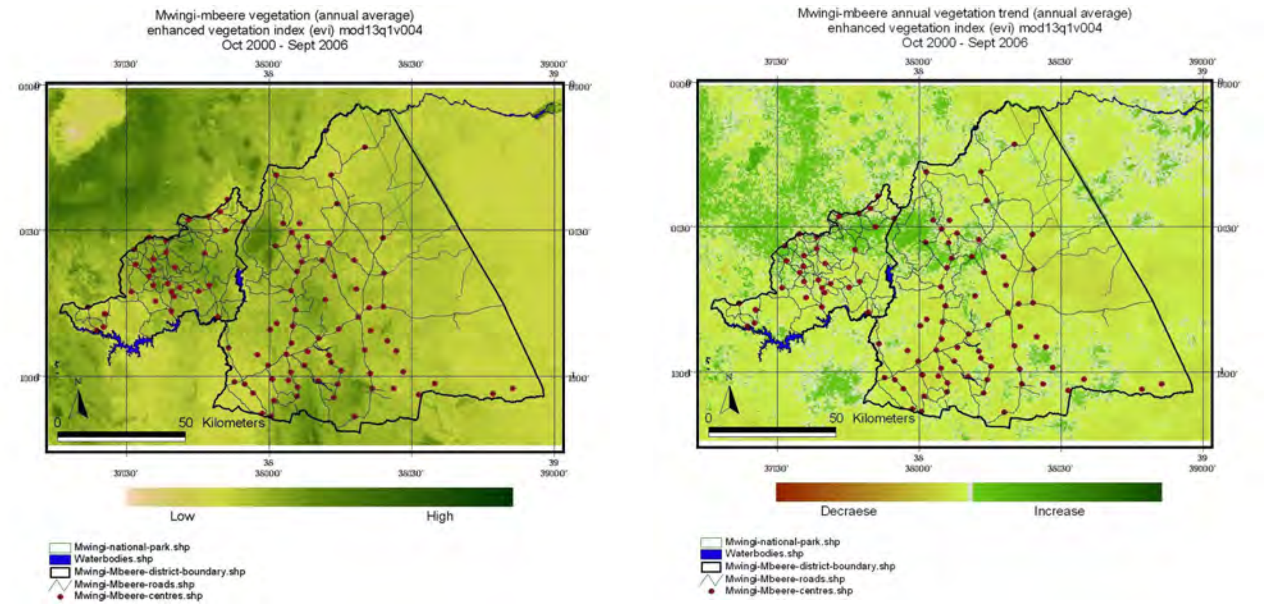

Fig. 2. Mbeere and Mwingi vegetation (MODIS EVI 250 m data for each 16 days 2000-2006) calculated as average annual vegetation cover for years going from October –September, left: average; right: trend. The time series is rather short for applying trend analysis. The use of the annual average vegetation can be misleading as it is sensitive to cloud contamination, and it overestimates vegetation growth in evergreen forests and shrub lands, but is the most commonly used annual index.

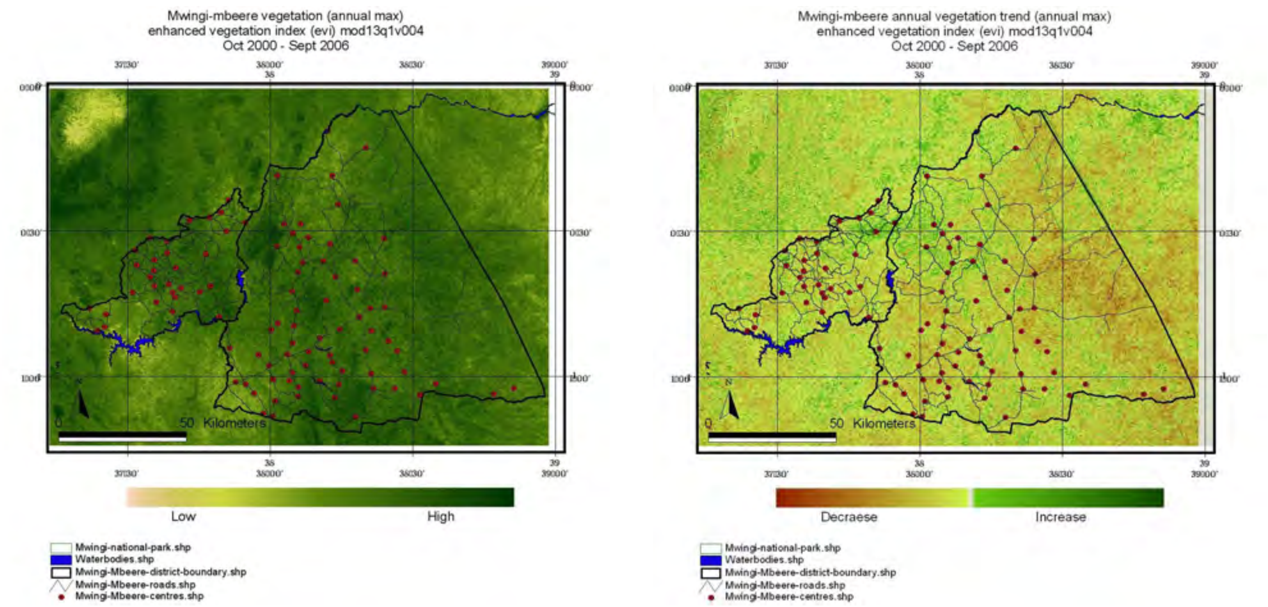

Fig. 3. Mbeere and Mwingi vegetation cover (MODIS EVI 250 m data for each 16 days 2000-2006) calculated as maximum annual vegetation cover for years going from October – September, left: average annual maximum; right: trend. The time series is rather short for applying trend analysis. The use of the annual maximum is common for croplands, where the maximum vegetation cover is hypothesized to represent standing crop before harvest. For pastoral landscapes it is less suited as the vegetation is continuously or intermittently grazed, but growth can still be higher compared to fallow or croplands.

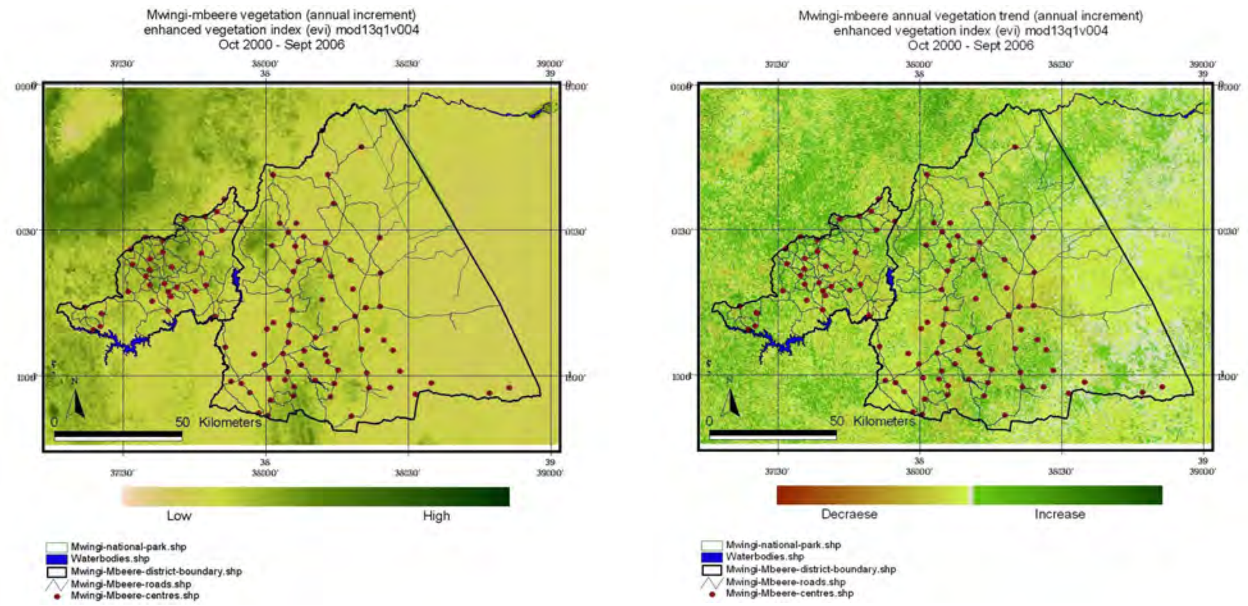

Fig. 4. Mbeere and Mwingi vegetation cover (MODIS EVI 250 m data for each 16 days 2000-2006) calculated as increments in annual vegetation cover for years going from October – September, left: average annual increment; right: trend. The time series is rather short for applying trend analysis. The use of the annual vegetation increment is sensitive to cloud contamination, but partly neutralizes overestimation of evergreen forests and underestimation of intermittent grazing, hampering other annual vegetation indexes.

4.3 Mbeere and Mwingi Rain Use Efficiency 2000-2006

The Rain Use Efficiency (RUE) in Mbeere and Mwingi was analyzed for the period September 2000 to October 2006. The RUE was calculated as the ratio between annual increments in MODIS EVI over rainfall. The trend in RUE was calculated using Ordinary Least Square (OLS) regression. The data is available as GIS data layers on the project CD (separate datasets for Mbeere and Mwingi).

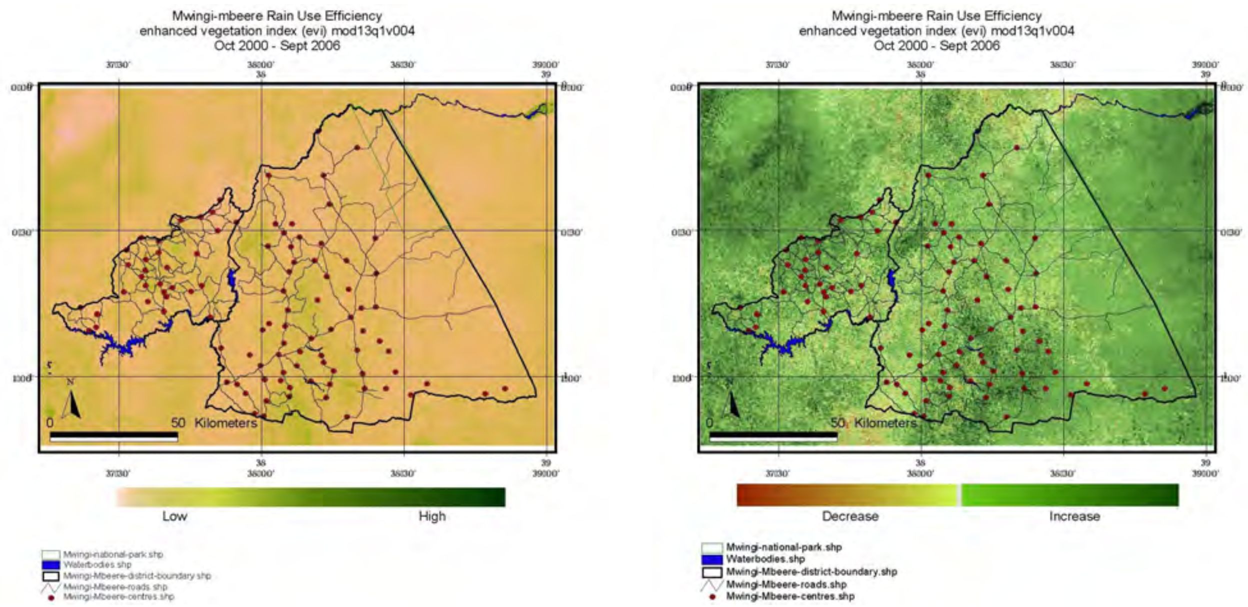

Fig. 5. Mbeere and Mwingi Rain Use Efficiency (RUE) calculated from MODIS EVI (Annual increments in EVI 2000-2006) and satellite based rainfall estimates for years going from October – September, left: average RUE; right: trend. The time series is rather short for applying trend analysis.

4.4 Mbeere and Mwingi degradation hotspots 2000-2006

A compounded index of land degradation was constructed averaging the trends for 1) annual average vegetation, 2) annual maximum vegetation, 3) annual increments in vegetation and, 4) Rain Use Efficiency. From this compounded index areas with a negative trend in all four indexes where identifed. Only contiguous areas larger than 1 km^2 were identified (Fig. 6). The project CD contains more detailed GIS-data on land degradation hotspots.

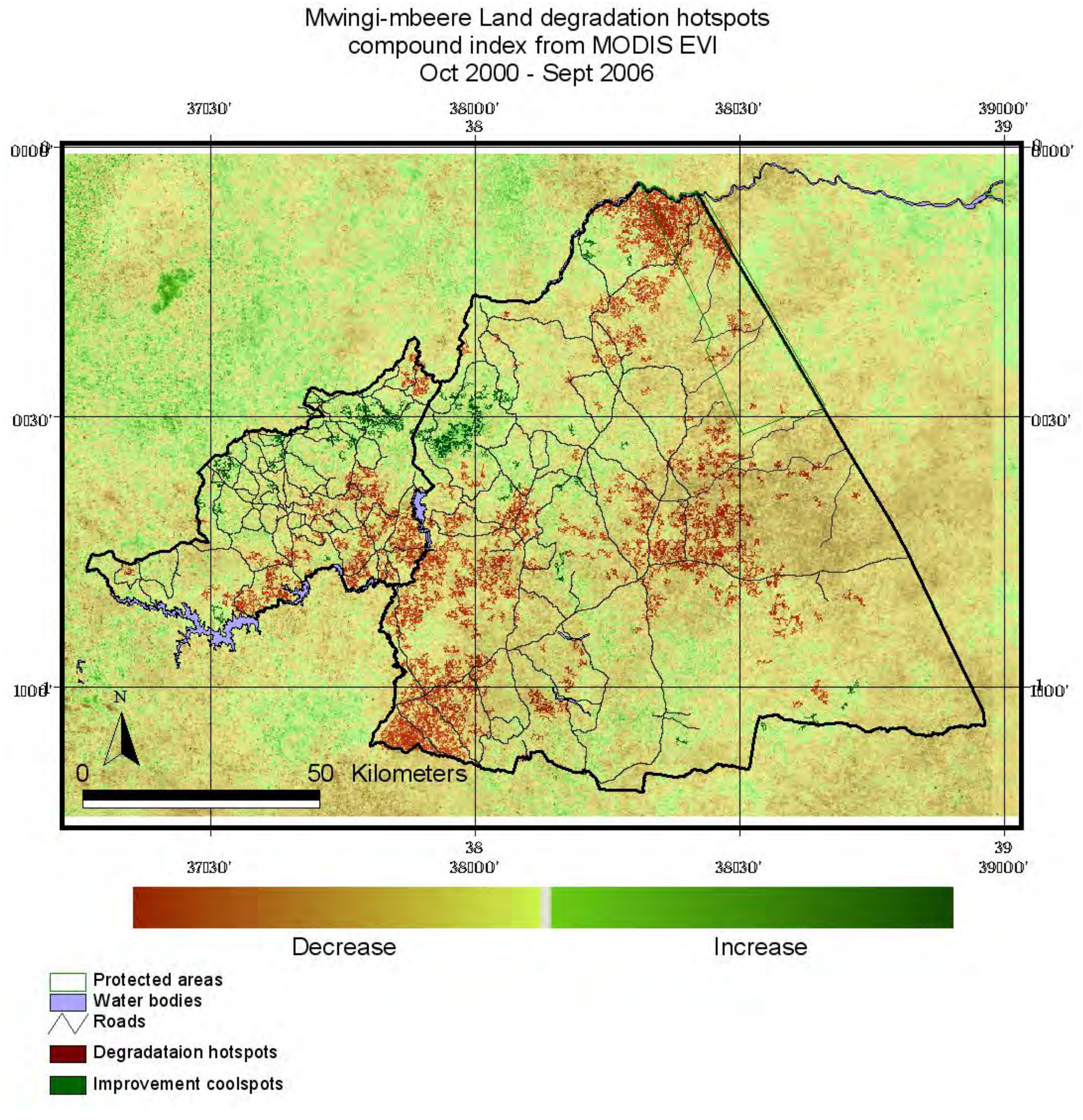

Fig. 6. Identified land degradation regions and hotspots in Mbeere and Mwingi districts. Hotspots were identified from a compounded index of vegetation changes derived from the MODIS EVI over the period October 2000 to September 2006 (see text).

4.5 Narok vegetation 2000-2006

The vegetation development in Narok district was analyzed for the period September 2000 to October 2006 using MODIS EVI data in 250 m resolution. Three annual indexes were calculated:

average EVI (Fig. 7), maximum EVI (Fig. 8) and increments in EVI (Fig. 9) over an annual growing cycle (October to September the following year). For each annual index the trend in vegetation growth was calculated using Ordinary Least Square (OLS) regression. The data is available as GIS data layers on the project CD.

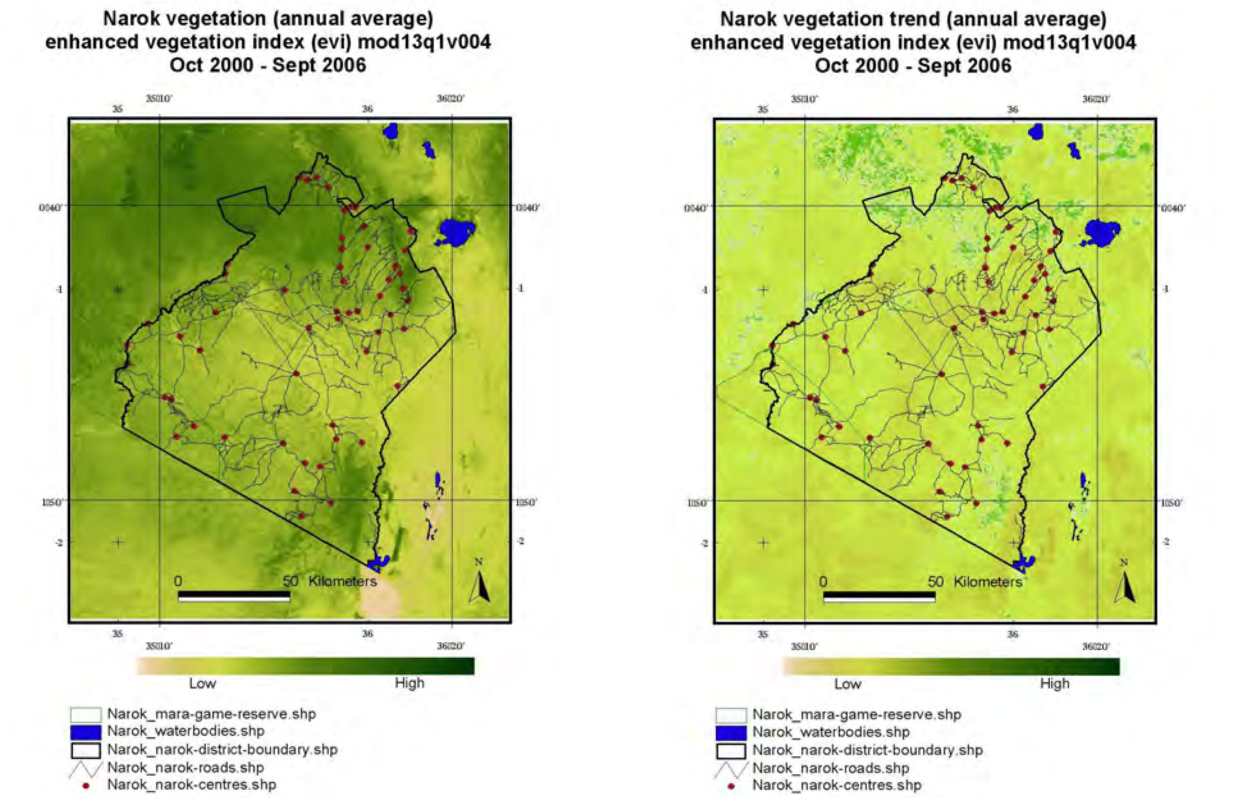

Fig. 7. Narok vegetation (MODIS EVI 250 m data for each 16 days 2000-2006) calculated as average annual vegetation cover for years going from October –September, left: average; right: trend. The time series is rather short for applying trend analysis. The use of the annual average vegetation can be misleading as it is sensitive to cloud contamination, and it overestimates vegetation growth in evergreen forests and shrub lands, but is the most commonly used annual index.

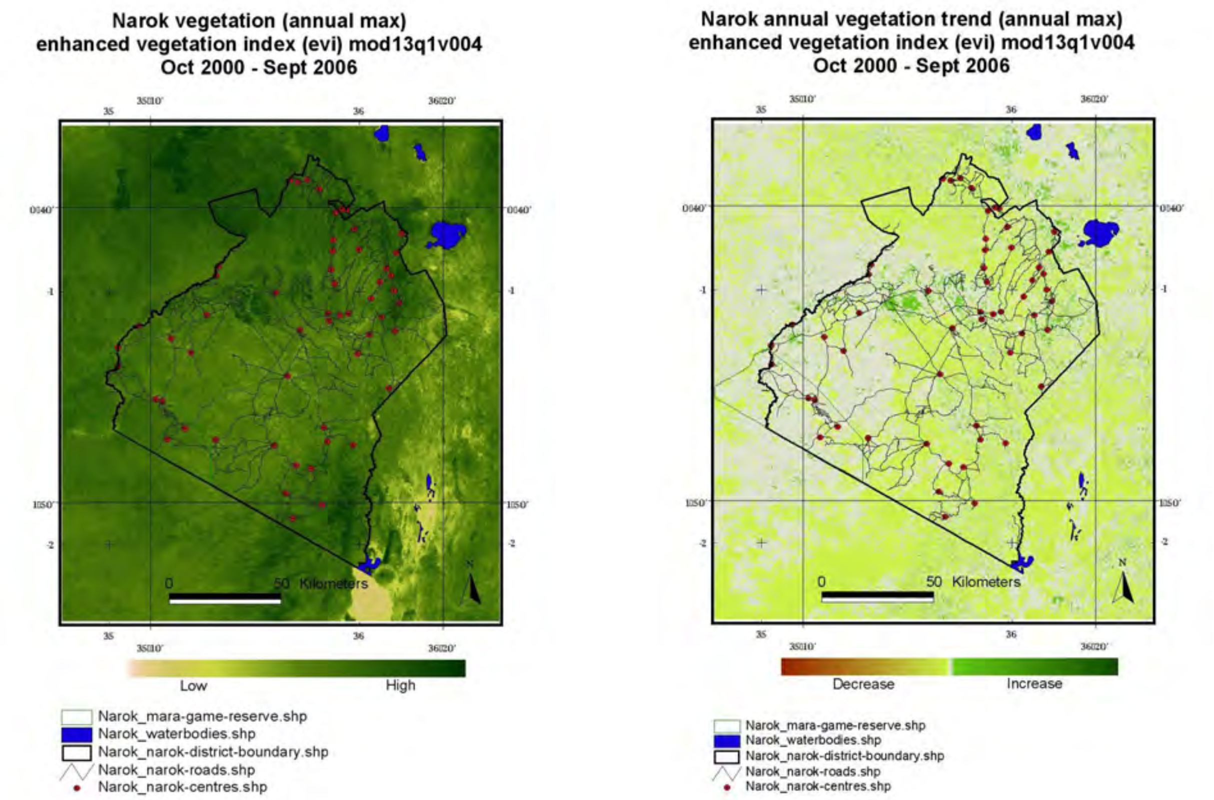

Fig. 8. Narok vegetation cover (MODIS EVI 250 m data for each 16 days 2000-2006) calculated as maximum annual vegetation cover for years going from October – September, left: average annual maximum; right: trend. The time series is rather short for applying trend analysis. The use of the annual maximum is common for croplands, where the maximum vegetation cover is hypothesized to represent standing crop before harvest. For pastoral landscapes it is less suited as the vegetation is continuously or intermittently grazed, but growth can still be higher compared to fallow or croplands.

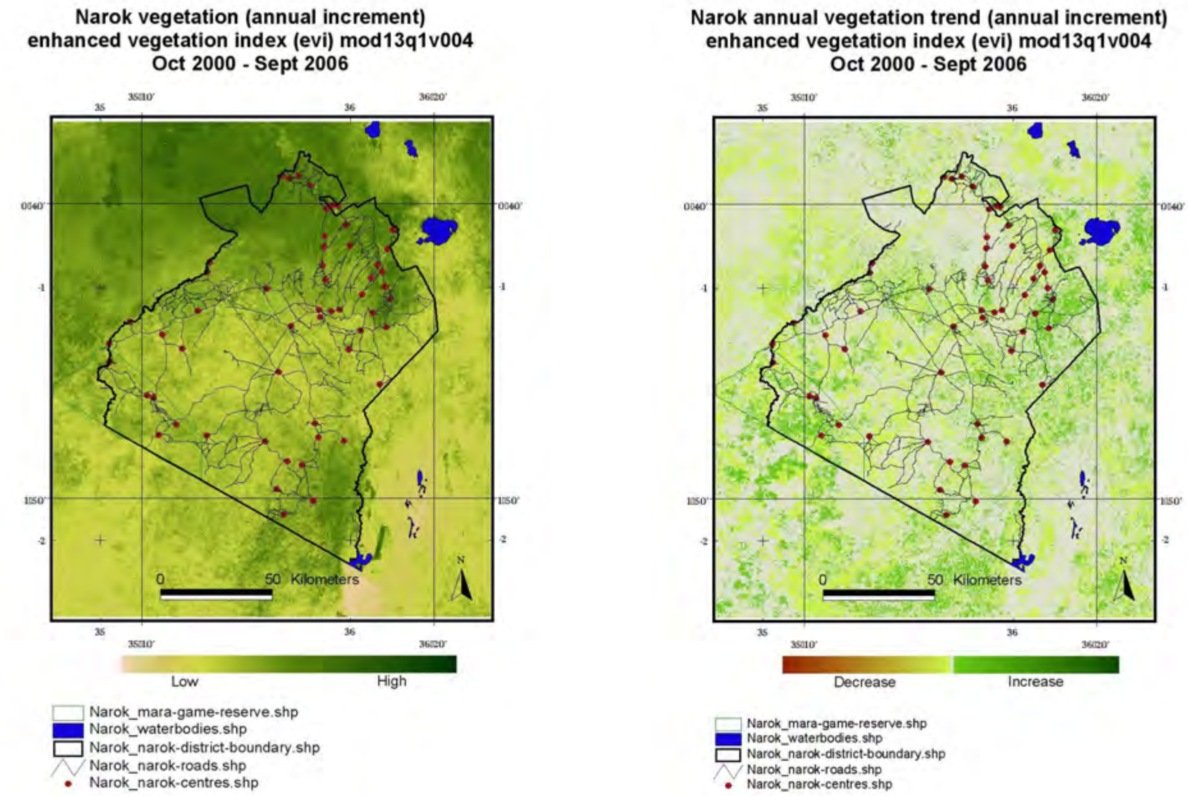

Fig. 9. Narok vegetation cover (MODIS EVI 250 m data for each 16 days 2000-2006) calculated as increments in annual vegetation cover for years going from October – September, left: average annual increment; right: trend. The time series is rather short for applying trend analysis. The use of the annual vegetation increment is sensitive to cloud contamination, but partly neutralizes overestimation of evergreen forests and underestimation of intermittent grazing, hampering other annual vegetation indexes.

4.6 Narok Rain Use Efficiency 2000-2006

The Rain Use Efficiency (RUE) in Mbeere and Mwingi was analyzed for the period September 2000 to October 2006. The Rain Use Efficiency was calculated as the ratio between annual increments in MODIS EVI over rainfall. The trend in RUE was calculated using Ordinary Least Square (OLS) regression. The data is available as GIS data layers on the project CD (separate datasets for Mbeere and Mwingi).

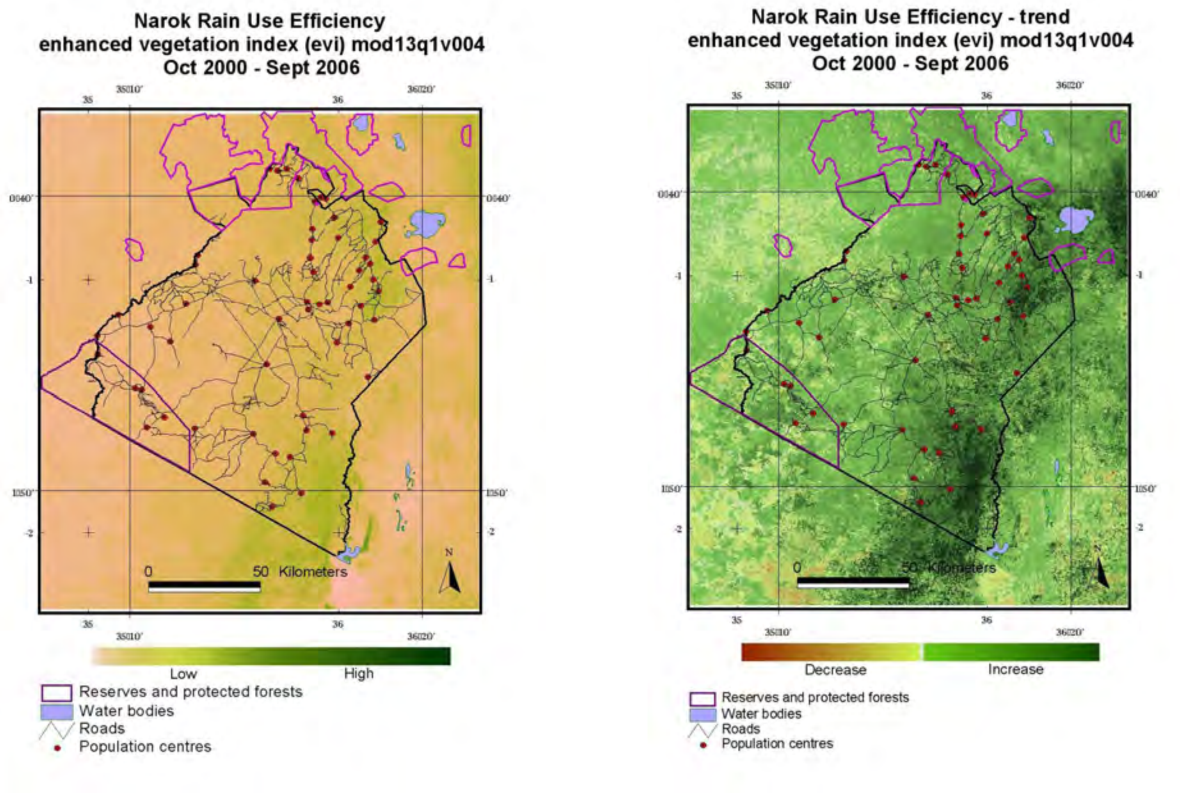

Fig. 10. Narok Rain Use Efficiency (RUE) calculated from MODIS EVI (Annual increments in EVI 2000-2006) and satellite based rainfall estimates for years going from October – September, left: average RUE; right: trend. The time series is rather short for applying trend analysis.

4.7 Narok degradation hotspots 2000-2006

A compounded index of land degradation was constructed averaging the trends for 1) annual average vegetation, 2) annual maximum vegetation, 3) annual increments in vegetation and, 4) Rain Use Efficiency. From this compounded index areas with a negative trend in all four indexes where identifed. Only contiguous areas larger than 1 km^2 were identified (Fig. 11). The project CD contains more detailed GIS-data on land degradation hotspots.

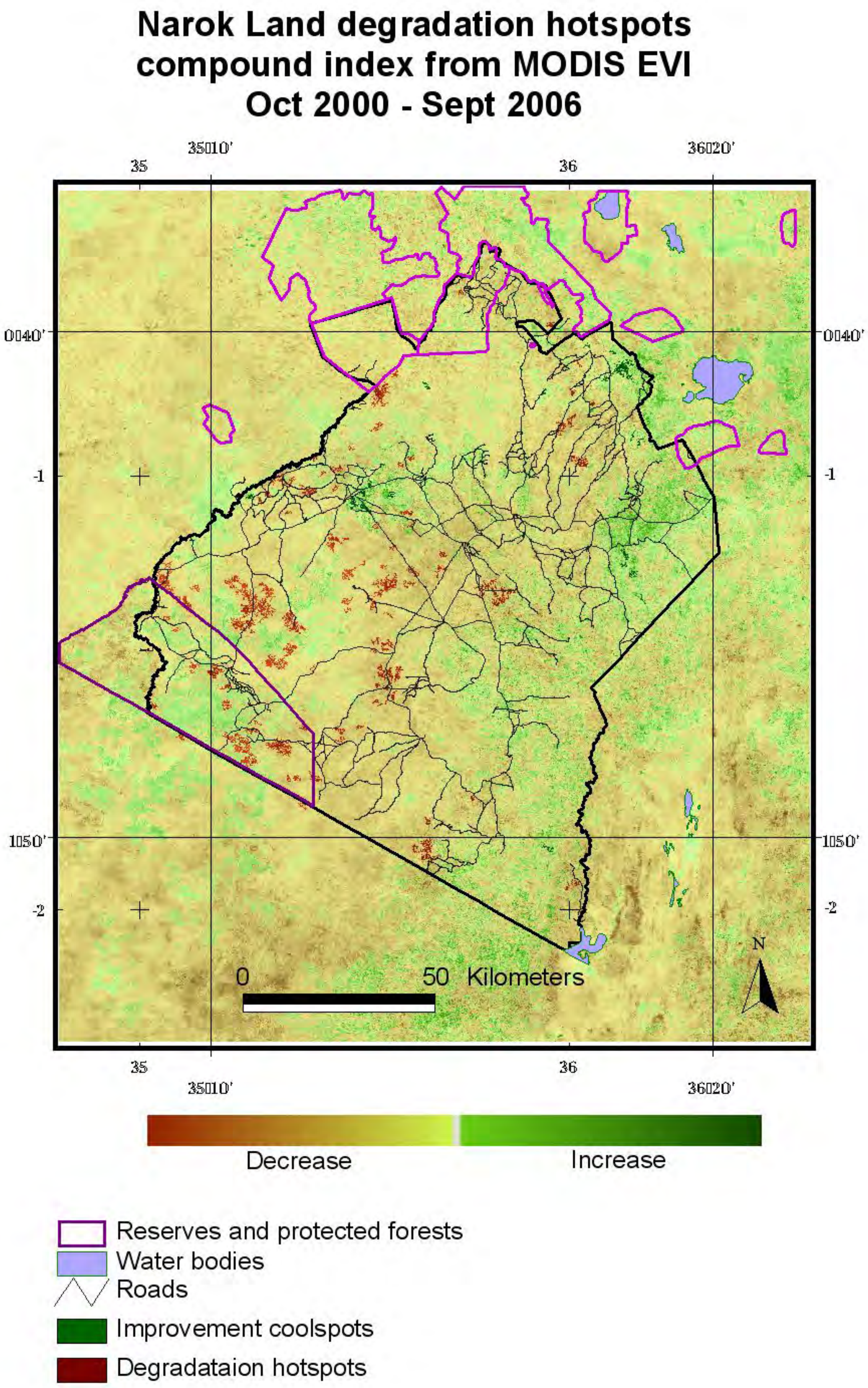

Fig. 11. Identified land degradation hotspots in Narok districts. Hotspots were identified from a compounded index of vegetation changes from October 2000 to September 2006 (see text).

5. Discussion and conclusion

Long-term vegetation changes in this study were captured using satellite derived NDVI data in 8 km resolution from several generations of NOAA-AVHRR sensors. This data is available from June 1981 and is still continuing. A clearly negative trend in overall vegetation growth was detected for Kenya as a whole for the last 25 years. Lack of reliable estimates of the spatial trends in rainfall prevented evaluating whether this trend is dependent on changes in rainfall or other factors.

Land degradation in the districts of Mbeere, Mwingi and Narok was screened using time series EVI data in 250 m resolution from MODIS (MOD13Q1v004). Several annual indexes were computed and used to evaluate vegetation changes in the period 2000 to 2006. A compounded index of vegetation degradation was developed to identify local and regional areas in the risk of becoming degraded. The EVI data indicate that Mwingi was the district least affected by negative vegetation trends over the last six to seven years. The negative trends in Mwingi were not as strong as the negative trends in Mbeere and Narok. In all three studied districts regional areas and local hotspots of declining vegetation were identified from the EVI data. In general no vegetation decline was identified in protected areas, with the exception of two smaller hotspots near population centers in the Mara Game Reserve (see Fig. 11). The time series are too short to make any definite conclusions, but the identified hotspot areas could be used for directing more intense studies of land degradation and soil conditions. The result of this study indicates that the moderate resolution EVI dataset from MODIS (mod13q1) is a useful source for analyzing vegetation trends. More detailed maps showing the exact degradation spots identified using the compounded index are included on the project CDs.

The level of detail derived form the MODIS EVI data will allow analyzing the influence of different bio-physical factors and of managerial regimes on vegetation growth and agricultural harvest. The framework dataset included in this study could be used to stratify the vegetation data and hence separately analyze the relations between vegetation growth and topography (upslope-downslope), soil, geology, land cover etc. The dataset included in this report also includes animal counts at species level; both regarding livestock and wildlife (Situma et al., 2007), and it should hence also be possible to analyze the relations between vegetation growth and stocking density. Such an analysis would need to consider the average amounts of vegetation consumed by each species. The MODIS EVI is still under development, and version 4 used herein is not the final algorithm. Recently version 5 of the MODIS EVI has been finalized, and the archived data is at present reprocessed to this improved level. Further studies should hence make use of this improved version of the EVI derived from MODIS.

6. Further studies

This study has shown the usefulness of employing both long-term coarse resolutions NDVI data derived from NOAA-AVHRR and short term moderate resolution EVI data from MODIS and AQUA. Attempts were made to overcome shortcomings in algorithms for estimating vegetation growth in different ecosystems (farmland, pastoral lands and woodlands). Framework data with relevance for studying land degradation and vegetation changes were also assembled, but due to time limitation were not used in the study. Further studies could build on the results reported here, and make use of additional data resources already available and in the pipeline of becoming (freely) available.

6.1 Improved statistical methods for trend analysis

In this study linear regression of annual vegetation indexes were used to generate trends of vegetation changes. The MODIS EVI time series in however rather short for applying time series analysis. Trend studies of vegetation in arid climate should also consider using more advanced statistical methods, including using normalized data and non-parametric methods.

6.2 Long term changes in rain use efficiency

The study of long-term vegetation changes would be greatly improved if reliable estimates of spatial rainfall could be interpolated from archived rainfall gauge data. In this project available rainfall station data was assembled going back to around 1900. No consistent interpolation algorithm could however be developed as the spatial variation is large and difficult to predict, e.g. in and around the Rift Valley. Algorithmic techniques however exist to overcome such problems, and could be done as a further study. Ideally additional (non-public) rainfall station data should be included in such a study.

6.3 Updating to MOD13Q1v005

At present the MODIS EVI is updated (also for archived data) to version 5, which has a higher quality compared to version 4. Further studies should hence use version 5 of the MODIS EVI.

6.4 Analysis of vegetation growth and topography

From a visual interpretation of the vegetation data it is clear that the topography at a scale of both 8 km and 250 m influences vegetation growth. In the NDVIg dataset Mount Kenya, Mount Kilimanjaro and other larger peaks are devoid of vegetation, whereas in the down slope positions vegetation growth is larger than elsewhere. This is a well-known phenomenon, but could be analyzed in more detail, including the effects of logging and forest clearing around mountains. In the 250 m EVI data from MODIS smaller valleys are easy to detect as bands with higher vegetation growth. Also here a further analysis could reveal if vegetation changes have been more pronounced on hilltops or in valley bottoms, and it trends in vegetation are bound to such environments.

6.5 Analysis of vegetation growth and land cover

Four land cover datasets at 500 m resolution with global coverage are included in the framework dataset. These datasets were derived from a phenological study of vegetation growth (for the period 2000-2001) using MODIS data and include i) vegetation classes, and ii) bare, iii) herbaceous and iv) tree cover (summing up to 100 %). The latter product is announced to be released as annual datasets in the near future (using version 5 of MODIS EVI). These land cover datasets could be used for stratifying the analysis of vegetation trends. This would allow evaluated which type of ecosystems that show the strongest positive and negative trends. Such a study would need also to consider topographic effects and spatial and annual variation in rainfall.

The EVI dataset used in this study would allow local phenology to be evaluated in greater detail (250 m resolution and 16 day return cycle) compared to the global dataset in 500 m resolution, and hence be used to identify areas that have been converted from one land use class to another. This would, however demand more detailed field studies to be conducted.

Other studies of vegetation change have found correlation between population density / proximity to population centers and vegetation changes. Such a study could also be conducted using the datasets included in this project (including population centers; population census data at sub-district level going back to 1970; and spatial estimates of population density derived from a combination of census data, satellite images and data on infrastructure, land cover and topography).

A more detailed land cover dataset produced from single scene Landsat ETM (Enhanced Thematic Mapper) imagery (from around 2000) at 30 m resolution and detailed classes is also included in the project dataset. With this dataset it would be possible to analyze the relation between vegetation growth (MOD13Q1) and land cover at a more detailed level. As land cover is related to topography the analyses should need to consider topographic effects in order to distinguish such effects from the effects caused by land cover. In such a study the variation of rainfall must also be considered, preferably managerial regimes in farmlands and pastoral lands should also be included. Stocking density of livestock is one important factor, and data on livestock and wildlife (at species level) is included in the framework dataset (Situma et al., 2007).

6.6 Analysis of vegetation growth and the water cycle

If additional data on river flow (and evapotranspiration) could be acquired the relation between topography, vegetation growth and stream flow/erosion could be further analyzed. Such an analysis could also include analysis of latent and sensible heat flow and if done in near real time (see section 6.7 and appendix A) be used to forecast the risk of vegetation dieback caused by drought during the growing season. This can be done by analyzing MODIS imagery for relations between vegetation status (EVI) ground temperature and evapotranspiration, all possible to compute using MODIS data.

6.7 Analysis of soil fertility and vegetation growth

MODIS originally captures data in 36 different wavelengths in both the visible, near and middle infrared spectra. Building a spectral library for soil conditions from ground samples and correlating sample information to spectral properties captured by the MODIS sensor would allow using MODIS to continuously monitoring changes in soil properties (e.g. soil fertility).

6.8 Creating a near real time system for vegetation monitoring and analysis

The time series data on vegetation and precipitation used in this study are continuously updated and made freely available over the internet by the data suppliers. The tools used in this study could be developed to create a system for automatic update of the time series and time series analysis of vegetation growth and Rain Use Efficiency, including prognosis of harvest and vegetation development over a growing cycle. Appendix A presents and outline for how such a system could be built.

6.9 Creating training modules and course curricula

The project CD included in this study includes all the datasets used in the study, plus many more framework datasets useful for more detailed analysis. All included datasets can be viewed as quicklooks from an included web-pages on the project CD. A training module is included to guide users through the steps needed to use the dataset. The module could be further developed to full curricula to be used at public and private institutions, including at regional universities. The training module is at present based on the free software DIVA-GIS, developed by the international potato centre (CIP). The format of the supplied data is open (shape files for vectors, binary grids for rasters and geotif for images) and the training module can hence be translated to e.g. the ESRI family of GIS software (Arc Explorer. ArcView or ArcGis) using the same data sources.

6.10 Expanding the study to all districts of Kenya

The study undertaken in this report used three districts in Kenya as examples. Instead of doing a manual interpretation and data compilation for each district, a suite of scripts and software programs were written in different programming environments (expect, MRT, Idrisi Macro Language, Delphi, Avenue for ArcView, PHP and javascript). These scripts and programs automatically created the final datasets and final data analysis. Most of the data assembled for this study further have either global, continental or national (Kenya) coverage. Creating datasets and analyses similar to those done for Mbeere, Mwingi and Narok could hence be done for all districts of Kenya (and other countries in Africa).

6.10 Scientific development of a compounded land degradation index

The compounded index used in this study has not been evaluated against any ground data or other independent data set. To develop a scientific more rigorous compound index of land degradation, combined with automatic data processing (see sections 6.8 and 6.9) would allow regional, and even continental or global evaluation of land degradation at moderate scale (250 m resolution) with estimated accuracy.

7. References

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Creating a near real time system for vegetation monitoring and analysis

The MODIS library of images is free to use, but each image tile containing vegetation data is around 500 MB in size. Two tiles cover the districts reported in this study. Download of MODIS image tiles can be automated using the free software expect. The downloaded images come in HDF format. Mosaicing, reprojection, cutting and export to more common image formats can be scripted in MODIS Reprojection Tool (MRT) a free software that can be downloaded from NASA. The exported vegetation data must then be analyzed and symbolized (i.e. colored so the user can intuitively understand its meaning). This can in principle be scripted in any programming language. For the images used in this project a combination of IDRISI and ArcView, and purpose written Delphi scripts were used. Before uploading and publishing, images need to be tiled if they are to be used with e.g. Google Earth (KML file type) or as interactive maps with pan and zoom functions. This tiling can be done in purpose written software, or programmed in e.g. ArcView. An automated process for near real time analysis and dissemination for MODIS vegetation data could be created as outlines in Fig. A.1.

Scripting in ArcView controlled the overall flow of image processing in this project. Hence ArcView was used to generate the scripts that were then fed to the other programs. Using a GIS software for the scripting has the advantage that the scripts for controlling expect and MRT can be written from inside the GIS. Other software will not have the capability to implement the reprojection and tiling functions as these processes demands geotransformations. The original projection of the MODIS HDF data is complex, and the final tiling to be sent to e.g. Google Earth must be followed by projection coordinates.

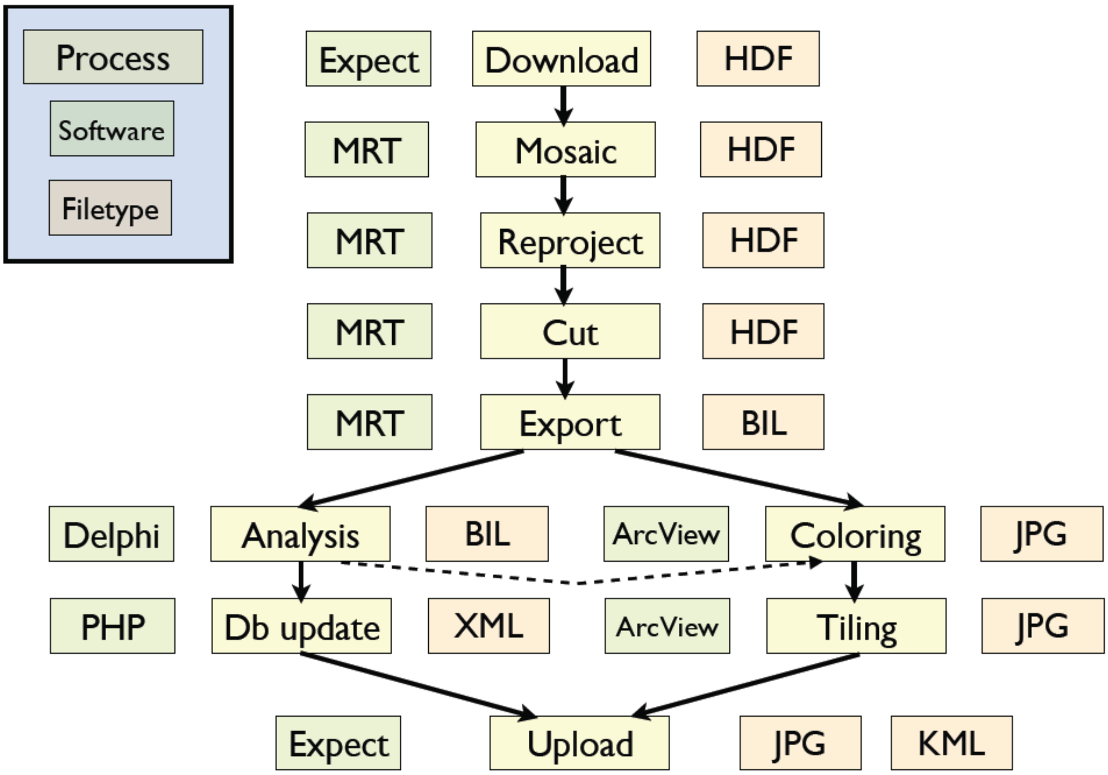

Fig. A1. Schematic process flow for creating a near real time automatic update of vegetation and time series analysis using MODI

Project CD

The project CD (version 1.0) contains this assessment report, the data used for the land degradation baseline survey, a free GIS (geographic Information System) software, and a training module for doing land degradation assessment using GIS and time series of vegetation data. All documentation is available both as Microsoft word document, and as web-pages. The CD can be used for viewing the datasets used in this study by just clicking the links to the data sets in the table below (this document must then be read from the CD). The GIS software included on the project can be used for redoing the assessment, but can also be done for other analysis and map making. To use the training module the DIVA-GIS software must first be installed, which is explained in detail in lesson 0.

The table below shows the folders (files) of the documents and other resources on the project CD, and if viewed in a web-browser, the links can be clicked to open up the different web-pages.

CD resource	**Folder**
Data set - Kenya	\data_spatial\ke
Data set - Mbeere	\data_spatial\mbeere
Data set - Mwingi	\data_spatial\mwingi
Data set - Narok	\data_spatial\narok
DIVA-GIS installation	\software\diva-gis
DIVA-GIS manual	\software\diva-gis\manual\DIVA-GIS5_manual.pdf
DIVA-GIS tutorial	\software\diva-gis\tutorial\DIVA-5_Tutorial.pdf
Training module	\training\index.pdf