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Remote sensing based study on land use/land cover change in a high populated region in Bamileke highlands, Cameroon

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Abstract

The study investigated the land use/land cover change (LULCC) and its driving forces in the *Bamileke* highlands in west Cameroon in Central Africa using a remotely sensed derived dataset, expert knowledge, official statistics and data collected in the field. The aim of the study was to detect LULCC over the period of 1959-2001 and analyse the link between LULCC and socio-economical conditions such as population growth, population distribution, and cultural behaviour of the population. The analysis based on the interpretation of information derived from population census statistics, analogue topographic and morphologic maps and Landsat imagery. On the one hand, in order to retrace the LULCC from the years 1959 to 2001, we visually interpreted two topographic maps from 1959 and 1961 as well as a Landsat MSS image from 1978. On the other hand, we carried out an automatic classification of multispectral Landsat images from the years 1988 and 2001. We tested different techniques of classification and obtained the best results by applying the Maximum Likelihood algorithm to information extracted from Principal Components of Landsat channels. The results revealed a clear change in the land use/land cover over the study period. The direction of the change and its magnitude vary between different land cover types. The highest change magnitude is associated with forest area. It decreased by 8.3 % alone during the period 1988-2001. The decrease of this land cover class during the whole period of 50 years was so enormous that in many localities a full disappearance of large forest areas was proved. The rapid decrease of forested area is caused by deforestation in advantage to the cultivated land and settlements. The area enlargement of these both land cover classes was driven by a rapid population growth and the change of the cultural behaviour of the population in the study region. The results of the study provides a better understanding about the nature of the LULCC in the rain forest belt in Africa and exposes its environmental and anthropogenic driving forces.

Introduction

Natural Landscapes stay as resources to the human being. These resources have been more or less used since the mid-age and over the industrial revolution in the 18th century till nowadays. The constant growth of the human population increase the pressure on the natural resources, leads to its disequilibrium, its degradation and the lost of its biodiversity. In order to assess this problem,

modern remote sensing techniques has been developed and it has been possible to assess the Land use and land cover change (LULCC) over the time. This is of great importance in area with poor cartographic coverage like the tropic regions (for example Cameroon). The results of these assessments are of great importance in the protection and the management of the natural resources (Fotsing, 1993, 1998).

Remote sensing approach has been recognized as a powerful and extensive method in studies on LULUC at all scales from the global to regional and local (Jensen, 2007). The use of remotely sensed data has been considered to be an effective tool for environmental planning and protection of areas from land degradation (Kappas, 1993; Kappas, 2001). This paper presents a study on the land use/land cover dynamic which was carried out in an region in the Cameroonian highlands. We investigated LULCC and their driving forces using simple techniques of remote sensing and univariate statistic (Albertz, 2001; Fleiss, 1981).

Study area

The analysed area is situated in the western Cameroonian highlands, in central Africa between the northern Latitudes 5°19'30'' and 5°33'25'' on the one hand and the eastern Longitudes 10°19'38'' and 10°34'25'' on the other hand. It covers an area of 701 km²

Data used in the study

To assess the LULCC in the Bamileke Highland we used topographic maps, satellite images datasets and fields data.

The topographic maps with the scale 1/50000 used in this study were from the year 1959 and 1961. These maps were used to reconstruct the landscapes of the corresponding time when there had been no satellite based survey of the surface. The information obtained from these maps was useful as reference for comparison with the landscapes of the recent time.

The second datasets were multi-spectral satellite images taken in the dry season from the American Landsat system: MSS, TM and ETM acquired respectively in the years 1978, 1988 and 2001.

During the field work we have collected through ground control points with a Garmin GPS¹ strategic land use and land cover data specially the vegetation cover after Braun-Blanquet which was of great importance during the cartographic and image analysis (interpretation and classification). Otherwise we used this section to speak with some key persons (traditional chiefs) in the Land use system of the study area.

Methodology

The process of data analysis has been done in two main steps: a visual interpretation of the test areas from topographic maps and the Landsat images on one hand and an automatic classification of multi-spectral images on the other hand, with the ENVI software 4.2.

The visual interpretation of the topographic maps consisted of finding the land cover dynamic and the land use change in the study area over the time using several channel combination (Albertz, 2001).

Before the step of the automatic classification or better the supervised classification the images have been geographically corrected and atmospherically calibrated. In order to reduce the amount of the channels to be classified we applied principal component analysis (PCA) which synthesized the signal from all individual channels into a group of main principal components (PC) (Jensen, 2007). The first 2 PC own about 99.2 % of the entire information from all Landsat channels. These PC were further used in the classification process. The first PC was plotted against the second PC and trainings area for each land cover class has been chose. While performing the classification, the separability of the land use classes has been checked as well as

¹ The Global Positional System (GPS) Has been developed by the American army for the positioning

their mean spectral signal, what is important to assess the difference between several land cover classes. This ended with the confusion matrix which allow to compare the obtain result with the distribution of the corresponding land cover classes in the reality.

Changes in land cover classes were computed through extracting areas of corresponding classes.

Results

The results revealed significant change in land cover classes during the study period. The interpretation of the results proofed that the observed changes in land cover coincide tightly with the population growth associated with the study period. We investigated this relationship on an example from the city of Bafoussam, the largest settlement in the study area. Table 1 demonstrates the dynamics of population and build up area in the city of Bafoussam between 1969 and 2001. The population of Bafoussam increased up to 50 % every ten years. This is a challenge to the landscape management of the area and its neighbourhoods, particularly the natural resources.

Comparing the results of satellite data's classification we realised significant change in the land use and land cover classes over the study period. This is due to the demographic development and the cultural dynamics which leads to changes in the population's behaviour particularly the younger people. Table 2 summarizes the change in land use development between 1988 and 2001. Within 13 years the land use in Bamileke highland has change. The results are showing a reduction of forest from up to 8% and an augmentation of cultivated land as well as of grassland respectively of 2.3 % and 4.4%. Then since the reference time (1959-1961) the agricultural activity has been strongly developed in the study area (Kamga Kamdem, 2003).

Tab.1 Development of population and the build up area in Bafoussam (1969-2001)

Year	1969	1978	1988	2001
Bafoussam's area [km ²]	2700	13030	18450	38050
Population	no data	64000	123000	250000

Tab.2: Land use development in Bamileke highland over 13 years.

Land cover class	02.02.1988 % from total area	05.02.2001 % from total area	Bilanz
Forest	35.00	26.68	-8.32
Grassland	28.95	33.44	4.49
Agricultural land	19.24	21.54	2.30
Build up areas	7.97	11.01	3.04
Bare areas	8.54	7.31	-1.23

Conclusion

In order to assess the land use and land change dynamic topographic map and remotely sensed data have been analysed. After methodology of visual interpretation and digital image analysis, topographic maps as well as satellite images have been analysed in order to detect the spatial and temporal dynamic of the Land use and land cover in a densely populated tropical area (Bamileke highland). Over thirteen years of observation significant changes have been realised particularly due to the human action. These results should help the decision makers to develop and to improve the land use management concept in order to achieve a sustainable development.

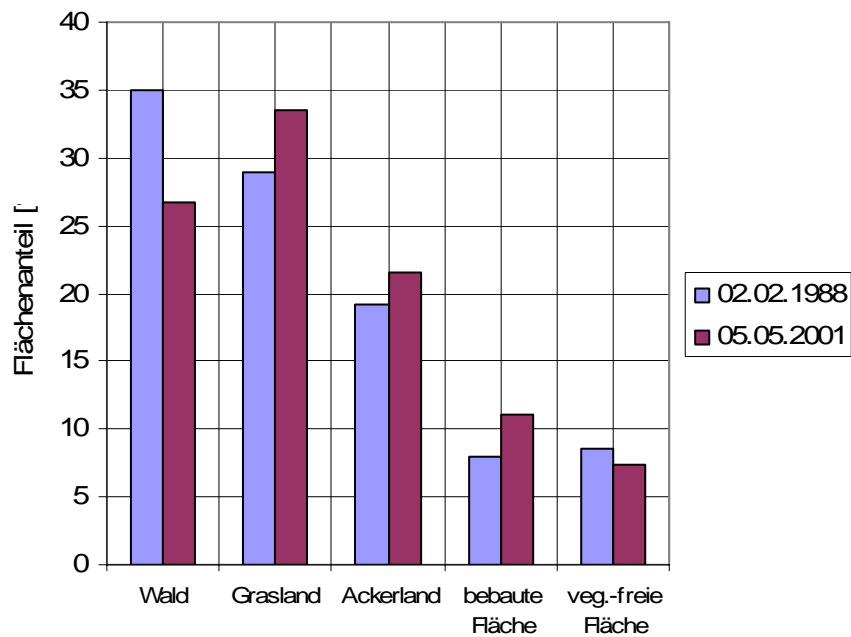


Figure 1: Change of the Land cover classes between 1988 and 2001.

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