EROSION IN THE HIMALAYAS ON CATCHMENT SCALE. INTEGRATIVE REMOTE SENSING ASSESMENT

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1. INTRODUCTION

The role of erosion in active mountain belts and the quantitative measurement of erosion rates are key questions in geomorphology. The rugged topography and the inadequate availability of monitoring systems are limiting the census of such information in the Himalayas. Satellite remote sensing in combination with adequate on-site calibration, offers the huge potential to monitor erosion and describe the geomorphological processes involved. Summer monsoon, anthropogenic activities and the high relief energy cause high erosion rates. In most of the areas along the Himalayan topographic front erosion plays a crucial role in regional development. The extreme topography is limiting the accessibility for field studies as well as conventional remote sensing approaches [1]. In theory landscapes evolution depends on the coupling feedbacks effects, e.g. when erosion does not compensate uplift, the topography becomes uplifted, which is defined as surface uplift (surface uplift = tectonic uplift - erosion). In any case starting from an initial steady-state topography, surface uplift results either from an increasing tectonic uplift rate or from decreasing erosion efficiency [2]. Erosion again, is strongly depending on the availability of water, its seasonal allocation and on the potential of the landscape morphology, while landscape morphology and precipitation depend on each other as well as on the driving forces of tectonic and erosion. So far no physical demonstration supports this theoretical approach, which presently is based on intuitive assumptions [2].

2. REMOTE SENSING AND AREA OF INTEREST

Here we present a set of several satellite image processing methods to register the (near-) surface conditions which account for erosion. Remote sensing technologies have the capability to measuring physical parameters, such as precipitation, land-use, vegetation coverage and tectonic uplift, with an area wide coverage and an high spatial resolution. Area wide remotely acquired parameter input, provides a powerful tool to understand the acting processes in the Himalayas [1]. The remote measurements are validated with ground truth information. This study is carried out in several small to medium scale watersheds (<100 km^2) and in one large catchments of Bhote Koshi River (approx. 2000 km^2), where adequate ground information is available. Sediment load and discharge volumes in rivers can be used to quantify the basin wide mean erosion rate of a watershed. Further more it can be used as background value for calibration. The People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himlayas (PARDYP) program maintained five target watersheds around the Himalayas (Pakistan, India, Nepal (2), Yuman/China). The watersheds are equipped with a narrow measuring devices network to obtained, meteorological, hydrological and erosion parameters [3]. This provides us with a unique set of ground truth information to calibrate our methods with. Beside the suspended sediment information, actual erosion rates for each occurring land-use type are available.

3. METHODS AND GOALS

The remote sensing data comprises of several optical data sets (ASTER and SPOT) as well as aerial photographs for one area. High resolution DEMs where extracted from stereo images and band ratio operation are carried out using the spectral information. In this study a modified Revised Universal Soil Loss Equation RUSLE (figure 1B) and the Vegetation cover Surface material and Drainage density (VSD) index are tested for their suitability in the Himalayas. The present state of remote sensing facilities and data acquisition allows to measure the parameters needed in RUSLE with very high accuracy and little on-site information [4]. Using classification methods - Maximum Likelihood (MLC), Support Vector Machines (SVM) (figure 1A) and Object Based (OBC) - precise land use mapping can be carried out and affiliated with typical erosion rates. Long term total erosion estimates are calculated from power law stream analysis. We will present the possibilities of erosion evaluation for high mountain areas by means of remote sensing, backed by ground-truth information. We show that none of the methods is absolutely trustworthy. Nonetheless these methods provide rough estimations that can be used as first order erosion rate estimation. Additionally relative values can help to provide erosion risk maps. We assume that the classification methods and the modified RUSLE give rates for pure soil erosion. Power law stream analysis provides overall erosion rates, including sudden events such as landslides.

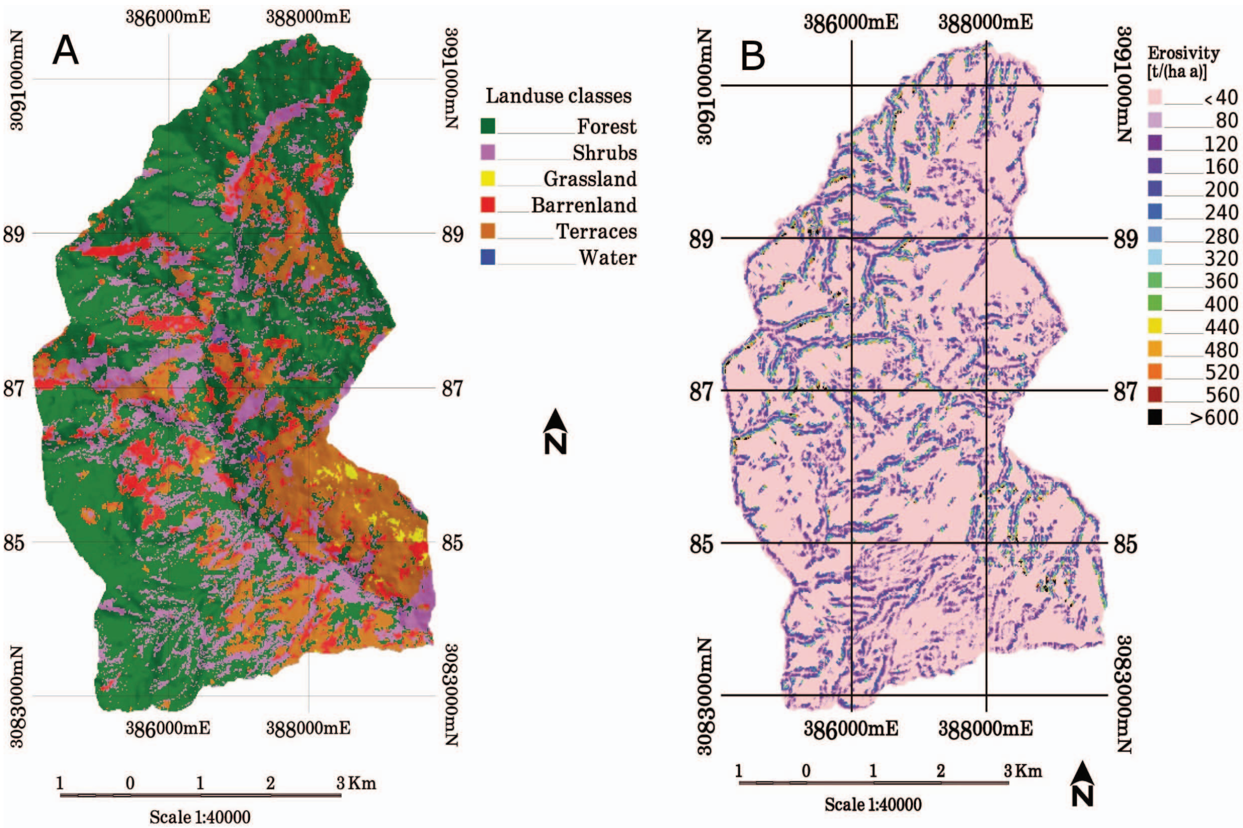

Figure 1. Examples for one of the six analyzed medium size watersheds. A) results of the SVM (Suport Vector Machine) classification with six land use classes. B) Result of the RUSLE (Revised Universal Soil Loss Equation) approach, where parameters have been determined by remote sensing techniques (source [1])

4. REFERENCES

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