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Identification of river terrace deposits using a semi-automatic mapping technique for irrigation purpose

Background

River terraces can morphologically be described as a staircase landform consisting of flat areas- or treads separated by steep risers. Terraces are typically underlain by a relatively thick layer of alluvial sediments, and the elevated position of treads above large floodplain. Their formation can be related to either tectonic activity, change of the erosional base level or climate oscillations and related hydrology and sediment supply changes.
The main objective of this research is to demarcate terrace area in the hilly terrain with the help of a semi-automatic mapping technique so that groundwater related project could be lunched in future for irrigation, drinking water and others. This preliminary information could be used for effective identification of suitable locations for extraction of potable water for rural populations.

Study area

The study area is the Marsyandi basin of Nepal (Figure 1). It is located between 27° 50'42"N to 28° 54'11"N latitudes and 83° 47'24" E to 84° 48'04"E longitudes. The Marshyangdi is a mountain river in Nepal. Its length is about 150 kilometers. The Marshyangdi begins at the confluence of two mountain rivers, the Khangsar Khola and Jharsang Khola, northwest of the Annapurna massif an altitude of 3600 meters near Manang village. The Marshyangdi flows eastward through Lamjung District. The Marshyangdi joins the Trishuli near Mugling as one of its tributaries. Some of the major land use area of district has been depicted in Figure 2.

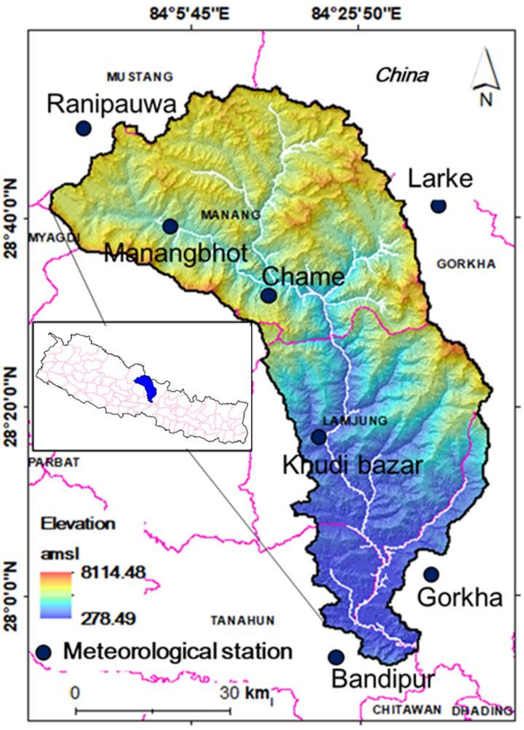

Figure 1: Location of study area

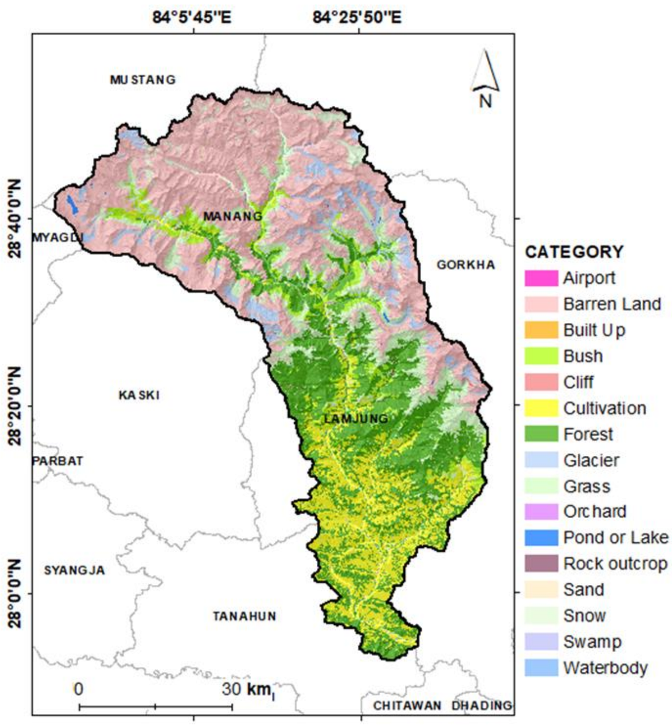

Figure 2: Landuse of study area

Method

This study investigated the hypothesis that the stacking of layers with different geomorphic criteria. The methodology employed comprised sequential steps in order to identify the possible terraces in the study area. Considering the field knowledge of the study area, the set of parameters considered were: digital elevation model (DEM), slope, normalized difference vegetation index (NDVI), curvature, the buffer (2 km) defining the distance to the river and the landuse map. Two widely used classification algorithms, support vector machine (SVM) and random forest (RF), were used to predict the probable river terrace deposits in the study area. The comparison between the results obtained by two models helps to improve the quality of the prediction. The independent variables were normalized into 0 to 1. After that, the tabular data for presence (1) and absence (0) data. The training dataset was used to train the SVM and RF models for terrace identification.

Results

The receiver operating characteristic (ROC) curve has been commonly used to validate the quality of a probabilistic model. The ROC curve is plotted by statistical index value pairs, with the false positive rate (sensitivity) on the x-axis and the "1−false negative rate" (1−specificity) on the y-axis. The ROC curve can be classified as a success rate curve or prediction rate curve, depending on the dataset used. The success rate curve, calculated using the training dataset, represents how well the results fit the data. It is observed that all the models have good success rates with the highest one being the RF model (AUC: 86.01%). The SVM has an AUC of 75.4%. Since the accuracy of the result given by RF model is higher so terrace identification by RF is more reliable than SVM model.

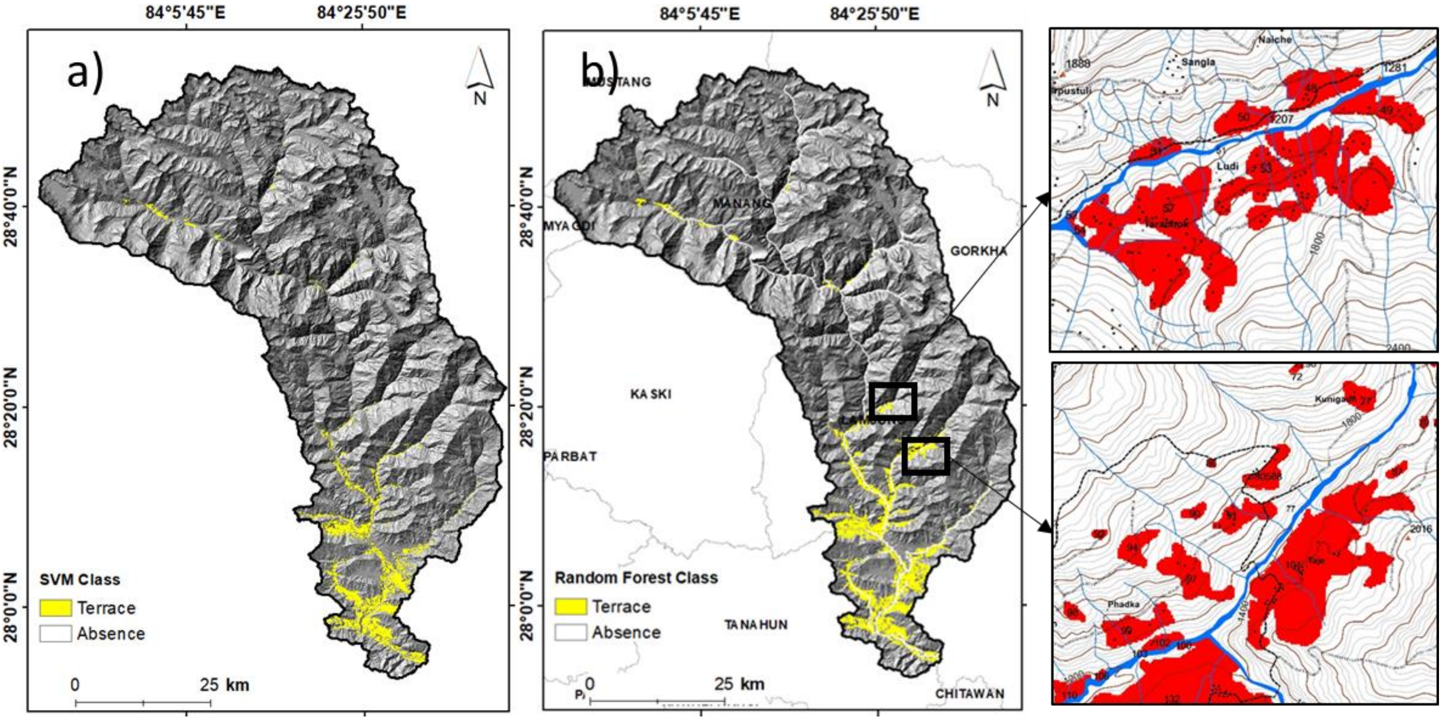

Figure 3: River terrace identification using: a) SVM and b) RF

Way forward

River terraces are the principal geomorphic features for unraveling tectonics, flood level, and climate conditions during the evolutionary history of a river. We made some recommendations for further study: 1) Mapping of complex terrains over large spatial extents is not an easy thing. For this kind of study high resolution DEM is required. The increasing availability of high-resolution topography data generated by low-cost Unmanned Aerial Systems (UAS) and modern photogrammetry offer an opportunity to identify and characterize these features which can be helpful to identify level of river terraces. 2) Ground control points (GCP) setup and image processing need to be additionally addressed as they are the most time-consuming steps in the mapping of complex terrains over relatively large spatial extents. And 3) A detailed survey should be conducted in the identified terraces for irrigation purposes.

In the past, acquiring knowledge on the regional distribution of river terraces was a "painfully slow procedure", but through advances in technology, particularly the development of geographic information systems and advancing remote sensing capabilities, the broad scale classification of the landscape is much more feasible. Through the use of GIS and remote sensing technologies, we have successfully developed an automatic model to extract the location of stream terraces in the Marshyangdi catchment. Although further ground-truthing should be performed, our model was successful in predicting river terrace locations in this region.

FOR FURTHER INFORMATION:
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