Estimation of Soil Deposition in Section of Punyamata River, Nepal, due to Flooding Using Unmanned Aerial Vehicle (UAV).

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ABSTRACT

Soil erosion has turned out to be one of the most challenging issue for the sustainable development of Nepal despite several infrastructural, awareness-raising and policy measures. This paper assesses the estimation of soil deposition in certain section of Punyamata River bank, Dhulikhel using Unmanned Aerial Vehicle (UAV). A section of 500*300 square meter was chosen as maximum deposition was observed in that area. Total number of images captured for the project site was 136 for year 2016 and 142 for year 2017 respectively. These two-time frame datasets were used for the estimation of soil deposition from annual flood. Image differencing technique was employed to quantify the volume of deposition. This technique resulted out the volume of soil deposition in the aforementioned section to be **74161.42 m^3**. Furthermore, the change in ground profile is also studied by cross section plot at certain chainage. The obtained cross section results were validated using ground surveying technique.

Keywords: image differencing, soil deposition, UAV photogrammetry, field survey

Introduction

Erosion and deposition are responsible for transformations into many landforms (Nouwakpo, 2010). Erosion is the transport of sediments. The water velocity carrying eroded soil due erosion is slowed down as soon as flat topography is met or flows into a body of still water. In the meantime, the sediments carried is settled in the form of deposition. Several different approaches ranging from ground surveying, utilizing high resolution satellite imageries used to be the key step on quantifying the mass deposition from flood. UAV being a rapidly evolving technology has made it possible for various geospatial applications (Molina, 2014). This equipment is either remotely controlled (i.e. flown by a pilot) or can fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems. This study reveals efficacy of UAV for estimating the soil deposition due to flood on a particular section of Punyamata River.

Problem Statement

Soil deposition is a well-known problem as it has a major impact in the vegetation and wildlife (Chapman, 2019). The wearing away of the topsoil due to the water current during flood has caused a major impact in agriculture. No quantitative assessment of volume of soil deposition has been initially made on the river especially because of the flooding. So, the aim of this study is the volume estimation of soil deposited on the river banks which could be used for assessing the damage associated with it.

Objective

The main objective of the project was to estimate the volume of soil deposition in certain section of Punyamata River bank using the UAV. The secondary objective included assessment of DTM accuracy by generating cross section at different section of the river.

Data & Software Used

Primarily, the datasets used were the UAV imageries which were captured in different dates. The first set of data was captured in the year 2016 followed by the data acquisition in the same time next year i.e. 2017. Ground control points (GCP) were established using the Differential Global Positioning System (DGPS). The raw data from DGPS were processed using the licensed version of Carlson GNSS software. For flight planning purpose, Pix4D capture mobile app was used Pix4D Mapper was utilized for the image processing. The rest of the volume estimation of the spatial extent was carried out in QGIS.

Methodology

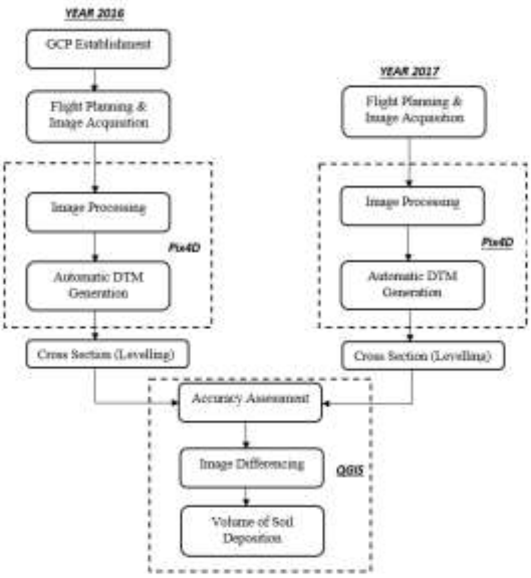

Figure 1: Overall workflow of study

The advanced differential static GPS surveying was carried out to establish the sufficient number of GCPs (i.e. 9 in our case) following a pattern that shows the optimum accuracy for photogrammetric work (Awasthi et al. 2019; Liew et al. 2012; Tihar et al. 2012) prior to UAV flights. GCP markers (i.e. square shaped white background with red cross) were placed on top of the surveyed points while conducting UAV flights over the area. A section of 500*300 square meter was chosen as maximum deposition was observed in that area. UAV flights were conducted over the study area for both time frame under observation i.e. 2016 and 2017. Total number of images captured for the project site was 136 for the former year and 142 for the latter year respectively. Subsequently those two sets of images were subjected for image processing to generate high resolution as well as accuracy assessed precise DTM. The resulting DTM for different time frame through the technique of change analysis using image differencing technique, the volume of soil deposition over the study area was quantified. Apart from this cross-section data was collected using total station field surveying equipment and technique at 3 different chainages starting from the northern section of the river. The difference of this data was compared with difference of cross section result generated from DTM as a way to validate the result which seemed to produce quite promising result.

Result and Discussion

The spatial variability of accumulated soil deposition from the annual flooding between the study period is represented below in figure 2. Deposition seemed to be normal at the upper section of the river whereas at the middle section of river it seemed to be high as it is the flattest region of the study region. A decreasing trend of deposition was observed at the southern end of the river as there was rapid change in elevation of the river. Moreover, in general the deposition was observed to be most in certain buffer zone of river. The total volume of soil deposition was evaluated to be **74161.4239 m3**.

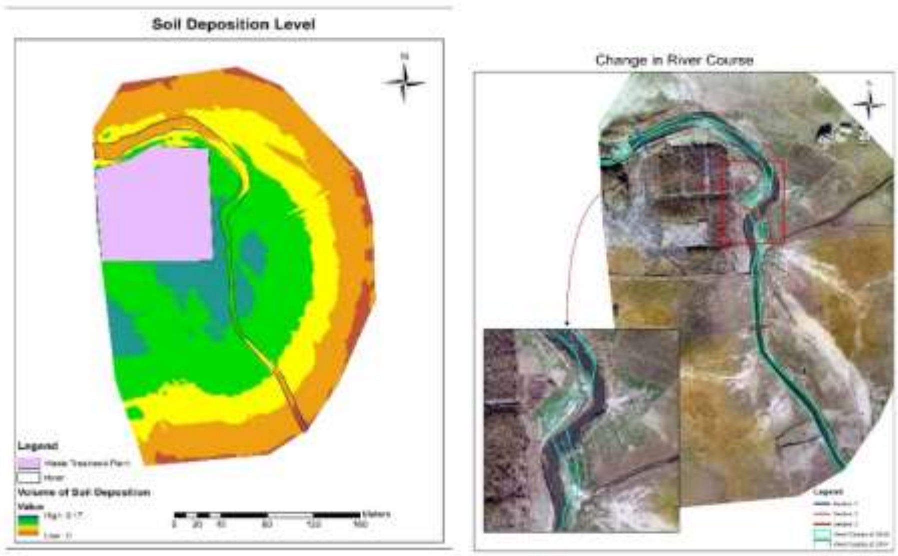

Figure 2: Soil Deposition Map (Left) and River course Change Map (Right)

Apart from soil deposition over the area, a noticeable change in river track was also observed which could be a valuable information for those who are studying the river track change analysis and its impact in agriculture as well as river discharge. Green line feature overlaid on top of orthophoto (i.e. of 2016) in the same figure represents the changed river course in the year 2017. Three cross sections were chosen (namely Section 1, Section 2, Section 3) to analyze the change in elevation along the same cross sections of the river due to deposition, the result of which is depicted in the figure 3 below.

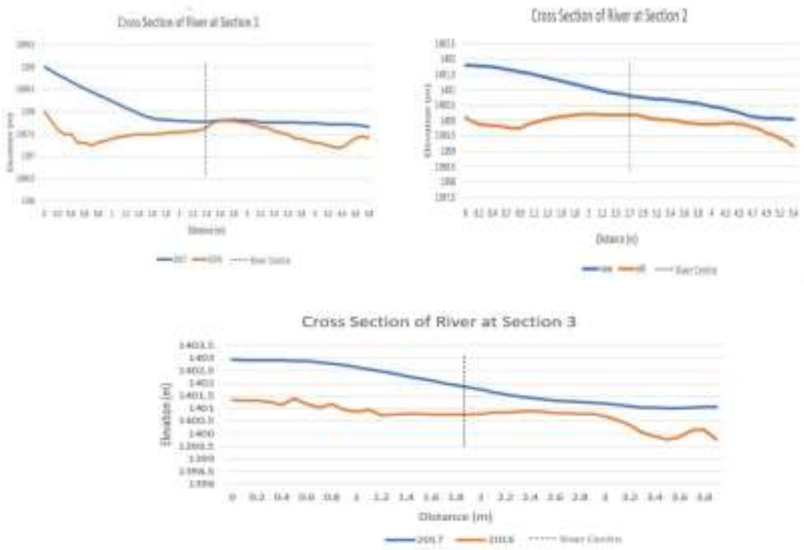

Figure 3: Change in Cross section at Section 1, 2 & 3

A clear picture of alteration could be seen on the ground elevation due to soil deposition as soon as the change was plotted in graph. Three different lines could be seen on those graphs meaning a blue and orange colored line representing ground level in the year 2017 and 2016 respectively. The third dashed solid line represents the centerline of the river. The soil deposition as per the graph seemed to be minimum at the centerline which is true regarding the fact that the river discharge is high in the center leaving eroded soil materials along the banks. The graph also showed that in general more soil deposition was observed on the right part of the river banks (right bank considering the flow of river). On the basis of change in elevation level for the aforementioned sections, it was observed that on an average the minimum and maximum depth of soil deposition along the cross sections was found to be 0.65m and 1.5m respectively.

Conclusion

Based on the idea presented in this study, it is seen that UAV imageries could be successfully utilized for the accurate estimation of soil deposition. The study concludes the efficacy of those imageries for establishing a cost and time effective method of monitoring, estimating and mapping the spatial and temporal variability of soil deposition/depletion along the river banks. Furthermore, such results could also be supposed as an asset for visual inspection of the damage caused to the physical infrastructures as well. Routine observation of river and its bank may be considered as an alternative method for surveying, recording and processing river centerline and cross section data for flood modelling. The generation of high resolution orthophoto allows to assess the river course change over a certain interval of time. Apart from this, such datasets (DEM) could also serve as a valuable input for flood hazard analysis.

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