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Delineating Watershed Area and Predicting the Impounded Area: Upper Paunglaung Dam

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Abstract: This study aims to delineate the watershed area and to predict the impounded area due to Upper Paunglaung dam. The Upper Paunglaung Dam is located at19 º 45′ 26.95" north latitude and 96º35'35.49" east longitude, a boundary area between Mandalay Division and Shan state in Myanmar. The Upper Paunglaung hydropower dam was started in 2004 and expected to complete in 2014. It is an installed capacity of 140 MW and 434 GWh annual generation. This study delineates the watershed of the Upper Paunglaung project using the digital elevation model. The flow accumulation, flow direction and drainage network and watershed were generated from DEM using ArcGIS software and land use/ land cover maps using ENVI software. And then, the study predicts the impounded area of 60km^2 of the total land according the topographic map (1:50000) analysis.

Keywords: Upper Paunglaung Dam, Topographic Map, Digital Elevation Model, Watershed Area And Impounded Categories.

I. INTRODUCTION

A watershed is an area that drains surface water to a common outlet. Watershed analysis refers to the process of using DEMs (Digital Elevation Models) and raster operations to delineate watersheds and to derive topographic features such as stream networks. The maps with 1:50000 standard scales are used to determine the area. Nowadays, applying topographical information in digital form is advantage in estimate a watershed area. GIS has been used to calculate the physiographical characteristics of watershed, flow accumulation, flow directions, etc. Required data for analyzing maps of different organizations was gathered with scale of 1:50000 and using the Universal Transverse Mercator (UTM) system. Geographical information systems (GISs) bring the opportunity to enhance predictable evaluation techniques [1]. Arc GIS provide a multipurpose hydrologic analysis system for use by watershed, water resource and land use. The raster data used in GIS carry spatial information and one of it is the coordinate of the earth surface. With the information of contour lines and river layer, it is enough for the GIS to manipulate it to determine the watershed area and delineate the boundary. Dams are one of the most important buildings in water resources and transferring. These buildings have been made from old times without access to hydrological, hydraulically, hydro mechanical information [2]. One of the objectives of a dam project must be to benefit the local community that it will directly affect. To construct a dam, it needs to manage the river, stream and inland for the benefits of human lives. On the other hand, it can make many environmental and social problems by constructing man-made structures. It requires studying the Environmental Impacts Assessment (EIA) before the constructing of the reservoirs [3].

II. STUDY AREA

A. Background of the Study Area

Upper Paunglaung Hydropower project is located on the Paunglaung River, the upper reach of Sittaung River. The Paunglaung river flows from it source in Western Shan state through the south west plateaus in to the join Sittaung. It is located at19 º 45' 27" north latitude and 96º35'36" east longitude, a boundary area between Mandalay Division and Shan state in Myanmar. Upper project is located southeast of Pyinmana Hill in southwestern Shan State, just 50 kilometers from Nay Pyi Taw. The dam is at the southern end of the Paunglaung Valley, the only fertile plain along the river. It was started in 2004 and expected to complete in 2014. It is an installed capacity of 140 MW and 434 GWh annual generation.

B. Data Description

The Table I contains the characteristics of Upper Paunglaung Hydropower Project.

C. Climate

The climate of the study area is semi-arid region. The rainy season is from June to September, the cold season is from October, to January and the hot season is from February to May.

TABLE I: CHARACTERISTIC OF UPPER PAUNGLAUNG DAM

Item no	Item	Character
1	River	Paunglaung
2	Purpose	Irrigation and energy
3	Dam	RCC Dam
4	Dam height	98m (322ft)
5	Dam Length	515m (1690ft)
6	Maximum water level	EL-370 m
7	Minimum water level	EL-352 m
8	Water surface area	60 km^2
9	Storage capacity	1042700Acre-ft
10	Dead storage capacity	284500Acre-ft
11	Install capacity	140MW
12	Annual generation	434GWh

III. MATERIALS AND METHOD

In this study, the topographic (1:50000 scale UTM) maps are used as the ground data of the study area and the satellite image (IRS) in 2010 to classify the land use land cover maps of the Upper Paunglaung project. Digital Elevation Model (DEM) is generated from source data such as contours, elevation points and river. This study provides simple method to estimate watershed delineation automatically from topographical map using standard digital elevation model (DEM) in ArcGIS software. A false colour composite of the ASTER image is generated and geo-referenced based on the Universal Transverse Mercator 1984 and Zone 47. The rectified images are then interpreted in the ENVI 4.2 software using the method of unsupervised classification. In this study, the maximum water level of the dam is 378 m and the full supply level of the reservoir is 370 m above mean sea level.

IV. DEVELOPING DIGITAL ELEVATION MODEL

Water resource management commonly requires investigation of landscape and hydrological features such as terrain slope, drainage networks, drainage divides, and catchment boundaries. DEM is traditionally created from topographic maps, field survey and/or photographic interpretations. A DEM is a raster grid of elevation values that represent a surface. They are used to create contour maps and perspective maps and for various types of land use planning applications. DEMs are created from source data (contour lines or point data) through the process of interpolation. In this study, the contour maps (1:50000) of the study area are imported to Arc GIS software. These maps are digitized and digitized topographic maps are used in preparation of DEM with cell size 10m x 10m. DEMs are created from source data (contour lines or point data) through the process of interpolation. The processing of digital elevation model is described in Fig1.

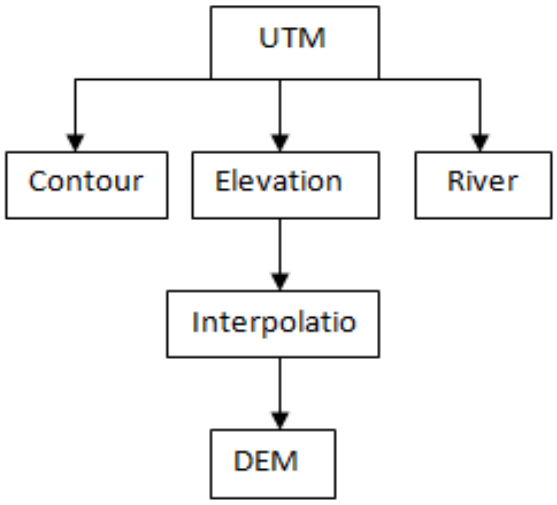

Fig. 1 Processing of digital elevation model.

The digital elevation model (DEM-10 m resolution) map of Upper watershed is shown in Fig 2.

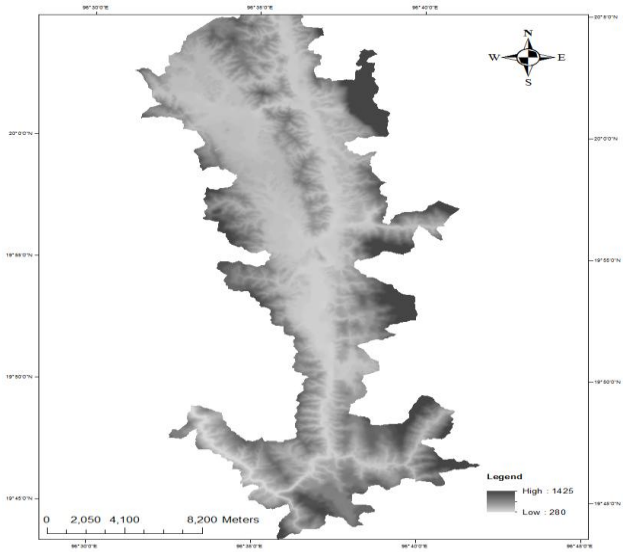

Fig. 2 DEM for Upper Paunglaung watershed.

Source: DEM (10m resolution) from UTM maps

V. PROCESS OF DELINEATING WATERSHED AREA

A. Flow Direction

Watersheds can be delineated from a DEM by computing the flow direction and using it in the Watershed function. The Watershed function uses a raster of flow direction to determine contributing area. Firstly, we use topographic (elevation) data to calculate the flow direction and accumulation, as well as produce streams and watershed boundary. A flow direction contains eight values (1, 2, 4, 8,16,32,64 and 128) representing the eight adjacent cells into which water flow[4]. The flow direction creates a raster of flow direction from each cell to its steepest downslope neighbor. The flow direction can be shown in Fig 3.

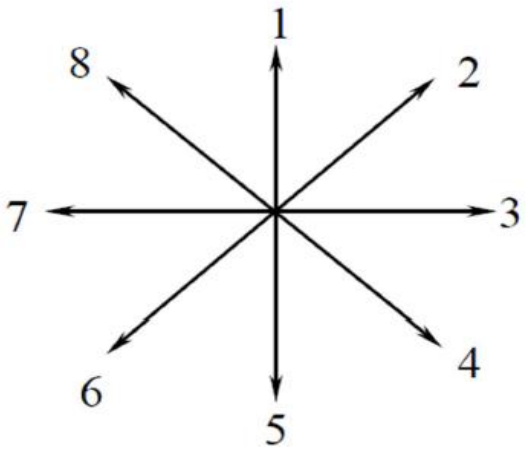

Fig. 3Slope/ Flow direction.

B. Sink and Fill

Sinks are depression in the DEM and they can be errors in the data.The possible sinks are performed for eliminating the unreasonable low elevation cells on the DEM with respect to the surrounding cells. When a sink is filled to its pour point, which is the minimum elevation along its watershed boundary[4]. The following Fig.4 describes a sink and fill.

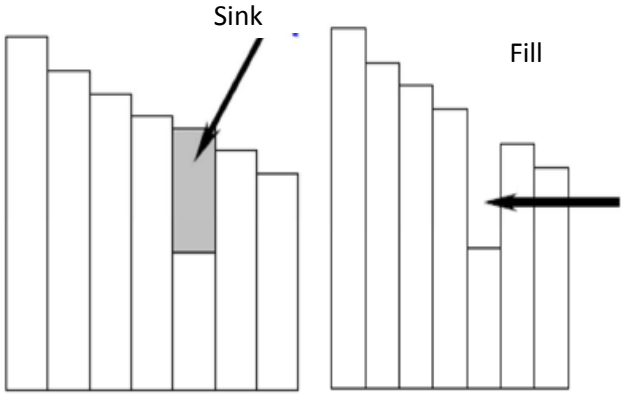

Fig. 4 Sink and fill.

C. Flow Accumulation

The flow accumulation creates a raster of accumulated flow to each cell. It represents the amount of water that flow into each cell, assuming that all water became runoff and groundwater. Boundary of watershed, flow accumulation flow direction, drainage network and stream order maps were generated using DEM-Hydro processing module [4]. The example of flow accumulation is illustrated in fig 5.

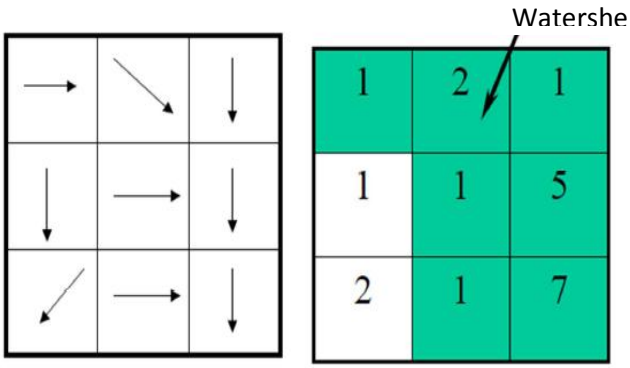

Fig. 5 Flow accumulation.

D. Delineating Watershed Area

A watershed is the upslope area contributing flow to a given location. Such an area is also referred to as a basin, catchment, subwatershed, or contributing area. Watersheds can be delineated from a DEM by computing the flow direction and using it in the Watershed function. The process of extracting watershed boundary is shown in Fig 6. Raster data of a flow direction was used to delineate watershed and later on the pour points has to be determined.

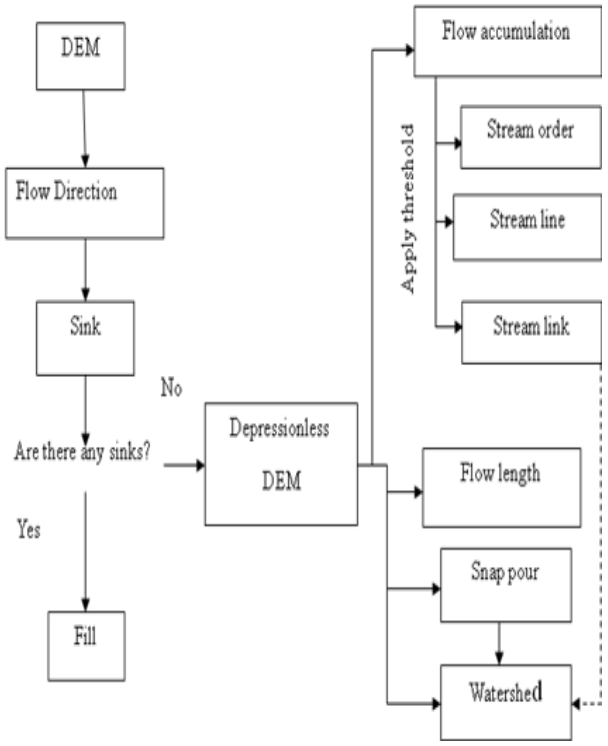

Fig.6 Procedure of the extracting watershed area.

VI. CLASSIFICATION OF IMPOUNDED CATEGORIES

The word “data” is plural, not singular. The cut-out images are digitized separately into Arc GIS (version 9.3) and then views generated from the aerial photographs are superimposed on the spatial databases. A false color composite of the ASTER image for the study area is generated and geo-referenced based on the WGS 1984 and Zone 47. The satellite images (Landsat ETM and IRS) of 2000 and 2010 for the Lower Paunglaung dam and that of 2010 for the Upper Paunglaung dam are used to classify the land use land cover maps. The rectified images are interpreted using the method of unsupervised classification (K means) in the ENVI 4.2 package. A combination of aerial photographs and satellite remote sensing (RS) images is used for land-use classification [5]. The land use land cover is classified as shown in Fig 7.

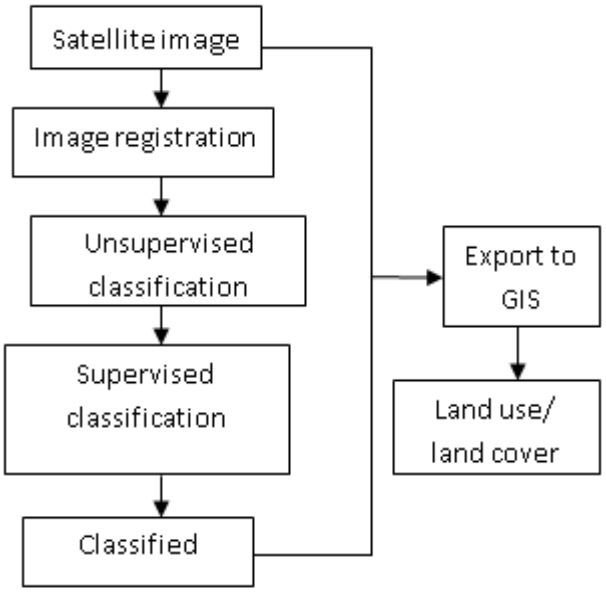

Fig.7 Classification step for land use land cover.

VII. PREDICTING IMPOUNDED AREA

The total impounded area around the dam site is about 60km^2 by digitizing the topographic map to use maximum water level (370m).The land use/ land cover around the reservoir area consists of five categories in Table II and Fig.8, out of which about 75 % is covered by the dense forest. Dense forest covers about 43.52 km^2 (72.62%) of the reservoir area. Cultivated area accounts for19.64% of the reservoir area, and settlement area is 1.38km^2 (2.3 %). The remaining area is water body and sandy bed, with an area of about 4.67% and 0.77% respectively. The percent of impounded area for each category is described in Fig 9.

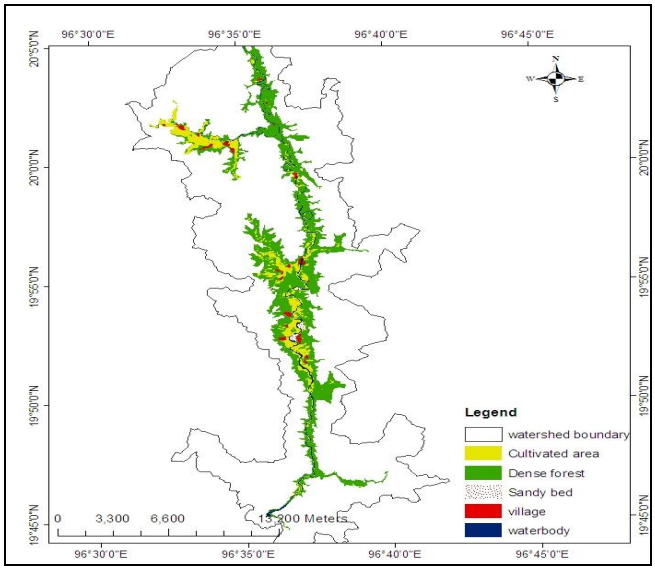

Fig.8 Impounded categories within Upper Paunglaung reservoir.

TABLE II: IMPOUNDED CATEGORIES DUE TO UPPER PAUNGLAUNG DAM CONSTRUCTION

Class name	Area (km^2)	Percent of total area
Forest land	43.52	72.62
Sandy bed	0.46	0.77
Village	1.38	2.3
Water body	2.80	4.67
Cultivated land	11.77	19.64
Total	60.00	100

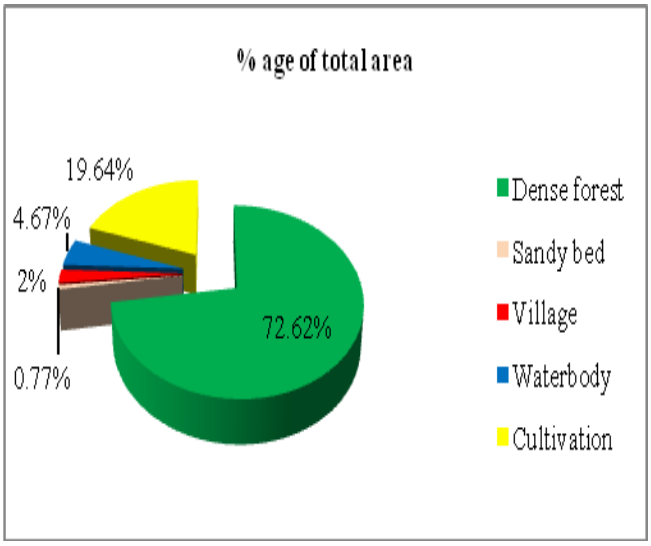

Fig.9 Percentage of impounded area due to Upper Paunglaung dam construction.

VIII. CONCLUSION

The watershed area is delineated from digital elevation model and flow direction, flow accumulation and using them in watershed function. The impounded area of the study area is evaluated using the topographic maps (1: 50000 scale UTM maps) and digital elevation model (DEM) in ArcGIS software. The land use land cover categories of the study area are classified using satellite image (IRS 2010 image) by the method of unsupervised classification. The total reservoir (or) flooded area around the dam site is about 60 km^2. The 22 villages, cultivated areas, and forest lands will be flooded after impounding the reservoir according the GIS map analysis.

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