WATERSHED MANAGEMENT APPROACH USING GRASS GIS IN BAGMATI BASIN

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Abstract
GRASS GIS has been used in watershed management, a case study in Bagmati river basin. The base maps contour, landuse, soil and river network are used to generate different watershed management maps. Contour map is used to generate Digital Elevation Map (DEM). DEM is used to derive slope and aspect maps. Slope and aspect maps are reclassified into certain categories. Slope map and landuse map are combined together to find out the area of different landuse on different slope categories. Similarly soil map and landuse map are combined together to get the area of landuses in different soils. Lot of modules by different researchers have been developed and imbedded into GRASS GIS. Important modules in watershed management in GRASS GIS are erosion hazard map preparation and erosion rate calculation.

1.Introduction

The general purpose of using geographical information systems (GIS) is to collect, analyze, manipulate and display spatial data with their associated attributes. During the last decades a variety of GIS have been developed. Private companies as well as governmental, municipal organizations and universities are using these systems. Geographical information systems offer a simple and efficient way of spatial analysis.
A powerful GIS-package is the GRASS-Software. The name of GRASS-GIS is an abbreviation for "Geographic Resource Analysis Support System". It is a hybrid GIS-package - it manages raster, vector as well as point data and contains image-processing modules. GRASS was released to public in the year 1989. GRASS is free GIS software available at ftp sites. Originally written by the U.S. Army Construction Engineering Research Laboratories (USA-CERL, 1982-1995), a branch of the US Army Corp of Engineers, as a tool for land management and environmental planning by the military, GRASS has evolved into a powerful utility with a wide range of applications in many different areas of scientific research. GRASS is currently used in academic and commercial settings around the world, as well as many governmental agencies including NASA, NOAA, USDA, the National Park Service, the U.S. Census Bureau, USGS, and many environmental consulting companies.
GRASS allows users to analyze, store, update, model, and display data quickly and easily. Although it was originally developed for use in land planning, its capabilities have been expanded and used in the fields of engineering, hydrology, geology, physics, statistics, remote sensing, business, and many others.
Due to the rapid growth and popularity of GRASS, the GRASS Development Team has grown into a multi-national team consisting of developers at numerous locations. The development currently underway has resulted in new GRASS versions, the release of new manuals and documentation, as well as continued research and development for new versions.
The GRASS GIS is run through the use of either a standardized command line input, or a Graphical User Interface based on Tcl and Tk. GRASS is also supported under Windows NT/2000 running Cygwin. GRASS can be used in shell scripts, which allow users and programmers to create new applications and link GRASS to other software packages. For programming a fully documented C-API (> 800 GIS library functions) is provided. Users can input new data through digitization, CD-ROM, floppy disk, or tape drive.

2 Project Description

The area to be investigated is within the middle mountain region of Nepal as shown in Figure 1, in the watershed belonging to river Bagmati. The area is chosen because of its bio- climatic diversity due to elevation differences from valley floors to mountain summits, and related land use changes having influence on soil erosion, which is considered typical for the Middle Mountains of Nepal. The Bagmati Watershed covers an area of 3500 sq. km. and drains out of Nepal across the Indian State Bihar to reach the Ganges. It, partially or wholly, spreads over 8 districts of the kingdom, Kathmandu, Lalitpur, Bhaktapur, Makwanpur,

Kavre, Sindhuli, Rautahat and Sarlahi. For technical purposes it has been classified into three main areas: the Upper, Middle and the Lower Bagmati Watershed Areas.

The Upper Bagmati Watershed Area covers the whole of the Kathmandu valley including its source at Shivapuri. From the Chovar gorge, the river flows into the Middle Bagmati Watershed Area across the Mahabharat and Siwalik ranges. The catchment area of upper and middle Bagmati Basin is 2807 km^2.

The Bagmati watershed area is mainly composed of three parts: Kathmandu Valley, the Middle Bagmati watershed area and the Lower watershed area. The terrain of the upper and middle BWA is rugged and comprised of several steep mountains except Kathamndu valley. The Middle Bagmati watershed area (MBWA) consists of the two physiographic regions of Nepal. Those regions are: (i) the Siwalik region (450-815 m above MSL, in the southern part of the MBWA) (ii) the middle mountain region (Highest pt. 2625m, in the Northern part of MBWA). The Kathmandu Valley is an almost circular, tectonic basin, some 26 km in E-W direction and 20 km in N-S direction. The valley bottom is composed of the small ridges and elevated flat land and low basins drained by Bagmati river and its tributaries. The average altitude is 1350 m above msl. The surrounding mountains, whose height range 1500 and 3000 m, contain 4 major passes.

The climate of the Bagmati watershed can be subdivided into three altitude/climate zones. These are: Subtropical sub humid zone below 1000 m. The southern most parts of the Bagmati Watershed area including the Siwaliks region lie in this zone Warm temperate humid zone between 1000-2000 m. A large part (more than 60 %) of the BWA lies in warm temperate humid zone between 1000-2000m altitudes. Cool temperate humid zone between 2000-3000 m. Only a small portion (about 5%) of the Bagmati watershed falls above 2000m.

3. Watershed Application of GRASS

The base maps contours, landuse, soil and river network, which were collected from different sources in Arc/Info format then imported to GRASS GIS. GRASS is compatible to all standard GIS software. Contour map is used to generate the DTM (Digital Terrain Model) of 100 m resolution using spline function. Almost all functions (spline, kriging, inverse distance weigheted method and Triangular Irregular Network) are available here. Using the GRASS-GIS function, slope in degree and aspect are calculated using DTM of 100m resolutions. Calculated slope map is reclassified into four categories (0^0-3^0: Flat, 3^0 to 15^0: Mild, 15^0 to 30^0: steep and > 30^0: Very Steep), which is shown Figure 2. The area of land in different slope categories is shown in Table 1. The aspect map, which is the direction of the slope has been calculated from DEM and reclassified into four categories i.e. North (315^0 to 0^0 and 0^0 to 45^0), East (45^0 to 135^0), South (135^0 to 225^0) and West (225^0 and 315^0). The area of the catchment in different aspect categories is calculated using functions of the GRASS and presented in Table 1. The aspect map is shown in Figure 3.The landuse map is reclassified into five categories i.e. cultivated (Agriculture), forest, shrub, urban and others. The area under different landuse classes are tabulated in Table 2 and the landuse map is shown in Figure 4. The soil type map is analyzed and the area of the catchment under different soil types are presented in Table 3 and soil map are presented in Map 5. The slope map of four categories is combined with landuse map. The landuse map and soil map are combined together (Union of two maps). The area of the major landuse on the different soils are calculated and presented in Table 3. The area of different landuse are calculated on different slopes categories by combining the slope categories and landuse map and presented in Table 4. A grass application in this basin to prepare an erosion hazard map can be seen in (Jha, 2002).

4. Conclusions

In the developing and under developed countries, where the commercial softwares are not affordable by the universities, government agencies and other organizations, GRASS GIS is the best GIS software for any GIS application. The capability of GRASS GIS is similar and some times better than the costliest software of GIS. In this study the GRASS GIS has been applied in the Bagmati Basin watershed management approach. This map could be used by the government organizations/ INGO / NGO/ researchers to fix the priority area for the integrated watershed management practice in the catchment.

	Slope			Aspect		
SN	Name	Area (Km^2)	Area %	Name	Area (Km^2)	Area (%)
1	0^0-3^0: Flat	380.1	13.5	East (45^0 to 135^0)	610.3	21.8
2	3^0 to 15^0: Mild	982.4	35	South (135^0 to 225^0)	687.1	24.5
3	15^0 to 30^0: steep	995.2	35.5	West (225^0 and 315^0)	815.7	29.1
4	> 30^0: Very Steep	49.3	16	North (315^0 to 0^0 and 0^0 to 45^0)	689.4	24.5

Table 1: Catchment Area under different slope and aspect categories.

SN	Name	Area (Km^2)	Area %
1	Agriculture	860.1	30.7
2	Forest	1603.5	57.8
3	Shrub	179.9	6.4
4	Urban	22.73	0.8
5	Others	118.76	4.3

Table 2: Area of Different Crops in Upper r Bagmati River Basin

SN	Soil Type	Area (Km^2)	Area %	Agriculture Area (%)	Forest Area (%)
	% of total area of the catchment		100	30.6	57.1
1	Sand/Cobbly	70.5	2.5	1.2	0.6
2	Sandy	5.5	0.2	0.1	0.1
3	Loamy	227.8	8.1	20.9	1.4
4	Loamy/Boulder	26	1.0	1.8	0.1
5	Loamy skeletal	2466.1	88.1	76.0	97.7
6	Fragmental/sand	3.8	0.1	0.1	0.1

Table 3: Area of the total catchment, agriculture and forest under different soil categories

SN	Landuse	% of total area of the catchment	% of Area under different slope categories			
			Flat	Mild	Steep	Very Steep
1	Agriculture	30.7	25.4	42.8	26.2	5.6
2	Forest	57.8	3.8	33.1	41.3	21.7
3	Shrub	6.4	1.7	22.5	50.6	25.3
4	Others	6	58.3	26.2	10.7	4.8

Table 4: Area of Different Crops under different slope categories in Bagmati River Basin

Reference:

1. Jha, Raghunath, 2002, Open Source GIS User Conference, GRASS 2002, Trento, Italy Sep 11-13, 2002

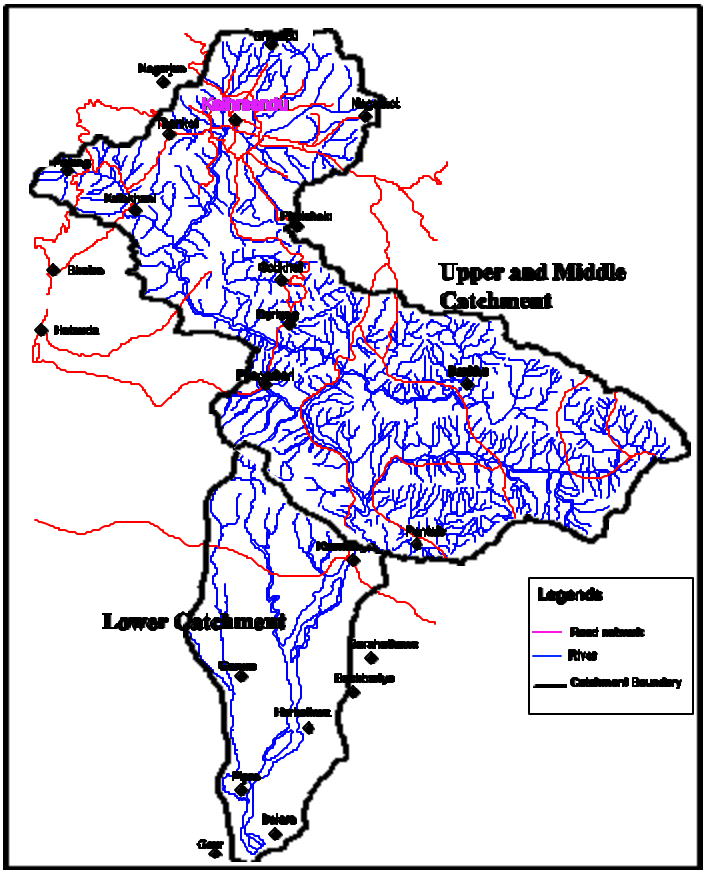

Figure 1: Project Area Details

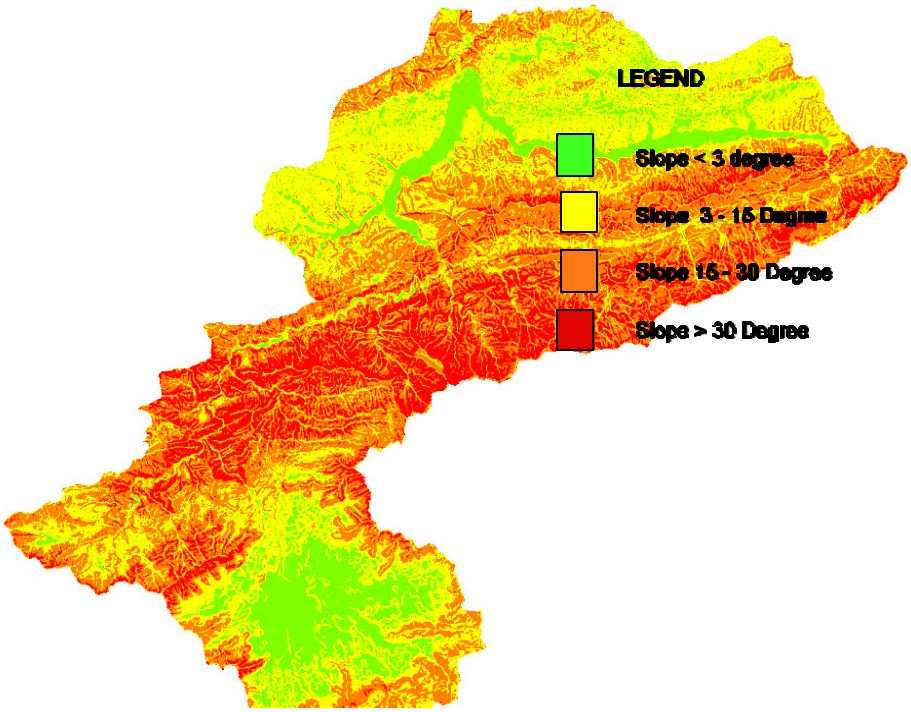

Figure 2: Slope categories of Upper Bagmati River Basin

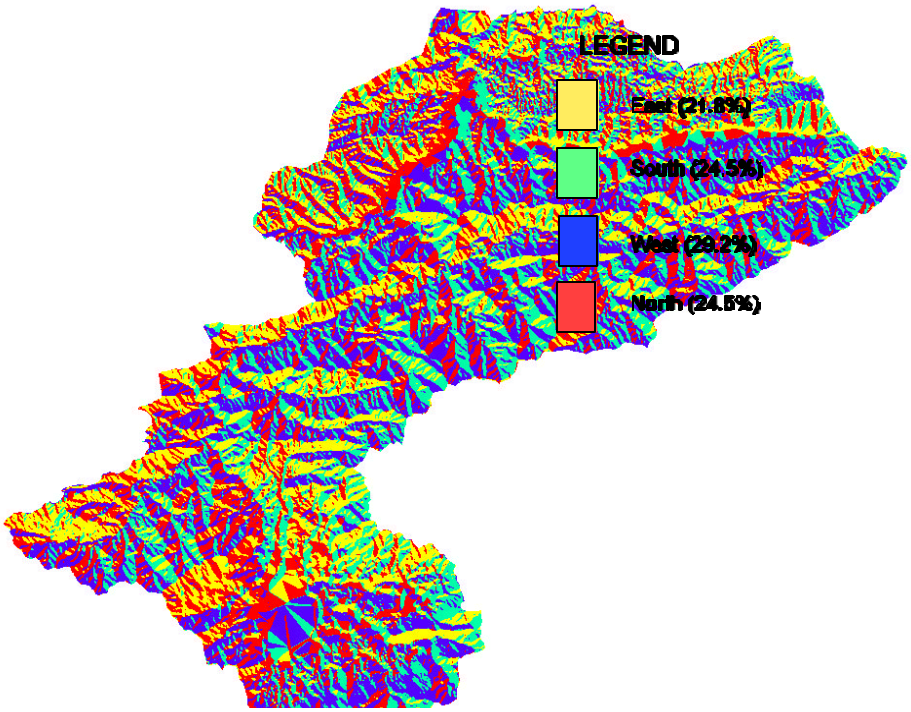

Figure 3: Aspect of Bagmati river basin

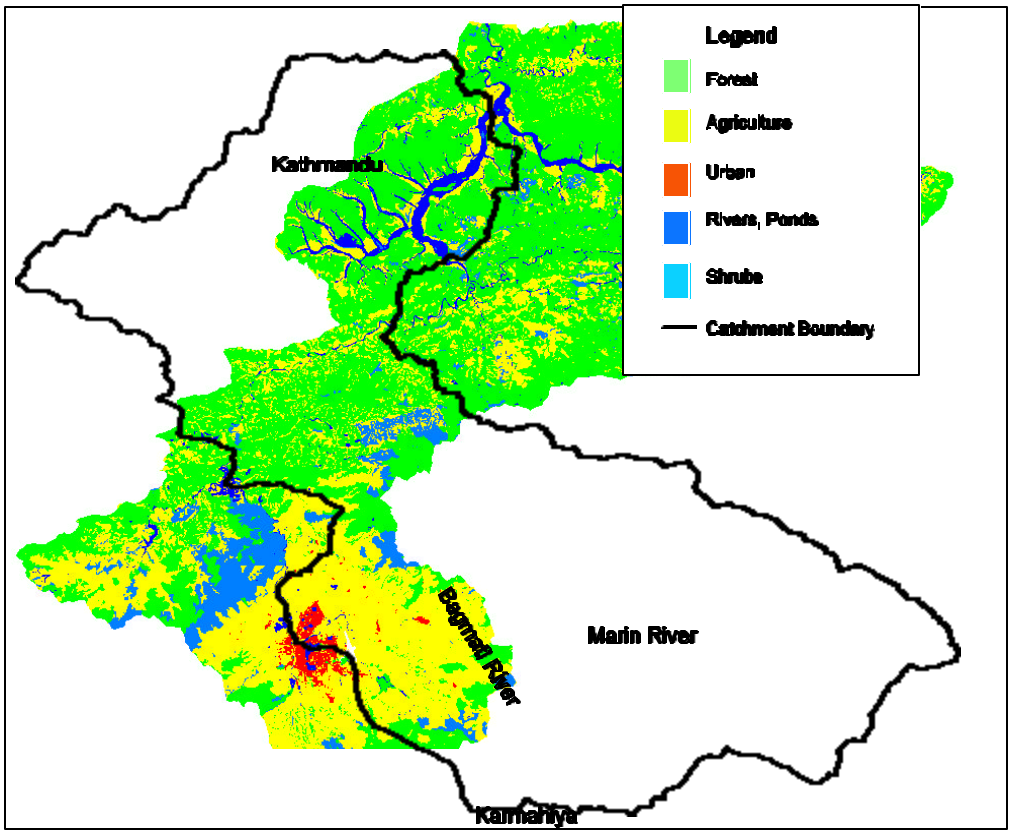

Figure 4: Landuse Classes in Upper Bagmati River Basin

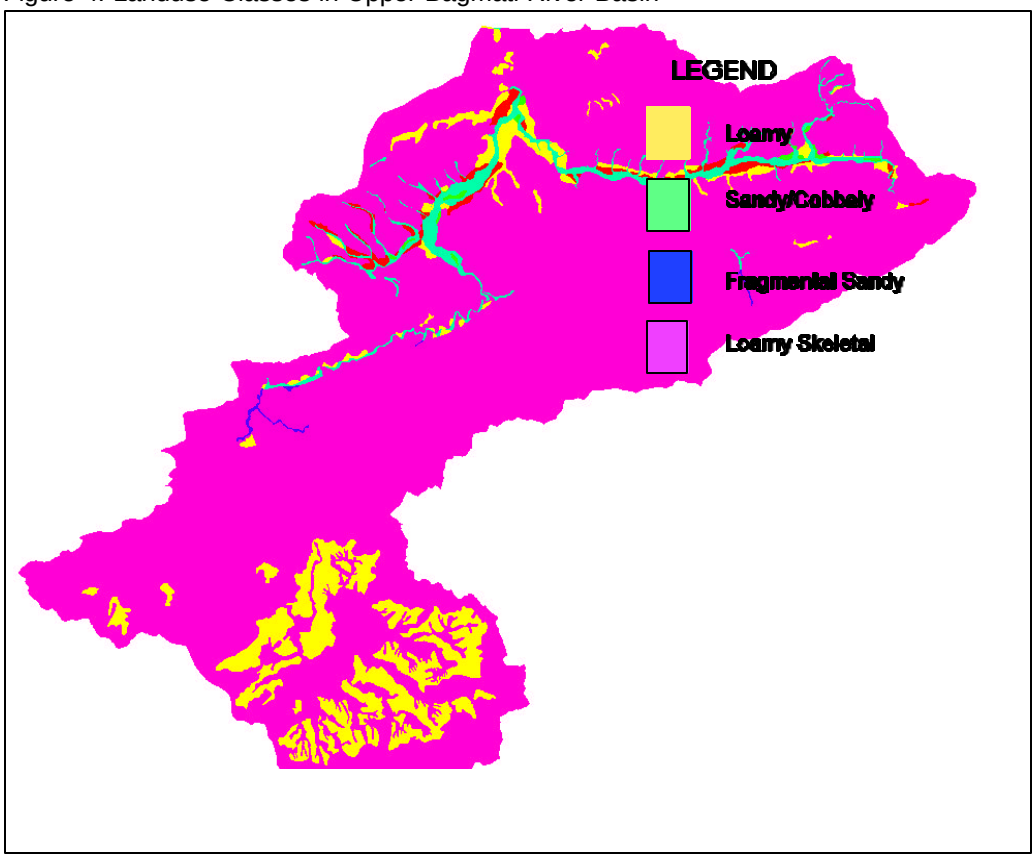

Figure 5: Soil Map of Upper Bagmati River Basin