

## DRAINAGE ANALYSIS OF EXTENDED AREA OF BANNERGHATTA NATIONAL PARK USING GIS

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**ABSTRACT:** The study focus on land use land cover, drainage network, stream ordering and age of the streams in the extended area of Bannerghatta National Park. The drainage network and micro watersheds are developed for the study, using ArcGIS by manually the drainage network and micro watersheds delineated and for these micro watersheds, bifurcation ratio was found using the Strahler method of stream order to find the age of the streams and also the drainage network and micro watersheds are extracted using ArcHyro tools. In the study area we have tried to understand the landuse and landcover by supervised classification using maximum likely hood classifier with the ENVI software.

**KEYWORDS:** Drainage network, Stream order, Bannerghatta National Park, Micro watersheds, Land cover.

### 1 INTRODUCTION

Drainage basin or catchment area is defined as an area in which all water flowing into it goes to a common outlet. Area upon which waterfalls and the network through which it travels to an outlet is referred to as a drainage system.

Digital elevation models (DEMs) provide good terrain representation from which drainages can be derived automatically using Geographical Information System (GIS) technology. The techniques for automated delineation of drainage have been implemented in various GIS systems and custom applications. GIS is basic tool used in this study to achieve various objectives, ArcGIS is software used to extract the information from DEMs, such as drainage, flow direction, watershed, stream order etc. ENVI is a GIS tool used for land use land cover study of area for different classifications such as forest, water bodies, settlements, agricultural, hillocks.

### 2 STUDY AREA

The study area selected was the extended area of Bannerghatta National Park (as per Notification No: FEE 302 FWL 2011-(II), Bangalore, dated: 27 -12-2011 of GOK) falling in Kankapura taluk, Ramnagara district of Karnataka in India. Total area of Bannerghatta National Park which was 102.74 sq km was as per recent notification extended by including Kodihalli wildlife range of area 157.76 sq. km. The total area of Bannerghatta National Park is now 261.51 sq. km. Study area lies between longitude of 77°32'26.175" to 77°32'2.677"E and latitude of 12°35'40.904" to 12°20'45.32"N covering old area of Bannerghatta National Park to its north, Hosur forest division of Tamil Nadu state to east, Cauvery wildlife range to south and Kankapura taluk of Ramnagara district to the west. It looks highly irregular in shape and measures a maximum of 27.5 km in

length from North to South and varies between 0.1 and 11 km in width from East to West. There are more than 30 water bodies (approx) in the park and many of them are naturally formed and are constantly renovated to augment their water holding capacity along with a few manmade ones. Extended area of Bannerghatta National Park falls under Kodihalli wildlife range with the area of 157.76 sq. km, which is divided into two sections Doddamaralavadi with the area of 110.92 sq. km and Hunasanahalli with the area of 46.84 sq. km. Each section is divided into four beats such as Doddamaralavadi is divided into four beats viz. Therubedi, Hanchaguli, Kadushivanahalli, Gowdahally and Hunasanahalli is divided into four beats viz. Manjunathabetta, Ramdevarabetta, Thattekere, Bilidale.

### 3 OBJECTIVES

- To understand the land cover pattern in the extended area of BNP
- To delineate and develop a drainage network of the extended area BNP using GIS
- Morphometric analyses of the streams using Strahler method of stream ordering and to find the age of streams

### 4 RESEARCH METHODOLOGY

#### 4.1 LAND USE LAND COVER CLASSIFICATION

Image classification, which includes both land use and land cover is the process of assigning pixels or the basic units of an image to classes. It is likely to assemble groups of identical pixels found in remotely sensed data into classes that match the informational categories of user interest by comparing pixels to one another and to those of known identity

ENVI's classification workflows include two different methods, depending on whether or not the user has classification training data

1. In a supervised classification, the user selects representative samples for each class such as forest, agricultural, water bodies, urban, settlements etc. from the image. These samples are referred to as training areas. The ENVI classification algorithms use the training data to learn what each class looks like in multi- or hyper-spectral data space. Once the user selects the training areas, then ENVI will perform the classification based on these training areas for the entire image.
2. In an unsupervised classification, ENVI uses an automated technique that searches for natural groups, or clusters, of pixels based on their brightness in several bands. Unlike the supervised method, unsupervised classification does not begin with a predefined set of classes. Here, the user will define the label which the grouped regions in the unsupervised results represent.

#### 4.2 DELINATION OF DRAINAGE NETWORK

In this method the DEM data is used for creating the drainage network. Study area is clipped from the DEM image which was intern delianted from Survey of India topo sheets of the study area.

Using editor tool in ArcMap, a shapefile, is created using polyline feature. The drainage network is created manually by visual interpretation.

#### 4.3 EXTRACTION OF WATERSHED VIA ARCHYDRO TOOL

Extraction of drainage network and watershed with help of ArcGIS is a unsupervised way of creating drainage network and watershed of the area.

Steps to extract watershed from ArcHydro tool

##### 4.3.1 DEM IMAGE

Digital Elevation Model(DEM) image, which is freely available in ISRO website is downloaded.

##### 4.3.2 FLOW DIRECTION

A digital elevation model (DEMs) image should be free of sinks. A depressionless DEM image is the desired input for the flow direction tool. The presence of sinks may result in an erroneous flow-direction raster. In some cases, there may be

legitimate sinks in the data. It is important to understand the morphology of the area well enough to know what features may truly be sinks on the surface of the earth and which are merely errors in the available data.

To create the depressionless DEM image, if there is any errors to remove from the image. First the raw image should be inputted to flow direction tool.

#### **4.3.3 SINK**

Sinks can be located using the Sink tool. This tool requires a flow direction raster that is created by the Flow Direction tool. The result is a raster that identifies any existing sinks in the data.

#### **4.3.4 FILL**

The Fill tool uses a variety of ArcGIS Spatial Analyst tools, to create a depressionless DEM. This tool requires an input surface, a fill limit, and an output raster.

#### **4.3.5 DEPRESSIONSLESS DEM IMAGE**

Once the depressionless DEM image is created from above process, the depressionless DEM image is used to the create watershed of the area.

#### **4.3.6 FLOW DIRECTION**

One of the keys to deriving hydrologic characteristics of a surface is the ability to determine the direction of flow from every cell in the raster. This is done with the Flow Direction tool. This tool takes a surface as input and outputs a raster showing the direction of flow out of each cell.

#### **4.3.7 FLOW ACCUMULATION**

The Flow Accumulation tool calculates accumulated flow as the accumulated weight of all cells flowing into each downslope cell in the output raster. If no weight raster is provided, a weight of 1 is applied to each cell, and the value of cells in the output raster is the number of cells that flow into each cell.

#### **4.3.8 STREAM LINK**

Links are the sections of a stream channel connecting two successive junctions, a junction and the outlet, or a junction and the drainage divide

The input stream raster can be created by "thresholding" the results of the Flow Accumulation tool.

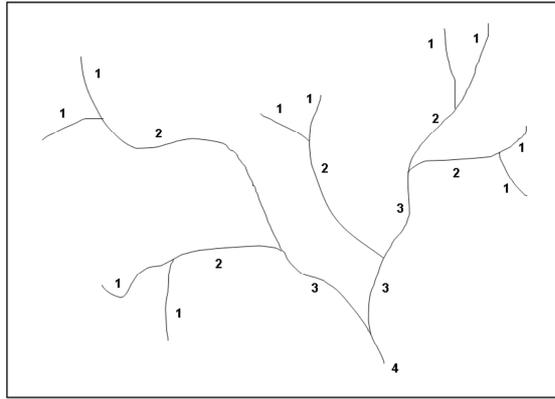
#### **4.3.9 WATERSHED**

A watershed is the upslope area that contributes flow generally water to a common outlet as concentrated drainage. It can be part of a larger watershed and can also contain smaller watersheds, called subbasins/micro watersheds. The boundaries between watersheds are termed drainage divides. The outlet, or pour point, is the point on the surface at which water flows out of an area.

Watershed can be delineated from a DEM by computing the flow direction and using it in the Watershed tool.

#### **4.4 STRAHLER METHOD OF STREAM ORDER**

One of the most common stream ordering method is Strahler method. The ordering system is simple wherein all streams start off as order one. If two order one streams join (converge), then they become an order two stream or 2<sup>nd</sup> order stream. If second order streams join, then they become an order three stream or 3<sup>rd</sup> order stream. The stream order will only increase if two streams of the same order join. If an order two stream and an order three stream join, then the resulting river will remain order three.



**Fig. 1 Strahler method of stream ordering**

The Bifurcation ratio looks at the relationship between the streams in different orders. The drainage basin shown (Fig. 1), has 10 order one streams, 5 order two streams, 2 order three and 1 order four streams. To calculate the bifurcation ratio you divide the total number of order 1 streams by the total number of order 2 streams ( $10/5=2$ ), then divide the total number of order two streams by the total number of order three streams ( $5/2=2.5$ ) and then divide the number of order three streams by the number of order four streams ( $2/1=2$ ). You then add together the results ( $2+2.5+2=6.5$ ) and divide by the total sets of values ( $6.5/3=2.166$ ). The drainage basin shown above therefore has a bifurcation ratio of 2.166.

The ratio of Bifurcation ratio between 0-3 is considered young stream, the ratio between 3-5 is called matured and  $>5$  it's considered as old stream.

## 5 RESULTS AND DISCUSSIONS

### 5.1 LAND COVER CLASSIFICATION OF THE STUDY AREA

Classification percentage wise for the Land cover pattern of extended area of BNP

**Table 1 Land cover classification statistics**

Class	Area in Percentage (%)	Area in sq.km
Settlements	1.121%	8.748
Forest Cover	60.79%	85.391
Water bodies	17.68%	32.154
Agricultural area	2.20%	10.621
Hillocks	15.62%	27.025
Total	100	156.97

#### ➤ FOREST COVER

Forest cover in the study area is found to be about 60.79% and area is about 85.39 sq. km, major portion is represented by forest in the study area.

#### ➤ WATER BODIES

Water bodies represents to area of about 17.68% which is equalent to 32.15 sq. km.

➤ **AGRICULTURAL AREA**

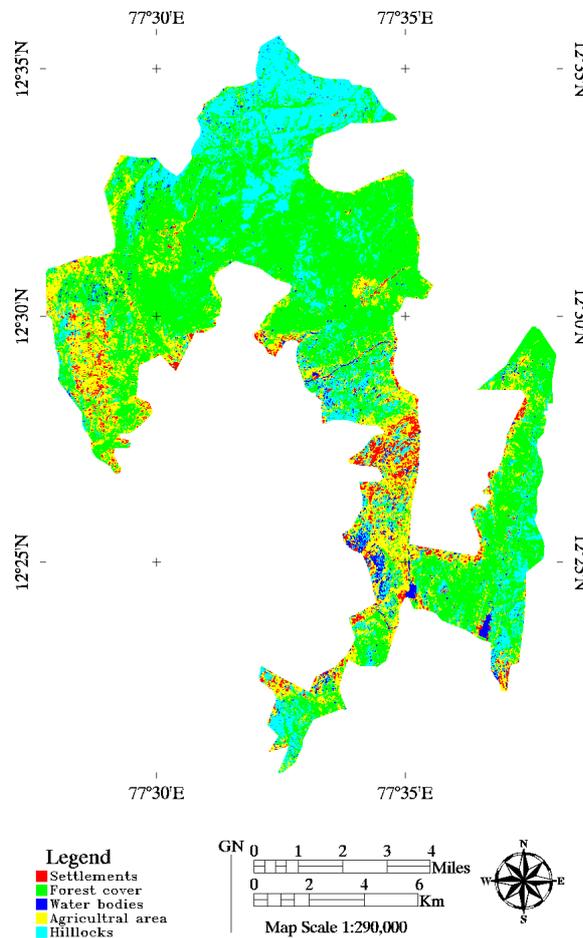
Agricultural area accounts to about 2.20% which is about 10.62 sq. km. Agricultural land found in this area are mostly illegal encroachments of the forest land.

➤ **SETTLEMENTS**

Settlements/built up area has about 1.21% as share in the study area which is equalent to 8.74 sq. km. It was also found that the settlements and agricultural lands were usually adjacent to each other, which is a clear indication of movement in to forest area.

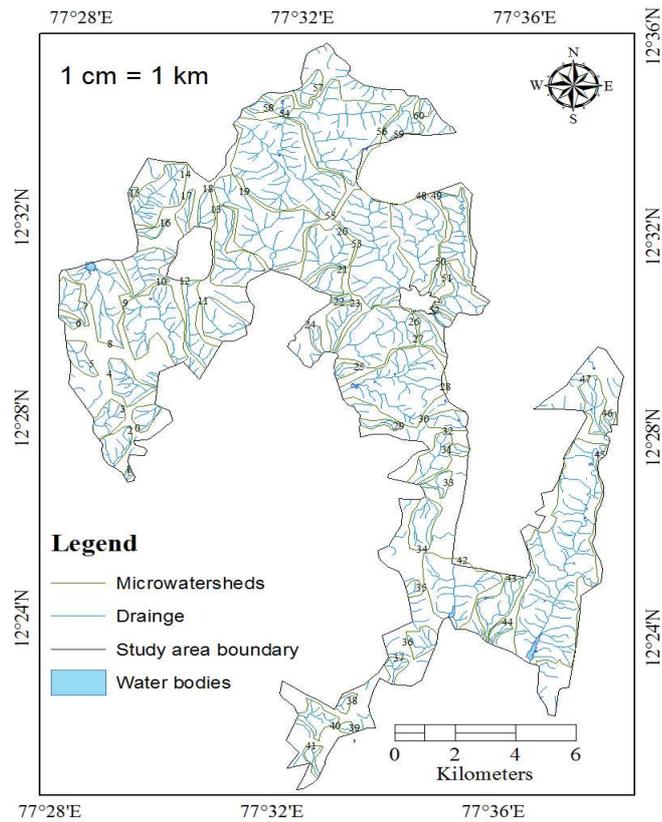
➤ **HILLOCKS**

Natural hillocks are also present in the study area accounting to about 15.62% which is equalent to 27.024 sq. km, The hillocks are present mostly at the the northernmost part of the study area.



**Fig. 2 Land cover classification map**

## 5.2 DRAINAGE MAP OF THE STUDY AREA



**Fig. 3** Manually developed drainage map with micro watersheds

Drainage network and micro watersheds were delineated manually for the study area, to find the stream order and age of the stream by Strahler method as shown (Fig. 3).

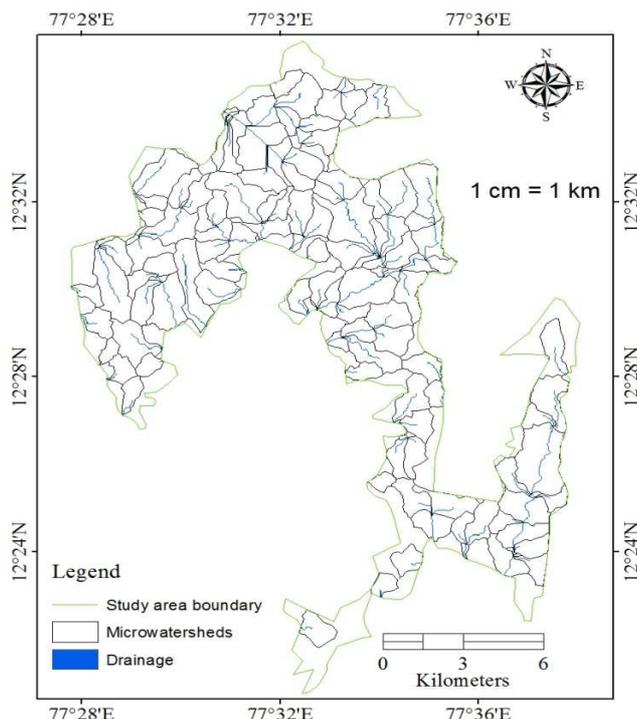


Fig. 4 Extracted drainage and microwatershed map

The drainage network is shown (Fig. 4) The Drainage and micro watersheds map was extracted from ArcMap 10. In the study we tried to better understand the drainage network by further breaking the drainage system to as many possible micro water sheds. It is observed that the manually developed map is more specific and accurate, when compared to GIS extracted map. Thus manually done delineation is used in the study.

5.3 STRAHLER METHOD OF STREAM ORDER

Table 2 Status of the micro watersheds

Status	Number of streams	Percentage (%)
Young	28	45
Mature	26	44
Old	7	10
<b>Total</b>	<b>61</b>	<b>100</b>

The map (Fig 3) shows the manually delineated micro watersheds for stream order from Strahler method and to find the age of the streams of the 61 micro watersheds within the study area. The above table (Table 2) shows the classification based on age of the streams in the study area.

6 CONCLUSIONS

The study done which is the extended area of Bannnerghatta national park reveals that there is some encroachment in the forest area. The percentage share of different classifications of the study are as follows: The major share falls under the category forest area with 60.79% of study area followed by the area of water bodies with about 17.68% the third largest is natural formed hillocks with an share of 15.62% of area. Agricultural and settlements account to 2.20% and 1.21% respectively.

The assessment of drainage network of the study area using Strahler method shows wherein total drainage network was divided into micro watersheds reveals that the total drainage network was further sub divided in to 61 micro watersheds and on analyses they can be categorized as a healthier. About 45% of the micro watersheds fall under young category, wherein

44% can be classified as matured and about 10% of them fall in old category. The results shows it has a very healthy drianage network for the flora and founa of the area which should be protected and preserved from any kind of illegal encroachments and sand mining activities.

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