

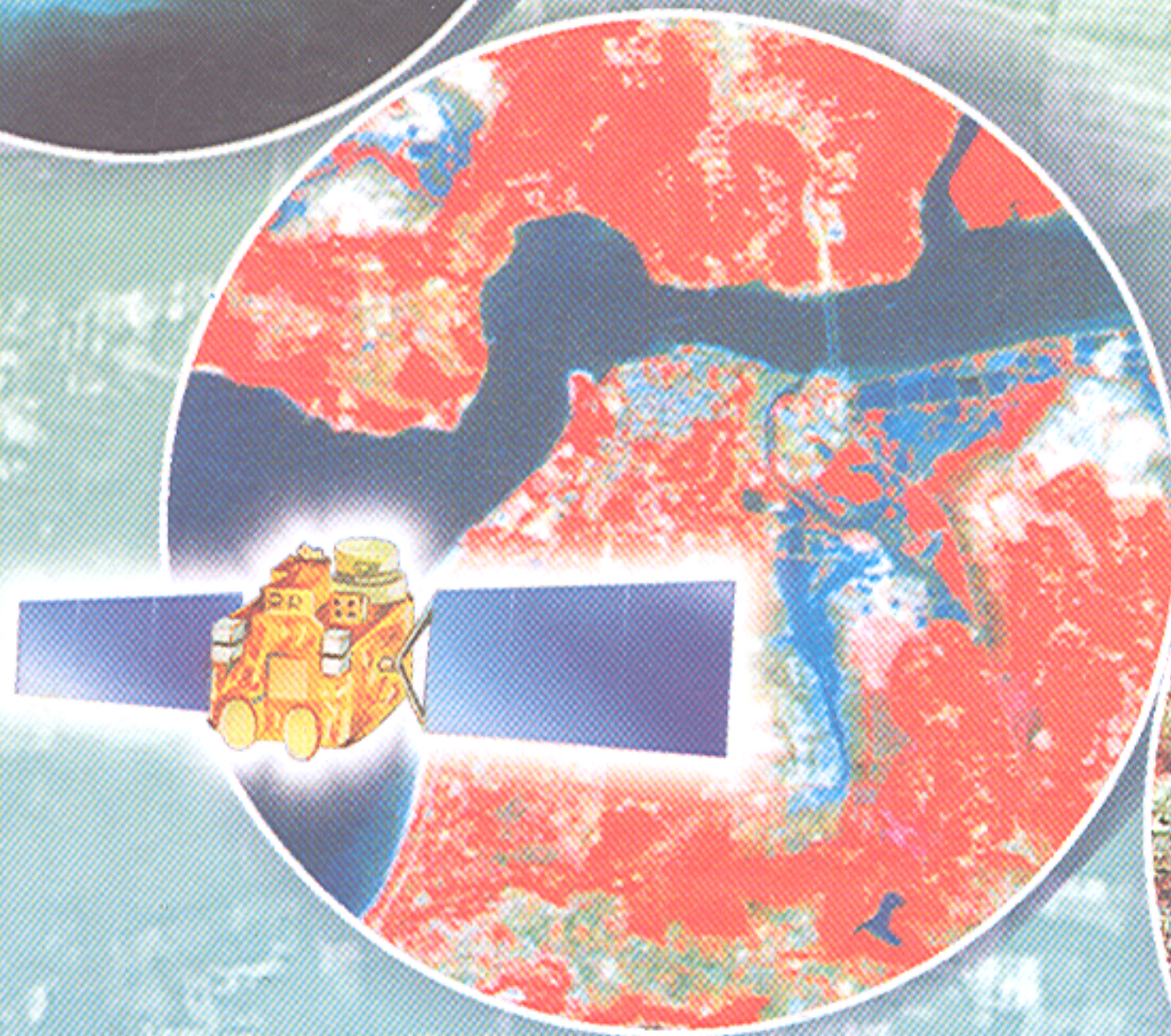
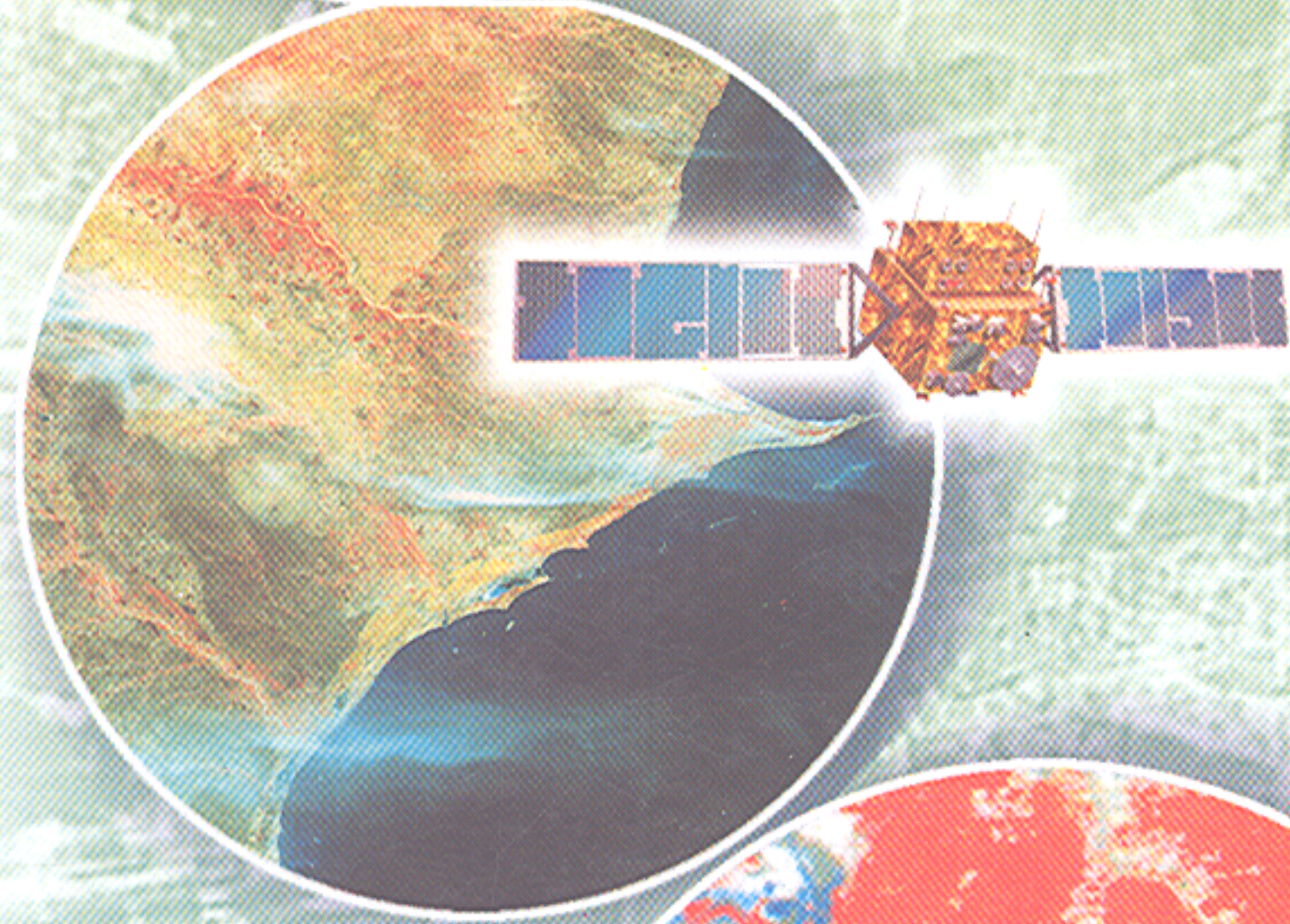
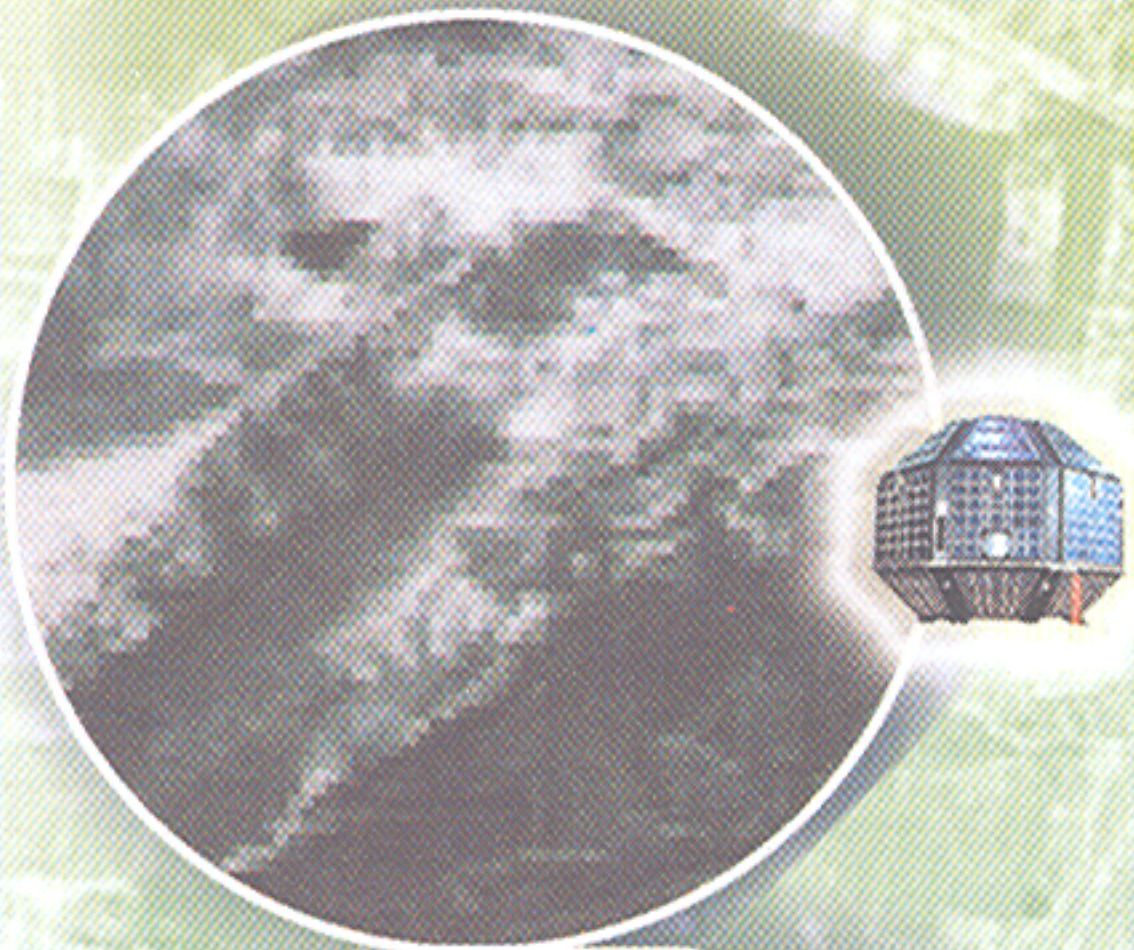
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Impact of Urbanisation on the Interconnectivity of Wetlands

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ABSTRACT

Wetlands are transitional zones between water bodies and dry land and are consequential part of the nation's natural resources. They vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Ecological process, values and functions differ with wetland type, which benefit human society in diversified ways. Although they are known for their function as abode for great diversity of flora and fauna, but less known for its hydrologic and water-quality functions and benefits, such as reducing the severity of flooding and erosion by modifying the flow of water or improving water quality. Unfortunately, due to rapid urbanisation and various developmental activities, these vital systems have been qualitatively and quantitatively degraded. Consequently, arises the need to conserve and restore these vital ecosystems. Wetland mapping and impacts due to urbanisation are to be assessed at regular intervals in order to manage, restore and conserve these systems. In this regard a study has been undertaken to assess the impacts of urbanisation on inter connectivity of wetlands in order to quantify the impacts on values and functions of wetlands. Nelligodde and Hesarghatta tank watersheds have been chosen for a detailed investigation. Study was carried out adopting an integrated approach consisting of remote sensing data, Geographic Information System (GIS) and Survey of India toposheets. The results of this analysis revealed discontinuity in drainage network on account of conversion of wetland habitat due to developmental activities. Impact due to various developmental activities was observed in both the watersheds.

Introduction

Natural resource in India, has been the target due to urbanisation. Various developmental and anthropogenic activities on wetlands have contributed to its quality deterioration apart from decline in spatial coverage. Rapidly growing population and unplanned developmental activities are the major contributing factors. Loss or degradation of wetlands has lead to serious consequences, such as increased flooding, extinction of species, and decline in water quality. The aftermath due to various human activities can be avoided by adopting an integrated approach in natural resource planning.

In recent years there has been growing concern about the management of wetlands. These wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including various human activities and disturbances due to the developmental activities. Wetlands can be defined based on the various official agencies based on the associated flora and fauna and various other components. The widely accepted definition of the wetlands given by Ramsar (tiner, 1995) is: "Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth at which low tide doesn't exceed 6 meters"

The broad range of function of wetlands help to

sustain wide variety of flora and fauna and of course the human beings. The other functions include such as recharge the ground waters, which increases region's ground water table, flood control, shoreline stabilization and check erosion.

The remote sensing data provides an excellent opportunity to carry out the watershed management study, to evaluate the land use land cover changes and its impacts for the same area using multi-date imageries. Remote sensing application on wetland study can be basically carried out in two forms. Primarily baseline data acquirement on the type, extent and the status of the wetlands and besides the temporal and spatial change analysis due to various natural and anthropogenic activities.

Remote sensing tool has been adopted to study the drainage connectivity of wetlands and to assess the impacts of various developmental activities on interconnectivity of wetlands of Bangalore district. Hesaraghatta and Nelligodde tank watershed have been chosen to analyze the impact of various land uses and land cover changes in the watershed area.

Objectives

The objectives of the current study are:

- To develop the drainage network map for the Bangalore district;
- To analyse the interconnectivity between the wetlands and to explore the causes for loss of interconnectivity;

- To estimate the temporal changes in the watershed areas of Nelligodde tank and Hesaraghata tank;
- To analyse the land use and land cover of the Nelligodde tank and Hesaraghata tank watershed area;
- To suggest suitable conservation methods for the watershed area.

Study area

Bangalore district is located in the southern part of the Karnataka state which is stretched between the latitudes $12^{\circ} 39' - 13^{\circ} 18' \text{ N}$ and between $77^{\circ} 22' - 77^{\circ} 52' \text{ E}$ longitudes. Bangalore, the State capital is one of the smaller districts of the state with an area of about 2,191 sq. km. The district has temperature ranging from the highest maximum of 33°C in April to the minimum of 14°C in January. The mean maximum temperature is the highest in the April with 36.2°C and the mean minimum temperature in January is 11.4°C . Bangalore district was divided into rural and urban districts on August 15, 1986. Fig. 1 depicts the study area covering urban and rural districts. Bangalore city with an area of about 151 sq. km lies at the centre of the Bangalore district. The Bangalore urban district consisting of north, south and Anekal

taluks, is located at an average elevation of 900 meters. Bangalore city area is spread over the north and south taluks.

The Bangalore rural district with an area of about 5,814 sq. km occupies about 3% total area of the Karnataka State, surrounds the urban district except in the south-eastern region near Anekal taluk. The district consists of eight taluks; Channapatna, Devanahalli, Doddabalapur, Hoskote, Kanakapura, Magadi, Nelamangala and Ramanagara.

Hesaraghata watershed is the biggest watershed in Bangalore north taluk. The watershed area stretches between the latitude. $13^{\circ} 13' - 13^{\circ} 36' \text{ N}$ and longitude $77^{\circ} 36' - 77^{\circ} 63' \text{ E}$. The watershed area of the Hesaraghata tank is about 470 sq. km and the water bodies in the watershed occupy about 41.29 sq. km. Hesaraghata tank caters drinking water requirements of almost one third of the Bangalore population.

The Nelligodde tank located in Ramanagara taluk, of Bangalore rural district is a good source for fisheries and agriculture. They also abode a vast variety of flora and fauna, apart from being a source for drinking water and various domestic activities. The watershed area stretches between latitude $12^{\circ} 75' - 13^{\circ} \text{ N}$ and longitude $77^{\circ} 25' - 77^{\circ} 51'$ and covers an area of about

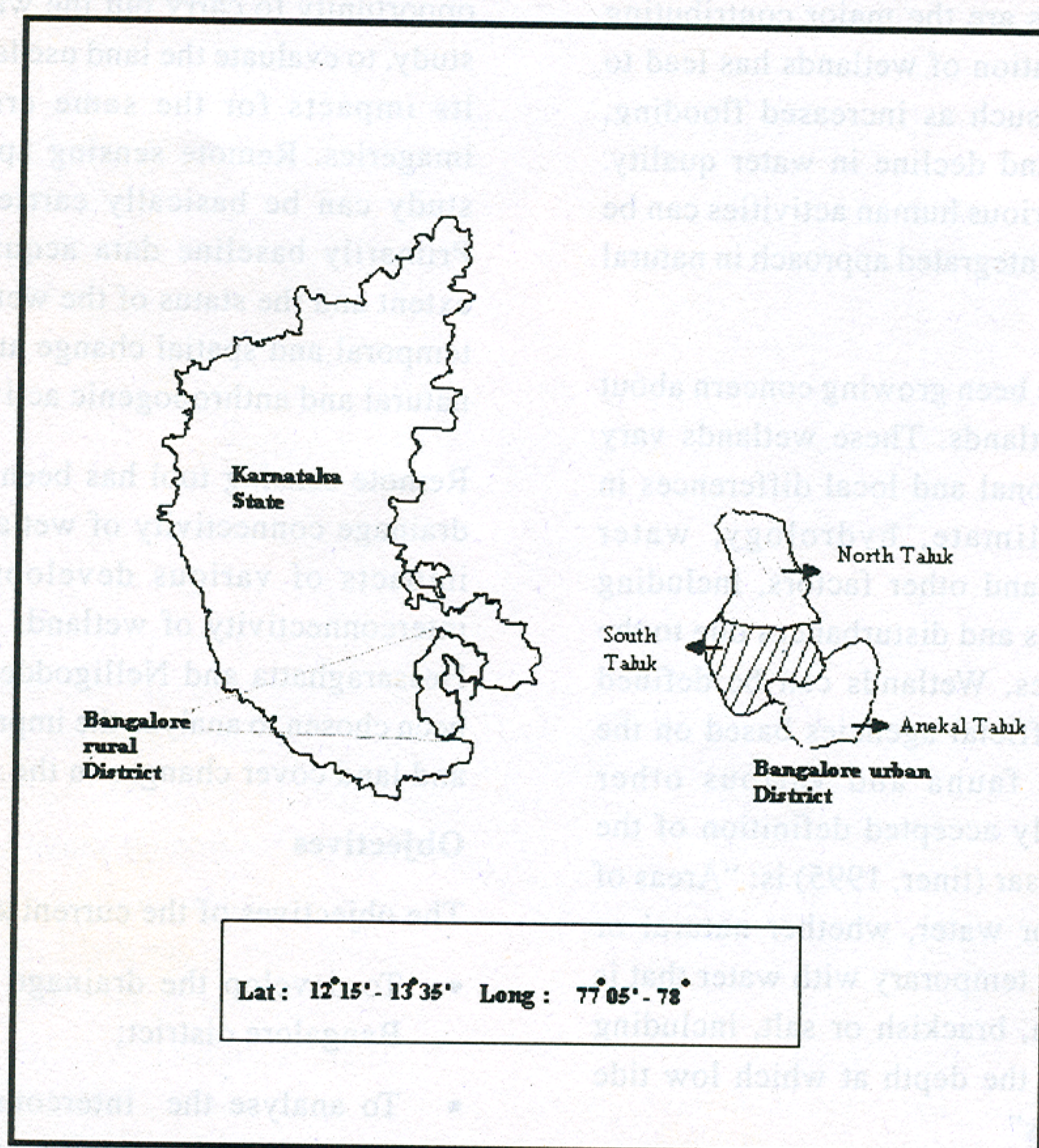


Fig. 1. Bangalore District

6803 ha or 68.03 sq. km. The water bodies in the watershed occupy about 2.11 sq. km.

Current status of wetlands of Bangalore

Bangalore has no natural wetlands, they were built mainly for various hydrological purposes and mainly to serve the need of irrigated agriculture. Majority of the wetlands occurs in the outskirts of the city, on the rural fringe (Krishna *et al.*, 1995). The uneven distribution of the Bangalore lakes with reference to the city present, is obviously the result of an explosive increase in the extent of the city from around 67 sq. km in 1961 to over 6 times that area to-day (Behra *et al.*, 1991). Prior to 1896 the water demand of the city was met by surface water bodies and dug wells. The unplanned development of the city has engulfed many water bodies and also blocked the catchment in these basins. The number of man made wetlands in the existing BCC and BDA area has fallen from 262 in 1960, to around 81 lakes at present (Lakshman *et al.*, 1986). Discharges of industrial effluent and domestic sewage have reduced the quality of water.

Methodology

To study the drainage network and watershed area an integrated approach involving interpretation of remotely sensed data, Geographic Information System [GIS] technique and conventional field survey have been adopted. The base maps and the drainage maps were prepared on using 1:50,000 scale toposheets.

Remote sensing and Collateral data

The survey of India 1:50,000 scale toposheets no; 57 G/3-8, 57 G/11, 57 G/15 -16, 57 H/1-3, 57 H/5-6, 57 H/9-10 and 57 H/13-14 were referred for topographical information, for locating ground truth sites in the field and preparation of base maps. IRS-1C & 1D Geocoded False Colour Composite (FCC) data for the above mentioned SOI toposheets of March 96 & Nov' 95 were used.

Ground verification

After the preliminary visual interpretation of the IRS-1C and IRS-1B data, field visits were made to check the interpretation accuracy and to identify unknown patches. Final maps were generated converting topographic information with field data into digital form and overlaying remotely sensed data using GIS. Various layers of maps prepared in this regard are ;

Base Map: Survey of India toposheets of 1:50,000 scale was used to prepare the base map. Thematic information generated for the study was compiled on the base map. The information layers of transportation networks (roads and railway lines) and regional boundaries (taluk and district) were overlaid on the base map.

Drainage maps: The drainage information of the study area including streams and drainage channels were derived from the 1:50,000 scale toposheets. This information would be useful for identifying sites to harvest surface water, to manage the whole watershed and to identify the major inter-connectivity of wetlands.

Land use and Land cover maps: Land use and cover maps of the Nelligodde and Hesaraghata tank were prepared using the remote sensing and corresponding filed data. The image characteristics - size, shape, tone/colour, pattern and various other features were considered for visual interpretation to classify the various land use and land cover categories. The current study is based on the following classification;

Level - I	Level - II
Built-up land	Built-up land
Agricultural land	Crop land(<i>Kharif/ rabi</i> double crop) Plantations (coconut, Causurina, Areca, etc.)
Forest	Scrub or degraded forest
Wastelands	Land with or with out scrub Stony waste (sheet rocks, boulders, rock exposures, etc.)
Water bodies	lake/ tank / canal

Results

Drainage network map of all the three taluks of Bangalore urban district and eight taluks of Bangalore rural district were mapped to study the interconnectivity between the wetlands.

Figure 2 refers to the drainage network of Bangalore North district. Hesarghatta being the major water body in the taluk covers a larger watershed area, which even stretches to Doddaballapur and Magadi taluks. Nagavara kere, Yelahanka kere and Jakkur kere are other major wetlands in this taluk. All these are well connected through drainage channels. Impact of anthropogenic stress could be seen in southern region, which is reflected in the form of poor interconnectivity, and less drainage network.

Bangalore South taluk's drainage network is shown in Fig. 3. Bellandur one of the major wetland in this taluk is interconnected to the surrounding wetlands, which drains into Varthur through a canal (Bellandur canal), finally drain into Dakshina Pinakini river in the east. Most of the water bodies in the southern part of this taluk drain into Suvarnamuki river, which finally joins Arkavathi river. Vrishbhavathi river with major chunk of catchment in the western part, flows from north to south west of the taluk.

Figure 4 delineates the drainage network map of Anekal district of Bangalore Urban district. Two major drainage network are: (1) In the northern part connecting Sakavar kere, Jigani kere, Hennagara kere, Mullanattur kere and Bidaraguppe kere and (2) In the southern part linking Anekala kere, chikkanagudde kere, chenneagrahara kere, tatanhalli kere and attibele kere which finally drains into Chinna river in the eastern part of the taluk. Most of the wetlands in the south western region of the taluk drain into Xebba halla and Jakkana halla, finally meets Antharagange hole in Kanakapura taluk.

Figure 5 shows the delineation of Chanapatna drainage network. Kanava reservoir is one of the major spread area is located in the northern region of the taluk. The other major wetlands such as Holegeredoddi kere, Chanapatana kere and Kudlur kere are knitted with the adjoining wetlands through drainage channels, finally drain into Kanava hole. Kanava hole runs from the north to South of the taluk, which finally meets Shimsha river in the South.

Figure 6 explains the drainage connectivity of wetlands of Devanahalli taluk. Major wetlands in the southern part are Rampur kere and Yellamallappachetty kere, which in turn links neighboring smaller water bodies. This network finally joins Dakshina Pinakini river in the western side of the taluk. Another well-connected network in this region is of Bagalur kere, Gamanahalli kere, Doddajallaamani kere, Bandagodigana halli kere, Bodigermane kere, finally drains into Hoskote kere of Hoskote taluk. Northern region of this taluk has a network of Sadahalli kere, kamamangala kere, Dodda sanna kere, Chikka sana kere and chana halli kere, finally drain into Ponnar river.

Dodaballapur taluk drainage network consisting of two major groups is shown in Fig. 7. The first group with a network of, Mallanayakan halli kere, Dodda hajji kere and Madhure kere drain into Hesarghatta tank of Bangalore South taluk. While, the second group connects Hambi kere, Doddaballapur kere, Palana kere, Konagotta kere wetlands in the northeastern region of the taluk also drain into

Hesaraghatta tank which finally reaches Arkavathi River.

Figure 8 portrays the Hoskote taluk's drainage network covering larger watershed area of Hoskote kere linking Hallur kere, Nallurhalli kere, Mugbal kere, Yelachchahalli kere and Tavre kere, finally flows into Dakshina Pinakini River in the Southern region of the taluk.

Kanakupara drainage network map is depicted in Fig. 9. Arkavathi a major tributary flows from north to South of the taluk meets Cauvery river at the Southern tip of the taluk. The Suvarnamuki river from the northern side joins Arkavathi. Most of the wetlands in the north - east and eastern region of the taluk drain into Antharagange hole and Rayanala hole joins Kuthe hole, which ultimately connects to Arkavathi.

The Magadi taluk's drainage network is illustrated in Fig. 10. Major water bodies are Ire kere, Bettahalli kere, Mayasandra kere, Biskur kere and Kalepalya kere. Network of these wetlands drain into Kunigal kere of Tumkur taluk in the southwestern region. Most of the wetlands in the eastern region of the taluk drain into Chikka tore, which joins river Arkavathi, flowing in the eastern region of the taluk. The Wetlands in the Southern region drain into Kanva hole of Ramangarm taluk.

The Nelamangala drainage network map is delineated in Fig. 11. Most of the wetlands located in the northwestern side of the taluk drain into Mavathur kere (Tumkur district) in the western region of the taluk. Chamarajasagar reservoir is the major wetland in this taluk receives inflow from catchments from the north and northeastern region of the taluk including river Arkavathi. All most all the water bodies in the southwestern region of the taluk drain into Kumudavathi river in the Southern region of the taluk.

Figure 12 depicts the Drainage network map of Ramangaram taluk. Nelligodde tank near Bidadi and Byramangala reservoir are the two major wetlands found in the taluk. The Vrishbhavathi River flowing from the South taluk of urban district finally connects Byramngala reservoir. Arkavathi River flows from north towards the southeast of the taluk.

In order to assess the impact of developmental activities, the wetland map of 1996 (generated with the help of IRS 1C data) was overlaid on the base map. This brings out the loss in connectivity between wetlands. Figures 13 and 14 show the interconnectivity of lakes at Madivala and Bellandur with the adjacent lakes, respectively. Due to

Drainage Network of Bangalore Rural District



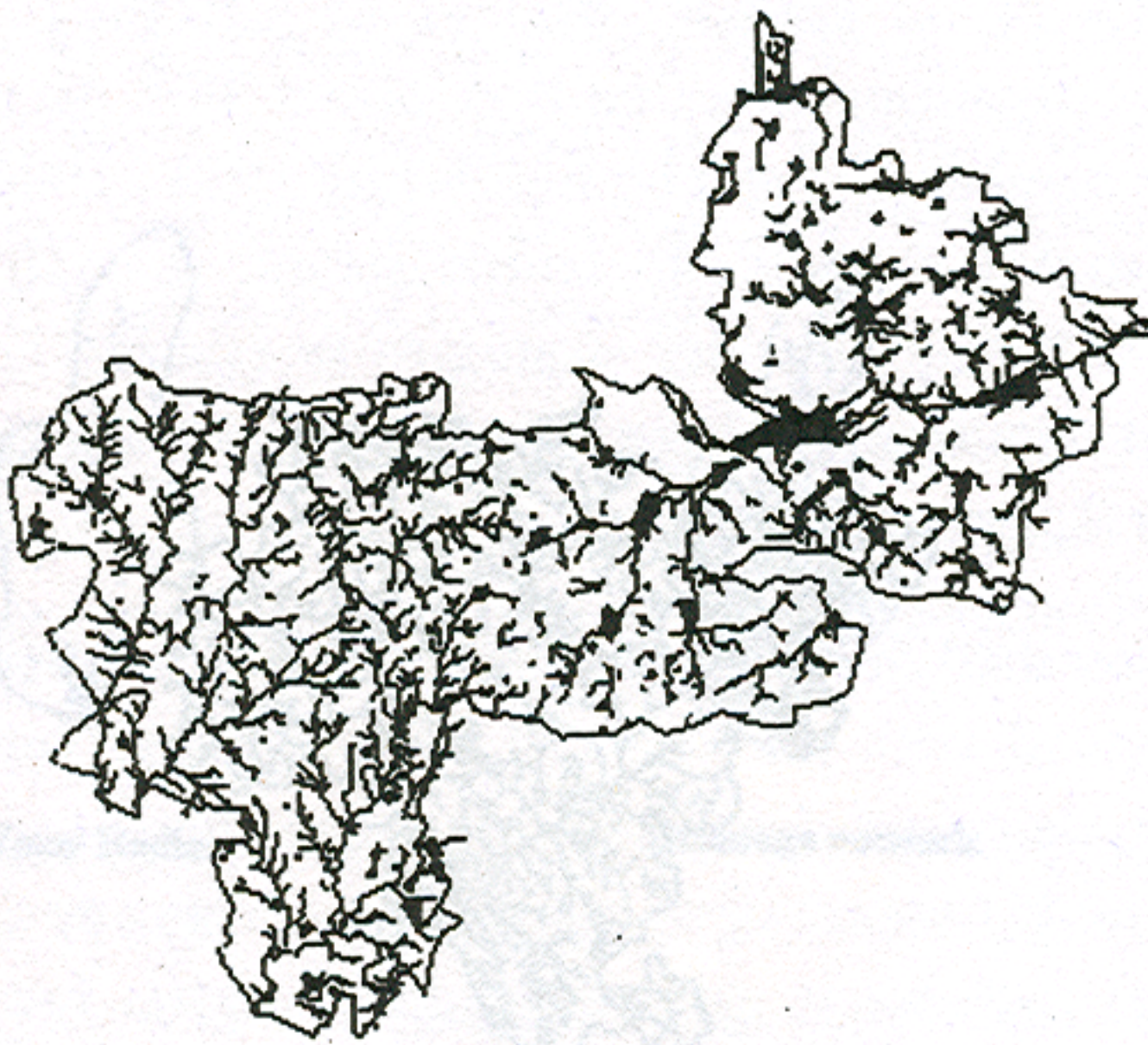
Lat: $12^{\circ} 91' - 13^{\circ} 23'$ Long: $77^{\circ} 43' - 77^{\circ} 66'$

Fig. 2. Bangalore North



Lat: $12^{\circ} 27' - 12^{\circ} 48'$ Long: $77^{\circ} 4' - 77^{\circ} 19'$

Fig. 5. Chanapatna



Lat: $12^{\circ} 72' - 13^{\circ} 07'$ Long: $77^{\circ} 40' - 77^{\circ} 78'$

Fig. 3. Bangalore South



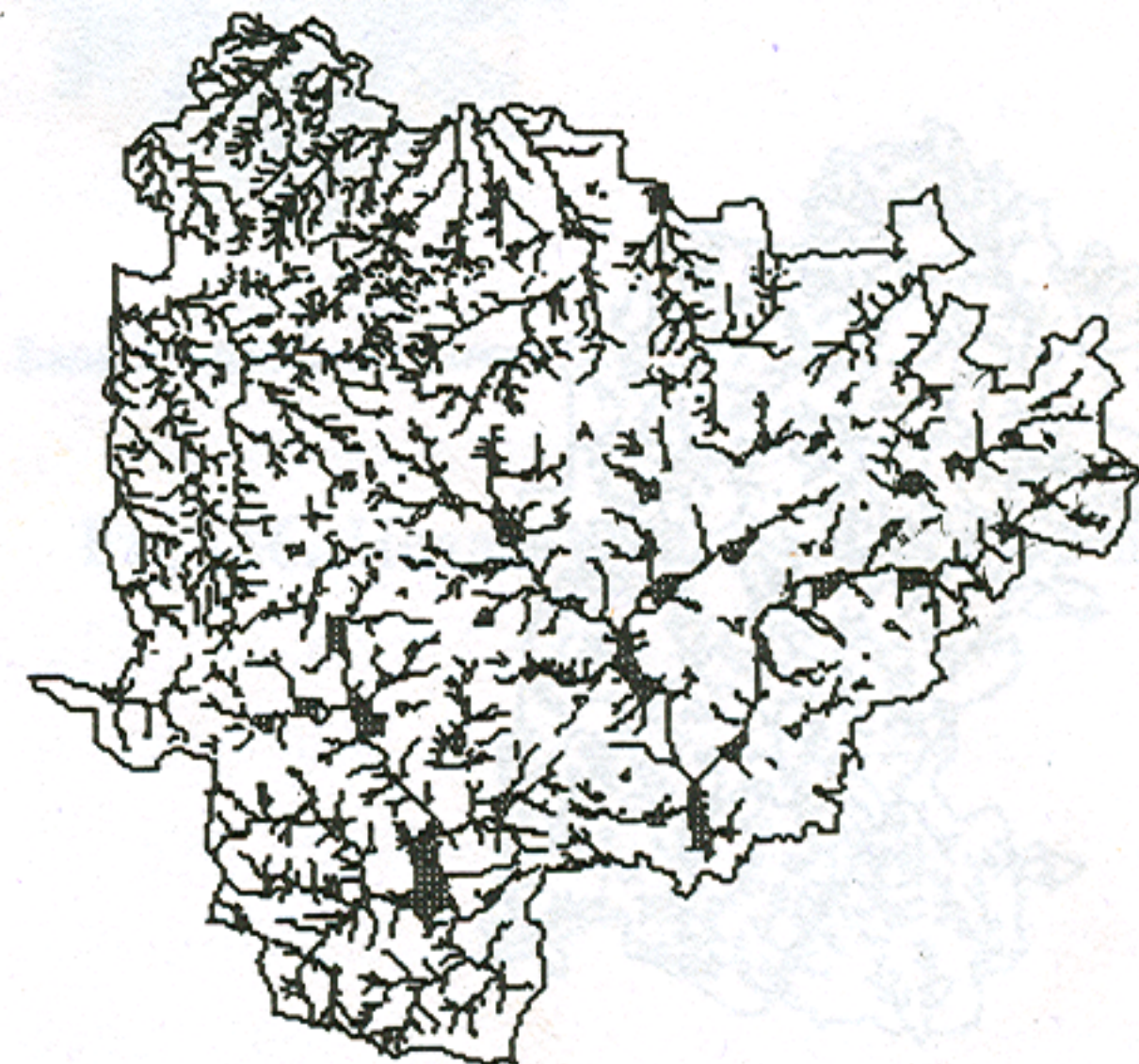
Lat: $13^{\circ} 5' - 13^{\circ} 21'$ Long: $77^{\circ} 33' - 77^{\circ} 49'$

Fig. 6. Devanahalli



Lat: $12^{\circ} 65' - 12^{\circ} 93'$ Long: $77^{\circ} 53' - 77^{\circ} 83'$

Fig. 4. Anekal



Lat: $13^{\circ} 9' - 13^{\circ} 30'$ Long: $77^{\circ} 18' - 77^{\circ} 40'$

Fig. 7. Doddabalapur

Drainage Network of Bangalore Rural District



Lat: 12° 51' - 13° 51' Long: 77° 38' - 77° 58'

Fig. 8. Hosakote



Lat: 12° 58' - 13° 19' Long: 77° 11' - 77° 29'

Fig. 11. Nelamangala



Lat: 12° 14' - 12° 48' Long: 77° 13' - 77° 38'

Fig. 9. Kanakapura



Lat: 12° 27' - 12° 48' Long: 77° 8' - 77° 29'

Fig. 12. Ramanagaram



Lat: 12° 49' - 13° 11' Long: 77° 4' - 77° 21'

Fig. 10. Magadi

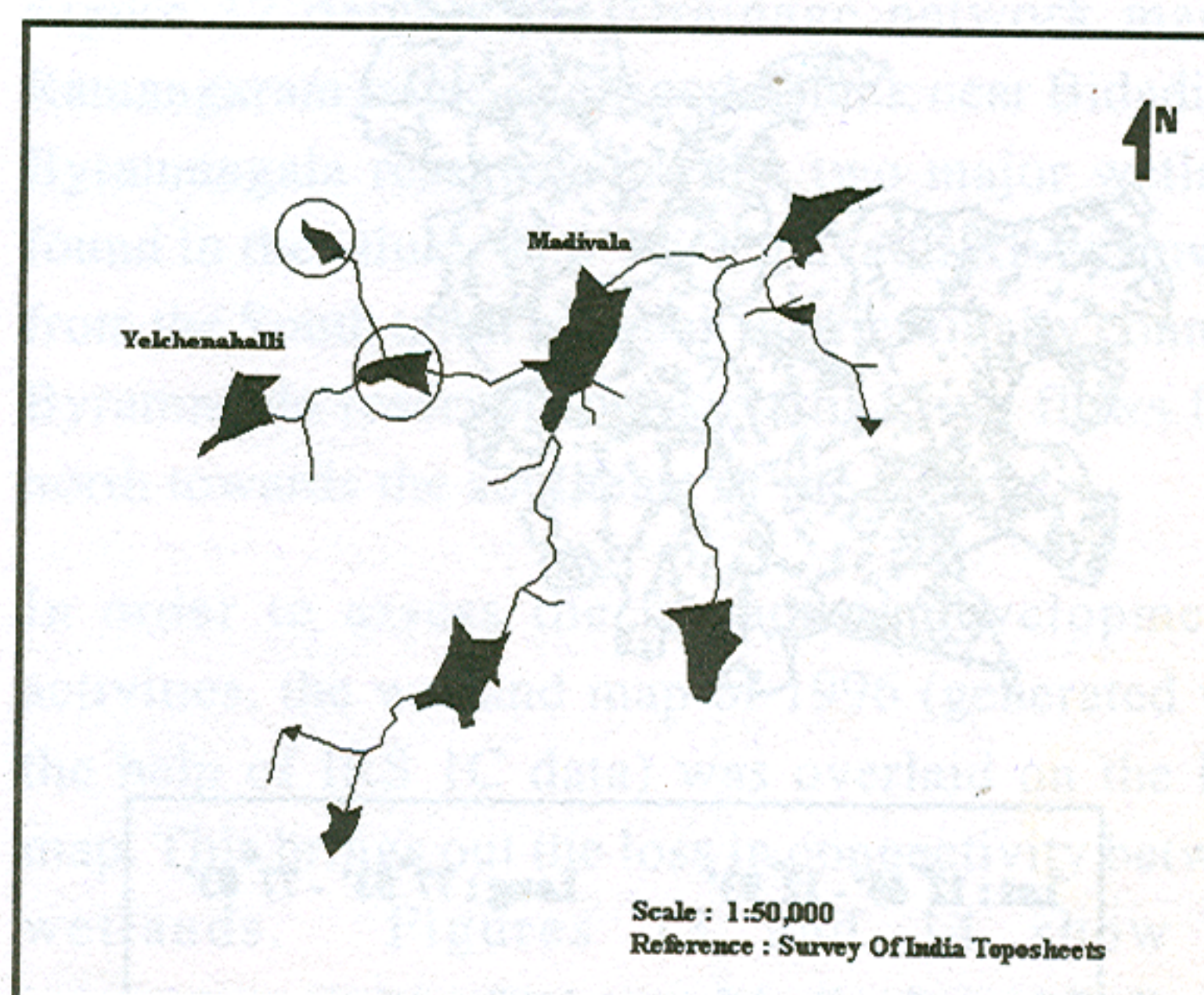


Fig. 13. Madivala Drainage Network

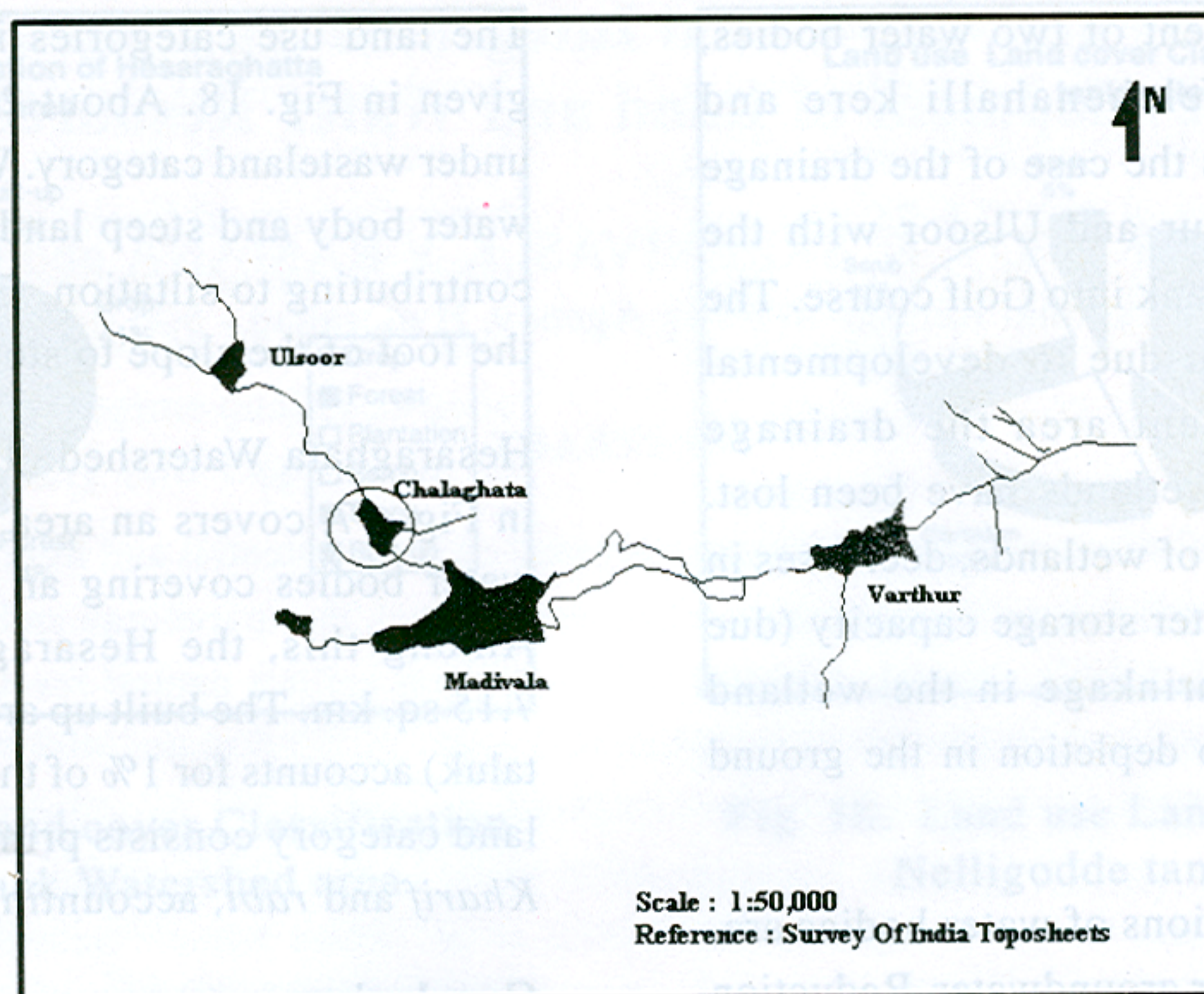


Fig. 14. Drainage Network of Bellandur

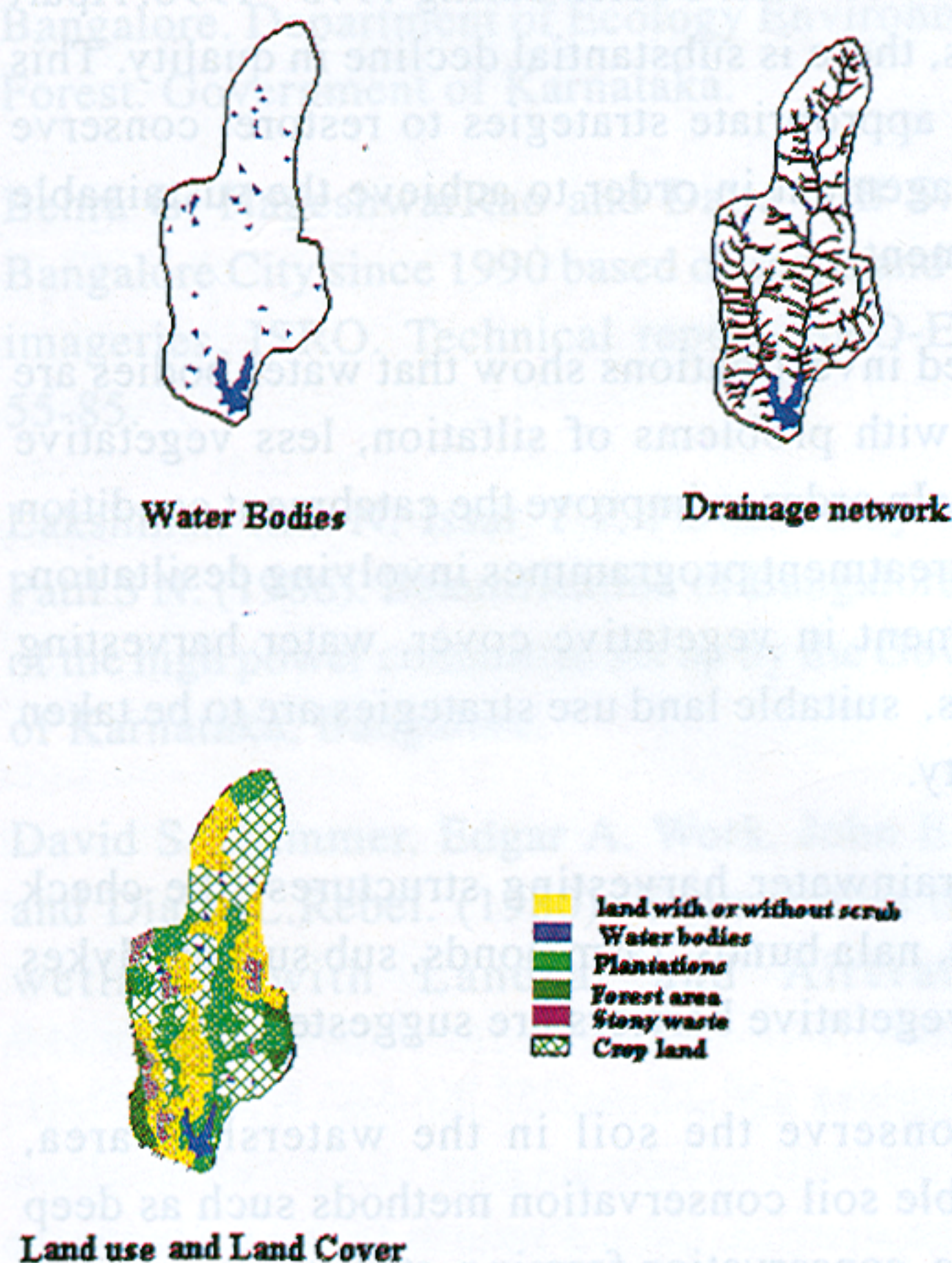


Fig. 15. Nelligodde watershed area

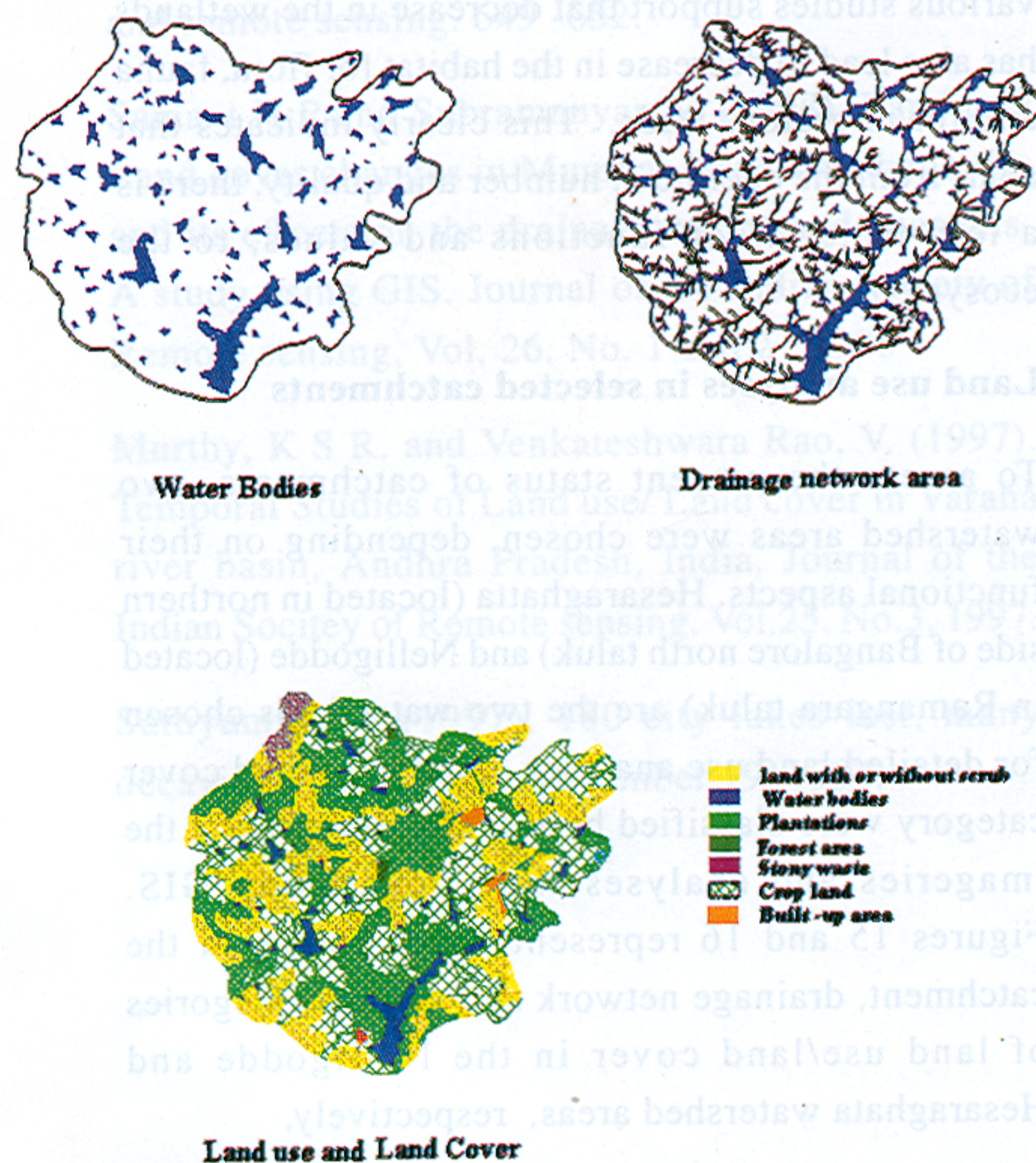


Fig. 16. Hesaraghatta watershed area

conversion and encroachment of two water bodies, connectivity between Yelchenahalli kere and Madivala is lost. Similar is the case of the drainage network between Bellandur and Ulsoor with the conversion of Challaghata tank into Golf course. The GIS analyses revealed that due to developmental activities in the catchment area the drainage connectivity between the wetlands have been lost. This has resulted in the loss of wetlands, decreases in catchment yield, loss of water storage capacity (due to sedimentation, etc.), shrinkage in the wetland area and also contributed to depletion in the ground water table.

One of the significant functions of water bodies are, they act as recharge zones for groundwater. Reduction in water bodies has serious impact on ground water level (bore wells) as is evident from the recent study that due to disappearance of lakes the ground water depth has decrease from 35-40 feet to 250-300 feet in 20 years (Satyamurthy, 1997). The results from various studies support that decrease in the wetlands has also lead to decrease in the habitat for flora, fauna and for migratory birds. This clearly indicates that apart from the decline in number and quality, there is a loss in terms of functions and values, to the ecosystem.

Land use analyses in selected catchments

To assess the present status of catchments, two watershed areas were chosen, depending on their functional aspects. Hesaraghatta (located in northern side of Bangalore north taluk) and Nelligodde (located in Ramangara taluk) are the two watersheds chosen for detailed land use analyses. Land use / land cover category were classified by visually interpreting the imageries and analyses were done using GIS. Figures 15 and 16 represent water bodies in the catchment, drainage network and various categories of land use/land cover in the Nelligodde and Hesaraghatta watershed areas, respectively.

Nelligodde watershed area: Watershed covering about 68.03 sq. km has major water body - Nelligodde tank with water spread area of about 1.7 sq. km. The area of the tank has reduced by 38% and siltation has contributed to reduce storage capacity. Field investigations revealed that, soil is being severely eroded constantly due to lack of proper vegetative cover. Suitable catchment treatment involving an appropriate soil conservation methods and improvement in vegetative cover are to be initiated in the watershed area to check further degradation and restore productivity of the land.

The land use categories in the watershed area are given in Fig. 18. About 27% of the land area were under wasteland category. Wastelands surrounding the water body and steep land in the western region are contributing to siltation. Check dams can be built at the foot of the slope to store the run off water.

Hesaraghatta Watershed: The watershed area shown in Fig. 17, covers an area of about 470 sq. km with water bodies covering an area of about 41 sq. km. Among this, the Hesaraghatta tank covers about 7.15 sq. km. The built up area (such as Doddaballapur taluk) accounts for 1% of the watershed area. The crop land category consists primarily of food fiber during *Kharif* and *rabi*, accounting for about 41%.

Conclusions

Urbanisation and anthropogenic stress in Bangalore has contributed to discontinuity of the drainage network on account of loss of wetlands. Earlier investigations revealed that, about 35% decrease in the number of water bodies during 1973 - 1996. Apart from this, there is substantial decline in quality. This calls for appropriate strategies to restore, conserve and management in order to achieve the sustainable development.

Watershed investigations show that water bodies are plagued with problems of siltation, less vegetative cover etc. In order to improve the catchment condition suitable treatment programmes involving desiltation, improvement in vegetative cover, water harvesting structures, suitable land use strategies are to be taken on priority.

- ◆ The rainwater harvesting structures like check dams, nala bunds, farm ponds, sub surface dykes and vegetative barriers are suggested.
- ◆ To conserve the soil in the watershed area, suitable soil conservation methods such as deep tillage, conservation farming, strip cropping, inter planting, Surface mulching etc. must be adopted in the study area.

Acknowledgement

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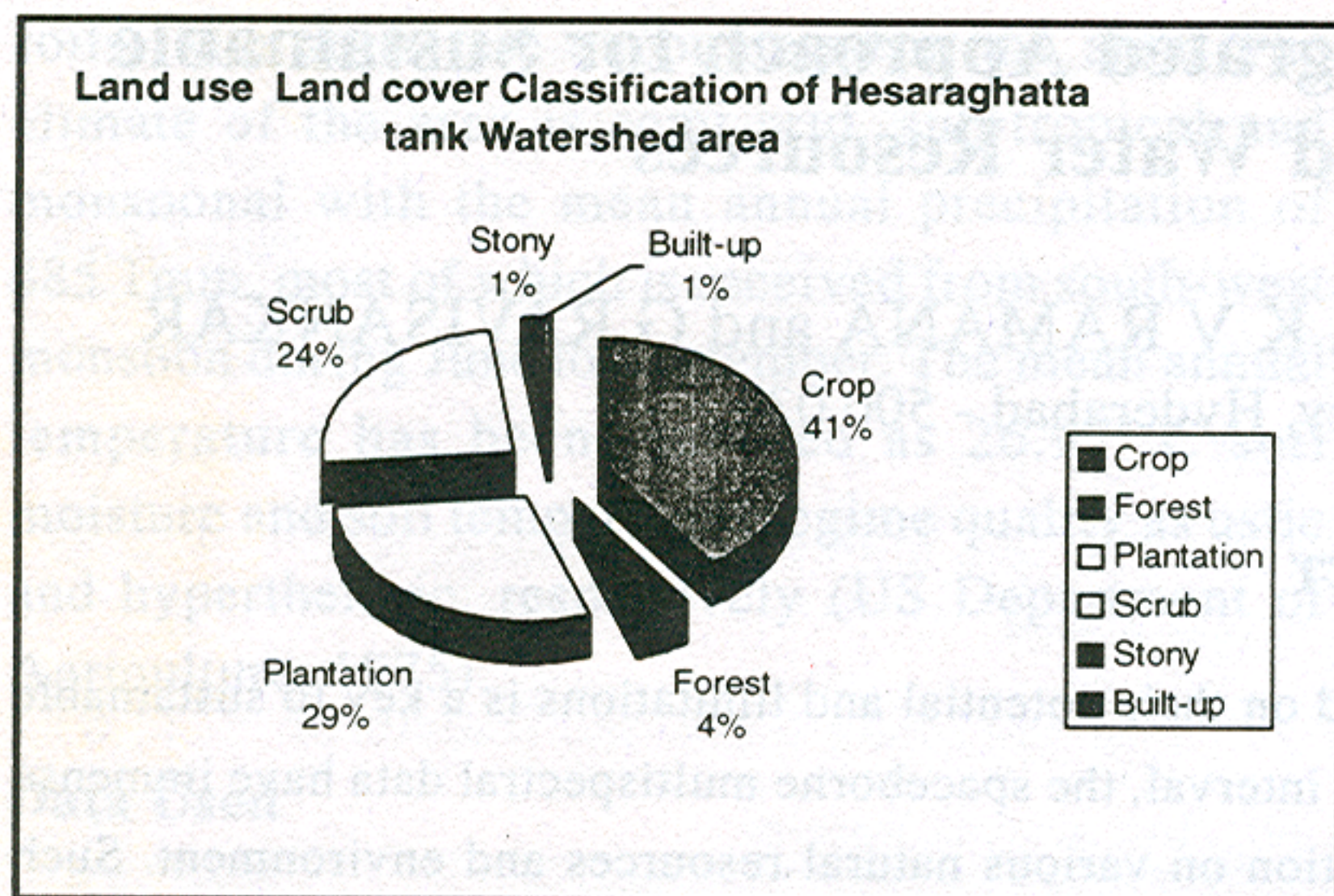


Fig. 17. Land use and Land cover Classification of Hesaraghatta Tank Watershed area

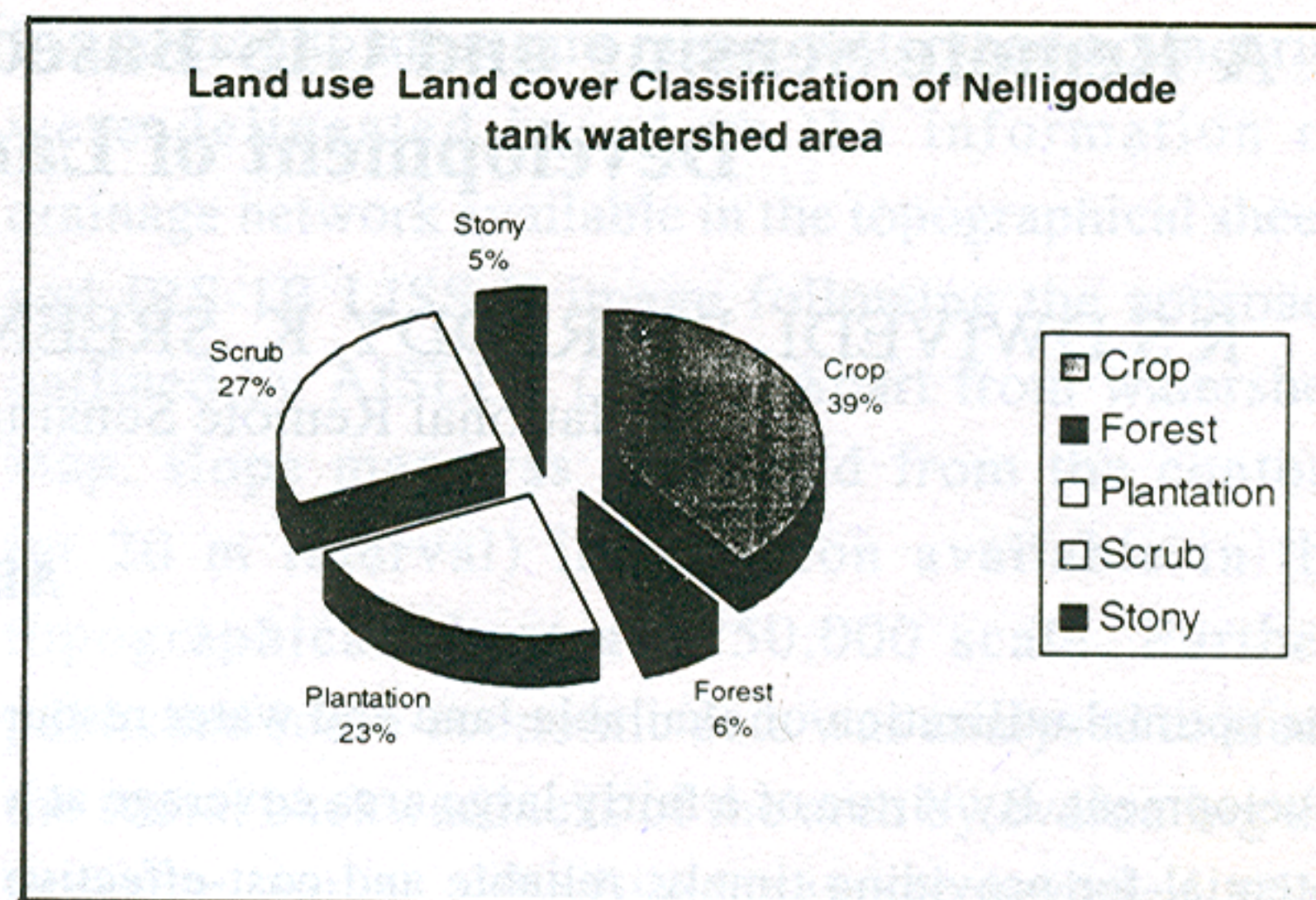


Fig. 18. Land use Land cover Classification of Nelligodde tank watershed area

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