REMOTE SENSING AND GIS IN WATERSHED AREA MANAGEMENT

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ABSTRACT:
Environment and Development are the two wheels of the cart. However, they become antagonists at some points. It has been witnessed many a times that development is done at the cost of environment. Analysis and assessment tools like GIS along with Remote Sensing have proved to be very efficient and effective and hence useful for management of natural resources. Watershed areas are prone to degradation accelerated by human interventions. Wastelands like gullied or ravenous land, upland with or without scrub, degraded pasture, degraded land under plantation, industrial wastelands are found prevalently in watershed areas. RS data and GIS tools and software like ILWIS 3.0 Academics along with topographical maps and ground truthing should be exploited to control watershed deterioration and implement management strategies. Effectual Management tools can be designed only with backup from extensive RS data and various GIS tools. Wasteland development in the watershed areas can be mitigated substantially by the proper and wide-ranging use of RS and GIS. The management tools like leveling of gullies or ravines, gully plugging, contour bunding, contour trenching, can be implemented as per the characteristic of wasteland. Thus, wastelands can be managed and converted to arable land by the use of this refined method.

1. INTRODUCTION

Since time immemorial Environment and Development are going together as two wheels of a cart. These two aspects are the determinants of human welfare and prosperity. However, history is witness to the fact that many a times development is done at the cost of environment and its quality. It directly reflects on productivity and hence on the economic development. In the context of many developing and underdeveloped countries, about 80 percentage of population who reside in the rural areas rely on the natural resources for day-to-day livelihood. This implies that more the degradation, higher the poverty and thence the health problems connected with poverty. This demands an appropriate management tools to be implemented on the affected areas. Analysis and assessment tools like GIS along with Remote Sensing data have proved to be very efficient and effective and hence very useful.

Watersheds are hydrologic units that are considered to be efficient and appropriate for assessment of available resources and subsequent planning and implementation of various development programmes.

Watershed is defined as "Natural Hydrologic entity that covers a specific area expanse of land surface from which the rainfall runoff flows to a defined drain, channel, stream or river at any point. (Watershed Atlas, 1990) Hence, all the basic natural resources viz. soil and water in the hydrological entity of the area should be managed. The integration of technologies, within the natural boundaries of a drainage area, for optimum development of land, water and plant resources to meet the basic need in sustainable manner is Watershed Management.

Diversity in physical landscape results in different types of land, which are subjected to different types of utilization to the maximum extent possible due to increasing pressure on land, for agricultural pursuits. This has resulted in uncontrolled exploitation of resources resulting in unproductive or degraded land. Such degraded lands, which can be brought under vegetative, cover with reasonable effort, and which are currently under-utilized and which are deteriorating due to lack of water and appropriate soil management or on account of natural cause are called Wastelands.

In Indian context, National Wasteland Development Board (NWDB) was constituted with the objective of upgrading and managing annually five million hectares of wasteland by massive programmes like afforestation, tree plantations, and other economic uses for fuel and fodder. For this Technological Task Group was formulated. It gave the classification of Wastelands (Appendix 1)

The National Wastelands Identification Project (NWIP) of India was initiated in collaboration with National Remote Sensing Agency and the Survey of India to prepare district-wise wasteland maps on 1:50 000 scale

by using satellite data. The selection of the districts is based on the criterion that five percentage or more of the geographical area of these districts is estimated to be wastelands.

2. STUDY AREA

The study area comprises of an upland watershed of Bhama, a major tributary of Bhima River in the upper Krishna basin. The river has its source in the Western Ghats on the leeward side of the mountains in Khed Taluka of Pune District, Maharashtra, India. The river is 40.37 Kms long and covers an area of 221 sq. Kms. The study area is located at about 18^0 49 ´ N to 19^0 2' N latitude and 73 ^{0} 34' E to 73^0 45' E longitude. The altitude of the site is approximately at 626.015 MSL.
According to the Water Resources Regions delineated in 1949 by Dr. A. N. Khosla, the area falls under region 4 and Basin D.

3. OBJECTIVES

The study was carried out with the following objectives:
- Mapping the area to get the distribution of the water channels
- To generate DEM
- To prepare a slope map
- To prepare wasteland inventory
- To find out the potential and probable causes which contribute to the development of wastelands
- To suggest appropriate mitigatory measures for the area

4. DATABASE

Three types of data were used for the study purpose viz.
1. Satellite Imagery obtained from IRS 1B taken by LISS II on Jan12, 1998
2. Survey of India Topographical map 47F/9 and 47 F/13 on 1:50 000 scale
3. Ground data obtained by field visits.

5. METHODOLOGY

The drainage map, boundary map and contour map of the Bhama Watershed area were scanned and then imported into ILWIS as image files and were digitized, geo-referenced and then overlaid with the imagery after selecting the co-ordinates of GCPs.
The methodology involved the following procedures:
- Base Map preparation
- Contour Map Preparation
- Geo-referencing
- Digitizing and Editing
- DEM Preparation
- Calculation of Slope and Slope Map Preparation
- FCC Preparation
- Ground Truth Preparation
- Unsupervised Classification of land use/land cover
- Supervised Classification of Land use/land cover characteristics of wastelands

For the study purpose, the satellite data provided by NRSA were digitized, geo-coded and geo-referenced. ILWIS 3.0 Academic was used for GIS and analysis. For the Image analysis following techniques were imposed:
- Image Enhancement
- Image Classification

Apart from these analysis, other GIS aided analysis were carried out viz. DEM Generation, Elevation Zone Map, Slope Map.(Figure 1.1)
The formula used for generation of DEM is as follows:
Dembound=iff(isundef(boundary),?,dem)
Where, Dembound is the name of the DEM map
       Boundary is the name of the boundary map which was obtained from digitized contour map

Elevation Zone Map was obtained by classifying the DEM into the corresponding elevations. The operation opted is Slicing in image analysis.

The formula adopted to obtain a Slope Map is as follows:

$Slopepct(\%) = 100 * Hyp(Dx, Dy) / pixel\ size\ (23.5)$

Where, Slopepct is the name of the Slope map where slope is given in percentage

Dx and Dy are the spatially filtered x and y co-ordinates obtained form DEM

The images classified in this way were crosschecked by subsequent field visit. Thus more realistic land use/land cover map could be prepared. The process was repeated till 98-percentage accuracy was obtained.
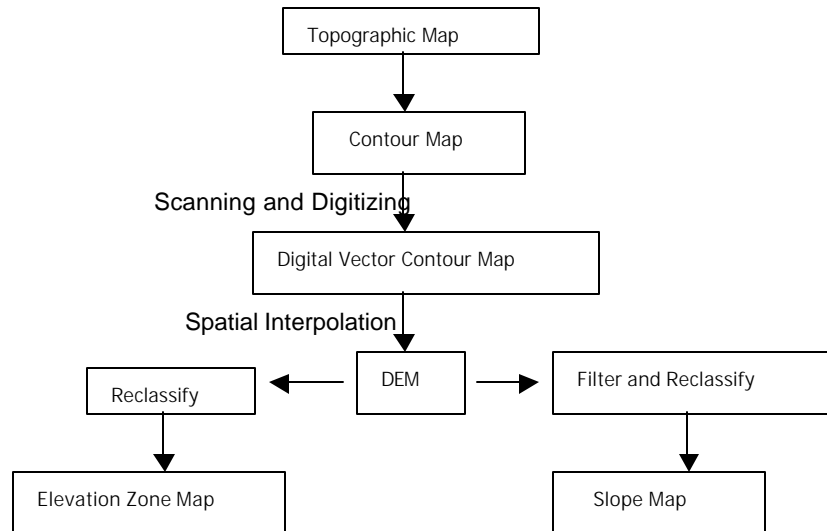
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                        ┌──────────────────────┐
                        │   Topographic Map    │
                        └──────────┬───────────┘
                                   ▼
                        ┌──────────────────────┐
                        │     Contour Map      │
                        └──────────┬───────────┘
       Scanning and Digitizing     │
                                   ▼
                    ┌──────────────────────────────┐
                    │  Digital Vector Contour Map   │
                    └──────────────┬────────────────┘
       Spatial Interpolation       │
                                   ▼
┌─────────────┐         ┌──────────────┐         ┌──────────────────────┐
│  Reclassify │◄────────│     DEM      │────────►│  Filter and Reclassify│
└──────┬──────┘         └──────────────┘         └───────────┬──────────┘
       ▼                                                     ▼
┌──────────────────┐                               ┌──────────────────┐
│ Elevation Zone Map│                              │    Slope Map     │
└──────────────────┘                               └──────────────────┘
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Figure 1.1 Flow Diagram of Methodology of Generation of DEM, Elevation Zone Map and Slope Map using GIS

6. RESULTS

The aim of the project was to make wasteland inventory and recommend the management tools as mitigatory and preventive measures. Hence, the work was executed at the following sectors:

- Drainage
- DEM
- Elevation Zone Map
- Slope Map
- Wasteland Inventory
- Recommendation of Management Aspects

Following inferences were drawn from the study:

1. Area of the watershed area was calculated to be 22.8 sq. km. or 2280 hectares.
2. The drainage pattern of Bhama is dendritic and it is a fifth-order stream. Most of the tributaries on both the banks are of third or fourth order.
3. DEM is the 3-D presentation of the surface derived by the interpolation of contour map. It represents x, y and z-axes in pixel size of the order 23.5 meters. The altitude or z axis ranges from 600 meters to 1230 meters above sea level.
4. Elevation Zone Map was derived from DEM. The altitude zones ranges from 600 meters to 1250 meters above sea level. (Appendix 2)
5. Digital slope was derived from DEM on pixel size of order 23.5 meters. (Appendix 3)
6. Digital Image Processing was done using various modules available in ILWIS 3.0. The satellite image obtained from IRS 1B LISS II on January 1998 was processed and then unsupervised classification as well as supervised classification was done. The following classes were identified from cluster image:

- Current fallow
- Dense forest
- Open forest
- Single cropped land
- Stony waste
- Upland with or without scrub

The supervised classification of the image was done using ground truth, maximum likelihood classifier. The classes identified are as follows:
- Open forest
- Current fallow
- Double cropped area
- Single cropped area
- Gullied or ravenous land
- Steep slope
- Stony waste land
- Upland with or without scrub

7. The gullied land is seen on the left bank of the river in the downstream region of the watershed area. In this region the ridge to valley width is higher than anywhere else. The slope is moderately steep.
8. The stony waste is extended in the source area. The slope in this area is very steep. The causative agents can be reel erosion, which removes the topsoil layer in the lower pediments on gently clopping areas. The underlying exposed rock is predominantly basaltic.
9. The association of the stony waste can be drawn with uncontrolled tree felling in the upland. It indicates the alarming rate of deforestation.
10. Current fallow is distributed in large proportion. It is mainly loose soil and is exposed to torrential rainfall on onset and withdrawal of the monsoon. It thus causes the loss of soil and contributes to formation of wasteland like gullied areas and also the upland without grassland.
11. Due to torrential rainfall, the eroded parts and also the grit act as erosive tool. These scrapes the gullies in its course downstream.
12. In the upstream, the management aspects like grassing, plantation and afforestation are largely practiced.

7. RECOMMENDATIONS:

The recommended reclamation and the management strategies of the wastelands in Bhama watershed are as tabulated below (Table #)

Sr. No.	Wasteland Type	Reclamation method	Suggested land use	Remarks
1	Gullied and /or ravenous land	Leveling of gullies or ravines Construction of check dams Gully plugging	Afforestation Fodder and fuel Agro-hortculture	Reduces erosion
2	Upland with or without scrub	Contour bunding Contour trenching Contour terracing Leveling Providing irrigation facilities	Natural regeneration of vegetal cover Forest plantation Sericulture Agriculture Grass/pastures	Protection or survival of plant is very important
3	Under-utilised/degraded forest land	Regulate grazing activity Restrict illegal forest felling	Terrace cultivation Permanent cultivation	
4	Stony waste and pastures	Regulate grazing activity	Pasture development	

8. CONCLUSION:
The study was conducted with the view to propose appropriate management strategies to reclaim the wastelands in the watershed area. The application of RS data and the ILWIS 3.0 Academics was very helpful in this venture. RS and GIS prove to be very comprehensive in the study of large areas like watershed where integrated and simultaneous activities have to be executed. Water has to be preserved. Water preservation will remain incomplete if the preventive measures are not undertaken. It is predicted that War for water is imminent. So, RS and GIS techniques should be explored and implemented appropriately. The natural resources are our Common Property so we should brainstorm and work hand in hand towards their conservation and preservation.

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Appendix

A.1 Classification of Wasteland

Category			Area (Million hectares)
Culturable Wasteland	1 2 3 4 5 6	Salt affected land Gullied or ravenous Waterlogged or marshy land Undulating upland with or without scrub Jhum or forest blank Sandy areas	3.90 4.32 0.89 10 79 2.40 10.53
			32.83
Culturable Wasteland	7 8	Barren hill ridge or rocky outcrop Anow covered area	2.25 17.70
			20.45
Total			**53.3**

Source: Mapping of Wastelands in India, 1985, NRSA, Hyderabad

A.2 The attribute table of Elevation Zone Map:

Class	Altitude (meters MSL)
H1	600
H2	700
H3	800
H4	900
H5	1000
H6	1100
H7	1200
H8	1300

A.3 The attribute table of Slope Map

| Slope Class (%)	Description
<1	Nearly Level
1-3	Very Gentle Slope
3-7	Gently Sloping
7-15	Moderately Sloping
15-25	Steep
25-45	Very Steep
>45	Very very steep

FALSE COLOUR COMPOSITE
Bhama Watershed Area, Khed Taluka
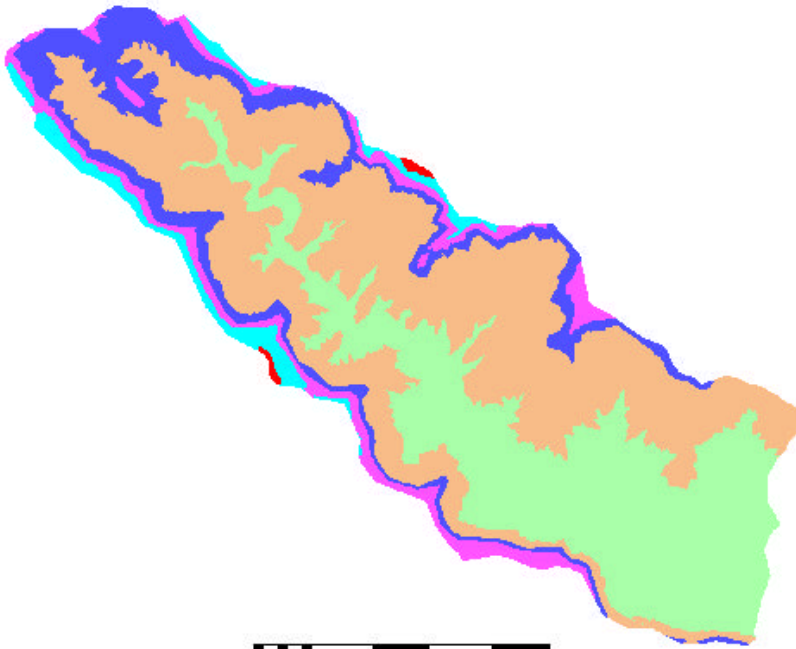(IRS 1B, LISS II, Feb 1998)

0   6000
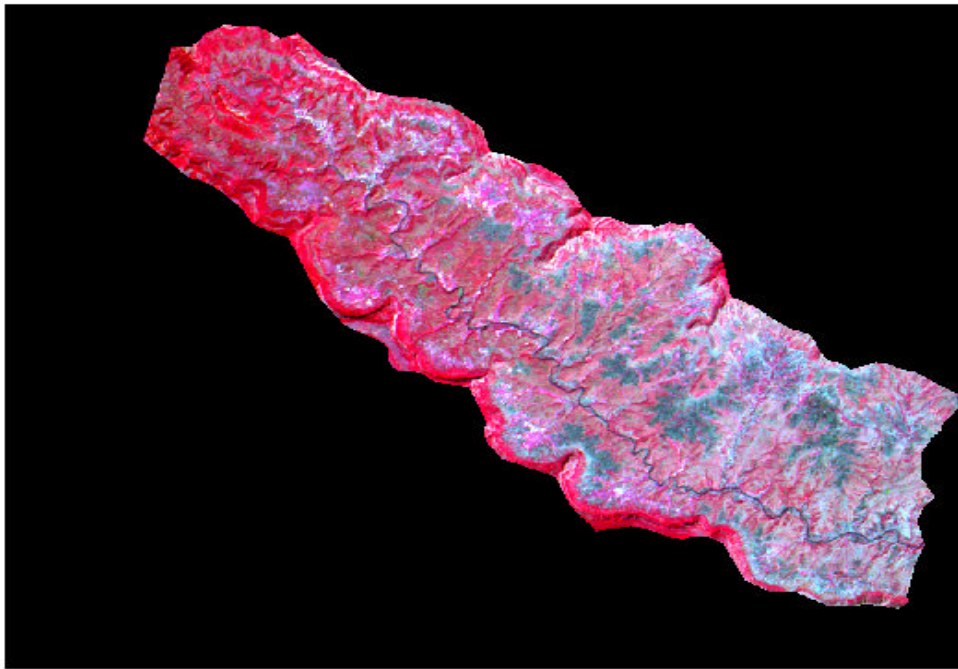
DIGITAL ELEVATION MAP
Bhama Watershed Area, Khed Taluka, Maharashtra
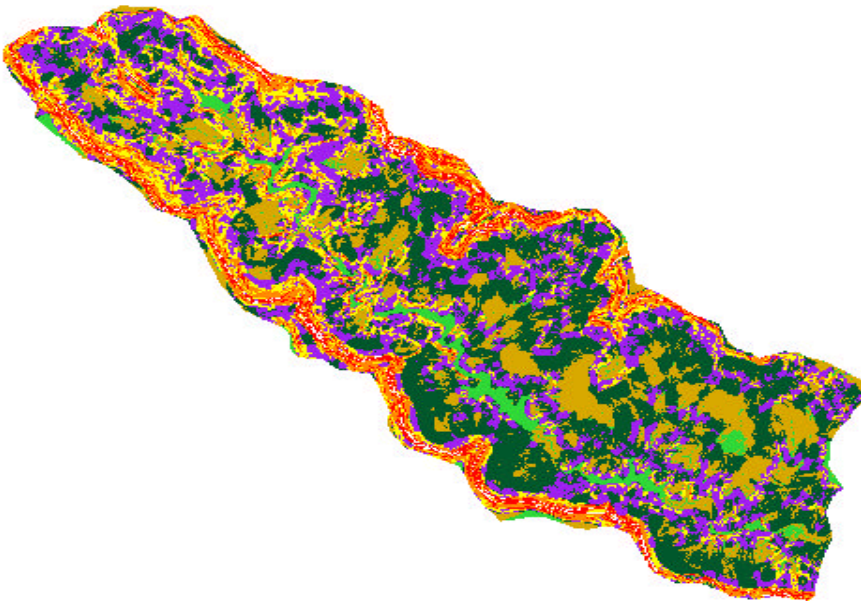(Digitized from contours obtained from topographic maps)

Elevation (meters)

1230.00

1108.00

986.00

864.00

742.00

620.00

0   15 km

ELEVATION MAP
(Bhama Watershed, Khed

N
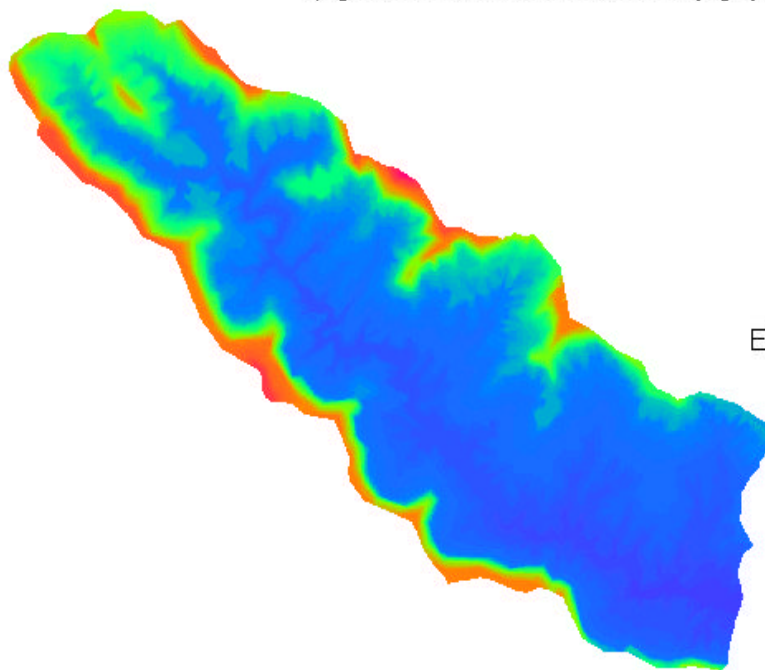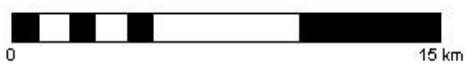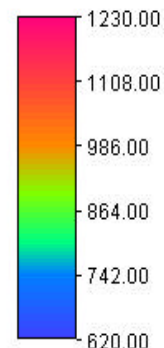
Height above mean
sea level

- Below 700 Meters
- 700-800
- 800-900
- 900-1000
- 1000-1100
- Above 1100

0   10 km

SLOPE MAP DERIVED FROM DEM
(Bhama Watershed, Khed Taluka)

N

- Nearly Level
- Very Gentle
- Gently sloping
- Moderately Sloping
- Steep
- Very steep
- Very very steep

0   10 km

UNSUPERVISED CLASSIFICATION
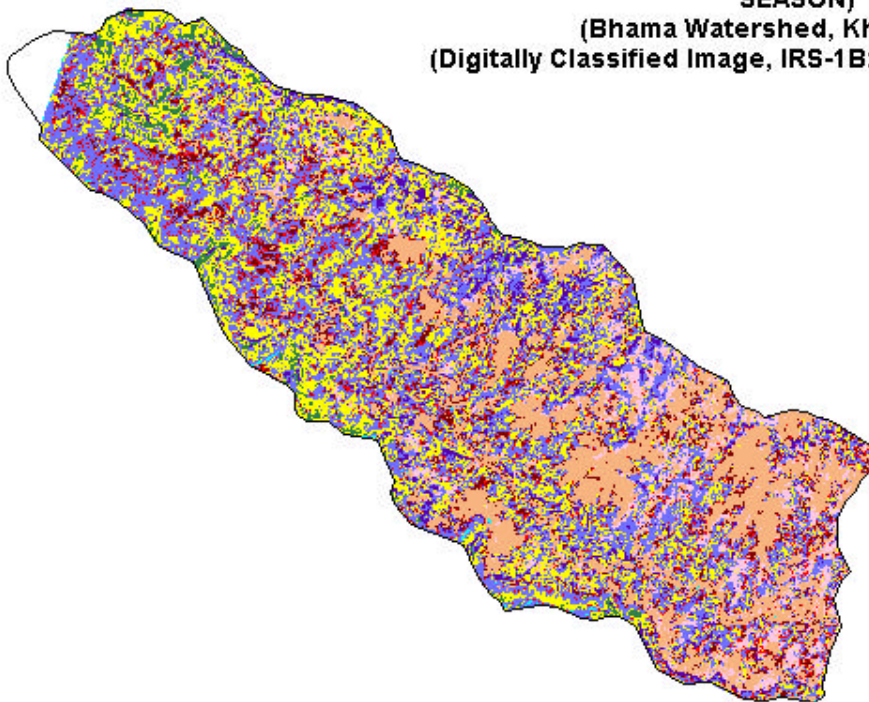(Bhama Watershed, Khed Taluka)
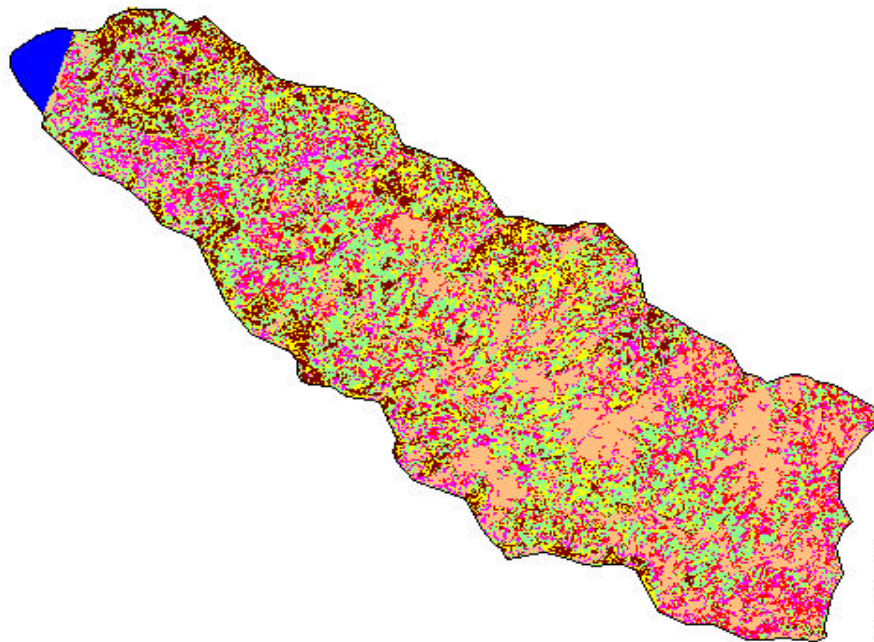
Clusters

- Current Fallow
- Dense Forest
- Open Forest
- Single cropped
- Stony Waste
- Upland with or without scrub

0   10 km

WASTELAND INVENTORY & OTHER LAND USES (POST-RAINY SEASON)
(Bhama Watershed, Khed Taluka)
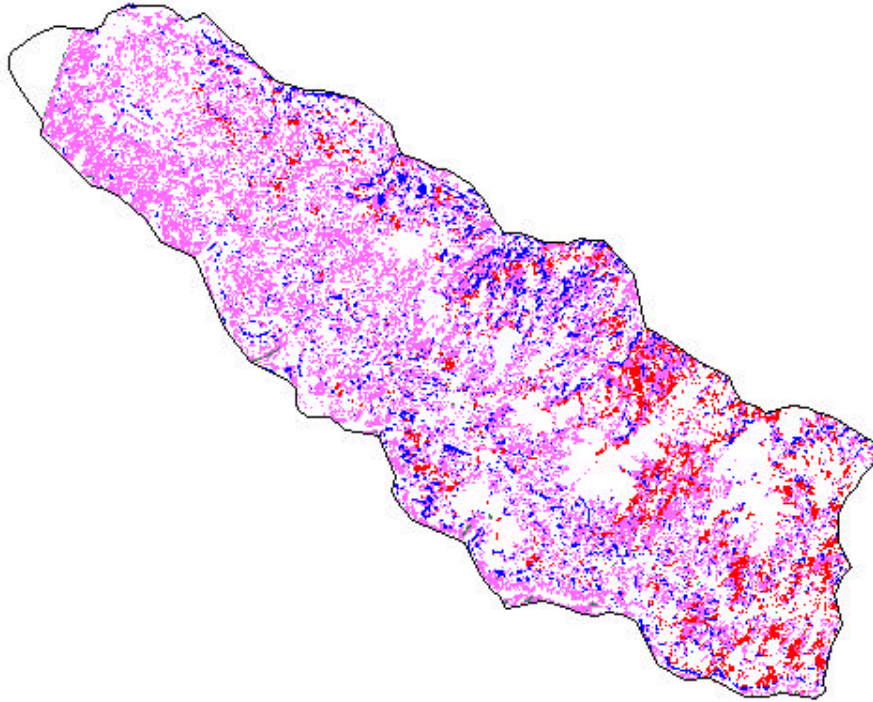(Digitally Classified Image, IRS-1B: LISS II, January, 1998)

Land use/ Land cover classes

- Current Fallow
- Dense forest
- Double cropped
- Gullied or Ravenous Land
- Open forest
- Single cropped
- Steep sloping area
- Stony waste
- Upland with or without Scrub

0   10 km

WASTELAND MAP
(Bhama Watershed, Khed

N

- Gullied or ravenous land
- Steep sloping areas
- Stony waste
- Upland with or without scrub

0   10 km