Water Storages Study in Hilly Terrain Using GIS and Remote Sensing Techniques

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ABSTRACT: (9 pt)

Water is a critical resource, it is mandatory to avail enough to meet the requirements of people for their daily consumption for drinking and household requirements. It is basic input for development in urban and rural sectors. The unregulated urban growth, rapid increase in the settlement area, disposal of domestic sewage in open drains passing through the water resources, erratic rainfall trends, continuous growth in population, deforestation etc are major factors affecting the water resources. The ignorance of people and poor management are also cause of decline in the available water resources in a hilly terrain. Springs and seepages occur where sloping ground and impermeable strata intersect with the water table (an imaginary line of water below ground). Occurrence of unconfined springs mainly depends on recharge area characteristics such as permeability of top soil, soil structure and depth, geology of the area, slope of the ground and surface cover characteristics. The number of springs and seepages are vanishing. It is the customary to start habitation near the available water resources in an area. With the passage of time an unregulated growth in such settlement area took place. Pollution grows with the increase in population. Deforestation takes place in order to provide more land for urbanization and agriculture.

Present study helps in identifying some of the factors affecting these water resources (springs and seepages) in hilly terrain. The remotely sensed data (Landsat images) has been mainly used to extract change in the study area from 1990 to 2010 for the Almora town is located at 29° 36' N and 79° 30' E in an altitudinal range of 1500–1700 m above mean sea level in the Kumaun Lesser Himalaya, Uttarakhand, India. The images are classified and derived statistics is used to compare temporal change in the study area. Geovisulization view of GIS is used for visualizing and analyzing the available data across time and effect of various factors.

1. INTRODUCTION

Water is a critical resource, it is mandatory to avail enough to meet the requirements of people for their daily consumption for drinking and household requirements, irrigation and other uses. There are different types of water resources based on the geological characteristics of an area. There are factors like erratic rain patterns, continuous population growth, unplanned urbanization and increase in settlement area, deforestation, amalgamation of filthy and polluted water into the recharge area of water resources.

The land-cover changes occur naturally in a progressive and gradual way, however sometimes it may be rapid and abrupt due to anthropogenic activities. Remote sensing data of better resolution at different time interval help in analysing the rate of changes as well as the causal factors or rivers of changes (Ramachandra, et al, 2004). Some noteworthy applications of remote sensing and GIS for natural resources management are available in literature (Huggel et al. 2002, Rawat et al. 2011, Rawat et al. 2012, Thompson et al. 2010, and Ukita et al. 2011).

Springs and seepages occur where sloping ground and impermeable strata intersect with the water table (an imaginary line of water below ground). Occurrence of unconfined springs mainly depends on recharge area characteristics such as permeability of top soil, soil structure and depth, geology of the area, slope of the ground and surface cover characteristics (Drever, 1982). There were 99 springs and seepages present before 1990 according to a survey. The number of these water resources is around 60 at present in the study area. The domestic sewage of the town is disposed untreated through cesspools, sanitary landfills and unlined open drains.

It is the customary to start habitation near the available water resources in an area. With the passage of time an unregulated growth in such settlement area takes place. Pollution grows with the increase in population. Deforestation takes place in order to provide more land for urbanization and agriculture. Prime objectives of the present endeavor are to study factors affecting springs and seepages of the study area. The specific objectives are to classify the study area into various land cover classes using Landsat images there by study of changes in forest and settlement areas, study rainfall and population change to deduce their effects in the water resources.

2. STUDY AREA

Almora town is located at 29° 36' N and 79° 30' E in an altitudinal range of 1500–1700 m above mean sea level in the Kumaun Lesser Himalaya, Uttarakhand, India. It is located on a ridge at the southern edge of the Kumaon Hills of the Himalaya range. In the shape of a horse saddle shaped hillock, it is surrounded by thick forests of pine and fir trees. Flowing alongside the city are rivers of Kosi (Kaushiki), and Suyal (Salmale). The snow capped Himalayas surrounds the town. The town is the seat of the district administration (Kumar, et al, 1997).

In Almora town, favorable geological characteristics in the form of fractured mica schists with interbedded thin layers of quartzite, are responsible for the occurrence of a number of springs within the town boundary.

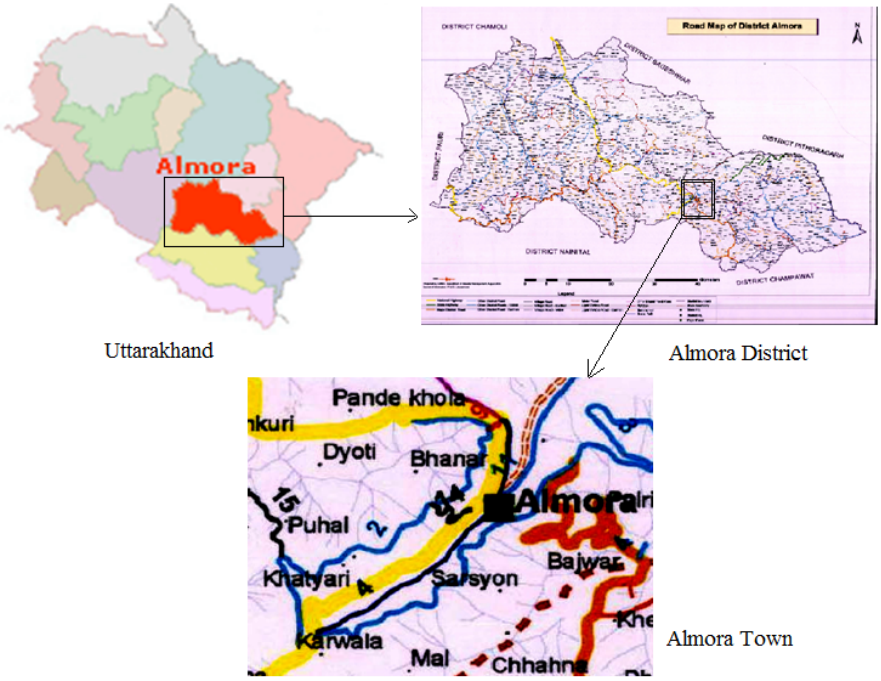


Figure 1: Study Area

3. METHODOLOGY

A major steps adopted in methodology to study the factors affecting the water resources of the study area are presented in the flow chart (Figure 2).

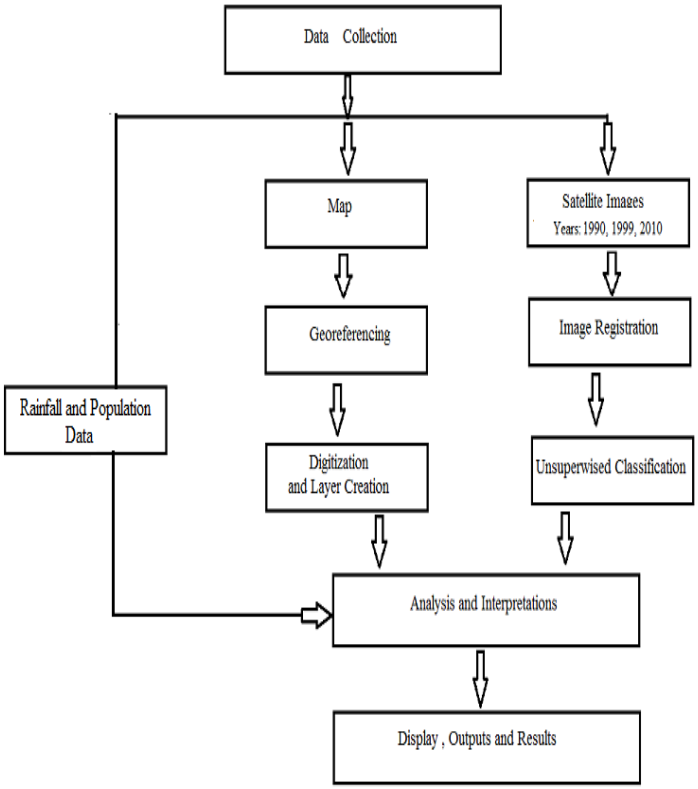


Figure 2: Major steps of the Study of Depletion of Springs and Seepages

Data Collection

1. Map of District Almora was collected from Disaster Management Office, Dehradun.
2. Kosi River Discharge Data and Rainfall Data were collected from Kumaun Sinchai Khand, Almora.
3. Existing drianage system map was collected from Nagar Palika, Almora.
4. Locations of reservoir of Kosi Jal Pariyojana were collected from Jal Sansthan, Almora.
5. Information about springs and seepages is based on the book " Parvatiya Jal Shrot" by Mr. Praful Chandra Pant, Personal Assistant of D.M. Almora.
6. Population Data is taken from the book "Parvatiya Jal Shrot" by Mr. Praful Chandra Pant, Personal Assistant of D.M. Almora and using the internet link http://www.north-india.in/

7. Satellite images of the study area for years 1990 and 1999 are downloaded from *Global Land Cover Facility (*www.landcover.org*). Satellite image of* the study area for year *2010 is downloaded from USGS.*

Software Used

ERDAS IMAGINE 2010: For processing and classification of satellite images

ArcGIS 9.3: Used for georeferencing and digitization of map.

4. RESULTS AND DISCUSSIONS

4.1 Satellite Images and Classification

In order to study the growth in settlement area LANDSAT images of 1990, 1999, and 2010 are taken. Image 1990 and 1999 are taken for the month of October, and 2010 is taken for the month of November. All three satellite images were classified into four major classes identified in the images named Forest, Settlement, Vegetation, and Bare land. The area surrounding Almora Town is cropped for deriving statistics to deduct change in Forest and Settlement classes.

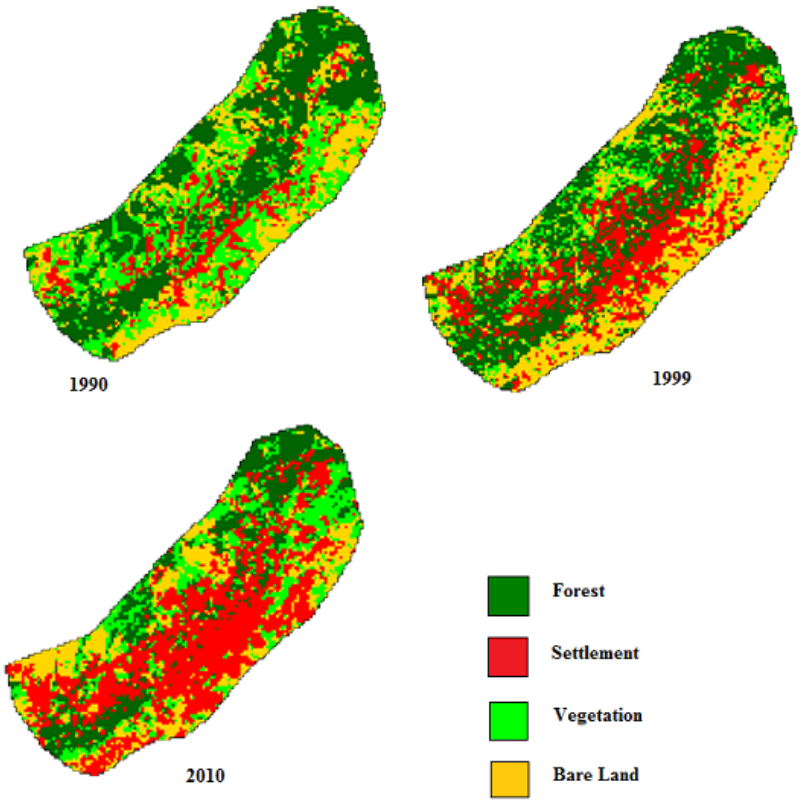


Figure 3. Classified Images

The area covered by various classes by using statistics of the classified images is shown in Table 1.

Table 1: Area (Hectare) Covered by Different Classes

S. No.	Class Name	Area (Hectare)		
		1990	**1999**	**2010**
1	Forest	261.46	254.07	142.31
2	Settlement	89.43	166.27	286.72
3	Vegetation	193.40	100.15	142.23
4	Bare land	159.61	183.41	132.64

4.2. Change in Settlement Area

There is a drastic increase in settlement area. The statics shows the settlement area increased approximately by the factor of 2 from 1990 to 1999 and increased by the factor 3 from 1990 to 2010 Figure.4.

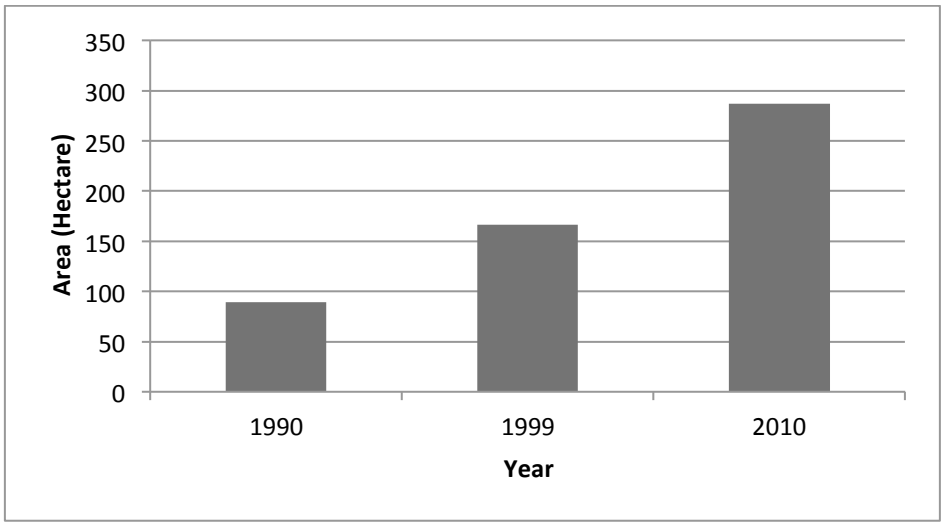


Figure 4. Chart showing change in settlement area in different year

4.3. Change in Forest Area

The forest area is reduced one-half from 1990 to 2010 as evident from Figure 5.

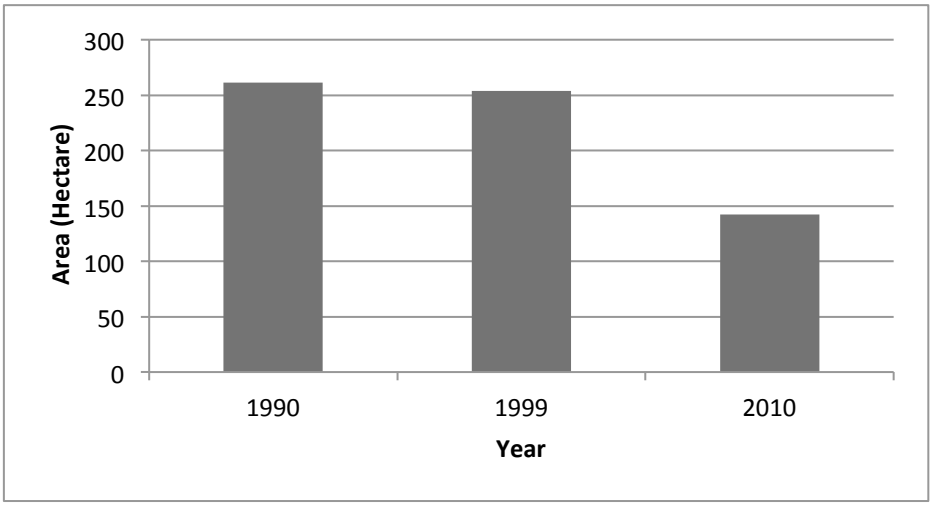


Figure 5. Chart showing change in forest area

4.4. Effect of Rainfall

The average rainfall (mm) for 74 years is 1561.08 mm, which is decreased to the average of 855.04 mm for last 10 years, with the worst case of 591.1 mm in 2001. The springs and seepages are recharged by the rain water. The statistics shows the countable decrease in the rainfall and its erratic pattern Figure 6.

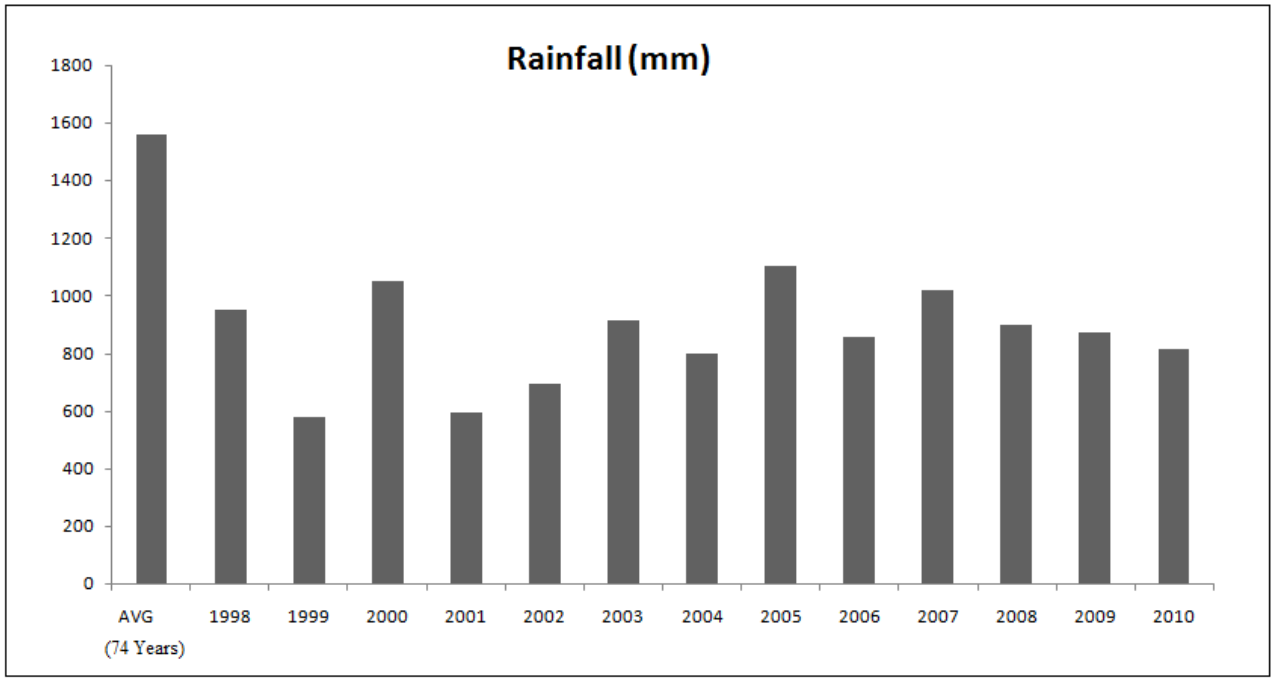


Figure 6: Rainfall (mm)

4.5. Effect of Population

The town is the seat of the district administration and is spread over an area of 9.03 square km. There is a constant increase in population of the town; therefore consumption of water is increased gradually Fig.7 .

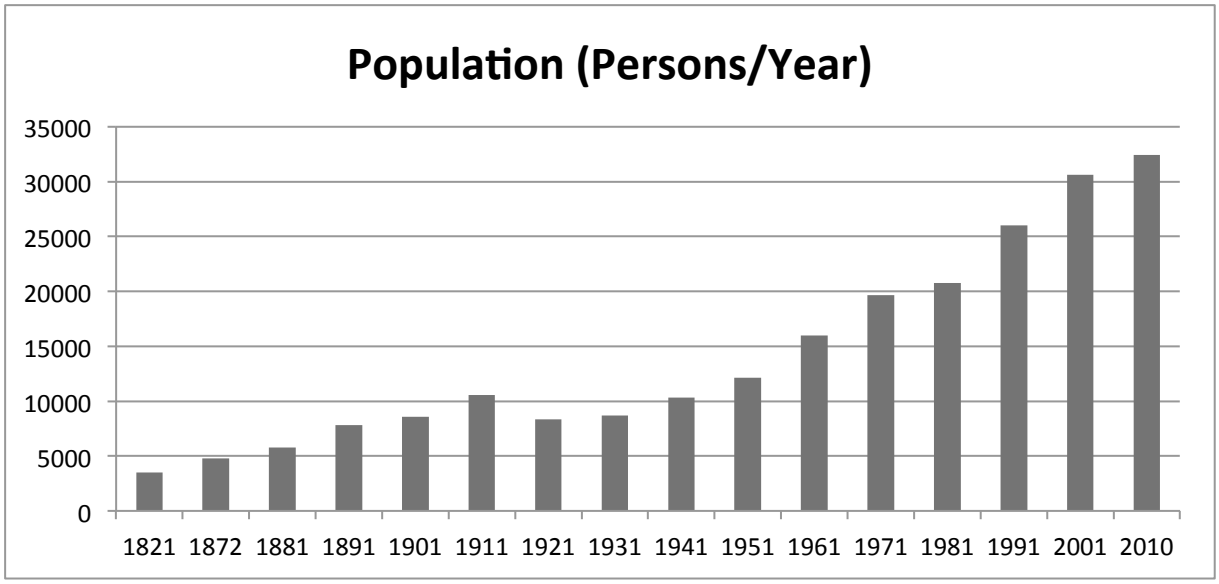
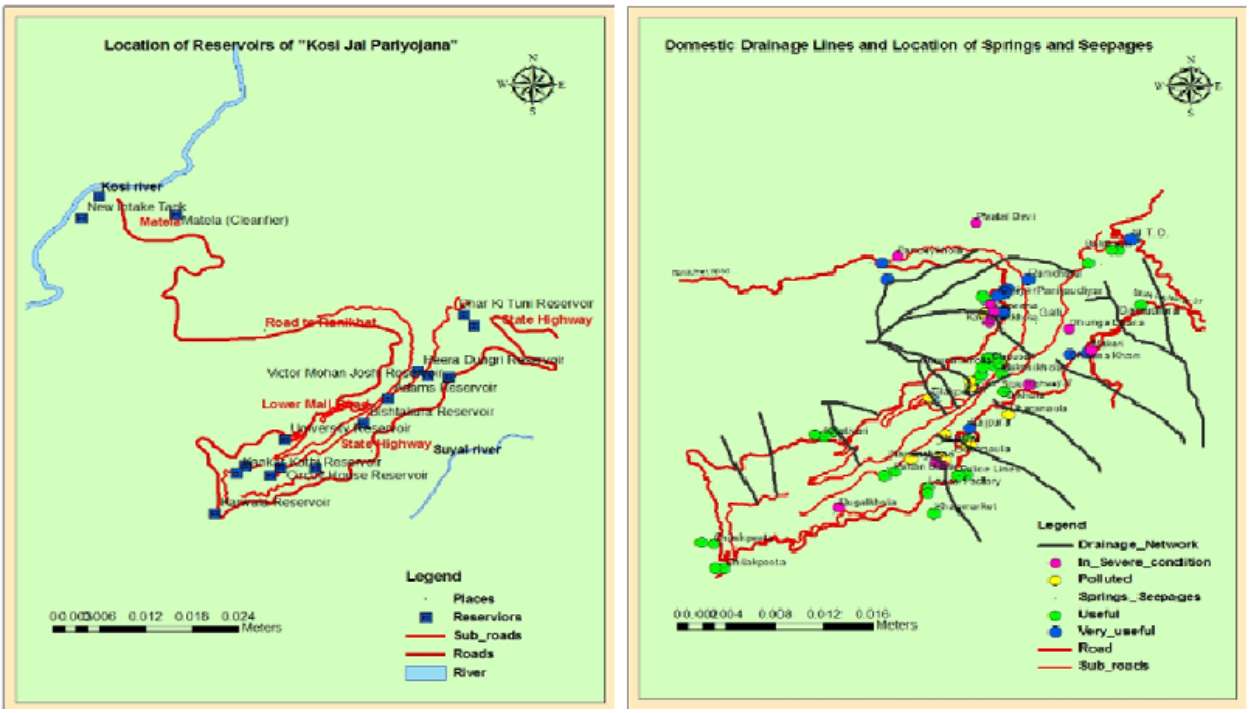


Figure 7. Graph showing Growth in Population of Almora Town

4.6. Effect of Existing Water Supply Scheme and Existing Domestic Drainage Lines

Water extracted from river Kosi is distributed to the reservoirs spread across the town. From these reservoirs supply is made to almost all the areas via water supply connections provided by “Jal Sansthan”. With the availability of water at the door people are careless for the sanitary and maintenance of the springs and seepages Fig.8a .

The domestic sewage of the town is disposed untreated through cesspools, sanitary landfills and unlined open drains. The two layers containing information about main drainage lines and classified springs and seepages are combined to find the effects of filthy drainage water on these water resources. It is found that those springs and seepages are polluted more severely which are situated beside the domestic drainage lines Fig.8b.



a b

Figure 8. a. Location of Reservoirs of Kosi Jal Pariyojana in the Almora Town. b. Location of existing springs and seepages and main drainage lines

5. Conclusions

The study of spectral patterns of the land cover in the present work gives the distribution of important land cover classes. The statistics shown in the present study is useful in identifying effects of these classes on water resources. There is a drastic change in the settlement area. The settlement becomes denser with time. The statistics shows the settlement area increased approximately by the factor of 2 from 1990 to 1999 and increased by the factor 3 from 1990 to 2010. That is increasing at the cost of decreased recharge area for the springs and seepages. There is a continuous decrease in the forest area. Approximately one half of forest area is decreased from 1990 to 2010. The springs and seepages are recharged by rain water. The temporal pattern of rainfall showed that ratio of average rainfall (mm) before 1980 and average rainfall (mm) for last 10 years is approximately 1:2. That is the main cause of decline of flow in these water resources.

Those springs and seepages are polluted completely that are situated near the drainage line containing domestic filth and garbage. The polluted water from these public drainage lines are absorbed by land of the recharge area of the polluted springs and seepages. The development of residential area always started beside the available water resources. The growth in population demands more area for residential purpose which directly consumes land nearby already settled areas which in turn occupies recharge area of these water resources.

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