IMPACT OF CLIMATE CHANGE ON LAND USE/LAND COVER USING REMOTE SENSING AND GIS IN CHOPAN WATERSHED, GUNA, MADHYA PRADESH (INDIA)

Mohd Yousuf Khanday* and Akram Javed

Department of Geology, Aligarh Muslim University Aligarh (INDIA)

*E-mail : ykhanday@gmail.com

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ABSTRACT

The satellite remote sensing provides a synoptic view of the earths surface and offers varied advantages hence has been widely accepted as a technique for mapping as well as monitoring of changes in land use/land cover. The present study makes an attempt to find out land use/land cover changes and its correlation with changes in climate over a period of 12 years using IRS data and GIS in Chopan watershed, Guna district of Madhya Pradesh (India). Standard methods of visual interpretation based on photographic and geotechnical elements were followed to delineate various land use/land cover categories such as cultivated land, uncultivated land, open forest, dense forest, open scrub, waste-land, water body, built up land. It was found that the area under cultivated land has decreased from 18.29 to 16.35 km^2 (-1.45%), uncultivated land has increased from 8.24 to 24.28 km^2 (12.02%), open forest has decreased from 38.05 to 36.95 km^2 (-0.83%), dense forest has decreased from 42.15 to 29.21 km^2 (-9.7%), open scrub has decreased from 14.86 to 3.80 km^2 (-8.29%), wasteland has increased from 9.91 to 19.03 km^2 (6.84%), water body has increased from 1.02 to 2.37 km^2 (1.02%), and the extent of built up land has also increased from 0.70 to 1.23 km^2 (0.40%) during twelve years (1989-2001), period.

Analysis of the temperature data of 1986-2003 from Guna district has been divided into three seasons as summer, winter and monsoon indicated that the day time temperature has increased by 1.63˚C, 1.83˚C and 0.15˚C, whereas night time temperature has also increased by 1.03˚C, 1.58˚C and 0.98˚C respectively during the past 17 years. At the same time analysis of historic rainfall data indicated that there is a great variation in the annual rainfall which varied from 1338.7mm in 1990 to 83.1mm in 1996. The increase in uncultivated land, wasteland, water body and decrease in cultivated land, are attributed in increasing trends in the meteorological parameters, however decrease in forest (Open as well as dense) may attributed to increase in population and built up land.

Key Words : Climate change, Land use, Land cover, Remote Sensing, GIS.

INTRODUCTION

Over the 20th century there has been a consistent, large scale warming of both land and ocean surface and is likely that most of the observed warming over the last 50 years has been due to the increase in green house gas concentration. The Global mean surface temperature has increased by 0.6˚C over the last 100 years, with 1998 being the warmest year and the 1990s being the warmest decade. The maximum increase in temperature has been

*Author for correspondence

observed over the mid and high latitudes of the northern continents, land areas have warmed more than the oceans, and nighttime temperatures have warmed more than daytime temperatures. Since the year 1950, the increase in sea surface temperature is about half that of the increase in mean land surface air temperature, and the nighttime daily minimum temperatures over land have increased on average by about 0.2^0C per decade, about twice the corresponding rate of increase in daytime maximum air temperatures. Precipitation has very likely increased during the 20^{th} century by 5 to 10% over most mid and high latitudes of northern hemisphere continents, but in contrast it has decreased by 3% on an average over most of the subtropical land areas. Increasing global mean surface temperature is very likely to lead to changes in precipitation and atmospheric moisture because of changes in atmospheric circulation, a more active hydrological cycle, and increase in the water-holding capacity throughout the atmosphere. There has likely been 2 to 4% increase in the frequency of heavy precipitation (50mm in 24 hours) events in the mid and high latitudes of the northern hemisphere over the latter half of the 20^{th} century. There were relatively small increases over the 20^{th} century in land areas experiencing severe drought or severe wetness in many regions, these changes are dominated by inter and multi-decadal climate variability with no significant trends evident[4].

The terms land use and land cover (LULC) are often used synonymously to describe maps that provide information about the type of features found on earth's surface (land cover) and the human activity that is associated with them (land use). Land use/land cover is one of the commonly used methods for development, planning and proper management of natural resources. Natural resources are being depleted with the corresponding increase in population and poor land management practices. Since the beginning of human civilization, mankind has lived in a close relationship with nature. While mankinds interdependence on environment is greater than that of any other organism; his restless pursuit of progress, comfort and security has resulted in increased stress on the environment which has led to land use/land cover changes over a period of time. Information on existing land use/land cover, its spatial distribution and change are essential pre-requisite for planning[7]. Thus land use planning and land management strategies hold key for development of any region[3]. In order to use the land optimally, it is not only necessary to have information on existing land use/land cover but also the capability to monitor the dynamics of land use change. For small and easily accessible area a suitable land cover may be based on ground observation and surveys. However such methods quickly become less feasible, if the area is too large or difficult to access. With the emergence of satellite remote sensing which provides a synoptic view of the earth's surface coupled with repetitive coverage, it has become possible to monitor the changes on a regular basis. For sustainable use of land resources it is very important to understand land use/land cover changes and its implications on ecosystem to identify the rate of change in land use/land cover, key drivers which cause land use/land cover changes[1,10] and their association with climate at regional scale require data analysis over a considerable period of time and space[1,12]. Change detection and monitoring can be done using multidate image to evaluate difference in land cover. This may occur due to human activity for development or by changes in environment conditions[20]. Landsberg[12] has indicated that when deforestation occurs and swamps or water bodies are drained, the climate is invariably altered due to changes in albedo. It is generally known that water bodies and wetlands have a property to buffer the heat and thereby reduce the daytime air temperature of the surrounding areas. Studies on the urban climate of Visakhapatnam City by Hemamalini and Rao[8], and in parts of Eastern Ghat region by Hemamalini and Rao[9] have indicated changes in climate as a result of altered land use/land cover.

Several studies have revealed that the micro-level changes of climate in terms of rainfall and temperature variations are related to albedo changes, which in turn could be land use/land cover modification. Charney et al[5] based on their model experiments have stated that when an area is experiencing appreciable evaporation, an increase of albedo causes reduced absorption of solar radiation by ground leading to a continuous flow of latent heat into the atmosphere which leads to decrease of the cloud cover and rainfall. Based on similar experiments, Chervin[6] has concluded that although there may not be any change of the global average, precipitation changes locally due to alteration of albedo. Meher-Homji[15] has observed that under barren conditions the albedo is as high as 30% as a result of which most of the solar radiation is reflected back to the atmosphere heating the upper layers of the atmosphere and thereby increasing the subsidence *i.e.* the downward sinking motion of the air leading to a reduction in the incidence of precipitation. The present study makes an attempt to find out the impact of climatic change on land use/land cover using multidate remote sensing data and GIS techniques in Chopan watershed of Guna district, Madhya Pradesh (India).

STUDY AREA

Chopan watershed lies in the southern part of Guna district of Madhya Pradesh and is seven and a half kilometer away from the main head quarter Guna, covers an area of about 133.38 km^2 lying between 77^o 15' 10" to 7^o 23' 20" E longitudes and 24^o 29' 20" to 24^o 38' 09" N latitudes. The maximum and minimum elevation encountered in the watershed is 570 m and 420 m above MSL respectively. The main Chopan stream flows almost South to North, abruptly changes its course and flows East to West at (24^{o}35' N and 77^{o}20' E). A check dam is built on the Chopan river in the western part of the watershed, which primarily serves as the source for G. P. Engineering College, Gail Companies (Gas Authority of India Limited) and National Fertilizer Limited for their domestic and industrial needs. Apart from this structure there are no other sources of irrigation and agriculture is mainly rain fed. There are nine villages in the study area and the main occupation of the villagers is agriculture activity. Soyabeen, Paddy and groundnut are the main Kharif crops whereas Wheat and Gram are the main Rabi crops. The area is represented by black and lateritic soils developed on steep, moderate and gentle sloping lands, and the thickness of black soil varies from 1 to 4.5 mbgl[20]. Geologically the area is represented by recent alluvium of recent age, some Laterites of Pleistocene and few deeply weathered exposures of Deccan traps of upper cretaceous to Eocene age are also reported in the area. The drainage in the area is dendritic to sub-dendritic. Locally parallel to sub-parallel pattern has also developed. The climate of the study area experience generally dry weather expect during the southwest monsoon season and the average annual rainfall is about 1042mm. Monsoon starts by about 15 June and withdraws by the last week of September. The maximum temperature rises up to 45^{o}C in June while minimum temperature can be as low as 7.9^{o}C in January. Chopan watershed represents a typical rain fed watershed, representing a varied slope from south to north and abruptly changes its course from east to west, defined by the course of Chopan trunk stream **(Fig. 1)**.

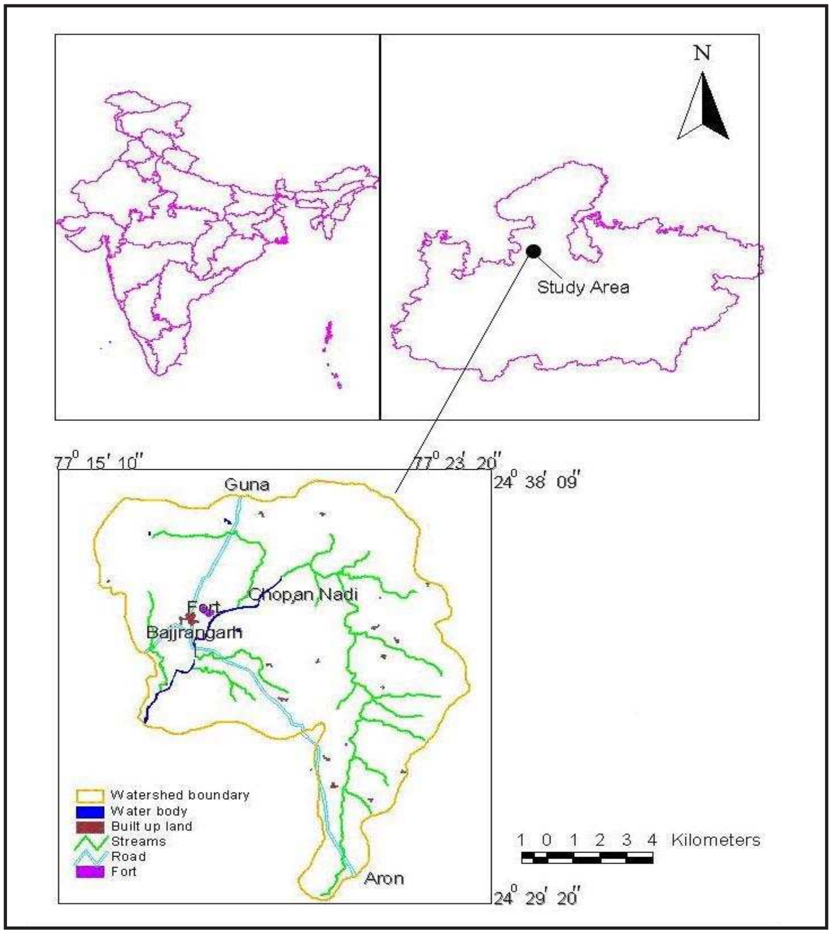

Fig. 1 : Location map of the study area

Data Used

Geocoded False Colour Composites (FCCs) of IRS 1A LISS II (Path-Row: 28-50) of 8 February, 1989 and IRS 1C LISS III (Path-Row: 97-54) of 27 February, 2001 of band combinations green, red and near IR used for deriving information on various parameters of watershed. The data correspond to nearly the same period/season in order to minimize seasonal variations. The Survey of India (SOI) topographic sheets No.s 54 H/6 and 54 H/7 (Scale 1:50,000) of 1982-83 was used for preparation of base map. Meteorological data on annual average maximum and minimum temperatures and annual average rainfall for the period (1986 - 2003) were obtained from IMD (Indian Meteorological Department), Pune. Besides, secondary information on the study area was collected from published and unpublished government sources and ground truth data was also taken as one of the inputs in the final analysis.

METHODOLOGY

The Survey of India (SOI) topographic sheets were used for preparation of base map. In order to analyse the land use/land cover patterns in the study area, standard visual image interpretation method based on photographic and geotechnical elements such as tone, texture, size, shape, pattern, association and field knowledge was followed to delineate various land use/land cover categories using IRS LISS II FCC of 1989 and IRS LISS III FCC of 2001. Limited ground truth verification was carried