ISSN: 0976-3376

Available Online at http://www.journalajst.com

ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Asian Journal of Science and Technology
Vol. 08, Issue, 08, pp.5333-5341, August, 2017

RESEARCH ARTICLE

LAND USE CHANGES AND THEIR IMPACT IN FLOOD ZONE OF GHAGGAR RIVER IN AMBALA DISTRICT, 2001-2011

***Priyanka**

Research Scholar, Department of Geography, MDU, Rohtak

ARTICLE INFO

Article History:
Received 29th May, 2017
Received in revised form
30th June, 2017
Accepted 04th July 2017
Published online 31st August, 2017

Key words:

Land Use/Land Cover,
Flood Buffer Zone,
Remote Sensing, GIS.

ABSTRACT

The study of basins to attempt to assess the impact to land use change has a long history from last one hundred years. Since the twentieth century, the frequency of global flood disaster has been higher than any time before one of the important reason is land use/land cover change by human activities. The major change in land use the affect hydrology are afforestation and deforestation, the intensification of agriculture, the drainage of wetlands, road construction, and urbanization (De Roo *et al*., 2001). The main objectives of the study are to assess the land use pattern in Ambala district from 2001 to 2011, to demarcate the area of vulnerability and appreciate effect of flood and to prepare a flood hazard zone in Ghaggar river map through remote sensing and GIS techniques. Urban occupied 2.94 percent of the study area in 2001 which has increases a total of 3.69 percent in 2011 showing net increase of 0.75 percent with an annual rate of increase of 118.189 ha area. Rivers have decreased from 5523.08 ha in 2001 to 5022 in 2011. River occupied 3.51 percent of the study area in 2001 which has decrease a total of 3.19 percent in 2011 showing a net decrease of -0.32 percent with an annual rate of decrease of 50.18 ha area. Flood risk zone were delineated by grouping the polygons of the integrated layer in to different risk zone. Create buffer utility of ARC/Map was used to create buffer zones around the river. Agriculture being the dominant activity in whole of the Ambala district has got maximum area under 500m high sensitive buffer zone. River having their area from 2001 to 2011 recorded growth of 509.87 ha under low sensitive flood prone zone.

INTRODUCTION

Land use is a primary indicator of the extent and degree to which man has modified the land resources. It is the application of human controls in a systematic manner, indicating an intimate relationship between prevailing ecological conditions and man (Vink, 1975). The regional differences in natural environmental and socio economic condition lead to significant regional variations in agricultural land use pattern. The information on the land use provided by the Statistical Abstract of Haryana is based on nine fold classification of land use by Revenue Department, Government of India. Ambala district of Haryana lies between 30º10: 31º35' north latitude and 76º 30': 77º 10' east longitude. Total geographical area of the district is 1574 sq. km. Administratively this district is controlled by Ambala division. It is devide into three tehsils namely Ambala, Barara, and Naraingarh, and sub devided into six development blocks namely Ambala 1, Ambala 2, Barara, Shahzadpur, Naraingarh. It is bounded by the district Yamuna Nagar in south-east. To its southern lies Kurukshetra district, while in its west are situated Patiala and Roper districts of Punjab and the union territory of Chandigarh. The Shivalik Range of Solan and Sirmaur districts of Himachal Pradesh bounded the Ambala district in the north and north east. The average altitude from the sea level is 900 feet approximately. Ambala district is comprised in 1574 sq. km. As per 2011 Census Ambala tehsil cover 46.63 percentage, Barara 19.31 percentage, and Nraingarh 28.56 percentage.

******Corresponding author:* **Priyanka,**
Research Scholar, Department of Geography, MDU, Rohtak

Data base and research methodology

The present study has been carried out utilizing both primary as well as secondary data sets. Primary data includes Survey of India toposheets on 1:50000 scale. For the study, Landsat satellite images of Ambala district were acquired for the time period; LANDSAT TM 2001 from Global Land Cover Facility, an earth science data interface (GLCF), while IRS-P6 LISS-III, for the year 2011 was obtained from (BHUVAN). The administrative state boundary map was also brought to Universal Transverse Mercator project in zone 43 and later the satellite imageries were clipped with the administrative boundary of Ambala. The different False Colour Composite

(FCC) of Ambala for different periods were prepared. Secondary data collected from government and semi-government departments, and from published and unpublished reports. The general characteristics of the satellite image that has been used for the generation of land use map of 2001 and 2011 are highlighted in the Table 1.

Table 1. Characteristics of Remote Sensing data acquired for the study

Satellite	Sensor	Band	Orbit	Altitude	Swath	Spatial
IRS P6	LISS III	4	24 Days	140 km	141km	Resolution 23m
Landsat5	TM	7	16	750km	185	30m

Source: http://earth.esa.int/web., Source: Landsat.gsfc.nasa.gov

Construction of a Digital Data base: The first step is the transformation of the soft copy into digital form. The preparation of base map of the study area is the first step in the analysis of land use and land cover. Various permanent features like settlement, rivers or any other land based features were to the transferred base map. Thereafter preliminary interpretation of satellite data was carried out and a preliminary interpretation key was prepared. The thematic maps like Base map, Drainage map, Land use/ Land cover map were generated from SOI toposheets of 1961. These toposheets were in photographic TIFF (Tagged image file format) format and were finally registered to a Universal Geographical Coordinate system. The second step involved is the on screen digitization of various themes like, drainage, land use/ land cover, etc in the form of feature data line, polygon and point. The process of digitization was done in ArcMap 9.3 a GIS software. The land use statistics obtained from the attributes tool of raster module of the software were analyzed to draw certain inferences. The absolute change in land use of the two dates was obtained by the difference of the values of different dates of the same category while percentage change was calculated by dividing it with the total area and multiplying by hundred. The ArcView 9.3 was used in preparation of final outputs in the form of maps. They were then exported to photographic formats for hard copy output.

RESULTS AND DISCUSSION

Land Use Change in Ambala District 2001-2011

The land use land cover change that has occurred in the study area from 2001 to 2011 is shown in the table. The figures given in the table 1.2 reveal that the highest change has occurred fellow land, build up, waterlogged area, river and scrub land. Agriculture in the study is witnessing an decreasing trend as the total area under it in 2001 was 134604.0 ha and by 2011 it has decrease 132990.2 ha area. A total area 1617.71 ha has been decreased to the agriculture with an average annual decrease of 161.71ha area thus, registering a net decrease of -1.03 percent. Built-up land increasing rapidly in the study area. Rural has increased from1775.6 ha in 2001 to 3005.1ha in 2011, thus, registering a net increase of 1129.50ha which is by means an insignificant figure. Rural has recorded an average annual increase of 112.95 ha. Rural occupied 1.13 percent of the study area in 2001 which has increased 1.91 percent showing net increased by 0.78 percent with an annual rate of increase of 11.295 ha area.

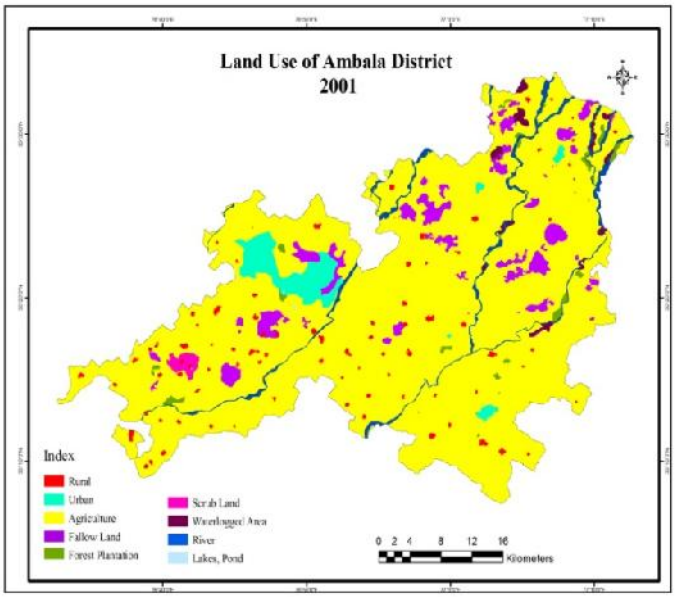


Fig. 1. Source: Generated from LANDSAT TM Satellite Image, 2001

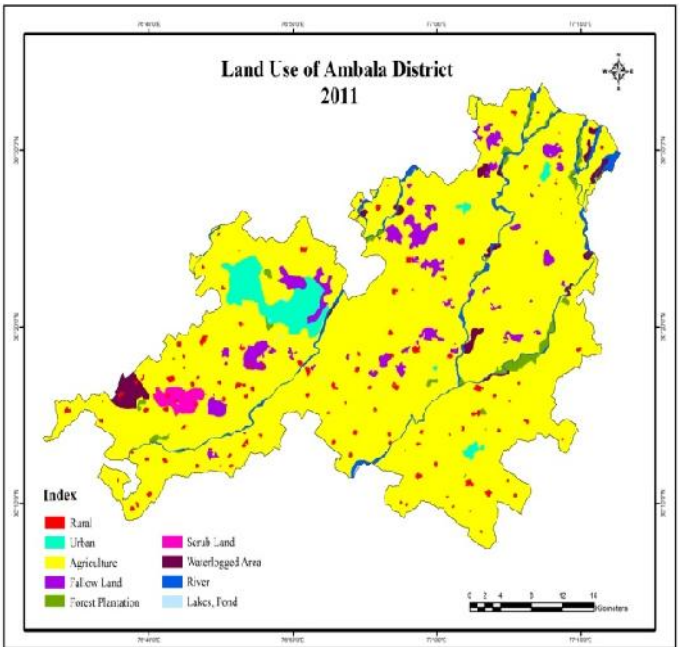


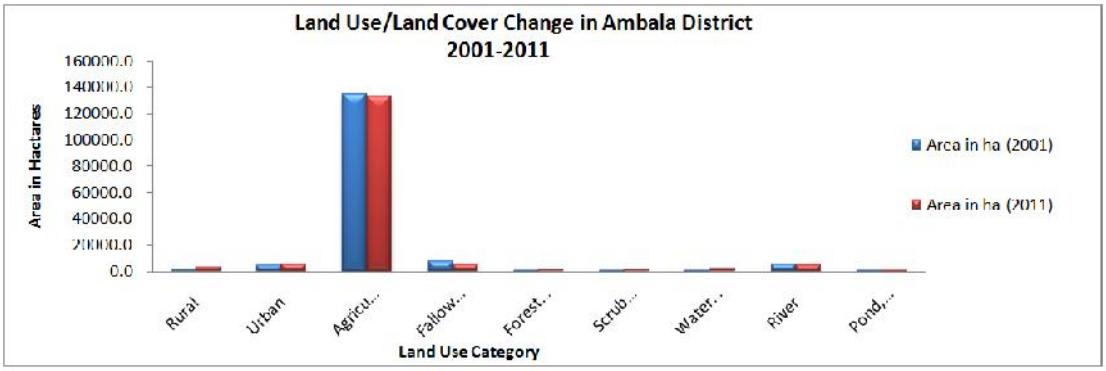
Fig.1. Source: Generated from IRS-P6 LISS III Satellite Image, 2011

Urban has increased from 4620.3 ha in 2001 to 5802.14 ha in 2011, thus, registering a net increase of 1181.89 ha. Urban occupied 2.94 percent of the study area in 2001 which has increases a total of 3.69 percent in 2011 showing net increase of 0.75 percent with an annual rate of increase of 118.189 ha area. Scrub has increased total area of 1230.62 ha in 2011 to 679 ha in 2001 thus registering a increase of 551.62 ha within a period of ten years. Scrub occupied 0.43 percent of the study area in 2001 which has increase a total of 0.78 percent in 2011 showing a net increase of 0.35 percent with an annual rate of increase of 13.79 ha area. Forests occupied 0.63 percent of the study area in 2001 which has increase to a total of 1.00 percent in 2011 showing a net increase of 0.37 percent. Forest plantation in the study is witnessing an increasing trend as the total area under it in 2001 was 989.4 ha and by 2011 it has increased upto 1572.29 ha area.

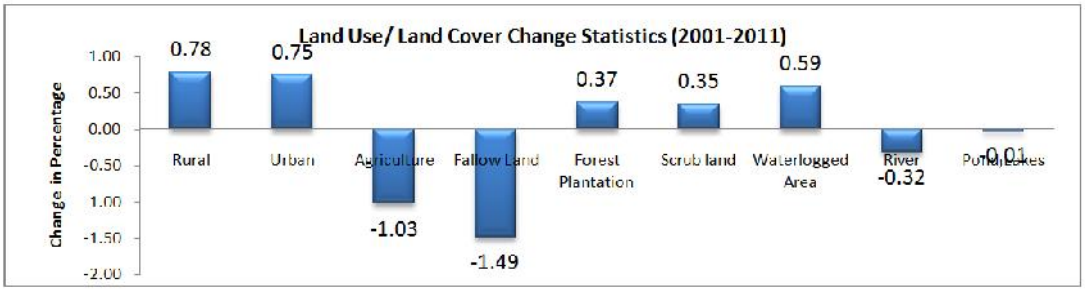
Table 2. Land Use/ Land cover Change in Ambala District 2001-2011

Land Use Class	Area in ha %age (2001)	Area in ha %age (2011)	Change in Area %age (2001-11)
Rural	1775.6 (1.13)	3005.1 (1.91)	1129.50 (0.78)
Urban	4620.3 (2.94)	5802.14(3.69)	1181.89 (0.75)
Agriculture	134604.0 (85.52)	132990.28 (84.49)	-1617.71 (-1.03)
Fallow Land	7596.1 (4.83)	5249.3 (3.34)	-2346.83 (-1.49)
Forest Plantation	989.4 (0.63)	1572.29 (1.00)	582.90 (0.37)
Scrub Land	679 (0.43)	1230.62 (0.78)	551.62 (0.35)
Waterlogged Area	1090.0 (0.69)	2016.21 (1.28)	926.20 (0.59)
River	5523.8 (3.51)	5022 (3.19)	-501.80 (-0.32)
Pond, Lakes	522.1 (0.33)	512.1 (0.33)	-10.00 (-0.01)
Total	157400.3 (100%)	157400.40 (100%)	-104.23 (-0.01)

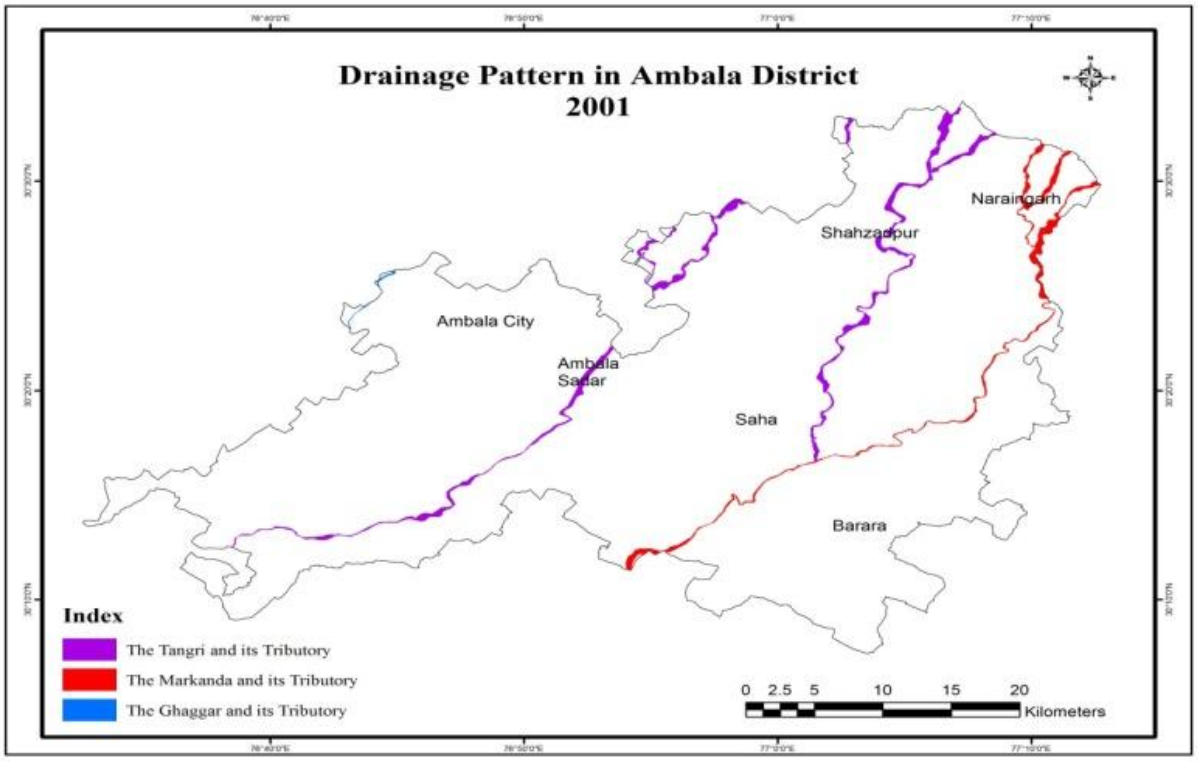
Source: Derived from LANDSAT TM Satellite Image, 2001 & IRS-P6 LISSIII Satellite Image, 2011.

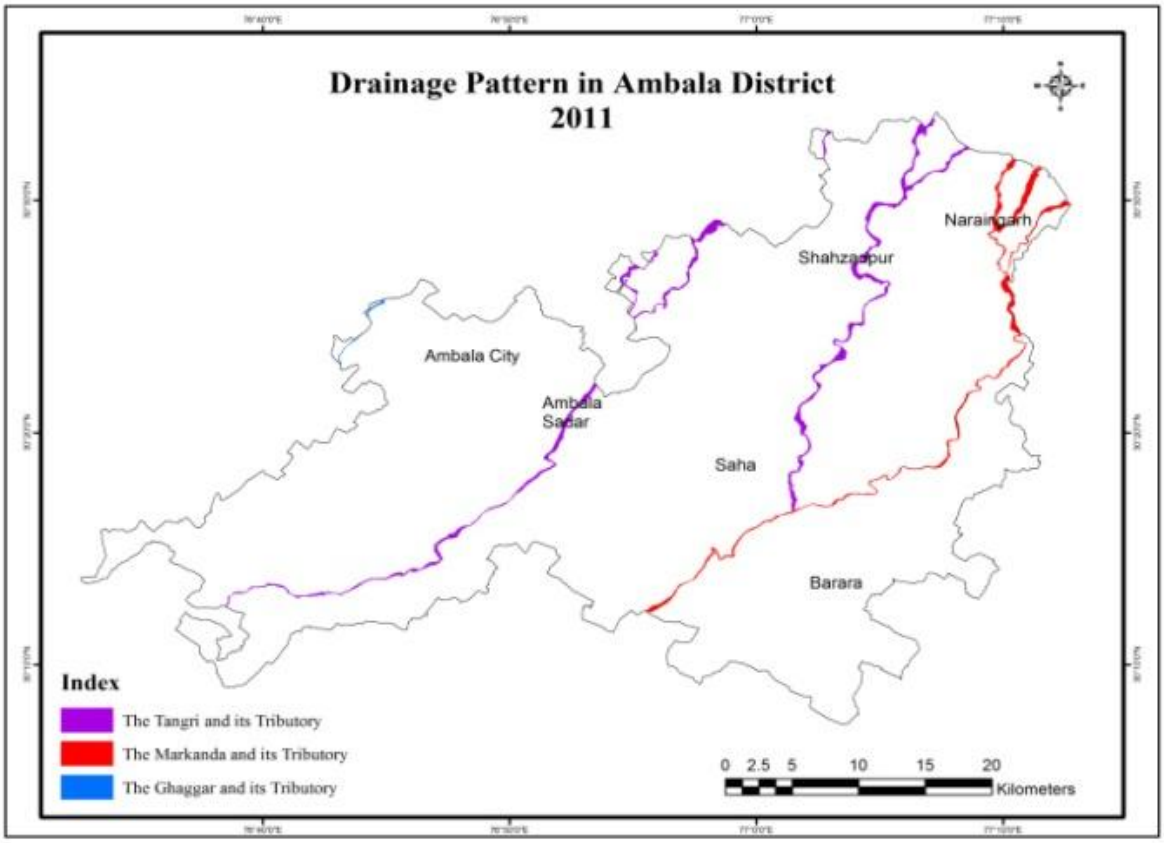


Source: Computed from LANDSAT TM Satellite Image, 2001 & IRS-P6 LISS III Satellite Image, 2011. Fig.1.3



Source: Computed from LANDSAT TM Satellite Image 2001 & IRS-P6 LISS III Satellite Image 2011. Fig. 1.4



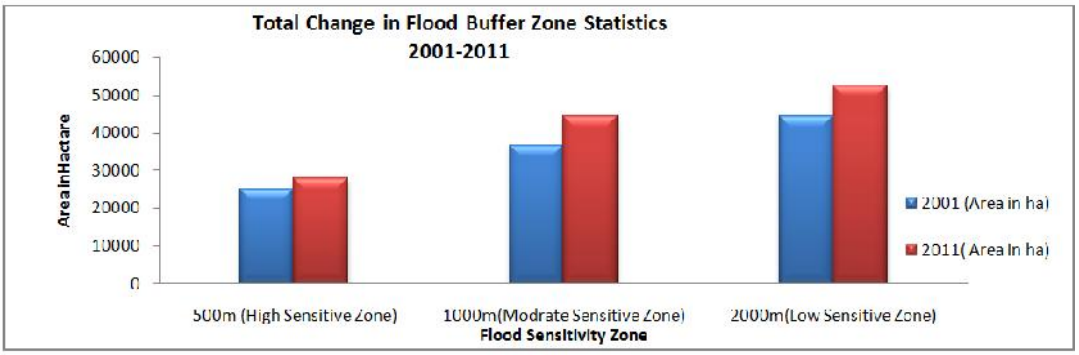


Source: Generated from LANDSAT TM Satellite Image, 2001 and IRS LISS III 2011 . Fig. 1.5, & Fig. 1.6

Table 3. Flood Buffer Zone 2001-2011

Flood Buffer Zone	2001 (Area in ha)	2011 (Area in ha)	Change in 2001- 2011 (Area in ha)
500m (High Sensitive Zone)	25181.22	28176.73	2995.51
1000m(Moderate Sensitive Zone)	36755.74	44518.8	7763.06
2000m(Low Sensitive Zone)	44463.15	52704.5	8241.35
Total	106400.1	125400.03	18999.93

Table 3. Generated from LANDSAT PM, 2001, & IRS-P6 LISS III Satellite Image, 2011.

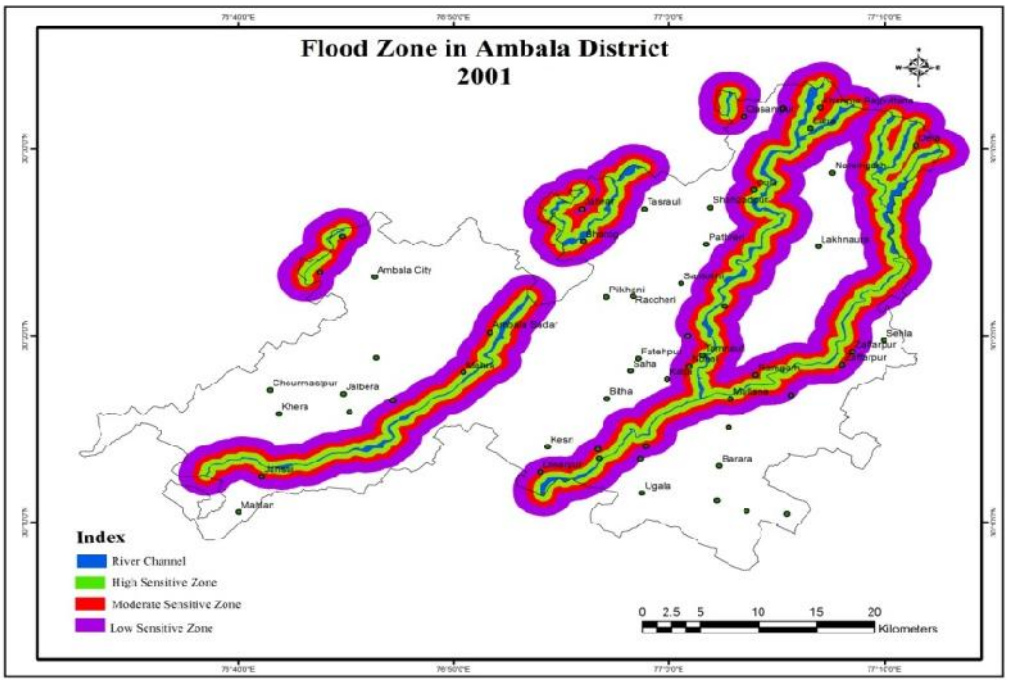


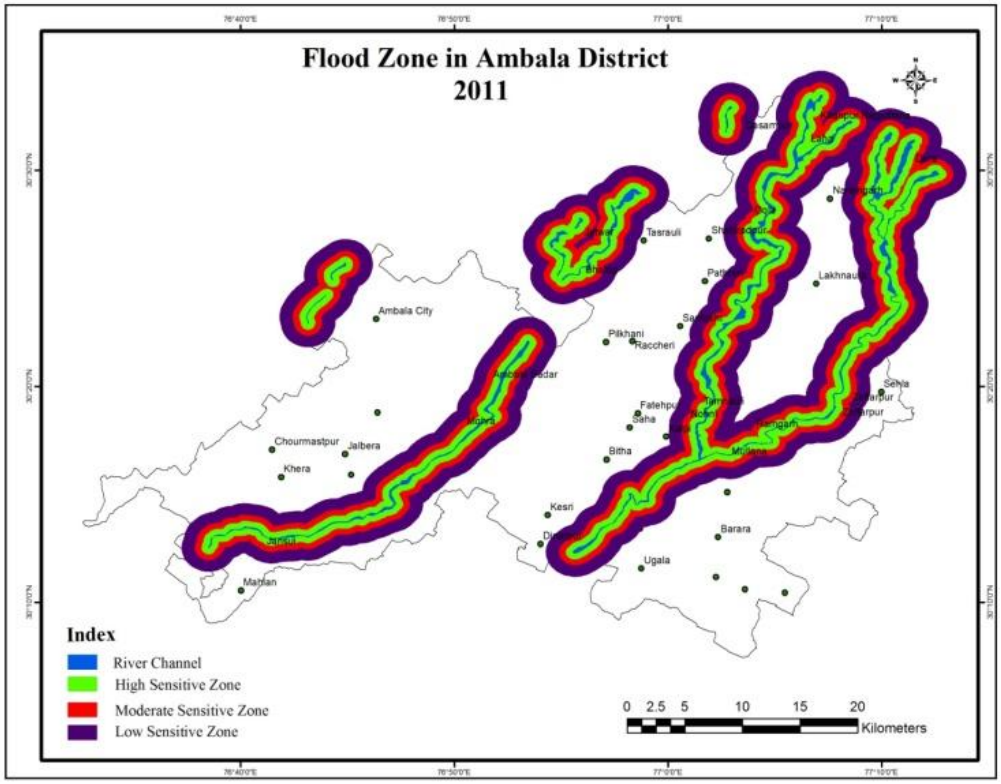
Source: Computed from LANDSAT PM, 2001, & IRS-P6 LISS III Satellite Image, 2011. Fig. 1.7

Table 4. Growth in Flood Buffer Zone (Land Use Class Wise) 2001-2011

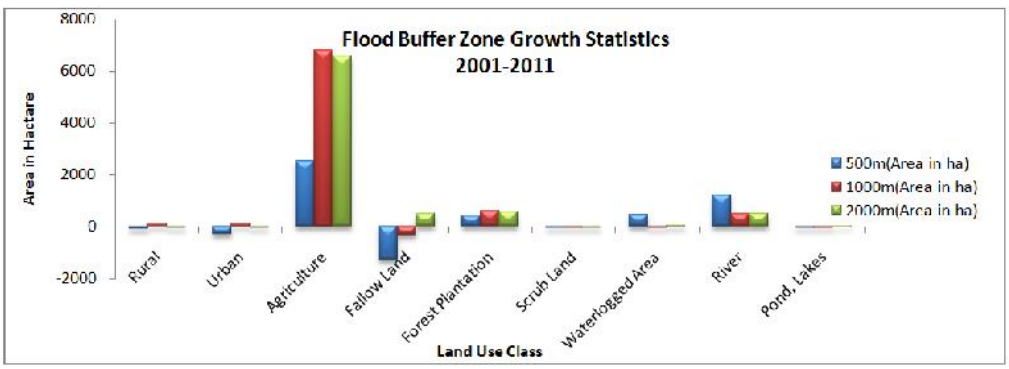
Land Use Class	500m(Area in ha) 2001-2011	1000m(Area in ha) 2001-2011	2000m(Areain ha) 2001-2011
Rural	-83.22	88.48	20.18
Urban	-273.04	102.83	2.83
Agriculture	2537.9	6808.92	6587.97
Fallow Land	-1262.78	-325.91	502.59
Forest Plantation	419.3	605.63	582.1
Scrub Land	-31.66	-31.67	-31.67
Waterlogged Area	474.5	18.79	39.73
River	1210.9	489.47	509.87
Pond, Lakes	3.55	6.52	27.75
Total	2995.51	7763.06	8241.35

Source: Derived from LANDSAT TM Satellite Image, 2001 & IRS-P6 LISS III Satellite Image, 2011.

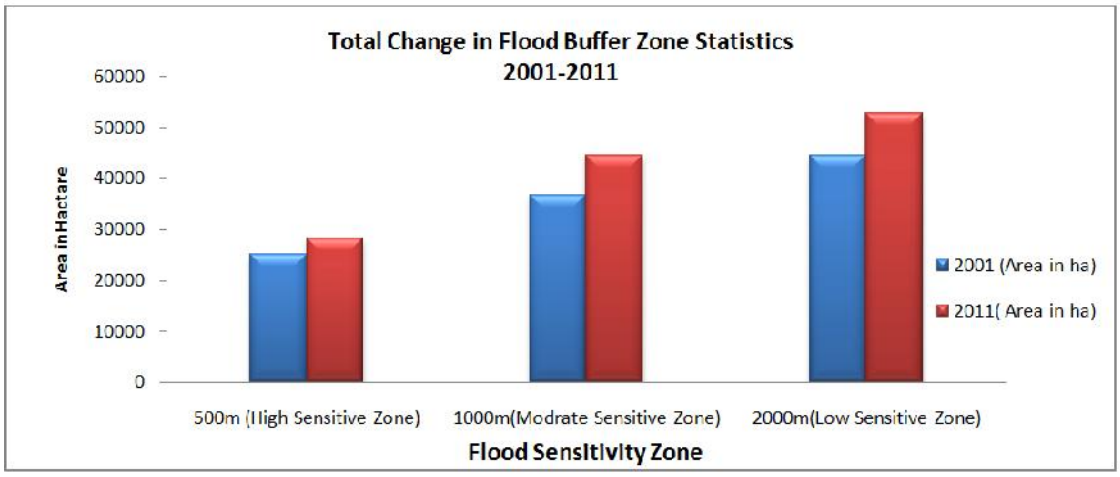




Source: Generated from LANDSAT TM Satellite Image, 2001 and IRS LISS III 2011, Fig. 1.8 & Fig. 1.9



Source: Computed From LANDSAT TM Satellite Image, 2001 & IRS-P6 LISS III Satellite Image, 2011. Fig. 1.10



Source: Computed from LANDSAT TM Satellite Image, 2001 & IRS-P6 LISS III Satellite Image, 2011

Fig. 1.11

Table 5. Total change in buffer zone 2001-2011

Flood Buffer Zone	2001 (Area in ha)	2011 (Area in ha)	Change in 2001- 2011 (Area in ha)
500m (High Sensitive Zone)	25181.22	28176.73	2995.51
1000m(Moderate Sensitive Zone)	36755.74	44518.8	7763.06
2000m(Low Sensitive Zone)	44463.15	52704.5	8241.35
Total	106400.1	125400.03	18999.93

Source: Derived from LANDSAT TM Satellite Image, 2001 & IRS-P6 LISS III Satellite Image, 2011.

A total area of 582.90 ha has been added to the forest plantation with an average annual increase of 58.29ha thus, registering a net increase of 0.37percent. Waterlogged was spread over an area of 1090.0 ha in 2001 and this figure has gone upto 2016.21 ha in 2011. Net increase in percentage is 0.59. On an average waterlogged area increased by 92.62 ha per year. A net decrease of 501.80 ha has occurred in the rivers located in the study area. Rivers have decreased from 5523.08 ha in 2001 to 5022 in 2011. River occupied 3.51 percent of the study area in 2001 which has decrease a total of 3.19 percent in 2011 showing a net decrease of -0.32 percent with an annual rate of decrease of 50.18 ha area. Pond and lakes in the study is witnessing an decreasing trend as the total area under it in 2001 was 522.1 ha and by 2011 it has decrease 512.1 ha area. A total area -10.00 ha has been decreased to the pond and lakes with an average annual decrease of -1 ha area thus, registering a net decrease of -0.01 percent. The district is mainly drained by non- perennial streams and drainage system of the district comprises the The Markanda, The Tangri, The Ghaggar and its tributaries.

Drainage Pattern in Ambala District 2001-2011

This category comprises areas with surface water reservoirs or flowing as streams and rivers. The major part of the alluvial plain to the west of Ghaggar suffers from lack of surface drainage except in the east where the river Ghaggar and its seasonal tributaries drain the area. However there is a plain of the tributaries of the Ghaggar river. All the seasonal rivers like Tangri, Markanda etc, submerge while flowing down in the non-perennial river Ghaggar. River Ghaggar and its tributaries cover the area of 3956.6 ha which was 2.51 percent of the study area in 2001.

A total area of 3467.59 ha occupied by rivers which is 2.20 percent of the total area in 2011. A net decrease of 501.80 ha has occurred in the rivers located in the study area. Rivers have decreased from 5523.08 ha in 2001 to 5022 ha in 2011. River occupied 3.51 percent of the study area in 2001 which has decrease a total of 3.19 percent in 2011 showing a net decrease of -0.32 percent with an annual rate of decrease of 50.18 ha area.

The Analysis of Parameter of Ghaggar Flood Zone

Flood Buffer Zone

Create buffer utility of ARC/INFO was used to create buffer zones around the river. Flood risk zone were delineated by grouping the polygons of the integrated layer in to different risk zone. The criterion analysis was applied to classify the flood zone map in to three sensitive risk zone classes. Corridors of 500m, 1000m, 2000m, were create around river and cover all land use categories and digitized as polygon data.

1). 500m Flood Buffer Zone (High Sensitive Zone)
2). 1000m Flood Buffer Zone (Medium Sensitive Zone)
3). 2000m Flood Buffer Zone (Low Sensitive Zone)

Flood Buffer Zone 2001-2011: The land use class of 2001-2011 of Ambala district comes under different buffer zone is given in the (Table 2).

1) 500m Buffer Zone (High Sensitive Zone): This zone comes under high risk sensitivity zone. River Ghaggar cover the area of 3021.11 ha area under 500m high sensitive zone of the study area in 2001. Total area 25181.28 ha affected by floods under 500 m buffer zone in 2001. The Ghaggar river occupy 4232.01 ha. and total area comes under high sensitivity zone has 28176.74 ha in 2011.

2) 1000m Buffer Zone (Moderate Sensitive Zone): River Ghaggar cover the area of sensitive zone of the study area. The area comes under 1000m buffer zone is moderate sensitive

zone area, 36755.74 ha in 2001 and 44518 ha. comes under 1000m moderate sensitive zone.

3) 2000m Flood Zone (Low Sensitive Zone): This zone comes under low risk zone. River the Ghaggar cover the area of 2986.11 ha area under 2000m low sensitive zone of the study area. Total area 44463.15 ha affected by floods under 2000 m low risk buffer zone. In 2011 this zone river which has 3495.98 ha area comes under low sensitivity zone. Total area comes under in this zone is 52704.5 ha. in 2011.

Total Change in Flood Buffer Zone 2001-2011

The flood buffer zone change that has occurred in the study area from 2001 to 2011 is shown in the table 1.5. The figures given in the table reveal that the highest change has occurred in 2000m low sensitivity zone. Low sensitivity zone of the study area in 2001 which has 44463.15 ha and 52704.5 ha in 2011 showing net increase of 8241.35 ha area. Moderate sensitivity zone has increased from 36755.74 ha in 2001 to 44518.8 ha and net increase 7763.06 ha of the flood buffer zone. A total area 500m flood buffer zone in the study is witnessing an increasing trend as the total area under it in 2001 was 25181.22 ha and by 2011 it has increase 28176.73 ha area. A total area 2995.51 ha has been increased. Total flood zone of the study area in 2001 which has 106400.1 ha and 125400.03 ha in 2011 showing net change in buffer zone has an 18999.93 ha. A total area 500m flood buffer zone in the study is witnessing an increasing trend as the total area under it in 2001 was 25181.22 ha and by 2011 it has increase 28176.73 ha area. A total area 2995.51 ha has been increased. Total flood zone of the study area in 2001 which has 106400.1 ha and 125400.03 ha in 2011 showing net change in buffer zone has an 18999.93 ha.

Growth in Flood Buffer Zone (Land Use Class Wise) 2001-2011

500 m Buffer Zone (High Sensitive Zone): Total percentage growth in different land use class in the study area is very high. Some land use classes have registered a positive growth while as others have witnessed a negative growth. Agriculture being the dominant activity in whole of the Ambala district has got maximum area under it. It has witnessed a growth of 2537.9 ha under high sensitivity zone. The unchecked population growth in the region demands more agricultural land to satisfy the need of this increasing population. Rural registered a negative of -83.22 and urban also witnessed a negative growth of -273.04ha area from 2001 to 2011. Fallow land comprises a negative growth -1262.78 ha area from 2001 to 2011 under 500 m buffer zone. Forest plantation recorded a positive growth 419.3 ha in a decade comes under high sensitive zone. Scrub having negative growth -31.66 ha and waterlogged area growth a rate 474.5 ha area in this zone. River increase their area from 2001 to 2011 recorded positive growth of 1210.9 ha under high sensitive flood prone zone. Pond and lakes having a growth of 3.55 ha area. Total growth of this zone recorded as 2995.51 ha land of the study area.

1000m Flood Buffer Zone (Medium Sensitivity Zone): Agriculture has witnessed a growth of 6808.92 ha under medium sensitivity zone. Rural registered a growth of 88.48ha and urban also witnessed a growth of 102.83 ha area from 2001 to 2011. Fallow land comprises a negative growth -325.91 ha area from 2001 to 2011 under 1000 m buffer zone. Forest plantation recorded a positive growth 605.63 ha in a decade comes under medium sensitive zone. Scrub having negative growth -31.66 ha and waterlogged area growth a rate 18.79 ha area in this zone. River decrease their area from 2001 to 2011 recorded growth of 489.47 ha under moderate sensitive flood prone zone. Pond and lakes having a growth of 6.52 ha area. Total growth of this zone recorded as 7763.06 ha land of the study area.

2000 m Flood Buffer Zone (Low Sensitive Zone): Agriculture has witnessed a growth of 6587.97 ha under medium sensitivity zone. Rural registered a growth of 20.18 ha and urban also witnessed a growth of 2.83 ha area from 2001 to 2011. Fallow land comprises a growth 502.59 ha area from 2001 to 2011 under 2000 m buffer zone. Forest plantation recorded a positive growth 582.1 ha in a decade comes under low sensitive zone. Scrub having negative growth -31.67 ha and waterlogged area growth a rate 39.73 ha area in this zone. River having their area from 2001 to 2011 recorded growth of 509.87 ha under low sensitive flood prone zone. Pond and lakes having a growth of 27.75 ha area. Total growth of this zone recorded as 8241.35 ha land of the study area.

Total Change in Flood Buffer Zone 2001-2011

The flood buffer zone change that has occurred in the study area from 2001 to 2011 is shown in the table 1.5. The figures given in the table reveal that the highest change has occurred in 2000m low sensitivity zone. Low sensitivity zone of the study area in 2001 which has 44463.15 ha and 52704.5 ha in 2011 showing net increase of 8241.35 ha area. Moderate sensitivity zone has increased from 36755.74 ha in 2001 to 44518.8 ha and net increase 7763.06 ha of the flood buffer zone. A total area 500m flood buffer zone in the study is witnessing an increasing trend as the total area under it in 2001 was 25181.22 ha and by 2011 it has increase 28176.73 ha area. A total area 2995.51 ha has been increased. Total flood zone of the study area in 2001 which has 106400.1 ha and 125400.03 ha in 2011 showing net change in buffer zone has an 18999.93 ha.

Conclusion

In the present work the effects of land use changes on the flood frequency, which have taken place in the last decades, have been investigated for Ambala district. The estimation of the hydrological effects of the land use changes is not an easy task to solve, even in light of the variability of such effects with the variations of the climate and of the geomorphologic characteristics of the territory. Changes in the characteristics of the catchment have influence on the characteristic and magnitude of flood regime.

REFERENCES

Ajin, R.S., *et al*. 2013. 'Flood Hazard Assessment of Vamanapuram River Basin, Kerala, India: An Approach Using Remote Sensing & GIS Techniques'. *Advances in Applied Science Research*, 4(3):263-274.

Alayande, A N. and Agunwamba, J. C. 2010. 'The impacts of urbanization on Kaduna River flooding' *Journal of American Science*, 6(5): 28-35.

Ambala, 2012. Haryana Government Town And Country Planning Department Notification The 6th September, 2012.

Arvind C. Pandy and M. S. Nathawat, 2006. 'Land Use Land Cover Mapping Through Digital Image Processing of Satellite Data – A case study from Panchkula, Ambala and Yamunanagar Districts, Haryana State, India'.

Betal, R.H. 'Flood Problems of Maladh a Geographical Analysis'. *Geographical Review of India,* 64(4):337-345.

Bhardwaj, P., and Kumar, S. 2012 'Urban Expention and Land Use Change Analysis of Karnal City in Haryana: A Study Based on Open Source Satellite Data'. *International Journal of Emerging Technology and Advanced Engineering,* 2(12):182-186.

Bhattacharya, S., and Kumar, V. 2010 'Unprecedent floods in Ghaggar Basin'. *Report SANDRP June-July,* 1-9.

EOSAT 1992. Lands at TM Classification International Georgia Wetlands in EOSAT Data

EOSAT, 1994. EOSAT, s Statewide Purchase Plan Keeps South Carolina Residents in the know, in EOSAT Notes, Vol. 9, No 1, EOSAT Company Lanham, MD.

Foley, J.A., *et al*. 2005. 'Global Consiquencies of Land Use'. www.sciencemag.ogr. 309, 570-574.

Forkuo, E.K. 2011. 'Flood Hazard Mapping Using Aster Image Data with GIS'. *Internatioal Journal of Geomatics and Geosciences,* 1(4):932-950.

Handmer, W.J. 1987 'Guidelines for Flood Plain Acquisition'. *Applied Geography,* 7:203-221.

Harun, S. 2009 **'**Remote sensing techniques for flood mapping in Bangladesh' Clark University, Bangladhesh.

Jaiswal, R.K., Saxena, R., and Mukherjee, S. 1999. 'Application of Remote Sensing Technology for Landuse/Landcover change analysis'. *J. Indian Soc. Remote Sensing,* 27(2):123-128.

Jeyaseelan, A.T. 2008. 'Droughts & Floods Asessment and Monitoring Using Remote Sensing and GIS'. *Satellite Remote Sensing and GIS Application in Agricultural Meterology,* 291-313.

Joshi, P. M., Sherasia, N.K., and Patel, D.P. 2012. 'Urban Flood Mapping by Geospatial Technique A case study of Surat city'. *IOSR Journal of Engineering (IOSRJEN),* ISSN:2250-3021, 2(6):43-51.

Kayastha, S.L., and Yadava, R.P. 1980. 'Flood Hazard in Lower Ghaghara Plain (U.P., India):A case study in Perception and Impact on Socio-Economic Development'. *The National Geographical Journal of India,* 26(1-2):21-28.

Kimiteru, S., and Monirul islam, M D. 2000. 'Flood hazard map and land development priority map developed using NOAA AVHRR and GIS data'. *Proceedings of ACRS 2000.*

Kumar. M. 2014. 'High Resolution Satellite Data for Land use/Land cover Mapping in Rohtak District Haryana, India'. *Redix International Journal of Research in Social Science,* 3(1)1-14.

Kundu, B.S. and Kumar Mothi, K.E. 1995. 'Mapping and Management of Flood- Affected Areas-Through Remote Sensing: A case study of Sirsa District, Haryana'. *Journal of the Indian Society of Remote Sensing,* 23(3):139-146.

Kundu, S., *et al*. 2012. 'Asessment of Spatio-Temporal Variations in Surface Water Quality of Ghaggar River (North-Western,India) utilized for Drinking and Agriculture Process'. *African Journal of Biotechnolgy,* 11(79):14428-14432.

Nawaz, F., and Shafique, M. 2003. 'Data integration for flood risk analysis by using GIS & RS as tools'. *Proceedings of Map Asia.*

Pande, A., and Jalal, D.S. 1997. 'Saran Flash Floods: A Geographical Analysis A Case Study in Upper Sarayu Basin, Kumaun Himalaya. *National Geographical Journal of India,* 43(2):122-130.

Platt, R.H., and Cahail, S.A. 1987. 'Automated Flash Flood Warning System'. *Applied Geography,* 7, 289-301.

Rahman, A., Kumar, Y., Fazal, S. and Bhaskaran, S. 2011. 'Urbanization and Quality of Urban Environment Using Remote Sensing and GIS Techniques in East Delhi-India'. *Journal of Geographic Information System,* 3: 62-84.

Rao, K.H.V.D., *et al*. 2014. 'Kedarnath Flash Floods: A hydrological and hydraulic simulation study'. *Current Science,* 106(4):598-603.

Rathore, N.S. 2003. 'Proposed Plan for Satluj-Ghaggar-Yamuna-Jojari-Luni-Sabarmati River Link Channels'. *Map India Conference,* gisdevelopment.net.

Report, 2013. 'Flood Hazard Management Plan Kaithal'. Proposed by Haryana Institute of Public Administration.

Resourcesat-1 (IRS-P6) Data User's Handbook, National Remote Sensing Agency, Department of Space, Goveronment of India.

Saini, S.S., and Kaushik, S.P. 2011. 'Land Use Changes in Haryana Sub Region of Chandigarh Periphery Controlled Area – A Spatio – Temporal Study'. *Institute of Town Planners, India Journal,* 8(4):96-106.

Saini, S.S., and Kaushik, S.P. 2012 'Risk and Vulnerability Assessment of Flood Hazard in Part of Ghaggar Basin: A Case Study of Guhla Block, Kaithal, Haryana, India'. *International Journal of Geomatics and Geosciences,* 3(1):42-54.

Samarasinghe, S.M.J.S., *et al*. 2010. 'Application of Remote Sensing and GIS for Flood Risk Analysis: A case study at Kalu-Ganga River, Sri Lanka'. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* 38(8):110-115.

Sandhu, HAS. *et al*. 2013. 'Temporal Analysis of Chandigarh and Surroundings Areas Using RS/GIS Techniques'. *International Journal of Computer Science and Communication Engineering,* ISSN 3319-7080. 121-125.

Sanjay, L.D. and Ravindra, A.O. 2012. 'Dynamic Flood Routing and Unsteady Flow Modelling: A Case Study of Upper Krishna River'. *International Journal of Advanced Engineering Technology,* 3(3):55-59.

Sathe, B.K., *et al*. 2011. 'Integrated Remote Sensing and GIS for Flood Hazard Mapping in Upper Krishna River Basin (India)'. *International Journal of Science and Technology,* 1(1):1-10.

Singh, N., Vangani, N.S., and Sharma, J.R. 1993. 'Flash Flood Damage Mapping in Arid Environment Using Satellite Remote Sensing A case study of Pali Region'. *Journal of the Indian Society of Remote Sensing,* 21(2):75-86.

Singh, P., Singh, K., and Singh, D.S., 2009. 'Flood and its Management in Down Stream Part of Rapti River Basin, (Ganga Plain Gorakhpur)'. *National Geographical Journal of India,* 55(4):65-74.

Singh, Y. 2009 'Floods: An Ecological Hazard of the Semi-Natural Drainage Ecosystem of the Inter State Chandigarh Region, India'. *Transaction of the Institute of Indian Geographer,* 22(2):85-97.

Sinha, R., Bapalu, G.V., Singh, L.K., and Rath, B. 2008. 'Flood Risk Analysis in the Kosi River Basin, North Bihar

using Multi- Parametric Approach of Analytical Hierarchy Process (AHP)'. *J. Journal SOC. Remote Sensing*, 36: 335-349.

Sreenivasulu, V., and Bhasker, P.N. 2010. 'Change Detection in Land use and Land cover using Remote Sensing and GIS Techniques'. *International Journal of Engineering Science and Technolgy*, 2(12):7758-7762.

Statistical Abstract of Haryana, 2010-2011.

Tali, P. A. 2011. 'Land use/Land cover Change and its Impact on Flood Occurrence: A Case Study of Upper Jhelum Floodplain', M-Phil Dissertation University of Kashmir.

Tamilenthi, S. *et al*. 2011. 'Application of GIS in Flood Hazard Zonation Studies in Pananasam, Taluk, Thanjavur District, Tamilnadu'. *Advances in Applied Sciences Research*, 2(3):574-585.

User Notes, Vol. 7, No 1, EOSAT Company, Lanham, MD.

Websites

http://glcf.umiacs.umd.edu/data
http://glovis.usgs.gov/(LANDSAT sources)
https://earth.google.com
www.ambala.gov.in
www.bhuvan.nrsc.gov.in
www.bhuvan.org
www.census2011.co.in
www.crisp.nus.edu.sg
www.gisat.cz
www.landsat.usgs.gov
www.sciencemag.ogr

****