MONITORING OF URBAN SPRAWL AND SPATIO-TEMPORAL VARIABILITY OF LANDUSE/LANDCOVER CHANGE IN ASAN WATERSHED, DOON VALLEY, UTTARAKHAND, INDIA

Ankita Sharma[1] and Dhirendra Singh Bagri[1]

[1]HNB Garhwal University

November 23, 2022

Abstract

Urban expansion is a global trend primarily determined by overpopulation, particularly in developing countries like India. The pattern and boundary of urban expansion could be observed and modelled on a Spatio-temporal dimension in the Asan watershed, situated in western Doon Valley, Uttarakhand, India. The specific objectives of the present study are: 1) Monitoring Land Use Land Cover (LULC) change detection and its impact on the hydrological regime of the watershed, 2) Generation of urban growth pattern map to identify the urban expansion along with the directions and distance from the watershed centroid. To achieve the objectives, the four LULC maps of different years are generated through Landsat and LISS-IV dataset from 1980 to 2016. The eight classified classes of LULC includes: build-up (urban and rural), cropland, fallow land, plantation, evergreen needle leaf forest, deciduous broadleaf forest, mixed forest, and water bodies. The LULC change analysis concludes that the built-up area continuously expanding at an alarming rate, nearly four folds in the last 36 years. The major areal portion of cropland and plantation are converted into build-up at a faster rate after 1995 whereas the areal extent of water bodies are also reduced. Based on monitoring of urban growth, the wind rose tool revealed that the southwest direction is the dominant direction of the urban expansion till 1980 and 1980-1995 which contribute 48% and 47.61% respectively of the total urban area of the watershed. However, in the period 1995-2008 and 2008-2016, the eastern direction is predominant, which contribute 36.44% and 35.27% respectively from the total urban areal expansion. This reflects a situation where the eastern direction is expected to dominate in the next years. Consequences of urban expansion create pressure on the into the watershed which leads to degradation of natural resources, forest environment and hydrological elements of the watershed.

MONITORING OF URBAN SPRAWL AND SPATIO-TEMPORAL VARIABILITY OF LANDUSE/LANDCOVER CHANGE IN ASAN WATERSHED, DOON VALLEY, UTTARAKHAND, INDIA

Ankita Sharma[1], D.S. Bagri[2]

[1]Department of Geology, Chauras Campus, HNBGU, Srinagar 246174, India
[2]Department of Geology, S.R.T. Campus, HNBGU, Badshahithol, New Tehri 249199, Uttarakhand, India

ABSTRACT

Urban expansion is a global trend primarily determined by overpopulation, particularly in developing countries like India. The pattern and boundary of urban expansion could be observed and modelled on a Spatio-temporal dimension in the Asan watershed, situated in western Doon Valley, Uttarakhand, India. The specific objectives of the present study are: 1) Monitoring Land Use Land Cover (LULC) change detection and its impact on the hydrological regime of the watershed, 2) Generation of urban growth pattern map to identify the urban expansion along with the directions and distance from the watershed centroid. To achieve the objectives, the four LULC maps of different years are generated through Landsat and LISS-IV dataset from 1980 to 2016. The eight classified classes of LULC includes: build-up (urban and rural), cropland, fallow land, plantation, evergreen needle leaf forest, deciduous broadleaf forest, mixed forest, and water bodies. The LULC change analysis concludes that the built-up area continuously expanding at an alarming rate, nearly four folds in the last 36 years. The major areal portion of cropland and plantation are converted into build-up at a faster rate after 1995 whereas the areal extent of water bodies are also reduced. Based on monitoring of urban growth, the wind rose tool revealed that the southwest direction is the dominant direction of the urban expansion till 1980 and 1980-1995 which contribute 48% and 47.61% respectively of the total urban area of the watershed. However, in the period 1995-2008 and 2008-2016, the eastern direction is predominant, which contribute 36.44% and 35.27% respectively from the total urban areal expansion. This reflects a situation where the eastern direction is expected to dominate in the next years. Consequences of urban expansion create pressure on the into the watershed which leads to degradation of natural resources, forest environment and hydrological elements of the watershed.

1. SUMMARY

- Land use and land cover pattern changes are the most important factors for the assessment to understand the topographical features and status of past, present and future conditions of classes in the watershed.
- Estimation and change in Land use pattern suggest the resources utilization through human interferences especially utilizing urbanization and agriculture
- Urban expansion is a universal phenomenon which is a consequence of the population growth as well as the economic and infrastructure objects. In India, the urban

population has risen from 18% to 31% in the year 1961 to 2011 respectively (Census of India, 2011).

- Mapping urban expansion is one of the valuable and significant application as of remote sensing.
- The wind rose is an 8-directional wind rose diagram is used to estimate the frequency of urban growth in a certain direction.

2. STUDY AREA

The Asan River watershed is located in Dehradun district, Uttarakhand state, India (Fig 1). The area geographically lying between 30°14' 14" N to 30°29' 54" N latitude and 77° 39' 42" E to 78° 05' 30" E longitude. It covers an area of 712.34 sq.km. Asan is the tributary of Yamuna River and their origin point is from Chandrbani (spring water) in Dehradun city. This perennial river is flowing through the central portion of the area from south-west to north-east direction.

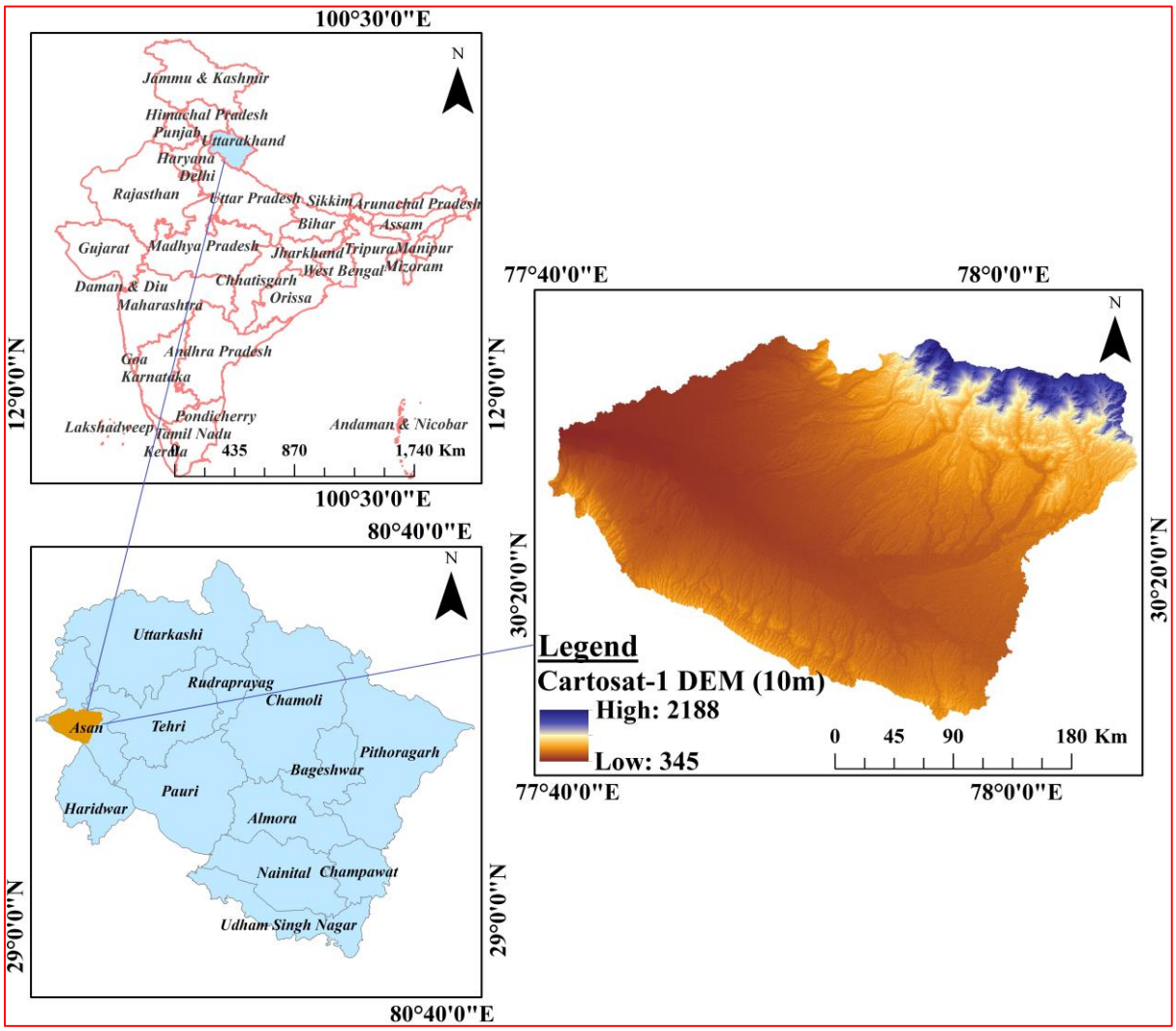

Fig. 1: Location map of the study area

3. OBJECTIVES & ADOPTED METHODOLOGY

3.1. OBJECTIVES

- Monitoring Land Use Land Cover (LULC) change detection and its impact on the hydrological regime of the watershed.
- Generation of urban growth pattern map to identify the urban expansion along with the directions and distance from the watershed centroid.

3.2. METHODOLOGY

- The methodology adopted to assess spatiotemporal changes in the urbanized areas and to identify the directions of urban expansion, based on the processing of space-borne multi-temporal images.
- The decadal LULC maps of the watershed for the different time period of 1980, 1995, 2008 and 2016 are prepared by visual interpretation of Landsat 3, Landsat 5 and LISS 4 satellite data (Fig.2). This includes the on-screen digitization of feature class.
- In this study, a total of eight different classes are classified as; built-up, cropland, fallow land, plantation, evergreen needle leaf forest, deciduous broadleaf forest, mixed forest, and water bodies.
- Form the decadal LULC maps the urban layer has been extracted and the potential wind rose method is adopted for calculating the direction and expansion of the urban layer in the watershed.

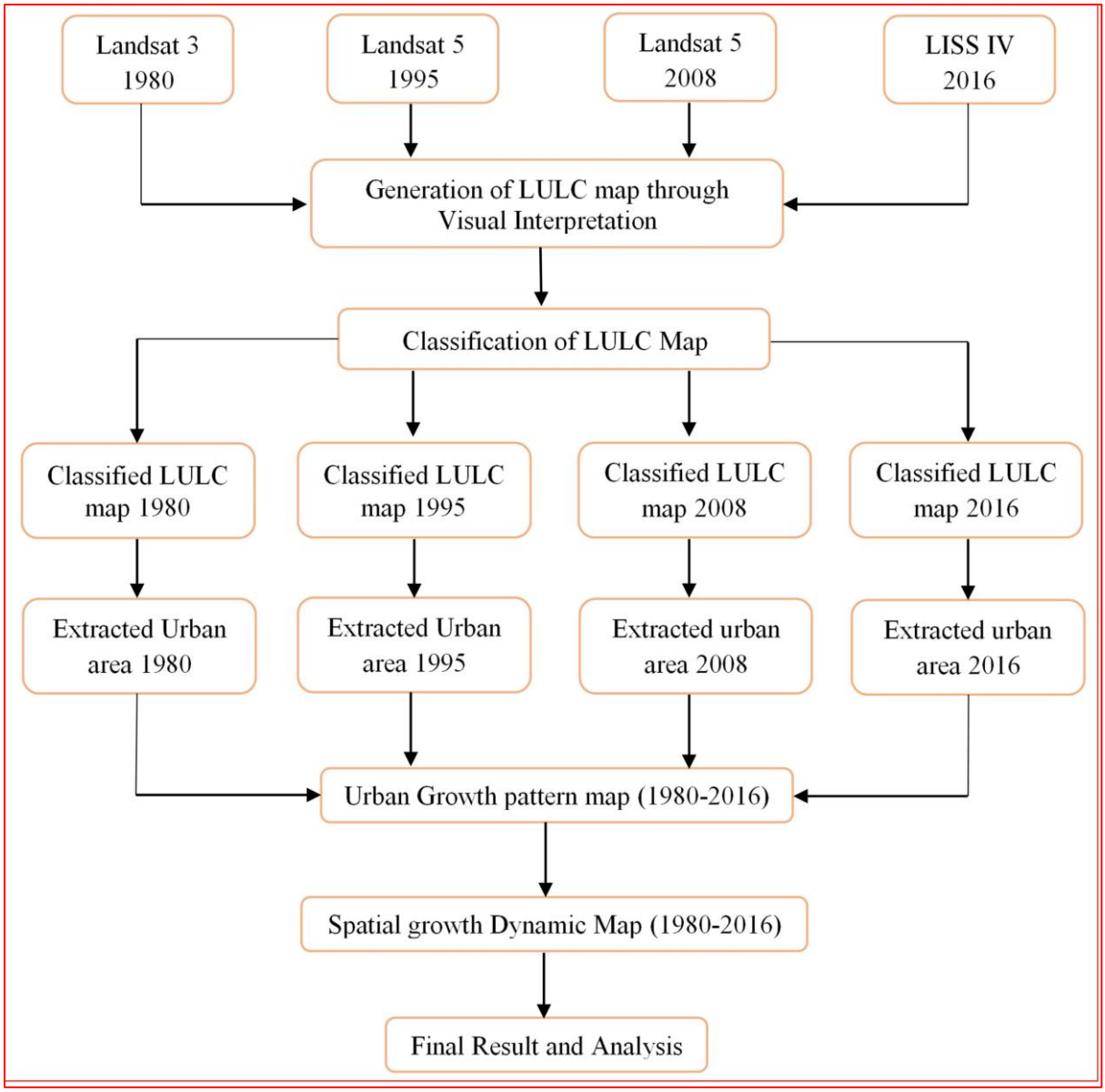

Fig. 2: Flowchart depicting the methodology adopted for the generation and classification of LULC maps

4. CHANGING LULC AND URBAN SPRAWL

- The digitization of the different classes of LULC is based on classification given by Ford-Robertson, 1971; UNESCO, 1973.
- The urban built-up is extracted from LULC maps to generate the urban growth pattern maps (Fig. 3).
- It is found that the areal change in a total built-up area which includes rural and urban settlement covers 9.10 sq.km in 1980 to 34.84 sq.km in 2016 (Table 1).

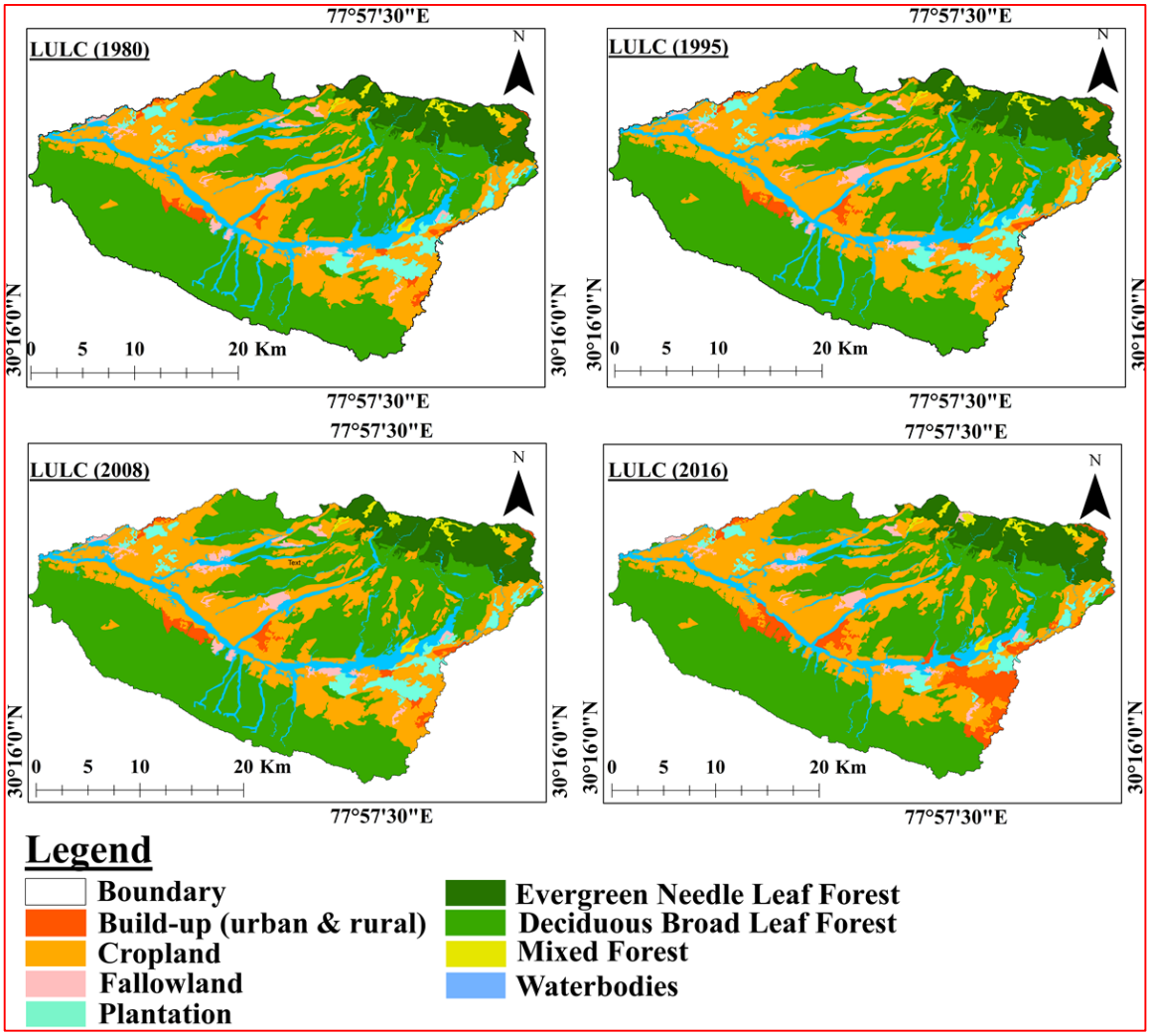

Fig 3: Land use/Land cover map of the study area for 1980-2016

In 1980, the urban area of the watershed occupied 9.55 sq.km (11.45%) which increased by 2.84% in 1995 to reach 12.39 sq.km (Fig 4). The continuous urban areal increment is visible in 1995-2008 with 12.52 sq.km increase in area to reach 24.91 sq.km (29.88 %) in 2008 and 11.59 sq.km of areal increment of 36.50 sq.km (45.79%) in 2016.

Table 1: Urban growth of Asan watershed (1980-2016)

Year	Urban Area (Km^2)	Urban area Change (%)	Increase (Km^2)
Till 1980	9.55	11.45	-
1980-1995	12.39	14.86	2.84
1995-2008	24.91	29.88	12.52
2008-2016	36.50	45.79	11.59

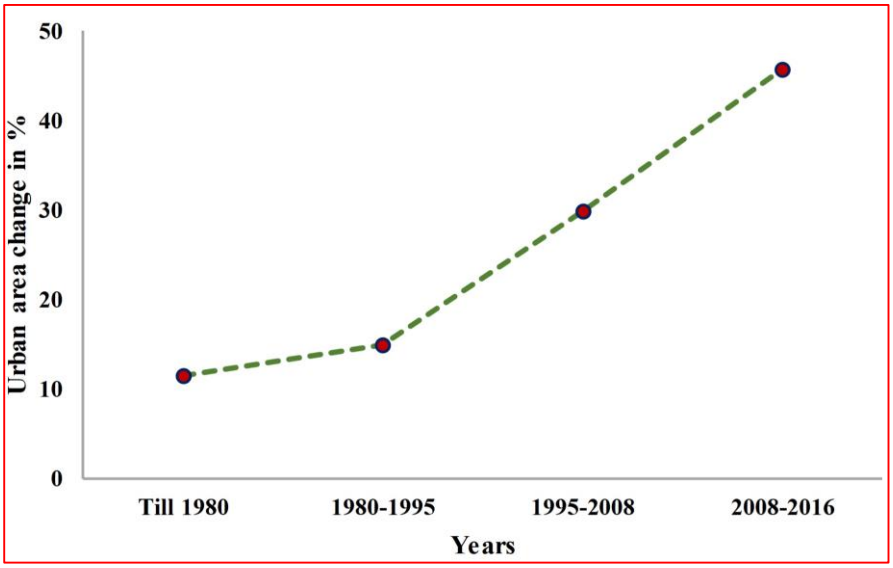

Fig 4: Percentage growth of Asan watershed

5. RESULT & DISCUSSION

- For the present study, the wind rose diagrammatic tool in the form of concentric circles with 1Km from the centre of the watershed up to 22Km are presented (Fig 5).
- The different direction of wind rose diagram divide the urban area in 8 zones namely A, B, C, D, E, F, G and H that corresponds to N, NE, E, SE, S, SW, W, and NW directions respectively.

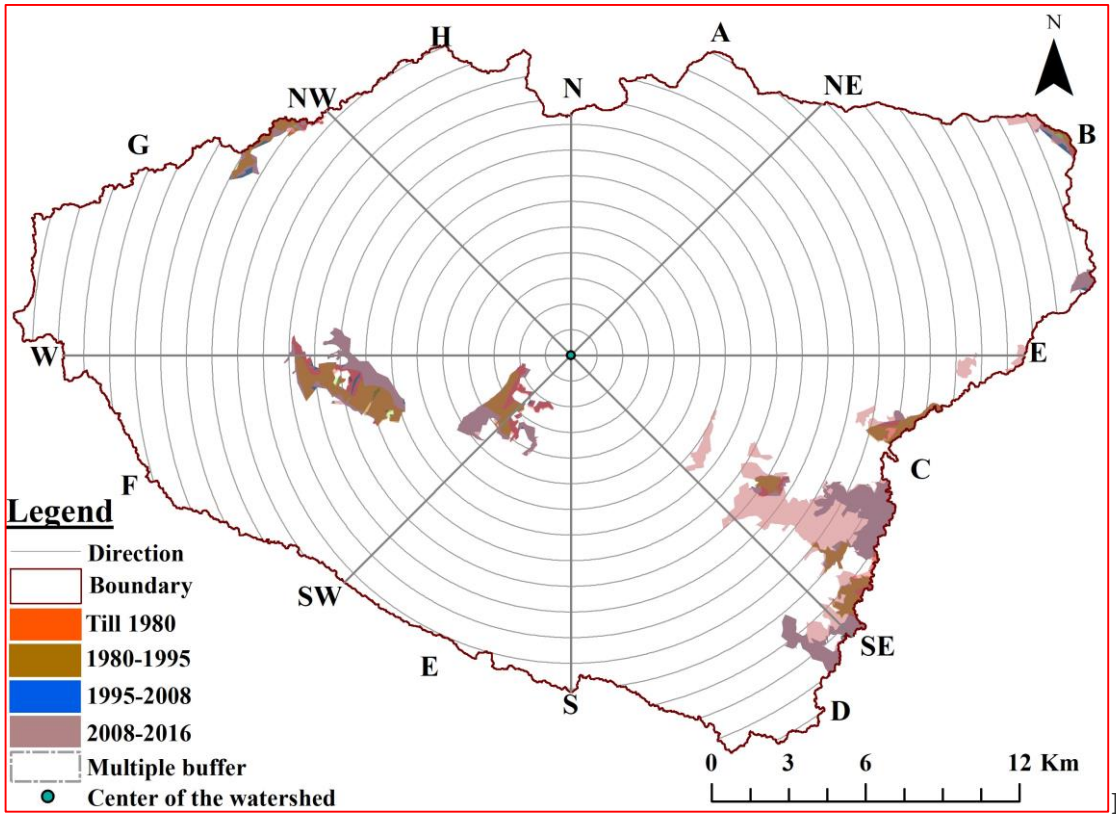

Fig 5. Spatio-temporal dynamics of urban growth in Asan watershed from based on the 8-directional wind rose scheme

- The results revealed that the southwest direction is the dominant direction of the urban expansion till 1980 and 1980-1995 which contribute 48% and 47.61% respectively of the total urban area of the watershed.
- However, in the period 1995-2008 and 2008-2016, the eastern direction is predominant, which contribute 36.44% and 35.27% respectively from the total urban areal expansion.
- This reflects a situation where the eastern direction is expected to dominate in the next years.

Table 2: Urban distance along the expansion direction from 1980-2016

Direction	Till 1980		1980-1995		1995-2008		2008-2016	
	Km^2	%	Km^2	%	Km^2	%	Km^2	%
N	-	-	-	-	-	-	-	-
NE	0.26	2.67	0.28	2.26	1.20	4.80	1.72	6.49
E	3.29	33.88	4.09	33.06	9.1	36.44	9.34	35.27
SE	-	-	-	-	2.03	8.12	2.97	11.21
S	0.25	2.57	0.77	6.22	1.22	4.88	1.23	4.64
SW	4.71	48.50	5.89	47.61	8.85	35.44	8.77	33.11
W	1.2	12.35	1.34	10.83	2.57	10.29	2.45	9.25
NW	-	-	-	-	-	-	-	-
Total	9.71	100	12.37	100	24.97	100	26.48	100

6. CONCLUSION

1. From the last 40 years, the changing pattern of LULC indicates that the urban area increased by four folds from 1980 to 2016 in four decades experienced a very high growth rate, almost 29% and 36% in 1995-2008 and 2008-2016 respectively which is comparatively higher than the previous years.
2. The trend of urban development with distance in different decades. It clearly illustrates that till 1980 urban development in the watershed is less, indicates the absence of development.
3. In between 1980-1995, the city started sprawling beyond but was confined within 15 Km.
4. In 1995-2008, urban development was more pronounced between 3-16 Km from the centre of the watershed.
5. During 2008-2016, the urbanization pattern tremendously increased and the density of development was more pronounced than the existing growth rate.
6. During this time, the watershed displays a very high growth and moving from entire watershed especially 8-15 Km distance from watershed centroid as the city has developed into commercial markets, educational and industrial institute.
7. The present rate of growth will convert the entire city to one of the metro city shortly.
8. The industrial effluent and discharge polluted the river and stream of the watershed contribute several hydrological changes have significant implications for the equality of fresh, clean water that is available for use by humans and wildlife.

REFERENCES

- **Census of India. 2011.** Office of the Registrar General & Census Commissioner, India, Ministry of Home Affairs, Government of India, https://censusindia.gov.in/2011-common/censusdata2011.html.
- **Ford-Robertson, F.C. (ed) (1971).** The terminology of Forest Science, Technology Practice and Products. Society of American Foresters, Washington D.C.
- **UNESCO. 1973.** International Classification and Mapping of Vegetation. Paris.

ACKNOWLEDGEMENT

I would like to thank my supervisor, Prof. Dhirendra Singh Bagri, for the guidance and advice he has provided throughout this research. The data and research infrastructure provided by Department of Geology, HNB Garhwal University, Chauras Campus, Srinagar, Uttarakhand is duly acknowledged.