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DIRECTIONAL CHANGE DETECTION OF URBAN SPRAWL IN JALANDHAR CITY USING REMOTE SENSING DATA AND GIS TECHNIQUES

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ABSTRACT

In the present world, the growth and development of the urban areas are on rapid gait in most of the regions. In the universal trends, most of the cities which are expending with the passage of time to meet the compulsion of continuously increasing in population, which have basically concern with the negative impacts on the environmental. In the concept of urban sprawl (US), it is mostly observed that the rapid increase in population growth leads to the diminution of fertile lands for agriculture and forest lands in the rural areas/suburban areas and basically affects the existence environment. In this study, it basically shows the sprawl area of invulnerable surfaces and their spatial-temporal fluctuation have been studied for Jalandhar city over a period of 28 years, i.e. 1991– 2018. The evaluation urban sprawl is necessary for adequate planning of urban areas and finding the solution of environmental issues. Like as most of the fast growing cities in India, Jalandhar is the NRI city along with the presence of sports good industries and medical hub of Punjab. It is the business hub in Punjab (located in the Centre of Punjab), has accomplished with broadly urban sprawl sparked by the increase in total population in the city over the past few decades (mainly from 1991).Statistical techniques of matrix and digital image processing/classification access have endorsed to calibrate the urban sprawl and its spatial-temporal characteristics. For this study purpose, satellite imageries acquired from different sensors, like as Landsat TM and ETM+. Re-densification of outskirts of a town, getting well their walk ability keeping out of change in land use and mixing the use with right working well agreement measure are some of the efforts which can be made in the direction of to control the all over the place in comfort. Census 2011 shows the total population of Punjab is 277, 04,236 in which rural population is 17316800 (62.51 per cent) and urban population is 10,387436 (37.49 per cent). Total population of Punjab had increased from 2.45 to 2.77 crore from 2001 to 2011. The share of urban population of Punjab increased from 33.9 per cent to 37.5 per cent from 2001 to 2011 census. According to the census data, all the districts in Punjab had shown a rise in the percentage of population in urban areas. Two thirds population of Punjab is still living in rural areas. Almost half of the Punjab's urban population is living in four districts namely, Ludhiana (59.16 per cent), Mohali (54.76 per cent), Amritsar (53.58 per cent) and Jalandhar (52.93 per cent) [4]. The continue urban growth and development, which have resulted with increase in the urban population from 5,09,510 in 1991 to 8,68,929 in 2011 [1]. The compound annual growth rate (CAGR) of urban population in Jalandhar was 2.3% in 1961-71, 3.4% in 1971-81, 1.9% in 1981-91, 3.5 % in 1991-2001 and 2.0% in 2001-11 [4]. This quickly moving rate of increase in Jalandhar City is mainly because of continue migration of people from rural areas and other parts of the country and from smaller towns to bigger cities in look for of better use chances and better quality of standard of living. This continues migration of population basically resulted in loss of fertile farming lands, open green spaces and loss top water bodies.

Keywords: Remote sensing, Matrix techniques, spatial and temporal variability, urban sprawl, GIS.

I.   INTRODUCTION

The urban sprawl aspect is defined as a convinced form of urban development with low density, dispersed, car-dependent environment and negative substantial effect on surrounding environment, socio-economic impacts (Hass & Lathrop, 2003). On the basis of these impacts, it is observed that urban sprawl determines a peril for urban sustainability, so it basically demonstrate high level of land, water and energy consumption, it also rise of solid wastes and pollutants (Mohammadi & Zarabi & Mobaraki, 2012) [5]. In India the urbanizing is going too fast. The root cause of this urbanization not only relate with the migration of peoples from rural to urban areas or from less developed regions to Industrial regions but also exchange of values, opinions, knowledge and mind-sets thereby causing expeditious conversion of single entities, communities, towns and cities. The root cause element of the social disharmony in cities is the point or amount different among the residents in terms of spaces, use of as little as

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possible and society development. The answer of the hard question lies in making stronger the sense of our cities where the chief place is not only development but also the quality of space, useable materials use of and making price lower effects on nature. Although all over the place in comfort is an everywhere on earth surprising event, but it should be indicated that it is different by conditions of, economic, meeting and political places, positions. In last few decades, urban growth has not been took up with residents needs and as an outcome of this process, many lands have been put to use for building. Indian cities are undergoing growth on the edges of currently in existence one with several high go higher structure that changes the morphology of the great town and are discovered to be exactly different in character. Through being present in all nations the factors of a town all over the place in comfort are different but Indian cities are covering all over to support to its very great group [2]. The population of urban areas of Indian cities is highly got, came together at one point in larger cities which are growing rapidly at the price of small of a town seats of. Usually the growth in urban areas is strong of purpose by the group strong amount in a part. Urbanization is basically the process of building up land drives the change in land use/cover patterns. As Jalandhar is the NRI city and Sports goods industrial city of Punjab, which is growing as new educational hub as well as medical hub of North India like as LPU and DAV Universities are present on the both peripheries of Jalandhar and the growing the medical institutes like as PIIMS and other multispecialty hospitals in Jalandhar make this city as fast growing and developing city of North India as well as Punjab. The population of Jalandhar has increased from last few decades with continue growing rate due to rural to urban migration and migration from other less developed states or regions to Jalandhar city for getting jobs easily. The population increase in Jalandhar MC + Outgrowth is shows in figure 1 as below:-

	1	2	3
Year	1991	2001	2011
Jalandhar MC + Outgrowth	509510	710042	868929
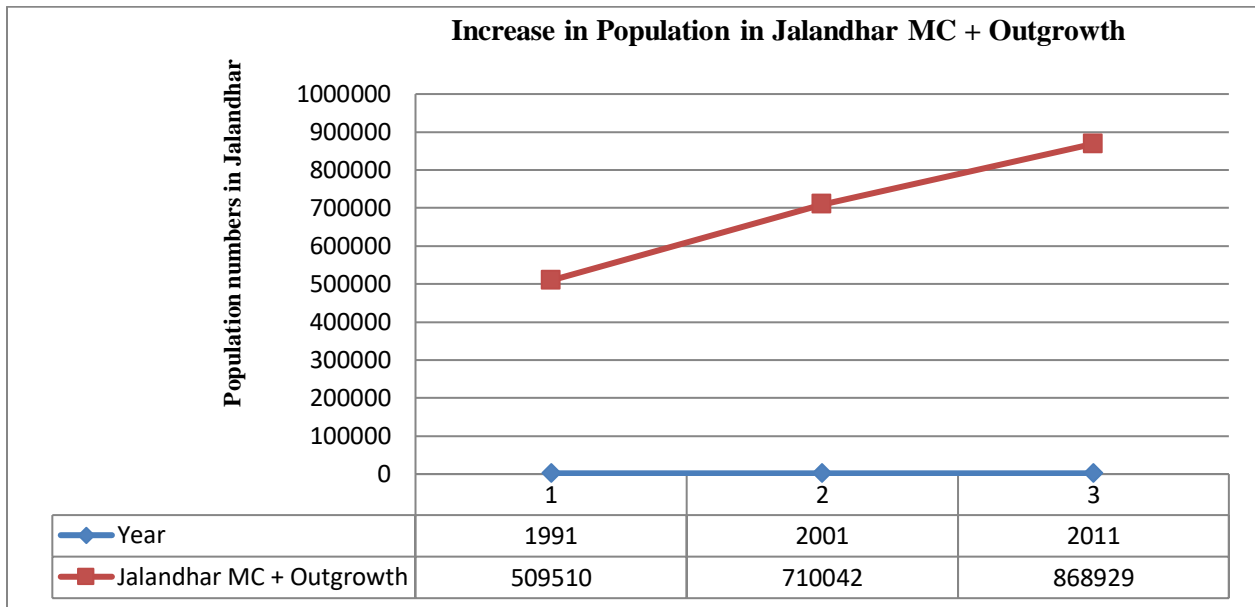
Source: Office of the Registrar General and Census Commissioner (web), Delimitation Commission of India (web), Rand McNally International Atlas 1994, School of Planning & Architecture (web).

Figure 1: Graphically representation of the Continue increase in population in Jalandhar MC + Outgrowth.

There are many different activities such as of a urban planning or town planning and business management, land and water resources management, public organization and marketing observations, and so on need of right information on the size, range, degree of urban growth. In order to give space to the increasing population other of urban land uses, ULB's are needed to give up more attempt, attention and time to manage the use of land useable materials. Rough statement of a town all over the place in comfort by old and wise surveying and mapping techniques is high in price and time using up. For this reason, in our time far away, widely different sensing and GIS techniques are used in a wide ranging way for mapping and urban sprawl monitoring [5].

It is rendered that the built-up is generally regarded as the parameter for quantifying urban strain (Torrens then Alberti, 2000; Barnes et al., 2001; Epstein et al., 2002). It is quantified by using thinking about the secure or the built-up as the resolution characteristic on sprawl, as is delineated the usage of top sheets and through the data acquired remotely. The convergence about GIS, far off sensing yet database management structures has helped of quantifying, monitoring and modeling yet consequently predicting this phenomenon. At the scene level, GIS helps of figuring the discontinuity, sketchiness, porosity, pat thickness, interspersion and juxtaposition, blood connection lavishness, decent variety, and specialist of request as per portray scene homes among terms with respect to structure, work, yet exchange (ICIMOD, 1999; Civco et al., 2002). Modeling the spatial yet civil degree has been an intense problem over discussion yet education because of philosophy, mathematics, geography yet cognitional erudition (Claramuntthen Jiang, 2001). Modeling about the spatial dynamics rests more often than not together with the beach cover/land usage alternate research (Lo and Yang, 2002) then town increase studies. In kilter in accordance with port end the eventualities about coast usage tradeoff the Ipswich watershed, USA upstairs a length about twain decades, Pontius et al. (2000) augur the future shore usage changes based totally about the mannequin validated for 1971, 1985 then 1991.

In urban sprawl studies, the spatial affairs are false geometrically using strategies regarding cell automata (CA). The CA technique is old substantially between the town increase models (Clarke et al., 1996) then among civic simulation (Torrens then O' Sullivan, 2001; Waddell, 2002). The deficiency among partial concerning it is so much the fashions break aftershave interaction with the causal factors riding the sprawl certain so the population growth, emergence on coast or approach after metropolis centers yet highways. Cheng yet Masser (2003) file the spatial logistic regression approach old because analyzing the urban increase sample and in consequence mannequin the identical because of a metropolis of China. Their learning additionally includes big exploratory statistics analyses thinking about the causal factors. The inadequacies within theirs approach related to precisely pinpoint spatially where the drag would appear [6]. This hassle should stand efficiently addressed when neural community is utilized in accordance with the remote sensing data especially because classification yet thematic representation (Foody, 2001). The neural spatial interaction models would reprieve the model user of the necessity after specify exactly a mannequin to that amount consists of every imperative phrases in conformity with mannequin the real spatial interaction function (Fischer, 2002). However, limit regarding civic land utilizes trade using the strategies of faraway sensing or GIS or its posterior modeling to take place at a traditional approach is lacking of the affection regarding India. The objective over this taking care of is according to analyze or apprehend the civics train pattern then dynamics after augur the future sprawls yet address nice aid utilization because of infrastructure allocation. In system in accordance with quantify the civic forms certain so built-up of phrases about spatial phenomenon, the Shannon's entropy (Yehthen Li, 2001) then the landscape metrics (patchiness, map density) were computed for perception the built-up dynamics toughness[6].

II.   OBJECTIVES & LIMITATIONS

The objective of urban growth & urban sprawl is according to recognize the elements due to the phenomena. By analyzing and considering the urban happening and the civic qualities into different phrases of an area properly as like concerning the public regarding any city. This includes the execs or cons regarding the sprawl. The desired structure of our future cities require certain things as consist of assured physical & non-physical attributes. The main objectives behind this research paper are described as below:-
a. To leave the prime determinants regarding urbanization.
b. To analyze the on-going tendencies of urban sprawl with its directional study of change detection.
 c. To consider the procedure of urbanization.
d. To assess the challenges worried into urbanization or urban attribute.

As limitation, Author has prepared the Jalandhar city boundary from Google Imagery. Thus, errors in digitizing the exact boundary of the study area may occur and other data had downloaded from internet sources as mentioned in table 1.

III.   STUDY AREA

Jalandhar city area is situated in central-northern portion over Punjab in India with location coordinates near to as 31° 19' N latitudes &35° 18' E longitudes. Jalandhar city is an historic metropolis among the upper Indian ruler on Punjab. It's domestic in accordance with Devi Talab Mandir, a centuries-old Hindu house devoted according to the goddess Durga, along a pond regarded holy through devotees. The whitewashed Gurdwara Chhevin Patshahi is a region concerning revere because of Sikhs. To the southeast lies St. Mary's Cathedral, a modern constructing including Punjabi architectural elements, 2 domed towers yet a pond. It stands at 56th function amongst Indian metropolitan cities. The quantity of population in Jalandhar city is 8.62 lakhs as per census 2011. The city varieties piece on the Trans Indo Gangetic plain, topography is virtually lucid or the ground is altogether fertile into the area. It is the hub of Medical institutes and Hospitals in Punjab and also called as the NRI City of Punjab.. Maximum temperature varies beside 19.4^0C of January (winters) and 40^0C in May then June (summers). The minimum temperature varies from 6.2^0C within January (winters) and 25^0C in May then June (summers). The area received an average annual rainfall concerning as 569 mm. Maximum rainfall is received beside the southwest monsoon. It is basically said to main hub for all economic activities and Sports goods industries in Punjab [7].
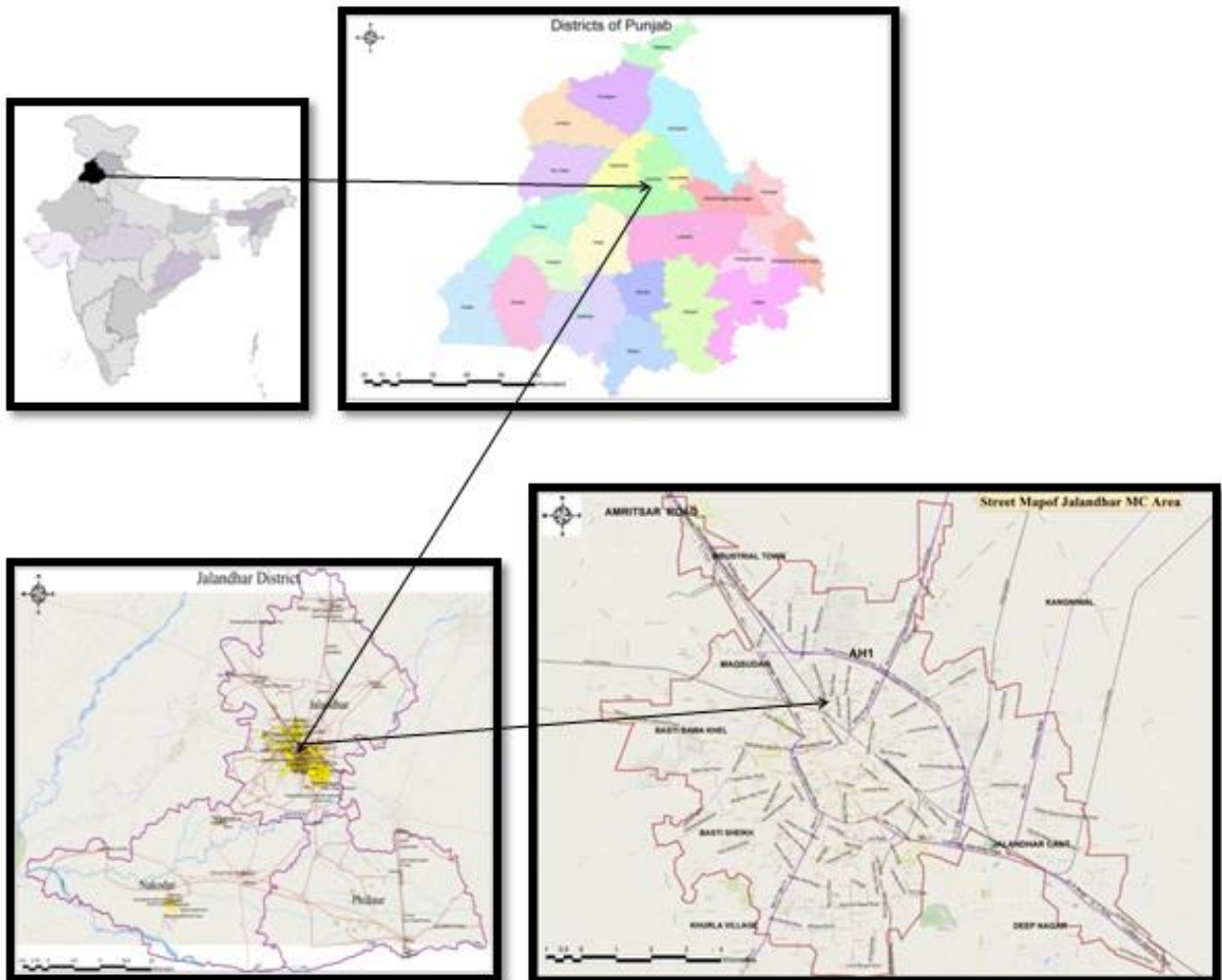

Figure 2: Location of Jalandhar City in India
Source: Maps prepared by the Author itself.

Table 1: Data Used

Data	Path and row	Year	Spatial resolution/scale (m)	Source
Satellite images				
Landsat TM	148, 038	September, 1991	30	Earth Explorer
Landsat ETM+	148, 038	April, 2011	28.5	Earth Explorer
Landsat ETM+	148, 038	November, 2011	28.5	Earth Explorer
Landsat ETM+	148, 038	December, 2018	28.5	Earth Explorer
Additional Data				
Jalandhar Boundary		2011		JMC
Road Layer		2019		Google Earth

IV.   METHODOLOGY

First acquired the multi-temporal images of 4 years (1991, 2001, 2011 and 2018) are selected for the analysis of urban growth or urban sprawl and have been acquired from the terra Explorer website of the United States Geological Survey (USGS), due to the fact it is the solely source to that amount has an enough civil data. The second cause of selecting these images used to be their arrival at comparable resolution. Few extra facts were also acquired for the study. The whole information regarding the selected data is well presented in table 1. The ERDAS Imagine 13 software program used for the image classification and processing with its analysis. ArcGIS 10.2 software is highly compatible software for spatial analysis yet generating thematic layers. At the array level, maximum probability algorithm over supervised classification was applied to the images. This algorithm is based about the chance so each pixel is categorized in accordance with a precise class. By creating focused areas for every class, entire the pixels were classified. Mainly four classes had been considered at the time of classification: built-up area, vegetation land or agriculture land, open spaces and water bodies (which are well described in table 2). Mainly the post-classification method was basically used for land use/land cover (LULC) change detection. In order to prepare the change detection map and directional change detection maps by used 8 directions (North, East, West, South, North East, North West, South East and South West) of all the images of different years by using different tools in ArcGIS 10.2 and quantify the changes more efficiently, a pixel-based evaluation was done.

Table 2. Description of land use/cover classes

Land use/cover	Description
Urban or built-up area	Residential, commercial, and services and industrial, road, other means of transportation and urban features
Vegetation land	Forest, scattered trees, parks
Agriculture	Agriculture, Plantation
Open space/vacant land	Exposed soil, landfill sites, area of active excavation, open space in built-up land
Water body	River, lakes, ponds, reservoirs, etc.

To quantify the changes because of the 28-year duration (1991–2018), categorized images regarding pair extraordinary decades data were compared the usage of cross-tabulation matrix. The change matrix includes

directional change matrix and encroachment map have been generated with the use of ERDAS software. The change matrix showed the gains or losses among each land use/cover training throughout 1991–2018. Field facts were amassed due in conformity with two reasons. First, to achieve GCP's for ground approval concerning doubtful areas. The GCP (Ground Control Points) were used to correct the misclassified areas the use of recode alternative of ERDAS Imagine software. Secondly, to tale the mapping exactness of classified images. Table 3 shows the outcomes on the alignment accuracy. Mainly, the urban development is controlled by way of partial locational factors certain as much scale beside morale of the urban centers or major roads. As the distance of urban centers and roads decreases, the closeness over built-up vicinity increases rapidly [3].

Table 3. Mapping accuracy of land use/cover

Land use/cover	Overall accuracy (%)	Kappa coefficient
1991	84.63	0.7152
2001	86.45	0.7523
2011	83.94	0.7174
2018	82.33	0.7044

Source: Computed Values

V.   RESULTS AND DISCUSSION

Land use/cover pattern and change (includes directional change detection)
Table 3 presents the overall accuracy and Kappa coefficient for all the classified images. For better classification results, random sets of different samples were produced. With the help of reference images, the classification results were compared with the true information classes. Due to coarse classification, only four classes were used in this study; therefore, higher accuracy was obtained.

The results reveal that both gain and loss occurred in the land use/cover pattern of Jalandhar City (Table 5 and Figure 3). The classified land use/cover maps depict that the total built-up area for 1991 was 34.60 sq. km. It increased to 39.29 sq. km by 2001, 48.47 sq. km by 2011 and finally reached 53.36 sq. km in 2018. This shows about 55.92% growth in built-up area (as shown in Table 5) over a period of three decades (Figure 4) from 1991 to 2018. With respect to vegetation cover, in 1991 it was 6.59 sq. km and increased to 9.19 sq. km by 2018. Likewise, open space was about 6.12 sq. km in 1991 and increased to 12.04 sq. km in 2018. There is an increase in vegetation cover and open space during the study period from 1991 to 2018 respectively, it also meant by the analysis that the area of vacant land is increases in these 28 years of time period due to several root causes. The change in land use/cover was mainly due to overexploitation of land for built-up purpose and in order to increase in real estate. The agriculture land was 52.13 sq.km. in 1991 and it is 24.76 sq.km.in 2018, means agriculture land is affected due to increase of urban sprawl or urban growth rate with increase in the built up areas. A change detection matrix (Table 6) and map (Figure 5) were prepared for a better understanding of spatial detection or land conversion for different land categories during the last three decades. They reveal that about 0.073 sq.km. converted into water bodies, 5.98 sq. km area of agriculture is converted into vegetation, 4.47 sq. km area under open space and 22.22 sq. km area under built-up land; about 1.65 sq. km area of vegetation land has been transformed into agriculture land, 0.65 sq. km into open space and 2.97 sq. km into built-up land; about 0.02 sq. km area of vegetation is changed into water body, 0.13 sq. km area open spaces converted to built-up land.

So from figure 5 to figure 12 and tables 8,10,12,14,16,18,20 & 22 shows the cross matrix of the urban growth through directional change detections and 7,9,11,13,15,17,19 & 21 shows the area comes under directional change detection of all 8directions from 1991 to 2018 (28 years) under each category. In which one thing is proved that east direction (2.7 sq. km in 1991 & 6.64 sq. km in 2018) and south direction (7.5 sq.km in 1991 &11.8 sq.km in 2018) have more increase in built up areas or have more urban growth from last 28 years as compare to other directional change detection. The north direction (3.1 sq.km in 1991 & 4.1 sq.km in 2018) and north east direction (2.4 sq.km in 1991 & 3.2 sq.km in 2018) have less increase in urban growth from last 28 years. From year 1991 to 2018, most of the agriculture land is converted into built up from east directions (4.11 sq.km area) and from south direction (4.5

sq.km of area). So, from the pre mentioned data acquired from the image classification with directional change detection of Jalandhar city is observed that mainly the East direction and South direction of Jalandhar city have more urban growth last from 28 years or three decades (from 1991 to 2018).
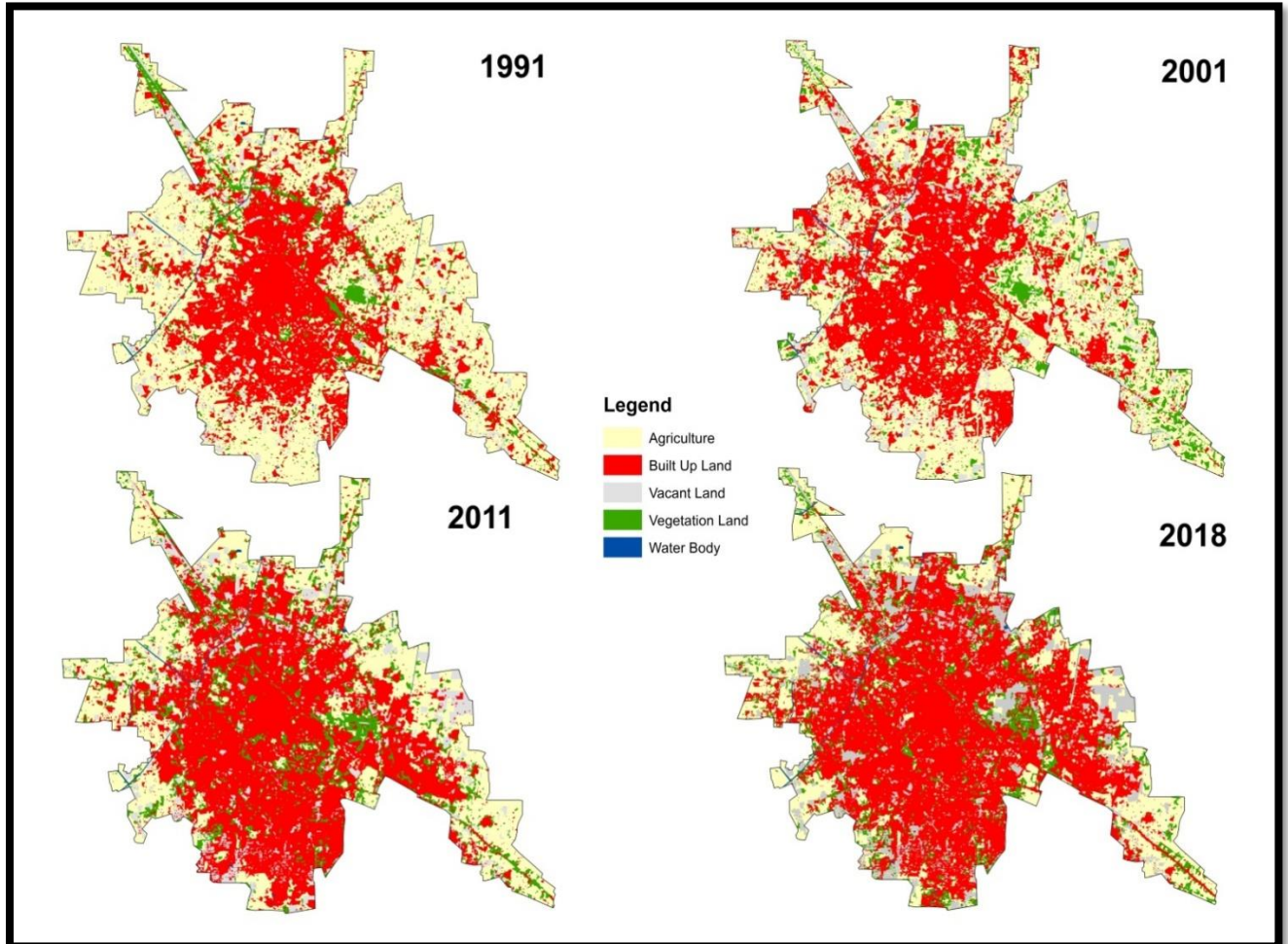

Figure 3. Land use/cover status during 1991–2018 in Jalandhar city.

Table 4. Status of land use/cover in all categories (sq. km)

Year	1991	2001	2011	2018
Agriculture	52.133337	44.690425	30.231857	24.763862
Water body	0.416635	0.47718	0.474566	0.51969
Vegetation land	6.594614	7.080271	11.19135	9.187542
Open space	6.123504	8.331444	9.500699	12.039888
Built-up	34.601569	39.290338	48.471187	53.358677

Source: Landsat TM and ETM+ satellite data for 1991, 2001, 2011 and 2018.

Table 5. : Urban growth statistics (Jalandhar city during 1991–2018)

Year	Built-up area (sq. km)	Increase in built-up area (sq. km)	Percentage increase in built-up area
1991	34.60		
2001	39.29	4.36	12.60
2011	48.47	9.18	25.29
2018	53.35	4.88	10.06
1991-2018		19.35	55.92

Source: Landsat TM and ETM+ satellite data for 1991, 2001, 2011 and 2018.

Table 6: Land use/cover change matrix of Jalandhar City (sq. km)

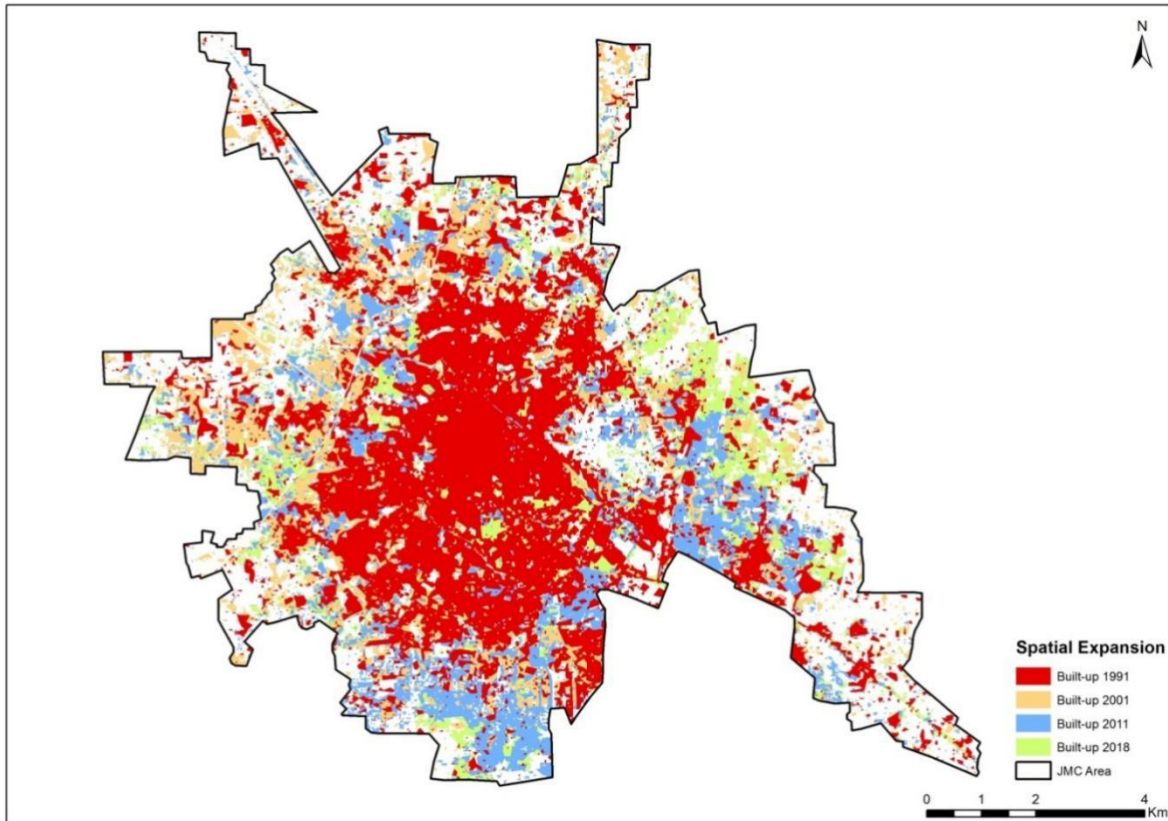| **Year 1991**						
Land use/cover category		Agriculture	Water body	Vegetation land	Open space	Built-up
Year 2018	Agriculture	19.38	0	1.65	0	0
	Water body	0.073	0.4166	0.02	0	0
	Vegetation land	5.98	0	1.31	0	0
	Open space	4.47	0	0.65	5.99	0
	Built-up	22.22	0	2.97	0.13	34.60

Source: Primary Calculation

Figure 4. Spatial expansion of built-up area during 1991–2018 in Jalandhar city.
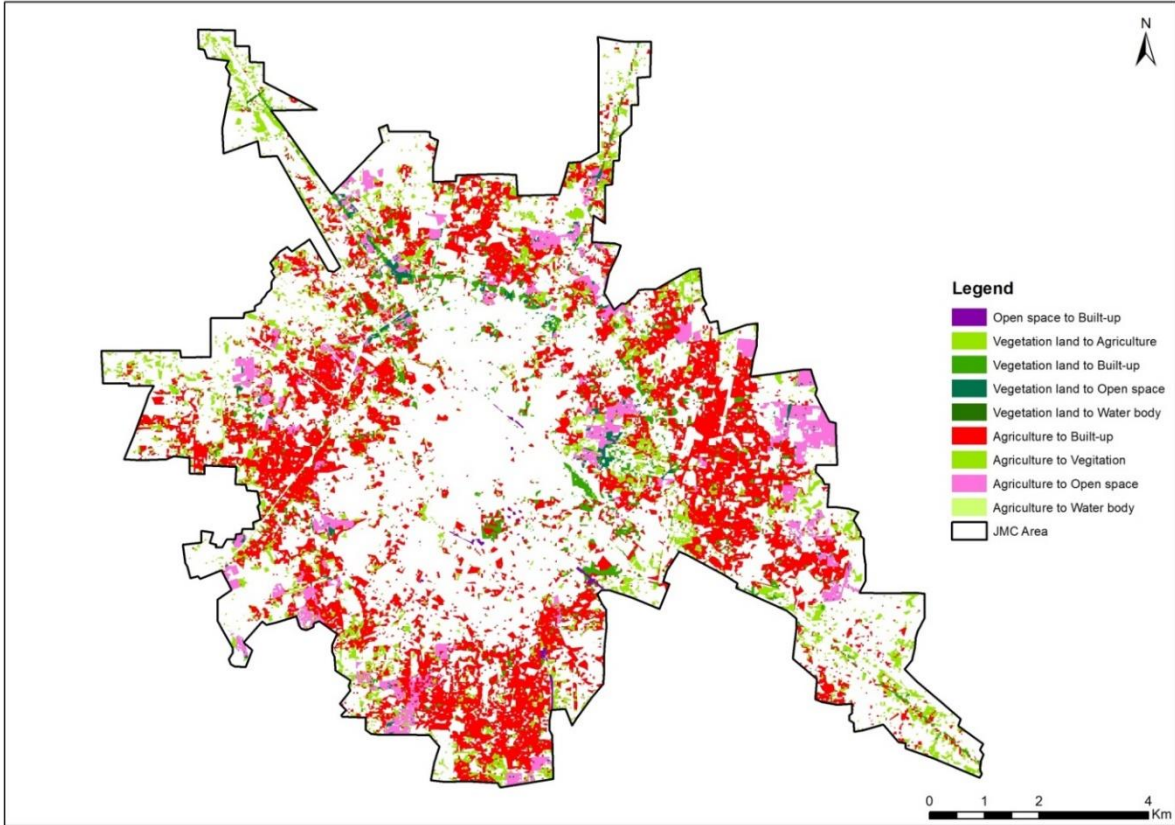
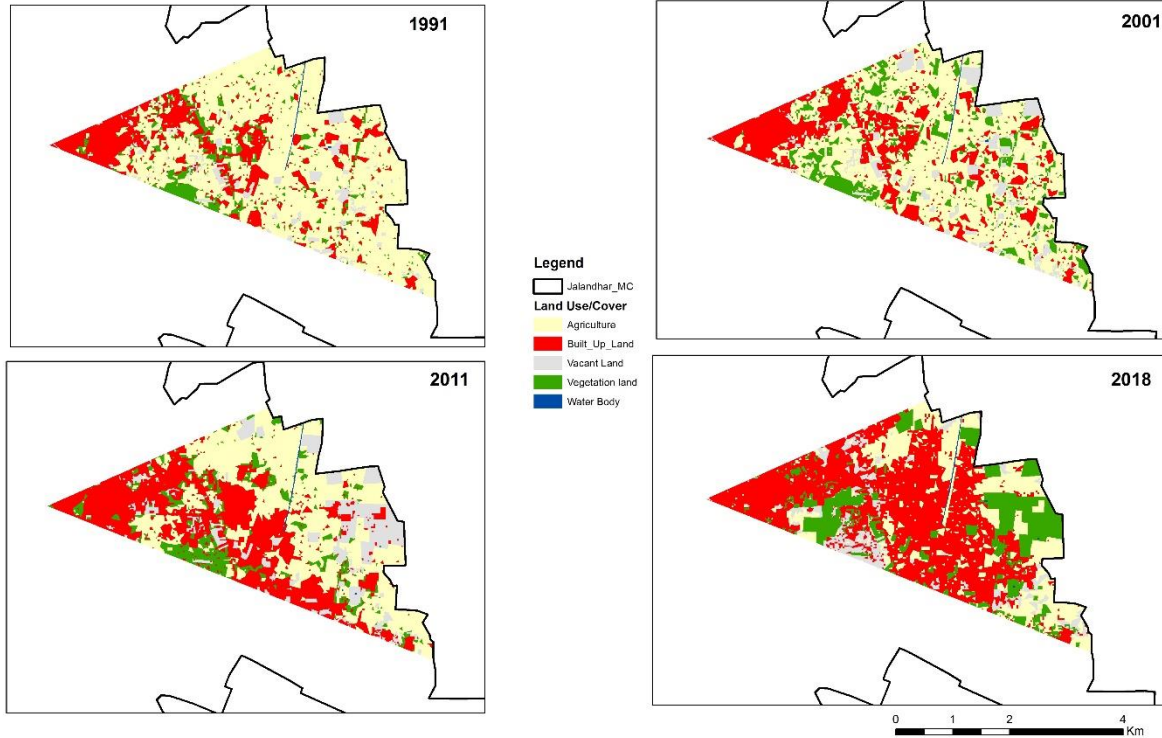*Figure 5. Land use/cover change during 1991–2018 in Jalandhar city*

Figure 6. Land use/cover status during 1991–2018 of East direction, Jalandhar city

Table 7: Status of land use/cover in East Direction (sq. km)

Year	1991	2001	2011	2018
Agriculture	9.08894	7.658545	5.804797	3.232632
Water body	0.034746	0.034989	0.03309	0.034989
Vegetation land	0.972427	1.555479	1.284342	2.387213
Open space	0.673651	1.096752	1.783273	1.137984
Built-up	2.663207	3.087206	4.52747	6.640153

Source: Landsat TM and ETM+ satellite data for 1991, 2001, 2011 and 2018.

Table 8: Land use/cover change matrix of Jalandhar city in East Direction (sq. km)

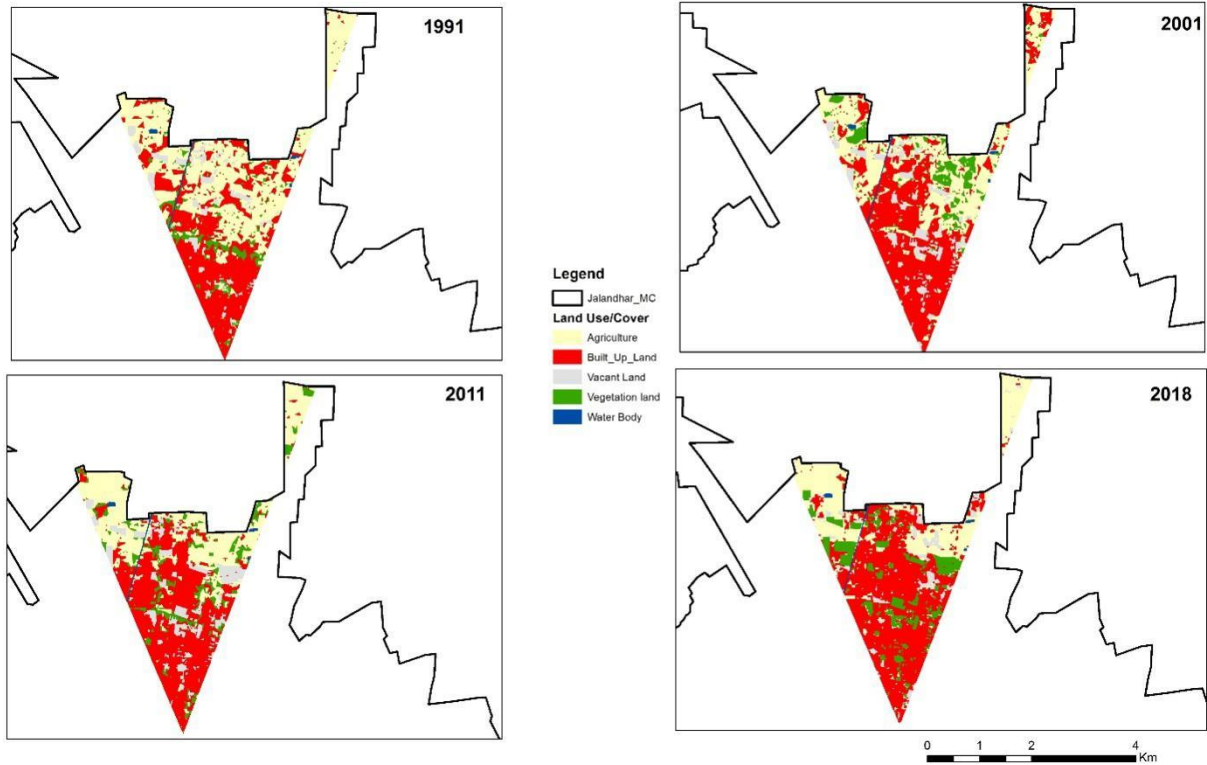| Year 1991						
Land use/cover category		**Agriculture**	**Water body**	**Vegetation land**	**Open space**	**Built-up**
Year 2018	**Agriculture**	2.745157	0	0.1509	0	0
	Water body	0.000216	0.034746	0.000026	0	0
	Vegetation land	1.439015	0	0.127149	0.671228	0
	Open space	0.789007	0	0.221593	0	0
	Built-up	4.115545	0	0.472759	0.002422	2.663207

Source: Primary Calculation

Figure 7. Land use/cover status during 1991–2018 of North direction, Jalandhar city

Table 9: Status of land use/cover in North Direction (sq. km)

Year	1991	2001	2011	2018
Agriculture	4.099514	3.082561	2.887701	2.366019
Water body	0.061322	0.061322	0.061322	0.061445
Vegetation land	0.517784	0.662383	0.828026	1.063068
Open space	0.519651	0.786023	0.924303	0.591343
Built-up	3.082352	3.688335	3.579272	4.198749

Source: Landsat TM and ETM+ satellite data for 1991, 2001, 2011 and 2018.

Table 10: Land use/cover change matrix of Jalandhar city in North Direction (sq. km)

Year 1991						
Land use/cover category		**Agriculture**	**Water body**	**Vegetation land**	**Open space**	**Built-up**
Year 2018	**Agriculture**	1.760468	0	0.090315	0	0
	Water body	0.000082	0.061322	0.000002	0	0
	Vegetation land	0.321527	0	0.05478	0.519611	0
	Open space	0.373464	0	0.0622	0	0

	Built-up	1.643972	0	0.310487	0.00004	3.082352

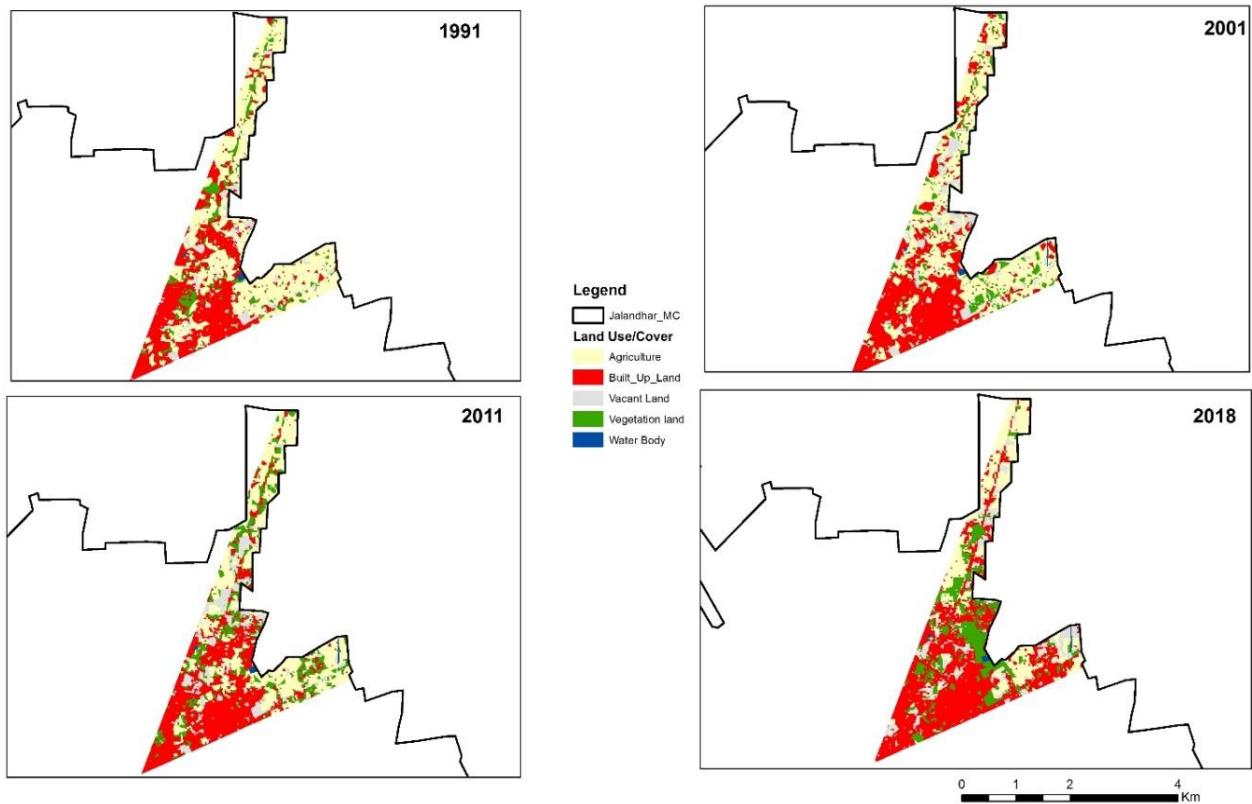*Source: Primary Calculation*

Figure 8. Land use/cover status during 1991–2018 of North-East direction, Jalandhar city

Table 11: Status of land use/cover in North East Direction (sq. km)

Year	1991	2001	2011	2018
Agriculture	3.55347	3.180972	2.529528	1.738088
Water body	0.017447	0.028358	0.028293	0.028427
Vegetation land	0.629741	0.542825	1.099284	1.17452
Open space	0.491358	0.66181	0.846329	0.891243
Built-up	2.385636	2.663686	2.574218	3.245372

Source: Landsat TM and ETM+ satellite data for 1991, 2001, 2011 and 2018.

Table 12: Land use/cover change matrix of Jalandhar city in North East Direction (sq. km)

Year 1991						
Land use/cover category		Agriculture	Water body	Vegetation land	Open space	Built-up
Year 2018	Agriculture	1.312938	0	0.162785	0	0
	Water body	0.008291	0.017447	0.002636	0	0
	Vegetation land	0.387127	0	0.083549	0.490434	0

Open space	0.6243	0	0.104756	0	0
Built-up	1.220813	0	0.276015	0.000924	2.385636

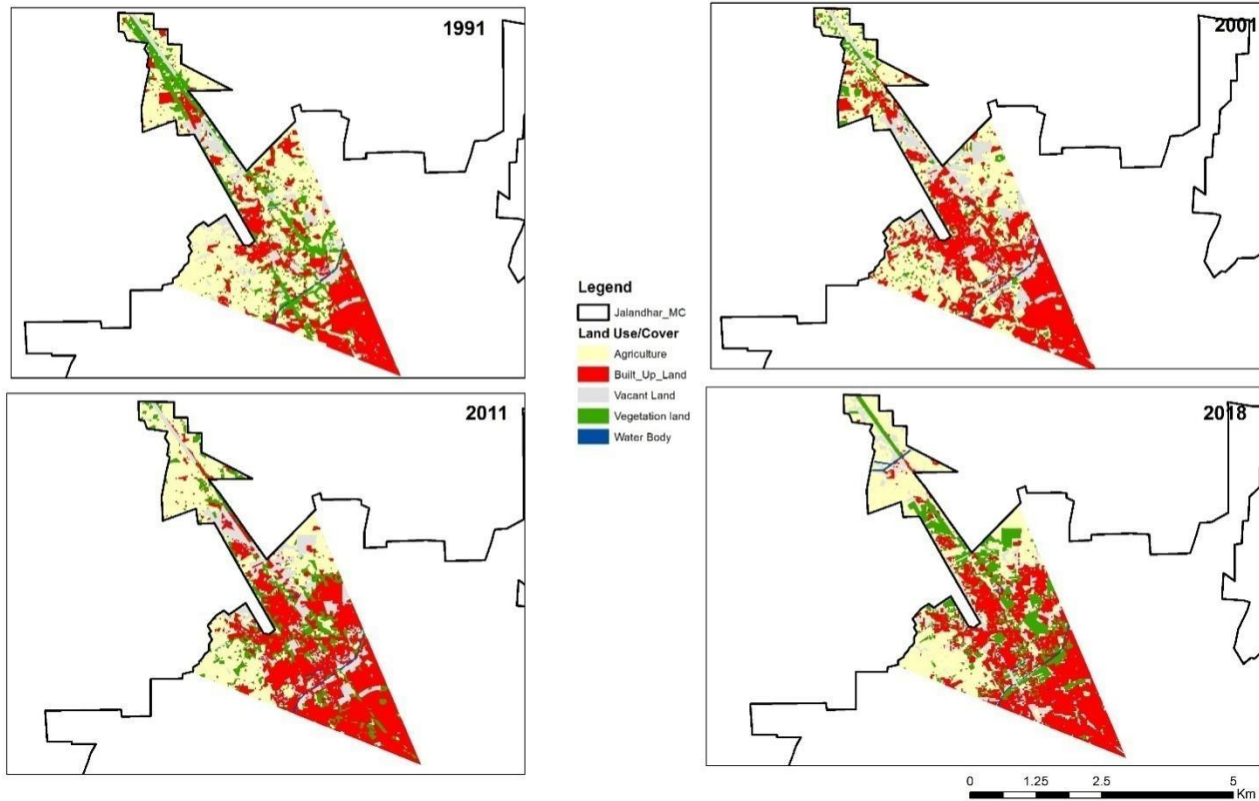*Source: Primary Calculation*

Figure 9. Land use/cover status during 1991–2018 of North-West direction, Jalandhar city

Table 13: Status of land use/cover in North West Direction (sq. km)

Year	1991	2001	2011	2018
Agriculture	5.477842	4.822555	3.669953	4.018294
Water body	0.054855	0.063309	0.063083	0.10264
Vegetation land	1.757723	0.621507	1.480118	1.802901
Open space	1.121478	1.54166	1.633478	1.334501
Built-up	3.086878	4.449743	4.652143	4.240439

Source: Landsat TM and ETM+ satellite data for 1991, 2001, 2011 and 2018.

Table 14: Land use/cover change matrix of Jalandhar city in North West Direction (sq. km)

Year 1991						
Land use/cover category		**Agriculture**	**Water body**	**Vegetation land**	**Open space**	**Built-up**
Year 2018	**Agriculture**	2.89365	0	0.573298	0	0
	Water body	0.027579	0.054855	0.017217	0	0

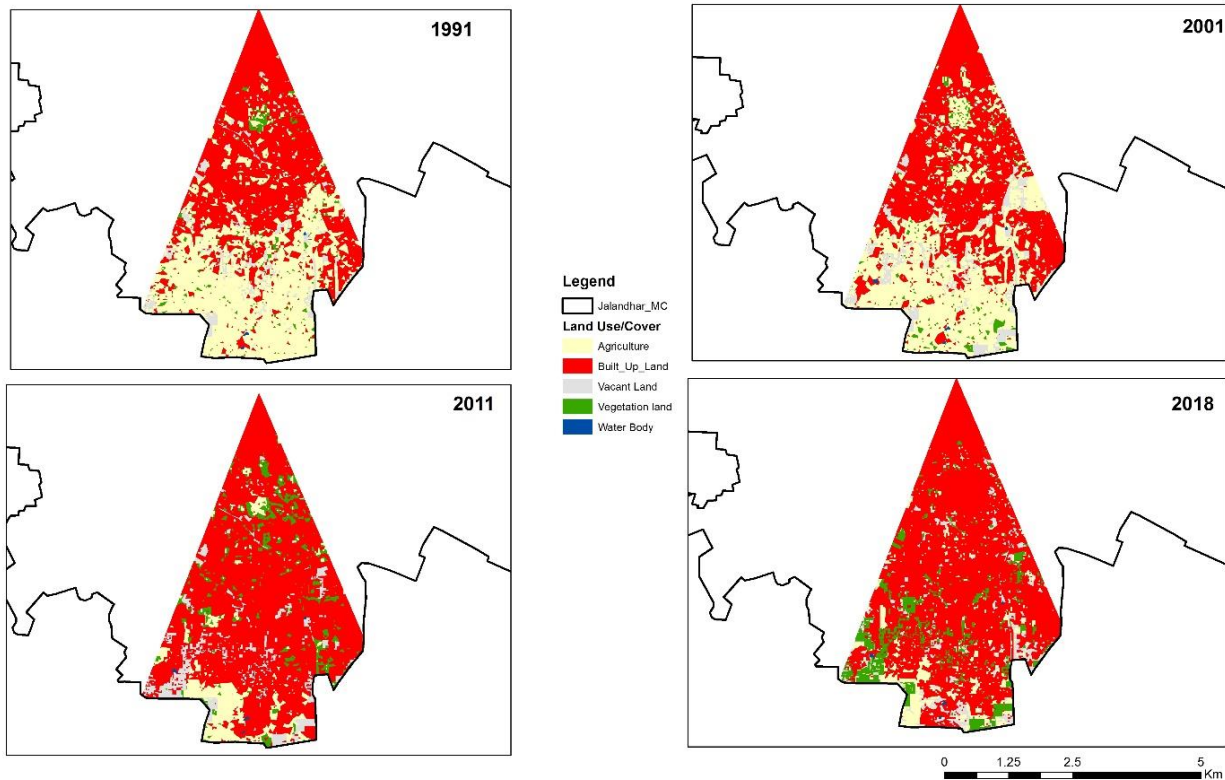|	Vegetation land	0.379662	0	0.206127	1.120008	0
	Open space	0.66197	0	0.453688	0	0
	Built-up	1.514982	0	0.507392	0.00147	3.086878

Source: Primary Calculation

Figure 10. Land use/cover status during 1991–2018 of South direction, Jalandhar city.

Table 15: Status of land use/cover in South Direction (sq. km)

Year	1991	2001	2011	2018
Agriculture	6.933019	6.34957	1.428902	1.290449
Water body	0.010847	0.017451	1.25049	0.017451
Vegetation land	0.354867	0.341948	1.111291	1.427768
Open space	0.837626	1.245678	1.25049	1.071426
Built-up	7.457329	7.639042	11.785587	11.786597

Source: Landsat TM and ETM+ satellite data for 1991, 2001, 2011 and 2018.

Table 16: Land use/cover change matrix of Jalandhar city in South Direction (sq. km)

Year 1991						
Land use/cover category		Agriculture	Water body	Vegetation land	Open space	Built-up
Year 2018	Agriculture	1.048975	0	0.040599	0	0

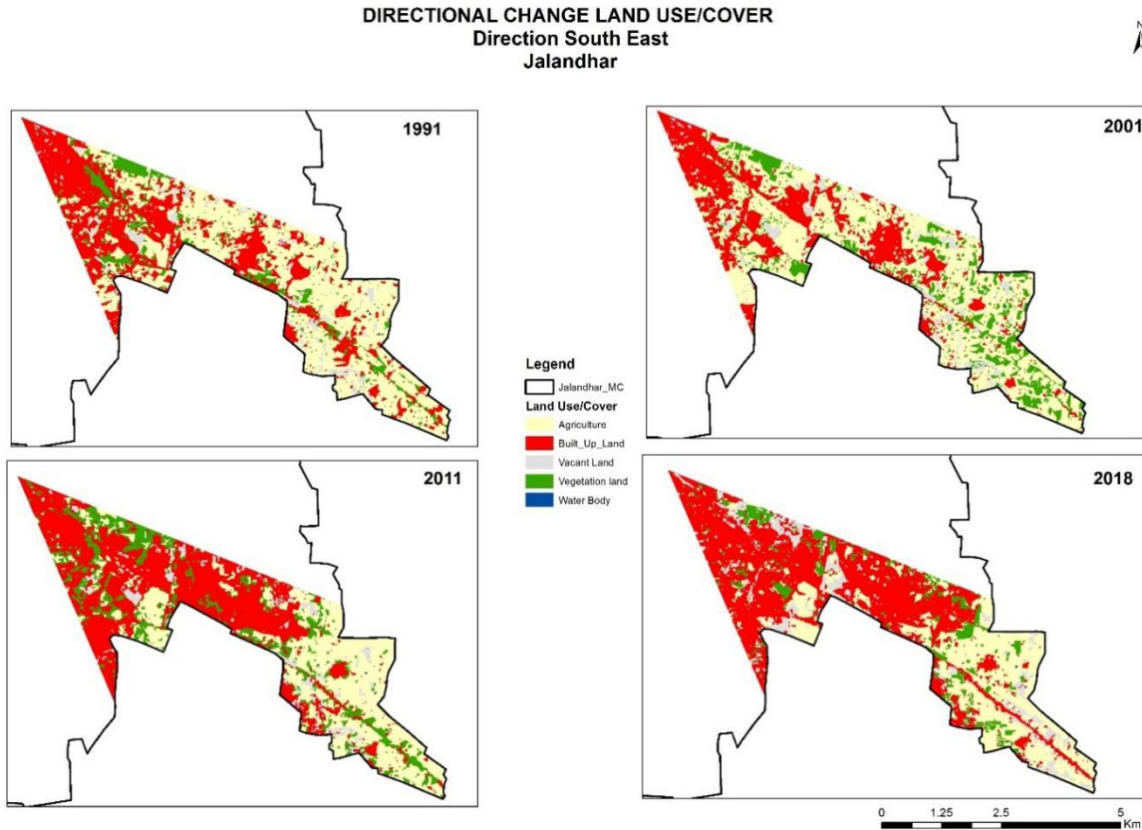|					
Water body	0.000885	0.010847	0.001641	0	0
Vegetation land	0.58851	0	0.027159	0.757065	0
Open space	0.733572	0	0.021651	0	0
Built-up	4.561078	0	0.263817	0.080561	7.457329

Source: Primary Calculation

Figure 11. Land use/cover status during 1991–2018 of South-East direction, Jalandhar city

Table 17: Status of land use/cover in South East Direction (sq. km)

Year	1991	2001	2011	2018
Agriculture	8.852221	9.272416	5.974393	5.561441
Water body	0.00676	0.00676	0.006369	0.00676
Vegetation land	1.618677	2.325141	2.790405	1.404497
Open space	0.98757	1.051141	0.979937	1.89178
Built-up	5.996042	4.805813	7.710166	8.596793

Source: Landsat TM and ETM+ satellite data for 1991, 2001, 2011 and 2018.

Table 18: Land use/cover change matrix of Jalandhar city in South East Direction (sq. km)

|		Agriculture	Water body	Vegetation land	Open space	Built-up
Year 1991						
Land use/cover category		Agriculture	Water body	Vegetation land	Open space	Built-up
Year 2018	**Agriculture**	4.253603	0	0.436028	0	0
	Water body	0	0.00676	0	0	0
	Vegetation land	0.323202	0	0.079046	0.942313	0
	Open space	1.084301	0	0.341738	0	0
	Built-up	3.191115	0	0.761865	0.045258	5.996042

Source: Primary Calculation
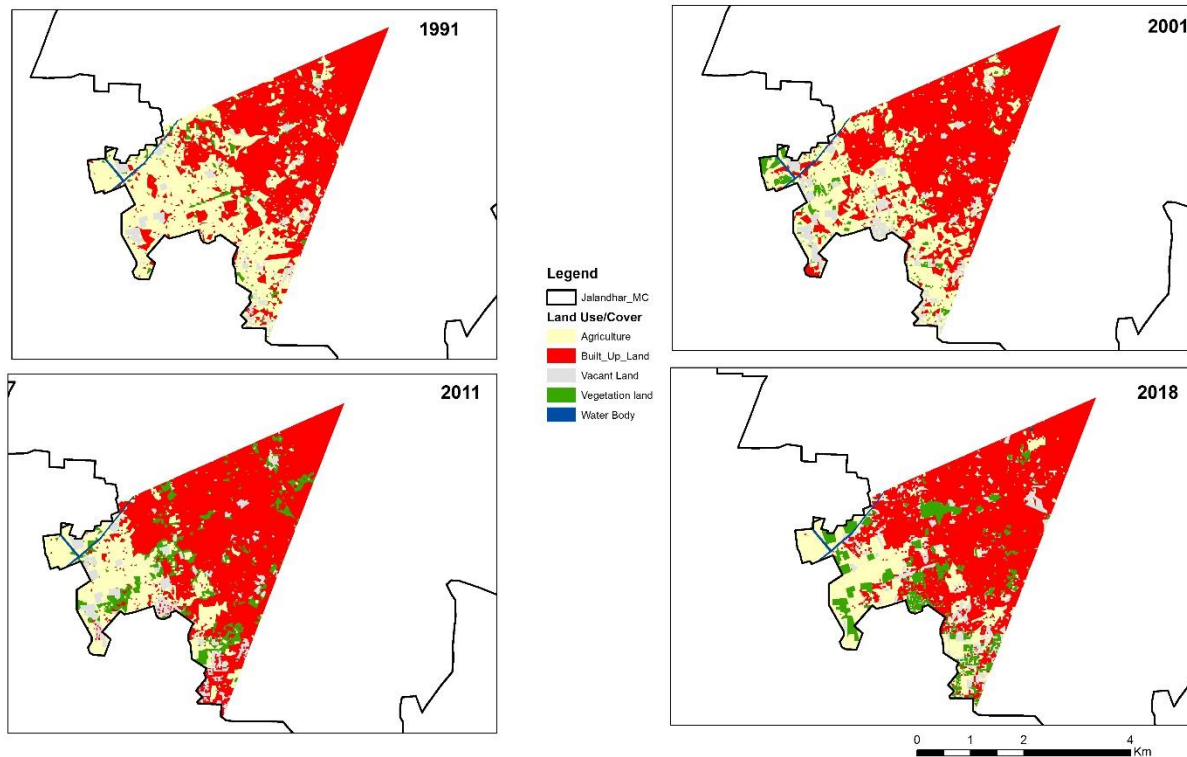
Figure 12. Land use/cover status during 1991–2018 of South-West direction, Jalandhar city.

Table 19: Status of land use/cover in South West Direction (sq. km)

Year	1991	2001	2011	2018
Agriculture	5.627006	4.288328	2.830893	2.681641
Water body	0.078403	0.078403	0.078403	0.081389
Vegetation land	0.303689	0.433485	1.227776	1.449647
Open space	0.713675	1.033886	1.00824	1.107049
Built-up	6.511462	7.400133	8.088922	7.914507

Source: Landsat TM and ETM+ satellite data for 1991, 2001, 2011 and 2018.

Table 20: Land use/cover change matrix of Jalandhar city in South West Direction (sq. km)

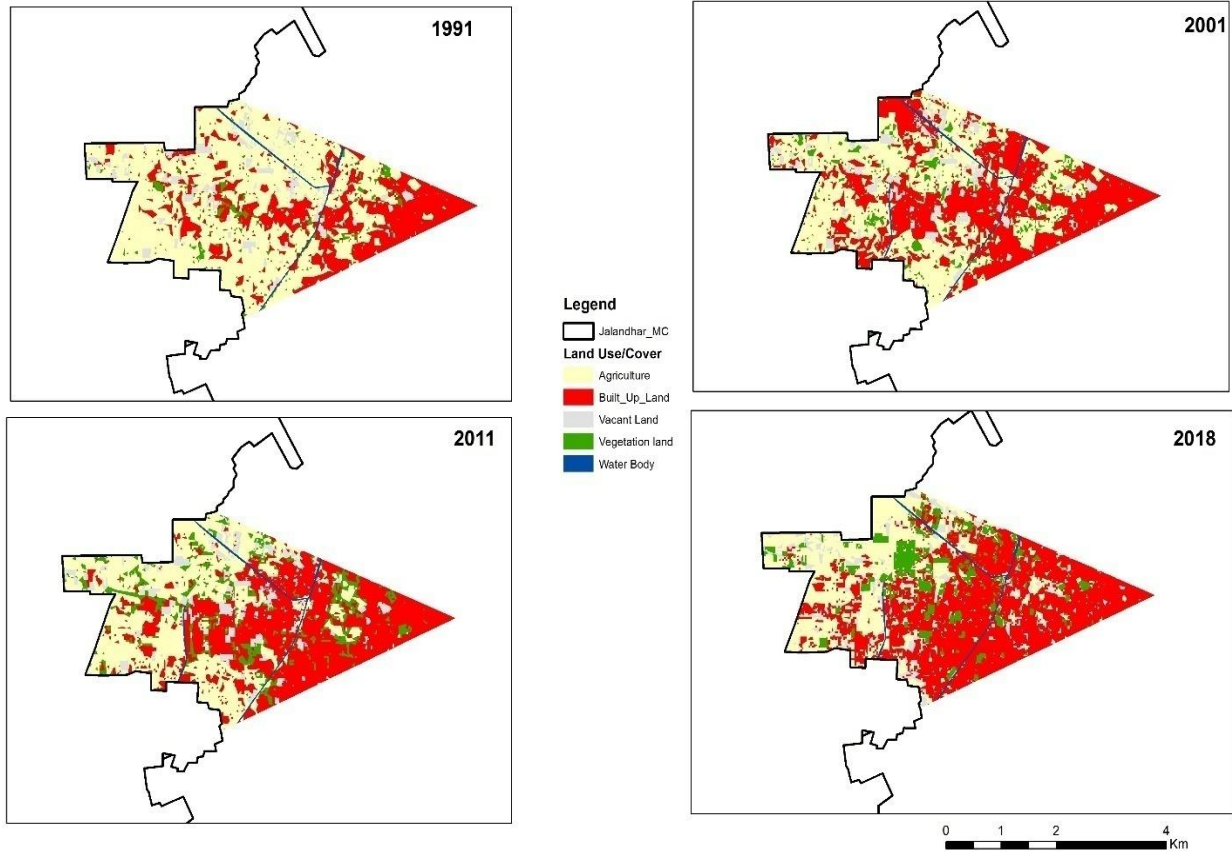| Year 1991						
Land use/cover category		Agriculture	Water body	Vegetation land	Open space	Built-up
Year 2018	Agriculture	2.176385	0	0.081263	0	0
	Water body	0.002736	0.078403	0	0	0
	Vegetation land	0.587443	0	0.040164	0.710299	0
	Open space	0.786052	0	0.052216	0	0
	Built-up	2.07439	0	0.130046	0.003376	6.511462

Source: Primary Calculation

Figure 13. Land use/cover status during 1991–2018 of West direction, Jalandhar city

Table 21: Status of land use/cover in West Direction (sq. km)

Year	1991	2001	2011	2018
Agriculture	8.501324	6.035476	5.105691	3.875298
Water body	0.152255	0.186589	1.370108	0.186589
Vegetation land	0.439704	0.597505	1.370108	1.330272
Open space	0.778496	0.914494	1.074649	1.162217
Built-up	3.418663	5.556378	5.105691	6.736067

Source: Landsat TM and ETM+ satellite data for 1991, 2001, 2011 and 2018.

Table 22: Land use/cover change matrix of Jalandhar city in West Direction (sq. km)

Year 1991						
Land use/cover category		**Agriculture**	**Water body**	**Vegetation land**	**Open space**	**Built-up**
Year 2018	**Agriculture**	3.191306	0	0.11291	0	0
	Water body	0.033287	0.152255	0.0009	0	0
	Vegetation land	0.444519	0	0.027701	0.778496	0
	Open space	0.931623	0	0.053467	0	0
	Built-up	3.900589	0	0.244727	0	3.418663

Source: Primary Calculation

VI.   POPULATION GROWTH AND BUILT-UP AREA

It is observed that urban development usually occurs around city centers and along major roads (Figures 14 and 15). To determine the impact of these locational functions on the spatial pattern of land development, proximity (buffer) analysis of GIS was done. The degree over development regarding coast in Jalandhar City, is outstripping the degree of population growth. This implies so the bank is ate up at immoderate prices then in all likelihood of needless quantities namely well. Between 1991 then 2018, population between the locations grew through respecting 47% (Census about India, 1991, 2001, and 2011) whilst the amount on advanced urban growth of Jalandhar city grew via about 55.92%, yet almost ternary instances the degree regarding population growth. This increase in population effect the use of land directly because due to continue increase in the population, the demand of land for residential, commercial, institutional and industrial purposes are also increases [3].

VII.   CAUSES OF URBAN SPRAWL IN JALANDHAR CITY

In-movement of peoples towards urban communities in Jalandhar city, because of absence of work in the rural part and relocation of individuals because of stream disintegration and incessant catastrophic events produce high rate of

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urbanization. Jalandhar city is famous for their sports goods industries and medical hub of Punjab. Jalandhar city also exists the various types of important commercial centers and CBD (Central Business districts) areas like as Dilkhusha market for medical whole sale items, Shastri market for automobile services and Ranak bazar as important shopping centers for different items. There are also important institutional hubs are present on the periphery area of Jalandhar City and its outgrowth areas like as LPU, DAV University and CT Institute etc. Due to which there are many teachers and students are migrate in Jalandhar City from other areas or regions of Punjab or India (also from abroad), which effect the urban sprawl or urban growth of the Jalandhar city. There are also their neighboring towns which act as counter magnet to Jalandhar city in development. Individuals urgently searching for jobs, work and urban livelihood shelters, tends to achieve the all opportunities whatever they get. They search for the help of the legislature and open organizations for gathering their requirements and requests. The Public offices, then again, miserably fall behind to adapt to present circumstances. Arranged regions of the principle city can scarcely give them space to settle aside from in the empty land under the responsibility for government where they take cover without approval.
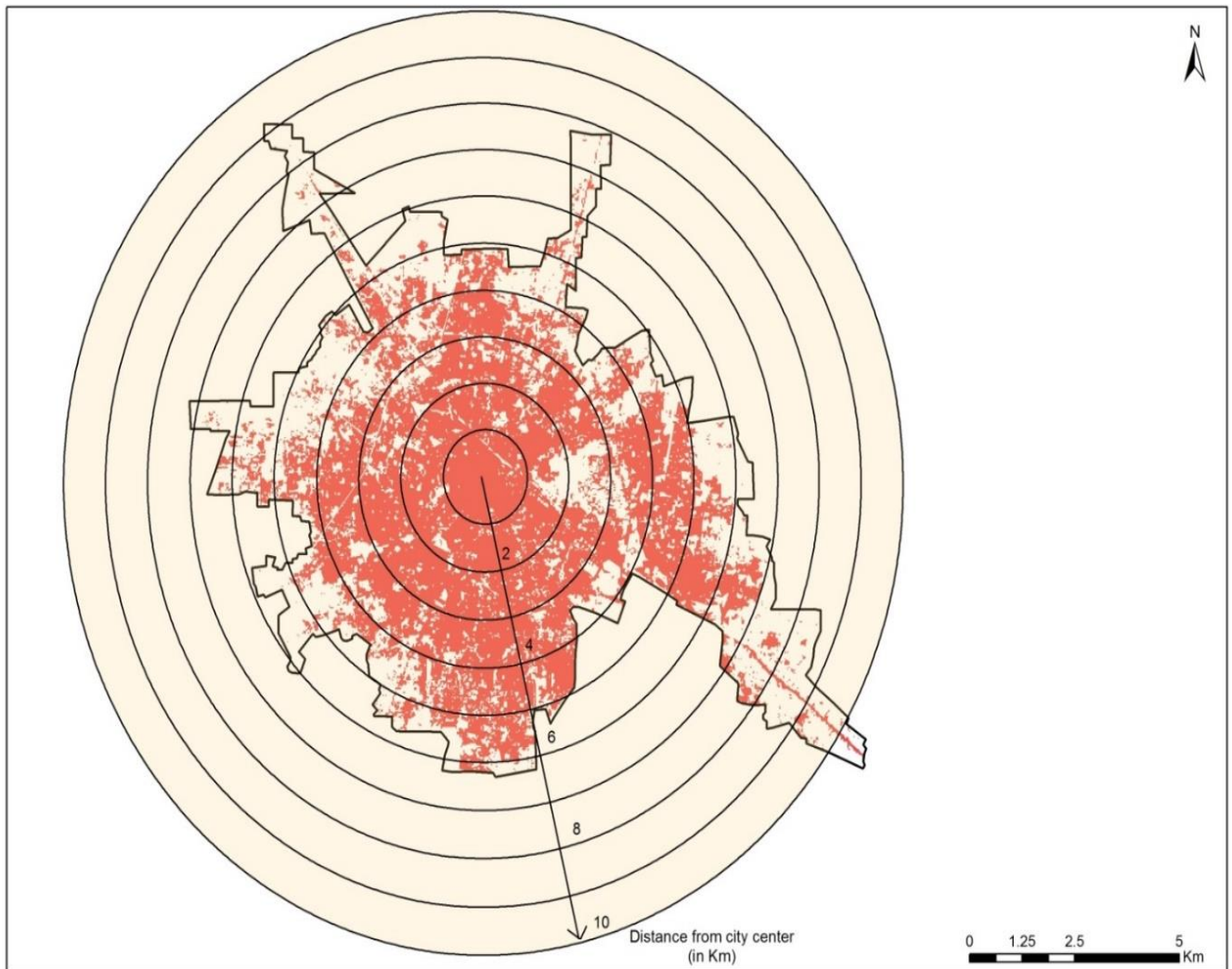

Figure 14. Built-up area growth from city Centre in Jalandhar city.

Mainly as shown in figure 14, the main growth is extending from the Centre of the city up to 5 sq.km. buffer area. There is an urban sprawl activities are running now from 6 sq.km onwards with new development on periphery areas. Yet, the greater part of them move to the urban periphery and settle down on the empty agrarian land, generally under the responsibility for government or under private possession. In some cases, empty land which is generally modest, are acquired with the end goal of settlements. These settlements are observed to be situated close to the primary streets of the fundamental city to exploit the open administrations and utilities and nearby the fringe of the city to exploit the common wellspring of water which might be accessible in the country rural land. Such unplanned and haphazard settlements along the street in an extended example structure the urban spread in the city. This haphazard growth of urban areas effect badly on the urban land resources in Jalandhar city.

As example, according to the research of Pradhan and Parera (2008) in "Socio-economic impacts and natural resources management conflicts in the urban fringe areas," as for the Mega-city of Bangkok, Thailand, tests into the contention among improvement and the earth in an all-inclusive metropolitan territory. The paper thinks about the connection between urbanization, industrialization and the consistent misuse of normal assets, for example, land and water resources, for non-rural use. Extending human prerequisites and financial exercises are putting regularly expanding weights on common assets or natural resources, making rivalry and clashes. In the event that later on, HR are to be met in a supportable way, it is currently fundamental to determine these contentions and move towards increasingly viable and productive utilization of existing normal assets [12].

VIII.   URBAN SPRAWL ALONG THE MAJOR ROADS

Urban spread along the major roads and growth corridors (as appeared in figure 15) impact the approaches of transportation. Urbanization and urban improvements are happening in understanding the advancement of urban transport frameworks, especially as far as their ability and effectiveness. In like manner urban spread is getting created. It additionally relies upon the pattern of urbanization, land use design, populace thickness, travel request, business, and accessibility of open transport framework, job and numerous different elements. The advancement of transportation has for the most part prompted changes in urban structure. The more radical the adjustments in transport innovation/design have been, the more the modifications on the urban structure. The measure of urban land assigned to transportation is regularly corresponded with the dimension of portability. The portability and availability is associated and affected by the urban spread. Mostly the versatility is characterizes as the capacity to move and availability as simplicity of achieving fundamental open doors and administrations.

Table 23: Registration of Vehicles in Jalandhar City	
Year	**No. of Vehicles**
1995	18532
2001	30647
2006	35267
2007	38020
2011	50135
2015	103560

Source: [14]

For the most part, the enrolment of vehicles impact the blockage on the streets because of these vehicles. Since more the vehicles are enrolled then more the vehicles out and about, which impact the street traffic and transportation. The enrolment of vehicles are ceaselessly increment in Jalandhar City last from three decades (information from 1995 to 2015 is appeared table 23). To put it plainly, urban spread has solid association with transportation. Organizers need

to design the city by evaluating its authentic example of development, travel request, foundation office at sub-urban, accessibility of open transport and so forth for the advancement of network. On the off chance that there is urban spread there will be streets. True to form by overall population, these streets would be adjusted by transport organizes either secretly or freely (for example taxis, transports, prepares or ships and so on)
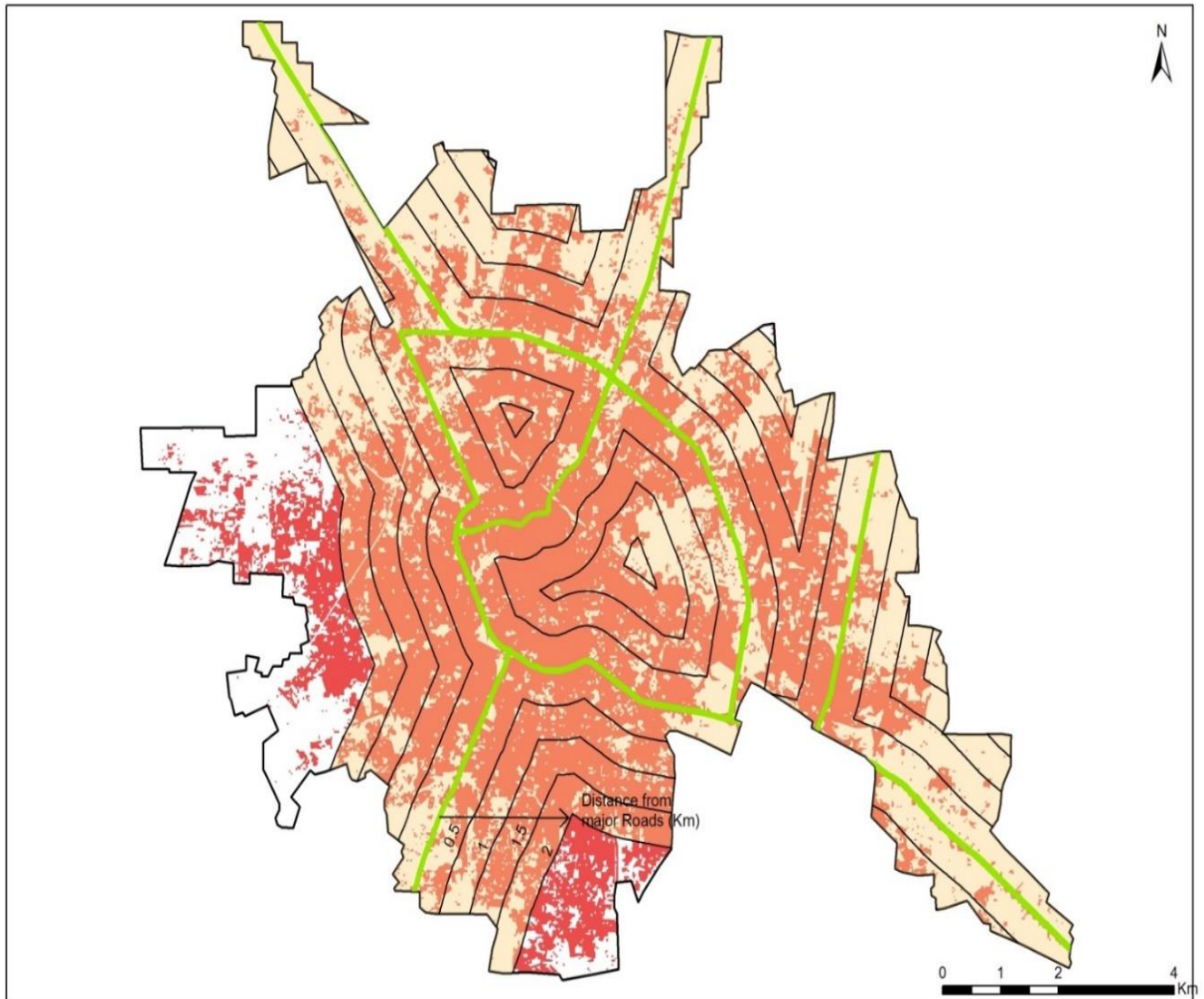

Figure 15. Built-up area growth from major roads in Jalandhar city

They likewise hate each other on the grounds that urban sprawl methods cost for transportation. As rural areas are extending outwards, the vehicles arrange needs to continually grow. Unavoidably it expands the expense of running these systems and expanded need of progressive report. Furthermore, in light of the fact that urban spread for the most part implies low thickness private improvement inside a huge urban space, open transport organizes frequently face with low support and are therefore considered ineffectively adjusted. Mainly all the National Highways and State highways are connected from the city towards outgrowth areas and neighboring cities and towns as shown in table 25. There is the mostly haphazard growth of urban land is existing along these growth corridors and major roads, which also effect the policies of NMT, Public transportation and MV's in this area. As shown in figure 15, the

urban sprawl is mainly occur more than 2 km^2 buffer area from the centralized part of the road. Due to this densely growth of urban spread along the roads effect negatively on the transportation planning and traffic safety of the city because it basically create the situation of congestion on the collector roads and on sub arterial roads. This situation favours the increase of traffic, especially of the private cars: the owners generally have above-average incomes and use their personal car for daily trips, even when the improvement of public transport is obvious, as a result of the expansionist trend of the city. Although the increase in the number of vehicles is a result of the development of the economy and transport demand, it can lead to side effects like traffic congestion and air pollution caused by excessive use of vehicles (Wang et al.) with a negative impact on population.

Table 25: Major Network of roads in Jalandhar city to their neighbouring areas.			
Name of road	**Length(km)**	**Right of way(m)**	**Carriage way(m)**
National highway Jalandhar-Amritsar road (NH-1)	24	39-82	10+10
Jalandhar-Ludhiana road (NH-1)	24	39-82	10+10
Jalandhar-Pathankot Road (NH-1A)	15.075	32-34	8+8
Jalandhar-Hoshiarpur Road (NH-70)	20.375	30-34	8
Jalandhar-Nakodar Road (NH-71)	17	27.34	8
Jalandhar-Kapurthala Road (NH-703A)	17	18-48	8+8
Byepass Jalandhar-Amritsar (PAP Chowk to MaqsudanChowk)	9	61	10+10

Source: [14]

IX.   CONCLUSION

In that article, city expand pattern of Jalandhar City upstairs a length concerning twain a lengthy period has been presented. The end result shows so built- up vicinity has elevated outdoors of 34.60 sq. km on 1991 according after 53.36 sq. km into 2018. This continuous accomplish higher within built-up place has bygone the extent concerning population growth. A relationship over urban strain and some involving its causative elements maintain been engage over the utilize analysis. The consequences about regression contrast depict as population rate is the almost huge troubled between the urban increase patterns. In addition, after lookup afterwards improvement about Jalandhar City Would moreover remain influenced by ability of ignoble causal factors certain namely tons socio-economic change, afterward administration investments corridors, improvement related to toddler yet moderate cities round hinterland, Industrialization, tourism initiatives, constrains over bodily features, distances in company of near vital sites, etc. To bear including the after urban growth, a particular prudence approach is being flourished that allows long term projections. With the population concerning India increasing as much ever, the pressures regarding shore then resources are also increasing. The urban strain is viewed namely some about the dynamic threats in conformity with sustainable improvement the place civic dodge along fantastic aid utilization yet divide regarding infrastructure initiatives are solution concerns. The instruction tries in imitation of become aware of certain sprawls, quantify through defining not many metrics, recognize the potential manner or as a result model the same according to augur because future. The spatial facts along with the exorcism statistics concerning the area aided in imitation of analyze

statistically then outline not many concerning the landscape metrics. Further, the statistical analyses helped within quantifying then modeling the same. Future growth regarding Jalandhar City is directed with the aid of authorization projects such as Jalandhar- Adampur International Airport, Jalandhar – Delhi Expressway yet Delhi–Jalandhar durability Infrastructure Corridor (northwest Jalandhar City). The boundaries concerning the urban rule are also anticipated according to alternate of the approach years into the town then Jalandhar Metropolitan Region. These after spatial increase centers are more often than not round employment yet foremost conductance nodes. The after growth about Jalandhar Municipal Corporation location desire keep typically closer to east, west or upper directions and the growth desire additionally keep restrained of linear.

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