

Urban System and Entropy Analysis for Settlements of Punjab

PANKHURI BHATIA*
ASHWANI LUTHRA**

ABSTRACT

Urban system, generally referred to as networking of towns and cities having socio-cultural and economic interdependencies, is witnessed to experience varying spatial distribution patterns on account of varying accessibility levels, economic potentials, availability of natural and human resources, administration primacy, statutory urbanization policy, etc. Studies on distribution of urban settlements reflect varying accessibility levels and absence of urbanization policy, which tend to bring about imbalances in their distribution pattern. Punjab is a rapidly urbanizing state of India, which presents different distribution patterns due to variations in physiography, economic base, and transportation network in its regions. An appraisal of urban settlement distribution pattern reveals clustered, nucleated, and linear patterns of distribution in the State. Disaggregated analysis through application of nearness neighbourhood principle on the urban settlements of Punjab reveals three distributional segments in the State namely random distribution of settlements in the west, linear clustering in the central and eastern parts. However, parts of the State away from the central rail-road corridor and closer to inter-state boundaries show varying spatial distribution patterns. The present paper focuses on the investigating varying distributional patterns in different regions of the State with an objective to suggest policy framework for balanced urban system.

Keywords: *Urbanization, Urban System, Spatial Distribution Pattern, Nearness of Neighbourhood*

*Research Scholar, Guru Ramdas School of Planning, Guru Nanak Dev University, Amritsar. Email: pankhu12virgo@gmail.com

**Professor, Guru Ramdas School of Planning, Guru Nanak Dev University, Amritsar. Email: ashwani.planning@gndu.ac.in

INTRODUCTION

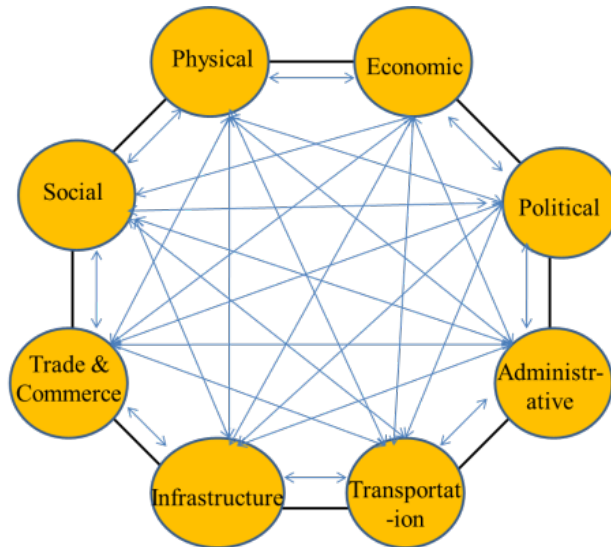
Urban settlements are considered as engines of growth, which do not develop in isolation, rather their interdependencies impact the growth of their surrounding settlements as well. Numerous push and pull factors tend to create link between the towns and cities. Citing Bucking (1967), Pred (1977) has viewed that 'system of cities can be expected to have a structure pattern of interdependencies and information linkages between its units which becomes increasingly intricate with the passage of time'. Thus, an urban settlement functioning as a network to depict interdependencies is generally termed as 'urban system'. Settlements are dynamic in nature and any significant change in them can bring change in the whole urban system. Rapid urbanization is prime factor accountable for bringing such changes leading to emergence of different distribution patterns. Present paper focuses on the study of changing urban system of Punjab in 1981 and 2011 using nearest neighbourhood technique to identify the imbalances occurring due to varying distribution patterns and to suggest a policy framework for balanced urban system.

UNDERSTANDING URBAN SYSTEM

Urban system depends on a variety of sub-systems including physical, economic, political, administrative, transportation, infrastructure, trade and commerce and social. Physical comprises land, topography, vegetation, mineral, and resources available; while economic includes employment, occupational structure, location, and hierarchy of market, etc. Social covers population, literates/illiterates, social status, and age group. Administrative incorporates role of various agencies responsible for development, and different policies and programmes. Numerous educational, medical, and institutional facilities constitute the components of infrastructure and transportation comprises of study of networks, modes, public transport, and terminals. However, integration and interdependence of all sub-systems is foremost for appropriate functioning of urban system. It should work as a grid so that urban system proves to be an efficient system as represented in Fig. 1. Thus, it can be said that urban system is networking between the cities and the neighbouring towns for different purposes and are represented in Fig. 2.

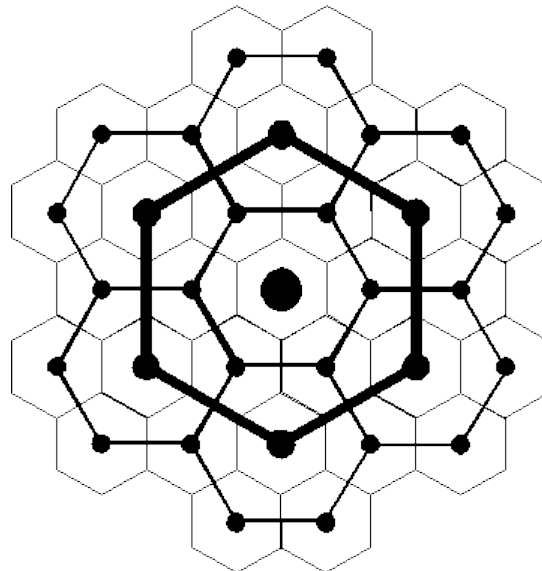
Acknowledging the same, Bourne and Simenons (1978) has defined 'urban system as set of cities in a region or nation and their attributes. It embraces the totality of activities in a nation accounting for the observed relationship among the regions and provides a model for the analysis of spatial variation of growth and change in system. In broader sense, it is still based on urban nodes, i.e. on spatial concentration of people and

Fig. 1: Urban System Mechanism



Source: Dr. Sonar Sanjaykumar G, Urban Sprawl: A System

Fig. 2: System and Sub-Systems of Settlements



Source: <https://rashidfaridi.com/2020/05/05/the-modification-of-august-losch/>

activities within a region or nation but it also includes the relationship of nodes to their surrounding areas and particularly the linkages among nodes'. Ramachandran (1989) is of the view that 'a system is a set of interacting and independent elements. It must be understood that it is not a settlement but its attributes that constitute the elements of that system. The attributes of a settlement are its population, location, aspect of spacing between settlements, the number of services offered and so on'. While clarifying urban system, Faisal (2003) has stated that 'urban system represents the frame within which all urban settlements are organized and interacted with each other regarding their sizes and functions'. System of urban settlements can be studied by applying different models introduced by various authors and researchers. Some of the models are Christaller's Central Place Theory, Losch Theory, Law of Primate City, Zipf's Rank Size Rule, Nearest Neighbourhood Analysis, Entropy Model, Gravity Model, etc. Nearest neighbourhood principle is used in the present research to appraise the urban system of the state of Punjab.

Concept of Entropy

Entropy is a term used to measure the spatial order, or uniformity of a system. In geography, it is applied to examine the distribution pattern of the settlements over a space. Nearness Neighbourhood Principle (NNP) is used to define the distribution pattern of the settlements. Ramachandran (1989) states that NNP is a technique to identify uniform, random, and clustered spatial distribution pattern of settlements based on measuring actual nearest neighbour distances between the settlements. In this analysis, settlements of a given hierarchical level are taken into account and nearest neighbours are identified for each settlement. The formula for calculating nearest neighbour is

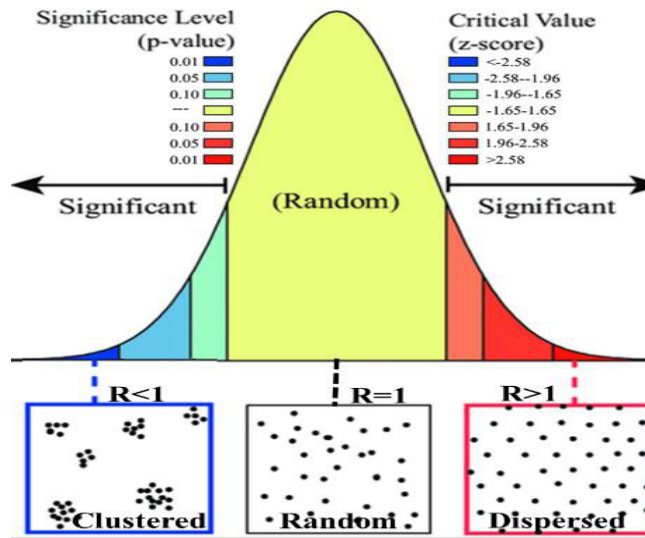
$$R_n = r_A / r_E \quad \text{where}$$

R_n nearest neighbourhood value
 r_A mean observed nearest neighbour distance measured as (r/n)
 r_E mean expected nearest neighbour distance measured as $(0.5 \cdot \sqrt{A/N})$.

Three possibilities exist in the mean nearest neighbour distance. The actual mean nearest neighbour distance may be greater than, equal to or less than expected mean nearest neighbour distance. The ratio of r_A to r_E is known as nearest neighbour statistic R_n that varies from 0 to 2.15. R_n values less than unity indicate clustered distribution; a value equal to unity represents random distribution and value greater than one

indicates a uniform distribution as represented in Fig. 3. In addition, the figure reveals that Z-score of ± 1.65 indicates random distribution pattern; Z-score less than 1.65 indicates clustered distribution tendencies; and Z-score more than 1.65 indicates dispersed distribution tendencies of the objects.

Fig. 3: Nearest N'hood Based Distribution Patterns



Source: Khan Academy, (2021), "Population Size, Density, & Dispersal".

METHODOLOGY

The urban population growth trends are examined to understand the degree and level of urbanization, and class-wise population pattern during 1951-2011. Punjab has distinct physiographic, socio-economic, transportation and political characteristics across its districts and micro regions, therefore, disaggregated analysis of urbanization trends is carried out for its districts to understand the distribution pattern of urban population. Demographic data of District Census Handbooks and Census of India of the respective census years is used for the purpose. With the objective to explore the change in the entropy urban settlements of Punjab, NNP is applied to the classification of urban settlements for the 1981 and 2011 census years. Also, NNP is applied to its micro regions viz., Majha, Malwa and Doaba to understand the urban settlement distribution pattern in them. Spatial distribution pattern is analysed and displayed by using ArcGIS software.

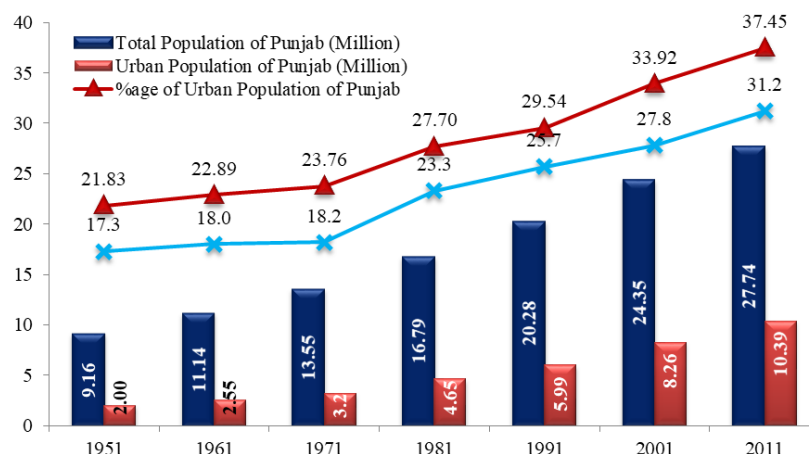
URBANIZATION TRENDS AND PATTERNS

Punjab has remained one of the most progressive states of India before and after Independence. Its economic progress is reflected in the pace at which it is urbanizing, especially since 1951. Following are some of the glaring facts about urbanization trends in Punjab:

Degree of Urbanization

As per Census of India 2011, Punjab is 5th most urbanized state of India. Its urban population stands at 10.3 million in 2011, which happened to be only 2.0 million in 1951 as represented in Fig. 4. Thus, there has been almost five times increment in the urban population of the state. In comparison, total population of the state has risen from 9.2 million in 1951 to 27.7 million in 2011, reflecting more than three times rise during 1951-2011. This indicates that the share of urban population to total population of Punjab is rapidly increasing. Whereas the share of urban population in the total population was 20.73 per cent in 1951, the share has increased to 37.18 per cent in 2011. Progressive industrialization, advanced infrastructure, high connectivity, and proactive government policies and programmes are responsible for higher degree of urbanization in the state. Resultantly, the degree of urbanization of Punjab has always remained four per cent to six per cent higher than the national average in the past six decades as represented in Fig. 4. The state has been on a rapid urbanization path since 2001 as it is growing by about 6 per cent higher than the national average.

Fig. 4: Population Trends of Punjab



Source: Data derived from Census of India, 1951- 2011.

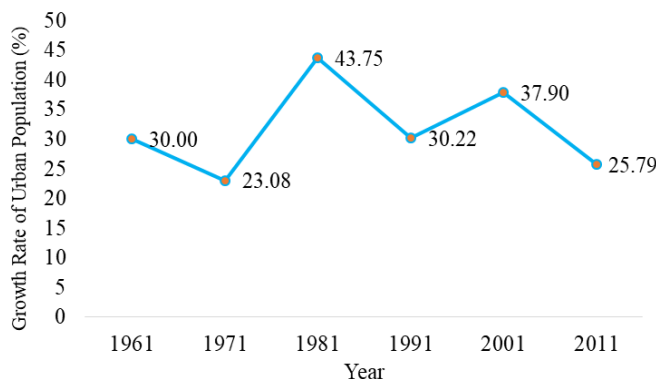
Level of Urbanization

It is not only the high degree but also even the pace of urbanization that is also of paramount importance to figure out the level of urbanization in a region. It is clear from Fig. 5 that oscillating urban growth behaviour is observed during the past six census decades (1951-2011) in Punjab. In 1981, the state registered the highest growth rate (43.75 per cent) in its urban population, which can be attributed to reorganization of the spaces after the enactment of Punjab Municipal Corporation Act 1976, migratory trends resulting from development of mandi towns, shifting tendencies towards industrialization and increased economic opportunities in the urban settlements. The state has witnessed urbanization level at 30 per cent or above in 1961, 1981, 1991 and 2001. Higher level of urbanization can be attributed to the proactive policies and programs of the state government. The growth rate of urban population in the state has decreased from 37.90 per cent in 1991 to 25.79 per cent in 2011.

District-Wise Distribution of Urban Population

Distribution pattern of urban population in the state depicts disparity in the level of urbanization in its districts. The number of districts has increased from 12 in 1981 to 20 in 2011 as shown in Table 1. It is clear from the table that in 1981 Ludhiana, Amritsar and Jalandhar districts contributed to about 16.44 per cent, 15.53 per cent, and 13.18 per cent in the urban population respectively. Rupnagar, Kapurthala and Hoshiarpur districts have shared less than four per cent of total urban population of State. The share of Bathinda, Sangrur, Faridkot, Firozpur, Gurdaspur, and Patiala districts ranges between four per cent to 10 per cent.

Fig. 5: Growth Rate of Urban Population



Source: Data derived from Census of India, 1951- 2011

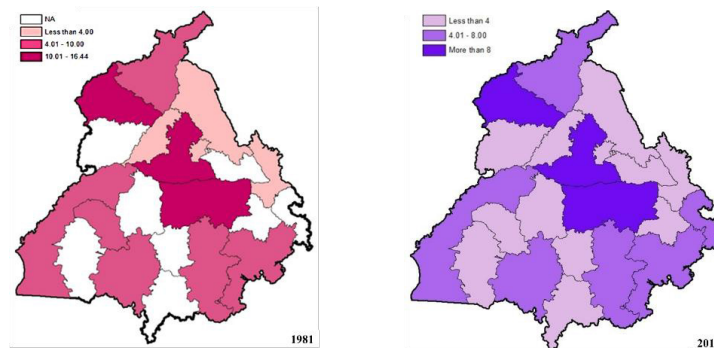
TABLE 1: PERCENTAGE SHARE OF URBAN POPULATION IN THE STATE AND DISTRICTS OF PUNJAB

Districts	Urban to Total Population of the State (Per cent)		Urban to Total Population of the District (Per cent)	
	1981	2011	1981	2011
Amritsar	15.53	12.83	32.97	53.58
Barnala	----	1.83	----	32.02
Bathinda	6.37	4.80	22.68	35.95
Faridkot	7.39	2.09	23.92	35.15
Fatehgarh Sahib	----	1.78	----	30.91
Gurdaspur	7.06	6.34	21.69	28.69
Hoshiarpur	3.86	3.22	14.44	21.11
Jalandhar	13.18	11.17	35.32	52.93
Kapurthala	3.52	2.72	29.97	34.65
Ludhiana	16.44	19.90	42.01	59.16
Mansa	----	1.57	----	21.25
Moga	----	2.19	----	22.82
Mukatsar	----	2.43	----	27.96
Nawanshaher	----	1.21	----	20.48
Patiala	9.99	7.34	29.59	40.26
Rupnagar	3.33	1.71	21.58	25.97
Sangrur	6.92	4.96	22.81	31.17
SAS Nagar (Mohali)	----	5.24	----	54.76
Tarn Taran	----	1.36	----	12.66
Firozpur	6.42	5.31	22.81	27.23

Source: Census of India, 1981 & 2011.

In 2011, the contribution of Ludhiana to the urban population has increased to 19.90 per cent and contribution of Amritsar and Jalandhar has reduced to 12.83 per cent and 11.17 per cent respectively as shown in Fig. 6. This is because Tarn Taran and Nawashaher districts have been carved out from Amritsar and Jalandhar districts respectively. It is clear from figure that though the contribution of Amritsar and Jalandhar districts has reduced but they still remain as top contributors. Also, the other districts such as Barnala, Fatehgarh Sahib, Mansa, Moga, Mukatsar, Nawashaher, Rupnagar and Tarn Taran have the lowest share, i.e. less than four per cent in State's urban population because these districts have come into existence after 2000.

Fig. 6: Percentage of Urban Population in Districts of Punjab

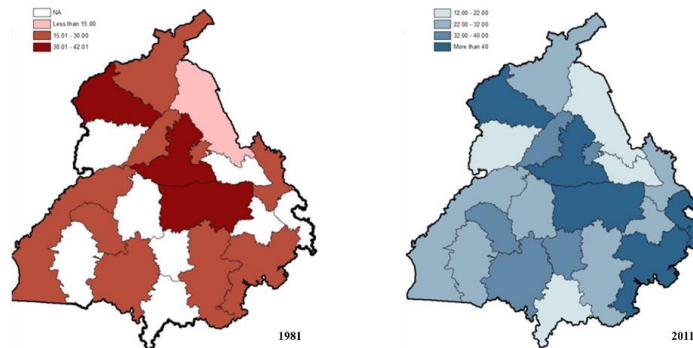


Source: Data derived from Census of India, 1981- 2011.

It is also important to study level of urbanization in the various districts of Punjab. Table 1 shows that in 1981, Ludhiana showed the highest level of urbanization, i.e. 42.01 per cent and ranks 1st followed by Jalandhar (35.32 per cent) and Amritsar (32.97 per cent). It clearly reveals that nearly 30 per cent of total population of districts resides in urban areas. Out of 12 districts, eight districts (66 per cent) have level of urbanization ranging 15 per cent to 30 per cent. Only, Hoshiarpur district has less than 15 per cent level of urbanization. However, Ludhiana, SAS Nagar (Mohali), Amritsar and Jalandhar emerged as most urbanised districts in 2011 (59.16 per cent, 54.76 per cent, 53.58 per cent and 52.93 per cent respectively). It proves that more than half of population of district resides in urban areas.

Though, SAS Nagar (Mohali) is a new formed district but the district emerges as one of the part of tri-city due to nearness to State capital. So, it is ranked second most urbanized districts of Punjab and displaced the Amritsar and Jalandhar district to 3rd and 4th rank. Also, these four districts constitute nearly half of population of Punjab. TarnTaran, Nawashaher, Hoshiarpur and Mansa have the lowest level of urbanization, i.e. 12.66 per cent, 20.48 per cent, 21.11 per cent and 21.25 per cent respectively as represented in Fig. 7. Out of these, TarnTaran and Mansa are the newly formed districts whereas Nawashaher and Hoshiarpur have the lowest population among all districts. The districts located along the central corridor namely Amritsar, Jalandhar, Ludhiana and SAS Nagar have highest percentage of urban population in 2011 as compared to Northern and Southern direction. Similarly, same districts have witnessed high growth rate due to influx of population, proactive government policies and programmes. This leads to create imbalances in terms of population distribution, infrastructure, resources, etc.

Fig. 7: Level of Urbanization in Districts of Punjab (1981 & 2011)



Source: Data derived from Census of India, 1991 and 2011.

Class-Wise Distribution Pattern of Urban Population

With the increasing urbanization, the number of urban settlements has increased in the state. It is clear from Table 2 that total number of statutory and census towns has increased from 134 in 1981 to 217 in 2011. Thus, the state has experienced an increase of 1.62 times in the number of urban settlements. Table 2 reveals that 27.38 per cent (4.6 million) of urban population is accommodated in 134 towns in 1981, which has risen to 37.18 per cent (10.6 million) in 217 towns in 2011, registering an increment of 1.36 per cent. Thus number of urban settlements have risen more than the urban population in the state.

Class distribution of urban settlements in Table 2 reflects that the number of class I towns has risen by about 2.3 times (from 7 in 1981 to 16 in 2011) and the population residing in them has increased by almost 2.5 times (from 2.2 million in 1981 to 5.9 million in 2011). Similarly, number of Class II towns has more than doubled during 1981-2011 (from 10 in 1981 to 24 in 2011) and their population has increased by about 2.8 times. Number of class III, IV, V and VI towns has increased by 1.85, 1.66, 1.28 and 1.14 times but their population has risen by 1.56, 1.80, 0.00, 2.00 times respectively. Thus, it is evident that class I and II settlements are increasing not only in number but their population is also rising by the same proportion, indicating polarization tendencies of urban population.

An analysis of percentage share of towns and population in each class in Table 2 clearly reveals polarization of urbanization in Punjab. It is evident that only 5.22 per cent (7 class I towns) of the total number of towns were accommodating 47.83 per cent (2.2 million) of the total urban population in 1981, in 2011 about 7.37 per cent (16 class I towns) of the total number of urban settlements are accommodating 57.28 per

TABLE 2: CLASS-WISE DISTRIBUTION AND PERCENTAGE SHARE OF URBAN SETTLEMENTS

Year	Urban Population (in million)	Total Towns	Number of Towns						Population					
			Class I	Class II	Class III	Class IV	Class V	Class VI	Class I	Class II	Class III	Class IV	Class V	Class VI
1981	4.6	134	7 (5.22)	10 (7.46)	27 (20.15)	36 (26.87)	40 (29.85)	14 (10.45)	2.2 (47.83)	0.6 (13.04)	0.9 (19.57)	0.5 (10.87)	0.3 (6.52)	0.05 (1.09)
2011	10.3	217	16 (7.37)	24 (11.06)	50 (22.58)	60 (28.11)	51 (22.58)	16 (8.29)	5.9 (57.28)	1.7 (16.50)	1.4 (13.59)	0.9 (8.74)	0.3 (2.91)	0.1 (0.97)

Note: Figures in parentheses are percentages from the row totals.
Source: Census of India, 1981 & 2011.

cent (5.9 million) of the total urban population in the state. Similarly, 7.46 per cent, 20.15 per cent, 26.87 per cent, 29.85 per cent and 10.45 per cent class II, Class III, class IV, class V and class VI towns respectively were inhabiting 13.04 per cent, 19.57 per cent, 10.87 per cent, 6.52 per cent and 1.09 per cent of the total urban population in the respective class of town in 1981. In 2011, 11.06 per cent, 22.58 per cent, 28.11 per cent, 22.58 per cent and 8.29 per cent class II, Class III, class IV, class V and class VI towns respectively are inhabiting 16.50 per cent, 13.59 per cent, 8.74 per cent, 2.91 per cent and 0.97 per cent of the total urban population in the respective class of town. Thus, small number of class I towns are bearing most of the brunt of urban population in Punjab.

It is worth noticing that class II towns have shown positive tendencies, i.e. with the increase in percentage share of number of such towns, they are accommodating an increased share of urban population. Share of class III towns has reduced from 20.15 per cent (27 in number) accommodating 19.57 per cent of the urban population in 1981 to 22.58 per cent (50 in number) accommodating 13.59 per cent of the urban population in 2011. But for all other classes of towns inverse tendencies are seen to indicate that the increasing number of class IV, V and VI towns are accommodating lesser percentage of urban population in them during 1981-2011. It is also evident from Table 2 that almost 59 per cent of the towns (class IV, V and VI towns) are inhabiting only 12.6 per cent of the urban population in them in 2011.

Thus, the share of urban population in lower order towns has decreased over a period of time and that is the sign of lopsided development in the State. This is also an indication of uneven distribution of population in towns of different classes. Resultantly, the pressure on class I towns is increasing because the population from lower order towns is migrating to them to avail better economic opportunities and other facilities.

Region-Wise Distribution of Urban Population

The distribution and growth of urban settlements in Punjab can be better observed by dividing the total State into regions/zones. Based on the division of terrain by rivers, the State is divided into three regions viz., Majha, Malwa and Doaba as shown in Fig. 8. The division depicts distinct socio-cultural features of each region. Majha region includes three districts, namely Amritsar, Gurdaspur and Tarn Taran. Malwa region is the largest region and comprises 13 districts viz., Barnala, Rupnagar, Ludhiana, Fatehgarh Sahib, Patiala, Sangrur, Moga, Bathinda, Mansa, Mukatsar, Faridkot, SAS Nagar (Mohali) and Firozpur. Doaba region is composed of four districts, namely Hoshiarpur, Jalandhar,

Kapurthala and Nawashaher. Since the composition of the region is not uniform, therefore, imbalanced urban population distribution is anticipated.

Fig. 8: Regions of Punjab



Source: https://2.bp.blogspot.com/-6Aqzm1cRfEU/WztYAIKMUTI/AAAAAAAAARc/M2ZOTkjfbwTN3YikFLiV0f5T_mjQr7awCLcBGAs/s1600/mmd.jpg

It is evident from Table 3 that about 58 per cent of total towns and about 57 per cent of the total urban population figured in the Malwa region in 1981. However, its share to total number of towns has decreased to about 57 per cent but its share in urban population has increased to 61 per cent in 2011. Concentration of industries, high rail-road connectivity/ accessibility, political focus, etc. can be designated as prime factors responsible for higher percentage share in urban population. Malwa region has three large cities (Ludhiana, Bathinda, Ferozpur) which inhabit nearly 35 per cent of the total urban population of the region. Excluding these cities would bring this region closer to the percentage share of the other two regions.

Majha region has experienced more than two times increment in the number of towns during 1981-2011 (rise from 22 in 1981 to 46 in 2011) but in percentage terms this share is only 16.42 per cent and 21.20 per cent in 1981 and 2011 respectively. The region accommodates almost 1/5th of the urbanites of the state. The urban population has increased in Majha region but the share to total urban population has decreased by almost two per cent during 1981-2011. Deficient economic activities and

TABLE 3: REGION-WISE DISTRIBUTION OF TOWNS AND URBAN POPULATION

Region	No. of Towns		Population (in million)	
	1981	2011	1981	2011
Majha	22 (16.42)	46 (21.20)	1.05 (22.63)	2.14 (20.58)
Doaba	34 (25.37)	51 (23.50)	0.95 (20.47)	1.90 (18.27)
Malwa	78 (58.21)	120 (55.30)	2.64 (56.90)	6.36 (61.15)
Total	134 (100.0)	217 (100.0)	4.64 (100.0)	10.4 (100.0)

Note: The figures in parentheses are percentages from their respective totals.
 Source: Census of India, 1981 & 2011.

nearness to sensitive international border are the key factors responsible for these conditions.

In case of Doaba region, the condition remains quite steady as the share of urban settlements showed slight fall of 1.87 per cent during 1981-2011, whereas the share of urbanities has reduced upto 2.2 per cent during the same period. Out-migration in search of better opportunities and lack of connectivity are the factors responsible for lesser and declining urbanization in the region.

Thus, it can be inferred that Malwa region is the most urbanized region in the state as it is accommodating 2/5th of urban population whereas other regions accommodate the remaining urban population. It clearly depicts polarization tendencies of urbanization towards Malwa region, which leads to regional imbalances.

ENTROPY ANALYSIS OF URBAN SETTLEMENTS

The changes in the number and population in the towns in 1981 and 2011 in Punjab describes the nature and magnitude of their distribution patterns. But spatial distribution of towns in the overall space and in different regions helps to understand different perspectives of urbanization. NNP is a common technique to study the spatial distribution pattern of the settlements. Applying nearest neighbourhood formula on the urban settlements of Punjab, it is evident that the nearest neighbourhood ratio (NNR) has reduced from 1.58 in 1981 to 1.43 in 2011 as shown in Table 4. According to the standards, if ratio is more than unity then it depicts uniformly dispersed pattern of distribution

of towns in the state. Also, Z-statistic greater than 2.58 indicates highly dispersed pattern of the settlement. As Z-statistic is more than 12.77 and 12.07 in 1981 and 2011 respectively, therefore, it can be inferred that the distribution pattern of towns in Punjab is very highly dispersed. Under such pattern, efficiency of infrastructure reduces to large extent. The large towns benefit whereas inhabitants of small towns have to travel longer distance to avail these facilities and services. As the ratio has reduced slightly, it is evident that distribution of the towns is moving towards randomness, which is again a sign of lack of interaction and imbalanced urban system. Similar tendencies are visible in Punjab as well indicating that appropriate actions need to be taken to balance the urban system of the State by following regional planning approach.

TABLE 4: NEAREST NEIGHBOURHOOD RESULTS FOR WHOLE OF PUNJAB

Aspects	Formula or Code	1981	2011
Number of Settlements	n	134	217
Area	A (sq. km)	50362	50362
Total Neighbourhood Distance	$\sum ra$ (km)	20516	28708
Observed Average Distance	ra (km)	15.31	10.88
Expected Average Distance	re (km) $(1/2\sqrt{A/N})$	9.69	7.62
Nearest Neighbour Ratio	R	1.58	1.43
Standard Error	SE $(0.26136/\sqrt{N^2/A})$	0.44	0.27
Test Statistic	Z = ra - re /SE	12.77	12.07

Source: Calculated figures.

Disaggregated analysis of the State reveals that NNR has reduced in all its regions as shown in Table 5. The ratio being more than one and reducing during 1981-2011 in all the regions indicates that the distribution of the settlements is becoming more imbalanced. It is evident from Table 5 that NNR has changed the highest in the Majha region where it has reduced from 1.65 in 1981 to 1.04 in 2011, revealing that the region is fastly heading towards random distribution of settlements. Interestingly, the Z-statistic value has shown a sharp fall during 1981-2011, i.e. 5.86 in 1981 and 0.47 in 2011, which indicates that town distribution pattern has moved from highly dispersed to random. More than double increment in the number of towns is the reason for the reduced NNR leading to the above tendencies.

Malwa is the next best region where tendencies of randomness are significantly visible. It is clear from Table 5 that NNR value has

TABLE 5: NEAREST NEIGHBOURHOOD RESULTS IN DIFFERENT REGIONS OF PUNJAB

Aspect	Formula or Code	1981			2011		
		Majha	Malwa	Doaba	Majha	Malwa	Doaba
Number of Settlements	n	22	78	34	46	120	51
Area	A (sq. kms)	8660	32806	8896	8660	32806	8896
Total Neighbourhood Distance	$\sum ra$ (kms)	360.8	1308.84	418.54	327.06	1185.60	396.27
Observed Average distance	ra (kms)	16.40	16.78	12.31	7.11	9.88	7.77
Expected Average Distance	re (kms) $(1/2\sqrt{A/N})$	9.92	10.25	8.09	6.86	8.27	6.60
Nearest Neighbour Ratio	R	1.65	1.64	1.52	1.04	1.20	1.18
Standard error	SE $(0.26136/\sqrt{N^2/A})$	1.11	0.61	0.73	0.53	0.39	0.48
Test Statistics	z = (ra - re)/SE	5.86	10.76	5.82	0.47	4.08	2.42

Source: Calculated figures.

reduced from 1.64 in 1981 to 1.20 in 2011. Here also the number of towns has grown from 78 in 1981 to 120 in 2011, an increment of 1.54 times. Malwa region occupies about 65 per cent of the geographic space of the state. Also, Z-statistic value has fallen sharply from 10.76 to 4.08 in 1981 and 2011 respectively, clearly indicating that town distribution pattern has moved from highly dispersed to dispersed, which may attain randomness in the times to come. Therefore, the chance of random distribution of the settlement is more. Such tendencies will have all the problems and issues as mentioned for Majha region. The NNR in Doaba region has reduced from 1.52 in 1981 to 1.18 in 2011 as shown in Table 5. Here also the number of towns has increased by 1.5 times, from 34 to 51 in 1981 and 2011 respectively. Here also Z-statistic value has reduced from 5.82 in 1981 and 2.42 in 2011, indicating that town distribution pattern has moved from highly dispersed to moderately dispersed pattern.

Thus, NNR is the highest in Majha region followed by Malwa and Doaba regions. But reducing Z-statistic values during 1981-2011 clearly indicates that these regions have tendencies of shifting from dispersed distribution to moderately dispersed or random distribution pattern. Apart from increased number of towns in the regions, differential accessibilities to different parts of a region may also have affected the ratio. Varying nearest neighbour ratio among three regions reflect the degree of imbalance through dispersion factor. As a result, Doaba region may be designated as a depressed or less developed region in future.

CONCLUSION

Balanced urban and regional development is essential to benefit all the inhabitants of each region. But disparities in urbanization result in varying distribution patterns of urban settlements across the regions, which tend to encounter infrastructural differentials. Similar tendencies are experienced in Punjab where uneven urbanization pattern has caused imbalanced urban system in the past census decades. Due to rapid urbanization, the number, size and distribution pattern of urban settlements in the state have grown enormously. During 1981 – 2011, the districts located along the central corridor i.e. Amritsar, Jalandhar, Ludhiana and SAS Nagar witnessed highest per centage of urban population in 2011, i.e. more than 50 per cent as compared to districts in Northern and Southern direction. These districts also experienced high growth rate due to influx of population, proactive government policies and programmes and high class infrastructure. This led to create imbalances in terms of population distribution, infrastructure, resources, etc. During 1981-2011, the number of towns has increased by 1.62 times in which the urban population has increased by more than five times. But

increased urban population shows polarized tendencies as about 57 per cent of the urban population resides in only seven per cent towns (class I category) in 2011. On the contrary, 50 per cent towns (class III and IV category) and 31 per cent towns (class V and VI category) accommodate only 22 per cent and three per cent of the total urban population of the State, reflecting lopsided urban population distribution. Region-wise distribution of urban population also reveals that more than 3/5th of the total population of the state resides in Malwa region, indicating polarized tendencies. Entropy modelling for the towns of Punjab clearly indicates imbalanced urban settlement distribution pattern in the state. Reduced NNRs clearly indicate that the state is moving from the state of dispersed distribution to the state of random distribution. Such a state tends to bring imbalances in the urban settlement distribution pattern reflecting unintegrated and deficient inter and intra regional infrastructure. This calls Punjab to prepare and adopt an urbanization policy, which tends to be balanced, well-integrated and infrastructural efficient to benefit all the inhabitants of the state.

REFERENCES

1. Bourne, L.S. and J.W. Simmone (1978), "System of Cities" Oxford University Press, UK.
2. Census of India, 1951, General Population Table, Punjab, Directorate of Census Operation, Punjab, Government of Punjab, India (1951).
3. Census of India, 1961, General Population Table, Punjab, Directorate of Census Operation, Punjab, Government of Punjab, India (1961).
4. Census of India, 1971, General Population Table, Punjab, Directorate of Census Operation, Punjab, Government of Punjab, India (1971).
5. Census of India, 1981, General Population Table, Punjab, Directorate of Census Operation, Punjab, Government of Punjab, India (1981).
6. Census of India, 1991, General Population Table, Punjab, Directorate of Census Operation, Punjab, Government of Punjab, India (2019), (www document) URL <https://censusindia.gov.in/digitalibrary/> (accessed November, 2019).
7. Census of India, 2001, General Population Table, Punjab, Directorate of Census Operation, Punjab, Government of Punjab, India (2019), (www document) URL <https://censusindia.gov.in/digitalibrary/> (accessed November, 2019).
8. Census of India, 2011, Primary Census Abstract, Punjab, Directorate of Census Operation, Punjab Government of Punjab, India (2019), (www document) URL <https://censusindia.gov.in/digitalibrary/> (accessed November, 2019)
9. Faisal, Abdul Maksoud, (2003), "Future Trends of the Urban Systems in Developing Countries in View of a more Globalized World", Future Trends of the Urban Systems, 39th ISoCaRP Congress (www document) URL <https://>

www.kas.de/upload/dokumente/megacities/futuretrends.pdf / (accessed September, 2016)

10. Kumar, Sonar Sanjay, (2008), " Urban Sprawl – A system dynamic approach, 44th ISOCARP Congress (www document) URL http://www.isocarp.net/Data/case_studies/1232.pdf / (accessed May 2018)
11. Pred, Allen (1977), "City Systems in Advanced Economies – Past Growth Present processes and Future Development options, A Halsted Press Book, John Wiley & Sons, New York.
12. Ramachandran, R, (1989), "Urbanization & Urban Systems in India", Delhi Oxford University press, New Delhi.
13. Khan Academy, (2021), "Population Size, Density, & Dispersal" (www document) URL <https://www.khanacademy.org/science/biology/ecology/population-ecology/a/population-size-density-and-dispersal> (accessed November 2018)