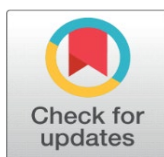


ARCHITECTURAL DESIGN STRATEGIES TO REDUCE URBAN TEMPERATURE IN AMRITSAR CITY

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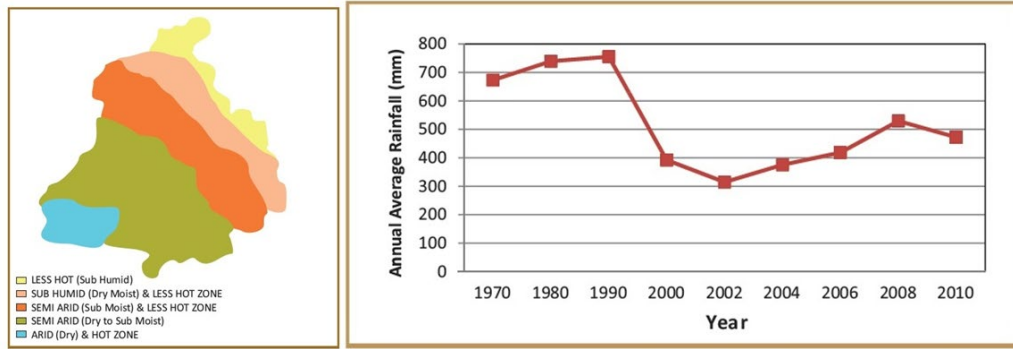
ABSTRACT

Amritsar is the largest city of Punjab with population more than 2.5 millions (Source 1). The purpose of this research paper is to highlight the ways in which we can mitigate the urban heat island effect in Amritsar city. The minimum and maximum temperature data of local climate is increasing. The frequency and intensity of heat waves have increased enormously. We need to immediately undertake the excess heat we feel inside and outside of the buildings. This study further emphasizes the role of urban planning, green infrastructure, and sustainable architectural interventions as key strategies to mitigate excessive heat accumulation. The findings aim to provide practical guidelines for policymakers, architects, and planners to create thermally comfortable and climate-resilient urban environments.

Keywords: Urban Heat Island, Local Climate

1. INTRODUCTION

The earth temperature is rising at steady rate and due to global warming planet earth is facing significant effect in frequency of extreme weather events like cold waves, heat waves, heavy rainfall and others. Intergovernmental Panel on climate change (IPCC, 2007) has projected that by the end of 21st Century the planet earth temperature will be warm by 2-4°C. Punjab state is majorly plain with 50,362 sq.km areas and situated at nearly 31.1471° N latitudes and 75.3412° E longitudes. As per Indian Metrological Department, the temperature trends in Punjab has raised over the years. It is projected that yearly maximum temperature is likely to get increase by 1.0°C -1.8°C in all parts of Punjab by 2021-2050. The average minimum temperature is also expected to increase by 4.0°C to 4.4°C. The yearly rainfall shows considerable downwards trend from the past few years. In year 2017, Punjab has received only 493mm rainfall. The downward drift has observed in summer and post monsoon in all cities of Punjab except mixed trend has been seen in winters.



Amritsar city lies at 31.6340° N latitudes and 74.8723° E longitudes in the state of Northern Western part of Punjab. Amritsar is hub of global tourist destination and one of the most visited cities of India. The annual maximum and minimum temperature is increasing in major cities of Punjab state as shown in Table 1. The analysis shows that Amritsar city has significantly increased in yearly maximum and minimum temperature among all other cities. As in Table 1, Amritsar city has lowered yearly rainfall range which is -6.2mm and has shown decreasing trend in Summer season, Monsoon season and Post monsoon season with -3.1, -0.2 and -1.1 respectively.

	Annual Temperature (°C)				Max/Min (°C) Season Wise				Rainfall season wise					
	Max	Min	Mean	DT R	Jan-Feb	Mar-May	Jun-Sept.	Oct-Dec.	Annual	Winter	Summer	Monsoon	Post Monsoon	Rainy days
Amritsar	0.09	0.01	+0.01	-0.2	-0.02/N.T.	+0.07/0.02	-0.03/N.T.	N.T./+0.02	-6.2	-0.2	-3.1	-2.0	-1.1	-0.2
Patiala	0.01	0.04	+0.03	-0.02	+0.04/-0.01	+0.08/+0.02	N.T./N.T.	+0.04/N.T.	-1.4	+0.2	-4.4	-0.01	-1.05	+0.02
Ludhiana	0.02	0.01	N.T.	N.T.	+0.01/N.T.	+0.07/+0.02	-0.02/+0.02	+0.03/-0.01	-4.5	+0.6	-2.7	+1.05	-1.2	-0.07
Chandigarh	N.T.	0.03	-0.03	-0.03	-0.03/N.T.	+0.04/+0.05	-0.03/+0.01	N.T./+0.02	+1.07	-0.2	-2.1	+6.1	-4.9	N.T.

Table 1- Increasing and Decreasing Trends of yearly means of maximum, minimum temperature, Diurnal temperature range (DTR) and rainfall. Data is from 1980-2010.

2. CAUSES OF URBAN HEAT ISLAND IN AMRITSAR

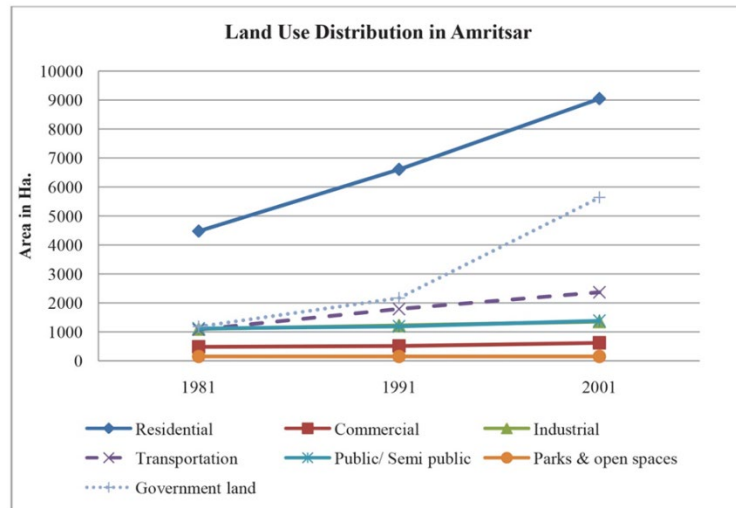
2.1. UNPLANNED LAND USE DISTRIBUTION

Amritsar is a historic city and having its own Social Cultural value. City Municipality limits have increased more than 2.5 times than in 1991. As per 2031, Master Plan of Amritsar has four different layers of land use that is walled city, area inside Municipal Corporation of Amritsar and Outside Walled city, future urbanizable limit and agriculture or field area. In past, number of proposals has affected the land usage of the city. From year 1979-1991, the distribution of residential area was from 42-44%. Currently the residential area occupies significant share 51.73%. This is due to increase in population over the years and migration to the city.

Type of Land Use	Land Use in Ha.	Percentage of Land Use
Total Residential	4311.56	51.73
Commercial	393.22	4.72
Industrial	445.73	5.35
Public and Semi Public	738.22	8.86
Government Land	882.14	10.58
Utilities and Services	27.2	0.33
Traffic and Transportation	1388.67	16.66
Recreational	124.89	1.50

Special Area	22.42	0.27
Total Developed Area	8334.05	100.00

Source Draft Master Plan of Amritsar (TPCD, Punjab).



Changing Land Use Pattern of Amritsar (1971-2001)

Amritsar city has unequal urban land use development pattern. The walled city part constitutes 18% of total population of the whole city. Only 30% area of city is developed with Town Planning and Development schemes while 70% of the city area has unplanned growth. The unequal distribution of the city development could be seen very easily. North part of the city has low density housing, with better roads, amenities like shopping mall and open spaces. South part of the city has unplanned narrow roads, low rise and high density housing and with lack of open spaces, parks and amenities. Numbers of Slum areas are also located in South part of the city. Due to this city has unequal distribution of population. Two Third of city population is living in South and South West part of the city. The open areas and parks have not increased with respect to the development of residential areas.

Due to this walled area of the city has congestion, more of concrete structures making it concrete jungle, no mass space relationship, lack of green spaces and urban sprawl. The major share of green areas of the city has converted into different development activities by changing their land usage. As per UDPFI guidelines 2014, norms for recreational or green space should be 20-25% but city has only 1.5% of the area which is considerably very low. The city urban areas have become concrete jungle with lesser green areas and contributing to city to become heat island. City has become uncomfortable hot in core area of city in summer season, not because of weather but due to urban areas and built environment also increase local temperature.

Type of Land Use	1991 (Percentage of Area)	2001 (Percentage of Area)	2011 (Percentage of Area)	URDPFI Norms 2014 (Percentage of Area)
Residential	48.43	43.99	50.94	35-40
Commercial	3.77	3.03	4.72	4-5
Industrial	8.97	6.6	5.35	12-14
Public and Semi Public	8.75	6.73	8.86	14-16
Recreational	1.11	0.74	1.5	20-25
Circulation	13.1	11.5	16.66	15-18
Government Land	15.88	27.41	10.58	
Total Area	100	100	100	

Land Use Distribution of Municipal Areas in Amritsar

The conversion of Agriculture land into residential townships like Ansal city, Metclafe Nirvana city, etc. on Jalandhar Highway road and conversion of traditional bazaars into shopping mall or complexes has raised the temperature of Urban Area of the city. The unplanned land usage over the years has contributed major share into Urban Heat Island effect of the city.



2.2. INCREASE IN VEHICLES

Amritsar city is one of the fastest emerging cities of Punjab State. It has one of the biggest tradescenters and it has figure of tourist map due to Golden Temple, Durgiana Mandir, Jalianawala Bagh. City has organic development. With the increase in Urbanization it adds on to more public traffic levels. The city has developed over the years but area for circulation and public transportation means are not increasing in that proportion. The deficiency of public transport is countered by private vehicles. The city travel demand is majorly met by private vehicles which is having major share of 74%, whereas 25% trips are served by intermediate transport modes, especially auto-rickshaw and 1% by bus transport. [Luthra, 2006]. The unprecedented growth in the number of vehicles has caused significant increase in the traffic volume on major roads of the city and causing congestion.

Table: Growth of Vehicles in Amritsar city

Growth of Vehicle	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Buses/mini buses	2082	2182	2207	2289	2379	2510	2682	2787
Cars	42672	47199	50649	55232	63832	68298	74355	82516
Jeeps	2330	2863	3250	3814	4414	3395	3268	3386
Two Wheelers	385476	411877	431995	458202	492587	516893	538281	573683
Trucks	6863	7551	7925	8938	9972	11895	13972	16256
Tractors	35249	35631	35914	36360	36690	37374	37581	38660
Combines	27	29	30	91	112	115	125	135
Total	474699	507332	531970	564926	609986	640480	670264	717423

Source District Transport Office, Amritsar

Vehicles running on the roads have important impact on environment through carbon emission and polluting the air quality of areas of the city which causing severe diseases like breathing problem, cancer, bronchitis, skin reactions, eye sores, stress, mental imbalances etc. Vehicles stuck into traffic areas of major roads are emitting heat into the surrounding area. The air conditioners exhaust emissions from cars heat up the adjoining areas and increase the urban temperature which is ultimately leading to Urban Heat Island effect.

Table: Degree of congestion of various roads in Amritsar

Road	Degree of Congestion
GT road - India gate- Putligarh Chowk	10-40
GT road- Putlighar Chowk- Maqboolpura	30-40
GT road- Maqboolpura-Bypass (Jalandhar Side)	10-40
Ramtirath Road	<10-30

Bypass	<10
Ajnala Road	<10
FatehgarhChurrian Road	<10-40
Majitha Road	>40
Pathankot Road	<10-40
Circular Road	<10-30
Lawrence Road	20-30
Mall Road	<10
Khemkaran Road	>40
Taran-Taran Road	>40
Jalandhar Road	10-20
Outer Circular Road	20-30
Hall Bazar Road	>40

Source Comprehensive Traffic and Transportation Study on Amritsar by RITES (1997)

2.3. ANTHROPOGENIC HEAT

Anthropogenic heat is heat generated by human activities in urban areas and contributing to the Urban Heat Island effect of the city. Buildings are one of the major sources of contributing anthropogenic heat into urban areas. With the increase in population and urbanization of Amritsar city, it has increased in the consumption of electricity in buildings. In today's time Air conditioners has become almost every household necessity. Air conditioners has not only increased energy consumption but also has elevated the outside urban area temperature by releasing hot air into atmosphere.

The heat of Amritsar city is very intense in summer period and has minimum temperature of 25.2°C in the month of June. The nights are even warm in summer period. City suffers with driest period in the summer season with relative humidity value of 25 or even lesser than this in afternoon period. In these extreme conditions it increases directly on energy load of Air conditioners to cool down the indoor areas. The per capita consumption of electricity has increased from 664KWH in year 2000-01 to 924KWH in 2015-16.

Table: Number of Households using Electricity in Amritsar

District	2011-2012			2013-14			2014-15			2015-16		
	Total House hold (No.)	House-hold using electricity (No.)	Percentage	Total House hold (No.)	House-hold using electricity (No.)	Percentage	Total House hold (No.)	House-hold using electricity (No.)	Percentage	Total House hold (No.)	House-hold using electricity (No.)	Percentage
Amritsar	480303	454179	94.56	525451	491590	93.56	537939	503951	93.68	552348	525712	95.18

Source State Statistical Abstract



Hall Bazar, Amritsar

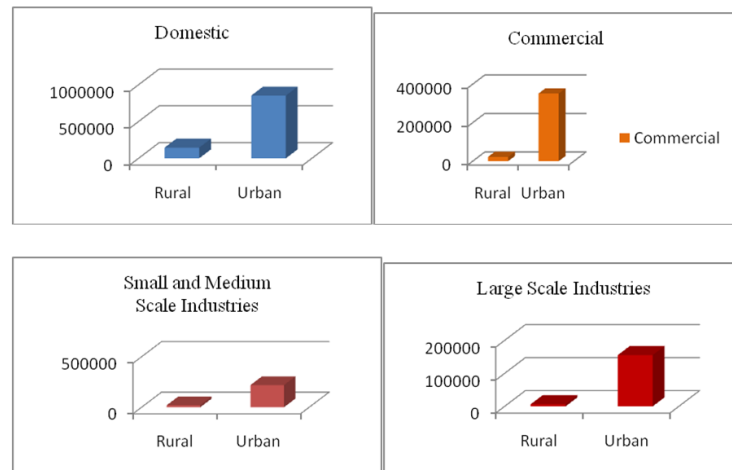


Celebration Mall, Amritsar

Amritsar city has 5.35% share of Industries from the total land usage. The heat generation from the industries is also contributing towards the urban heat island. It majorly has textile industries in the city after residential and commercial buildings, industry sector of the city consume maximum number of electricity units 1481.70 KW in 2015-16

year. (Source: Punjab State Power Corporation Limited). The electricity consumption of urban areas with respect to rural areas of the city is very high thus releasing more anthropogenic heat into urban areas which is ultimately leading to urban heat island of the city.

Comparison of Urban and Rural Electricity Load in KW of Amritsar city till 31st March 2016

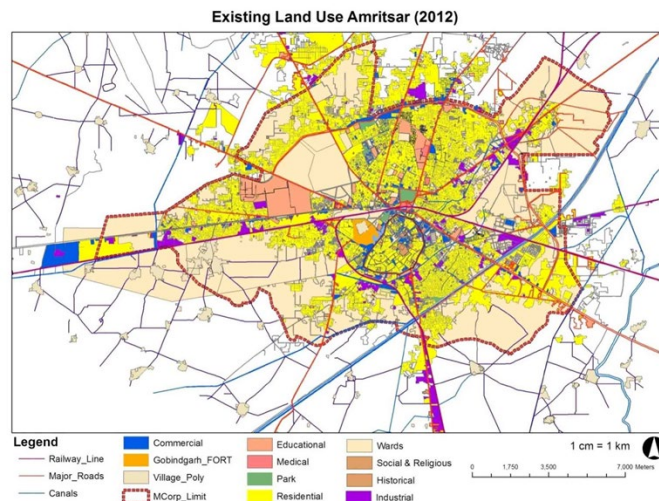


Source Punjab State Power Corporation Limited

2.4. URBAN GEOMETRY

In order to understand Urban Geometry of Amritsar, it is important to know city development can be divided into five periods i.e. Gurus period (1577-1628), Mughul period (1628-1764), Misls period (1665-1802), Maharaja Ranjit Singh Period (1802-1849), The British Period (1849-1947), and Industrial Development. Amritsar has history dates back to nearly 500 years ago, the city was created by fourth Sikh Guru, Shri Guru Ram Das Ji, in 1577AD. From 1665 to 1802 number of Misl's were created. In time period of Maharaja Ranjit Singh, a massive city wall was constructed with 14 gates and poly nucleated city was made. After India got independence, the city has suffered major setbacks due to its geographical location near to border area.

The walled city streets are densely congested and have no sufficient space for parking. There is majorly traffic in this area due to lesser street width. Encroachment on the roads has degraded the aesthetic value of the area. The current housing in the walled city area is in poor state of condition with average building height of G+3 with 100% usage of ground area with no consideration of setbacks and road widths are too small. The construction of modern and contemporary style of architecture in North and other part of the city is demolishing the heritage character of the city especially in walled area. The walled city area is known for mixed use development and also known as the commercial business district of the city. The walled city has commercial on the ground floors and residential on the upper floors.



2.5. POPULATION AND URBANIZATION

Amritsar city is one of the most urbanized city of Punjab state as the level of urbanization is growing regularly and population of the city is 11,32,761 people as per the Census 2011.

City	Proportion of urban population to total population in districts			Decadal growth of urban population (%)	
Year	1991	2001	2011	1991-2001	2001-2011
Amritsar	34.08 (14.25)	40.00 (14.91)	53.64 (12.86)	44.01	9.22

Source Census of India 1991, 2001 and 2011 (Provisional totals)

The city is developed even after the first half of 20th Century and has highest population growth pattern in year with +65.30% was reason of more migration of labor to fulfill the needs of emerging industry sector and also inclining birth rate and lowering death rate. During independence and initial period of India got independence, the city has faced major setback but first time during 1951-1961, the city has faced population growth rate of +15.52 as in below Table. During 1971-1981, Chheharta and other nearby villages were become part of the city and city population growth rate emerged to +35.47. With the continuous increase in population city has become second largest city of the Punjab after Ludhiana in 1991. During 1991-2001, city has the maximum growth rate of +42.67% defeating all other cities of state. In last decade, city has growth rate lower down to +13.22 which is likely similar trend in other mega cities of the nation.

Population growth rate of Amritsar city

Population Growth of Amritsar City Census Years	Total Population	Percentage Increase
1868	135813	
1881	151896	+11.84
1891	136766	-9.96
1901	161039	+18.77
1911	152756	-05.96
1921	160218	+04.88
1931	246840	+65.30
1941	391010	+47.64
1951	325747	-16.69
1961	376295	+15.52
1971	434951	+15.59
1981	589299	+35.47
1991	708835	+19.16
2001	1016079	+42.67
2011	1132761	+13.22

Source Census of India 1981, 1991, 2001, 2011

With the increase in urbanization and population, city has developed in organic way and very lesser area of the city has planned development. To accommodate the population more number of residential, commercial and other buildings were built. The more built environment has reduced the green areas into the city with increase in more asphalt, brick and concrete buildings.

2.6. DENSITY PATTERN OF THE CITY

The population in the city is not equally divided due to this reason density in some areas are tightly populated like walled area of the city, having more density and other areas are less populated as they are more planned developed due to this factor they are having lesser density.

Density in Amritsar City

Year	Persons/Sq.Km	Persons/hectare
1991	6163.78	61.63
2001	7136.78	71.36
2011	7956.3	79.56

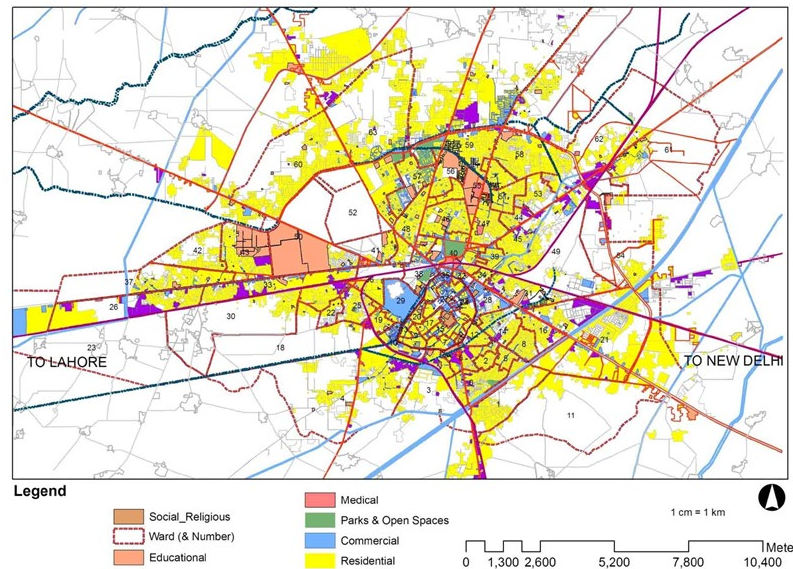
Source Census of India

Amritsar city is divided into 65 wards and sizes of wards are having differences in each other due to unplanned development from 22.26 hectares to 1201.13 hectares. The density of wards is too low to 14 people and as maximum as 721 people per hectare. The population distribution is having a lot of difference in municipal area of the city and walled area of the city due to this reason population density is very higher in these regions as compare to the wards on the outer part of the city.

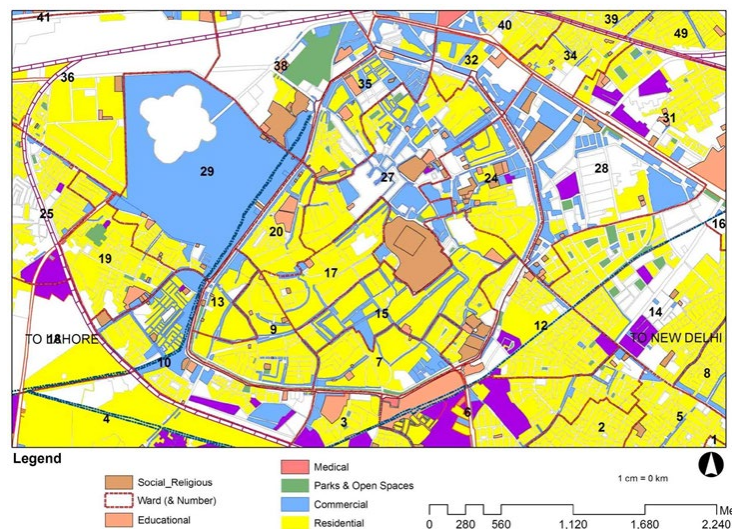
Population density in different wards of the Amritsar

Density	Ward Nos.	No. of Wards	Percent
Upt to 100	1,3,4,5,6,7,9,14,15,16,17,18,20,30,31,33,37,51,54,59,60,62,64,65 and 22	25	38.46
101-400	2,8,10,11,13,19,21,23,24,25,26,29,32,34,35,36,38,39,41,47,48,49,50,52,53,55,56,58,61 and 63.	30	46.15
Above 400	12,27,28,40,42,43,44,45,46,57	10	15.38

Wards in the city



Wards in Walled area of Amritsar



The wards which are on the outer edge of the city are having only 38.46% of population density which is less than 100 persons per hectare as it is clear by correlating with the above table and figure. In these wards there is a lot of area which is currently open and not developed. The other wards in the city which are on the border of walled city are having 46.15% of population density in which only 101-400 persons per hectare other than southwest area of the city. The remaining 15.38% wards of the city which is walled or core area of the city or inside 2Km radius of core area of the city is containing population density of 400 persons per hectare. This area is having a lot of a lot of commercial and residential activities.

2.7. BUILT ENVIRONMENT SURFACE

The city has witnessed a lot of incidents like India and Pakistan partition that led to the communal riots, damage to the city and the migration of population from Pakistan in 1947. After Independence, the city population has grown rapidly due to which the city has developed at very faster rate. The city has become second biggest city of the state in 2001 with population growth rate of 42.67% refer above table no.

Growth of Household and Occupied Residential Houses in M.C. Amritsar

Year Occupied Residential Houses Growth rate of residential houses (%) No. of Households Growth of Households

	Year	Occupied Residential Houses	Growth rate of residential houses (%)	No. of Households	Growth of Households
Amritsar Municipal Corporation	1981	99140	-	105429	-
	1991	114935	13.74	126283	19.78
	2001	169743	51.52	179057	41.79
	2011			202270	12.96

Source Census of India: 1981,1991,2001,2011

Due to increase in population, city has observed increase in number of residential houses. The city has majorly nature of residential with 50.69% in land usage of the city with planned and unplanned development. During 1991-2001, city has witnessed highest growth rate in household which is 41.79% though growth rate of 12.69% in from 2001-2011.

The old age buildings of housing structures are built with brick and lime. The post independence buildings are built with brick, cement and concrete. The walled city area has densely packed adjoining structures without following the setbacks and building byelaws.



The new townships and housings which are developing on Jalandhar-Amritsar highway, North or North Eastern part of the city and other prime areas of the city like Ranjit Avenues are using more glass in external façade and made of brick, cement and concrete. The usage of glass irrespective on South and South west side are increasing the temperature due to that there is substantial increase in Air conditioners requirement. The building materials like brick, cement concrete, aluminum sections and Mild Steel pipes are absorbing more heat and releasing back into environment due to this reason the urban temperature is increasing.

The south area of the city has narrow roads and north side has wider roads and open spaces. While in some areas of the city, with increase in vehicles in the city, elevated roads and bridges are constructed and in few areas road width has widened. The road network has increased from 11.5% to 16.5% from year 2001 to 2011 respectively. The asphalt and bitumen increases with the increase in new roads and widened width of roads. The increase in asphalt has increased the urban temperature by emitting heat into the environment as absorbing more sun heat.



CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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