

## Measurement of Urban Sustainability of Dehradun City

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### ABSTRACT

More than half of the world's population lives in cities and this figure will rise to more than two thirds by 2050. Rapid urbanization has created a stress on the local resources. Efforts should be taken by the city planners, policy makers and urban local bodies to make this urbanization more sustainable. Sustainable urbanization takes into consideration all the social, economic and environmental factors. Thus attaining sustainable urbanization is a difficult challenge. These urban sustainability indicators help the policy makers and city planners gauge the performance of the city. This study evaluates the sustainability of urbanization of Dehradun city. It shows the present condition and predicts the level of sustainability for year 2020 and 2022. It studies the 11 indicators of socio-economic and environmental dimensions through which a composite urban sustainability index value is obtained. Firstly a relative value is derived for all the 11 indicators. Then those 11 indicators are grouped into two dimensions socio-economic and environmental dimension and an average sustainability index is calculated. By combining this value for each year a composite sustainability indicator value is calculated for the year 2015, 2020 and 2022. The results of the research indicate that the value of composite indicator in year 2015 was 0.12 which indicates very low level of sustainability. In year 2020 the level of sustainability will increase to 0.36 and 0.45 in 2022 which is just average. The speed of achieving urban sustainability is very slow. Hence the city planners and policy makers should not only try to make policies which will help in achieving sustainability but also focus on the implementation aspect.

**Keywords :** Sustainable Development, Sustainable Urbanization, Composite Indicator, Sustainability Indicators

### I. INTRODUCTION

Overall, world urbanization is expected to increase from 47% in the year 2000 to just fewer than 56% by 2020. If this world is to survive for the enjoyment of these generations, it is high time to organize a way to insure that cities are indeed sustainable (Choguill C., 2008). The unplanned and uncontrolled rapid growth has resulted in serious negative effects on the urban dwellers and their environment (Chadchan, J., Shankar, R., 2012). Urban areas have a crucial influence on sustainable balanced development; they're continuously growing and changing the image

of the Earth with densely populated parts, industrial areas and extensive transport and road net-works. Activities in the city have a negative influence on the environment i.e. air, soil, water, waste, audio and visual pollution. These problems indirectly affect the human habitat, people's health and quality of life. Within the city organism we wish to gain environmental, social and economic balance, so-called internal sustainable balance (Divjak MS, 1998). As a focus of sustainable development, urban sustainability has become increasingly prominent on political agendas and scientific studies during the recent decades (Lu H., Wu. J., et al, 2015). The overall

sustainability is only achieved if the economic, environmental, social and human sustainability criteria are met (Choguill C., 2008). Urban sustainable development attempts to balance economic growth, ecological construction, environmental protection, and social progress, and the difficulty of this challenge has made it a major focus of current research around the world (Riley, 2001). Urban sustainability is seen as a desirable state of urban conditions that persists overtime. It is often characterised by issues such as inter-generational equity, intra-generational equity, protection of the natural environment, minimal use of non-renewable resources, economic vitality and diversity, community self-reliance, individual wellbeing, and satisfaction of basic human needs (Adinyira, E., Seifah S.O., et al., 2007).

Along with the definitions of sustainability, a variety of sustainability assessment tools, such as indicators, have been also developed and applied to measure the actual sustainability status of societies. Each assessment tool has its own characteristic strengths and weaknesses and, thus, should be applied with specific assessment types and purposes in mind. It is indeed indispensable to adopt the most suitable assessment tools for investigating the sustainability status of regions from multilateral perspectives (Hara K., Uwasu M., et al., 2009). Sustainability indicators are one of the central tools of sustainability assessment (Ness et al. 2007). Sustainability indicators are particularly aimed at measuring environmental improvement, social progress, and economic development (Hara K., Uwasu M., et al., 2009). They are the tools that aim at making the concept measurable by quantifying trends in society and try to address the key question: Are we, or are we not, moving towards sustainability? The aim of SIs is to guide decisionmakers at various levels so they can contribute to the development of society towards sustainability (Lundin M., 2002).

## **STUDY AREA**

Dehradun is the capital city of the State of Uttarakhand in north India. Dehradun nestled in the foothills of the Himalayas lies at 30°19'12"N latitude and 78°2'34"E longitude. Dehradun, which is a part of Dun valley, is located in the western part of the state. Dehradun city governed by Municipal Corporation is a part of Dehradun Urban Agglomeration. The city population has increased from 447808 in 2001 to 574840 in 2011. The current rate of decadal growth is 40 percent. The sex ratio also increased from 890 females per 1000 males in 2001 to 907 females per 1000 males 2011. The literacy rate has also seen a jump from 76 percent in 2001 to 88.36 percent in 2011. The density of population increased from 6700 persons per sq km in 2001 to 8026 person per sq km in 2011.

After becoming the capital of Uttarakhand, Dehradun has seen a tremendous growth in population. Dehradun, has expanded rapidly in the last decade due to migration and tourism. It is expected that Dehradun will experience a period of population growth in the near future, especially with an increase in the floating tourist population in the summer months (Rao K.H.V., 2005). At present the city is battling with major issues like haphazard growth, congested roads and heavy vehicular traffic, unequal distribution of water, inadequate coverage of area under sewerage system, dilapidated condition of storm water drainage, inefficient solid waste management system, large number of slum population, rising pollution level to name a few. In the year 2001 the Dehradun municipal boundaries were increased leading to assimilation of 53 villages into its limits leading to 7% decline in rural population growth from 1991 (L.R.B. Jitendrudu 2006). Dehradun city presently spread over an area of 66.21 square km. In 2001 the municipal boundary was 52 square km

which has increased by 14.21 square km (27.37 percent) within a decade (Sharma K., Jalan S., 2013).

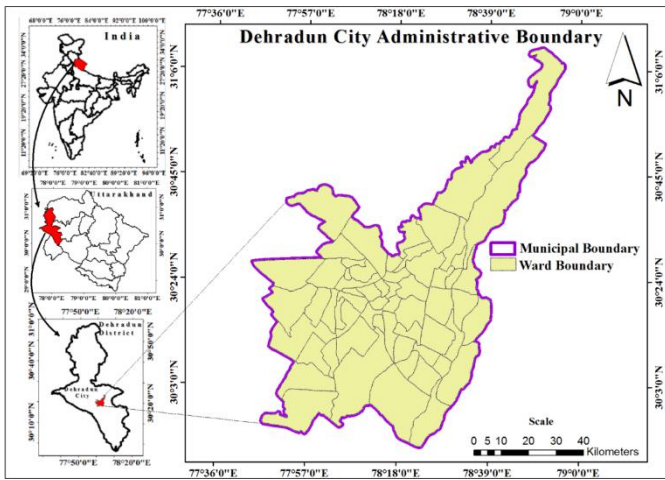


Fig.1 Location map of Dehradun City

II. METHODS AND MATERIAL

Sustainable city development means that the city together with the surrounding countryside achieves ecological and social-economic balance. The urban system that has not achieved this balance has fallen into crisis and this reflects the negative consequences of our industrial-technological society. The term sustainable embraces the care for natural sources and

environment, and also cultural and human demands (Divjak MS, 1998). OECD defines indicator as “a statistic or parameter that, tracked over time, provides information on trends in the condition of a phenomenon and has significance extending beyond that associated with the properties of the statistics itself (Visvaldis V et al., 2013). Most of the urban sustainable studies have been done in other countries and these countries have developed their own set of indicators. Satterthwaite (2004) in his framework for assessing the environmental sustainability of cities, the provision of adequate water, sanitation, drainage and garbage collection come first followed by the goal to reduce chemical and physical hazards within the home, workplace and wider city (Shaw A.,2018). Hara K., Uwasu M., et al., (2009), Li F., Liu X., et al., (2009), Scipioni A., Mazzi A., et al., (2009), Moreno S.H., Martinez J.H., et al., (2010), Banica A., (2010), Tanguay A., Rajaonson J., et al., (2010), Alpopi C., Manole C., et al.,(2011), Reddy B.S., Balachandra P.(2013) have taken indicators related to unemployment, sewage, sanitation, drainage, slum population, pollution, crime rate, open spaces etc which are also some of the major problems of the Indian cities.

Table 1 : Urban Sustainability Indicator for Dehradun City

Category Indicator	Theme Indicator	Key Indicator
Socio-Economic	1. Education	1. Student teacher ratio in schools
	2. Slum Dwellers	2. Proportion of city population living in slums
	3. Safe Drinking Water Supply	3. Per capita water supply
	4. Sewerage	4. Household level coverage of water supply
		5. Coverage of sewage network services
		6. Collection efficiency of sewage network
		7. Incidence of water logging
Environment	1. Air Pollution	8. Air Pollution level in PM10
	2. Noise Pollution	9. Maximum noise level
	3. Water Pollution	10. Quality of water supply
	4. Public Open Space	11. Percentage of public open spaces to total area

For the present study the 11 indicators grouped under socio-economic and environmental dimension are taken. Following are the key indicators which are taken with respect to Dehradun city.

All these indicators are in different units. Hence we need to standardize these indicators first. Thus for each of these 11 indicators a relative indicator will be calculated by using the following formula

$$U_{ij} = \frac{C_{ij} - C_j^0}{C_j^1 - C_j^0}$$

Where:

$U_{ij}$  = Relative Indicator

$C_{ij}$  = The Actual Value for the year

$C_j^0$  = The base value

$C_j^1$  = The service level benchmark

Further a composite urban sustainability index is calculated by using the following formula

$$USI = \left( \frac{\sum_{j=1}^J d_j^2}{J} \right)^{0.5}$$

Where:

$USI$  = Urban sustainability index

$d_j$  = Dimension “j”,  $j = 1, 2, \dots, J$

$J$  = Number of variables in a dimension

The final result is the collective index of sustainability giving the elaborate grade. The raw data for year 2020 and 2022 was calculated in excel through forecast method. The overall all urban sustainability value is compared with the values shown in table 2 showing classification criterion for urban sustainable development developed by Li F., Liu X., et al., (2009).

**Table 2:** Classification criterion for urban sustainable development

Level	Value of Indicator	Qualitative Evaluation
I	>0.75	Excellent
II	0.50-0.75	Good
III	0.25-0.50	Moderate
IV	<0.25	Bad

Source : Li F., Liu X., et al., (2009)

### III. RESULTS AND DISCUSSION

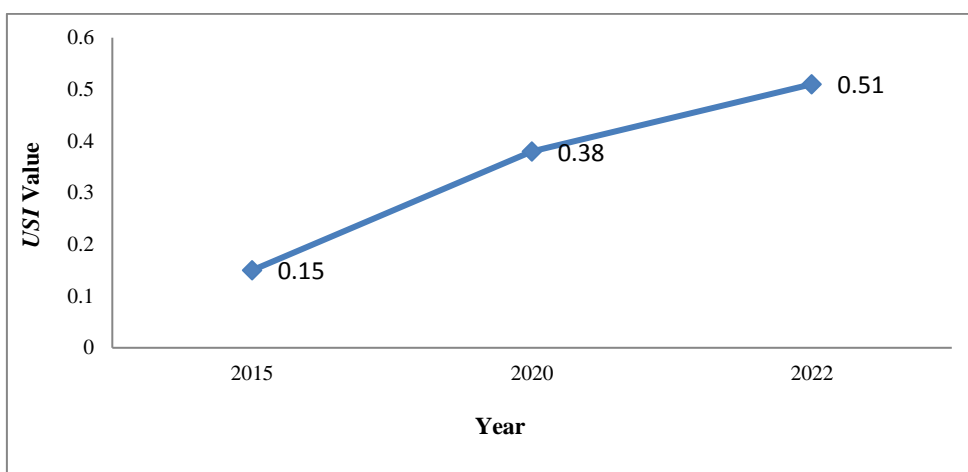
Table 3 shows that the average socio-economic *usi* in 2015 is 0.15. it will increase to 0.38 in year 2020 and 0.51 in 2022. Fig 2 displays that the trend of increase has been linear and there has been no sharp increase. By comparing these results with the classification criteria it can be seen that the socio-economic *usi* was very low in 2015. This will rise to a moderate level in the year 2020 and by 2022 it will be good. As the city is developing it is hoped that the proportion of population living in the slums will decrease. At present 27 percent of city’s population lives in slums. To address the housing requirements of slum dwellers, housing for all scheme is being implemented in Dehradun nagar nigam. It seeks to rehabilitate the slum dwellers with the help of private developers. Coverage of sewage network services is also very poor. The service level benchmark is 100 percent and the present status of coverage of sewage network is 20 percent. This is extremely low and the ULB’s should do their best to achieve the national target. Collection efficiency of sewage network is also very poor. The service level benchmark is 100 percent and the present collection efficiency is 15 percent. Dehradun has been famous for its schools. As the result the student teacher ratio in Dehradun is higher than the national level. The per capita water supply in the city

is equivalent to the national target of 135 lpcd. Hence there will be an improvement in the socio-economic condition of the city as the years go by and hopefully Dehradun will achieve more sustainability. As the

city will expand the ULB will have to undertake more and more work to achieve the service level benchmark and hence achieve sustainability.

**Table 3: Socio-Economic *USI***

Socio-Economic Indicators	Relative Indicator Value in 2015	Relative Indicator Value in 2020	Relative Indicator Value in 2022
Proportion of city population living in slums	0.057	0.171	0.229
Household level coverage of water supply	0.318	0.636	0.795
Per capita water supply	0.061	0.242	0.181
Efficiency in collection of sewage	0.117	0.352	0.471
Coverage of sewage	0.058	0.176	0.235
Incidence of water logging	0.2	0.6	0.8
Student Teacher Ratio in Schools	0.081	0.243	0.351
<b>Socio-Economic <i>USI</i></b>	<b>0.15</b>	<b>0.38</b>	<b>0.51</b>



**Fig 2 : Socio-Economic *USI* Trend**

Table 4 shows the average *usi* of environmental indicators. It can be seen that the average environmental *usi* for the year 2015 is 0.11 which is very poor. This will increase to 0.31 in year 2020 and 0.39 in year 2022. By comparing these results with the classification criteria it can be seen that the environmental *usi* was very low in 2015 and in the

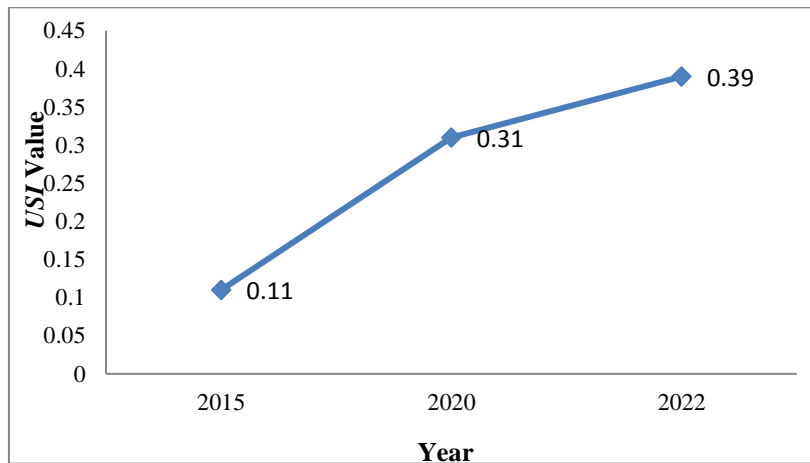
upcoming years it will remain moderate unlike the socio-economic indicators which shows promising growth despite it's certain shortcomings. In the years to come the environmental indicators does not show a promising growth. It will take more number of years to reach the acceptable sustainability level. Fig 3 shows a sharp rise between year 2015 and 2020 that is

due to the fact that the quality of water supplied to the city has reached the 100 percent benchmark and the percentage of public open spaces have been rising gradually and in the upcoming years it will achieve its target of 15 percent. The air pollution and the noise pollution have been growing at a very fast pace. Both

the air and noise pollution are way above the permissible limit set by CPCB. As there will be more development the pollution level will keep on rising unless checked and pose a threat to the health of the city dwellers as well as they will pose a hindrance in achieving higher sustainability.

**Table 4:** Environmental *USI*

<b>Environmental Indicators</b>	<b>Relative Indicator Value in 2015</b>	<b>Relative Indicator Value in 2020</b>	<b>Relative Indicator Value in 2022</b>
Air Pollution level in PM10	0.297	0.793	0.994
Maximum Noise Level	0.346	0.678	0.978
Percentage of public open spaces to total area	0.028	0.086	0.115
Quality of water supply	0.091	0.272	0.363
<b>Environmental <i>USI</i></b>	<b>0.11</b>	<b>0.31</b>	<b>0.39</b>



**Fig 3:** Environmental *USI* Trend

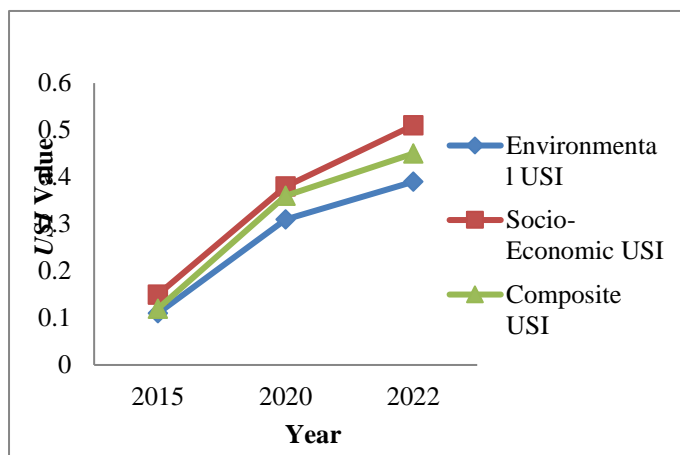
Further a composite *usi* is calculated which shows the overall performance of the city. It is calculated by combining the results of socio-economic and the environmental indicators. The overall performance of the city was poor in year 2015 and in the year 2020 it will be 0.36 and in the year 2022 it will be 0.45. The socio-economic conditions of the city will improve with time but the environmental indicators show that

the growth is very slow due to the degradation of environment and if kept unchecked it will keep on increasing and the city will never be able to achieve the desired sustainability. By comparing these results with the classification criteria it can be seen that the composite index value will remain moderate in the upcoming years. And it does not show a sharp growth. The increasing population base and paucity of

resources have put a tremendous pressure on the city. It will take quite a long time for Dehradun to reach the adequate sustainability level.

**Table 5 :** Composite urban sustainability index for Dehradun city

Year	Socio-Economic USI	Environmenta l USI	Composite USI
2015	0.15	0.11	0.12
2020	0.38	0.31	0.36
2022	0.51	0.39	0.45



**Fig 4 :** Composite growth pattern for Dehradun city

#### IV. CONCLUSION

The present study demonstrates the applicability of urban sustainable development studies. The sustainability index can help the policy makers to appraise the current sustainability scenario of the city and identify and focus on the indicators showing low growth and take corrective measures in the different dimensions of urban sustainability. Urban sustainability index can also be calculated for the other urban areas of Uttarakhand. These indicators can be used for gauging the performance of other cities and other area specific indicators can be added as well

which will help in giving a crystal clear view of the development. These indicators of sustainability help us to make decisions which will refine the urban planning. From local to global level it is necessary to consider sustainable development as the decision making strategy. It is very important to consider the accessibility of micro level data for sustainable assessment. Due to the lack of data certain indicators cannot be used which can show a much clearer picture of urban sustainability. A more detailed data set will help in comparing the performance of city at the national and the international level.

It is necessary to consider that a lot of work has to be done when it comes to sustainable urbanism in Dehradun city. The fringe area has also been developing at a growing pace due to which the nagar nigam expanded its city's boundary and increased the wards from 60 to 100. The city will keep on developing and growing its boundaries as the population will increase. We need to reduce our consumption of resources and avoid air, water and noise pollution thereupon reducing environmental impact and helping in giving a better quality of life to the city dwellers. The result of composite index for Dehradun puts a question over the performance of the city. At present the city is doing poorly and it might take another 10-15 years to reach at the sustainability level which is above 0.50. The government of India plans to make 100 new SMART cities and Dehradun is one of them. The question arises that will this step help Dehradun rise the ladder of sustainability or will it just make it more unsustainable with the expanding population base.

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