

Urban Infrastructural Development: An Assessment of Disparities in Rudrapur City Using GIS

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Abstract: Infrastructure predominantly influences urbanisation by promoting faster growth. It is required for social and economic growth and promoting the quality of life in urban areas. In this paper an attempt has been made to study the basic infrastructural facilities available in different wards of the Rudrapur city. The study is based on secondary data collected from different departments of Rudrapur Municipal corporation, pertaining to infrastructural facilities like Roads, sanitation, street lights, health care facilities, education facilities and recreational facilities. To fulfil this study Composite Z-score statistical technique has been used to analyse the data obtained to ascertain the infrastructural facilities in different wards. This method was applied to transform raw data of each variable into a standard score. open-source QGIS software has been used for the representation of data. This study identifies some challenges associated to a lack of infrastructural facilities and recommends solutions to these concerns.

Keywords: Infrastructural disparities, Composite Z-score, QGIS, Rudrapur city.

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I. INTRODUCTION

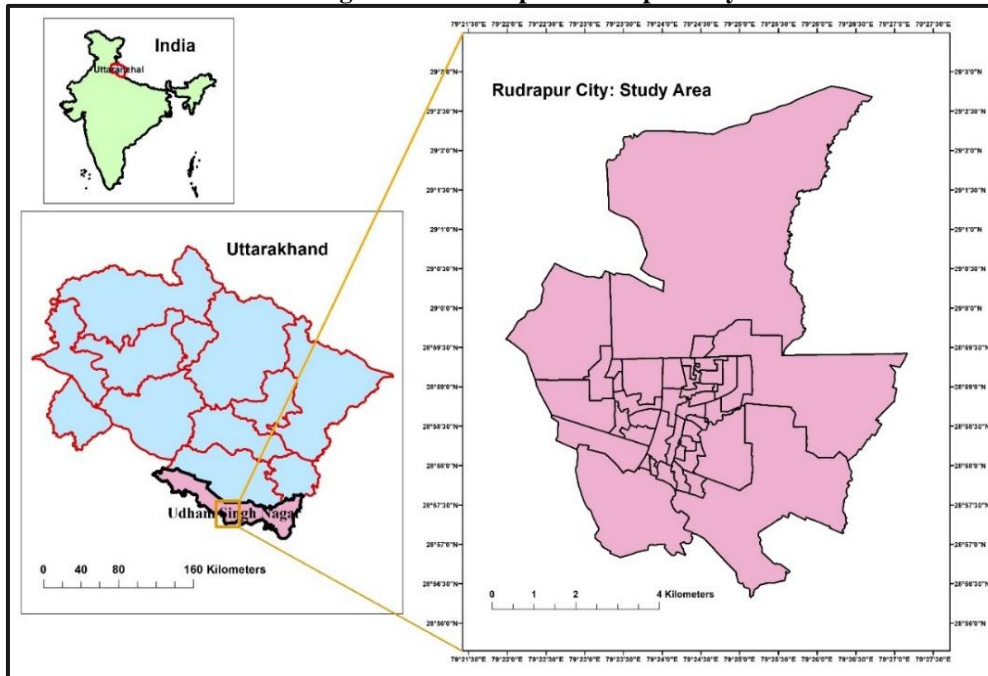
Infrastructure development is crucial to the urban growth of any region as society progresses, the activity of economic development and urbanisation increases, creating a demand for urban amenities. Likewise, the need for infrastructure grows. As a result of urbanisation, the demand for and supply of services and infrastructure has increased and the upgrading of infrastructure has been slow. India has the second largest population in the world and more than people lives in 471 cities that have population of over one lakh. Urban population of India have increased from 27.7 per cent in 2001 to 31.14 per cent in 2011 (census 2011). Increase in Urban population has put immense pressure on urban infrastructure to support quality of life and manifest itself as overcrowded, rise in crime rates, physical and mental illness and poor living conditions (Khwairakpan, 2013). The discrepancy between infrastructure demand and supply for essential services damages the physical environment and quality of life in cities. The constraint on infrastructure caused by existing demand is closely linked to people's consumption habits. Rising demand for basic services in cities is generating severe deterioration in housing, transportation, health care, water supply, sanitation, education, and other things. Infrastructure services are unable to satisfy demand as urbanisation continues to accelerate. Nadia Anis (2012) attempted to find disparities in the distribution of infrastructural facilities and status of social well-being in Aligarh city. She also used linear regression to find out the relationship between urban infrastructural facilities and social well-being. Rahaman. M & Siddique N.A. (2019) analysed the Spatial Concentration of Urban Infrastructural Facilities in Berhampur Town of West Bengal. They find out that the town's infrastructure is distributed unevenly. They also applied quantitative methods to analyse the data, such as Location Quotient, Average Ward-wise Composite Score, and Composite Indicators.

II. STUDY AREA

The Rudrapur city is located in the foothill zone of the Himalayan state Uttarakhand in India. At present, the city has a total area of 55.22 km² which is located between 28°55' to 29°4' north latitude and 79°22' to 79°27' east longitudes in the fertile Terai region, whose southern border is Uttar Pradesh and northern border is adjacent to the Technology, Pantnagar. Rudrapur the second most populous city in Kumaon and the fifth birth place of Green Revolution, Pandit Govind Ballabh Pant University of Agriculture and most populous city in Uttarakhand. Rudrapur is well connected by road with all the major cities of the state and region. Delhi is at a distance of 234 km whereas Nainital is just 72 km away. The place is a junction of roads heading in four directions. One towards Kashipur and beyond to Haridwar, the other to Nainital, the third towards Kichha leading to Bareilly & Lucknow and the last one heading towards the national capital, New Delhi. Population of

Rudrapur is increased from 88,815 in 2001 to 1,54,554 in 2011. It was upgraded from Nagar palika parishad to Nagar Nigam on 28thfeb2013. The city has total area 27.65 sq.km in 2011 and in 2018 the growth of area & population was recorded because 11 villages were incorporated within its boundary. Presently, Municipal Corporation Rudrapur is divided into 40 wards in 2018 after delimitation with the population 175723. According to Rudrapur Municipal’s official website, current population of Rudrapur is more than two lakhs.

Fig.1Location Map of Rudrapur City



Objectives of the Study: Main objectives of this paper are as follows:

- To assess the current scenario of existing pattern of infrastructural facilities in Rudrapur City.
- To calculate the composite z-score of different infrastructural facilities in the city.
- To assist the local administration with an efficient framework for urban infrastructure development.

III. DATABASE AND METHODOLOGY

The data used in this study were gathered from secondary sources, which included the Rudrapur Municipal Corporation, government documents, books, research papers, and websites. The data concerning population, roads, sanitation, solid waste management, street lights, health care facilities, education facilities and recreational facilities etc. are collected from different departments of RudrapurMunicipal Corporation.

The raw data for each indicator that affects the spatial variations in urban infrastructural facilities have been compiled into a standard score, known as a Z value or Z-Score. The score expresses in a comparable manner the deviation of each unique observation. Thus, the original data undergoes a linear change. It can be written as:

$$Z_i = \frac{X_i - X}{SD}$$

SD

Where,

Z_i = Standard score for the i th observation,

X_i = Original value of the observation,

X = Mean for all the values of X , and

SD = Standard deviation of X .

The Z-Scores of all the variables were summed ward-by-ward in the second stage, and the average was then calculated for these variables, resulting in the Composite Score (CS) for each ward, which can be mathematically stated as:

$$CS = \frac{\sum Z_{ij}}{N}$$

Where, CS stands for composite score.

N refers to the number of variables.

$\sum Z_{ij}$ indicates Z-Scores of all variables i in ward j .

Positive values for the city's Z-Score explain the high level of amenities, while negative values reflect the low level of amenities in the research area.

Besides, advanced statistical technique, QGIS 3.16 Hannover version software has been applied to show the ward disparities of infrastructural facilities among the wards of the city through maps.

IV. RESULTS AND DISCUSSION

Six indicators were selected computing the Z-score values for the analyses of infrastructural development in the city: a) Roads b) Sanitation c) Street lights d) Educational facilities e) Health care facilities and f) Recreational facilities.

Table: 1 Average Ward-Wise Composite z-score

Ward no.	Ward Name	Roads z-score	Sanitation z score	Street lights z-score	Educational z-score	health facilities z-score	Recreational facilities z score	Average composite z-score
1	Fulsunga / Fulsungi	1.78	2.86	3.56	0.70	-0.07	0.13	1.49
2	Transit Camp East	-1.75	0.22	0.11	0.11	1.12	0.43	0.04
3	Transit Camp Central	-0.14	1.11	-0.22	1.69	-0.27	-0.31	0.31
4	Transit camps Western	-1.22	0.35	-0.50	1.32	-0.50	-0.46	-0.17
5	Mukerjeenagar	0.11	-0.26	-0.46	-0.75	-0.50	-0.46	-0.39
6	Jagatpura	-1.43	-0.08	-0.46	0.01	-0.29	-0.46	-0.45
7	Ajad Nagar	-1.42	0.13	0.02	0.12	-0.50	-0.31	-0.33
8	Vivek Nagar	-0.59	-0.50	-0.33	2.05	-0.50	-0.61	-0.08
9	Shiv Nagar	-0.74	0.21	0.02	0.96	-0.50	-0.61	-0.11
10	Raja Colony / Takurnagar	-0.45	0.16	-0.59	0.13	-0.29	-0.61	-0.28
11	Sanjay Nagar	0.06	-0.45	-0.77	-1.29	-0.31	-0.31	-0.51
12	Industrial Area	-0.69	0.26	0.38	-1.18	-0.31	-0.31	-0.31
13	Dudia Nagar	-0.26	-0.62	-0.60	-0.46	-0.50	-0.61	-0.51
14	Bhadaipura	-0.49	-0.23	-0.27	0.07	-0.29	-0.46	-0.28
15	Paharganj	-0.6	0.31	-0.30	-0.20	-0.50	-0.61	-0.32
16	Bigwarha	1.05	2.64	2.43	0.31	0.56	-0.61	1.06
17	Kherha Southern	-0.74	-0.84	-0.61	2.90	-0.50	-0.01	0.03
18	Kherha Middle	-0.42	-0.95	-0.53	0.73	1.19	-0.31	-0.05
19	Kherha North	-0.48	-0.52	-0.60	-0.31	-0.50	1.32	-0.18
20	Bhutbangla northeast	-1.39	-0.19	0.14	-0.34	-0.50	2.22	-0.01
21	Bhutbangla West South	0.49	-0.78	-0.65	1.18	0.17	-0.46	-0.01
22	Rampura East	-0.76	-0.80	0.28	0.64	-0.50	-0.61	-0.29
23	Rampura Middle	3.26	0.46	-0.69	0.86	1.21	-0.61	0.75
24	Rampura Western	0.69	-0.69	-0.76	0.82	-0.50	-0.61	-0.18
25	FajalpurMahraula	-0.14	3.30	0.36	-0.89	-0.50	-0.61	0.25
26	Seergotia	-0.53	0.34	0.29	-1.38	-0.13	-0.16	-0.26
27	Gandhi Colony	1	-0.40	-0.61	-1.11	-0.12	0.43	-0.14
28	Main Market	1.58	-0.77	-0.19	0.07	0.54	2.96	0.70
29	Aadarsh Colony SRA	-0.44	-0.69	-0.41	-1.14	-0.50	-0.01	-0.53
30	D1, D2	0.47	-0.42	-0.34	0.20	0.76	1.77	0.41
31	Alliance Colony	0.09	0.42	-0.27	-1.61	0.60	-0.31	-0.18
32	Bhurarani	0.02	1.20	3.25	0.57	0.15	-0.61	0.76
33	Singh Colny	-0.76	-0.11	0.27	-0.70	-0.11	-0.61	-0.34
34	Indra Colony	1.55	-0.64	-0.52	0.20	-0.29	-0.61	-0.05
35	Aadarsh Indra Colony	1.23	-0.48	-0.57	-1.18	-0.50	-0.61	-0.35
36	Aadarsh Colny Ghas Mandi	-1.46	-0.73	-0.34	-0.91	1.63	0.58	-0.21

37	Kalyani View / Ravindrangar	0.42	-0.47	-0.42	-0.81	0.08	-0.01	-0.20
38	Awas Vikas west	0.84	-0.86	0.01	-0.71	1.07	3.56	0.65
39	Awas Vikas east	-0.58	-0.50	-0.62	-0.17	-0.09	-0.31	-0.38
40	Sidcul	2.89	-1.00	1.55	-0.49	1.05	-0.16	0.64

Source: data computed by authors based on the data collected through different departments of RudrapurMC*.
*Municipal corporation.

Roads

Road connectivity is considered to be the harbinger of development because it helps the people of remote and backward areas in development and utilization of environment and improve their economic activities. The total area of Rudrapur City is 55.22 sq. km, with a total length of 681 km of roads, and the road density is 12.33 sq.km while India’s road density estimated 1.80 km per sq.km. (Road statistics, 2016-17). level of road development in city were measured on the basis of two variables, i.e., the road length per sq.km and road length per thousand of population in each ward. Table 2 reveals that, the highest value of composite mean z-score 3.26 in roads development is secured by Rampura middle ward whereas, the lowest value below -1.75 by the ward of Transit camp East.

Table: 2Roads development in the city,2021

Level of development	Composite z score	Total No. of wards
Very low	-1.75 to -1.22	06
Low	-1.21 to -0.26	15
Medium	-0.25 to 0.69	10
High	0.70 to 1.78	07
Very high	1.79 to 3.26	02

Source: data computed by authors.

Fig. 2 Road Infrastructure

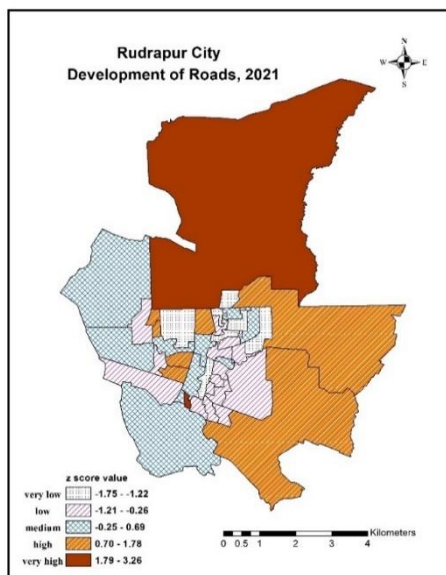
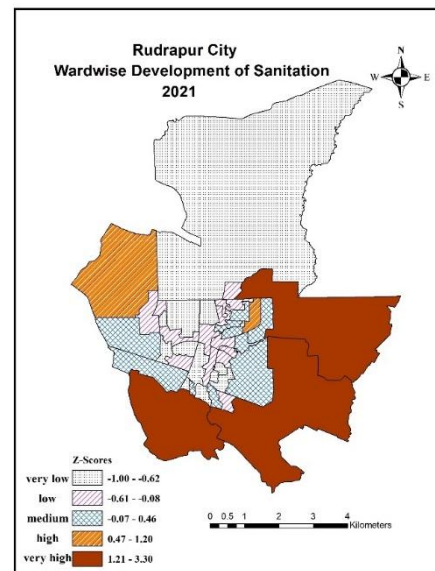


Fig. 3 Sanitation infrastructure



Sanitation

The present status of sewerage system in the city are grossly inadequate. The total length of (nallahs) drains in the city is 196.97 km. because of no sewer system or insufficient drains most of the waste water gets discharged into river Kalyani in the city. River Kalyani is the main drainage in the city which receives municipal drains from residential areas of Rudrapur city located adjacent to the industrial estates. During the rainy season the river water creates a flood situation in the surrounding areas, which causes the problem of water logging and waste water is accumulated on roads, which causes erection of water born disease in the city. Access to sanitation as per the Census of 2011, the total number of households in Rudrapur city was 29,662 and IHHT was available with 66.2% of the households. It was reported that 28% of the households practiced open defecation

(Situation Assessment Report Faecal Sludge and Septage Management Uttarakhand State April, 2019). One variable: Drain length in km per thousand person have been taken into consideration to measure the sanitation development in each ward of the city.

Table: 3Sanitation Development in Rudrapur City, 2021

Level of development	Composite z-score value	No. of wards
Very low	-1.00 to -0.62	11
Low	-0.61 to -0.08	13
Medium	-0.07 to 0.46	11
High	0.47 to 1.20	2
Very high	1.21 to 3.30	3

Source: data computed by authors.

Street lights

Infrastructure for street light is one of the important indication.it ensuring safety and security for the residents of the city.Lighting of the streets help to prevent the accidents and crimes in the society, and facilitate the people. Two variables: total number of working street lights and total number of street lights serving per 1000 persons in each ward. The highest Z- score value of 3.48 in street lights development is scored by Funsungi ward and the lowest value of – 0.77 by Rampura western ward.The peripheral zone of the city surprisingly has highest number of working street lights.

Table:4Status of Street Lights in the city,2021

Level of development	Composite z score value	No. of wards
Very low	-0.77 to -0.50	14
Low	-0.49 to -0.19	12
Medium	-0.18 to 0.38	10
High	0.39 to 1.55	01
Very high	1.67 to 3.56	03

Source: data computed by authors.

Educational Facilities

Education plays a vital role in a nation’s development and is a basic right of every human being. In Rudrapur city there are educational institutions for primary to graduate level studies. There are seen 11 junior basic schools and 15 senior basic school, the no. of higher secondary is 32, among them two is specially for girls. Total number of degree colleges are three. But there has no university though it is the headquarters of the district. In Rudrapur city the Levels of educational development have been measured by selecting three variables as: number of junior & senior basic schools per 1000 of persons, number of higher secondary schools per 1000 of persons, and number of colleges per 1000 of persons.

Table: 5 Level of Educational Development in Rudrapur City, 2021

Level of development	Composite Z-score value	No. of wards
Very low	-1.61 to -1.11	07
Low	-1.10 to -0.31	10
Medium	-0.30 to 0.31	11
High	0.32 to 1.32	09
Very high	1.33 to 2.90	03

Source: data computed by authors.

Fig. 4 Street lights infrastructure

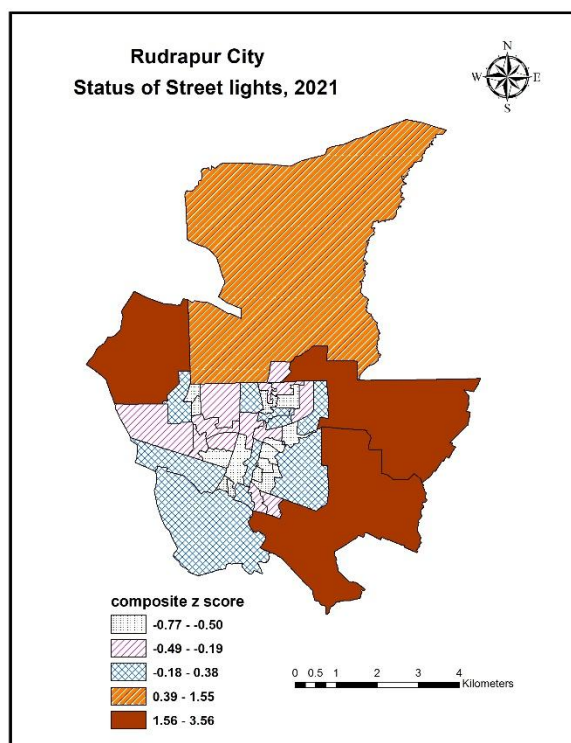
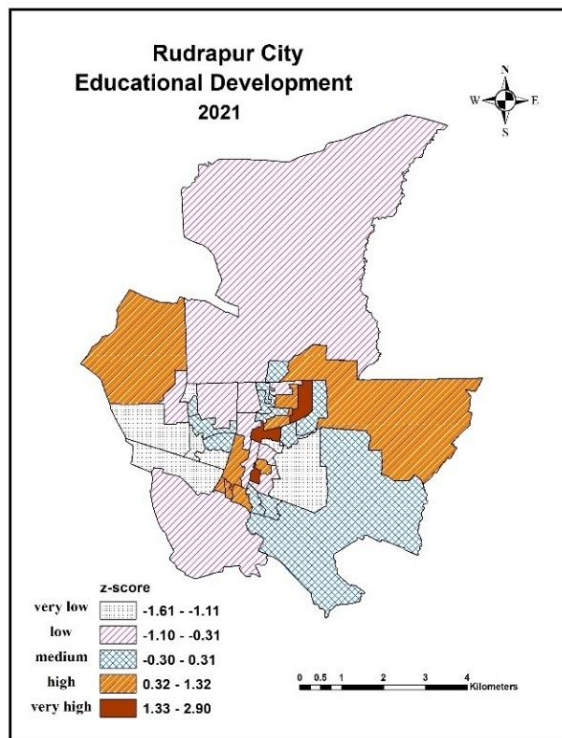


Fig. 5 Educational Facilities



Health Care Facilities

Health facilities in Rudrapur are of average standard. There is only one district government assisted hospital namely Jawahar Lal Nehru District Hospital (JLN), and three urban PHC namely Urban PHC transit camp, Urban PHC Rampura, Urban PHC Khera. Besides these, there are number of private clinics and nursing homes located in different wards of the city. The city has more than 400 plus medical stores and almost 84 plus private clinics or hospitals. Disparities in level of health care development were analysed taking into consideration two variables: number of govt/ PHC per 1000 persons and number of private hospitals per 1000 persons in the city. Only 6 wards of the city characterized by very high level of health care facilities. Ward Adarsh colony ghas mandi and Awas vikas have the highest number of private clinics. Table 6 shows that there are 15 wards under the category of very low with the composite z-score values ranging from -0.50 to 0.45. The wards Transit camp western, Mukerjeenagar, viveknagar, shiv nagar, Ajad nagar, Dudia nagar, paharganj, khera southern, khera north, Bhutbangla northeast, Rampur east, Rampur western, Fajalpurmahraulla, Adarsh colony SRA and Adarsh Indra colony have very low status of health care facilities. (fig.6)

Table: 6 Level of Health Care Facilities in Rudrapur City, 2021

Level of health care facilities	Composite Z Score	No. of wards
Very low	-0.50 to -0.45	15
Low	-0.44 to -0.27	06
Medium	-0.26 to 0.17	09
High	0.18 to 0.76	04
Very high	0.77 to 1.63	06

Source: data computed by author.

Fig. 6 Health Care Facilities

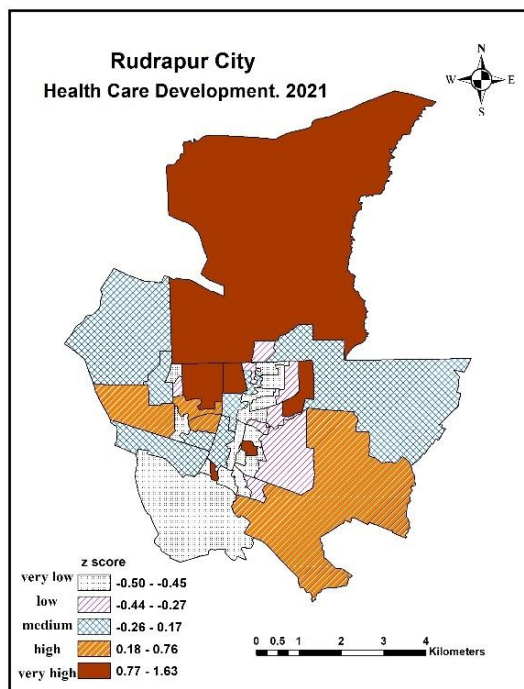
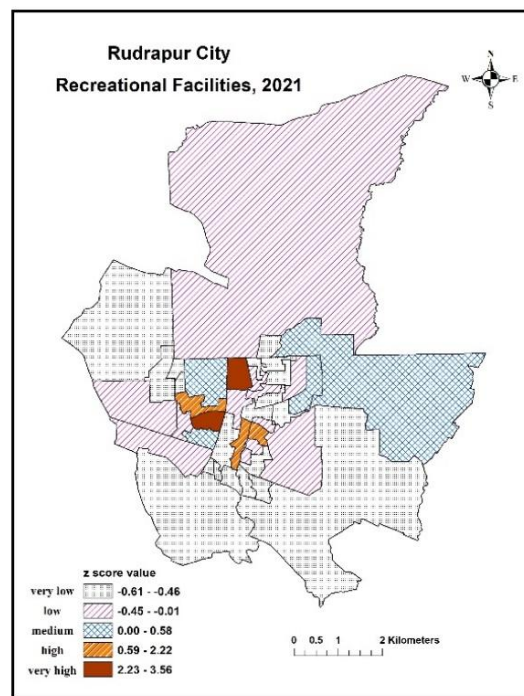


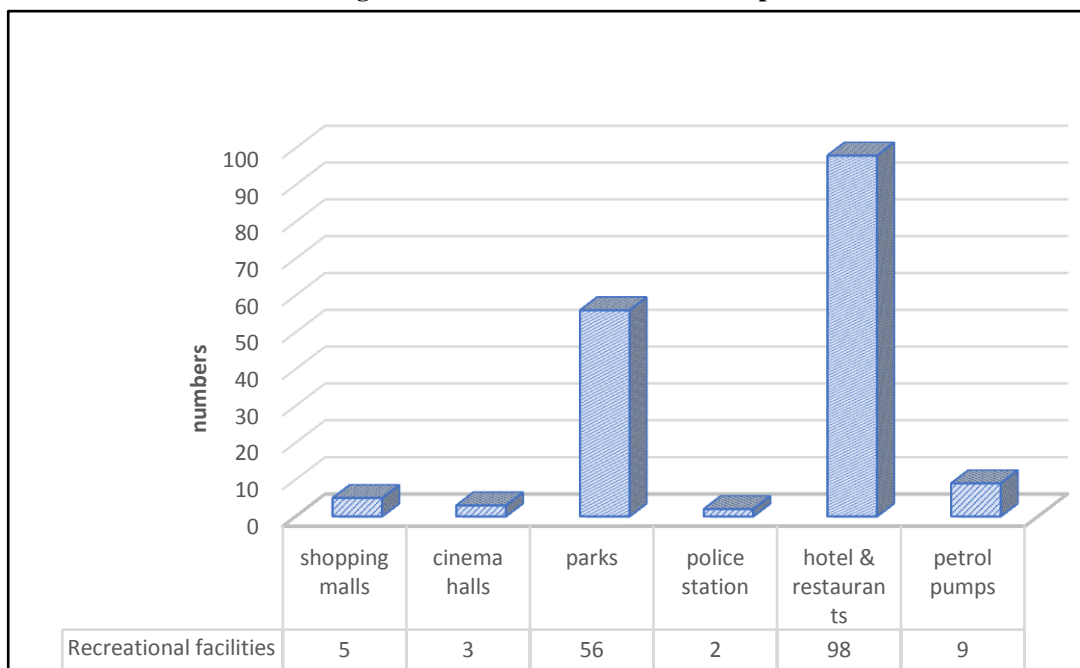
Fig.7 Recreational Facilities



Recreational Facilities

Figure 8 shows that, there are only five shopping malls namely Vishal mega mart, V mart, Shopper Street hypermarket, G Mart and Big Bazar mall and three cinema halls named as Rave, Wave and movie times and 56 parks and 02 police station nearly 98 Hotels and Restaurants situated in the city. Recreational facilities are lacking in the city. Most of the parks serve as the garbage dumping sites. Number of shopping malls have recently been increased and more super markets are opening in the city.

Fig. 8 Recreational facilities in Rudrapur.



Source: Municipal corporation Rudrapur,2021.

Level of recreational facilities in Rudrapur City were measured on the basis of six variables, number of shopping malls, number of cinema halls, number of parks, number of police station, number of hotel and restaurants and number of petrol pumps in each ward.

Table: 7 Wardwise development of Recreational Facilities in the City, 2021

Level of development	Composite z-score	No. of wards
Very low	-0.61 to -0.46	19
Low	-0.45 to -0.01	12
Medium	0.00 to 0.58	04
High	0.59 to 2.22	03
Very high	2.23 to 3.56	02

Source: data computed by author.

Overall Urban Infrastructural Development in the city

Six different aspects of infrastructural facilities for which z-score values calculated are roads, sanitation, street lights, educational facilities, health care and recreational facilities in Rudrapur city. All these indices have been plotted and interpreted separately with respect to their spatial distribution in Rudrapur city. Finally, a composite index of infrastructural development of each component area unit (ward) of the city has been calculated. Wards have been grouped into 5 levels of infrastructural development of very low, low, medium, high and very high on the basis of their mean z-score value.

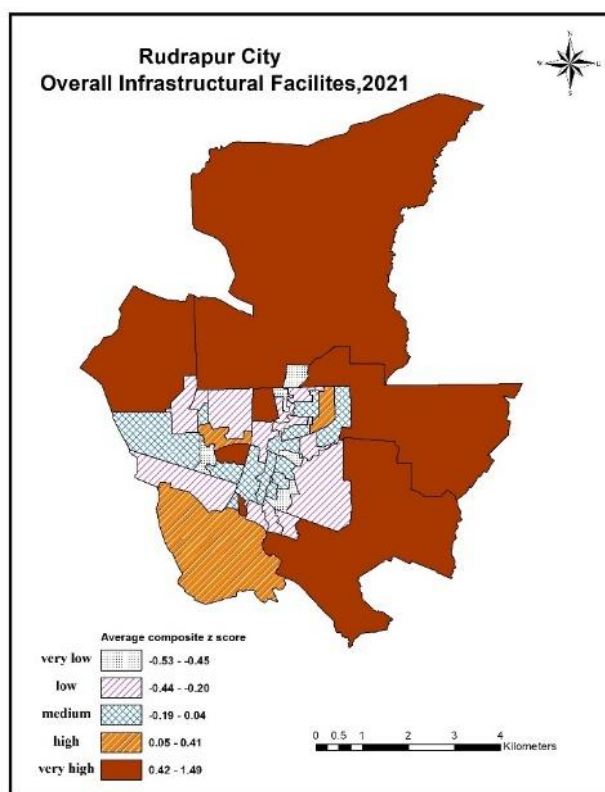
Table: 8 Overall Urban Infrastructural Development in the city, 2021.

Level of development	Composite z-score	No. of wards
Very low	-0.53 to -0.45	04
Low	-0.44 to -0.20	13
Medium	-0.19 to 0.04	13
High	0.05 to 0.41	03
Very high	0.42 to 1.49	07

source: data computed by authors.

Table 8 shows that, only 07 wards of the city are categorized as having very high level of infrastructural development. Wards belonging to this category are namely, fulsunga, bigwarha, bhararani, SIDCUL, Awasvikwas west and main market. Most of these wards have recently been added to the municipal limits. A sum of 13 wards with composite mean z-score values ranging from -0.19 to 0.04 are grouped under medium level of infrastructural development. These wards mainly belong to old parts of the city. Very low level of infrastructural development is represented by 04 wards. These wards account for 12 per cent of population of the city. These wards are mostly located in core areas of the city. and completely devoid of urban amenities. Garbage is seen spreading over vast areas. These regions are congested part of the city. The table 8 also shows that there is huge variation among the wards in terms of infrastructural development. The Ward Fulsunga has the distinction of being at the top with composite z score values 1.49 and highly developed ward, while Aadarsh colony SRA remains at the lowest with composite z score values of -0.53. The difference between these two composite scores is 2.02, which is quite extreme. The mean score of infrastructural development for all the wards is -0.01, median is -0.18 and standard deviation is 0.46. This clearly shows that there are spatial disparities in Infrastructural Facilities among the Wards of Rudrapur city. (fig.9).

Fig. 9 ward wise composite z score for overall infrastructural facilities.



V. CONCLUSION AND RECOMMENDATIONS

In this study of urban infrastructural facilities, the unequal distribution of infrastructure is seen throughout the city. A high concentration of urban infrastructure facility is found in outskirts of the municipality. The central regions are identified as moderate to a low level in terms of infrastructural concentration. The jagatpura, shivnagar, sanjaynagar, khera, Rampura east and Rampura west, seergotia colonies dominated by slum people are deprived of the basic civic facilities in city. The city is well connected with road network. But the rapid development of the peripheral areas of the city has increased demand for new networks and transport facilities to deal come out challenges. There is a big challenge regarding sewerage and cleanliness in the city. Dumping of sewage through drains in Kalyani River is also a matter of concern. During the rainy season the river water takes the form in flood in the surrounding areas, which causes the problem of water logging, and waste water is accumulated on roads, which causes erection of water born disease in the city.

Some proposals must be executed in the concerned city in order to improve various infrastructure facilities. There is a need to focus on widening of roads, removal of encroachments, construction of flyovers, development of parking lots and improvement in traffic considerations and resources. The government should create a university to improve higher education for the people of Rudrapur and the Udham Singh Nagar district. The number of primary health care centres in the city needs to be expanded. People still migrate to the cities like Delhi and Dehradun for treatment of serious health diseases. There should be more Government and private hospitals in the city. There should be a provision for park & open spaces in the congested areas of the city. The Urban Local Bodies (ULB) should improve the city's educational, health, and recreational amenities, among other things. Infrastructure schemes must be executed in order to improve the quality of various infrastructure amenities in the city.

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