Spatial Planning of Infrastructural Facilities in Rural Areas around Roorkee, Uttarakhand, India

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INTRODUCTION

Even after 56 years of independence, India is still a developing country. India is a rural based country, where 73% of the people live in habitations and nearly 260 million people live below poverty line. Rural development is one of the important missions for transforming India into a developed nation. Apart from agriculture, road transportation, storage system, chilling plants, communications relating to multiple technology and management have to be networked. Presently, there is a big gap between the urban and rural India in terms of basic civic amenities and employment. From 1951 onwards, various rural development schemes under five-year plan have been started by the Indian Govt., but even today the desired goals have not been achieved.

Development of rural infrastructure cannot be viewed in isolation, an therefore an integrated strategy may be required. An example of this is PURA (Providing Urban Facilities in Rural Areas) model that envisages a habitat designed to improve the quality of life in rural places, to make special suggestions to remove urban congestion and to bring rural wealth & prosperity. Our basic strategy for social and economic transformation of India towards its vision as a developed society by year 2020 would be a strong focus on providing urban amenities in rural areas in a most creative and cost effective manner.

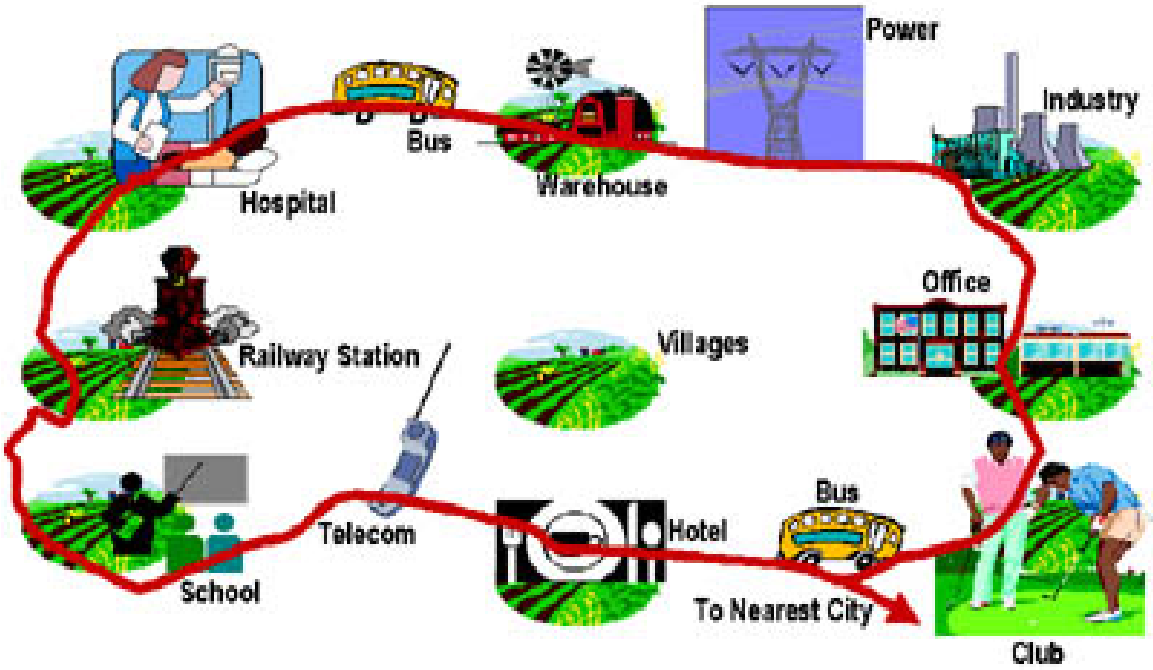
In a developing country like India, a structured planning procedure is required such that the development activities and infrastructure facilities are available at both urban and rural area. However, in such a condition where majority of people leave in rural area and are provided with the least infrastructure facilities, creates a regional imbalance in development, causing migration of population from rural to urban areas. Proper infrastructure planning helps in eradication of mass poverty, creation of more employment opportunities, checking of mass city-ward push migration, improvement in living standard of the masses, narrowing the gap between the urban and rural living and generation of a self-sustaining development process.

PROVIDING URBAN FACILITIES IN RURAL AREA (PURA) :

PURA is one of the mechanisms which is proposed to be utilised for transforming rural India into a productive economic zone. Five thousand PURAs have already been announced by the Government of India. PURA is a Vision 2020 project, hence, it is spread over three Five-Year Plans. Each PURA might call for an average investment of Rs 100 crores (or about $20 million).

PURA model is to be implemented on a cluster consisting of 10-20 habitations connected with a ring road of approximately 30 km in circumference, having physical, knowledge, electronic and economic connectivities (Fig. 1). This will integrate all the connected habitations into one market. The habitations will become a city of sorts with the potential to expand and accommodate a population of 3-5 lakhs.

To achieve the target, proper planning is required using a conceptual model. In order to address these considerations, it is necessary to integrate a large amount of spatial information and knowledge from several disciplines. Advances in Geographic Information Systems (GIS), multiple objective decision making and physical simulation make it possible to develop user-friendly, interactive, decision support systems for rural development planning and management.



ROLE OF GIS IN INFRASTRUCTURE PLANNING:

Spatial data analysis is a multidisciplinary activity concerning water resources, geography, urban planning, hydrology and earth sciences. These data sets may be derived from text, maps, charts, organizations, aerial photographs, satellite images and ground information. The management and analysis of such large volumes of spatial data require a computer-based system called Geographic Information System (GIS) which can be used for solving complex geographical, hydrological and planning problems.

GIS is defined as system of computer hardware and software, designed to allow users to collect, manage, analyze and retrieve large volumes of spatial referenced data and associated attributes collected from a variety of sources. In planning process at regional level, integration

of various spatial data and their attributes is required to arrive at different alternatives. GIS is a useful tool for the integration and analysis the multi-thematic information for a particular application, thereby, providing managers and planners with necessary tools for generating new information from existing thematic layers of information required for a particular need.

In GIS, both spatial (*e.g.*, satellite images, maps) and non-spatial (*e.g.*, census surveys) data may be integrated and a set of spatially registered layers can be analysed independently or in combination. GIS supports multiple views of data and yet provide integration that would minimize redundancy and maintain data integrity and security. It allows concurrent access to multiple users and processing of user transactions in an efficient manner.

GIS BASED APPROACH – A CASE BASED STUDY

The present study emphasizes the power of GIS technology which will help the Government of Uttarakhand State to better understand and evaluate the spatial data of Roorkee cluster by creating graphic displays and identify gaps in existing facilities using scientific criteria. GIS shall also be used to optimize the use of facilities required to be provide in the study area. As GIS does more than just display the data; it enables the users to dynamically analyse and update the information linked to those locations spatially, and therefore can help to further strengthen the e-governance.

In the long run, it is necessary to improve quality of life of rural habitation by providing them modern economic linkages. To achieve this, economically viable cluster of habitations have to so created through a mission mode programme into physical, electronic, and knowledge connectivity, leading to the sustained economic prosperity for the group of habitations. The objective is to make India's rural areas as attractive to investors as its cities are. Then, rural areas will generate urban-style employment to halt rural-urban migration.

(A) The Study Area

The study areas covers Roorkee and its surrounding area, which is situated between 77^0 55'- 78^0 00' East longitudes and 29^0 45'- 29^0 55' North latitudes. Roorkee, a quite city of moderate size in the district of Haridwar (Uttarakhand), and is located on the banks of the upper Ganga Canal, which takes off from Haridwar, about 30 km away. About 30 km south of the Shivaliks, 170 km north of Delhi on the Delhi-Dehradun-Mussoorie highway and 55 km Roorkee-Haridwar-Rishikesh road takes off from Roorkee, which further leads to Badrinath, Kedarnath, Gangotri, Yamunotri (all Hindu pilgrim places) and the northern national boundary. Fig. 2 shows the study area which covers 23 habitations in and around Roorkee area within a radius of 4 km from Roorkee city.

Data regarding roads, rail, river, canal, telephone line, power line, etc., are gathered from 53G/13 toposheet and field visits. Demographic data, agro-economic data, socio-economic data are collected from various literature, atlases, organizations, reports and personal field

visits in each habitation. The following parameters are required to be studied and analyzed for the overall development of rural areas:

1. **Physical connectivity:** It includes transportation, power, basic infrastructure, availability of goods, tourism, etc.

2. **Economic connectivity:** It includes employment, economic strengthening, banks and cooperatives, market & service centers, women empowerment, small-scale industries, quality of life, etc.

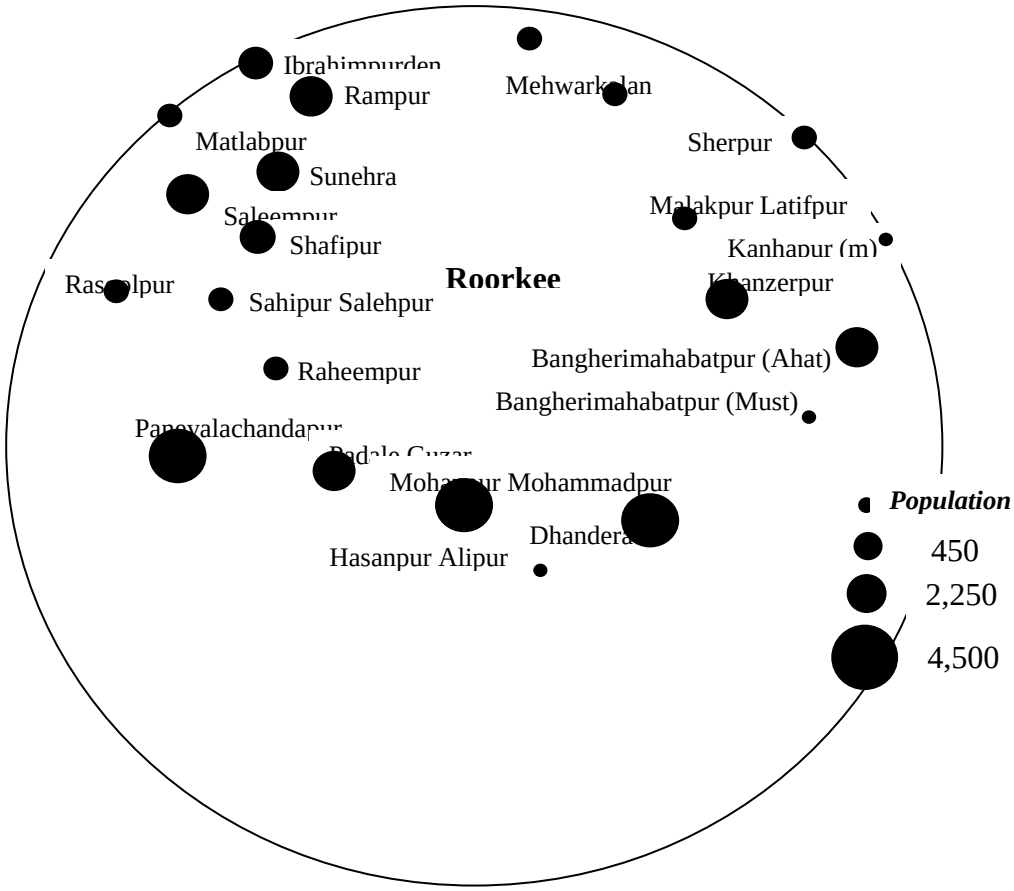
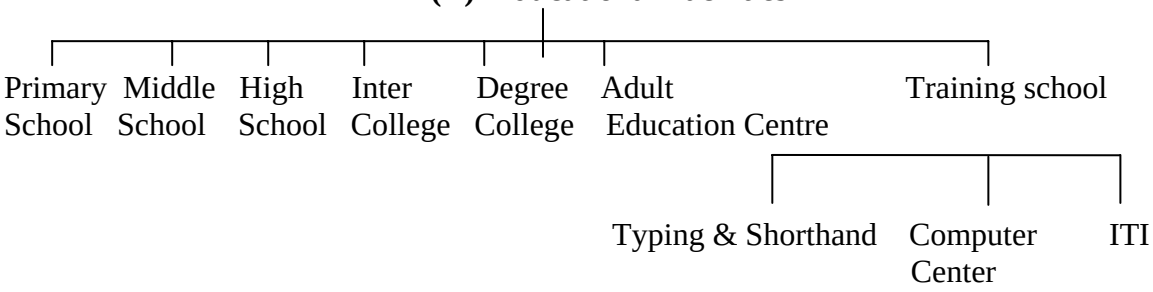


Fig. 2 : Location of 23 habitations in and around Roorkee

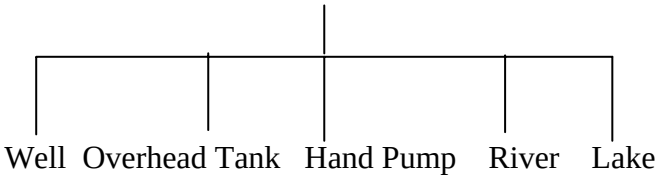
3. **Electronic connectivity:** It includes telecommunication, computer literacy, tele-education, such as cyber cafés, internet facilities, tele-medicine, e-governance, such as tele-info centre, habitation info grid, etc.

4. **Knowledge connectivity:** It includes vocational training centres, professional institutes, sectoral planning and management related to health, environment, and drinking water and sanitation, non formal education, community participation etc.

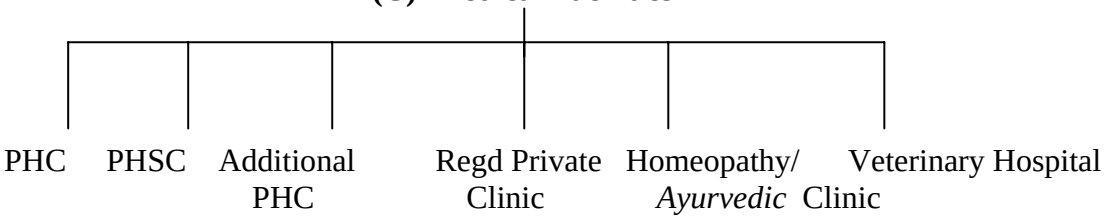
(A) Educational Facilities



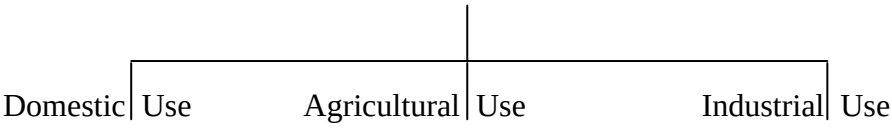
(B) Drinking Water Facilities



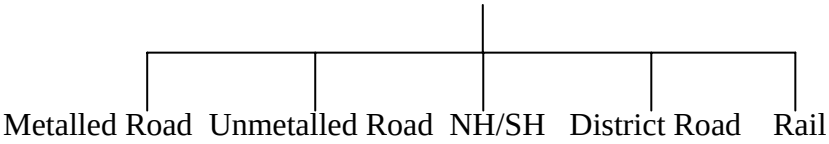
(C) Medical Facilities



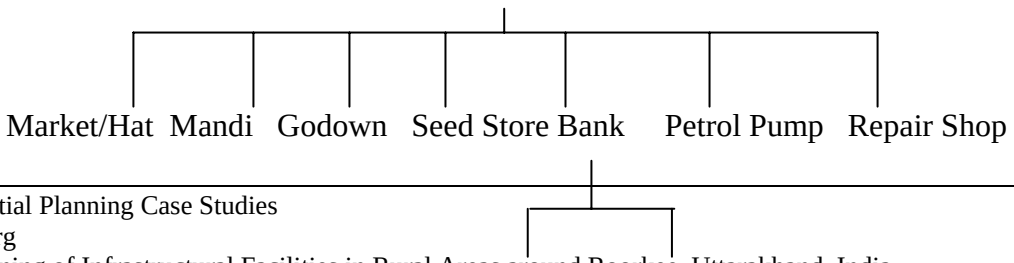
(D) Power Supply *(duration in hours)*



(E) Physical Connectivity



(F) Commercial Activities



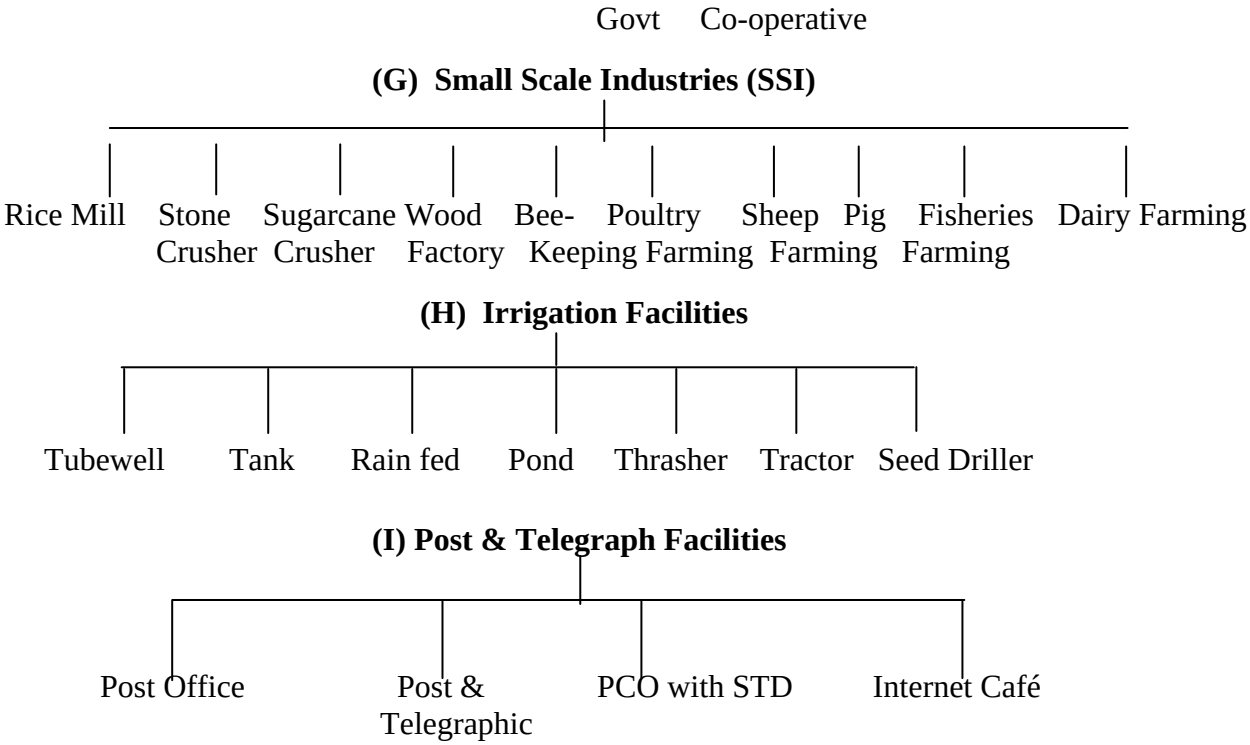


Fig. 3: Data collected in the study

In total, the study area has 23 habitations. All these habitations with their administrative boundaries have been digitized in GIS. The non-spatial attribute data are incorporated to each of the habitations. The software used for the present study include Arc GIS and Microsoft Excel, and programs are developed in VB 6.0.

The following digital maps have been created in GIS environment. Extensive field visits have been carried out to collect the information on various facilities habitation-wise. Out of 111 parameters, the following parameters which can be shown in spatial form are considered in GIS environment for spatial analysis.

Total Population : The habitations have been classified into five categories i.e. (i) ≤ 1000, (ii) 1001 - 2500, (iii) 2501 – 5000, (iv) 5001-10000, and (v) > 10000. The population has been further classified into three community i.e., Hindu, Sikh, and Muslim. In the study area, fourteen habitations have majority of Hindu community, one habitation has majority of Sikh community, and six habitations have majority of Muslim community. Two habitations i.e. Bangerimahabatpur Ahat and Hasanpur Alipur have very little population. A total of 23 habitations and their codes and population statistics (1991 and 2005) are shown in Table 1.

Table 1 : Habitation name and their codes

Sl. No.	*Habitation name*	*Codes*	*Area (Ha)*	*Population (1991)*	*Population (2005)*
1	Alamaspur	296	83.00	22	40
2	Bangerimahabatpur (Must)	302	75.00	4312	16200
3	Bangerimahabatpur (Ahat)	303	140.00	-	-
4	Dhandera	322	310.00	10018	20500
5	Ibrahimpurden	286	420.00	1671	3900
6	Hasanpur Alipur	323	67.00	-	-
7	Kanhapur (m)	227	110.00	-	2000
8	Khanzerpur	301	150.00	4266	12500
9	Malakpur Latiphpur	300	180.00	373	1495
10	Matlabapur	287	110.00	902	2650
11	MehwarKalan	213	360.00	646	10550
12	Mohanpur-Mohammodpur	321	230.00	5790	23500
13	Padale Guzar	320	240.00	4236	15040
14	Paneyalachandapur	294	440.00	5526	11600
15	Raheempur	293	130.00	1300	3450
16	Rampur	297	210.00	3742	11650
17	Rasoolpur	291	140.00	1118	2170
18	Roorkee City	999	1400.00	97064	97064
19	Sahipur Salehapur	292	55.00	750	1730
20	Saleempur Rajputan	288	220.00	3592	15300
21	Shafipur	299	3.60	1952	14400
22	Sherpur	225	110.00	1037	2000
23	Sunhera	298	41.00	2678	8900

River Network : The study area has Solani river flowing north-east and Upper Ganga Canal passing through Mewarkala, Roorkee city, Padale Guzar, and Mohanpur Mohammadpur habitations. The canal water is extensively used for irrigation purpose. Solani river mainly carries water during rainy season.

Road Network: The study area has national highway, *Pucca* road, *Kutcha* road, foot path and railway line (Fig. 3). The railway line is passing through Sahipur Salehpur, Dhandera, Roorkee city, Padale Guzar, and Mohanpur Mohammadpur habitations. National highway Delhi-Roorkee-Dehradun and Roorkee-Hardwar are passing through the area and connecting some habitations. All the habitations do not have *Pucca* roads. From the data, it is evident that road connectivity is essentially required in all the habitations. Some habitations need

additional roads while in other habitations existing *Kutcha* road needs to be converted into *Pucca* roads.

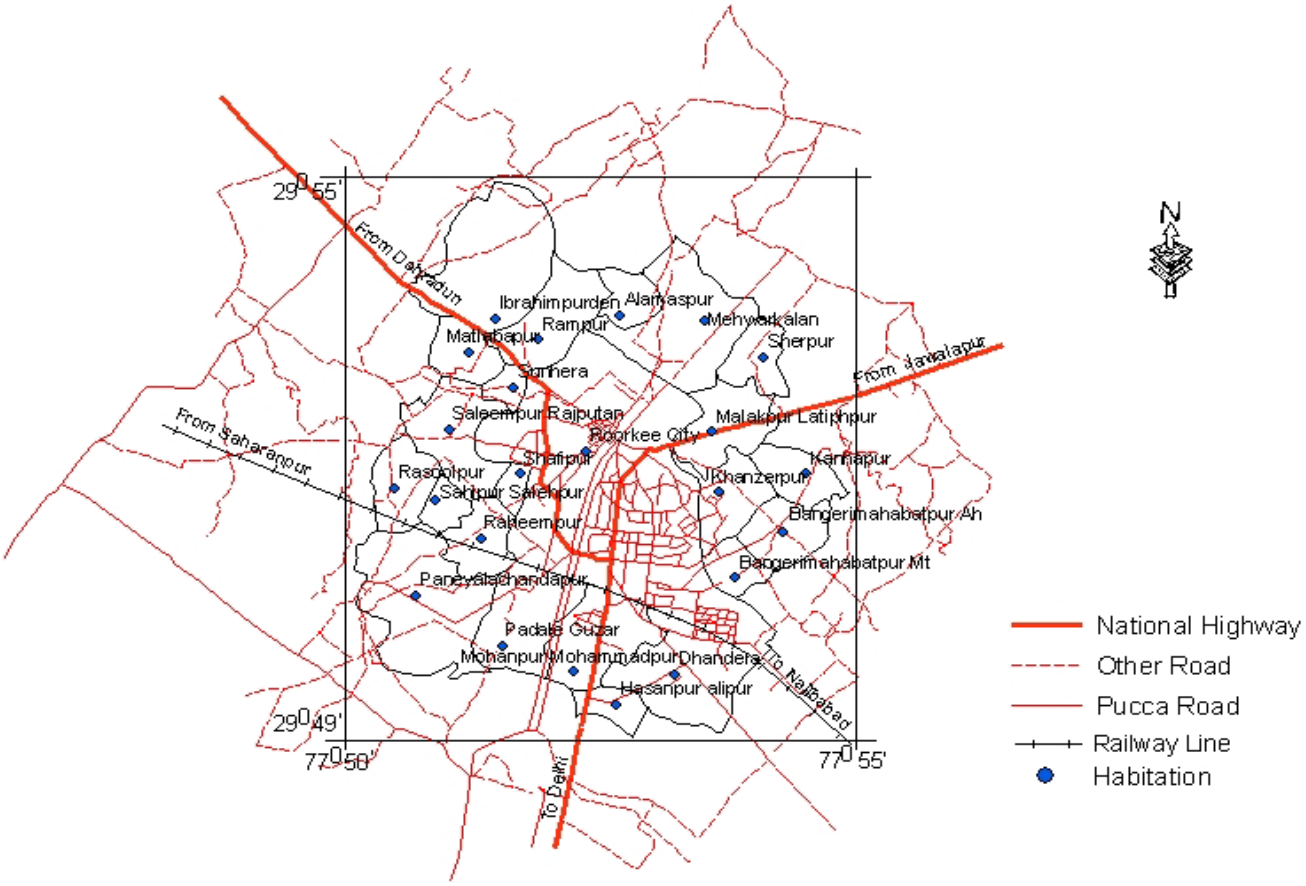


Fig : 3 Road Network Map

(C) Development of Various Facility Indices

It is important to study the above facilities in combination. To integrate various thematic layers of above facilities created in GIS software, it was necessary to write computer programs. One of the ways to integrate these layers is combing them theme-wise (i.e. merging them together representing one major facility, like education, medical, communication, transportation etc.). For each major facility, most popular and widely accepted approach is to find cumulative weight by assigning weights to each parameter under that major facility. To find various major facilities indices, computer programs have been developed in VB 6.0. These indices are explained below:

(1) Educational Facility Index (EFI)

The Educational Facility Index (EFI) is a measure of the importance education from settlement point of view. EFI has been calculated using weighted indexing method, as given below. If I_i is the index of particular function "f" of i^{th} habitation, then:

$$I_i = \sum_{j=1}^{n} W_j X_j \quad (1)$$

Where W_j = Weight of j^{th} function

$$W_j = \frac{\text{Total no.of villages in block}}{\text{villages having } j^{th} \text{ function}}$$

X_j = Value or availability of j^{th} function in i^{th} habitation.
N = Number of functions / facility available in i^{th} habitation.

$$EFI_i = NI + PI + MI + HI + II \quad (2)$$

Where $PI = W_{p.} * X_p$

N = Nursery school (Wt.1.50)
P = Primary school (Wt. 1.17)
M = Middle school (Wt. l5.25)
H = High school (Wt. l4.20)
I = Inter college (Wt. 3.00)

The EFI values are computed for each habitation and presented in Table 3. The highest value is obtained as 115.87 for Roorkee city, as expected because of availability of all types of educational facilities. Five habitations i.e. Alamaspur, Bangerimahabatpur Ahat, Hasanpur Alipur, Kanhapur (Must) and Malakpur Latifpur are found to have no educational facilities with EFI = 0. These habitations are categorized into 4 classes i.e. (i) EFI $\leq$ 10.00, (ii) EFI between 10.01 and 20.00 (iii) EFI between 20.01 and 50.00, (iv) EFI between 50.00 and 100.00 (v) EFI > 100.00. Twelve habitations fall under 2^{nd} category, five habitations under 3^{rd} category and Rookree city under 4^{th} category.

(2) Medical Facility Index (MFI)

The Medical Facility Index (MFI) is a measure of the availability of medical facilities in the habitation, and thus it is the level of importance based on medical facilities. It is calculated using the same method as for computing the EFI:

$$I_i = \sum_{j=1}^{n} W_j X_j \quad (3)$$

Where W_j = Weight of j^{th} function

$$W_j = \frac{\text{Total no.of villages in block}}{\text{villages having } j^{th} \text{ function}}$$

X_j = Value or availability of j^{th} function in i^{th} habitation.
n = number of functions / facility available in i^{th} habitation.

$$MFI = PHCI + COMMI + PVTI + HM\_AYI + VTI \quad (4)$$

Where $PHCI = W_p * X_p$

Table 3 : The Educational Facility Index (EFI)

Sl. No.	***Habitation Name***	***EFI***	***Category***	***MFI***	***Category***	***CFI***	***Category***
1	Alamaspur	0.00	I@	0	I@	0	I@
2	Bangherimahabtpur Must	10.48	II	6	II	15	III
3	Bangerimahabatpur Ahat	0.00	I	0	I	0	I
4	Dhandera	20.17	III	5	II	75	IV
5	Ibrahimpurden	6.17	II	5	II	2	II
6	Hasanpur Alipur	0.00	I	0	I	0	I
7	Kanhapur	0.00	I	0	I	0	I
8	Khanzerpur	13.03	II	13	III	8	II
9	Malakpur Latiphpur	0.00	I	0	I	3	II
10	Matlabapur	4.17	II	0	I	2	II
11	MehwarKalan	19.45	II	4	II	8	II
12	Mohanpur-Mohammodpur	23.50	III	0	I	60	IV
13	Padale Guzar	6.83	II	0	I	0	I
14	Paneyalachandapur	18.62	II	23	III	8	II
15	Raheempur	3.50	II	0	I	0	I
16	Rampur	19.75	II	0	I	8	II
17	Rasoolpur	5.33	II	0	I	0	I
18	Roorkee City	115.87	IV*	635	V*	1457	V*
19	Sahipur Salehapur	22.17	III	0	I	0	I
20	Saleempur Rajputan Rajputan	37.87	III	2	II	13	II
21	Shafipur	17.50	II	4	II	96	IV
22	Sherpur	6.17	II	0	I	0	I
23	Sunhera	27.17	III	9	II	38	III

*@ – Poor Facility * – Good Facility*

PHC = Primary Health Center (Wt. 10.50)
COMM = Community Health Center (Wt. 21.0)
PVT = Private Health Center (Wt. 2.10)
HM_AY = Homeopathic and Ayurvedic Hospital (Wt. 5.25)
VT = Veterinary Hospital (Wt. 5.00)

Roorkee City has a maximum of 635 MFI values, whereas 11 habitations have zero values indicating no medical facilities. Medical facility index has been classified into 4 category i.e. (i) MFI = 0, (ii) MFI between 1 and 10, (iii) MFI between 11 and 25, (iv) MFI > 25. Thirteen habitations have no medical facility and therefore fall under 1st category. Seven habitations fall under 2nd category, two habitation under 3rd category, and Roorkee city under 4th category.

(3) Transport Facility Index (TFI)

The Transport Facility Index is a measure of availability of transport facility in the habitation. For this index also, a program has been written in VB. To find TFI, the length of National Highway (NH), State Highway (SH), District Road, Earthen Road and *Kutcha* Roads and Rail Route have been taken into consideration. These values are shown in Table 5. The habitations having good road network have TFI

The TFI is calculated by given weights to each class of transportation i.e *Pucca* road (PR), *Kutcha* road (KR), Foot path (FP), Railway line (RL) and NH/SH using the following equation.

$$TFI = PRI + KRI + FPI + RLI \quad (5)$$

(4) Communication Facility Index (CFI)

The Communication Facility Index (CFI) is a measure of availability of communication facilities in the habitation. To find CFI, availability of Cyber Café (CC), Post Telegraph (PT), Post Office (PO), STD PCO (STDPCO) have been taken into consideration, and a program is written in VB to determine CFI.

The CFI is calculated using the following equation. In this eqn., Cyber Café is given weight 10.50, Post Office as 5.25, STD PCO as 1.50, and Post telegraph as 21.0.

$$CFI = CCI + PTI + POI + STDPCOI \quad (6)$$

From computation, it is evident that these facilities are poor in all habitations, except Roorkee city. Eleven habitations have no communication facility, and therefore fall under 1st category, Eight habitations fall under 2nd category, two habitations under 3rd category, three habitations under 4th category and Roorkee city under 5th category.

(D) Suggesting the new locations for providing facilities

Various buffer zones are created around each of the existing facilities to locate the zones which are not covered within the buffer. Buffer analysis is one of the important approaches in GIS to locate the critical areas. While creating the distance buffer around a facility, it was assumed that the population within the buffer area will use that facility easily because of the approachable distance. The areas, thus left uncovered by such buffer, are those regions where that particular facility is required to be planned. The facilities are proposed in such a way within the uncovered regions so that the entire region is now covered when a distance buffer is again created. For example, a 2 Km radius buffer zone was created for facilities like Middle Schools, High Schools, Hospitals Private Clinics Primary Health Centre Homeopathic/Ayurvedic Hospitals, and Governments Banks & Cooperative Banks, a 1.5 Km Buffer was created around Post Office, and a 3 Km buffer was created around Degree College and Police Station.

Fig. 4 shows the buffer of 2 km radius around existing Middle School. Out of 23 habitations, Malakpur Latiphpur, Kanhapur, Khanzerpur, Bangerimahabatpur (Must), Padale Guzar, Mohanpur Mohammadpur, Dhandera, villages do not fall under the buffer zone, so Middle School facilities are required for these habitations. If 2 new Middle Schools are planned, one each at Mohanpur Mohammadpur and Khanzerpur and again a buffer zone of 2 km radius created, it is found that most of the area is covered. Similarly, Fig. 5 shows the buffer of 2 km radius around existing High School. If 2 new High Schools are planned, one each at Mohanpur Mohammadpur and Ibrahimpurden and again a buffer zone of 2 km radius created, it is found that most of the area is covered.

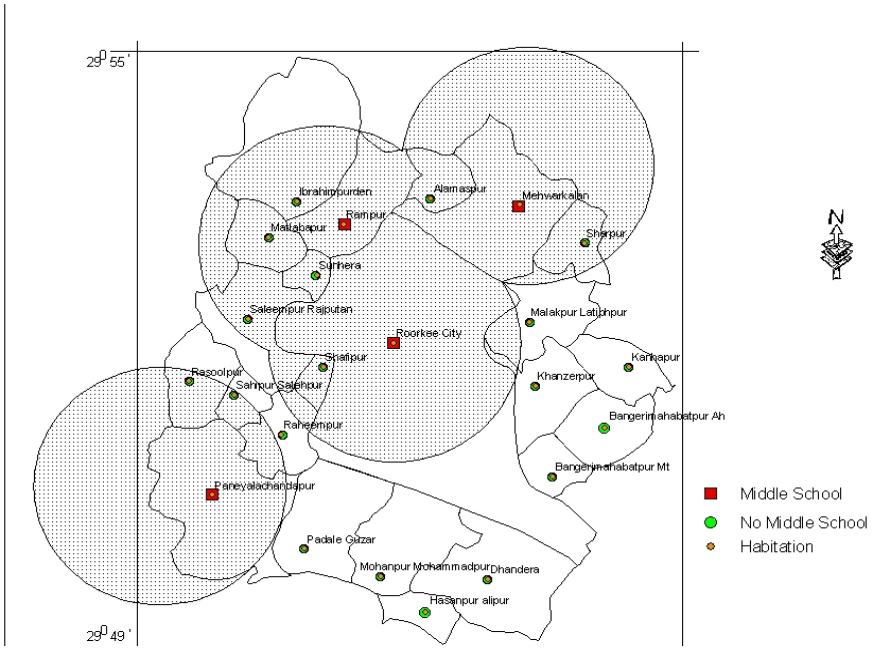


Fig : 4 Buffer of 2 km Radius around Middle School

A summary of all the above facilities required are given in Table 4.

Table 4 : Facility required

Sl. No.	***Habitation***	***Facility Required***
1	Dhandera	Primary Health Centre
2	Ibrahimpurden	Post Office, High School
3	Kanhapur	Primary Health Centre, Cooperative Bank
4	Khanzerpur	Hospitals, Post Office, Middle School, Degree College, Govt Bank, Police Station
5	MehwarKalan	Hospitals, Homeo/Aurvedic, Primary Health Centre
6	Mohanpur-Mohammodpur	Homeo/Aurvedic, Private Clinic, Post Office, Middle School, High School, Degree College, Police Station
7	Padale Guzar	Govt. Bank, Cooperative Bank
8	Saleempur Rajputan	Primary Health Centre

CONCLUSION:

The basic aim of this study was to demonstrate the importance of utilizing GIS in planning infrastructure of an area and helps the administrators and local body in the development of region. The planning in the area needs to be carried out on basis of norms specified by the government. Roorkee city and its surroundings have immense potential for educational facilities developmental activities. For overall development, first it is important to concentrate in providing the basic amenities such as education, health, and drinking water. Hence the GIS approach is proposed here is effective and satisfies the stated objective in the field of education. The buffer analysis along with educational facility index incorporated in maps showing several demographic related data, along with current status of education will help the State Government for better governance. This approach would help in prioritizing and developing a similar database for other facilities, like health, drinking water supply etc. in future. This study can be further extended to provide customized interface to GIS be more user friendly.

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