# GIS and remote sensing based integrated geospatial approach for implementation of Right to Education Act: A case study from Rural India

Sonam AGRAWAL[1], Rajan Dev GUPTA[1]

[1] GIS Cell, Motilal Nehru National Institute of Technology Allahabad, Prayagraj, India-211004
sonam@mnnit.ac.in, rdg@mnnit.ac.in

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**Abstract**

Child education is vital for any nation, as it plays a key role in the development of human resources. In India, the government has made primary education compulsory through the enactment of the Right of Children to Free and Compulsory Education (RTE) Act, aiming to achieve universal primary education across the country. The establishment of a sufficient number of new primary and upper primary schools is a fundamental requirement for the successful implementation of the RTE Act. The present research was undertaken to develop a GIS based integrated geospatial approach for identifying suitable locations for new schools under the RTE Act in Bara tehsil, which includes the Shankargarh and Jasra blocks of Prayagraj district, India. A GPS based field survey was conducted to collect the locations of existing schools. Subsequently, two rule based spatial models were developed and implemented to identify and prioritize suitable sites for the establishment of new primary and upper primary schools, based on RTE criteria. The analysis revealed that 42 new primary schools and 4 new upper primary schools are needed in Bara tehsil. Additionally, a Land Use and Land Cover (LULC) map was generated using Sentinel-2B satellite imagery to support administrators in the final site selection, taking into consideration surrounding LULC classes, terrain conditions and local socio-economic factors. The framework of the developed integrated spatial approach is modular and can be adapted for application in other blocks or districts across India.

## 1. Introduction

After independence, on the recommendation of the Education Commission 1964-66 (popularly known as Kothari Commission), 1st National Policy on Education 1968 was framed. This policy is considered as a major step that recognized the role of primary education in the country. In India, primary education is imparted to the students of 6–11 years for providing the knowledge of reading, writing, mathematics and social studies (Halim et al., 2015). In general, the elementary education includes the children of 6 to 14 years age in the primary (class I-V) and upper primary (class VI-VIII) classes. Several initiatives were then taken by the government for the universalization of education. In the year 1986, National Policy on Education 1986 was designed that emphasized the concept of free and compulsory education for all children below the age of 14 years (Chauhan, 2009). In 1994, District Primary Education Programme (DPEP), an umbrella programme of all the internationally funded projects on primary education, was launched with the external aid of Rs. 370 million in 1993–94 that increased to Rs.12.85 billion by 2002–2003 (Tilak, 2008). It was aimed to improve the education quality along with removal of social and gender gaps in primary education. However, it got limited success in handling the diversity of district as it was controlled centrally (Varughese and Bairagya, 2020).

Then, Government of India (GOI), in 1987, initiated Operation Blackboard (OB) programme for the improvement of school quality by laying the minimum requirements of two classrooms, two teachers and teaching-learning aid that included books, science kit, math kit, maps, charts and blackboard (Dyer, 1996). Although this programme improved the facilities but it was found that in OB there is a misallocation of teachers, wastage of human and financial resources and low quality of Teaching and Learning Activities (TLA) (Chin, 2005; Dyer, 1999). To remove the classroom hunger of the children, improving the enrolment and attendance of the students and increasing the social equality, mid-day meal, another sponsored scheme for primary schools, was launched (Ramachandran, 2019). Through sustained efforts for imparting quality education to all the children in India, in year 2000-2001, another flagship education programme of Sarv Sikha Abhiyaan (SSA) was launched by the Government by merging various educational schemes and programmes running at that time (Sriprakash 2012).

Government of India, for making primary education universal in the country, initiated another major step in the form of Right of Children to Free and Compulsory Education (RTE) Act, 2009 through Indian constitution to ensure the educational rights of a child (RTE, 2009). According to this act, it is the responsibility of the government to secure the admission of a child in school, to make the child to attend the school and to ensure the completion of elementary education of the child. Apart from the requirement of large financial resources, several challenges are being faced in the implementation of the RTE act which include availability of schools, gender disparity (Bhagavatheeswaran et al., 2016), public private partnership (Aggarwal, 2000; Kumari, 2016) and teacher issues (Rajput and Walia, 1998). In the year 2018-19, government has extended the programme to Samagra Shiksha Abhiyan by including SSA, Rashtriya Madhyamik Shiksha Abhiyan (RMSA) and Teacher Education (TE) that involved the students from preschool to class 12 (Ellis 2021).

However, universalization of education, targeted under RTE, is possible only if there are sufficient schools where any child can go for education (Agrawal and Gupta, 2020). The availability of schools is a critical issue in India due to large youth population and needs to be properly managed through modern technological intervention. Although there is constant improvement in the number of children reaching the schools but many times it is found that a child could not enrol in a school because it is located far away from the residence and / or sometimes there is only a single school with a large population that turns up into a situation of limited seats resulting in the denial of the admission for the prospective child. The opening of new schools at proper geographical location is the foremost condition in the successful implementation of RTE so that every child can be educated in India. RTE Act stipulates certain norms, which are defined at the

State level, for the establishment of new schools at appropriate location which include both the population and distance criteria. Thus, there is a need to put a system in place that could identify locations for establishing new schools as per GOI mandated norms through the use of modern technological tools including Geographic Information System (GIS) and remote sensing.

GIS and remote sensing provide reliable information and associated processing tools for micro-level planning for urban and rural set-up. There are diverse areas of education where GIS could be used including selection of a new location of a school which is a multi-criteria decision making problem through the use of spatial regression and other spatial techniques (Yoon et al., 2020; Zhang and Ruther, 2021). A crucial part of child education is the commutation between home to school. GIS can help in deciding the mode of transportation which can be active or passive (Carver et al., 2019). GIS based studies have been conducted to identify which are the related parameters that leads to the selection of the mode of transportation like proximity to road, pathway, traffic signal, topography and other parameters (Mehdizadeh et al., 2017; Villa-González et al., 2018; Wati and Tranter, 2015). The next problem related to transport is route selection. Tools and techniques like Global Positioning System (GPS), geocoding, participatory mapping can be used for this purpose (Dessing et al., 2016; Elford and Adams, 2019; Mohandas et al., 2021). In fact, there is multifaceted use of GIS and remote sensing techniques in school infrastructure establishment. Thus, GIS and remote sensing together can be efficaciously utilised for establishment of new schools in accordance with norms of RTE Act.

In particular reference to Indian scenario, there is a need to develop geospatial model which implements RTE norms by taking care of demographic set-up, socio-economic conditions and prevailing terrain conditions for establishing new primary and upper primary schools. This geospatial model should give the possible locations where there is a need of new schools as per RTE norms. The establishment of new schools is a long term process with limited resources and is generally taken progressively over a period of time because it is not possible to start the construction of schools at all the identified locations in one go. Therefore, planners and decision makers need some scientific and unbiased support that helps them in prioritizing the establishment of new schools in a phased manner. To resolve this issue, the geospatial model should also assign the priority to the identified locations.

Keeping the above in mind, present research is undertaken to develop a GIS and remote sensing based integrated geospatial approach for identification of suitable locations of new schools under RTE Act in Bara tehsil of Prayagraj district of India. This goal is achieved through three main objectives, namely, (1) To carry out GPS based field survey for getting location of existing schools in the study area; (2) To develop and implement rule based spatial model for identification of suitable locations using norms of RTE Act for setting up new primary and upper primary schools; (3) To prepare LULC map of the study area using remote sensing imageries and using the same for prioritisation of identified primary and upper primary school locations.

## 2. Study Area

The Bara tehsil lies in the Prayagraj district of Uttar Pradesh State of India and consists of two blocks, namely, Shankargarh block and Jasra block (Figure1). The study area extends from 25°02'09.6"N to 25°21'21.6"N latitudes and 81°30'43.2"E to 81°50'34.8"E longitudes covering an area of 743.60 sq. km. There are 326 villages in the Bara tehsil in which 212 villages belong to the Shankargarh block while 114 villages to Jasra block. Most of the area of Bara tehsil falls under the rural category and is underdeveloped. About 43% of the population of this tehsil is illiterate in which the share of female illiteracy is quite high as compared to male.

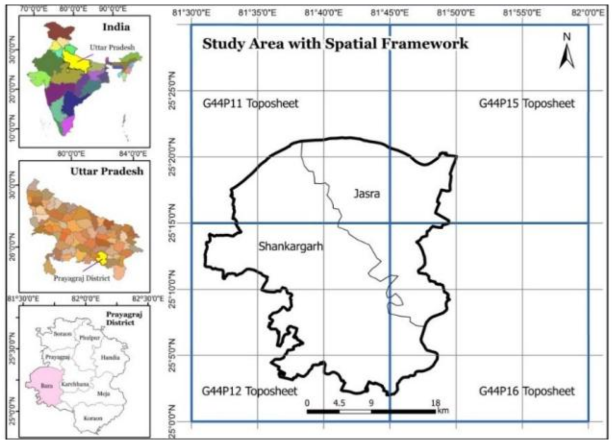


Figure 1. Basemap of Bara tehsil, the study area, with spatial framework

## 3. Data Used

The data used in the present work is compiled in Table 1 which includes data type, source and data capture method. Government of India conducts census survey every ten years which includes data related to demography, education, occupation and basic facilities. Data from last Census 2011 is used for the analysis purpose in this research work. It provides 93 parameters. Out of 93 parameters collected during the Census, 11 parameters that are required for the analysis in this work are used. These include state code, district code, sub district code, village code, total population, number of males and females, number of literate males and females, number of illiterate males and females.

## 4. Methodology Adopted

Figure 2 shows the methodology adopted for finding the new primary and upper primary school location. Accordingly, a rule based spatial model is developed that will provide the new primary and upper primary school locations. The developed spatial model will give all possible locations where there is a need for schools as per RTE norms. This spatial model requires a location map of existing primary and upper primary schools which is generated by carrying out GPS based field survey.

Criteria adopted for the development of the spatial model for identification of new school location is based on RTE guidelines of Uttar Pradesh Government (Uttar Pradesh State Education Department, 2011). There are two criteria, namely, distance and population criteria which need to be satisfied for the creation of new primary and upper primary schools, as notified by State of Uttar Pradesh, India. These RTE criteria are used to develop spatial model in GIS for finding the locations of new schools at primary and upper primary level.

| S. No. | Data | Type | Source | Data Capture Method |
|---|---|---|---|---|
| 1. | Administrative boundary of district, tehsils and blocks | Spatial/ vector polygon | SOI topographic maps | Digitization |
| 2. | Administrative boundary of villages | Spatial/ vector polygon | Village boundary maps from Block Offices | Digitization |
| 3. | Census data | Attribute | Census of India | Electronic data transfer and attribute data table join |
| 4. | School location | Spatial/ vector point | GPS based field survey | Field survey |
| 5. | School attribute data | Attribute | DISE | Electronic data transfer and attribute data table join |

Table 1. Data used

## 5. Creation of Thematic Maps

### 5.1 Creation of Village Boundary Map

Topographical maps of 15' x 15' extent at 1:50,000 scale for Prayagraj district were obtained from SOI. Prayagraj district is covered in 15 maps. Out of these maps, the study area is covered in map number G44P11, G44P12, G44P15 and G44P16. The base map of Bara tehsil consisting of the boundary of Shankargarh and Jasra blocks (as shown in Figure 1) is then created. The maps containing the boundaries of all villages of Shankargarh and Jasra blocks were obtained from the respective Block Development Offices, Prayagraj. These hard copy maps are then geo-referenced using the base map.

The on-screen digitization process is followed for creation of village boundaries of all the villages of the study area. Each village was assigned a unique-id based upon its village location code in accordance with Census 2011 records. The demographic and existing amenities details are then linked with each village using this unique code of each village for further analysis. Quantum GIS software is used for this purpose. Figure 3 is showing village boundary map of the study area. There are 212 villages in Shankargarh block and 114 villages in Jasra block leading to 326 villages in the Bara tehsil.

### 5.2 Creation of Location Map of Existing Schools: GPS based Field Survey

The geographic position of each existing school of Bara tehsil is required for the development of rule based spatial model. The spatial location of the schools was not available, therefore, GPS based field survey was conducted to collect the location of each school. Handheld GPS with 3-5 m accuracy is used. Juno 3B handheld GPS, manufactured by Trimble, is used for this purpose which is a rugged device that provides 3-5 m accuracy. The location of all the 475 schools is then collected, out of which, 204 schools fall in Jasra block while 271 schools in Shankargarh block.

Attribute data for schools is collected from District Information System for Education (DISE), New Delhi, India which is an annual information system of schools. Reaching each and every school was a challenge of GPS based field survey as only school address was given the DISE data, and at times, it took hours to search several schools which were deep inside the village. The school locations collected from hand held GPS was exported to the point shapefile that gives the location of each school in Bara tehsil. Figure4 is showing the location of all schools overlaid on the village boundary.

### 5.3 Creation of LULC Map: Classification of Sentinel-2B Images

After the identification of locations for establishing new schools, it is necessary to identify what LULC is present in those identified locations for facilitating planning process and taking informed decision. This is achieved by the use of LULC map of the study area. For this purpose, the LULC map of Bara tehsil is generated using freely available remote sensing imagery of Sentinel 2B satellite. The satellite images of Sentinel 2B are downloaded from European Space Agency (ESA) website. The study area is covered in two tiles with IDs T44RNN_20190310T050649 & T44RNP_20190310T050649. There are twelve bands in the Sentinel 2B out of which four bands are used in classification, i.e., Blue, Green, Red and Near Infrared bands having 10m resolution.

All the bands of each tile are first stacked together. Both the stacked tiles are then joined through mosaicking. The study area is then clipped from the composite image using Bara tehsil boundary shapefile. Supervised classification using Maximum Likelihood Classifier (MLC) is performed on the image for the generation of the LULC map. Ten LULC classes present in the study are taken, viz. canal, forest, open land, rail, road, sand, scrubland, urban, vegetation and water. Training samples are collected for each class keeping in mind that: (a) an individual sample is homogeneous, (b) sufficient samples are taken for each class to cover intra-class variability, (c) samples are taken in a distributed manner to avoid similarity that occurs due to spatial autocorrelation, and (d) samples do not cover outliers. Gaussian maximum likelihood classifier is then used to carry out the supervised classification. This classifier assigns the class to each pixel based on the variance and covariance matrix. Accuracy assessment is necessary to perform to judge the quality of the classification. The overall accuracy achieved is more than 85%. The classified map in the form of LULC map of Bara tehsil is shown in Figure 5.

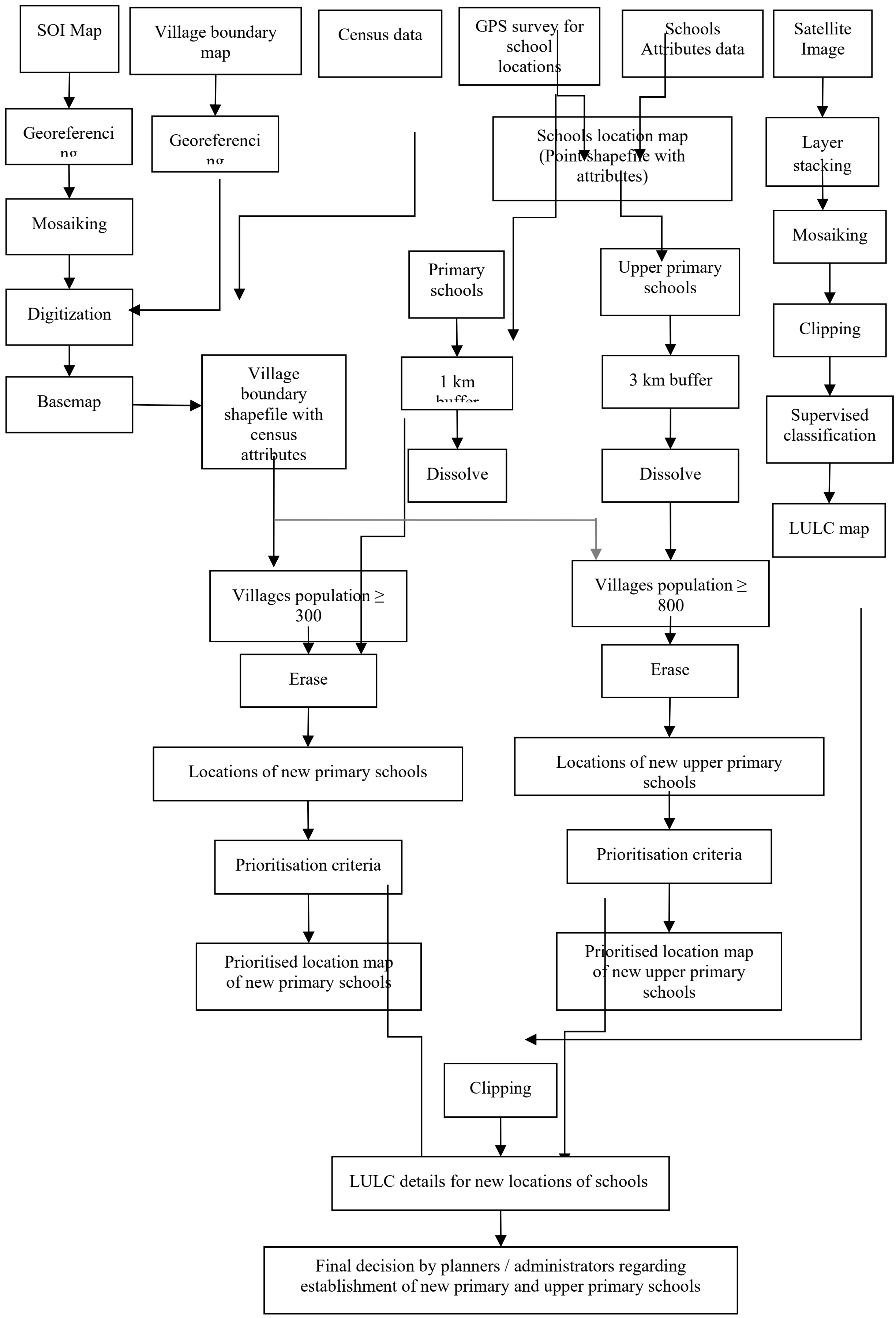


Figure 2. Methodology adopted

This contribution has been peer-reviewed.
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## 6. Development of Rule based Spatial Model

### 6.1 Identification of Suitable Locations of New Primary Schools

The rule based spatial model is developed by implementing two RTE criteria, i.e., distance criteria and population criteria, for primary schools, as per guidelines of Uttar Pradesh State, under GIS environment for finding the suitable locations of new schools on prioritised basis. These RTE criteria for children of primary schools, i.e., classes I - V are given below:

i. Distance Criteria: Establish schools within a walking distance of 1.00 km of the neighbourhood

ii. Population Criteria: School must cover minimum population of 300

Accordingly, based on the analysis carried out using developed spatial model, the area locations where there is a need for new primary school are shown in Figure 6. It is observed that 257 villages out of total 326 villages contain some area where there is a need for a new primary school in Bara tehsil. There are 167 villages in Shankargarh block and 90 villages in Jasra block where there is a need of new primary school. Further, the thematic map showing the villages with no primary schools is created (Figure 7). It is found out that there are 89 villages out of total 326 villages in Bara tehsil where there is no primary school. Out of 89 villages in Bara tehsil, 66 villages fall in Shankargarh block while 23 villages fall in Jasra block where there is no primary school. This information of villages that have no schools is used for refinement of the locations of new primary schools in Bara tehsil already obtained. This resulted in obtaining the refined locations for the establishment of new primary schools in those villages which have no schools. The village wise spatial extent of final locations of new primary schools in the villages is shown in Figure 8. It is found that there are 42 villages out of 326 villages where there is an urgent need of new primary school. Out of 42 villages in Bara tehsil, 25 villages fall in Shankargarh block while 17 villages fall in Jasra block where there is no primary school.

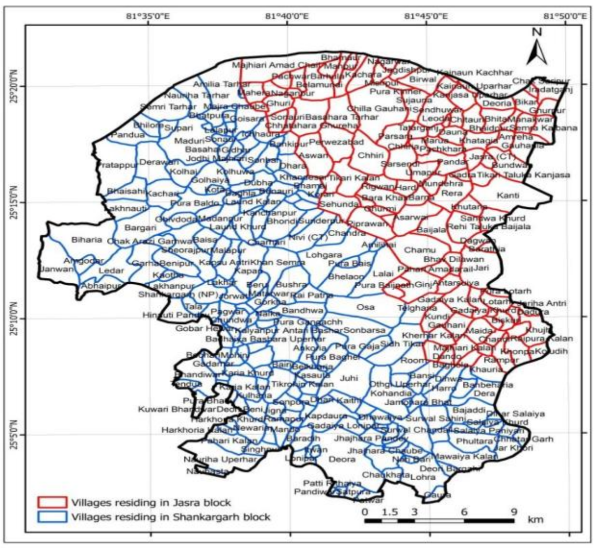


Figure 3. Village boundary map of Bara tehsil

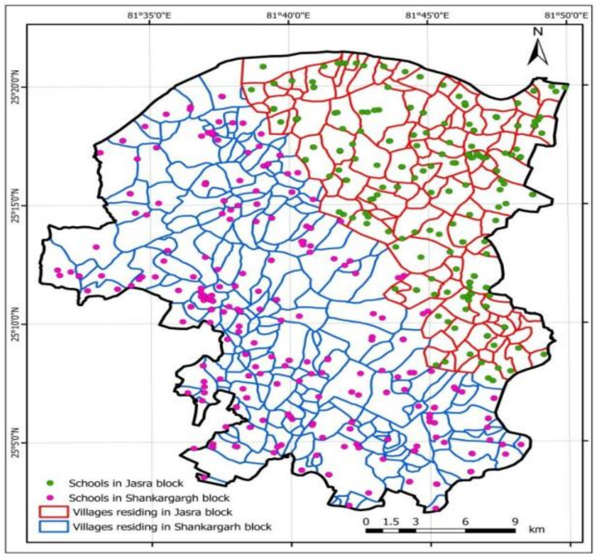


Figure 4. School location map of Bara tehsil created through GPS field survey

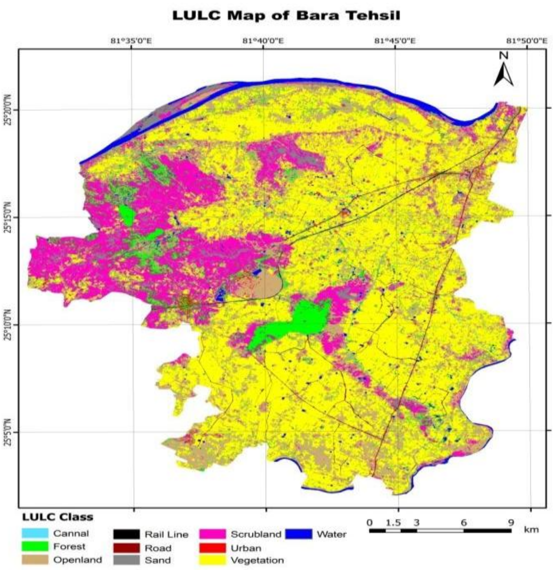


Figure 5. LULC map of Bara tehsil

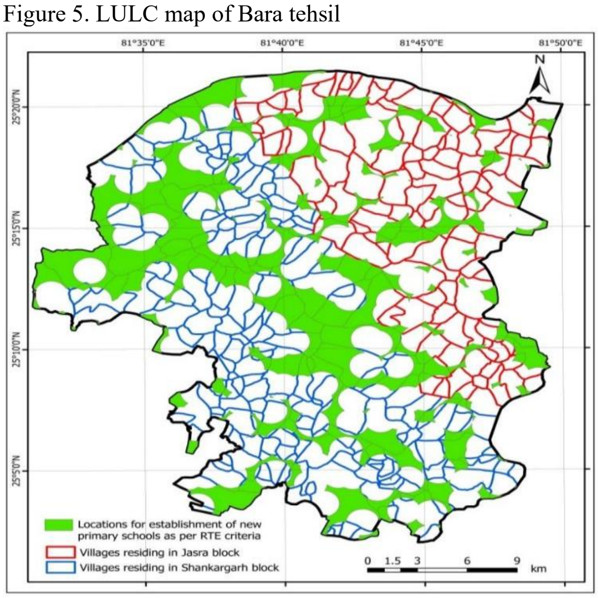


Figure 6. Locations for establishment of new primary schools

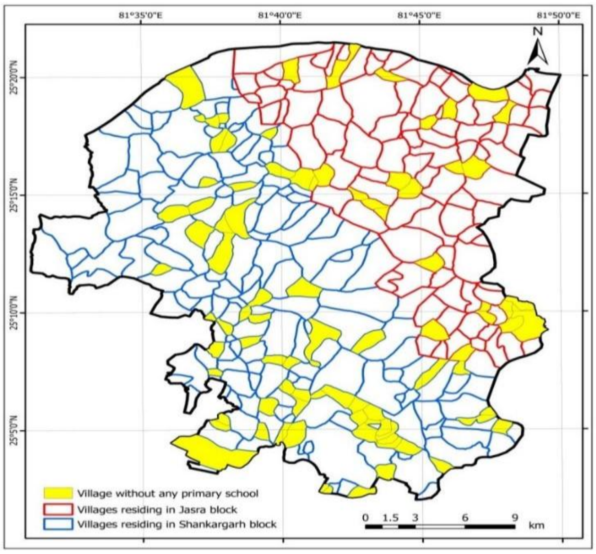


Figure 7. Villages with no primary school

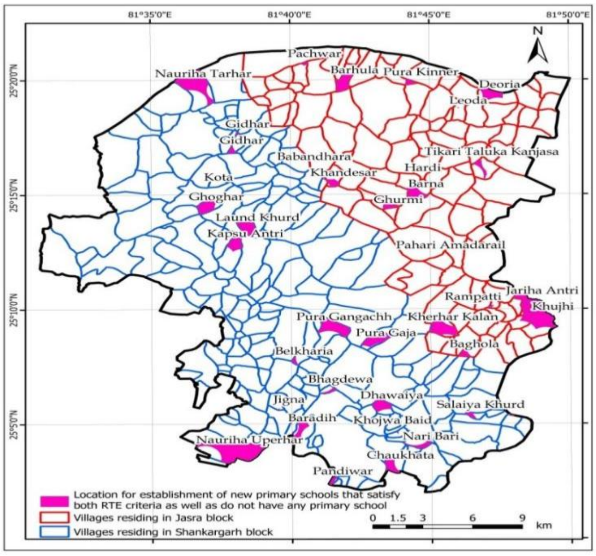


Figure 8. Final locations for new primary schools that satisfy both RTE criteria as well as do not have any primary school

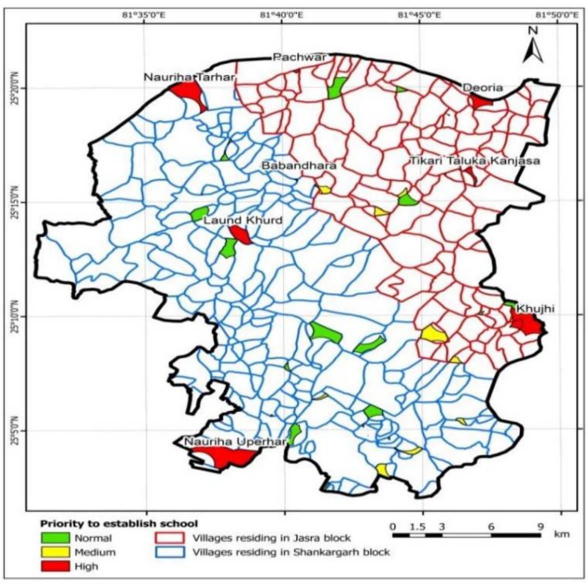


Figure 9. Prioritised locations for new primary schools

Due to limited resources, it may not always be possible to open all the 42 primary schools simultaneously at in all the villages. Therefore, planners and decision makers need to give the priority to these identified 42 locations of new primary schools. Thus, to support the decision makers, there is a need to prioritize the establishment of new primary schools. This is achieved based on the population of each village and using the additional criteria for prioritisation as shown in Table 2. Further, final map showing the prioritised locations for establishment of new primary schools is shown in Figure 9.

| Village Population | Priority | Total new locations in Bara tehsil | New locations in Shankargarh block | New locations in Jasra block |
|---|---|---|---|---|
| > 1000 | High | 09 | 04 | 05 |
| 601 to 1000 | Medium | 13 | 08 | 05 |
| 300 to 600 | Normal | 20 | 13 | 07 |

Table 2. Criteria adopted of prioritisation of establishment of primary schools

Thus, it is found that there are 09 villages that have high priority, 13 villages with medium priority and 20 with low priority in Bara tehsil. Since the population of these high priority 09 villages is more than 1000 coupled with the fact that there is no primary school in these villages, therefore, schools must be established in these villages as per the location shown in the final map (Figure 9) on an urgent basis.

### 6.2 Identification of Suitable Locations of New Upper Primary Schools

A rule based spatial models is developed adopting a similar methodology as that for primary schools, as discussed in section 6.1, for identification of suitable locations for establishment of new upper primary schools but using following RTE criteria in respect of children of upper primary schools, i.e., classes VI - VIII:

i. Distance Criteria: establish schools within a walking distance of 3.00 km of the neighbourhood

ii. Population Criteria: school must cover minimum population of 800

Further, prioritisation of establishment of new upper primary schools is achieved based on the population of each village and using the criteria as shown in Table 3.

| Village Population | Priority | Total new locations in Bara tehsil | New locations in Shankargarh block | New locations in Jasra block |
|---|---|---|---|---|
| > 2000 | High | 01 | 01 | 0 |
| 2000 to 1501 | Medium | 01 | 01 | 0 |
| 1500 to 1000 | Normal | 02 | 02 | 0 |

Table 3. Criteria adopted of prioritisation of establishment of upper primary schools

Further, by adopting a similar methodology as that for primary schools, the final map showing the prioritised locations for establishment of new upper primary schools is generated (Figure 10). It is found that there are 04 villages where there is a need for establishment of new upper primary school in Bara tehsil. All these 04 locations of the villages fall in Shankargarh block.

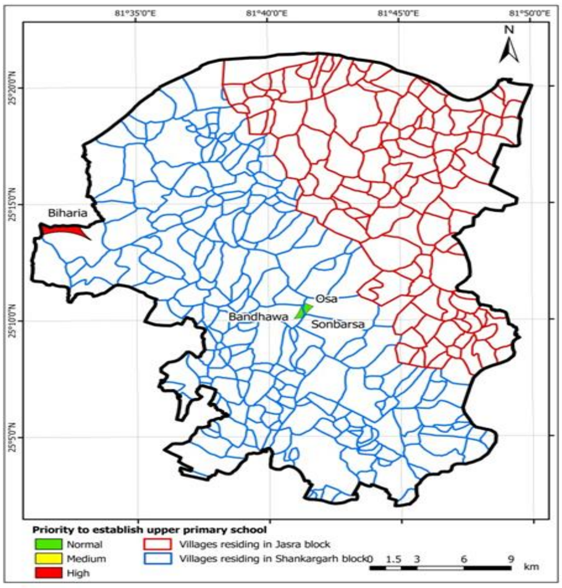


Figure 10. Prioritised locations for establishment of upper primary schools in Bara tehsil

## 7. LULC classes at identified locations of new primary and upper primary schools

Based on the LULC map of Bara tehsil (Figure 5), the types of LULC classes present at the identified locations of new primary and upper primary schools is obtained and further analysed to help the administrators to make an informed decision about the final location of establishment in the respective village. This is achieved by performing clip operation in GIS between the LULC map and map of new school locations (Figure 11). Thus, the area of each LULC class of all the new locations is quantified.

The determination of the exact final position of the new schools also needs a supplemental information which can be determined after doing the field survey of the identified prioritised locations to assess the terrain conditions as well as by taking into consideration the local socio-economic issues. The prevalence of LULC classes is one such parameter and preparation of LULC map and its analysis is carried out to take care of the same. The exact place inside each of the identified villages can be selected based on the major LULC classes present therein. For selecting final location of new school in any village, there is need to avoid land parcels with high percentage of water and large percentage of sand. The areas with high percentage of vegetation and forest need to be preserved and hence should be avoided. On the other hand, the land parcels with high percentage of open land and high urban activities should be preferred. The preference should also be given to areas having good road connectivity.

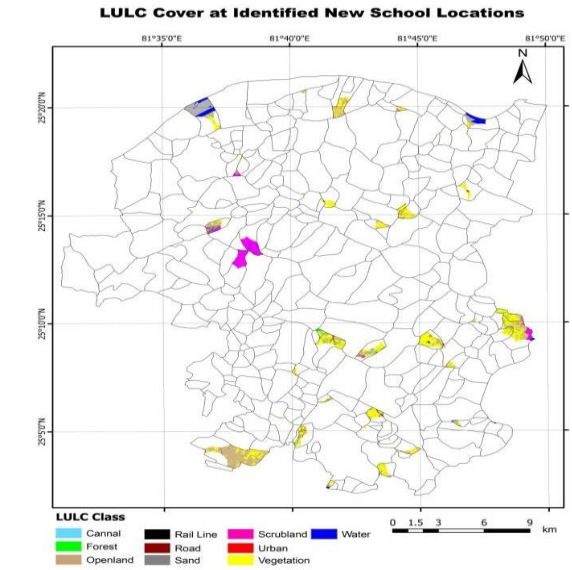


Figure 11. Map showing LULC classes present at the locations identified for the establishment of new primary and upper primary schools in Bara tehsil

In this region, mining and quarrying took place in the past, in particular, in Shankargarh block. Therefore, those locations that have the scrub class should be avoided because of the health hazards. The fine rock and mineral dust at these places may affect the respiratory system of the children or contaminate the drinking water.

Further, for finding the final location for establishment of new primary and upper primary school in a village, detailed village map in the form of Khasra map and Khatauni map must be taken into consideration. If Government land is available, then that land parcel should be preferred because this will avoid the process of land acquisition and compensation to the owner of the land which in general is a lengthy process.

## 8. Conclusions

The enactment and implementation of the Right of Children to Free and Compulsory Education (RTE) Act by the Government of India marks a significant step toward achieving universal primary education across the country. While every child should have access to a nearby school, the availability and establishment of new schools remain a major challenge in India, necessitating modern technological interventions for effective planning and management. The present research, conducted in a rural setting at the village level in Bara tehsil—comprising the Shankargarh and Jasra blocks of Prayagraj district (India)—is an effort to support the implementation of the RTE Act through the integrated use of GIS, remote sensing, and GPS technologies.

Based on the analysis conducted through the development and implementation of two rule-based spatial models, using the stated criteria of the RTE Act for identifying suitable locations for the establishment of new primary and upper primary schools, it is observed that there is a need for 42 primary schools and 4 upper primary schools in Bara tehsil. Furthermore, to assist administrators, the locations of these new schools were prioritized by applying additional population-based criteria, ensuring that available resources in the rural setup are utilized in a phased and efficient manner. It was found that 9 primary schools and 1 upper primary school are needed on a high-priority basis to uplift educational standards in the region.

LULC map of the study area was generated using freely available Sentinel-2B remote sensing satellite imagery (10m resolution) through supervised classification techniques. This enables planners to access detailed information about existing LULC classes in the identified locations, thereby facilitating the planning process and supporting informed decision-making. It is recommended that supplemental information—such as existing LULC classes, terrain conditions, prevailing socio-economic factors and detailed village maps—be considered when finalizing the exact locations in the prioritized villages for the establishment of new primary and upper primary schools. A further micro-level study integrating these parameters would be valuable and is suggested for future research.

This work will assist decision-makers and administrators in making informed and judicious decisions regarding the allocation of funds and other resources for the establishment of new primary and upper primary schools in rural villages, in line with the implementation of the RTE Act in India. The integrated geospatial approach developed and implemented in this study is modular in nature and can be adapted with minor modifications for application in other blocks or districts across the country.

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