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Decentralization of civic amenities using geographic information system – A case study of Sriperumbudur town in Tamil Nadu, India

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Abstract: With the advent of industrialisation and modern amenities, growth of urban areas in India is expanding at a faster rate than the growth of urban infrastructure. The infrastructural facilities available are limited to central area in the town only. GIS aided evaluation helps the decision makers to take action in regulating urban expansion and providing infrastructure in those areas. Accessibility map modelled using RS and GIS gives a fair idea of spatial variation of development within an urban unit. As a case study, Sriperumbudur, a small town near Chennai in India has been chosen as the study area and decentralization of existing facilities has been demonstrated in this paper. The amenities like hospital, nursing home, dispensary, park, police station etc are considered and evaluated. The locations lacking infrastructures and existing centralized facilities requiring relocation are identified for the study area from the analysis.

Keywords: Decentralization, Amenities, GIS, urban

1. Introduction

A country needs efficient transport, sanitation, energy and communication system to prosper and provide a decent standard of living for the citizens. Unfortunately, many developing countries possess insufficient infrastructure and management which hamper their growth. Hence, decentralization comes into account in order to redistribute the facilities.

Decentralization is the process of dispersing functions, powers, people or things away from a central location. Most of the towns in India have rural characters due to lack of infrastructure and excessive population pressure. Urbanization as experienced in Indian context is more of concentration of population than growth of infrastructure in settlement area. GIS aided evaluation helps the decision makers to take action in regulating urban expansion and providing infrastructure in those areas. Accessibility map modeled using remote sensing (RS) and Geographic Information System (GIS) gives a fair idea of spatial variation of development within an urban unit. As a case study, Sriperumbudur, a small town near Chennai in India has been chosen as the study area and decentralization of existing facilities has been demonstrated in this paper. The objectives of this paper are

1. To study the spatial pattern of amenities available in the study area.
2. To evaluate supply and demand status of existing amenities.
3. To identify the zones lacking infrastructure of amenities.
4. To identify suitable site for additional infrastructure development and for the relocation of existing amenities in tune with the distribution of population.

2. Methodology

The methodology adopted for the study is shown in Figure 1. Primary data required for the study are the location of amenities, ward boundary, land use, road network, ward wise population of town panchayat and urban development plan formulation and implementation (UDPFI) standards. Road network and land use are prepared using satellite imagery. Point feature based amenities like schools, hospitals, bus stands, banks, ATM, recreation centers have been mapped using coordinates obtained from GPS of reliable accuracy. With these coordinates spatial database of primary data is created in GIS platform. Such spatial database is analyzed to determine infrastructure development map by performing proximity analysis, weighted overlay (weights are assigned based on questionnaire survey) and map slicing. From the infrastructure development map, level of development is determined.

For decentralization of amenities, supply and demand of amenities in the study area are evaluated using UDPFI standards. In case of lack of supply, additional new sites for infrastructure development are identified. Relocation is suggested for amenities which are excess in supply demand evaluation and are centralized to a particular area. Wherever same types of amenities are available within 2 km radius, those amenities are centralized. The above criteria for the relocation of existing amenities were decided based on public

preference through opinion survey. Finally recommendations are made for optimum utilization of amenities.

3. Study area

Sriperumbudur is a Class IV town located about 45 km, south west of Chennai, Tamil Nadu on the Chennai-Bangalore NH-4. The town area extends over 19.39 km^2 with 15 wards According to the census of India the present population of this town is 29,710 with decadal population growth of about 8.4%. The geographical location of this town is latitude: 12.93^0N to 12.98^0N, longitude: 79.91^0E to 79.97^0E.

4. Data collection

Data required for the study were collected from government offices, Google earth and by field survey. The data collected for this study includes study area boundary, road network, land use/cover details, population data, ward map, location of facilities and (UDPFI) guide lines.

5. Analysis

In Google Earth Pro, facilities were digitized as point features, line features and polygon features for the purpose of analysis. Facilities such as schools, hospitals, police station etc. were considered as point features. Road network was considered as line feature. Ward boundary, land use/cover etc. were considered as polygon features. The locations of above features at site were obtained from google imagery and also using hand held GPS. Demand and supply were computed based on provision of facilities available in the study area and UDPFI standards as shown in Table 1. Evaluated results are shown in Table 2.

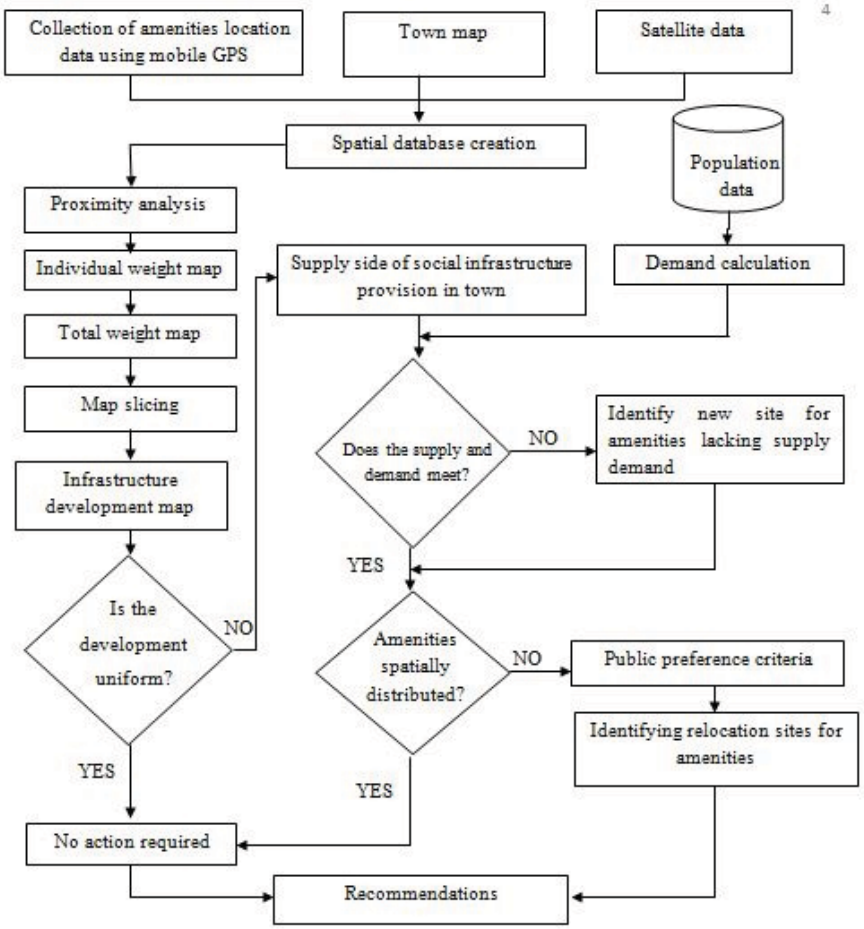

Figure 1: Flow chart showing methodology

The accesses to various urban infrastructures have been analyzed using GIS to evaluate the demand and supply side of urban facility and utility points (Patnaik, 2013). Easiest to graduated difficulty levels of accessibility have been modeled to demarcate zones of different accessibility zones for each infrastructure type.

Accessibility to amenities available is computed by proximity analysis coupled with population density. Except for road network and police station, all other amenities (nursery, primary school, secondary school,

hospital, nursing home, dispensary, community hall, spiritual centre, banks, ATMs and post office) are considered for creating multiple ring buffers at 500 meter interval and the areas served by various amenities were arrived using ArcGIS (Gade et al., 2013; Oh and Jeong 2007; Ahamed et al., 2013). For example, buffers for accessibility to educational amenity are given in Table 3.

Each layer is taken as a theme and every layer has 5 zones except for road which has four zones as shown in Figure 2. The accessibility maps for dispensary, post office and bank are shown in Figure 3, Figure 4 and Figure 5. Road access zones are given rank of 2 to 5 with a unit interval. For other layers viz., educational institutions, financial institutions, health care facilities and other important places, the five zones have been given rank of 1 to 5 (Khadri et al., 2013; Ali, 2013; Mali et al., 2013; Feyissa, 2013). Total score is calculated by summation of weight assigned to a particular layer multiplied with rank with in that particular layer as given below. Total score varies from 8.8 to 44.12 with a mean of 17.65 and standard deviation of 5.7. The classes for development are taken as under developed, least developed, moderately developed and developed categories with a score range of below 14.8, 14.8-20.5, 20.5-26.2, 26.2-31.92 and above 31.9 as shown in Figure 6.

Weightage assigned to various amenity proximity layers in finding the overall development is determined by questionnaire survey conducted with public and local body officials of Sriperumbudur town. In Analytic Hierarchy Process, priority obtained for each layer is checked for consistency ratio (CR). If the consistency ratio is less than 0.1 then the priorities are considered for overlay. CR ratio observed for the present analysis in AHP is 0.025, which is well within the acceptance limit.

Table 1: Urban Development Plan Formulation and Implementation (UDPFI) standards

Type of amenity	Number of people served by one service	Area needed by one service (m^2)
Educational Facilities :		
• Nursery	2,500	800
• Primary	5,000	4000
• Secondary	7,500	16000
Health care Facility :		
• Hospital	1,00,000	3000
• Nursing home	50,000	3000
• Dispensary	15,000	1200
Socio cultural Facility :		
• Park	5,000	8704
• Spiritual centre	1,00,000	5000
• Community hall	15,000	2000
• Police station	40,000	1600

Table 2: Supply demand evaluation of facilities

Type of amenity	No. of people requiring amenity (demand)	No. of people recommended by UDPFI for one service	No. of services required as per UDPFI norms	No. of existing services	No. of people served by existing amenities (supply)	No. of additional services required	Supply demand difference (supply - demand)	Remark
Educational Facilities :	24,863							
• Nursery		2,500	10	4	10,000	6	-14,863	Deficient
• Primary		5,000	5	6	30,000	Nil	+5137	Excess
• Secondary		7,500	4	5	37,500	Nil	+12637	Excess
Health care Facility :								
• Hospital		1,00,000	1	7	7,00,000	Nil	+6,75,137	Excess
• Nursing home		50,000	1	3	1,50,000	Nil	+1,25,137	Excess
• Dispensary		15,000	2	10	1,50,000	Nil	+1,25,137	Excess
Socio cultural Facility :								
• Park		5,000	5	3	15,000	2	-9,863	Deficient
• Spiritual centre		1,00,000	1	4	4,00,000	Nil	+3,75,137	Excess
• Community hall		15,000	2	6	90,000	Nil	+65,137	Excess
• Police station		40,000	1	1	40,000	Nil	+15,137	Excess

Table 3: Accessibility of educational amenity

Distance from amenity (in meter)	Access type	Weight	Area (in km^2) served by the amenity		
			Nursery	Primary school	Secondary school
< 500	Nearest	5	1.928	3.458	2.586
500 – 1000	Near	4	3.381	4.406	4.484
1000 – 1500	Far	3	4.231	4.031	4.417
1500 – 2000	Far away	2	3.229	2.894	3.411
>2000	Farthest	1	5.567	3.545	3.436
Total area of town			18.337	18.337	18.337

Total score = (A*(Rank layer 1)) + (B*(Rank layer 2)) + (C*(Rank layer 3)) + …
where,

A, B, C are weights assigned to individual layers considered in analysis; and
Rank layer refers to the rank assigned to different levels within a layer (In this paper, different levels of accessibility are assigned values from 1 to 5).

Analysis shows that from the present location of financial institutions, 78% of total population is benefited and as far as the community hall is concerned, 88% of total population is benefited. It is found that nursery school and park lack supply while primary school, dispensary and police station are sufficient but in centralized condition.

To find out the suitable sites for nursery schools, layers such as accessibility, land use, park existence and population density (0-4 age group) were considered. All the layers were given weightage as shown in Table 4 and overlaid using weighted overlay tool in ArcGIS. Then candidate score was calculated using rank and weightage assigned. Using standard deviation, suitable sites were created and divided into different classes as very high, high, medium, less and very less suitable. Then the polygons below 800m^2 (based on UDPFI standards) area were removed and other polygons are recommended as new nursery school site locations as shown in Figure 7.

Table 4: Pairwise comparison matrix for assigning weights to nursery school

	AHP priorities			
Land use	Land use	Proximity nursery	0 to 4 age	Park existence
Proximity nursery	1	0.33	0.5	1
0 to 4 age	3	1	1	2
Park existence	2	1	1	2
Weightage	1	0.5	0.5	1

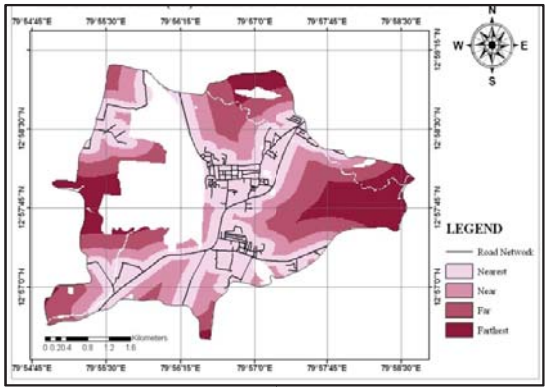

Figure 2: Road accessibility map for Sriperumbudur town

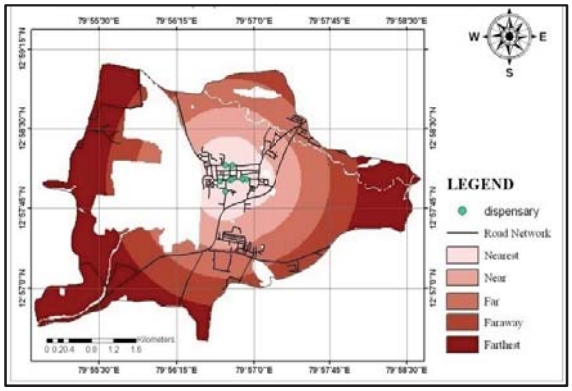

Figure 3: Dispensary accessibility map of Sriperumbudur town

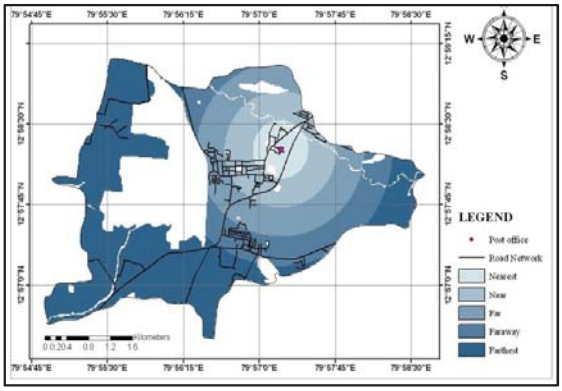

Figure 4: Post office accessibility map of Sriperumbudur town

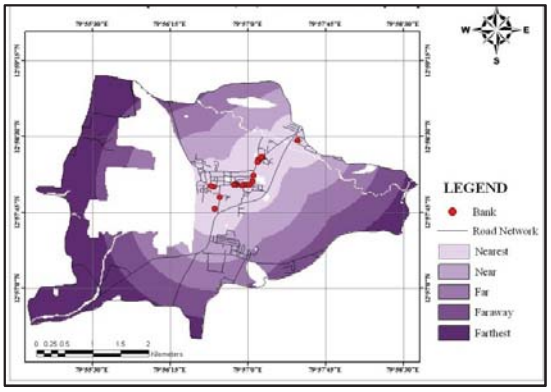

Figure 5: Bank accessibility map of Sriperumbudur town

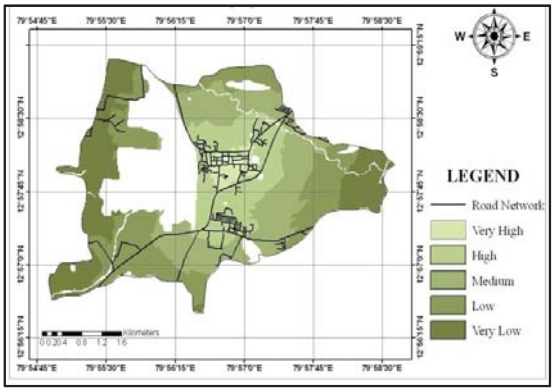

Figure 6: Overall development map of Sriperumbudur town

Since dispensary count in Sriperumbudur town is excess, suitable sites were identified only for its relocation. For this analysis dispensary accessibility map, land use map and population density map of different age groups were used. Accordingly for all the layers weightages were assigned and overlaid using weighted overlay tool. Then using rank, candidate score was calculated and standard deviation was used to classify the suitable sites into different classes. From the differentiated classes suitable site is identified as shown in Figure 8.

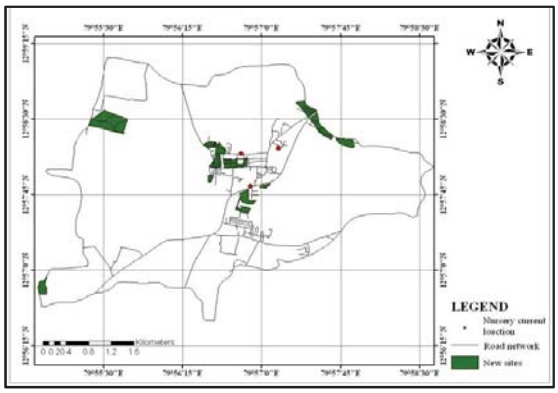

Figure 7: New sites for nursery in Sriperumbudur town

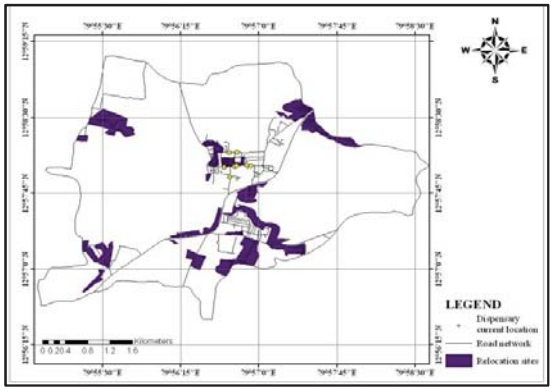

Figure 8: Relocation sites for dispensaries in Sriperumbudur town

6. Conclusions

From the analysis, it is found that

- Most of the amenities in Sriperumbudur town are concentrated in the developed central part spread over 18.7 percent of the total town area.
- Amenities like primary schools, secondary schools, dispensary etc. centralized in one region are to be relocated to get a uniform development in Sriperumbudur town.
- This study also provides potential locations for the establishment of new service centres for reducing the stress on the particular service centre place.
- A planned decentralisation of public amenities in future, especially while approving the establishment of such

amenities, will help in a rational and uniform development of the town.

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