Application of GIS in urban development plan, West Bengal, India

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Abstract
The last two decades have witnessed high population growth in India’s urban areas. Urban centres are the hub of the manufacturing, services and trade. As a result, more people are migrating from rural areas to urban centres, making municipal governance a very complex issue. The complexity is more pronounced in states like West Bengal which has on of the highest population densities. One of its towns, Kalyani is a planned industrial town but with large unplanned settlements in form of slums. It has a university and number of colleges. It is part of the Kolkata Metropolitan Development Authority and is surrounded by villages. It is situated on the bank of river Ganges on its natural levee. With such uniqueness, the preparation of GIS-based decision support system for the municipality is a very challenging task.

Providing municipal services to the growing population is becoming increasingly difficult. Moreover, the economically marginal people residing in urban slums need support not only on services but also on crucial livelihood issues. Proper GIS database provides crucial planning input for infrastructure planning, land use planning, environmental planning, slum development planning, local economic development, livelihood support and planning related to health and education.

GIS database provides invaluable inputs not only for planning of infrastructure like road, sewerage and drinking water, but also helps manage important services to various stakeholders. All the above planning components are interlinked with each other. Moreover, the whole municipal planning is related with the regional planning and the planning of neighboring municipalities. It is possible to integrate slum development plan with infrastructure development as well as the local economic development plan. In a democratic setup, this GIS framework simultaneously provides transparency to the elected representatives who run the municipalities and to the stakeholders.

Introduction
In the beginning of this millennium, the world has witnessed an unprecedented shift of human settlements to the cities; over 50 percent of the world population is now living in cities. While India’s population remains substantially rural, it is emerging as one of the fastest urbanising countries in the world with a staggering large urban population of around 285 million. It is estimated that by the middle of this century or probably earlier, India would reach the same milestone that the world reached now - of becoming more urban than rural. It is also true that this rapid urbanisation has overwhelmingly been on account of urbanisation of poverty. Large scale migration of rural poor to select urban locations in search of employment and livelihood is common. While India has made a significant stride in containing rural poverty but handling urban poverty is entirely a different issue altogether.

Cities are emerging as the engines of the Indian economy the rural agriculture based economy is changing fast. At this time, the nation started investing in the destined social and economic functions of cities and ensures that cities deliver a quality of life that would enable them to become national assets and engines of economic growth. Jawaharlal Nehru National Urban Renewal Mission programme of Government of India (GOI) is a programme in that direction. The migrants are vital contributors to the urban economy without whom many of the support systems as well as economic activities in city life would collapse. But the influx has fuelled the growth of unplanned expansion of the cities in the form of slums. These unplanned slums have very little civic amenities with very poor to non-existent infrastructure. In this process, the poor seem to have exchanged rural unemployment for demeaning urban survival. This trend is common across the entire developing world. It is clear that if urban governance fails to deal poverty constructively, poverty would seriously affect the cities economy and social life.

Urban local bodies [ULBs] in India which are statutorily responsible for provision and maintenance of infrastructure and
services in cities and towns are under fiscal stress. Many of these ULBs are becoming increasingly dependent on the state and central governments for their operation and maintenance requirements. Besides the limitations of small resource base, poor planning process, lack of poor resource generating abilities, poor information system and records management are some of the basic weaknesses in the present municipal administration. For better management of ULBs, GOI has taken several steps. One such policy level step is the 74th Constitutional Amendment Act. It is an initiative to decentralise power and strengthen democracy at local level and empower the urban local bodies with political, functional and fiscal autonomy for good governance.

GIS and draft development plan in West Bengal

The State of West Bengal is one of the highly urbanised states of India with 27.5 percent of total population residing in different cities and towns as per Census 2001. The rate of growth of urban population has been 20.2 percent from 1991 to 2001. Unfortunately, GIS though being a very important tool for urban planning, is not explored fully for these complex planning issues in different ULBs in West Bengal.

The state of West Bengal enacted Municipal Act 1993 which requires municipalities and municipal corporations in state to prepare draft development plan (DDP) covering a period of five years and addressing a range of municipal functions as laid down in the act. To implement that, a detailed guideline was prepared to provide guidance to the municipalities in preparing their perspective DDPs. This was initiated under DFID project named Kolkata Urban Services for the Poor (KUSP) for 2007 to 2010 period.

The main areas of planning in this five year development plans are;

Part 1: Infrastructure land use and environmental development,

Part 2: Social and livelihood development,

Part 3: Municipal institutional strengthening.

In DDP the information-based planning brought a new concept in the urban development of West Bengal. Creation of the municipal data bank gives updated spatial information of all the wards along with the infrastructural details (roads, pipelines, drainage, stand point, lamp post etc.). All important places and public utilities along with information on non spatial attributes like the house owner’s name house takes, rental status, family numbers, health education, infrastructural availability, structural status of the building, land use etc. were collected through various surveys of the DDP.

Although the application of GIS in urban planning is well recognised since long, but application of GIS in DDP is very limited. Attempts are made for physical planning of DDP of the city incorporating various physical infrastructures like road, sewerage line, water line, electricity and land use zoning etc. This could have been the most important decision support system to the ULBs. Even in DDP documents the use of GIS has been mentioned with utmost importance but not as a DSS tool.

Development of GIS database in the context of DDP is different than creation of GIS for mere city planning or management of services /facilities. In case of Kalyani Municipality it can be noticed that various GIS elements, which goes beyond only physical planning and management, should also capture the people’s aspirations. The municipality is having different responsibilities toward different stakeholders and it must be reflected in the GIS. Therefore it is necessary to integrate the individual ward planning with the total municipality planning seamlessly which can be accessed by all the related people effortlessly.

After detailed study of various DDP components and subcomponent it has been found that the GIS database with municipal MIS is very useful for first two parts of DDP in Part 3 it has limited role as Part 3 primarily deals with development of municipal organisation. In Part 1, infrastructure land use and environmental development- plays a very crucial role with all spatial data of infrastructure at various levels. This also helps various departments associated with infrastructure development of municipalities with necessary maps.

In Part 2, use of GIS is more as a decision support system for targeting various programmes for the socio-economic development of the citizens particularly economically marginalised citizens living in slum areas.

In Part 3, GIS role is limited but in case of revenue generation under this component GIS can be a very helpful tool. Importantly the GIS mapping used for the DDP did not felt the necessity of adopting the MIS (Management Information System) for giving the entire process a sense of totality. The present system of adopting certain schemes in any sectors of the society, (it could be water supply, education, self employment, sewerage & drainage, health, roads, recreation) either for development or maintenance, is often neither fully transparent nor contains any details regarding the beneficiaries. The primary information of all the holdings including tax, house structure, land use, availability of urban facilities and all infrastructure details were put into digital format mainly in spatial form but non spatial attribute data would have made this effort more meaningful.

GIS in Kalyani Municipality:

http://geospatialworld.net/Paper/Application/ArticleView.aspx?aid=1420
Kalyani Municipality is the northern most ULB of Kolkata Metropolitan Area (KMA). Within eastern India Kolkata is the largest city and it is one of the India’s three mega cities. Considering the urban outgrowth around Kolkata Municipal Corporation (KMC) and its importance Govt. formed KMA, comprising of KMC and 40 other contiguous municipalities for better planning purpose and Kalyani municipality is one such ULB.

Kalyani with around 22 sq. km. area is on the eastern bank of River Hoogli like Kolkata. It is situated on the natural levee of river Ganges. In its south and east, two other municipalities of KMA, are there whereas in north few villages are present. Kalyani, is a planned industrial town but with large unplanned settlement in the form of colony. It has a university, and number of govt. and private colleges. A number of industries are present in Kalyani industrial area. It has around 82,000 populations (in 2001 census) with over 18,500 household. Kalyani has 16 slum pockets with over 39,500 people residing in these slum areas, which is over 48 percent of the total population. Kalyani is having one of the highest percentages of slum population in KMA area.

From the landuse map of Kalyani, Fig-1, the planned part of the city with regular road and urban zoning mostly present in ward nos. 4,5,6,7,8,10,11,12,13,16,17 and 18, can be easily identified. Ward Nos. 5,6 is the Industrial area 4 is having university. Incidentally in last forty years the migration of people from rural areas occupied the open unused areas of ward nos.1,2,3,14,15 and other words open areas along railway line of the municipality. These areas were later declared as slum and as a result nearly 48 percent of the existing population is residing in places which were not planned for but need immediate attention.

1) In the DDP for infrastructure planning like road, sewerage, drinking water pipeline and various services facilities GIS based maps are recommended. But application potential of GIS in decision making process for selecting the location of facilities like education and health centers particularly for underprivileged is not explored in this case. Whereas due to socio-political reason and transparency use of GIS plays a very important role in such decision making process. The location of such services is to be selected in such a place so that it is the best possible location in terms of majority of the stakeholders.

In Kalyani the slums present mainly in ten wards namely, word nos. 1,2,3,4,5,6,9,10,14,16,18 and 19 with varying numbers of slum population numbers Fig-2. The populations are spread unevenly across the municipality. As a result the selection of locations of such facilities is becoming more challenging in slum areas. Based on the available data such exercise was run in GIS database for exploring its efficacy in tackling such problem.
For selection of 10 such Govt. approved service centers it is important to find suitable locations considering the slum dwellers population. It must be optimum with respect to the slum households. First we mapped the available land for the facility and then we run the algorithms of centre of gravity on the slum household represented as nodes. In this algorithm for a given set of nodes, called clients, finds the “central” node that minimises the path length to travel from the center to each of the clients and then return to the center or vice versa. In this case a health, centre should be located where slum dwellers can reach everyday with an optimum travel distance. However, the general idea of minimising distance can be applied to many network problems. In the spatial analysis it is to specify the number of different service centers that are to be found so that the operators will find a dispersed pattern of the given number of service centers, placing each to optimise the access to service facilities. The optimum number of service centers in this case is 10. Fig–3 shows the location of these 10 centers in different slum areas. These locations are best suited locations considering the overall coverage of the slum dwellers in total Kalyani Municipality.

Though the location selected using algorithm of ‘Center of Gravity’ may be ideal but land may not be available at the selected location. Selection of the best location from a number of available plots for such facilities is a challenging task. For the slum dwellers Ward nos. 1,2,3,4,5 and 14 few lands are available for the facility to set up the service center (Fig-4). By overlaying the available land against the best locations, the decision makers can take decision with the help of stakeholders’ participation. This activity would have helped the planners as well as the stakeholders to actively engage into a meaningful discussion for the finalization of the locations transparently without any bias. Such exercises make participatory planning very powerful democratic means to resolve various contentious issues.

Further household health data related to various diseases in the GIS database helps the municipality to take targeted preventive actions much faster and meaningfully which is missing in the planning process.
2) Another very important area is disaster management where the DDP planning process till now failed to utilise GIS although in DDP programme the planning related to Disaster management is clearly specified. Kalyani is situated in the delta region of the Ganges, in the natural levee area surrounded by the remnants of an ox-bow lake. During monsoon with high level of water flow, flood is a common phenomenon in certain parts of Kalyani. In the planning process the digital elevation model of the terrain of the municipal area could have provided a very useful flood disaster management model of the area.

We found that heights of certain areas within the municipality are higher, particularly the planned areas whereas the many slum areas later situated in low land areas of the municipality. In fig-5, this has been shown on a SRTM data. The average height is around 11 to 12 mt from MSL whereas Ganges is flowing in its west around 5 Mt of MSL. It also shows that south-eastern side (towards Ganges) is relatively lower compare to the western side and the levee part in the central planned part and the north western Industrial area. The highest elevation is approximately above 15 mt. MSL is near the city centre. There are height variations in between, particularly around the rail line areas (Fig-5).

Using the terrain model and by increasing the water level to higher levels through simulation the flood prone areas and/or wards could be identified (fig.-6). It has been observed during simulation exercise that the scenario of the area changes a little from the 10 mt water level to 11 mt. Only a little extra part of ward no. 8, 13, 17 & 18 will be affected, where ward no. 9, 10, 16 and 19 will be affected mostly with this 1 mt change in the water level. From Fig.6 it is evident which wards/areas are vulnerable to what extent.
Based on the vulnerability, various wards are identified as high, medium and low vulnerable wards with respect to the most common natural hazard like flood, along with the number of ward population (table-1). Such GIS based simulation exercise as part of the DDP would have helped the stakeholders as well as Municipal Authorities to take disaster management actions more meaningfully.

**Conclusion:**
The application of GIS in integrated urban development plan for Kalyani municipality has been studied with the specific case of identifying flood prone areas and finding optimum locations for service centers. The applicability is multifarious and provides a very scientific and meaningful platform for participatory planning process. The usefulness for slum development in urban areas and in disaster management the use of GIS in the planning process in West Bengal, India needs more thrust and emphasis.
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Table-1

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