URBAN LAND USE PLANNING USING DIGITAL CARTOGRAPHIC MODELLING

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ABSTRACT:

The growing urbanization in developing economies, especially in India, have the potential to change existing land use patterns with the urban fabric as well consume vast open lands surrounding the existing urban islands. Planning practice in India is directed by regulations and norms established at the national and state level. Within this directive is the creation of master plans for town development, the creation of which is closely directed by the collaboration of the governmental planner and the consultant planner. This paper examines how using cartographic modelling, the ability to make representative geospatial representations or maps that help with modelling and studying complex geo-spatial inter-relationships we can create a more responsive urban growth strategy. Learning from existing development characteristics, the behavioral landscape can be modelled to reflect the impact of introducing major urban infrastructure such as transport connectivity. Further, the cartographic models can well integrate the most environmentally suitable patterns for development balancing between agricultural productivity and urban economic growth. Such analytical practices offer the potential for a more environment friendly and responsive paradigm for Urban Planning, not only in India, but in other regional developing economies.

Keywords: Urban Planning, Land Use, Cartographic Modelling, and GIS

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1. Introduction:

Urbanization is an index of transformation from traditional rural economies to modern industrial one (Davis, 1965). More than half of the world's population is now urbanized but India is still largely a rural country, 65-70% of the population still lives in villages (WWF, Report, 2010). Indeed, it has been a very reluctant urbanizer compared to other Asian countries. However, as economic development shifts increasing numbers away from subsistence agriculture, the country is about to embark on a period of rapid urbanization (Sanjeev, 2008). It is estimated that urban areas generate over 60% of the country's GDP and account for 90% of the government's tax revenues. Urban India today is "distributed" in shape-with a diverse range of large and small cities spread widely around the nation. India will probably continue on a path of distributed model of urbanization because this suits its federal structure and helps to ensure that migration flows aren't unbalanced toward any particular city or cities (Wood, 1958). In India the urban situation had become serious because of the large increase in population since 1921. While the percentage increase for the nation as a whole was 11%, 14%, 3% and 13.4% respectively, for the decennial periods 1921-1951, the urban areas increased by 21%, 32% and 54% respectively, during the same periods (Sahay et al., 2008). The urban drift is continuing unabated.

2. Land Use Planning:

Land-use planning is an overall or special arrangement on land-use in a certain range of time and space, according to land resources, land suitability and demands of economic and social development (Zheng Weiyuan, 2000). It is a public policy exercise that designates and regulates the use of land in order to improve a community's physical, economic, and social efficiency and well-being (World Bank, 2010). By considering socioeconomic trends as well as physical and geographical features such as topography and ecology, planning helps identify the preferred land uses that will support local development goals. The final outcome is allocation and zoning of land for specific uses, regulation of the intensity of use, and formulation of legal and administrative instruments that support the plan. Land use planning is done to identify alternatives for land use and to select and adopt the best land use options (FAO, 1991). The main objective of land use planning is to allocate land uses to meet the economic and social needs of people while safeguarding future resources. Urban Planning can be defined as the design and

regulation of the uses of space that focus on the physical form, economic functions, and social impacts of the urban environment and on the location of different activities within it (Susan, 2011).

Ever since independence, India's planners and policy makers have shown concern for efficient use of land, water and other natural resources for accelerated as well as sustainable economic development (Haque, 1997). The questions of efficiency, equity and environment protection have been flagged in almost all Five Year Plans. It is also being felt in India particularly in the wake of economic liberalization that market alone should determine the land use patterns, even though in reality the relevance of land use planning for efficiency, equity and sustainability remains intact. The problem arises because market driven, albeit unplanned diversification as well as urbanization often results in non-sustainable patterns of development. A market driven land use pattern may yield higher returns in the short run, but may pose several unmanageable problems for future generations due to unplanned overexploitation of land, water and other natural resources. Hence, arises the need for appropriate land use planning. There is no denying the fact that under free market forces, it is the relative profitability of various enterprises and their suitability from the points of view of agro-climatic characteristics which largely determine the land use patterns. But, while market forces should be allowed to operate, the management of land, water and other natural resources and also our orientation of technological and institutional changes should be such as to meet both present and future needs. In other words, the development process should be sustainable both in the short run and long run, based on conservation, of land, water, plant and animal genetic resources. Besides, such sustainable development would be environmentally non-degrading, technically appropriate, economically viable and socially acceptable (FAO Report, 2003).

Planning practice in India is directed by regulations and norms established at the national and state level. Within this directive is the creation of master plans for town development, the creation of which is closely directed by the collaboration of the governmental planner and the consultant planner. Conceived as a grand intent for a comprehensive approach to urban planning, in the absence of a well-developed geospatial database and associated tools and techniques to intellectually use the data, the normative approach devolves down to an individualized development of a specific master plan (Soussan, et al., 1999).

3. Cartographic Modelling:

Maps are the essential tools for geographical information visualization. Geographical information could be efficiently transmitted to users who are capable of capturing the knowledge on location, shape, quantities and qualities traits and the change information with maps helping (Yang et al., 2008). With the rapid advancements taking place in the space technology, computer hardware and GIS software, more interactive land use models are being developed. The input data for the models ranges from high spatial and temporal resolution satellite images to cadastral maps and secondary source information.

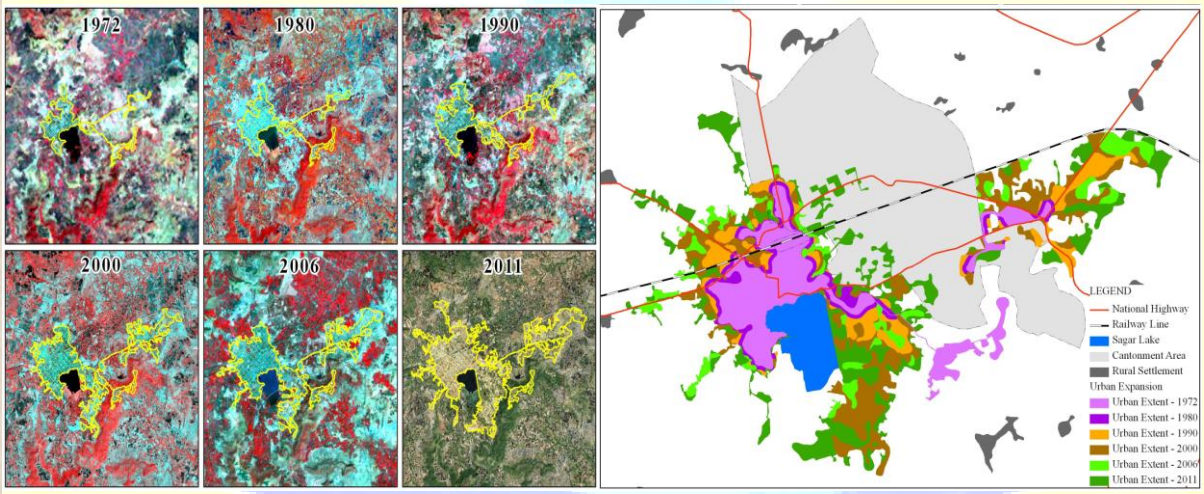

Figure 1: Example of Cartographic Model to Calculate the Urban Change of a Small Town

The use of cartographic modelling in urban land use planning is very effective. Cartographic modelling offers a rigorous procedure for integrating map layers and designing analysis schema for spatial data (Tomlin, 1991). It is a generic way of expressing and organizing the methods by which spatial variables, and spatial operations, are selected and used to develop an analytical solution with a GIS. Cartographic modelling is based on the concept of data layers, operations, and procedures. The purpose of the method is to create new map layers using existing map layers and operations that are sequenced in procedures. An example application of a cartographic model to calculate the percentage change in value between two dates is shown in Fig 1. Cartographic modeling applies map algebra tools together with other basic analysis operations in GIS. A cartographical model is a graphic representation (Berry, 2004).

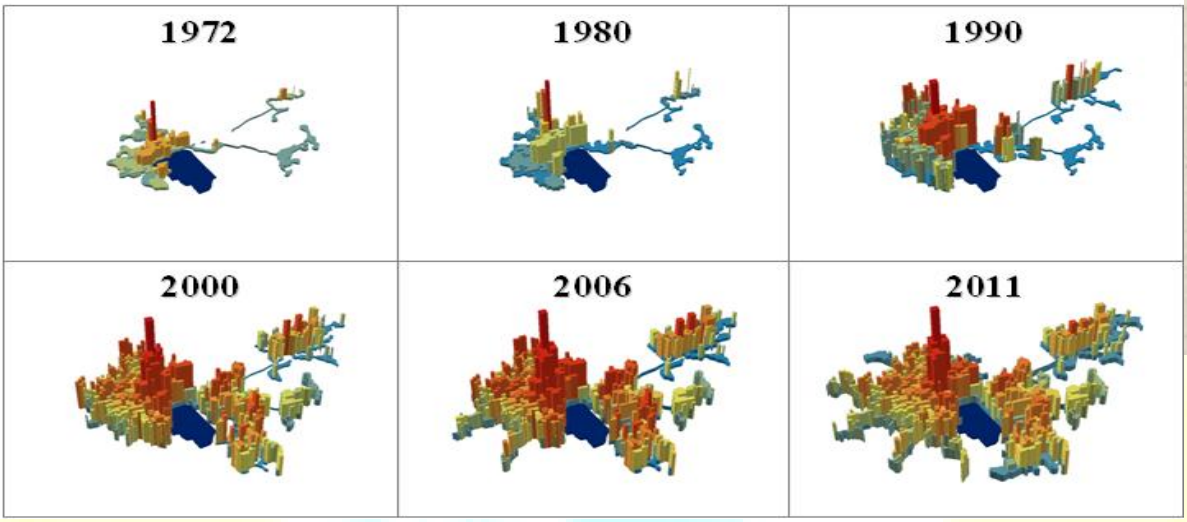

Figure 2: Representation of 3D Cartographic Model of Sagar Town

Cartographic model diagrams should adhere to some conventions in terms of symbology as a common set of symbols and a standard style of presentation make it quicker to build a model and easier for others to comprehend the model. Spatial data layers are extensively used in the cartographic modelling. Cartographic modelling conventions follow the representation of each data file type by a unique shape. These symbols are used connected with arrows to represent the flow in a model (Fig.2). While using the language for modelling some verbs of spatial operations area (Table 1) also being used though this may vary as per the users.

Table 1: Examples of Natural Language Verbs

Operation	**Verb**	**Description**
Make a corridor from a linear data set	SPREAD	Renumber all loci with a value reflecting their distance from a given starting point or line
Intersect two polygon networks	OVERLAY	Lay two polygon networks over each other and produce new polygon set
Select according to a condition	EXTRACT	Select specified values and / or ranges of values from one layer to make a new layer

4. A Conceptual Framework of Urban Land Use Planning using Digital Cartographic Modelling:

In this conceptual framework, transportation network, environmental consideration, existing & proposed infrastructure and geographical & demographic parameters like slope, soil type, drainage pattern, geomorphology, elevation and population are the major factors contributing towards urban land use planning (Daniel, 1992).

Cartographic models of transportation network uses growth factors based on the recent trends. It is useful for comparing the impacts of various growth assumptions and for evaluating alternative transportation improvement programs (Todd Litman, 2011). It is imperative to develop relationships between travel demand and socioeconomic characteristics and land uses. Land use and transportation are linked by complex, yet identifiable, relationships. Tools are needed to formalize this relationship and to take it into account when decisions are made.

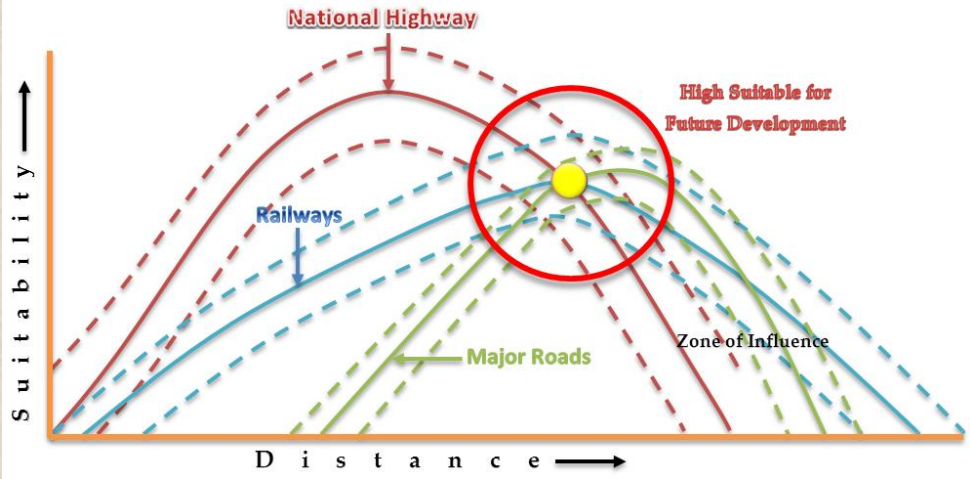

Figure 3: Suitability Curve of Transport Network for Cartographic Modelling

Location and network of roads and railways play a major role in planning and development of a town (John Gormley et al., 2010). Roads could primarily be categorized into highways, major roads and streets. Though highways have the major influence however other roads type also stimulates the infrastructure and socio-economic development of town (Boarnet 1998, Boarnet and Haugwout 2000, Giuliano 1989, 1995, Forkenbrock and Foster 1990, 1996, Isserman and Rephann 1994, Moon 1989, Stephanedes and Eagle 1987, Hansen, Gillen, and Puvathingal, 1997, and others). Based on the categorized level of influence the spatial data on road network

could be assigned specific values to be used as one of the input for modelling. A fuzzy membership function could be assigned to a road/rail based on its zone of influence. Fig 4 shows the diagrammatic and flow representation of input generation of transport network (e.g. highways, and railway) for cartographic modelling. The cartographic map has been displayed in a gradation of red to green. The green patches represent the most suitable locations for urban development while the red patches denote the least.

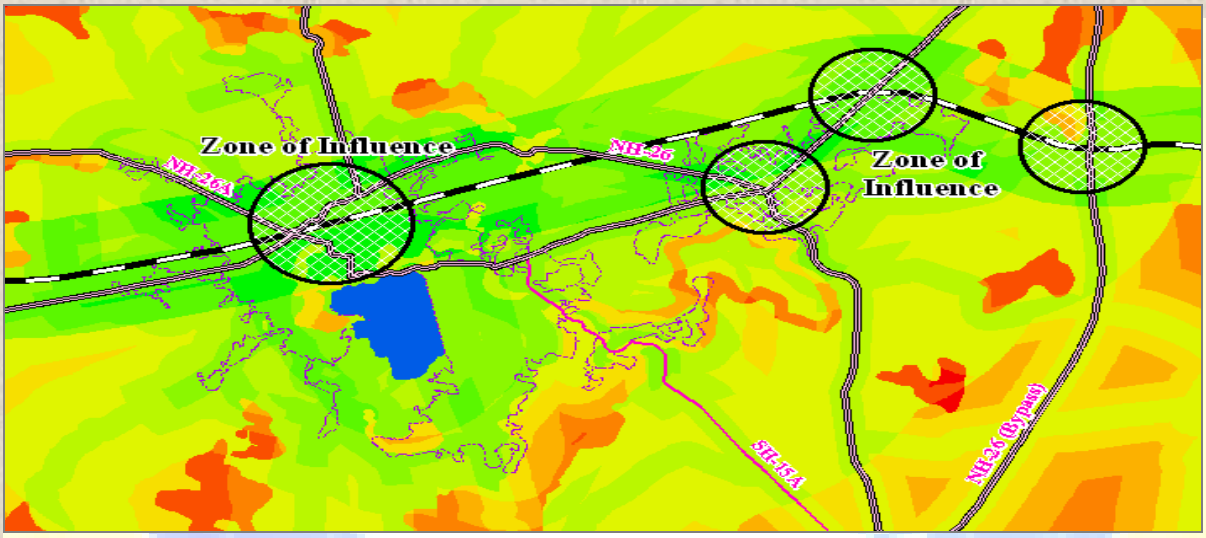

Figure 4: Schematic Representation of Input Generation of Transport Network for Cartographic Modelling

The more conventional challenges of urbanizing societies is of providing adequate housing, public transportation and other civic amenities however it is also imperative to analyze the overall environmental impact of a city's urbanization (Sanjeev et al., 2010). The concept of ecological footprint is a prime requisite in the small town growth strategy. Ecological footprint is a measure of how much biologically productive land and water an individual, population or activity requires to produce all the resources it consumes, and to absorb the waste it generates using prevailing technology and practices (Glossary, GFN). It is usually measured in global hectares. India has an average per capita ecological footprint of 0.8 global hectares which is far less than the average per capita ecological footprint of 6.43 global hectares of the developed countries mainly due to low standards of living in both urban and rural areas. A city's ecological footprint depends on the number of factors (Marks et al., 2006), Fig.5.

Figure 5: Factors that Determines the Ecological Footprint of any City/Country

Keeping the environmental consideration for growth strategy for a town, cartographic models can well integrate the most environmentally suitable patterns for development, balancing between environment sustainability and urban growth. Fragmentation analysis of "green lungs" or vegetation patches within a city can produce an appropriate spatial layer which can be used in the cartographic model (Waran, 2001). These vegetation patches can be allocated fuzzy membership functions to play a more realistic role by becoming one of the factors in development of growth strategy for assessing the environmental sustainability of a city.

Existing & proposed infrastructure in city plays a major role in the development of growth strategy of a city. Like other developing countries, the nature and character of spatial developments in India does not only pose a daunting and challenging task of improving the lives of the urban dwellers but also searching for optimum solutions to the haphazard spatial developments and inadequate infrastructure within settlements. Of all urban land uses, residential use demands for more land than any other and thus it is the most significant land use in the context of space needs. It is therefore imperative that suitable land for residential use has to be identified to maximize space utilization and limit environmental degradation. The suitability of urban land use is largely the strategic nature of a tract of land that would enable economically and socially feasible utilization of such land (Shuaib, 2005). Thus biophysical factors, spatial economic factors (such as land values), social factors (such as preferences on distances to travel) are all important in the assessment of the fitness of land for urban development (Peter et al.,

1995). Other factors such as socio-economic development of the area also demands existence and proposition of infrastructures such as industries, educational institutions and hospitals. With the advent of very high resolution satellite images such as IKONOS, Cartosat-2, Quick Bird, aerial photos etc. the city's infrastructure could be mapped to a very useful extent. Since remote sensing may not provide all the information needed for a full-fledged assessment, many other spatial attributes from various sources are needed to be integrated with remote sensing data (Sokhi and Rashid, 1999). The preparation of base maps using the remote sensing techniques helps in urban planning (Table 2).

Table 2: Urban Planning Stages and Base Map Requirements

S. No.	Planning Stage	Base Map Scale
1.	Master Plan / Land use Plan	1:10,000 & Larger
2.	Zoning Plan	1:4,000
3.	Inner City/Urban Cadastral	1:1,000 to 1:2,000
4.	Urban slums/Unauthorized Developments / Encroachments	1:5,000 to 1:1,000

The various existing and proposed infrastructure could be categorized into a defined classes and could be assigned fuzzy membership functions (Jörg Habetha el al., 2002). The spatial layers obtained can be used as another input factor in the growth strategy of small towns using cartographic modelling.

Involvement of geographical & demographic parameters is the prime requisite in urban land use planning. Several factors such as slope, soil type, drainage pattern, geomorphology, elevation and population forms an inseparable part in it. These factors could be categorized accordingly and a fuzzy membership functions could be assigned to each layer.

Land use planning requires a suitability analysis which in turn is the integration of several data sets to model land use requirements and the characteristics of the land for the alternatives (Lewis D. Hopkins, 1977). With different representative raster/vector layers attributed with fuzzy membership function, a Multi Criteria Evaluation could be carried out to identify out those area which are suitable for a particular land use (Jacek Malczewski, 2003). A generalize cartographic

model of growth strategy for town involves an interactive though complex relationship among different parameters (Fig 6). This technique can bridge the gap to a multi-disciplinary approach for land use planners on all levels of land use planning (Hala et al., 2009). Applying the technique on a national scale provides indicator maps that despite its need for further screening and enhancement by detailed local analysis, it can be used as a guide for the local scale, zoning plans and land use strategies.

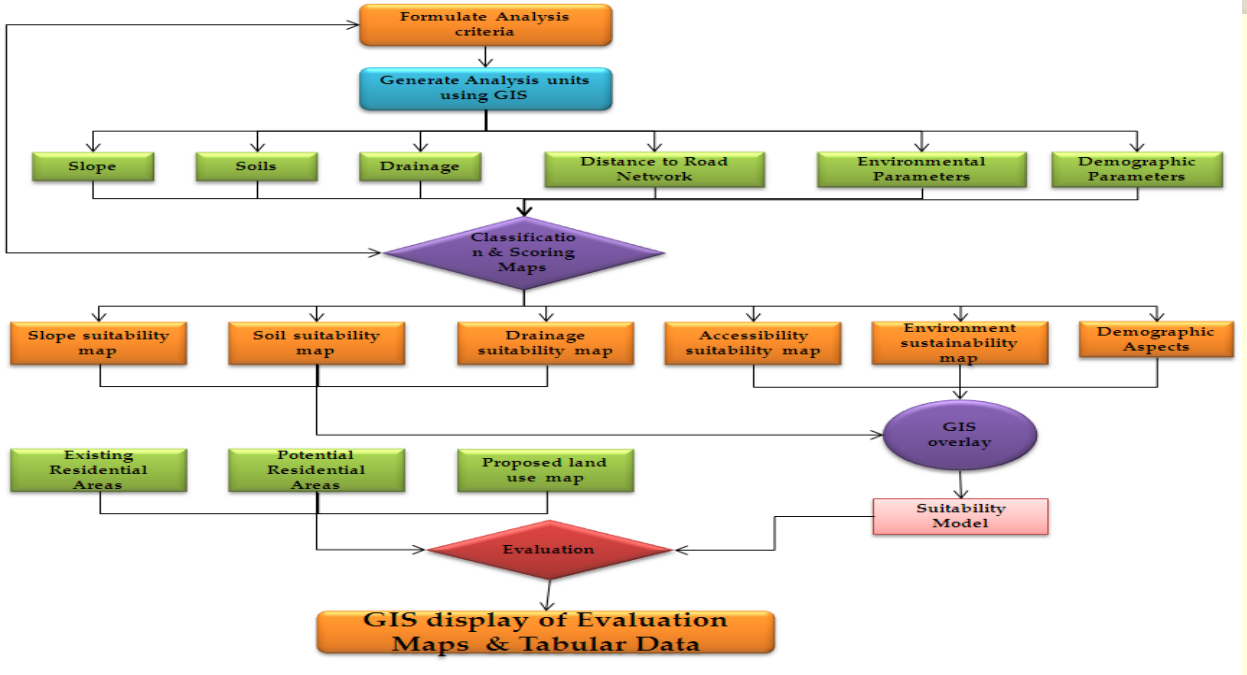

Figure 6: Flow Diagram of the Cartographic Modelling

Much of the rural population of India depend on small urban centers for access to goods and services and many of the schools and health care services needed to ensure that the health and education. Despite this reality, most urban debates and research are focused on mega cities. These cities might be more aesthetically attractive, as they have become global cities concentrating large proportions of foreign investment, infrastructure mega projects and tourists (UN-HABITAT 2006, 2009). While megacities present management problems of their own, it is the smaller cities that suffer particularly from a lack of planning and services to cope with growth. In the face of this eluded challenge, there is an urgent need of refocusing the attention from central governments, international development cooperation and urban researchers towards supporting small cities, where the bulk of global urban problems reside. With a local and regional scale of analysis, the modelling process will help develop a regionally distributed urban

development framework where the collective synergy of the small towns, connected through appropriate infrastructure, will operates as a larger urban economic system without the carbon footprint of a mega-polis (Droege, 1999-2008).

5. Conclusion:

Planning and managing cities in the new era of globalization and economic liberalization would be a demanding task calling for new skills and approach. Indian cities will have to compete with others to attract investments and, therefore, issues like quality of infrastructure, energy efficient services provision and environmental conditions in a city besides economic stability would play a significant part in such competition. Urban planning profession in general will have to address these issues and respond rapidly. It is worthwhile noting that spatial dynamics of cities is complex to fathom and urban theory is still static. In other words, the urban planning authorities and agencies in every parts of the country should adopt new technologies like remote sensing and GIS. These have capability to provide necessary physical input and intelligence for preparation of base maps, for planning proposals and act as monitoring tool during implementation phase(s). Satellite remote sensing with repetitive and synoptic viewing capabilities, as well as multispectral capabilities, is a powerful tool for mapping and monitoring the ecological changes in the urban core and in the peripheral land-use planning, will help to reduce unplanned urban sprawl and the associated loss of natural surrounding and biodiversity. Furthermore the smaller towns of India are of great importance to urban sustainability initiatives and should be a primary focus of sustainable development in the future. Connections these cities with larger ones will also be of great importance as secondary cities have the potential to be sites of modelling and experimentation because of their size relative to infrastructure.

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