Ecological Planning for Sustainable Development with a Green Technology: GIS

Anuj Tiwari, Merugu Suresh, Arun Kumar Rai

Mother Nature is Green.

***Abstract*—Throughout the years, with the significant contribution from various technologies like computer science, information technology, remote sensing, advance multimedia world etc, GIS evolved from traditional geographer's or cartographer's tool for surveying and planning to a rapidly expanding primary technology for understanding our planet and related geospatial opportunities to foster a sustainable green world. GIS technology bridges the gap between different sectors and acts as an integrated cross sectoral platform to collect, manage, compile, analyze and visualize geospatial, temporal information for sustainable ecological and environmental planning. In this paper a GIS based suitability analysis model is used for current ecological assessment to determine the optimum site arrangement for activities while minimizing negative impacts on the environment. This developed GIS model tries to indicate areas that have considerable conservation priority or, on the other hand, areas that are suitable for further development at various level. Thus, this paper examines how GIS is considered as a powerful green technology and contributed immensely for the sustainable green city development.**

***Keywords*— GIS, Ecology, Sustainable Development, Urbanization, Green Technology.**

I. INTRODUCTION

Urbanization refers to a process in which an increasing proportion of an entire population lives in cities and the suburbs of cities. Urbanization is an index of transformation from traditional rural economies to modern industrial one. It is a progressive concentration of population in urban unit [2]. More than one half of the world population lives now in urban areas (UNFPA. 2007), and virtually all countries of the world are becoming increasingly urbanized. In 2008, for the first time in history, more than half of the world's population will be living in towns and cities and by 2030 this number will swell to almost 5 billion. Rapid urbanization is unarguably the most complex and important socio-economic phenomenon of the 20th and 21st centuries. Generally understood as a shift from a predominantly rural to a predominantly urban society, it also represents major and irreversible changes in production and consumption and the way people interact with nature [1].

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To achieve development of the urban areas and protection of the environment with an eye to equity in employment, shelter, basic services, social infrastructure and transportation in the urban areas there is an urgent need of Sustainable urban development [4].

In the last fifty years the population of India has grown two-and-a-half times, but urban India has grown nearly five times. In 2001, 306.9 million Indians (30.5%) were living in nearly 3700 towns and cities spread across the country, and it is expected to increase to over 400 million and 533 million by 2011 and 2021 respectively. Urbanization is impacting almost every state of India. For the first time in India's history, the nation will have five large states Tamil Nadu, Gujarat, Maharashtra, Karnataka and Punjab that will have more of their population living in cities than in villages (Source: Indian Urbanization Econometric Model, McKinsey Global Institute Analysis Report).

In India, the movement in support of environmental concerns and sustainable development really started in the early 1980s, partly influenced by international developments but mainly due to the devastating effects of the Bhopal gas tragedy in 1984. The Bhopal tragedy was followed by a number of policy statements and legislations in order to meet environmental challenges. Economic reforms and liberalization introduced in 1991 along with the forces of globalization to which the country was now exposed, no doubt accelerated the pace of Gross Domestic Product (GDP) growth but also raised concerns about inequality, poverty, damage to the environment and natural resources [Planning Commission, May 2012].

II. GREEN SUSTAINABLE URBANIZATION

The green city theory is centered on the historical ideals on how a city should function ecologically and environmentally. Going green must be a key part of city development plans, agendas. In this modern century where urbanization and industrialization have rapidly been consuming the green cover of the precious earth planet, resulting into severe adverse environmental impacts and fatal health problems. Green technology play an important role in enhancing urban environmental conditions and present a promising source of growth. But the main challenge in front of decision maker is to explore a technology that "steer urbanization from its current, unsustainable path towards healthy, greener cities that ensure *food and nutrition security*, decent work and income, and a clean environment for all their citizens."

Ecological planning

Ecological planning is the process of understanding, evaluating, and providing options for the use of landscape to ensure a better fit with human habitation [11]. An understanding of ecological planning is dependent on the study of human activities in, and the nature of, natural ecosystems. It also depends on the fact that people are a part

of nature, and as a result nature is of value to humans [25]. Ecological planning investigates the problem of realizing the values of the natural resources, while ensuring the long-term survival of such resources.

III. GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Nowadays, immense value and broad applicability of Geographic Information Systems (GIS) is obviously a major driving force of some significant changes happening around us. GIS was basically developed as a computer system for capturing, storing, querying, analyzing and displaying geographically referenced data [9] but with the advancement in web, mobile technology, GIS emerged as a broad term and a complete package, which can refer to a number of modern technologies and advance processes and become more mainstream that expands knowledge of the nature and connections among people [3]. As an indispensable decision-making tool GIS is now finding its place among decision-makers for assessing and creating sustainable urban policies.

Geo-spatial data and geographic information system (GIS) are essential components for building smart cities in a basic way that maps the physical world into virtual environment as a referencing framework. On higher level, GIS has been becoming very important in smart cities on different sectors. In the digital city era, digital maps and geospatial databases have long been integrated in workflows in land management, urban planning and transportation in government [22].

IV. RELATED WORK

The concept of the ecological-niche was first proposed for the natural systems by Joseph Grinnell in 1917 [17]. Although originally developed to describe the ecological requirements of a species, the concept of ecological niche can easily be applied to other scales of biological organization (Doledec et al. 2000). This Landscape ecological planning can provide a conceptual framework for the assessment of consequences of long-term development processes like urbanization and industrialization on biodiversity components and helps in evaluating and visualizing the impacts of alternative planning scenarios (Mortberg et al. 2007). In recent decades, GIS-based ecological and environmental planning has contributed immensely to sustainable development. The potential use of GIS in EIA in general [9] and for ecological assessment in particular [8,14] has been recognized worldwide [18]. Environment planning and ecological planning can be incorporated into both large and small scale development projects and will help in choosing the best available land that helps to reduce environmental impacts and preserve biodiversity.GIS analysis helps in evaluating large data at landscape and regional level easily and helps decision makers to visually understand the environmental consequences of the project.

V. STUDY AREA & NEED OF SUSTAINABLE DEVELOPMENT

Agra is the city of the inimitable TajMahal and former capital of Hindustan. The Agra district is situated on the banks of the river Yamuna and in western U.P. between 27.11' degree Latitude North and 78.0' degree to 78.2' degree Longitude East. Its Altitude is 169 meters above sea level. According to Census 1991, the area of Agra district is 4027.00 square km., where rural area is 3838.60 square km. and urban area is 188.40 square km. Its Total Population is 27, 51,021 out of which Males are 15, 01,927 and Females are 12, 49,094. Of the Total Population, 16, 39,935 constitute the Rural Population and 11, 11,086 are makes the Urban Population.

Figure1. Study Area: Agra City

Agra suffers from acute shortages of water and power supply, severe air pollution, and serious problems of traffic congestion and solid waste management. Yamuna River is the main source for drinking and industrial water supply to Agra city. With the rapid urbanization and industrialization along the bank of the river, the water has become severely polluted. The main sources of pollution were public waste and industrial waste. Industrial waste included discharge from the metal works (Aluminum, Brass, Iron, Lead and Zinc industries), oil extraction mills, flour and grain mills, pesticides, dairy, soap and lather manufacturing industries [16]. The residents of Taj city Agra are facing problems due to severe power outages of six to eight hours every day. High floating urbanization, Rapid growth in industrialization, together with inadequate measures to conserve the environment, have led to adverse environmental impacts affecting the health of the local population. City's rapid expansion has been chaotic, leading to unsanitary conditions and other deterrents that could cripple its most valuable tourism industry. The prominent destinations of the World Tourism, Agra need an urgent ecological assessment for the environment friendly sustainable urban development. This city requires a fair and equitable distribution of the benefits of development, improved well-being for citizens and respect and care for the environment.

VI. ECOLOGICAL ASSESSMENT FOR SUSTAINABLE DEVELOPMENT: ROLE OF GIS

Ecological assessment and sustainable development needs a multidisciplinary approach, with input and expertise required from many fields - physics, life sciences, geology, hydrology and statistics being some of them [19]. Geographic Information Systems (GIS) created new possibilities that allow qualitative as well as quantitative ecological assessment for a sustainable urban development. Through the GIS it is possible to collect a wide range of simple to complex, spatial as well as non-spatial, and quantitative as well as qualitative input data, available spatial and non spatial analysis functions in turn are used in ecological risk assessment and site suitability analysis. Thus with the GIS it is possible to keenly monitor and access different recourse in underlying area, mapping and analysis tools are able to evaluate them and create a clear view of existing urban scenario and the challenges to enhance it up to a level of sustainability in front of decision makers. Identification of the

patterns of urban sprawl and analyses of spatial and temporal changes would help immensely in the planning for proper infrastructure facilities (Barnes et al., 2001). Ultimately GIS came as a technology that has enough capability to provide necessary physical input and intelligence for preparation of base maps, for sustainable urban planning proposals and act as monitoring tool during implementation phase(s).

VII. SUITABILITY ANALYSIS MODEL

Land suitability evaluation is a prerequisite for land-use planning and development [24]. It provides information on the constraints and opportunities for the use of the land and therefore guides decisions on optimal utilization of land resources [10]. The aim of land suitability analysis is to provide more flexible and more accurate decisions to the decision makers in order to have a sustainable urban development. land suitability analysis and ecological Site Assessment is an integral part of the development design and assessment process. Its primary aims are outlined below and form stages in the Assessment process [12].

Stage 1: Identify Ecological Features and Functions: System starts by capturing the data for the underlying ecosystem. At first flora, fauna and habitat of site are accessed to determine the ecological features and functions of the study site;

Stage 2: Identify Governing Factors: To ensure an accurate sustainable analysis, it is important to define the governing factors affecting system ecology. These factors include social component, socio-economical characteristics, environmental conditions, development agenda and plans etc.

Stage 3: Preparation of the Data as Thematic Maps: As thematic map is a map that focuses on a specific theme or subject area so the variety of phenomena like geological, geographical, political and administrative are mapped for the site. Thematic maps are best suited for geospatial analysis and to compare patterns on two or more maps.

Stage 4: Creating Gis Model: To analyze the collected spatial, temporal and attribute information overlayed on thematic map is analyzed with a GIS model that has two prime component. Land Use Suitability Model: to determine the relative suitability of each site for each land use category [12].Potential Model for Urban Development: to identify all the lands suitable for development within the study area [12].

Stage 5: Analysis of Potential and Site Sensitivity: Potential impacts of operation and construction phases of development in relation to the ecology of site is determined.

Stage 6: Identify Ecologically Significant Areas: Identify ecologically significant areas (Land for Rehabilitation and Land for Sustainable Development) of the site and identify the measures required to maintain their viability.

Stage 7: Discussion and Recommendations: Recommend any measures or changes to the development design that may be required to avoid or mitigate any impacts of the proposed development design, construction and operation.

Stage 8: Refinement of The Model: As this is an interactive increment model so after the successful execution, model is again refined by choosing appropriate governing factors, type of input data and processing methods.

VIII. RESULT AND DISCUSSION:

In this paper to achieve the sustainable urban development by using GIS as green technology, site suitability analysis model is executed that results ecological significant and rehabilitation areas. In the model various thematic maps (listed below) are used that emphatically address the concerned land use property and help to analyze the ecological, environmental, political urban development and help to predict the accurate sustainable agenda for environmental friendly ecosystem development.

Base Map: Base map depicts visible surface features and boundary information about Earth's surface, essential for locating additional layers or types of georeferenced objects. Base map may include features as roads, rivers, major structures, contours etc. In our paper, Base map provides background on which thematic data is overlayed and analyzed.

Road Proximity Map: A Simple Proximity Buffer identifies the distance to roads throughout buffered area. Buffer radius for underlying analysis is 50 meter which helps to identify the area of prime location (with reference to property cost).

River Proximity Map: A Simple Proximity Buffer identifies distance to water lines throughout the buffered area. Buffer radius for underlying analysis is 500 meter which helps to identify land across river, well suited for a specific type of river bank side vegetation and construction prohibited area.

Railway Proximity Map: A Simple Proximity Buffer identifies the distance to railway lines throughout the buffered area. Buffer radius for underlying analysis is 20 meter which helps to identify railway land that can be used for vegetation, Jatropa Carcus plantation (renewable source of energy) etc.

Slope Map: Slope is the rise or fall of the land surface and slope map gives information about degree (steepness) of slope for a particular terrain (or other continuous surface). Slope map presents hilltops, upper slopes, saddles (upland valleys), lower slopes, and lowland valleys.

Aspect Map: An aspect map shows to which side a slope is directed. Here it is used for estimation of rain (or, in some cases, chemical spills or leaks) run-off and direction. The aspect of a slope can make very significant influences on its local climate (microclimate).

Contour Map: contour maps are the topographic map on which the shape of the land surface is shown by contour lines, the relative spacing of the lines indicating the relative slope of the surface .Contour maps are very useful since they provide valuable information about the terrain. It is possible to identify suitable site for any project from the contour map of the region.

Classified Landsat ETM Satellite Imagery: Remote sensing technology is currently being offered wide variety of digital imagery that covers most of the Earth's surface. This up-to-date image data is a promising tool for producing accurate land cover maps. Accurate image classification results are a prerequisite for many environmental and socioeconomic applications [13] and estimation of biophysical, demographic, and socioeconomic variables [6, 7].

The purpose of this exercise is to gain some hands-on experience with the fundamentals of image classification. Multiband images of the Earth's surface are a very important source of information about land cover and land use.

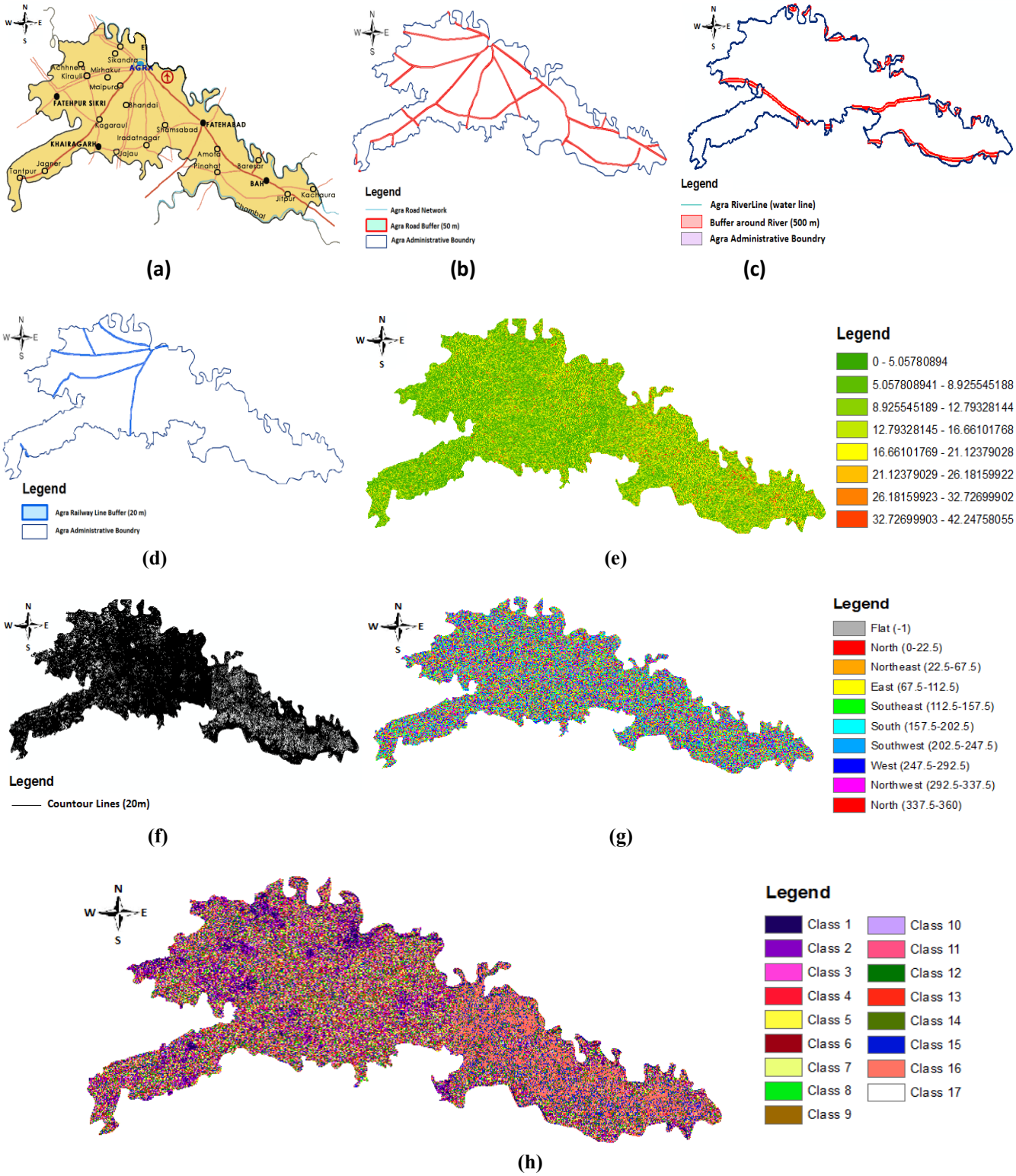

Figure 2. (a). Base Map, (b). Road Proximity Map, (c). River Proximity Map, (d). Rail Proximity Map, (e). Aspect Map, (f).Contour Map, (g). Slope Map, (h). Land use Land Cover Map

Because satellites beam back information every day and feature database is constructing for automatic land cover classification, feature database has information of eight class (water, rural, barren, wetland, grass, forest, agriculture and urban) features in Landsat images. The information provided one can be sure that the classification of the images yields consistent results and gives convenient environment to non-specialist users.

CONCLUSION

Urbanization brings the need to integrate ecological planning with a environmental friendly sustainable development plans. Present study demonstrates the use of GIS technology to evaluate large dataset at landscape and regional level for ecological assessment. Further it helps decision and policy makers to visually understand the environmental consequences of development projects. Ultimately GIS came as a technology that has enough capability to provide necessary physical input and intelligence for preparation of Green urban development, and act as a strong monitoring tool during implementation phase(s).However; better GIS-based ecological planning is required to move on the path of sustainable development and Green Cities. A framework that makes GIS based environmental policy and legislative framework mandatory for developmental projects will be a huge step towards Green City.

Beside this, emerging trends of GIS like web GIS, mobile GIS and location based services, more user interactive maps are publicly available that help citizens to understand proposed green plans, crowd source the information, and garnering support for development initiatives. In this way GIS technology offer the support need for enhancing green plans including data creation and sharing; visualizing and analyzing data; and delivering that information to both the end users and policy makers at the same time.

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