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EVALUATION OF LAND SUITABILITY TECHNIQUES FOR URBAN DEVELOPMENT

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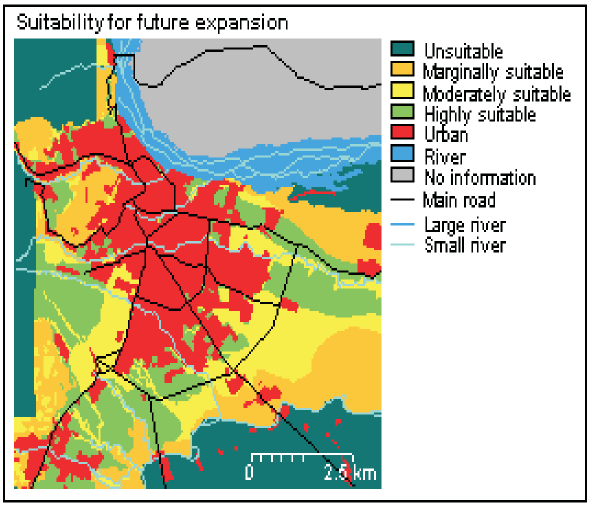

ABSTRACT

In recent years, cities around the world, especially in developing world, have been facing rapid population and economic growth. This growth is largely unplanned and gradually leading to the decline of natural resources and rural lands. Given this situation, strategies and policies are needed to address to this phenomenon problem before negative effects on the environment become irreparable. These strategies and policies may be long-term plans at the local, regional, national, and international levels. Role of Remote Sensing and GIS techniques in monitoring and directing urban planning strategies have become very crucial.

KEYWORDS :*Urban Development , economic growth , strategies and policies .*

1.1 INTRODUCTION

Urban development has become a global issue, resulting in the heightened concern planners and decision makers over the future impacts on the ecosystem. Simulating urban growth patterns has become essential to ecosystem protection and sustainable development. In addition, the complex structure of the urban environment must be understood to simulate urban dynamics correctly. Urban growth simulation needs to consider the chronology of the issue of sprawl and wide historical information to understand spatial and temporal relationships accurately. Hence, obtaining the true knowledge of growth factors that affect future land uses can be improved using simulation techniques, such as land suitability analysis. Understanding the spatial and temporal changes, as well as all effective elements, is facilitated using remote sensing (RS) and geographic information system (GIS) techniques. Suitability analysis for urban growth is considered one of the most important and effective techniques for identifying the best locations for urban growth by employing different types of criteria and weights. Land suitability evaluation involves the selection of suitable locations of development by mapping the suitability index of a specific area. Moreover, GIS techniques have become significant tools for controlling and monitoring changes in urban development and their impact on ecosystems. Land suitability analysis based on GIS environments is a process that aims to identify the best locations of development while considering environmental sustainability. Land suitability analysis is used for different types of applications: identification of suitable locations of urban development, prediction of future land-use changes, organization of green spaces, development of natural wastewater treatment systems, enhancement of crop production and biomass production, and research on ecosystems, sanitary landfills, and coastal areas.

The essence of land evaluation is to compare or match the requirements of each potential land use with the characteristics of each kind of land. The result is a measure of the suitability of each kind of land use for each kind of land. These suitability assessments are then examined in the light of economic, social and environmental considerations in order to develop an actual plan for the use of land in the area. When this has been done, development can begin. Ideas on how the land should be used are likely to exist before the formal planning process begins. These ideas, which often reflect the wishes of the local people, are usually included among the possible uses to be assessed in the evaluation and will thus influence the range of basic data that needs to be collected. A wide range of specialist knowledge is needed to collect and analyze all the data relevant to land evaluation. The work is best undertaken by a multidisciplinary team that includes social and economic expertise as well as biophysical scientists. Ideally, such a team should work together throughout the study so that each member can influence the others with his or her special knowledge and viewpoint. In practice it is not always possible to field the whole team at once. In this case, the physical aspects of land are usually studied and mapped first to provide a geographical framework into which the socio-economic dimensions are inserted later. A two-stage approach is obviously less well integrated and will take longer to complete. The reliability of a land evaluation can be no greater than that of the data on which it is based. Ideally, fresh data should be obtained to answer all questions raised by the study, although time and expense usually prevent this being done as thoroughly as is possible. The one really important requirement is that the evaluation process can be 'automated' and carried out quite rapidly once all the necessary data are available, by setting up a computerized data bank or geographical information system, and establishing rules or decision trees to carry out the matching process which produces the evaluation.

1.2: OBJECTIVES

The present study focuses on review of various techniques of urban land suitability model largely based on Remote Sensing and GIS Techniques. The main objective of this study is

- To explain the process of Land Suitability Technique for Urban Development
- To evaluate various techniques of Land Suitability used for Urban Development.

1.3: STAGES IN LAND SUITABILITY EVALUATION:

Following are the different stages in Land Suitability Evaluation.

- Defining objectives
- Collecting the data
- Identifying land uses and their classification
- Identifying the physical parameters
- Identifying environmental and socio-economic issues
- Assessing land suitability

1.3.1: DEFINING OBJECTIVES: -

The definition of objectives is a critical step in the evaluation procedure. It also ensures that the investigations set off in the right direction, with a good chance of providing all the advice that the planner will need. The objectives must establish the boundaries and thus the size of the study area. The

objectives may be one or more as follows
- To ensure that all development is managed to protect the quality of life
- To encourage the development of a coordinated network of environmental resources and open spaces through preservation initiatives and the development process.
- To control the pace of development through availability of developable land and adequate infrastructure
- Provide flexibility in development design that reflects the growing needs and desires of the community.
- Ensure that the future land use plan provides for an appropriate mix of land uses while preserving existing neighborhood characteristics
- Protect and conserve natural, agricultural, historic, scenic and open space resources to improve the quality of life.
- Approve development only where adequate infrastructure exists or will be available.
- Promote in-fill and redevelopment in existing communities
- Promote a range of alternative community designs to facilitate a pattern of sustainable development.

The study team needs guidance on these issues because the choices must reflect the special interests of the planners and the aspirations of local people. Without this guidance the choice of land-use alternatives to be considered could be infinite.

In framing the objectives, the need for comparisons in land-use planning must be recognized. The prime objective of the study may be to establish the suitability of a particular kind of use, but this can be achieved most effectively by making comparisons with other feasible uses of the same land. Environmental conservation is always an objective of land evaluation.

The major stages are to:
- identify relevant types of land use;
- carry out surveys to establish needs and wishes of the local land users and needs of the community as a whole;
- And rank objectives in order of priority.

1.3.2: COLLECTING THE DATA:

Reliable knowledge of land characteristics, and of the way these differ from place to place, is essential to good land evaluation. The range of data that could be relevant to land evaluation is huge, and collecting it can be costly, in both time and money. There are three main ways to minimize costs: - Focus on data that are essential to the evaluation; - search out and make maximum use of existing data; and - use new technology in data collection. The need and kinds of physical data that may be considered for land suitability analysis for urban development are summarized in the Table 1.1.

Sl No	Parameter	Category	Constraint	Development Considerations
1	Soil	Soil Depth	Foundation Inadequacy	Very deep to deep soils are required for urban development from the foundation point of view as well as providing infrastructural facilities. The cost to be incurred for developing rocky areas is very high and uneconomic.
		Soil Texture	Foundation Inadequacy	Areas with unsuitable foundation materials such as swelling / shrinking soils, compressible soils etc. Pile foundation is required in such soils which is expensive.
2	Physiographic	Slope	Steepness and stability	2 Land where high and medium slopes (more than 7 per cent) provides constraint for urban land use and development. It is uneconomic to develop this type of lands.
3	Land use	Agricultural and forest lands	Productivity	Productive agricultural and forest lands should not be considered for development as they are essential for producing food and fiber and fiber/wood etc.
4	Flood	Flood plains and low lying areas	Land subjected to flooding	Development of low lying areas is not cost effective.
5	Erosion	Ravenous land	Land subjected to gully erosion	These are loose and unconsolidated material areas where the development cost is quite high.
6	Ground water	Excellent, very good and good prospects	Nil	These are the areas to be conserved for the purpose of future water requirements and not to be taken up for the development as water has already been over exploited.
7	Surface water	Lakes / ponds	Nil	Needs conservation for future use
8	Drainage	Rivers / streams	Poorly or excessively drained	Land where the drainage status is a problem
9	Deposition	Mining / quarrying	Water storage / depositional land area	Land where sediment removal during conventional earthworks for urban development is likely to be excessive, causing damage to receiving waters and depositional land areas.
10	Road	Road network	Infrastructure	Areas nearer to transportation network have higher potential for development. Areas away from the road network require development of infrastructure facilities and are expensive.
11	Rail	Rail head network	- do -	- do -

Table 1.1: List of physical parameters and their importance in land suitability for urban development

The new technology that is available for land evaluation consists mainly of the use of remote sensing and computers. Stereoscopic examination of paired, black and white, photographs obtained by conventional aerial photography - the best tested form of remote sensing - remains the mainstay for interpretation of landform, vegetation, land use, soils and geology, and for other purposes such as contouring

Type of survey	Data source	Range of data
Satellite	Digital tapes, photographs, other imagery	Water resources, vegetation, land use, infrastructure, landform, soils
Aircraft	Photographs (conventional, infra-red), radar imagery	Landform, soils, vegetation, land use, farm boundaries, water resources, crops, infrastructure
Ground	Reports, questionnaires, maps	Soil, climate, landform, vegetation, land use, population, social and economic data

Table 1.2: Sources of data

While the newer forms of remotely sensed imagery (such as infra-red and radar) may not yet match the precision or stereoscopic capability of conventional air photography, they have other advantages. Each image sensed from space covers a comparatively large area - especially helpful in analyzing and mapping landform. Satellites return at regular intervals to obtain new imagery of the same sites, so that libraries of sequential imagery can be built up showing the changes at a single site over time. Satellites can now record at up to seven different wavelengths simultaneously. Radar wavelengths are particularly useful in the humid tropics because they can obtain images of the Earth through dense cloud. Computers can now be used to store and manipulate the huge amounts of data needed in land evaluation. Tough, portable, micro-computers are being increasingly used to record, store, interpret, test and communicate data at the survey site itself. The main impact of these new technologies has been to save time and money, and to extend the range and depth of land evaluation, allowing data a greater complexity of land-use alternatives to be collected than was possible in the past. However, many kinds of data have to be collected in traditional ways. The soil surveyor must dig or drill holes to describe the sequence of soil 'horizons' with depth. The hydro-geologist may have to drill deeper holes to prove the existence of suspected groundwater whilst hydrologists set up gauges on streams to measure surface water flow. The meteorologist has to rely on systematic measurements of change in the weather at established weather stations. Agriculturalists, economists and sociologists observe people in action in farms, villages and markets and, by means of questionnaires and other enquiries, establish the patterns of their business. These and other scientists collect the central core of basic data on land much as they have done for decades

1.3.3: Identifying land use and their classification -

Definitions: The distinction between land cover and land use is fundamental. They are defined as follows (Sims, 1995; De Bie, 1995):

‘Land cover is the observed physical cover, as seen from the ground or through remote sensing, including the vegetation (natural or planted) and human constructions (buildings, roads, etc.) which cover the earth's surface. Water, ice, bare rock or sand surfaces are counted as land cover.’

‘Land use is based upon function, the purpose for which the land is being used. Thus, a land use can be defined as a series of activities undertaken to produce one or more goods or services. A given land use may take place on one, or more than one piece of land, and several land uses may occur on the same piece of land.’ Definition of land use in this way provides a basis for precise and quantitative economic and environmental impact analysis, and permits precise distinctions between land uses if required.

1.3.4: Classification of land cover/land use

Classification is an abstract representation of the situation in the field using well-defined diagnostic criteria, the classifiers. Sokal (1974) defined it as "the ordering or arrangement of objects into groups or sets on the basis of their relationships". A classification system describes the names of the classes and the criteria used to distinguish them. A classification is, therefore, scale independent and is independent of the means used to collect information (whether satellite imagery, aerial photography or field survey or a combination of them are used).

1.3.5: Classification structure:

Classification systems come in two basic formats, hierarchical or non-hierarchical. A hierarchical classification offers more flexibility because of its ability to accommodate different levels of information, starting with structured broad-level classes which allow further subdivision into more detailed sub-classes.

1.3.5.1: Criteria for a (Reference) Land Cover Classification:

There are many classification systems in existence throughout the world. However, there is no single internationally accepted land cover classification system. Such a system should meet the criteria that: - It must be comprehensive

- It should be a common reference basis for all derived (and when possible existing) classifications.
- It meets the needs of a variety of users (it should not be single project oriented) which may take only part of the classification and develop from there according to their own specific needs.
- it must be arranged in a hierarchical structure to be used at different scales and at different levels of detail allowing cross-reference of local / regional with continental/global maps without loss of information. Some existing classifications are designed to be used at a specific scale and/or consider only or mainly classes derived from satellite imagery.
- It must be able to describe all land cover features as derived from its general definition.
- It must be adaptable to the variety of land cover types (all possible combinations of the classifiers should be considered).
- A class must be defined by a combination of well-defined diagnostic criteria, the classifiers. In most classifications there is an unclear or unsystematic description of the classifiers from which the class should be derived.
- Classes must be mutually exclusive and unambiguous.
- A clear distinction must exist between the types of classifiers used. Often no underlying common principle has been identified and used to define land cover. These factors influence land cover but are not inherent features of it. This type of combinations are frequently applied in an irregular way and often do not follow any hierarchy. This leads to confusion in the final nomenclature.
- The diagnostic criteria or classifiers used in the classification must be selected because of easy measurement and permanence.
- It should be suitable for mapping and monitoring purposes.
- It must be scientifically sound and practically oriented.

A primary source for the persistent use of “land use land cover”, or LULC, is the so-called Anderson classification system, published by James Anderson and colleagues in the 1976 USGS Professional Paper 1964. The Anderson system formed the backbone of most land feature mapping done by the USGS during the last three decades, although the classification schema has been slightly altered over time. Land cover mapping is not standardized at present. It is unlikely that it can be standardized at finer levels of detail given the vast differences in the landscape across geographies, and the many different purposes for which land feature mapping is required. The USGS has produced several iterations of land cover and use maps for the continental U.S. that may be considered as standard-setting.

The classification system used for NLCD is modified from the Anderson land-use and land-cover classification system. Many of the Anderson classes, especially the Level III classes, are best derived using aerial photography. It is not appropriate to attempt to derive some of these classes using Landsat TM data due to issues of spatial resolution and interpretability of data. Thus, no attempt was made to derive classes that were extremely difficult or "impractical" to obtain using Landsat TM data, such as the Level III urban classes. In addition, some Anderson Level II classes were consolidated into a single NLCD class.

1.3.5.2: Similarities and differences between Anderson and NLCD systems

Urban or built-up classes: Commercial, Industrial, Transportation, and Communications/Utilities (all separate Anderson Level II classes) were treated as one NLCD class (Commercial/Industrial/ Transportation). No attempt was made to derive Anderson Level III classes in NLCD. "Recreational" grasses, such as those that occur in golf courses or parks (treated as an urban class by Anderson) are considered to be a non-urban class in NLCD (a subdivision of "Herbaceous Planted/Cultivated). Residential (an Anderson Level II class) was divided into Low and High Intensity classes in NLCD.

- Water: Anderson Level II Water classes (Streams/Canals, Lakes/ Ponds, Reservoirs, Bays, Open Marine) were classed as a single class (Open Water) in NLCD.
- Agriculture: Agriculture: Agricultural areas that are herbaceous in nature (Cropland and Pasture; Anderson Level II) are subdivided into four NLCD classes: Pasture/Hay, Row Crops, Small Grains and Fallow.
- Rangeland: - Rangeland: Rangeland: No rangeland class (Anderson Level I) is identified by NLCD. Rather, "rangeland" is subdivided by NLCD into Grasslands/Herbaceous and Shrub land classes.
- Forest land: - Forest land: Forest land: Evergreen Forest, Deciduous Forest and Mixed Forest are the same in both Anderson and NLCD. Clear-cut and burned areas are classed as "Transitional Bare" areas in NLCD.
- Wetlands: - Wetlands: Wetlands: Two classes are defined by NLCD. These are Woody wetlands and Emergent/Herbaceous wetlands. These are very analogous to the Anderson Level II wetland classes.
- Bare: - Bare: Three NLCD classes are recognized. These are: Bare Rock/Sand Clay, Quarries/Strip Mines/Gravel Pits and Transitional Bare. These represent a consolidation of Anderson Level II classes.
- Tundra: - Tundra: Tundra: While "tundra" is treated as a distinct Anderson Level I class, tundra (including arctic/alpine vegetation) is considered to be either "Grasslands/Herbaceous" or "Shrub land" classes by NLCD.

1.3.6: Identifying environmental and socio-economic issue

The land suitability not only is based on a set of physical parameters but also very much dependent on the socioeconomic factors. Before a land use can be recommended in a development plan, its environmental and socioeconomic implications must be evaluated further. A new or improved land use can succeed only if it can be adapted to fit local social and economic conditions. Socio-economic investigations are therefore a vital part of land evaluation, starting with the initial formulation of the study's objectives. Attention needs to be given to markets (local, national and perhaps even international), population levels and growth rates, the availability of skilled and unskilled labour, transport of products and inputs, availability of building materials etc. Local religions and cultures may be important. Political circumstances cannot be ignored, and any analysis should take account of the needs of all members of the population, including minority groups.

1.3.7: Assessing suitability:

Suitability is a measure of how well the characteristics of a land match the requirements of urban development. The preparation of urban development plan requires consideration of all components of the environment that exist before the new plan's creation and the environment to be created by the new development plan. The plan may not be effective if any of these components are treated separately or loosely. Therefore the development plan should interrelate all elements that form a community. It is primarily because, the land is a concrete form and any plan must be flexible enough to change established uses either to correct mistakes or to accommodate changing needs. The steps that are followed in the preparation of development plan proceeds from deciding what land to develop to when and how to develop it. So the development plan should encompass physical characteristics, constraints and socioeconomic possibilities. Basically it refers to the potentiality of the land for the development. Land potentiality includes both land suitability as well as land value. The land suitability designates land according to its physical capability regardless of any planner's conceptual interest. The integration of land suitability map and land value map produces a land potential map which can be later combined with the socio-economic variables to prepare final alternative development plan.

CONCLUSION:

Land Suitability analysis for urban development is a very useful and necessary process for sustainable urban development to overcome the problem of limited natural resource with respect to recent d ec4zrecent d ec4zdrastic urbanization. The GIS based evaluation technique is very simple and flexible which can be used to analyze various land suitability for urban areas.

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