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The Role of Geographic Information Systems (GIS) as an Effective Tool in Environmental Planning and Management

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Abstract

The role of Geographical Information System (GIS) in Environmental Management is extremely important to human life because of its contributions to environmental protection, resource conservation and sustainable development. In our modern society, understanding the information on variability and features of environmental issues is necessary to support decision-makers in establishing environmental management plans. Geographic Information Systems (GIS) is one of the most popular tools in storing, analyzing, and visualizing data relating to geographically referenced information which can support decision-making in environmental management matters more effectively and accurately. The main purpose of this paper is to examine the capabilities of GIS technologies in environmental planning and management, discuss the application of GIS technology in environmental management for future research directions.

Keywords: Geographic Information System, Environmental Management, Environment, Technology

Introduction

Human activities have radically altered the assimilative capacities of environmental components i.e., air, water and land especially over the past 200years, largely to meet the rapidly growing demand for resources along with economic development. These demands are considered important drivers of ecosystem degradation and biodiversity loss (Shende, Janbandhu & Patil, 2015). As a consequence, the policies and implementation of both economic development and ecosystem/biodiversity conservation should be formulated and carried out in the context of Environmental Planning and Management (EPM).

Environmental Planning and Management strives to solve the needs of human beings sustainably with minimum interruption of the environmental components. The activities of EPM in most cases deal with management of natural and environmental resources which naturally exist and are part of complex ecosystems. These ecosystems should not be interfered with even as human beings exploit the resources for development and betterment of their life on earth. In striking a balance between sustainable utilization of these resources and maintenance of ecosystems, information is key to decision making (Omusotsi, 2019). Thus, Geographical Information System (GIS) provides a tool for gathering relevant information, integrating the information in a database and manipulating these data to come up with scenarios and possible impacts of development programmes on the environment and ecosystems. It is against this backdrop that this paper examines the role of GIS as an effective tool for Environmental Planning and Management.

Conceptual Review

Geographic Information System

There are different definitions for Geographic Information System, each developed from a different perspective or disciplinary origin. Some focus on the map connection, some stress the database or the software tool kit and others emphasize on applications such as decision support. Defining GIS can be done by either explaining what it can do (Functions) or by looking at the components. Both are important to really understand and use it optimally.

Ali, (2020). Define Geographic Information System (GIS) as a system of computer software, hardware and data, personnel that make it possible to enter, manipulate, analyze, and present data, and the information that is tied to a location on the earth's surface. This system comprises of Software, Hardware, Data, and Personnel that make it possible to enter, manipulate, analyze and present information that is tied to a location on the earth's surface.

Environmental Systems Research Institute (ESRI). Define Geographic Information System (GIS) as a computer-based tool for mapping and analyzing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps.

National Aeronautics and space Administration (NASA) Define Geographic Information System (GIS)as an integrated system of computer hardware, software, and trained personnel linking topographic, demographic, utility, facility, image and other resource data that is geographically referenced.

Fig 1. A schematic diagram to illustrate the layered nature of a GIS; different data sets are combined together to give a single spatial representation of the data.

Source: Adapted from Ali, 2015.

Environmental Planning and Management (EPM)

The recognition of the importance of the environment for human survival resulted the issuing of Agenda 21 by the Earth Summit in 1992, which urged all nations to include environmental planning as an integral part of their development process.

Jafari, Karimi & Alavipoor, (2019) Defined Environmental planning and management as a discipline in science that considers the current situation and provides methods to achieve a suitable environment. It includes decision-making to protect natural resources and ensure their sustainable use for future generation. All global participants from all the continents of the world meet to deliberate on environmental issues and on the need to plan, manage, and educate people to understand the situation, protect their environment, work on clean air and build their homes and workplaces on a suitable site without dangerous implications for environment.

Baldwin, (1985). Environmental Planning and Management (EPM) is defined as the initiation and operation of activities to direct and control the acquisition, transformation, distribution and disposal of resources in a manner capable of sustaining human activities with a minimum disruption of physical, ecological and social processes.

GIS in Environmental Planning and Management

GIS is an effective tool for environmental planning and management. GIS stores spatial information (data) in a digital mapping environment, it serves as the ultimate communication of environmental information to the public and policy makers since it is the technical basis for the multimedia approach in environmental decision-making. The evolution of spatial data standards, the internet, and the next generation of GIS technology allow all types of users to access the environmental information in its proper spatial context (Sharma, Mohammed & Uppuluri, 2009).

On completion of data analysis GIS helps in Planning and Managing the environmental hazards and risks. In order to plan and monitor the environmental problems, the assessment of hazards and risks becomes the foundation for planning decisions and for mitigation activities. GIS supports activities in environmental assessment, monitoring, and mitigation and can also be used for generating Environmental models. Some of the applicable areas where GIS can be implemented for effective planning and management includes: Disaster management, hazard mitigation, air pollution & control, managing natural resources, waste water management, forest fires management, oil spills and its remedial actions, wild land analysis, emergency Services like fire prevention, sea water/fresh water interface studies, coal mine fires among others. (See also Figure 1).

Figure 1: Diagram showing the application of GIS for various environmental solutions. Source: Adapted from Sharma, Mohammed & Uppuluri, (2009)

Apart from data analysis in laboratories GIS can also help the environmental data analysts in the field, the GIS tool is flexible enough to work in the field to give the exact location of devastation and amount of devastation. Some of the examples in field where GIS is applicable are

- Using GIS in the field, an environmental inspector can rapidly map waste storage sites; describe the volume, content, and state of waste containers.
- Retrieve previous inspection records to compare with the existing environmental conditions.
- View environmental data in relation to adjacent geographic features such as waterways, neighborhoods, or other sensitive areas such as high-risk zones for landslides, water pollution etc.
- Integrated with a global positioning receiver, a field crew can use GIS to accurately locate the ground through satellite imagery in oil spill mapping and its effects on surrounding ecosystem.

Spatial Analysis of Environmental Information

Majority of GIS software offer tools for in-depth analysis of environmental information hence providing insights that are useful to environmentalists and managers for decision making. This is made possible by the capability of GIS systems to integrate different layers of information within a given reference system. The analysis systems focus on sophisticated query, advanced analysis and visualization tools. The analysis system is based on the primary database; it is an active information production process. While in the query systems the information is depending on the human interpretation, here the GIS produce directly machine readable" information. Using the analysis of software you can understand the geographic context of your data, allowing you to see relationships and identify patterns in new ways. The software helps organizations make better decisions and solve problems faster. With the analysis of software, you can build new geographic data sets quickly and easily; create publication-quality maps; manage your file, database, and Internet data resources; customize the user interface around the tasks that you need to accomplish. With spatial analysis systems, you can find suitable locations, perform land-use analysis, predict fire risk, analyze transportation corridors, determine pollution levels, determine erosion potential, perform demographic analysis, etc (Markus, 2011). some of the analysis enabled by most GIS application software includes: Querry functions, Temporal Analysis, Surface Interpolation Analysis, 3D Analysis, Connectivity analysis.

Constraints of using GIS

i. Limited access to technology and digital infrastructure. The absence of adequate digital infrastructure inhibits the collection, storage, and dissemination of geospatial data.

ii. Insufficient human resource capacity. The limited number of competent and knowledgeable GIS practitioners hampers the implementation and sustainability of GIS projects.

iii. Data quality and reliability issues. Challenges related to the quality and reliability of geospatial data used in GIS applications.

iv. Financial constraints. The implementation and maintenance of GIS require significant financial resources.

Conclusion

In conclusion, GIS plays very significant role in environmental planning and management and in every part of our daily life. it has grown from simple numerical representation of geo-data into a self-sustaining visual database and data processor that has emerged into a new powerful discipline of science. GIS provides a platform for effective data input, retrieval, update, visualization, analysis, modeling among other functions. as EPM strives to solve the needs of human beings sustainably with minimum interruption of the environment, GIS will continue to provide the tools to effectively carry out these activities.

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