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LAND USE MANAGEMENT OF THE ADJOINING AREAS OF A FRESHWATER WETLAND USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

Shibu, K*. and Nithya R. Govind
Department of Civil Engineering, College of Engineering Trivandrum, Thiruvananthapuram-695 016, Kerala, India
**Email: shibukrishnanp@gmail.com*

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Abstract: Wetlands are transition zones where the flow of water, cycling of nutrients and energy of sun meet and forms a unique ecosystem which plays a pivotal role in climate adaptation and mitigation. Of late, the progressive encroachment of fresh water wetlands is an issue of global concern. Since the land use pattern of the adjoining area of wetlands play a key role in the preservation of wetland system, its conservation demands high priority. Being versatile ecosystems, proper land use management of the adjoining area of wetlands is an essential step towards reducing the overall environmental burden of natural fresh water systems. The fresh water wetland considered in this study is Sasthamkotta wetland system, the largest freshwater lake in Kerala which caters the drinking needs of half a million people in Kollam district. But the lake is slowly dying owing to many reasons, including an alarming decrease in the water level and pollution of the lake. Large tracts of catchment area have been cleared and people are undertaking paddy, plantation and tapioca cultivation. Thus the basic objective of this study is to carry out a land use suitability assessment for proper land-use management for the adjoining areas of Sasthamkotta fresh water wetland system using Geographical Information System and Remote Sensing data. The location map of the study area was collected to identify spatial and topographical characteristics of the study area and thereafter the toposheets were scanned and later digitized using Arc GIS Software. The spatial analyzing system incorporated the use of a multi-criteria mechanism in Geographical Information System for the suitability of evaluating the adjoining areas of Sasthamkotta lake. Analytic hierarchy process was used to address the uncertainties during the process of evaluation and weightage for the selected criteria namely land use, vegetative cover and population was assigned. The area adjoining the Sasthamkotta wetland system was divided into different categories such as Highly suitable, Moderately suitable and Less suitable based on the suitability assessment by analyzing the selected criteria and related Geographical Information System data. The results of this study indicate that a major portion of the study area comes under the category Highly suitable and hence be conserved and protected as these regions are crucial for recharging the lake. This categorization procedure may help local authorities better understand and address the complex land-use system, and initiate comprehensive control measures to improve the environmental quality of this 'stressed' lake environment.

Key words: Fresh water Wetland, Sasthamkotta Lake, Land use suitability assessment, Multi criteria analysis, Analytic hierarchy process, Categorisation

INTRODUCTION

Rapid urbanization has imposed significant pressure on the land-use structure and aquatic ecosystems, of various urban fringes. Meanwhile, there is still a lack of integrated land-use planning for such areas, leading to many serious socio-economic and environmental consequences, such as disorganized urban development and allocation of land-use types, over-consumption of land and water resources etc (Fu Yang *et al*., 2008). Over the past years, many tools based on the geographic information systems (GIS) and the remote sensing (RS) techniques have proved useful for land management. The incorporation of multi-criteria evaluation methods into GIS has emerged as a promising research area attracting many planners and managers (Yong Liu *et al*., 2007). In this respect, an integrated GIS-based analysis system (IGAS) is developed in this study for supporting land-use management of lake areas in urban fringes (Yong Liu *et al*., 2007).

The suitability assessment is the fundamental step in regional land-use management. Land-use suitability assessment has developed from hand-drawn and sieve mapping to expert knowledge

replication under a variety of situations (Richard Ready and Charles Abdalla (2003), Yong Liu *et al*., 2007). Land use suitability assessment is a multi criteria decision-making problem, and hence a Multi Criteria Analysis method was used for classifying and weighing criteria.

The Analytical Hierarchy Process (AHP) is a multi-criteria decision making tool which can be used to solve complex decision problem which uses a multi-level hierarchical structure of objectives, criteria, subcriteria, and alternatives (Yong Liu *et al*., 2007; Luo lingjun *et al*., 2008). The pertinent data are derived by using a set of pairwise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion.

Bing maps were employed while assessing the Land use suitability. Since the settlements in the study area were scattered and spread out each settlement was identified with the help of bing maps.

The objective of the study was to develop, an integrated GIS-based analysis system (IGAS) for a more efficient and scientific management of the study area. The proposed IGAS may better reflect the complex, dynamic and integrated characteristics of land-use management systems, and thus make management more practical (Yong Liu *et al*., 2007).

The wetland considered in this case study is the Sasthamkotta which supplies drinking water to approximately half a million people in Kollam district. But the area of the lake is getting reduced year after year and a proper land use management is necessary. Identifying the suitability of different regions will help in conserving the natural water system in this area.

MATERIALS AND METHODS

Study area

Sasthamkotta fresh water lake is one of the 25 important fresh water resources in India, approved under "Ramsar wet land" category, in the Ramsaor convention. This lake is situated in the North – West portion of Kollam District, near the bank of Kallada river, in Kunathoor thaluk. The district of Kollam extends from latitude 9° 28' N to 8°45' N and longitude 76°28' E to 77°17' E. Other major lakes in the vicinity of the study area are the Ashtamudi Kayal and Paravoor Kayal (Fig. 1 & 2).

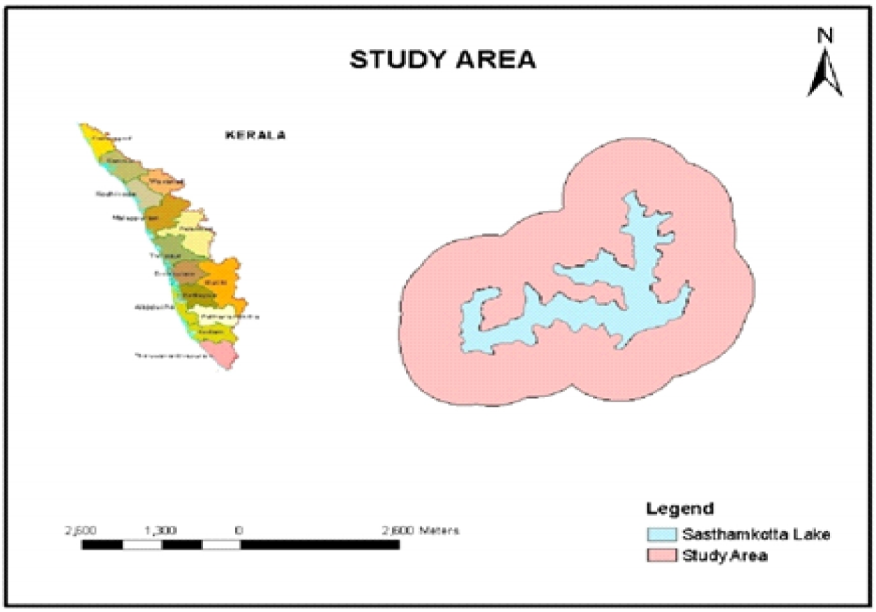

Fig: 1. Location map of Study Area

Fig.2. Photograph of Study Area

The Sasthamkotta Lake lies near the Sasthamkotta town on the right bank of Kallada river. The lake spreads out in Sasthamkotta, Western Kallada and Mynagapally Panchayats respectively. The lake lies between latitude 9°11'N to 9°41'N and longitude 76°36'30"E to 76°40'E. The lake is at an elevation of 33 meters above mean sea level and the average depth of the lake is around seven meters whereas the maximum depth is about fourteen meters.

Sasthamkotta is the only fresh water lake in Kollam district and caters to the needs of the Kollam municipality. It is surrounded by small residual hills on three sides, and the lake has an irregular shape. An artificial bund in the south eastern part of the lake which was constructed in 1956 separates it from the surrounding lowland. The Kallada River flows about 2.5 kilometers south east of the lake.

The lake holds about 22390 million litres of water and the present area of the lake is about 375 hectares since large part of the lake is occupied for agriculture. This wetland supports about twenty seven species of freshwater fishes and two genera of prawns. But the lake is slowly dying owing to many reasons, including an alarming decrease in water level and pollution of the lake. It is also seen that large tracts of land around the lake have been cleared and the local people are undertaking paddy, plantain and tapioca cultivation.

METHODOLOGY

The study area was digitized from 1967 SoI toposheet (58C12). A buffer zone extending up to 1km around the lake was considered as the study area. Many data sources were employed including toposheets, administrative zoning information and socio economic statistical information (Ahmed Wahid *et al.*, 2009). The various criteria for Multi Criteria Analysis (MCA) were selected based on previous studies conducted on the study area and expert opinions. The various natural environment and socio economic conditions such as land use were selected and analysed (Fig. 3) and for each of the criterion corresponding map was generated.

Land use

Land use map was prepared from bing map of the study area. Various type of land use types were identified using visual interpretation and

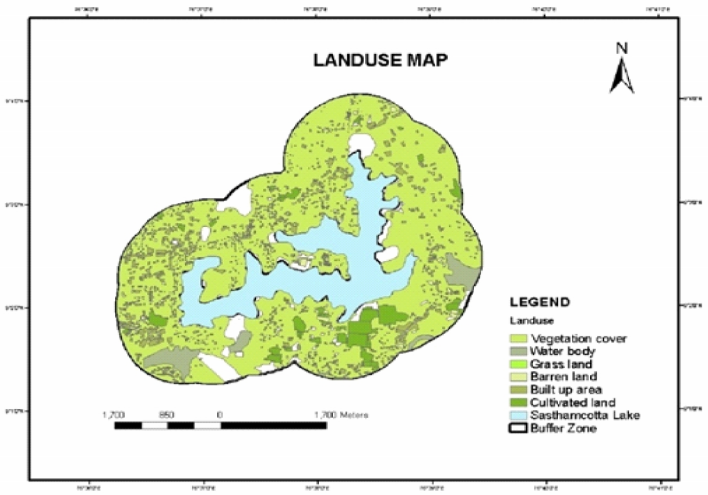

Fig. 3. Land use map of the study area

spatial pattern recognition. The study area encompasses mainly six types of land use.

They are vegetation cover, water body, grass land, barren land, built up area and cultivated land respectively. Each land use type was digitized from the bing map as polygons. Thus a land use map of the study area was prepared using ArcGIS 9.3 software (Fig. 3) and it was found that majority of the areas were covered by vegetation cover.

Analytical Hierarchy Process

Analytical Hierarchy Process was used to assign weightage for each selected criterion. A pair wise comparison matrix was prepared from the three criteria and the priority was assigned (Fu Yang *et al*., 2008). In Land use criteria, cultivated land was given the highest weightage followed by vegetation cover, grass land, water body, built up area, barren land respectively (Table 1).

Land use suitability values for the study area were evaluated by weighted sum overlay analysis using ArcGIS 9.3 software. Based on the Land use suitability values the study area was divided into three regions (Table 2) namely Highly Suitable, Moderately Suitable and Less Suitable.

RESULTSS AND DISCUSSIONS

Land use suitability map of the study area was generated and the area was divided into three regions based on suitability. Land use suitability assessment in this study was assessed by land keeping in mind the conservation of the natural ecosystem. The regions were subdivided into three regions namely Highly Suitable, Moderately Suitable and Less Suitable. Figure 4 demonstrate the land use suitability classification map and the results indicate that reasonable land-use management policy and land planning measures must be adopted to maintain the sustainable development of the study area.

Highly Suitable

Major part of the study area comes under this category which covers farmlands, vegetative cover and water bodies. Most of this region is situated in West Kallada grama panchayat. The said areas should be protected as key ecological protection areas for their fragile ecosystem and important ecosystem service value. Proper measures should be strengthened for restoration and rehabilitation of the damaged ecosystem as well. Industrial development is also forbidden in these areas.

Moderately Suitable

It covers smaller portion of vegetation cover and it includes regions with high transportation accessibility. These regions are less fragile thus excessive exploitation of the region shall be avoided. Most of the region coming under

Table 1. Suitability assessment indicators for land use

Layer A	Layer B	Weight	Layer C	Weight
Land use suitability	Land use	0.5	Cultivated land	**0.048**
			Vegetation cover	**0.095**
			Grass land	**0.143**
			Water body	**0.190**
			Built up area	**0.238**
			Barren land	**0.286**

Table 2. Land use suitability Classification

	Suitability Classification		
	Highly Suitable	Moderately Suitable	Less Suitable
Value	1 to 2	2 to 3	3 to 4

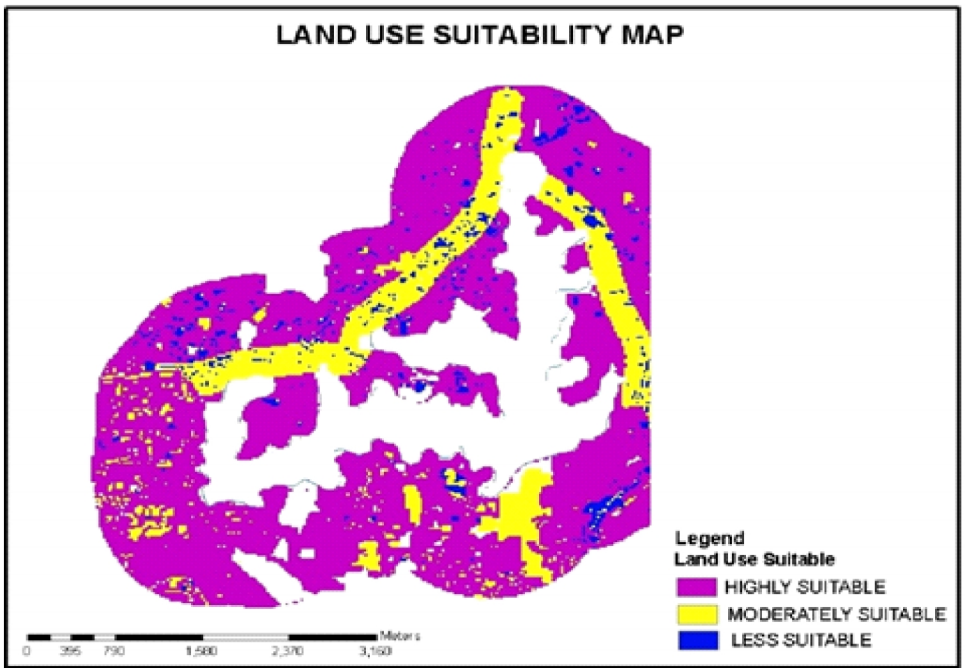

Fig. 4. Land use suitability map

Moderately Suitable is situated in the Sasthamkotta grama panchayat

Less Suitable

This includes the built up land in the study area and it marks areas of no vegetation. These are areas with small ecosystem sensitivity. Most of the region coming under this category is situated in Sasthamkotta and Mynagapally grama panchayat.

CONCLUSIONS

Land use suitability assessment is a complex problem in which different goals and criteria must be considered. The integration of GIS and Multi Criteria Analysis was proved to be effective in the assessment of land use suitability and this case study has proved to be an effective tool in the decision making process. Ecological conservation of water systems and riparian area was a significant task in assessing land use suitability in this case study. The integration of Analytical Hierarchy Process has helped to resolve the uncertainties that have arised in the suitability evaluation. The different levels of importance of the criteria can be reflected through the weights to avoid subjectivity and randomness.

Land use suitability of lake areas at urban fringes is a very dynamic process. The adjoining areas of the Sasthamkotta lake mainly includes grasslands and vegetative cover. Local ecological conditions can be improved by conserving these grasslands. The study will be a reference to policy makers and urban planners in the rapidly changing environment especially in developing countries. Allocation of land based on the land use suitability would enhance the ecological stability of the area. Incorporation of more criterions will help in achieving a better land use suitability classification. As a problem in future research, it is worthwhile to develop integrated approaches which can take into account the principles of selecting criteria and the uncertainties of different systems during human decision-making process related to environmental management and planning.

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