Land suitability identification for a production forest through GIS techniques

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Abstract
The main aim of this study was to identify the suitable land parcels for a production forest. Production forest is a forest plantation that has been specifically planted on economical objectives. In this study, the land suitability analysis has been carried out to identify suitable areas within the University of Peradeniya, Sri Lanka for a production forest. Climate, slope, soil, topography, vegetation, accessibility were considered as important factors in identifying the suitability. In this study, climate and soils were considered as homogenous throughout the study area. The required spatial layers were obtained from existing topographic map sheets of 1:10000 scale and the land use/ cover map of the area of 1:10000 scale. The spatial layers were digitised and incorporated into the Geographical Information System environment. Criteria for suitability have been identified as the areas having 30 –60% land slope, areas with non permanent land use, good accessibility (at least 50 meters from an existing road) and the areas away from fire hazards since sporadic incidences of fire are reported in the area. The digital layers were reclassified and given weightings to be analysed further. Finally, suitability map was prepared with three suitability categories namely, suitable, moderately suitable and not suitable.
According to the final suitability map, 5.35ha of land is under highly suitable category and 0.65 ha of land is under moderately suitable category. The majority of the land (68.5ha) is not suitable according to the given criteria. It is recommended that a field checking should be carried out in suitable and moderately suitable land areas for further verification before implementing any aforestation activity.

Introduction

Uses of the land to humankind are multi-facet. As a source for primary production system, it serves as a store of water and nutrients required for plants and other living organisms. Proper use of land is essential to obtain the maximum benefit out of it. The proper use includes growing of suitable crops and plants, efficient soil & water conservation measures etc. Land as a resource cannot be measured by the surface area alone, hence the types of soil which is critical for productivity, underlying geology, topography, hydrology and plants and animal population also have to be considered. These attributes limit the extents of land available for various purposes. The growing population, industrialisation and misuse & overexploitation of land resources have in effect increased the demand for land.
The total land area in Sri Lanka is 6.56 million hectares. In Sri Lanka, population increase has significantly changed the use of land since independence. The per capita land availability in the country in year 1871, when the population was 2.4 million was 2.7ha. It has reduced to 0.38ha in year 1991 when the population was 17 million. This value is expected to be going down further with the forecasted growth of population (Natural Resources, Energy & Science Authority of Sri Lanka, 1991). The degradation of land resource due to overexploitation & misuse and consequent economic, social and environmental impacts have intensified the pressure on the land resources in the country. Cultivation and settlements in unsuitable land is a grave problem in major upper watershed areas. This has been identified as a significant threat to the productivity of land and also to the downstream reservoirs constructed for hydropower generation and irrigation purposes. The lifespan of the reservoirs can be reduced considerably due to siltation as a result of high soil erosion in the headwater areas. Water quality problems have also been encountered in major agricultural areas as a result of over-fertilisation (Department of Census & Statistics, 1998). It has been observed in Sri Lanka that the extents under agriculture and human settlement and other uses have gone up and the extents under forests and wildlife conservation have gone down rapidly. This clearly illustrates the fact that the growth of agriculture and other human activities have exerted pressure on the extents under forests and wildlife conservation. Therefore, it is of paramount importance to identify suitable land for various uses in optimum utilisation while causing minimum impact to the environment.

Land Suitability Evaluation

The first stage in evaluating land and preparing a land-use plan to gather data to classify the land according to their use is called land suitability. Land capability, which is also considered as land suitability (FAO, 1978) is primarily the potential biological productivity of land. Productivity of land can be determined by four main components of the environment namely climate, local topography (ruggedness, steepness, exposure-which cause local variation in climate and disposition of soil type), soil and existing vegetation. Land suitability evaluation involves identifying land use patterns and the economic & environmental feasibility of its current use.

Land Suitability Mapping with GIS

Traditionally, spatial data has been acquired and rendered into pictorial form to accomplish variety of activities related to land resource management. With the introduction and dissemination of high speed computers and of data capture and display devices, the importance of developing a computer based system of efficient and cost effective land resource data management was emphasized. As a result, database systems for spatial data, commonly named as Geographical Information system (GIS) were designed and developed enabling the acquisition, compilations analysing and displaying topological interrelations. Therefore, it is apparent that the accomplishment of almost any project aimed at land resources planning may be greatly facilitated by the use of and efficient GIS.

Useful land suitability assessments cannot solely be based upon biophysical resource information. Transportation networks, scale dependent localised economies, and social factors such as education and demographics dealing with large number of spatially related information have also to be considered in this process (ESRI, 2002). The surface and overlay analysis capabilities in GIS can effectively facilitate in handling this vast amount of spatial information. Today, remote sensing and are playing a very significant role in land evaluation systems such as production of land suitability maps (Perera & Tateishi, 1994).

Aim & Objectives

The main aim of this study was to identify the suitable land parcels for a production forest within the premises of University of Peradeniya, Sri Lanka. The objectives include studying of existing land use, topography, road network etc. in the study area, identification of suitability criteria for a production forest and compilation of the information in GIS for further analysis.

Methodology

The complete methodology includes identification of the spatial characteristics of the study area, conversion of information into digital form, suitability analysis within the GIS environment and presenting the outputs using a thematic map.

The Study Area

The University of Peradeniya is located in the Central province of Sri Lanka and is the largest residential university in the country. University is located in the foothills of Hantana mountain range and is spread over a considerable extent of land. A significant part of the university land is covered by plantation forests. A number of forestry related subjects are offered by the university hence, it was decided to identify the existing suitable land for a production forest with native species so that the students have accessibility to study the production forest environment. Figure 01 presents the existing land use condition of the area.

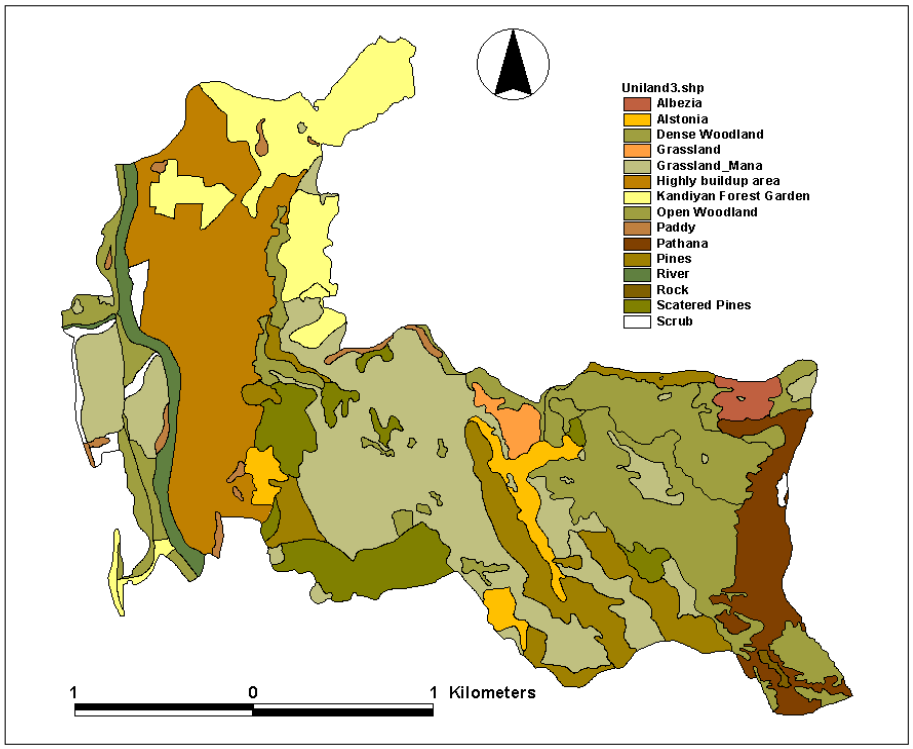

Figure 01: Land use of the study area

Data and Required Information

The topographical map sheets of 1: 10000 prepared by the Survey Department of Sri Lanka (1993) were used to identify the topography of the area. The land use/ cover map prepared by the Forest and Environment Conservation Division of Mahaweli Authority of Sri Lanka (1991) was used to obtain the land use and road network. Criteria for analysing land suitability for a production forest has been identified through a literature survey. Accordingly, highly accessible, high soil depth low fire hazard land of between 30% to 60% slopes with no perennial vegetation have been identified as the most suitable for a production forest. In order to be economically viable the size of the land parcel should not be less than of 10ha though it was not considered in this study.

GIS Analysis & Map Preparation

The maps were scanned & screen digitised and the thematic layers of land use, slope, accessibility, fire hazard were prepared with the help of GIS. Land use/ cover classes of 'mana' grassland and scrublands were identified as suitable, scattered pines and open woodlands as moderately suitable and other perennial vegetation and built up areas were identified as not suitable. The slope map was prepared with the contour information and is presented in Figure 02.

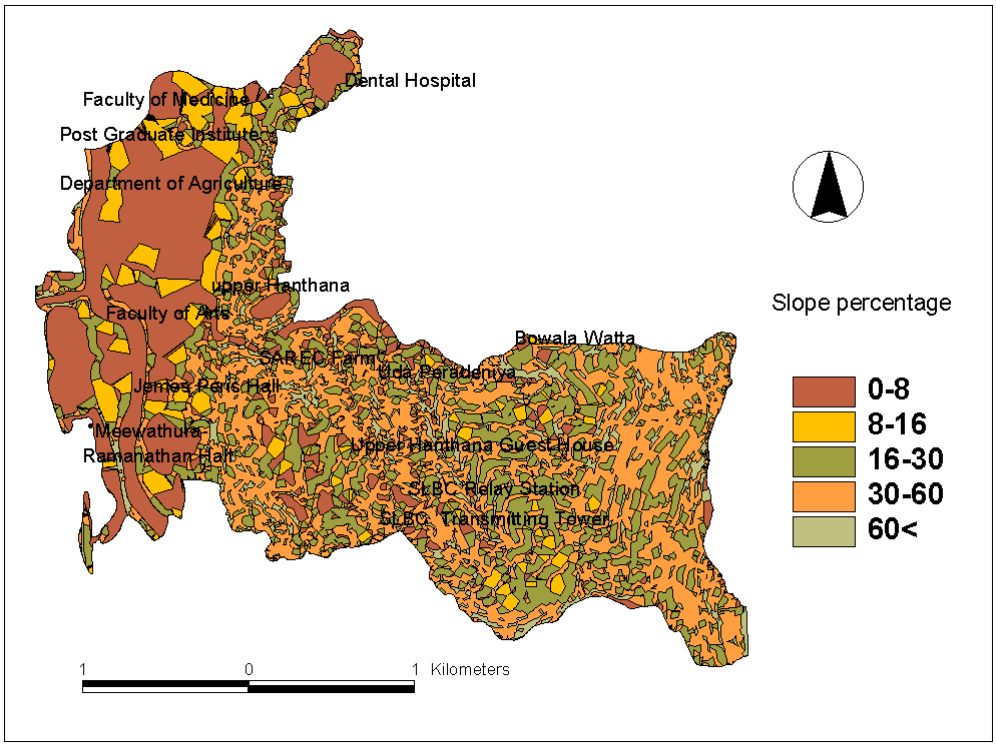

Figure 02: Slope map of the area

Considering the size of the study area and the limited information availability on soil, it was decided that the climate and the soil depths are constant. Fire hazard zonation and the accessibility maps were prepared according to the proximity to existing road network. In this process, five meter distance from the roads were identified as highly vulnerable to fire, 5-10m as moderately vulnerable and >10m as not vulnerable. Up to 40m distance from an existing road was taken as highly accessible, 40-80m as moderately accessible and >80m was taken as poorly accessible. The criteria were analysed to give suitable weightings to the thematic layers to prepare the final suitability map. The Figure 03 presents the complete flow of the methodology adopted in this study. Finally, the suitability was identified using three categories namely, highly, moderately and not suitable for a production forest.

Results & Discussion

The prepared land suitability map for a production forest is presented in Figure 04. According to the map, 5.35ha of land is under highly suitable category and 0.65 ha of land is under moderately suitable category. The majority of the land (68.5ha) is not suitable according to the given criteria. However, the suitable land parcels do not fulfill the requirement of minimum 10ha size of plots in order for the production forest to be economically viable. However, since the main objective of having this within an academic environment is educational, that minimum plot size was not taken into consideration. No field checking was carried out to verify the obtained results hence it is recommended to carry out a field checking with the prepared map

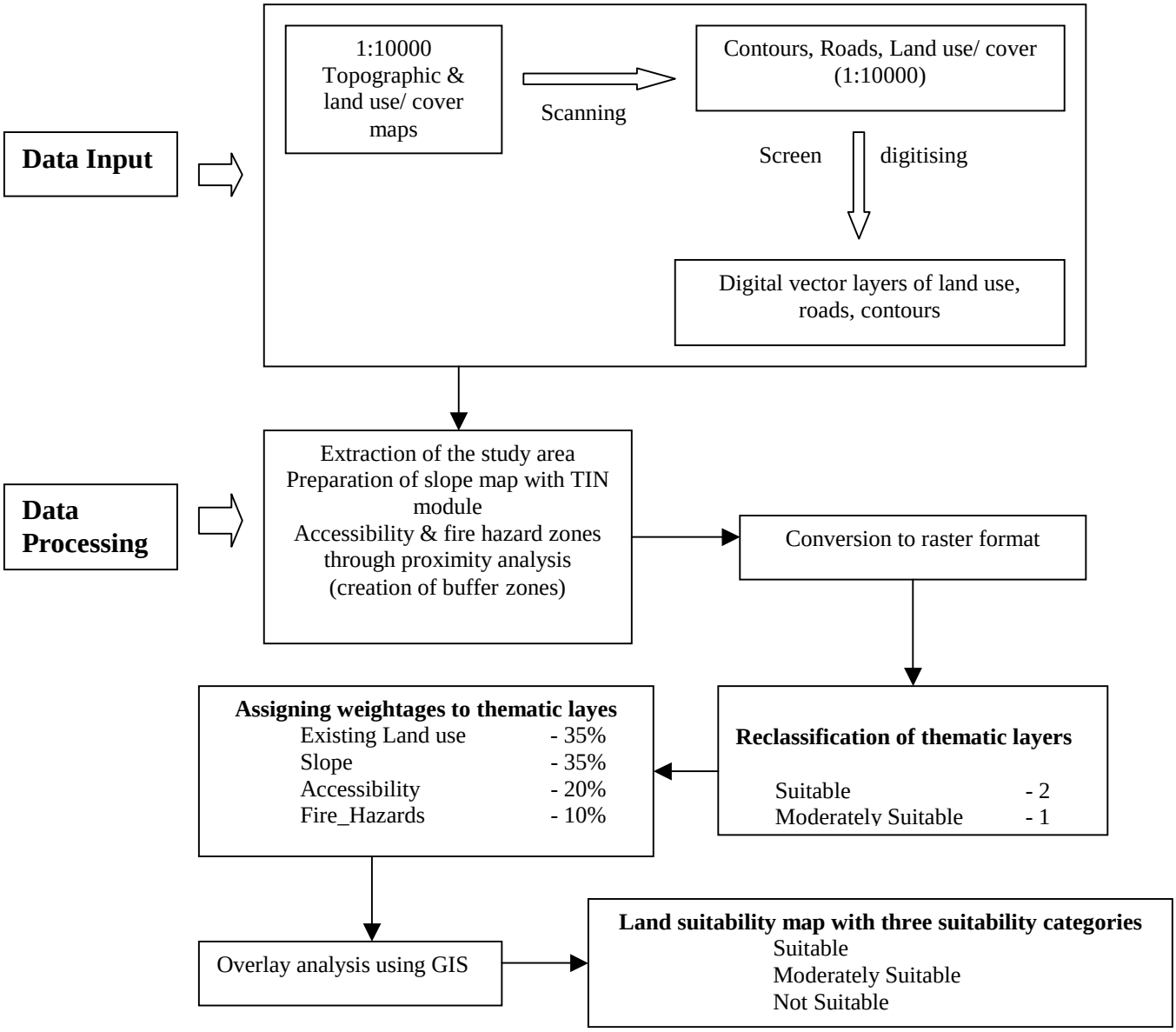

Figure 03: Flow diagram of the methodology

Conclusions

This study demonstrates an attempt to use the available spatial information for the identification of suitable areas for forest plantations in the university lands. According to the results of the study, it can be concluded that there is a very low potential for forest plantations in the university lands. Perhaps, a different land use scenario would be better suited for these lands and further studies need to be formulated to identify the best land use options for these lands in the university.

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