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HABITAT SUITABILITY MODELLING FOR FOREST ELEPHANT

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ABSTRACT

The primary intent of this paper is to demonstrate how Geographical Information System (GIS) and a modular modelling method can be implemented and utilized by agencies and authorities to create various management schemes and options for an overview and assessment of habitat suitability modelling for forest elephant. An overview of forest elephant habitat suitability applications with regard to GlS illustrates a broad expanse of activities. GIS capabilities include data capture through scanning and manual digitizing, data processing and manipulation, cartographic modelling (map overlay) imaging, map production and query. GIS is therefore an important tool in conservation management with several advantages and very useful in planning and taking decision in wildlife management. It was clearly evidence that scale-dependent species-environment relationship assist in predicting and understanding of spatial distribution of elephant with respect to particular space for feeding, habitation, safe place to spend their times and avoidance of human treats. It also revealed that GIS was an instrument for observing, monitoring forest elephant habitat selection and migratory away from human threat due to their activities as well as protection of endangered species. The paper therefore concluded that GIS have assisted tremendously in management of elephant. Maps derived from hssabitat suitability modelling can be used to facilitate conservation, help to explain variation in abundance and distribution of species in terms of habitat characteristics.

Key words: Geographical Information Systems, Habitat suitability, Modelling, Forest elephant

Introduction

Geographical Information Systems (GIS) has been widely acknowledged as an important tool in conservation management, it is used in planning strategies and decision support in protection and management of biodiversity (McNulty, 2013). Maintaining a balanced and diverse habitat selection system inhibits the possibility of fragmentation, degradation and depletion of natural resources (food and land cover), environmental conditions, safe place for species to spend their times as well as avoidance of human threats, which are essential to global forestry conservation (McNulty, 2013; Boyce *et al*., 2002). Habitat selection constitute a means in which animals in their environment select and show preferences for a particular space for feeding and habitation (Manly *et al*., 1993) and according to Valeix

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et al. (2011) this attribute is driven by several factors such as the availability of high quality food resources, competition and risk from predation. Employing data from other sources combined with environmental variables can be used together to predict the distribution of species through the analysis of intensity of resources with selection and distribution models (Graham and Hijnans, 2006; Boyce *et al*., 2002).

The importance of scale in the selection of habitats and resources by forest elephants has been emphasised (De Knegt *et al*., 2011; Boyce, 2003). De Knegt *et al.* (2011) demonstrated the capabilities of GIS in analysis of the effect of environmental characteristics at various large scales ranges in assessing and predicting habitat selection by African elephants. The study carried out in South Africa (Kruger National Park (KNP), showed that assessment of habitat selection is dependent significantly on the scales, the variables of environment are factored and that the predictive capacity of habitat suitability models increases depending on the setting at landscape scales. The results of the study show that habitat selectivity and response of the elephants are scale-dependent and more of hierarchical pattern. Forage characteristics at coarse spatial scales and surface water at fine spatial scales were identified as the major drivers for habitat selection. It was discovered that elephant seek for different resources at both smaller and larger spatial scale depending on availability of forage; resource distribution as well as human threats. Habitat is said to be of high-quality when it can provide high carrying capacity and support high rates of growth, with respect to survival, or reproduction for a given species, while unsuitable habitat will have little or no carrying capacity (Boyce *et al*., 2002; Boyce and McDonald, 2000).

The method involves analysis of the responses of the elephants to their major requirements of food and water through spatial scaling. Elephant occurrence data and environmental variables were all entered into a GIS with 1-km resolution and referenced to a regular grid covering the study area. The map displayed showing general distributions and the Habitat selection by elephants was analysed by comparing the environmental variables to the reference conditions in the study area using the analytical tools Mahalanobis distance statistic (D2); the ecological-niche factor analysis (ENFA) and the Mahalanobis distance factor analysis (MADIFA) (De Knegt *et al*., 2011). An overview of forest elephant habitat suitability applications with regard to GlS illustrates a broad expanse of activities.

Application of Geographical Information Systems (GIS) in Habitat Suitability Modelling for Forest Elephant

The use of GIS in wildlife management for example have been demonstrated with its ability to model and assess habitat, species population, abundance and spatial distribution, habitat use and preferences (Brambilla *et al*., 2009; Reza *et al*., 2013). Whatever that affects a particular species of interest in terms of its distribution and abundance required the application of knowledge of the extent, spatial arrangement and connectivity in conservation management. The incorporation of GIS technology is an instrumental factor for the observation and monitoring and management of forest elephant habitat selection and migration, human threats due to their activities, carrying capacity as well as the protection of endangered species (McNulty, 2013).

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Several methods are applied in predicting habitat selection of species (Guisan and Zimmermann, 2000; Austin, 2002). For instance, Austin (2002) described the generalised linear models (GLMs) as techniques utilised in estimating the dependent variables function as a linear combination of a set of predictors applied in predicting habitat selection of species. Austin (2002) explained that the GIS are utilised for matters such as comprehensive statistical foundation for ecological modelling relationship accomplished by working with GLMs which is an important tool for distribution of species. The application of this model involves dividing the study area into cells and data on the account of species being absent or present with respect to abundance. Determinations of species spatial distribution related to their variables within the grids are referred to their spatial reference (Augustin *et al*., 1996; Boyce *et al*., 2002).

In another study for example in Sumatra, Indonesia, GIS was used to predict the distribution of Asian elephant habitat using the presence-only modelling (Rood *et al*., 2010). The study area is within a protected area, known as Ulu Masen Ecosystem covering 75,000km of both lowland and Mountain forest. The study looks at both abiotic and biotic characteristics that affect elephant distribution in the area. Three Landsat Thematic Mapper with satellite scenes were used for collecting data, using regression algorithm as observed by (Moisen and Frescino, 2002). Stratified sampling method was adopted to collect data which include 12 different sites at 500m intervals each covering three types of covers; 300 transects lines of 5m wide and 200m. While Global positioning system (GPS) was used in confirming the availability of dung in the area which indicates the presence of elephant in the study area. A GIS technique in association with habitat suitability conservation goals and practices enhances the assessment and usefulness of these numerous applications.

With the incorporation of GIS index values, the mapping and analyses of areas of potentials distribution for a species can be carried out which permits a more accurate evaluation (WCS, 2005). The use of variables in building up the suitability model using GIS techniques, the database capabilities of GlS allows for a more informative and powerful representation of spatial information. For instance, the technique ranges from forest encroachment map used to develop two layers estimating vegetation productivity (ii) 90m by 90m digital elevation model used to develop two layers estimating high terrain ruggedness (iii) Employing GlS, high curvature values which is associated to exposed area or elevated (iv) Spatially explicit habitat suitability model was equally developed to integrated the three layers. The model was applied to cover the ecological variations available in the studied area. Ecological niche factor analysis (ENFA) was used and findings show the areas with high potential presence of elephant distributions as well as Habitat suitability index which account for the effect of forest encroachment destruction on elephant distribution (Rood *et al*., 2010).

Mongkolsewat and Chawket (2007) used GIS and satellite data for the assessment of Asian elephant in Thailand. Different methods used include ground survey and spatial analysis of habitat variables for Asian elephant to establish a condition for them as well as logistic regression model according to Mongkolsewat and Chawket (2007) as cited by the authors. Overlay operation was performed to display habitat suitability map for the Asian elephant which are assessed and evaluated through the GIS. It is in habitat suitability assessment that contemporary technologies associated with GIS, used were sourced from landsat thematic mapping (LTM); topographic mappings, ground survey and Geographical Positioning System

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(GPS). The case in point is acquisitions of basic environmental variables, which include food and land cover; physical landscape (elevation and slope) as well as unknown activities. With such information, mapping habitat suitability of forest elephant was carried out by Wildlife Conservation Society's (WCS, 2005) using Living Landscapes Programme method, a GIS-based conservation modelling technique for analysis and assessment of habitat suitability for various types of species. The model emphasises the importance of both biological and human landscape layers considering the impact of species habitat and the threat human pose to the species (Forest elephants). The modelling capabilities of GlS have been quite effective in these applications.

Rood *et al.* (2010) employed the Boyce validation technique to validate Habitat suitability (HS) model which shows that there was a good correlation between various values considered which include expected and observed values as well as habitat suitability scores using 160 random pseudo-absence calculated in addition to obtained predictive power. With information and data produced by GIS model predictions from the maps clearly indicate that elephants are predominately found along the valley by the edges of the forest which shows that there choice of habitat is influenced by high density of forest cover composition and vegetation productivity. The result of the study revealed that there was a drastic decline in range and numbers of elephants along road network, flat areas; steep slopes and areas due to human encroachment expanding their habitat. Outdated or scanty data are available; not reliable and is not easy to compare the data, have being the challenges of the study. Likewise ecological niche factor analysis does not indicate that all habitats are suitable to elephant in the area (Boyce and McDonald, 2000).

Areendran *et al*. (2011) use spatial analysis and remote sensing data for the assessment; dispersal corridor and habitat suitability for elephant in Central India. Methodology of assessment is Analytical Hierarchy Process (AHP). Weighting were assigned to environmental factors of importance which include nearness to water source; vegetation cover and human present. The results of the analysis identified the migration and movement routes of elephants along specific corridors.

Advantages of Geographical Information Systems (GIS)

- Before the advent of GIS technology, conservation managers rely on information that have to be carried out through extensive field work which is time consuming and take up a lot of resources (integration of many information).
- GIS provides an opportunity to use existing and readily available information from different sources.
- GIS capabilities include data capture through scanning and manual digitising, data processing and manipulation, cartographic modelling (map overlay) imaging, map production and query.
- Its uses in predicting habitat suitability for species based on known environmental attributes has proved to be a powerful tool in wildlife conservation.
- The implementation of GIS to produce habitat suitability maps is similar to conventional cartography but GIS with its analytical query capability makes it the preferred choice over manual cartography.

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- It has the ability to store and assess the habitat data that was not possible in earlier programmes being analogy.
- Within the last decade, GIS technology has been widely accepted to have contributed positively in the study of elephant ecology.
- GIS is very useful in planning and taking decision in wildlife management.
- Maps derived from Habitat suitability modelling can be used to facilitate conservation, help to explain variation in abundance and distribution of species in terms of habitat characteristics (Areendran *et al*., 2011; Boyce and McDonald, 2000).

Disadvantages of Geographical Information Systems (GIS)

- Despite the capabilities of GIS as a powerful tool for wildlife conservation purposes It can equally give wrong impression of reality.
- The issues of data sources, uncertainties and accuracy are potential sources of errors and limitations in the application of GIS.
- However, more attentions are required in the area of using GIS to evaluate existing elephant geographical distribution and habitat preference. Hence, this paper focuses on the application of GIS in habitat suitability modelling for forest elephant.
- To establish an equitable scheme amongst resource conservation and resource use, specified activities must be reconciled and has become a global concern (Areendran *et al*., 2011; Boyce and McDonald, 2000).

Conclusion

The importance of GIS as a tool in conservation management has been acknowledged, it is demonstrated that GIS is very useful in planning and taking decision in wildlife management. Maps derived from Habitat suitability modelling can be used to facilitate conservation, help to explain variation in abundance and distribution of species in terms of habitat characteristics. Results from the models can also be used in making decision on increment or restoration of critical habitats. The studies demonstrate that the consideration of scale-dependent species–environment relationships can assist in predicting and understanding of the spatial distribution of elephants more effectively. It also shows that spatial scale is a major consideration in the analysis of spatial configuration in ecological context which can give significant outcomes.

Recommendations

Further studies should be carried out on fragmentation, corridor and habitat suitability of elephant and their complexities to support habitat resilience and conservation management. As a priority, efforts should be directed at looking into the connectivity of the respective elephant distribution in the area. The need for data accuracy and model validity must be addressed through careful and adequate data collection that meets the required quality and requirement for the application

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