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GIS In Analysis of potential Sites For Ecotourism – A Case Study of Kwale County

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Abstract: *The Ecotourism is considered as the most attractive subset of tourism industry which can contribute to natural resource conservation and local development under proper management. The most stable solution in developing countries for developing ecotourism is through proper assessment, identification and prioritization of different areas with the capacity to support tourism within the counties and country at large, and then creating enabling environment through infrastructure creation. This paper presents an identification of the potential areas for ecotourism in enhancing the socio-economic status of the indigenous communities of the Kwale County, using Analytic Hierarchy Process and Geographic Information System. The research used satellite data and weighted overlays of auxiliary data from analytical hierarchy process which were then integrated with other GIS datasets to evaluate and assess the ecotourism potential in Kwale County. The analysis indicates that the highly suitable areas are mainly located in Matuga constituency and LungaLunga. Matuga is characteristically endowed green forests and abundances of wildlife, since Shimba Hills Game Reserve and Mwaluganje elephant sanctuary are located here. LungaLunga also has a variety of forests and mangrove.The moderately suitable areas are mostly located in Kinango and Matuga constituencies, since most of these are largely free from urban settlements with a unique and outstanding natural beauty, diverse attractions and great tourism potential. The marginally suitable areas were located in Kinango and parts of LungaLunga constituencies. These areas have low levels of visibility and a presence to settlements. The unsuitable areas for ecotourism were mainly located in parts of Kinango, Matuga and LungaLunga. These areas are generally rugged, have settlements or are not visible thus lack scenic beauty.*

Keywords : *Ecotourism, Geographic Information Systems, Analytic Hierarchy Process*

I. Introduction

Since the late 20th century, there has been a growing trend towards ecotourism in both the developed and developing world. This is because ecotourism brings together the elements of a self-sustaining society through sharing the benefits resulting from tourist activities. At its core, nature is among major areas where ecotourism is ensuring emergence of a better environment for the future generations. The welfare of the community within the tourist sites is another area where ecotourism pays a keen interest, through ensuring that the community gets an economic return out of the activities undertaken around them. Through the giving back policy ecotourism tries to restore balance to our world.

Ecotourism is considered as the most attractive subset of tourism industry which can contribute to natural resource conservation and local development if it is properly managed. The sector has been growing at a fast pace with an estimated yearly growth rate of 20-34% since the 1990s [1]. In recent years, global ecotourism is estimated to generate as much as U.S. $300 billion in revenues annually [2]. It is based on the ecological principle and sustainable development theory which aims to conserve resources e.g. biological diversity, and maintain sustainable use of resources, hence bring an ecological experience to travellers, conserve the ecological environment and gain economic benefit to the communities. In an ideal situation, ecotourism can help conserve fragile biodiversity, build ties between parks and communities, and increase awareness of environmental issues; it also includes a profit impetus for businesses.

Ecotourism has several definitions although there is no consensus as to the best description. One of the earliest definitions of ecotourism was proposed by [3] stating that ecotourism is tourism that involves travelling to relatively undisturbed or uncontaminated natural areas with the specific objective of admiring, studying, and enjoying the scenery and its wild plants and animals, as well as any cultural features (both past and present) found in the areas. However, a more widely accepted definition was given by [4] stating that ecotourism is a form of tourism inspired primarily by the natural history of an area, including its indigenous cultures. Ziffer also added that an ecotourist visits relatively undeveloped areas in the spirit of appreciation, participation and sensitivity and these ecotourists practice a non-consumptive use of wildlife and natural resources and contributes to the visited area through labour or financial means aimed at directly benefiting the conservation of the site and the economic well-being of the local residents.

Ecotourism's perceived potential as an effective tool for sustainable development is the main reason why developing countries are now embracing it in their economic development and conservation strategies [5]. This can be judged with the help of criteria and indicators approach, which is basically a concept of sustainable ecotourism management developed in a set of principles, criteria and indicators [6]. A multi-criteria approach can thus be adopted based on application of relative weights to each criterion in a GIS environment.

II. Study Area

Kwale County is located in southern part of Kenya between 38.44° to 39.64°E and 3.56° to 4.70°S(Fig. 1). It has four major topographical features namely the coastal plain, the foot plateau, the coastal uplands and the Nyika plateau. The county has a monsoon type of climate; it's hot and dry from January - April while June - August is the coolest period of the year. Rainfall comes in two seasons i.e. short rains are experienced from October to December while the long rains run from March- June/July. The average temperature of the county is 24.2°C and rainfall amounts range between 400mm and 1,680 mm per annum. The main rivers and streams are Marere, Mwaluganje and Ramisi.

The County has immense ecotourism products presented by natural phenomenon like the Nyika plateau that provides opportunities in form of trekking trails, vantage points for bird watching, places for construction of Eco lodges and educational studies. The people have a rich heritage in terms of songs and dances, folklore, traditional cuisines, Swahili villages, artefacts, colonial ruins that are partially exploited, not exploited at all, exploited at the detriment of the environment and in most cases not known to be of touristic value.

The county also has rich titanium deposits with extraction activities. It also hosts small scale farming especially in the inland areas. A mixture of fruits, vegetables and cereals are grown giving the county huge agricultural potential. Fisheries also play a major role in the economic arena of the county accounting for more than half of the income of households along the coastline of the county.

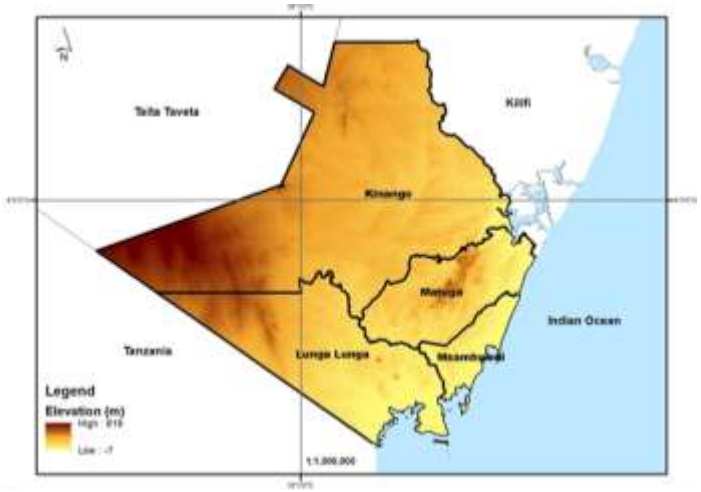

Fig 1: Map of Kwale County

III. Methodology

DATA COLLECTION

The primary data from the field survey was collected through interviews and questionnaires from experts, who were selected based on their knowledge in sustainable development and their experience in tourism, ecology, economics, wildlife conservation, natural resource management and GIS. The natural and cultural attraction sites were collected using a GPS receiver.

The secondary data required for this research were sourced from various government data centers and organizations. These data included administrative boundary maps, digital elevation models, road networks and forest maps, protected areas, satellite imagery and population data.

ANALYTICAL HIERARCHY PROCESS (AHP)

The 15 structured questionnaires were administered to respective professionals in the period of study November 2015 to January 2016. The questionnaires feedback were analyzed using AHP. There are three basic steps involved while considering decision problems using AHP method i.e. (1) decomposition - construction of a structural hierarchy consisting of a goal and subordinate features, (2) evaluation - establishment of pair-wise comparative judgments between elements at each level and (3) synthesis of priorities through propagation of level-specific, local priorities to global priorities [7]. The principal eigen value is used to

test the level of consistency for the weights derived. The principal eigen value and the corresponding normalized eigen vector of the pair-wise matrix give the relative importance of the various criteria being compared. The elements of the normalized eigen vector are termed as weights with respect to the criteria or sub-criteria and ratings with respect to the alternatives [8].

The consistency of the matrix of order ***n*** is evaluated. Comparisons made by this method are subjective and the AHP tolerates inconsistency through the amount of redundancy in the approach. If this consistency index fails to reach a required level, then answers to comparisons may be re-examined. The consistency index, CI, is calculated as [8]:

$$\boldsymbol{CI = \frac{\lambda_{max} - n}{n - 1}}$$

where$\boldsymbol{\lambda_{max}}$is the maximum eigen value of the judgement matrix. This ***CI*** can be compared with that of a random matrix, ***RI***. The ratio derived,$\frac{\boldsymbol{CI}}{\boldsymbol{RI}}$, is termed the consistency ratio ***(CR)***. The ***CR*** value suggested should be less than 0.1[8].

Table 1: The Saaty scale for weighting used in AHP

Scale	Explanation	Degree of performance
1	Two activities contribute equally to the objective	Equal weight
3	Experience and judgments slightly favor one activity over another	Moderate
5	Experience and judgments strongly favor one activity over another	Strong
7	An activity is favored very strongly over another and dominance is demonstrated in practice	Very strong
9	The evidence favoring one activity over another is of the highest possible order of affirmation	Extremely strong
2,4,6,8	When compromise is needed	Intermediate value between adjacent judgments

Source: Adopted from Saaty T. L. (1980)

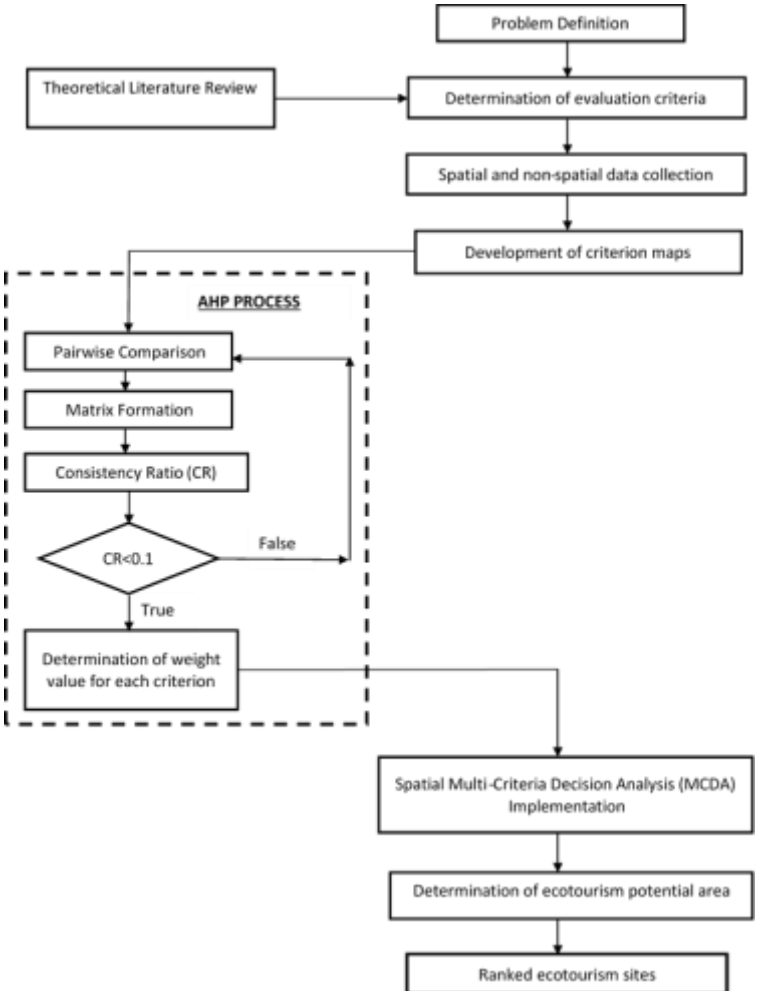

Fig 2: Summary of adopted methodology

STUDY PROCEDURE

The research adopts the use of GIS in analysis and additional algorithms such as AHP in the derivation of relative weights for weighted overlays. Various datasets e.g. topography, slope, protected regions, income levels, proximity to existing sites, are overlaid in a GIS environment. The methodologyadopted and a map of potential ecotourism sites was developed based on the evaluation criteria. Alternative sites can also be proposed based on the suitability index.The Table 2of criteria for this research adopts five of the seven key factors suggested as having applicability in ecotourism development according to [9]i.e. environmentally and socially responsible; focused on elements of the natural environment; managed in such a way as to have minimal environmental and social impacts; non-consumptive; capable of providing desired economic benefits to local residents; compatible with other resource uses in the area; and appropriate in scale for conditions and environment.

Table 2: Criteria and factors in land suitability analysis for ecotourism

Criteria	Factors		Factor Suitability Rating				
		Units	High	Moderate	Low	No	Reference
Landscape Naturalness	*Visibility (Line of sight)*	Kilometre	>6	4 - 6	1 - 3	0	[10]
	Land Cover	Class	Forested Areas	Vegetated Areas	Bare land	Urban	Interviews
Wildlife	*Protected Areas*	Class	Wildlife Sanctuary	Game Reserves	Non-Forest	Areas outside any criteria	Interviews
Topography	*Elevation*	Meters	300 – 400	100 - 300	> 400	< 100	[11]
	Slope	Percent	0 – 5%	5 – 25%	25 –	>35%	[11]
Accessibility	*Proximity to cultural sites*	Kilometre	0 – 10	10 - 20	20 - 30	>30	Interviews
	Distance from roads	Kilometre	Area outside	10 km Buffer	5 km Buffer	2 km Buffer	[9]
Settlement size	*Population*	Population Size	0 – 5	6 - 20	21 - 100	>100	Interviews

Source: Approach adopted from [12]

Criteria maps were developed based on the factor suitability rating in Table 2. Since the factors have different scales of measurement, they cannot be compared by their raw scores. Therefore the standardization of factors was done based on 4 levels: high, moderate, low and no ecotourism potential areas, in order to allow comparability.After standardization and applying weights to data layers, overlays of weighted maps was performed for each factor and finally the suitability map was achieved for ecotourism potential sites in Kwale region.

IV. Results and discussion

CALCULATION OF CLASS WEIGHTS

The AHP method is usually implemented using pair wise comparison technique that simplifies preference ratings among decision factors. In this study, experts' opinions were used to calculate the relative importance of the involved criteria and factors. The 15 experts from relevant organizations were involved through the administration of a questionnaire that contained pairwise comparisons of the 5 important criteria and 8 factors selected for this study. The calculations of pair wise comparison matrix and computation of consistency ratio are as given in Tables 3 and 4, respectively.

Table 3: Development of the pair wise comparison matrix

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**
Landscape/Naturalness (C1)	1.00	4.90	3.98	4.96	4.52
Wildlife (C2)	0.20	1.00	0.68	2.17	1.93
Topography (C3)	0.25	1.47	1.00	2.63	3.90
Accessibility (C4)	0.20	0.46	0.38	1.00	1.82
Community Characteristics (C5)	0.22	0.52	0.26	0.55	1.00
Total	1.88	8.35	6.30	11.31	13.17

Table 4: Computation of the criteria weights and the consistency ratio

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**SUM**	**Weight**	**Consistency Measure**
C1	0.53	0.59	0.63	0.44	0.34	2.53	0.51	5.37
C2	0.11	0.12	0.11	0.19	0.15	0.67	0.13	5.20
C3	0.13	0.18	0.16	0.23	0.30	1.00	0.20	5.17
C4	0.11	0.06	0.06	0.09	0.14	0.45	0.09	5.07
C5	0.12	0.06	0.04	0.05	0.08	0.35	0.07	5.09
Total	1.00	1.00	1.00	1.00	1.00		**CI =**	**0.05**
							RI =	**1.12**
							CR =	**0.04**

LAND SUITABILITY ASSESSMENT FOR ECOTOURISM

The total suitability score for each land unit i.e. each raster cell in the map was calculated using the following formula:

$$S_i = \sum_{i=1}^{n} W_i \times R_i$$

Where W_i is the multiplication of all associated weights in the hierarchy of i^{th} factor and represents the class weight given for specific class of thei^{th}factor found on the assessed land unit. Finally, the total suitability score from each factor were assembled to create site suitability map for ecotourism. The land suitability map was created, based on the linear combination of each factor's suitability score. The suitability maps were then organized to present 4 suitability classes for ecotourism (Table 5), indicating the degree of suitability with respect to the criteria and factors considered.

Table 5: Class Score Ranges for Land Suitability Classification

Suitability class	Score range	Degree of suitability
Highly suitable	3.63 – 4.31	Suitable capacity of locations is high and satisfies all criteria set up
Moderately suitable	3.00 – 3.62	Suitable capacity of locations is medium and satisfies most of the criteria set up, but some criteria are not satisfied
Marginally suitable	2.36 – 2.99	Suitable capacity of locations is low and satisfies some of the criteria set up, but most of the criteria are not satisfied
Not suitable	1.48 – 2.35	Can assume that all of criteria are not satisfied

Based on the suitability map, it was found that the areas marginally suitable is about 55.80% and are located in the western and central parts of Kwale County. The moderately suitable areas make up about 9.73% and are located primarily on the Western parts. 33.99% of the county was found not suitable for ecotourism. Only a few percentage 0.47 % of the area were classified as highly suitable, and were mainly located in protected areas such as Shimba Hills Reserve.

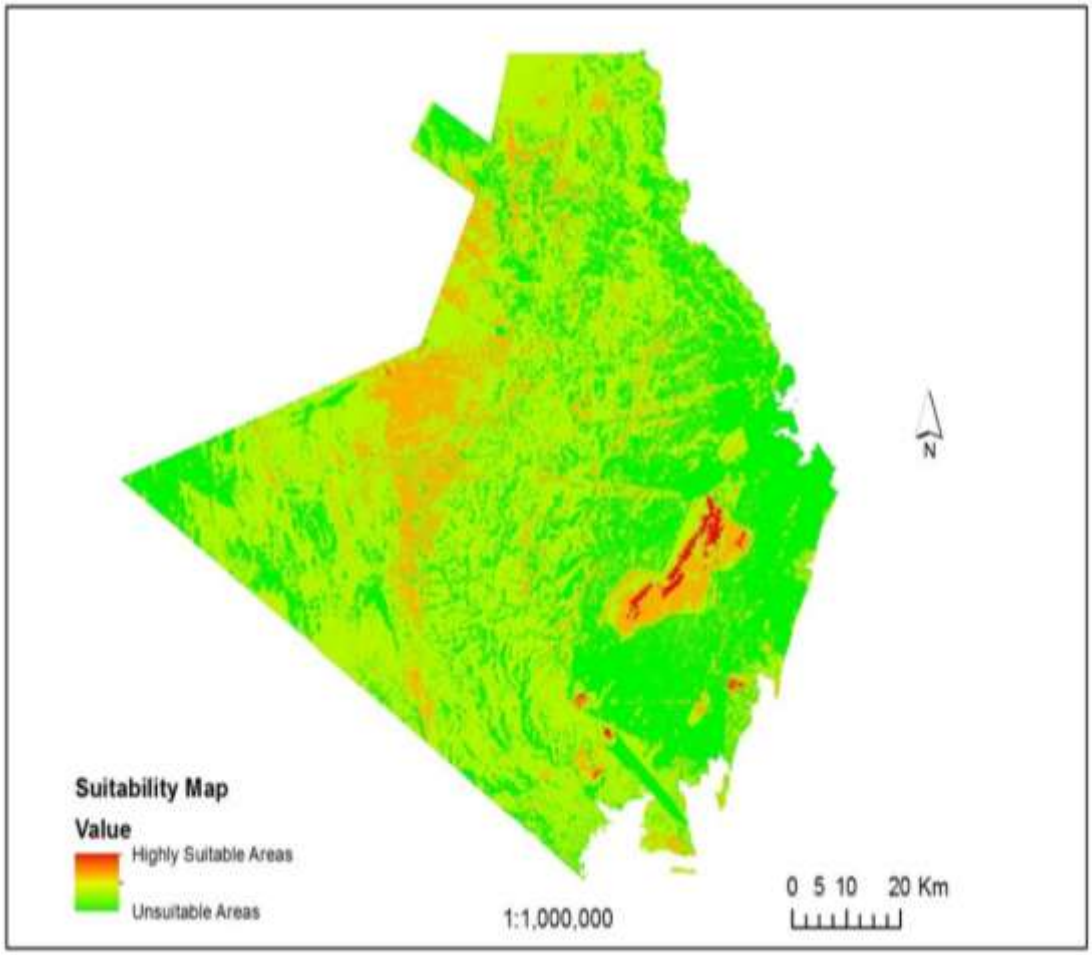

Fig 3: Classified land suitability map of ecotourism potential in Kwale County.

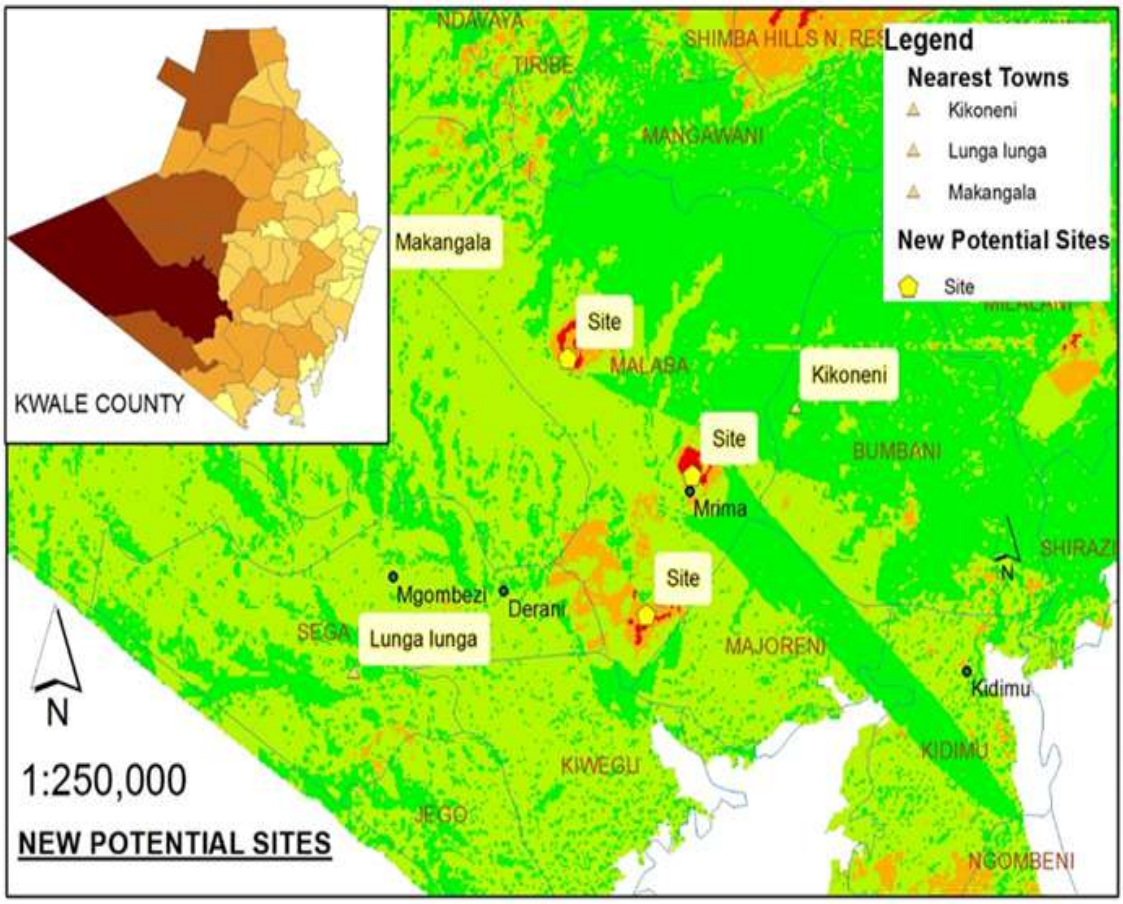

Fig 4: New Potential Sites in Kwale County

The potential sites identified in this study are majorly located in Malaba sub location, as shown in Fig 4. The first potential site is located at the middle between Makangala and Kikoneni towns. The second site is located on the south west side of the Kikoneni town near the Mrima town. The last potential site is located the southern side of the Malaba sub location, with Derani as the nearest town. The activities suitable for this sites includes; traditional dances and folklore, trekking, and educational tourism.

V. Conclusion

This study presents an integrated approach of GIS with AHP combination to assess the ecotourism suitability in Kwale County by matching the characteristics of an area with those attributes most appropriate for sustainable ecotourism.The research identifies and prioritizes the potential ecotourism sites in Kwale County, based on five criteria and eight factors in form of eight GIS layers. These factors and criteria were; landscape or naturalness (visibility, land use/cover), wildlife (reservation/protection), topography (elevation, slope), accessibility (proximity to cultural sites, distance from roads), and community characteristics (settlement size).

Based on the results of the research, the areas highly suitable for ecotourism were mostly located in the Matuga constituency which houses Shimba hills, Mwaluganje Elephant Sanctuary and Sheldrick Falls. The moderately suitable areas are mostly located in Kinango and Matuga constituencies due largely to absence of urban settlements with a unique and outstanding natural beauty, diverse attractions and great tourism potential. The marginally suitable areas were located in Kinango and LungaLunga constituencies. These areas have low levels of visibility and a presence to settlements. The unsuitable areas for ecotourism were mainly located in Kinango, Matuga and LungaLunga. These areas are generally rugged, have settlements or are not visible thus lack scenic beauty.

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