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REMOTE SENSING AND GIS BASED SITE SUITABILITY ANALYSIS FOR TOURISM DEVELOPMENT

Dr Kuldeep Pareta*

Abstract: *Geographic Information Systems (GIS) and Remote Sensing are now recognized widely as a valuable tool for managing, analyzing, and displaying large volumes of diverse data pertinent to many local and regional planning activities. Due to the complex nature of tourism planning issues, the potential of GIS in resolving these issues is increasingly acknowledged. This paper will discuss some of the potential of GIS applications in tourism planning. Generally, GIS applications in tourism have been confined to recreational facility inventory, tourism-based land management, and recreation-wildlife conflict; and have been limited by lack of funding, and uncoordinated procedures. Using the example of site suitability analysis for tourism development and mapping, this paper highlights some applications of GIS in tourism planning in Hai An, Quang Nam Province, Vietnam.*

As per our present study; the most suitable tourism site identified according to the analysis are within major towns (Hoi An). The urban centre with possibility to grow into tourism centres. The remaining land show low suitability scale due to lack of major attraction to create a strong pull factor. Accessibility is a prerequisite for tourism development. Good road network connectivity with proximity to railways station or airport showed strong tourist potential site, this coupled with nearness to scenic beauty depict a high suitability. Major tourist attraction such as heritage site, coastal beaches and water bodies or lake showed high suitability. This can be correlated to the fact that heritage sites and other high suitable features are translated into suitable tourism site.

Keywords: *Site Suitability Analysis, Multi Criteria, Tourism Landuse, Remote Sensing, and GIS*

***Senior Project Manager (RS/GIS & NRM), Spatial Decisions, New Delhi, INDIA

1.0 INTRODUCTION:

Geographic Information Systems (GIS) and tourism share a common characteristic, that is, both cross the boundaries of disciplines and application areas. GIS has been applied in many disciplines including geography, forestry, urban planning, and environmental studies. Similarly, tourism has been a subject of interests to geographers, economists, business, environmental planners, anthropologists, and archaeologists *(Wayne Giles, 2003)*[1]. As such, the potential for GIS applications in tourism is significant. GIS is now recognized widely as a valuable tool for managing, analyzing, and displaying large volumes of diverse data pertinent to many local and regional planning activities. Its use in environmental planning is rapidly increasing *(Bualhamam, 2009)*[2]. Tourism is an activity highly dependent on environmental resources. It is also a phenomenon, which in the event of a lack of planning and management is likely to erode its environmental base. Hence, the strength of tourism planning can be enhanced by GIS applications. GIS can be regarded as providing a toolbox of techniques and technologies of wide applicability to the achievement of sustainable tourism development.

This paper will discuss some of the potential of GIS applications in tourism. In particular, it will highlight the limitations of tourism-specific GIS applications. In order to evaluate the value and scope of GIS in tourism planning and development, this paper will review existing GIS applications which are pertinent in tourism planning *(Savigny, & Wijeyaratne, 1994)*[3]; discuss some methodological limitations in applying GIS in tourism planning; and identify some potential areas of applications in Hai An, Quang Nam Province, Vietnam. Site suitability is a process which analyzes the merits of possible locations in which a defined use or activity can be performed *(Opadeyi, & Nizeyimana, 2005)*[4]. Its purpose is to identify the most appropriate areas for a possible land use development activity, such as industrial development, tourism development such as agricultural land use, potential areas for forestry, and other such land use activities.

The process of site suitability requires the identification of the appropriate locations for a particular land use activity by considering physical resources *(Laurin, & Ongaro, 2006)*[5] (elevation, slope, aspect, climate), natural resources (soils, geology, hydrology, flora and fauna habitat, and environmentally sensitive areas), and existing land use and development (manmade facilities such as transportation systems, existing urban areas, and utility

networks). These different types of information constitute the "criteria" based on which the area under consideration *(Keeney, & Raiffa, 1993)*[6]. These criteria are individually considered to identify areas of opportunity (areas suitable to the land use under consideration) and constraints (areas not suitable to the land use under consideration). The main objectives of this study are: Protect and conserve cultural heritage and natural resources; Create new tourism opportunity; Promote ethnic diversity; and Facilitate equitable economic growth *(Zopounidis, & Doumpos, 2002)*[7].

2.0 STUDY AREA:

Hoi An is an exceptionally well-preserved example of a South-East Asian trading port dating from the 15th to the 19th century. Mixed cultural influence by French and Spanish traders and missionaries makes Hoi An a popular tourist destination in central Vietnam. Its buildings and its street plan reflect the influences, both indigenous and foreign, that have produced this unique heritage site. It has two world heritage sites; Hoi An Old Town, My Son Sanctuary besides numerous festivals and annual events happening all through the year. Da Nang airport facilitate good connectivity for tourists so, there are tourists visiting all round the year. This town attracts people because of its cultural and historical values. The Champa ruins and relics is a potential tourist attraction which date back to the 11th century AD. Evidence of Vietnam War on these ruins is an interesting fact for tourist *(ICOMOS, 1999)*[8].

Tourism in study area is mainly centered on Hoi An city (Figure - 1) due to the existing two world heritage and available number of goods and products for tourists. It has been noted that tourist spending in Hoi An is higher compared to Da Nang because it has more locally produced items as souvenirs and gifts. Increase in market products and rise in labor (direct and indirect) has been observed over the past years.

Figure - 1: Location Map of the Study Area

Tourism sector in study area has increase over the recent years. The total tourist inflow is observed to be 55 % domestic and 45% international at present. Annual average tourist budget increased is almost 50% from 2003 to 2007. Growth rate in tourist arrival is 30% from 2003 to 2007. Going by the current scenario and existing tourism potential, tourism sector is anticipated to grow in the plan years expecting to bring in more tourists thereby increasing employment opportunity *(Chettri, & Ghimire, 1995)*[9]. Tourism is expected to create a ripple effect into other sector with increase in employment in agriculture, services and household industry as well. Major tourist traffic inflows are to Hoi An city and coastal beaches. The tourism study shows that tourist comes to Hoi An for cultural tourism as well as relaxation. Hoi An is a major catalyst for Quang Nam tourism growth, the historic and cultural characteristics of the city attract large number of tourists.

Table - 1: Tourist Visiting Hoi An

Year	2007
Tourist Visiting Historic Town	158,315 (46.4% are foreign & 53.6% are domestic)
Average tourist in town	6,440/ per month, 215/ per day

3.0 DATA USED AND SOURCES:

Table - 2: Data Used and Sources

S. No.	Input Data Layer	Sources
1.	Base Map	▪ Topographical Map @ 1:25,000 Scale ▪ LANDSAT - 7 ETM+ Satellite Imagery (30 m Spatial Resolution) ▪ LANDSAT - 7 PAN Satellite Imagery (15 m Spatial Resolution) ▪ Other Related Maps
2.	Land Use Map	▪ LANDSAT - 7 ETM+ Satellite Imagery (30 m Spatial Resolution) ▪ LANDSAT - 7 PAN Satellite Imagery (15 m Spatial Resolution) ▪ Other Related Maps
3.	Topographical Map	▪ Topographical Map @ 1:25,000 Scale ▪ ASTER - DEM (30 m Spatial Resolution)
4.	Soil Map	▪ Republic of Vietnam General Soil Map ▪ Soil Map updated through Multi-Spectral Satellite Imagery
5.	Geological Map	▪ Department of Geology and Minerals of Vietnam ▪ Geological Map updated through Multi-Spectral Imagery
6.	Hydrology	▪ LANDSAT - 7 ETM+ Satellite Imagery (30 m Spatial Resolution) ▪ Topographical Map @ 1:25,000 Scale
7.	Environmental Sensitive Area	▪ LANDSAT - 7 ETM+ Satellite Imagery (30 m Spatial Resolution) ▪ Topographical Map @ 1:25,000 Scale

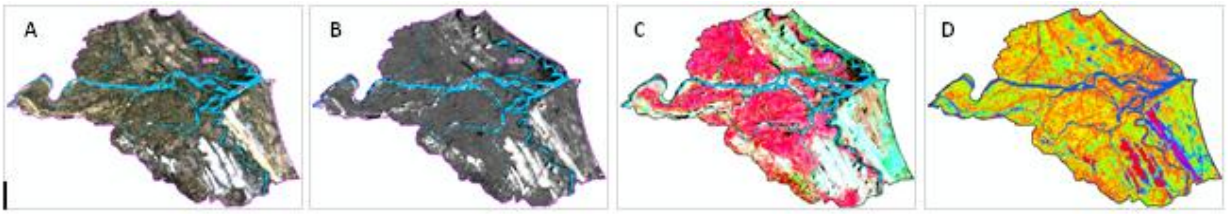


Figure - 2: A - LANDSAT-7 ETM$^+$ Natural Color Imagery (30 m), B - LANDSAT-7 PAN Panchromatic Imagery (15 m), C - LANDSAT-7 ETM$^+$ & PAN Merge Imagery (15 m), and D - NDVI using Landsat Satellite Imagery

4.0 METHODOLOGY:

The methodology for locating appropriate sites for each land use activity is guided by the intent to minimize the possible adverse effects of development on the environment and on existing communities, and to emphasize the positive impacts of such development, by locating them in a most suitable location *(UN Guideline, 1999)*[10]. This is achieved by examining a number of individual criteria, assigning them relative levels of importance as a whole, and using a mathematical resultant model to identify the most suitable location. By adopting this site suitability method, it is possible to systematically identify the criteria considered, clearly document the relative importance of one criterion over another, analyze the net outcome using a Geographic Information System, and then possibly revisit the mathematical relationships in this "decision model" *(Salo, & Hamalainen, 1995)*[11]. By revising the relative importance to identified criteria based upon the particular land use under consideration, it is possible to generate "suitability maps" for each individual land use, and then generate a final composite land use that is based on a best possible collective suitability of multiple land uses.

To achieve this, all the criteria are assigned a "rank" denoting their relative levels of importance within the suitability study. These ranks are assigned as numeric values ranging from 1 to 10, with 1 reflecting a low level of importance and 10 reflecting a high level of importance. For example, within the criteria of road networks, national highways would have a different level of influence on the suitability for a particular land use, as compared with local roads. Further, the distance from each of these features would further modify the relative suitability of a land use based on the proximity to a particular type of road. To appropriately include this geographic variability across the regional planning extent, a

similar scale of 1 to 10 is used to assign individual "weights" based on the proximal relationship to each particular feature type within a specific criteria used in the decision model *(Ligmann-Zielinska, & Jankowski, 2008)*[12]. Collectively, the weights, multiplied by the rank, provide a suitability score that cumulatively is used to identify the most suitable locations for the identified land use within the regional planning space, which is displayed as a "land suitability map".

4.1 - Criteria for Site Suitability Analysis:

The decision criteria for site selection are examined for assigning relative ranks and individual feature weights based on the land use type for which suitability is being examined. For benefit of analysis, the criteria under consideration in this paper activity are organized as:

Critical Criteria: Criteria that will be very significant in the site selection of the identified land use and will act as key drivers in the selection of the geographic location *(Get W. Moy, 2004)*[13]. These criteria can be clustered into a single decision model and the outcome collectively reviewed. These criteria have a strong influence in the final suitability.

Additional Criteria: Criteria that will have to be examined one at a time to carefully assess its relationship with the proposed land use activity. These criteria have a positive influence in the final suitability.

Constrained Criteria: These criteria impose strong negative opportunities in the selection of areas for the identified land use. Consequently, they inform of us of where the particular land use under consideration should not be located. These criteria serve to limit or exclude areas from the final suitability.

4.2 - GIS Site Suitability Analysis Model:

We were developed a tourism site suitability analysis model in ArcGIS - 9.3.1, which is shown in Figure - 3.

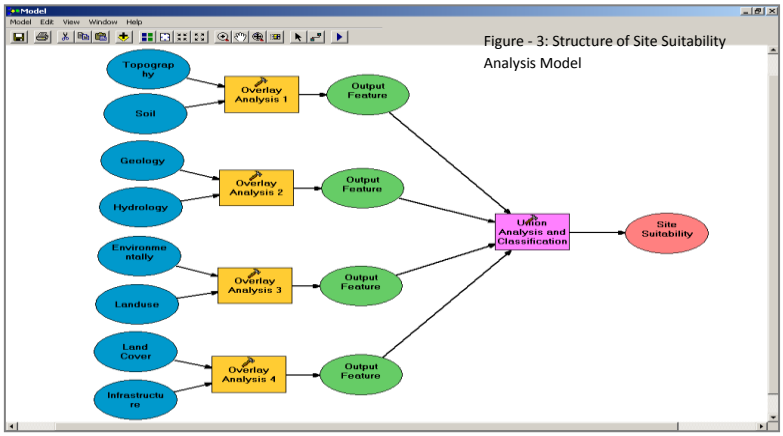


Figure - 3: Structure of Site Suitability Analysis Model

4.3 - Input Data Layer and Rank, Wright, and Score for Modelling:

Table - 3: Input Data layer, Data Description, and Suitability Score

Input Data Layer	Data Description	Ranks	Weight	Score
1. Topography	Elevation (0 to 2.5 meter)	5	1	05
	Elevation (2.5 to 5.0 meter)	5	8	40
	Elevation (More than 5.0 meter)	5	5	25
2. Soil Data	Soil Suitability for Construction Importance	5	3	15
	Soil Suitability for Open Space Development	6	6	36
3.Geological Data	Geological Suitability for Mineral Resource Importance	7	6	42
	Geological Suitability for Construction Importance	4	5	20
4. Hydrology	River (Buffer 0 to 50 meter)	8	7	56
	River (Buffer 50 to 250 meter)	8	6	48
	Lake (Buffer 0 to 50 meter)	8	9	72
	Lake (Buffer 50 to 250 meter	8	8	64
	Ocean (Buffer 0 to 500 meter)	9	9	81
	Ocean (Buffer 500 to 1000 meter)	9	8	72
	Ocean (Buffer 1 to 3 kilometer)	9	7	63
5. Environmentally Sensitive Area	Area Below 2.5 Meter	-4	2	-08
	White and Yellow Dune Sand	-4	3	-12
	Protective Forest Land	-4	7	-28
6. Land Cover Data	Forest	6	4	24
	Forest (Buffer 0 to 1 kilometer)	6	6	36
	Forest (Buffer 1 to 3 kilometer)	6	3	18
	Open Space	6	2	12
7. Land Use Data	Existing Heritage / Cultural Center (Buffer 0 to 5 kilometer)	9	9	81
	Existing Heritage / Cultural Center	9	8	72

	(Buffer 5 to 10 kilometer)			
	Existing Heritage / Cultural Center (Buffer 10 to 15 kilometer)	9	7	63
	Built-up Area	6	5	30
8. Infrastructure	National Highway (Buffer 0 to 1 kilometer)	7	2	14
	District Road (Buffer 0 to 1 kilometer)	7	4	28
	Minor Road (Buffer 0 to 250 meter)	7	7	49
	Coastal Road (Buffer 0 to 500 meter)	7	10	70
	Railway Station (Buffer 0 to 4 kilometer)	7	2	14
	Railway Station (Buffer 4 to 7 kilometer)	7	4	28
	Airport (Buffer 0 to 10 kilometer)	7	4	28
	Airport (Buffer 10 to 20 kilometer)	7	7	49

5.0 RESULT AND DISCUSSION:

Tourism land use requires equally good connectivity and accessibility besides infrastructure development. Given below is the rationale against tourism land use suitability analysis. This set of factors has been used to analyze the basic suitability of the region. This stage considers all the standard factors that normally determine the suitability of a region from tourism development standpoint. The scale for weighing and ranking is 1 to 10, with 1 being assigned to the factor with lowest importance and vice versa.

5.1 - Topography:

Elevation determines the level of land below and above sea level (Figure - 4). Low lying areas below 2.5 meters are prone to flooding, which is why it is assigned low weightage. Between 2.5 to 5 meters is considered best for any land use, beyond 5 meters it becomes relatively not so desirable.

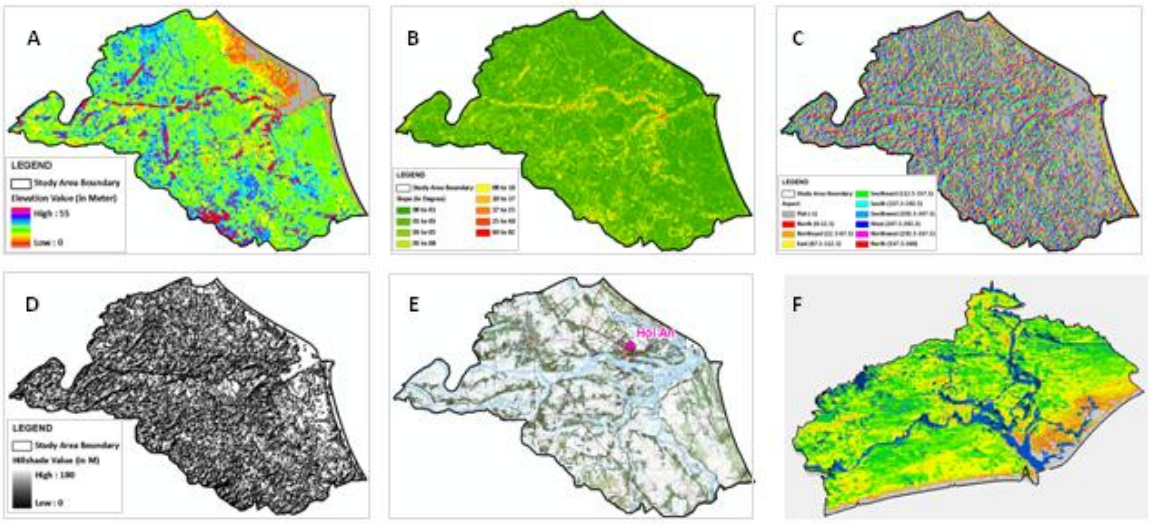


Figure - 4: Topographical Maps, A - ASTER - DEM with 30 m Spatial Resolution, B - Slope Map, C - Aspect Map, D - Hillshade Map, E - Toposheet (1:25,000 Scale), and F - 3D View of the Study Area

5.2 - Soil and Geology:

Soil is categorized into importance for open spaces and construction (Figure - 5). Soil has relatively less influence over decision making process for tourism location, yet, soils with less porosity and permeability is preferred to prevent ground water contamination from waste. In terms of geological suitability it is considered in relation to the importance of mineral resource and construction purpose (Figure - 6).

5.3 - Hydrology:

Water front are good recreational sites, with appropriate buffer it can be develop into high value for tourism activities. Following sub types are assigned different scoring as per their importance (Figure - 7).

Water Bodies / Lakes: Water bodies are ideal for tourism development as it provides a recreational space. They can be developed for appreciation and enjoyment for tourism related activities. They are awarded with high rank of due to this beneficial characteristic.

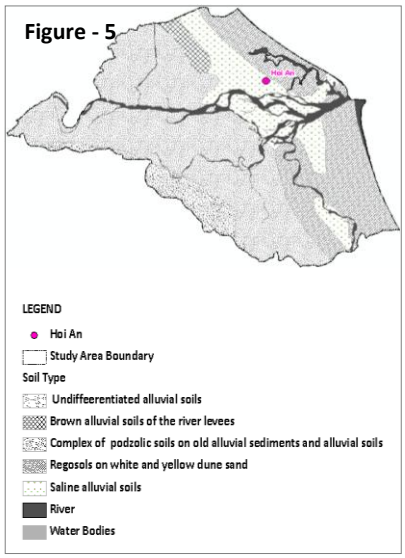
Rivers: Rivers and river fronts are potential recreational site. It can be developed into active sports and water-based recreational site. Activities such as white water rafting, fishing, swimming and bird watching site etc can be introduced to create tourist attraction.

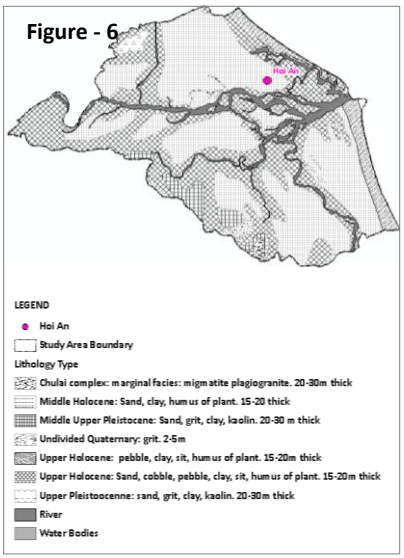
Ocean/Coast: Ocean and coast are the best location for recreational and tourist activities. They provide water related activities and relaxation along the beach. It is major tourist

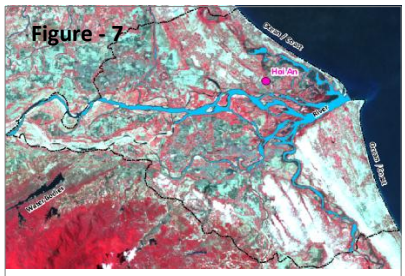
attraction as it has scenic value. Yet, ocean and coasts are environmental sensitive areas; they are home to some fragile ecosystem like corals and aquatic species and also vulnerable to natural hazards like cyclone and typhoon. Despite this fact, coastal areas are the most sought after tourism site, based on this it is awarded with highest rank of 9. Limited development should be allowed to protect them from getting damaged, buffer of 500 meter based on CRZ regulation has been applied here too.

5.4 - Environmental Sensitive Area:

Specific areas have been demarcated as environmentally sensitive (Figure - 8), this is done to avoid negative impacts and to prevent from aggravating nature hazards like flooding and resource depletion. Areas considered under these categories are; land below 2.5 meters, white and yellow sand dune, and protective forest land.







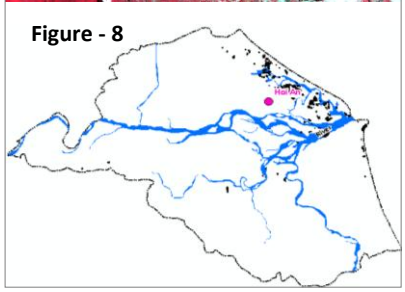


Figure: 5 - Soil Map, 6 - Geological Map, 7 - Hydrological Map, and 8 - Environmental Sensitive Area

5.5 - Land use / Land cover:

Existing heritage and cultural center are important tourist attraction (Figure - 9). They could be ancient cultural relic site or architectural remains. They hold value for tourist as they are an interesting object. Tourists are fascinated to see and learn information about new and unique cultural heritage. Such sites are favorable for tourism development so, a highest rank of 9 has been assigned to these sites.

Forest: Area of 1 km buffer of is taken to allow sufficient protection from encroaching into forest area. Land beyond this buffer is suitable for tourist, as it given a quiet getaway from

the polluted and noisy urban areas, much seek after by the tourist. A ranked of only 6 is given to this land use.

Built-up Area / Existing Urban Centres: Urban centres have already developed infrastructures and services which are required for setting up tourism sector. It can be further enhanced by creating few recreational areas to attract tourist. A rank of 6 has been assigned to this land use based on this condition.

Open Spaces: Open spaces can be developed into tourist area with the condition that it is proximity to existing tourist hub.

Existing Heritage / Cultural Site: This site has potential to grow into major tourist centre provide with good infrastructure, thus it has a high rank (Figure - 10).

Existing Tourism Recreation: his includes already existing facilities which acts as a catalyst for tourism development and expansion. It includes basic facilities like accommodation (hotels and resorts), tour and travel services, recreational spot and other tourist attraction which will pull more tourists into the area.

5.6 - Infrastructure / Facilities:

Tourism requires fair amount of connectivity over land and its surrounding area. One travels from point of origin to the destination in pursue of tourism related activities (Figure - 11). This is only possible by traveling from one place to another through road, rail, and air. Three means of transports are use for measuring tourism suitability here.

Road: Road network connects from major tourist transit to the interior parts of the region. It provides facility for easy and faster movement. In a terrain where other mode of transport cannot be built, road provide the most convenient means of transport. Road is the basic prerequisite so, it has been assigned with 6 rank.

Railway Station: It provides connectivity between smaller towns and urban area. They are not only cheaper but faster than road transport. Tourism potential area with railway connectivity has a better prospect to grow into a bigger tourism centre. Based on this railway stations are also allotted with rank 6.

Airport: Air connectivity is essential for tourism development. Air traffic brings in tourist from within the country and also from abroad. Air transport is fastest and most convenient mode of transport and it facilitate travel for tourist from far off places. Tourism related activities are not recommended right next to airport, since airports are also sensitive area,

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so a buffer of sufficient size should be allowed. A higher rank of 7 has been assigned to airport since it is a decisive factor in tourism development.

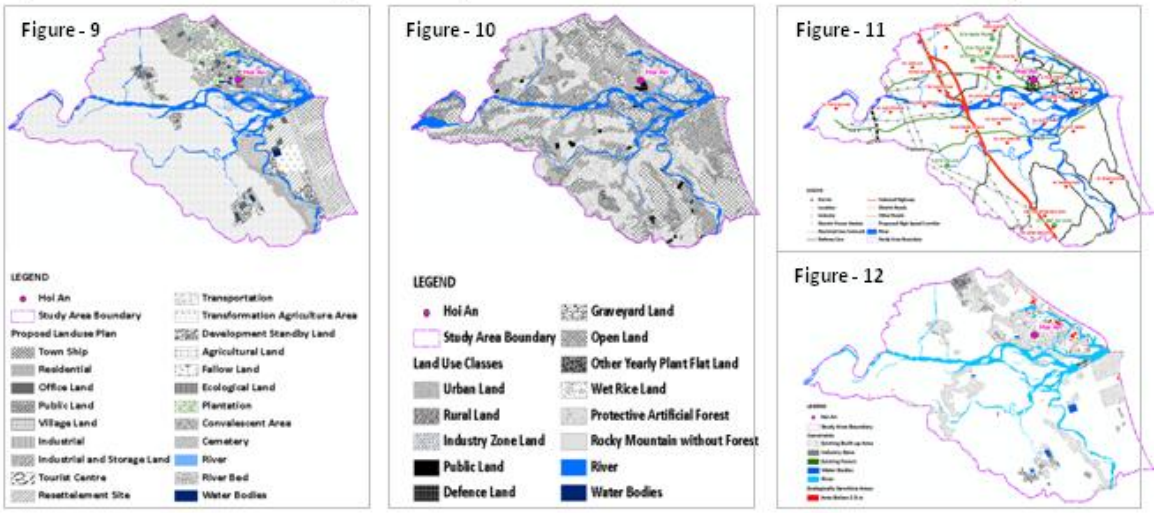


Figure: 9 - Existing Landuse, 10 - Proposed Landuse, 11- Infrastructure / Facilities Map, and 12 - Constraints Map

5.7 - Constraints Selected for Tourism Suitability Analysis are:

Areas which are not suitable for tourism development either due to absence of requisite characteristics or presence of non-confirming land uses are considered as constraints for tourism sites (Figure - 12).

These are: Ecologically Sensitive Areas, Existing Forest, Existing Built-up Area, Existing Industrial Zone, Lake / Ponds, River, and Ocean.

5.8 - Outcome of Suitability Map for Tourism Development:

The final suitability map (Figure - 13) has been displayed in a gradation of red to green. The green patches represent the most suitable locations for tourism development while the red patches denote the least. The most suitable areas are the ones which have got an aggregate score close to 10.

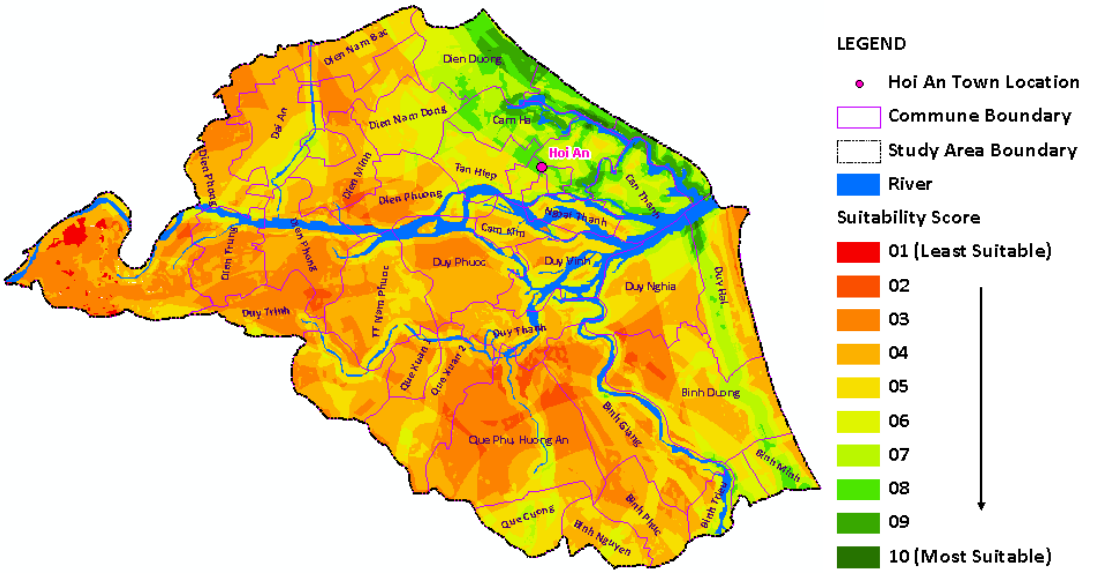
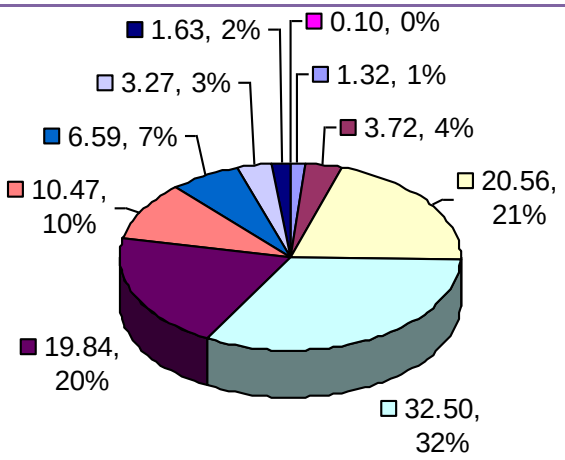


Figure - 13: Suitability Map for Tourism Development

Table - 4: Suitability Classes with Area in the Study Area

S. No.	Suitability Classes	Area (In Sq Kms)	(In %)
1.	Class - 1	04.83	01.32
2.	Class - 2	13.56	03.72
3.	Class - 3	74.95	20.56
4.	Class - 4	118.50	32.50
5.	Class - 5	72.33	19.84
6.	Class - 6	38.18	10.47
7.	Class - 7	24.01	06.59
8.	Class - 8	11.93	03.27
9.	Class - 9	05.95	01.63
10.	Class - 10	00.36	00.10
	TOTAL	364.59	100.00



6.0 CONCLUSION:

Tourism is a highly complex activity, and thus requires tools that aid in effective decision making to come to terms with the competing economic, social, and environmental demands of sustainable development. Applications of GIS in tourism and recreation planning illustrate that GIS is a strong and effective tool that can aid in tourism planning and decision-making *(Pareta, 2010)*[14]. The power of GIS lies not only in the ability to visualize spatial relationships, but also beyond the space to a holistic view of the world with its many interconnected components and complex relationships. Three important observations that can be made from the map are:

- The most suitable tourism site identified according to the analysis are within the major towns (Hoi An). They are urban centres with possibility to grow into tourism centres. The remaining land show low suitability scale due to lack of major attraction to create a strong pull factor.
- Accessibility is a prerequisite for tourism development. Good road network connectivity with proximity to railways station or airport showed strong tourist potential site, this coupled with nearness to scenic beauty depict a high suitability.
- Major tourist attraction such as heritage site, coastal beaches and water bodies or lake showed strong green colour depicting high suitability. This can be correlated to the fact that heritage sites and other high ranking features are translated into suitable tourism site.

Hence, the tourism zones that can be identified for tourism site are (in order of hierarchy based on the proportion of suitable areas in that zone):

- **Hoi An:** Hoi An is identified as the most suitable site for tourism development. It has maximum green patches which are translated from the existing characteristic such as proximity to Da Nang airport, good transport network and existing two world heritage site located within the town, supports tourism expansion for future. It can draw advantage from the fact that it is close to the coast and accelerate tourism activities from the town to other surrounding areas.
- **Coastal Area:** Coastal stretches are very attractive site for tourism development. Beach recreation and water based activities can be developed in these sites. To ensure environmental sustainability low development strategies are to be adopted.

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