

GEOGRAPHICAL INFORMATION SYSTEM AND REMOTE SENSING DATA BASED FOR MAPPING ECOLOGICAL UNIT IN MANAGEMENT OF COASTAL SANDY SOIL IN CENTRAL VIETNAM

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ABSTRACT

The sandy soil areas span 337.768 ha, distributed across 1000 km along central Vietnam coastline (from Quang Binh to Binh Thuan provinces). 45 individual ecological units were identified and grouped into 10 main coastal sandy soil areas. The 10 main areas were further classified into 3 major eco-zones. This was achieved with the assistance of Landsat (TM) data captured in 2004, and ground-truth surveys and the integration of 29 data themes describing natural, economic and social factors, and coastal sandy soil use models.

The ecological map was analyzed in terms of sustainability, environmental degradation, and socio-economic development to bring out the proposed overall solutions to the rational use of coastal sandy soils. Landuse models followed 4 scales (small family farms, medium sized farms, large farms and village level eco-tourism) were proposed. 3 experimental landuse models in the study area gave clear proof for the following solution. Based on ecological map, we recommended that: 1) the maximum area of individual industrial shrimp farming projects should not exceed 50 ha, and 2) eco-tourism may be a more appropriate means of exploitation for these areas; and 3) integrated development planning for land use suitability of residential areas, industrial zones and tourism were best suited to economic development, promoting conservation and sustainability.

Key word: GIS, Remote sensing, spatial analysis, landscape ecology, landuse suitability, and coastal sandy soil

1. INTRODUCTION

The total area from Quang Binh to Binh Thuan is 62,100,000 ha, including 337,768 ha (appropriate 5,44% of the total area) of coastal sandy areas. It has 702 communes of 6,600,000 households. The average per capital income is about \$300 per year, however, 69 communes are very poor, for example, Dong No is one of the poorest villages in Phu Yen province, the per capital income is only \$7.30 per month. 73,6% of households in Dong No have income from agriculture-forestry-fish breeding but the sandy soils have limited productivity. Therefore, this area is required the solutions to rational use of sandy soil and protection land, water resources and develop infrastructure, agriculture, industry, aquaculture, and tourism.

The landscape ecology approach as a method for integrated protection and suitable use of the natural resources is a good approach (chapter 10 of the Agenda 21). This article presents methods for applying GIS and RS for establishing ecological maps of the sandy soils of central Vietnam, recommending rational landuse, economic development and protection of natural resources in this area.

2 OBJECTIVES

- Establishing a landscape ecology map depicting the ecological units in the study area at scale 1:250,000.
- Proposed overall solutions to the rational use of coastal sandy soils based on ecological units.

3 METHODS

Ecological units were understood to be sandy dunes, sandy beaches etc, having the same formation, material composition, geomorphological processes as well as biological and climatic factors. This was achieved with the assistance of Landsat (TM) data captured in 2003-2004, ground-truth surveys and GIS database. This process to establish the ecological map in GIS software is show in figure 1.

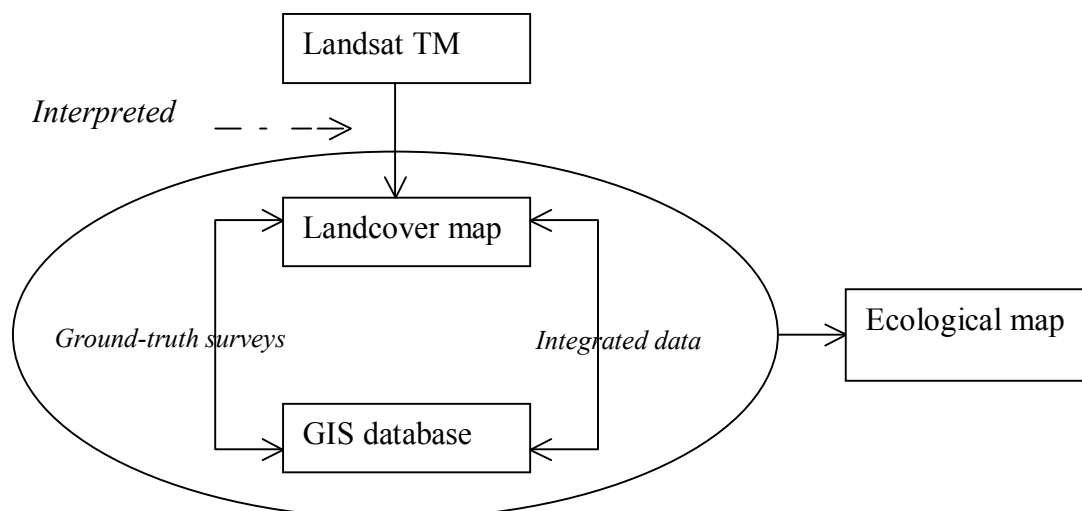
























Fig 1. Process to establish ecological map from Landsat TM and GIS data analysis.

3.1 Interpreted Satellite Image to establish land cover map

Landsat TM images were interpreted by visual method. To achieve the best interpretation results, channel combinations have been applied: combination 1: Red = 4, Green = 3, Blue = 2, and the samples of land cover categories are collected (table 1).

Table 1. Land cover samples for Landsat TM 2004 in the study area.

Sample	Land cover unit
	Rice fields
 	Cultivated crops
	Aquaculture
	Rural areas
 	Urban areas or land cleared for construction
 	Hill land or mountains
	Wetlands (flooded)
	Alluvial
 	River or lake
	Tourism areas
	Dune roving
	Dune without vegetation
	Sand area with vegetation
	Sandbank nearly coastal line (with spare forest)
	Sandbank nearly coastal line (without vegetation or with spare grass)
	Sandbank nearly coastal line in the agriculture land
	Red sand-hill with spare grass-plot
	Red sand-hill with spare forest

3.2 Survey the study area and establish GIS database

- To collect data to establish GIS database
- To collect sample of land cover categories to interpreted Landsat TM
- To correct land cover map

3.3 Integrated data

Three Ecological zones were classified by mean annual average temperature, annual high temperature, annual average rainfall, rain type and the number of dry months futures. These zones were fill up by 45 ecological units that identify by using RS tools to classify landcover and then using GIS to analyze and integrate landcover with natural factors (terrain, geology, geographical location, landcover, hydrology, soil, vegetation) and socio-economical factors (settlement, population, infrastructure, and funds).

The functions were used to analysis and integrate data to establish an ecological map using the spatial analysis module of Arcview software 3.2 that following:

- Terrain analysis
- Attribute functions
- Neighborhood functions
- Overlay operations

4 OUTPUT AND DISCUSSION

4.1 GIS database and literature

GIS database at a scale of 1:250,000 for the whole of the study area including 29 data themes describing natural, economic and social factors. Literature of the coastal sandy soil use models, local knowledge and experiences were also collected.

4.2 Ecological map

Ecological units were understood to be sandy dunes, sandy beaches etc, having the same formation, material composition, geomorphological processes as well as biological and climatic factors. They are depicted in the ecological landscape map of the study area in scale 1:250,000. This map shows the 45 ecological units distributed across the 3 major eco-zones. All of these eco-zones are monsoon tropical climate however they have specific characteristics that showed in the table 2.

Table 2. The climatic characteristics of the eco-zones.

Characteristics	Eco-zone 1	Eco-zone 2	Eco-zone 3
Distribution	Quang Binh, Quang Tri and Thua Thien – Hue provinces	From Hai Van mountain pass, thought Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, and Khanh Hoa provinces	Ninh Thuan and Binh Thuan provinces
Climate	Hot and humid with cold winter	Hot and humidity, no cold winter	Hot and dry, no cold winter
Mean annual temperature	22-25 ⁰ C	25 ⁰ C	25 ⁰ C
Mean daily minimum temperature in coldest month	18-20 ⁰ C	No cold winter	No cold winter
Mean temperature range	4-9 ⁰ C	4-9 ⁰ C	Below 4 ⁰ C
Rain reason	Summer - autumn - winter rain	Autumn - winter rain	Autumn – winter rain
Mean annual total of precipitation	Above 1500mm	Above 1500mm	Below 1500mm
Dry period	Below 4 months with hot and dry westerly wind (from Laos to Central Vietnam)	Below 4 months	4-6 months
The number of ecological units	8	22	15

Other landscape researchers (Hai P.H., Hung N.T., and Khanh N.N., 1997; Long N.T., et. al., 1993) used geomorphological characteristics as the dominant element in landscape zoning for the whole of the Vietnam territory. This divided central Vietnam into 6 landscape zones. However, this method produces inconsistencies when analyzing the coastal sandy areas. Instead of geomorphological elements, we used bio-climatic characters such as mean annual average temperature, annual amplitude temperature, annual average rainfall, rain type and the number of dry months.

Mapping ecological zones has a role in small scale development strategies. So that, 45 landscape units were identified according to looking for different characteristic of landcover, natural factors (terrain, geology, geographical location, landcover, hydrology, soil, vegetation) and socio-economical factors (settlement, population, infrastructure, and funds). However, these characteristics can change over time, especially landcover and socio-

economical data. Because of this temporal variation, the landscape ecological map should be reviewed prior to landuse planning.

Because of needing quickly updated information, satellites were used to interpreted landcover map and GIS modules were used to integrate information.

4.3 Proposed overall solutions to the rational use of coastal sandy soils

4.3.1 Rational use of ten coastal sandy soil sub-zones

Today, the trend to development farms in medium or large scale is apparent. So 45 ecological units were also grouped into 10 main coastal sandy soil areas on the basis to develop rational landuse in farming practices on coastal sandy soils in central Vietnam.

The coastal sandy soil area No.1 contains ecological units with light yellow sand near shorelines that belong to the ecological zone 1 from Quang Binh to Thua Thien Hue provinces, it was proposed this area develops forestry projects to protect against dune drift and erosion, also to protect freshwater and soils inland. Some areas were also recommended for aquaculture projects.

The coastal sandy soil area No.2 includes ecological units with white sand of interior areas of eco-zone 1 from Quang Binh to Thua Thien Hue provinces, they were utilized for agriculture.

The coastal sandy soil area No.3 contains ecological units in light yellow sand near shoreline that belong to the eco-zone 2 from Da Nang to Khanh Hoa provinces. They were recommended for urbanization, however protective forestry projects should also be considered.

The coastal sandy soil area No.4 contains ecological units with light yellow sand of interior field that of eco-zone 2, sand lands areas can be cultivated, combined with domestic livestock, however this is improved land, with developed industrial zones. It is distributed in Song cau and Tuy An districts belong to Phu Yen province.

The coastal sandy soil area No.5 contains ecological units in light yellow sand near shorelines that belong to the eco-zone 3, they were proposed for developing tourism. It lies on coastlines of Ninh Thuan and Binh Thuan provinces.

The coastal sandy soil area No.6 contains ecological units in saffron sand near shoreline that belong to the eco-zone 2, this is good for fruit-tree plantations, and national parks, eco-tourism. It is set in Mo Duc, Duc Pho (Quang Ngai province), and Hoai Nhon districts (Binh Dinh province).

The coastal sandy soil area No.7 contains ecological units with white sands near the shorelines of eco-zone 2. They can be used to extend existing tourism zones. It is distributed in Cam Ranh (Khanh Hoa province).

The coastal sandy soil area No.8 includes ecological units with white sand in the interior areas of eco-zone 2. Sand land areas here can be cultivated, combined with domestic livestock, this is improved land, with developed industrial zones. It is located in Thang Binh, Nui Thanh, Tam Ky belong to Quang Nam provinces.

The coastal sandy soil area No.9 contains ecological units of orange-yellow sands near shoreline that belong to the eco-zone 3. They have developed sea and desert tourism industries. It is distributed in Bac Binh, Than Thiet, Ham Thuan Nam and Ham Tan belonging to Binh Thuan province.

The coastal sandy soil area No.10 includes ecological units with red sands of Ninh Thuan and Binh Thuan provinces belonging to eco-zone 3. In these areas there is a lot of water, wet crops can be planted, and in the dry areas, the drought resistant plants can be cultivated.

4.3.1 Proposed overall solutions to the rational use of the study area

Some land use models for the study area were identified and prescribed based on the characteristics of ecological composition. These land use models were developed using a dual scale approach, one method focusing on ecological units, the other focusing on coastal sandy areas. Two major themes were concluded from this process, 1) we strongly recommended that the maximum area of individual industrial shrimp farming projects should not exceed 50 ha, and 2) eco-tourism may be a more appropriate means of exploitation for these areas.

Proposed overall solutions to the rational use of coastal sandy soils includes 5 main measures i) Afforesting against sand movement to protect freshwater and soils inland; ii) Territorial planning measures in developing infrastructures, and integrated development planning for residential areas, industrial zones and tourism; iii) approach to economic development, promoting conservation and sustainability, iv) recommend procedure for Environmental Impact Assessment (EIA) in planning and development strategies; v) proposed measure aimed at improving community awareness, poverty reduction, community participation, tax incentives etc.

In addition, the project successfully developed 3 land use models, for a family farm in Tuy Phong, a medium farm in Thang Binh and a forestry model against moving sands in Gio Linh. These models were developed in collaboration with local farmers.

4 CONCLUSION

29 data themes contain 90 data layers of GIS database were established by unifying a variety of information from many sources into UTM projection format. This database is basic information for environmental management in the central Vietnam.

Costal sandy soil in the central Vietnam was classified into 45 ecological units with specific characteristics. They were localized in 10 bands belong to 3 eco-zones that showed in the landscape ecological map. This zoning based on GIS and RS is a new approach for the landscape science in Vietnam. Supporting of GIS and RS will improve the use of landscape maps in planning rational use of resources and environmental management in Vietnam.

Solutions to the rational use of sandy soils were proposed based on specific characteristics of ecological units and 10 main coastal sandy soil areas. These are reliable solutions for planners and managers in planning and management to economic development and environmental protection. The success of 3 land use models for a family farm in Tuy Phong, a medium farm in Thang Binh and a forestry model against moving sands in Gio Linh provide the evidence of this.

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