Demarcation of Potential Sites for Construction Material Using RS and GIS Techniques in Eastern Province, Sri Lanka

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Abstract: Demand for construction materials in the Eastern province of Sri Lanka has risen significantly due to accelerated construction work in progress to restore the destroyed infrastructures during the civil war. Ground surveying methods to locate quarries within this area are not applicable due to security reasons and inaccessibility. Thus a Remote Sensing method is suitable for this task. This study introduces a methodology to locate suitable quarries and sand mines for constructions in the Eastern province. LANDSAT ETM+ images were used for classification. Feasible rocks and sand deposits for quarry operations were located using Multicriteria Analysis (AHP). Four different criteria were used by assigning weights to each criterion. Proximity to roads, construction locations, important places and land use type were the four criteria used. Rocks and sand deposits were given a map value according to the suitability and divided in to four groups. The highly suitable rock quarries and sand deposits were considered in closest facility analysis. The results showed that the integration of Remote Sensing (RS) and Geographic Information System (GIS) can serve as an effective tool in demarcating suitable sites for construction material and this methodology can also be applied for projects of similar nature.

Keywords: Closest facility analysis, MCDA, Sand deposits, rock quarries

1. Introduction

The twenty years long civil war has resulted in impoverishment and under-development, especially in the areas of Northern and Eastern provinces of Sri Lanka. Most of the infrastructures were severely disrupted by bombs, barbed wire, blockades and land mines. Presently, it has become a challenge to rebuild those areas. The demand for construction materials has also gone higher as a result of the major development and construction projects. Hence exploration programs needed to be carried out to find

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suitable places to obtain construction materials. There are several methods available for this task. Many of them are related to direct field surveys and observations. Since the field access and observation are obstructed by underlying land mines. Remote Sensing (RS) and Geographic Information System (GIS) techniques can be use for this task (Sabins, 1998). Objectives of this project is to use satellite images for identification of the available rock and sand deposits which are major construction materials along with the use of GIS analysis for demarcation of economically viable construction material occurrences in the area considering all the relevant factors.

2. Material and Methods

Literature review

Data collection
- Images (LANDSAT ETM+, QuickBird)
- Topological and Geological maps
- Field observations and ground truth data collection

Image classification
- Supervised classification Parellel piped method (Yuan at al., 2005)

Preparation of data layers
- Distance to roads and construction locations
- Road network
- Ongoing construction locations
- DIstance from sensitive places
- Land use

Overlaying layers, Multicriteria analysis
- Assess proximity to roads, construction locations, sensitive places and the suitability of the landuse
- Conduct the Multicriteria AHP analysis (Jacek,1999)

Network analysis (Husdal, 1999)

Figure 1 - Methodology

3. Results and Discussion

$$\text{Accuracy} = \frac{\text{No of classified rocks/sand}}{\text{Total No of rocks/sand}}$$

Table 1 - Accuracy of classification

Construction Material	Accuracy of Classification
Rocks	91.47%
Sand	85.21%

Table 2 - Calculated weights for Individual criterion

Criteria	Weight
Distance to roads	0.4929
Distance to construction locations	0.3082
Land use	0.1056
Distance from sensitive locations	0.0936

Land suitability for quarry sites = [DR] * 0.4926 + [DC] * 0.3082 + [LU] * 0.1056 + [DI] * 0.0936 ....(1)

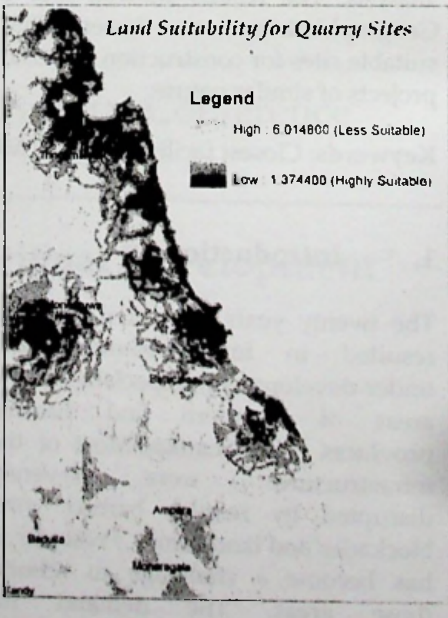

Figure 2 - Land suitability for quarry sites

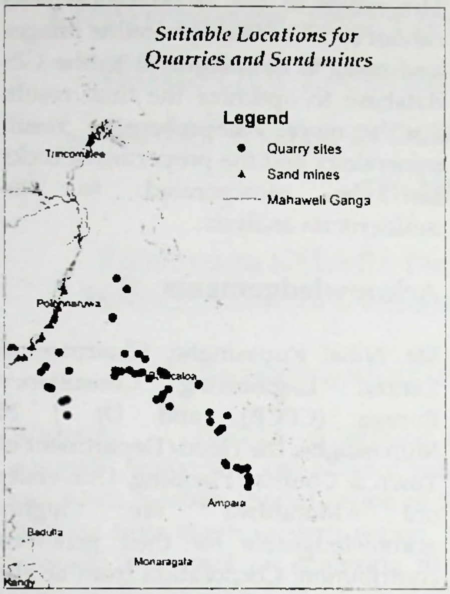

Figure 3 - Suitable Locations for Quarries

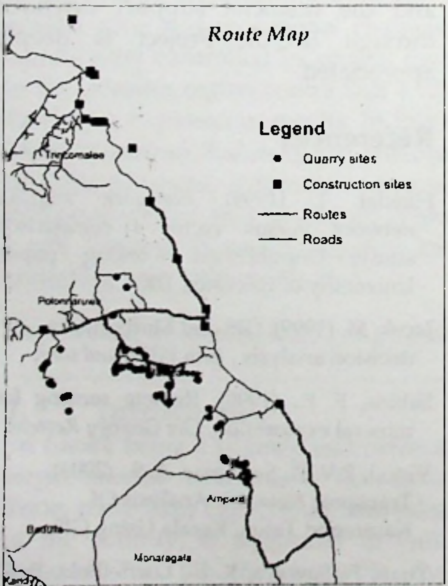

Figure 4 - Final route map for Quarry sites

In this study, highly exposed rocks were accurately classified **(Table 1)**, but the classification accuracy of rocks is greater than sand. Sand deposits along the flood plain of the Mahaweli River, sandy soil, beach and lagoons were classified as sand abandoned areas.

The classification gave a few erroneous results; mostly the roofs thatched using "Asbestos" and some flat bare lands were wrongly classified as rocks and sand respectively. Field observations showed that rocks were not classified where the vegetation cover and overburden is thick and rock slopes are steep. Also, where vegetation is less but scattered all over the rock top minimizing the visible area for one pixel has excluded that area from the classification. In the classification of sand, the major obstacle encountered was the classification of sandy soils which are not suitable for sand mining. Locating only the possible sites for rocks and sand is not sufficient as they may not be economically viable to put up a quarry.

Calculated weights for Individual criterion using Multicriteria AHP techniques were shown in Table 2, the following criteria were ranked; the rocky land should be easily accessed, must be located close to the construction sites, should be easy to acquire for quarry operation and the quarry should be located considerable distance away from sensitive locations. The overall land suitability should address all the above needs and it is obtained from the equation 1 (**Figure 2**). Economically viable Quarries and sand mines should be categorized based on that land suitability.

Under the prevailing categorization of the suitability of rocks and sand deposits for quarry operations, highly suitable category contains the most preferable places to locate quarries (**Figure 3**). The criteria and ranking in the decision making process can vary depending on the type of data input and the objectives of the stakeholders.

Finally, the network analysis was used to obtain the best quarry sites and sand mines with least cost (distance, time) manner to reach construction sites. That is the best path in which a particular quarry site can transport, it's construction material to a construction site with minimum cost.

Any network analysis requires impedances (speed) associated with each road in the network, by which priorities are given to the different roads for analysis. The vehicle speeds were assigned to individual road types which are main roads and jeep or car tracks (Vinod and Sukumar, 2003). Shortest paths between quarry sites/sand mines and construction sites are shown in Figures 4.

The shortest path between quarries and the customers will facilitate the truck drivers to deliver construction materials to maximum number of customers in efficient manner. This helps a quarry to have an idea about how many customers are within a particular distance and the closest cities from the quarry to carry out selling of construction materials.

4. Conclusions

The accuracy of the rocks and sand classification is satisfactory enough to proceed with the remaining analysis. Therefore, 15m upgraded resolution LANDSAT ETM+ images are suitable for rocks and sand identification. Rocks tend to classify accurately if the exposure is high with a less overburden and low vegetation cover.

The highly suitable quarries indicate that area is within the favorable limit of the criteria defined according to the study objectives.

Final results after network analysis gives feasible quarries based on the route suitability selected to reach the construction sites in a minimum time.

The extent of the archeological sites cannot be identified by satellite images and need to be integrated to the GIS database to optimize the final result. For a more comprehensive result mineralogy and the properties of rocks can be incorporated to the multicriteria analysis.

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