CONSTRUCTION PROJECT PERFORMANCE ANALYSIS USING GIS FOR PONNANI TALUK

Site suitability analysis using GIS

Thasni K M1, Anukrishana U2, Jayadeep T3
1,2 Civil department, MES college of engineering
3 Assistant executive engineer, Harbour engineering investigation

Abstract--- The construction industry is vital for the development of any nation. A model for construction industry performance can be helpful for measuring the pace of the economic growth of any nation. Increasingly awareness about the need of designing and performing new sustainable development models has made necessary the implementation of many more new factors and variables than those presented in traditional location models. This fact is causing a major complexity for the decision making processes. Here, the analysis been implemented with help of Geographic Information System for ponnani taluk. Methodology utilizes GIS technology for the input, management and visualization of the geographic data and analysis the spatial data with spatial analysis. A GIS platform can be used to spatially analyze the suitability of ponnani taluk to locate the suitable site for the construction projects.

Keywords--- GIS, Construction project, performance analysis, spatial analysis, weighted overlay, Ponnani taluk

I. INTRODUCTION

The construction industry is the second largest industry in India after agriculture. It makes a significant contribution to the national economy and provides employment to large number of people. Building project performance evaluation is a novel research interest in performance measurement and it is the process of quantifying the efficiency and effectiveness of construction activities. A number of studies have been conducted to examine factors impacting on project performance in developing countries. The shortage of skills of manpower, poor supervision and poor site management, unsuitable leadership, shortage and breakdown of equipment among others contribute to construction delays. Causes of client dissatisfaction and conflict, poor workmanship and incompetence of contractors to be among the factors which would negatively impact on project performance [1]. The quality and attitude to service is one of the key factors constraining successful project delivery [3].

An information system designed for construction industry should be capable of integrating various types of data and provide the required information and data timely that will finally support various decision and operation. Complex and vast amount of information available for a construction project requires a coordinated system that may help in integrating whole information together. With the advances in the field of information technologies, construction industry has started taking the advantages of some of these developments [4]. GIS is a relatively new branch of such technologies for managing the spatial and non-spatial data. Database is the essential part of any information system employed for construction management so the usefulness of geographical information system need to be explored.

II. LITERATURE REVIEW

A project is made up of a group of interrelated work activities constrained by a specific scope, budget, and schedule to deliver capital assets needed to achieve the strategic goal of an agency. The
project management institute (PMI) (2013) defined a project as a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of project indicates a definite beginning and end [1].

Construction project development involves numerous parties, various processes, different phases and stages of work and a great deal of input from both the public and private sectors, with the major aim being to bring the project to a successful conclusion. The level of success in carrying out construction project development activities will depend heavily on the quality of the managerial, financial, technical and organizational performance of the respective parties, while taking into consideration the associated risk management, the business environment, and economic and political stability. Construction is becoming more complex, a more sophisticated approach is necessary to deal with initiating, planning, financing, designing, approving, implementing and completing a project.

Construction project performance evaluation is the process of quantifying the efficiency and effectiveness of construction activities. Success of construction project depends upon its performance, which is measured based on timely completion, within the budget, required quality standards and customer satisfaction. Many investigations done in this field, findings that the most important factors affecting project performance are: delays because of materials shortage; unavailability of resources; low level of project leadership skills; escalation of material prices; unavailability of highly experienced and qualified personnel; and poor quality of available equipment and raw materials.

2.1. Geographical Information System (GIS)

A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS provides a useful tool for managing and coordinating many project elements such as, project tracking, cost estimating, and project critical path method (CPM), and site selection. GIS has not been widely used in managing projects, but recently engineers have started to think about the GIS concept. The GIS can generate graphic maps, which could be very useful for engineers, including charts, bar charts, histograms, and scatter plots. For the purposes of this project, the use of various GIS functions, which include GIS tools, applications, and custom applications were investigated. A GIS function has been defined as tools that allow you to create address-lookup searches, and edit data and maps. The results of these operations can be displayed in the software suite [1].

In GIS software spatial analyst tool is generally used for this analysis. It provides answers to simple spatial questions such as: How steep is it at this location and what direction is this location facing. Also find answers to more complex spatial questions such as: Where is the best location for a new facility and what is the least costly path from A to B. The comprehensive set of Spatial Analyst tools within ArcGIS allows to explore and analyze spatial data and enables to find solutions to spatial problems. Run tools from the Spatial Analyst toolbox or the Python Window, accessible via any ArcGIS Desktop application. Here in this project the weighted overlay spatial analysis is used to overlay the surveyed data and making a site suitability map of Ponnani taluk.

III. METHODOLOGY

3.1 Modelling

The geographical area selected has distinctive factors affecting the construction performance, such as varying soil types, proximity to sea, urbanization, terrain conditions etc. The construction projects here are analyzed for five major parts, ie, site preparation, foundation, walls, slabs and finishing works.

The data for analysis comprise of real life case studies of projects already completed, projects under construction and projects in planning stage in this area. Various details of the project are collected using a field survey of formalized un-concealed questionnaire and the location of the project is geo-
referenced for GIS analysis. Soil types and other geo-specific properties are mapped from external data sources such as satellite maps, published data on the area etc.

GIS and its programmable interfaces will be employed to find the existing correlations and distribution of various project performance elements from the data collected. Evaluate the performance of construction projects in Ponnani taluk with the help of GIS using spatial analysis.

3.2 Study area
Ponnani Taluk is a tehsil in the Indian state of Kerala (figure 3.1). Its Headquarters is in Ponnani. It serves the administrative center of the Taluk and Block Panchayath of the same name. It is situated at the mouth of Bharathappuzha (Nila River) and is bounded by the Arabian Sea on the west. Ponnaniptovide a natural ground for establishing a port. Ponnani is a sea shore town along the south banks of Bharathappuzha. It is located at 10° 46’ N 75° 54’ E / 10.77 N, 75.9 E at the earth global. It has an average elevation of 5m (16feet).

![Figure 3.1 Ponnani Taluk in Kerala administrative division map](image)

3.3 Data collection
Data were collected through formalized and unconcealed questionnaire survey, which formulated with the details from field survey and suggestions from the experts. Questionnaire survey done in
Ponnani taluk in which the information collected from 4 categories of builders such as owner, single entrepreneur, group with sub-contractors, large scale. The questionnaire would be include details about project details, site details, foundation details, wall details, rcc details and finishing details. Construction like residence, commercial building and other public building and structures were included in this survey. Generally the type of project which could include in survey were classified into 4 categories such as single residence, multi-residence, commercial building and other structure. Geographical information like place name, latitude and longitude were include in questionnaire survey for georeferencing the maps in Arc GIS. Details about terrain, water source, foundation soil type and type of foundation were useful for creating raster data for spatial analysis in GIS. Details about total cost, time schedule, labour details, type of building and no. of floors were included in questionnaire for the fuzzy logic analysis in Mat-lab.

3.4 SITE SUITABILITY ANALYSIS IN GIS

Site selection or suitability analysis is a type of analysis used in GIS to determine the best place or site for something. Potential sites used in suitability analysis can include the location of a new hospital, store or school among many others. When performing site selection analysis users must set various criteria from which the GIS software can rate the best or ideal sites. Site selection analysis can be performed with vector or raster data but one of the most widely used types of site selection, weighted site selection, uses raster data. Weighted site selection analysis allows users to rank raster cells and assign a relative importance value to each layer. The result is a suitability surface which ranks potential sites from 1 to 3. Sites with a value of 1 are most suitable and those with a value of 3 are least suitable.

In order to use weighted site selection there is a standard workflow that should be followed. This workflow usually begins with defining a problem or criteria such as locating some potential sites for a new building. The next step is to gather data and create raster surfaces to be used in the analysis. This step is followed by reclassifying the layers, weighting them and then overlaying the output layers with background information such as a map of topography to see the best potential sites. Reclassification is important in weighted site selection because it is used to simplify the interpretation of raster data by changing a single input value into a new output value (ESRI). It can also be used to group ranges of cell values into a single value. For example you can assign a value of 1 to a set of values that range from 1-50 and 2 to values that range from 51-100. This simplifies weighted site selection because different types of raster data will have different values based on what they show. By using reclassification they are all based on the same ranking scheme that can be used to compare and rank the least and most suitable sites.

Weighting layers is another critical step in weighted site selection because it allows the user to place varying levels of importance on different factors such as proximity to a soil type and water availability. Weights are usually determined by a panel of experts on the subject being tested and they are based on specific criteria for the analysis. Weights are assigned as different percentages that must add up to 100%.

3.4.1 Vector shapefiles

A shapefile stores non-topological geometry and attribute information for the spatial features in a data set. The geometry for a feature is stored as a shape comprising a set of vector coordinates. Because shapefiles do not have the processing overhead of a topological data structure, they have advantages over other data sources such as faster drawing speed and edit ability. Shapefiles handle single features that overlap or that are noncontiguous. They also typically require less disk space and are easier to read and write.

Shapefiles for Ponnani taluk, water availability, latitude, foundation type, soil type and data collection were created. Ponnani taluk shapefile created by importing the data source as keraladivision 2011 map (figure 3.1) available in vlist.in site. And the soil type shapefile created by add data source as keralasoil map (figure 3.2). Steps for creating shapefiles as
follows: Open arc catalog, right click on our file name → new → shapefile → it will open the dialogue box as create new shapefile → type name and feature type → for changing the spatial reference click edit → browse the xy coordinate system as WGS 1984 UTM Zone 49N → click OK OK.

Shapefiles for data collection, altitude 150 – 300m, altitude sea level to 150m, foundation without plinth beam, foundation with plinth beam, Ponnai taluk, gravel soil, sandy soil, claley soil, water availability high and water availability low were created (figure 3.3, 3.4, 3.5,3.6,3.7,3.8). And merge the shapefiles which comes under same categories like: gravel soil, sandy soil and claley soil are under same category named soil type so they all merged to form one shapefile named soil type. Likewise, merged shapefiles called water availability, foundation and altitude were created (figure 3.9). Steps for merge the shapefiles as follows: Arc toolbox → data management tools → general → merge → select the input datasets ( eg: gravel soil, sandy soil,claley soil) → give name for new shapefile browse for the location in output dataset → OK.

![Figure 3.2 Kerala soil (http://esdac.jrc.ec.europa.eu/)](image)
Figure 3.3 Data collection shapefile

Figure 3.4 Shapefiles for altitude 150 – 300m and altitude sea level to 150m
Figure 3.5 Shapefiles foundation without plinth beam and foundation with plinth beam

Figure 3.6 Shapefile for ponnani taluk
3.4.2 Raster data
Raster data is a representation of the world as a surface divided into a regular grid of cells. Raster models are useful for storing data that varies continuously, as in an aerial photograph, a satellite
image, a surface of chemical concentrations, or an elevation surface. These data is made up of pixels (or cells), and each pixel has an associated value. In GIS the pixel values may represent elevation above sea level, or chemical concentrations or rainfall etc. The key point is that all of this data is represented as a grid of (usually square) cells. The difference between a digital elevation model (DEM) in GIS and a digital photograph is that the DEM includes additional information describing where the edges of the image are located in the real world, together with how big each cell is on the ground. This means that your GIS can position your raster image (DEM, hillshade, slope map etc.) correctly relative to one another, and this allows you to build up your map.

Any feature class (geodatabase, shapefile or coverage) containing polygon or any other features can be converted to a raster dataset. Vector shapefiles converted into raster data by following steps: Arc tool box → conversion tools → to raster → polygon to raster → input features → select vector data set in input feature → select value field as name → give an output name in output raster data set → OK. The vector shapefilesie water availability, Ponnani taluk, soil type, foundation and altitude were converted into raster data set (Figure 3.10) for the analysis purpose.

DEM file used for adding the elevation and the contour lines are downloaded from earthexplorer.usgs.gov by giving the coordinates as Ponnani (10° 45’ 59.55” N, 75° 55’ 36.79”E), Kozhikode (11° 15’ 13.51”N, 75° 46’ 50.11”E), Perinthalmanna (10° 58’ 30.69”N, 76° 13’ 52.59” E) and Ottapalam (10° 46’ 11.82”N, 76° 22’ 49.29”E). Set the dataset as digital elevation with Aster elevation. By clicking the result we can get 2 or more DEM files for download. For import these raster file in GIS, change the coordinate system as WGS 1984 UTM Zone 49N and add DEM from add data. For blend the DEM file follows the following steps: Windows → image analysis → blend, click on mosaic. The new DEM will be in new layer form give new name, format as Tiff and compression type as LZW (figure 3.11).
Figure 3.11 DEM mosaic file in GIS (Ponnani taluk area)

Clip the ponnani taluk from the DEM with the following steps: Arc tool box → Raster → Raster processing → Clip tool → input raster select as DEM → output extent as ponnani taluk → Give out file name as elevation → OK. Out put clip raster file as shown in figure 3.12.

Figure 3.12 Clip raster of ponnani taluk each colour represent each range of elevation
Make contour line for the area with following steps: Search ‘contour’ in search tools → input raster select as ponnani clip → give output file name as contour lines → give interval as 15 → OK. Symbology for different contour values gives different colours (figure 3.13).

Figure 3.13 Contour lines in Ponnani taluk

3.4.3 Site suitability – spatial analysis
GIS Technique can be used in giving a better solution by considering all the parameters required. GIS is a digital data base management system designed to manage large volumes of spatially distributed data from a variety of sources and process suitability modeling. In the first part of the process of data storage, editing, transformations and integration into a GIS is explained. In the second section, the process of retrieving useful information from attribute or geometrical data (querying) is outlined. The third section gives an overview of the spatial functions developed to support spatial analysis. The different steps involved conducting spatial analyses successfully are reviewed in the fourth section. The final section deals with a technique called ‘Multi-Criteria Analysis’, which can assist in the process of spatial decision-making. A GIS is a powerful and useful tool for spatial analysis. However, the GIS user must remain vigilant. Selecting and using the inappropriate techniques and functions or using inaccurate data may negatively influence the end result of the analysis.

Weighted overlay spatial analysis for the Ponnani taluk can be done with the following procedures:
- Create a folder named as <spatial analysis> in catalog and create two file geodatabase named as <input> and <output> in spatial analysis folder
- Drag and drop the required raster and vector dataset into the input geodatabase (ie. Ponnani taluk, water availability, soil type, foundation, contour lines, altitude, elevation and data collection)
- Open new map document, new map → connect to folder → browse to ‘input’ file geodatabase just created → add → OK
- To setting the workspace: geoprocessing → environments → workspace → current work space → browse to input geodatabase → scratch work space → browse to output geodatabase → OK
- Adding data to the new map: open catalog → click on input geodatabase in catalog tree → drag and drop in Arc map → save the document named as <Thasni.mxd>
- Checking out the spatial analysis license: customize → extensions → click on spatial analyst
- Add the spatial analyst toolbar: customize → toolbar → spatial analyst
- Creating a hillshade: search → tools → type ‘hillshade (spatial analyst) → enter → double click on the icon → input raster select as elevation → OK
- Create a toolbox: right click on spatial analysis file in catalog → new → toolbox → named as <Tool box>
Create a new model: right click on tool box → new → model → model property → general tab → name <sitesuitability> → label <Find suitable site for construction> → click on store relative path names → OK

Environment tab → check on processing extent → extent, next check on raster analysis → cell size

Click values → processing extent → extent → same as layer elevation, next → raster analysis → cell size → same as elevation layer → apply → OK

Drag and drop the required raster to be consider in analysis (ie., water availability, soil type, elevation, foundation, altitude) into the model display space

Create required tools ie reclassify and weighted overlay in toolset. Drag the tools into the model and connect the tools to the layer with add connection tool (figure 3.14)

Open the tools and give required parameters and ranges. For reclassify give reclassified ranges and reclass field as value for each layers and for weighted overlay give % of influence and scale value for each parameters in each layers

% of influence for layer based on their influence on site suitability: for water availability 25%, for soil type 25%, for elevation 15%, for foundation 25%, for altitude 10%

Run the model, the output layers will be displayed in output geodatabase (figure 3.15)

For the layout view click on layout view on screen or view → layout view and change the layout from layout tool box

Output from reclassify tools also displayed in output geodatabase

If the output layers displayed in table of content it will available under output geodatabase in catalog drag and drop in Arc map
IV. RESULT AND DISCUSSION

4.1 Site suitability using GIS

Site suitability of construction project for Ponnani taluk can overcome the problem of unexpected variation in cost of the project, serviceability of the building, water availability in site etc. Ponnani taluk is generally a coastal area and the soil type is sandy soil. Construction in these areas are complicated because of this soil type. Also ground water availability is different in different part of the taluk, it make the difficulty in available of water source. Cost for constructing the foundation in sandy soil is comparatively high. And quality of water in coastal area is poor, it make the total cost for the construction in this area comparatively high. So the site suitability for location of construction in Ponnani taluk is essential for constructing a building with low cost, high quality and within time period.

The output for weighted overlay analysis in GIS shows (figure 3.15) that coastal area in Ponnani taluk is least suitable for construction compared to other areas. For sandy soil area, it is necessary to provide the plinth beam for the foundation which causes to increase the cost for foundation than other construction. And in south-east area the water availability is low, this make the cost for water source high. Water availability in north east area is high, also the soil type is gravel which is suitable for strong foundation, which make this area most or average suitable in site suitability map from GIS. This site suitability map is very useful for the site selection for a new building. Also to take additional precautions for the construction in least suitable areas.

Figure 3.15 Output layer from weighted overlay

In site suitability layer 1 represent the most suitable part, 2 represent medium suitable part and 3 represent least suitable part
V. CONCLUSION

Growth in construction field mostly influence the economic growth of the nation. Construction project performance is relevant factor for growth of construction field. Location of the site will be a strong point for the performance of construction. Location of construction is an extremely relevant decision for future performance of the construction project activities. This activities are mostly effect the activities in the surrounding area and the whole development in the region. In Ponnani taluk region the site suitability analysis done with GIS will suggest suitable site in Ponnani taluk. Which will improve the performance of constructions in Ponnani taluk. This analysis will reduce the investigation tests and preliminary tests in site. This analysis are very helpful for those who are not familiar about the Ponnani taluk and more helpful for gaining the information about the site.

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