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SUITABILITY ANALYSIS OF SETTLEMENT IN MOUNTAINOUS REGION USING MCDA TECHNIQUES CASE STUDY OF DHORPATAN MUNICIPALITY

Sagar Karki[1], Ramjee Prasad Pokharel[1]
[1] *Department of Geography, Prithvi Narayan Campus, Tribhuvan University, Nepal*
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Abstract

Nepal government is planning to establish 10 cities along the mid-hill highway and Burtibang is one among them which lies in Dhorpatan municipality. Since Nepal is a country with around 65% hilly area with a steep slope and difficult terrain it is always at high risk of natural calamities. So, due to unmanaged and unscientific planning of settlement country is facing a huge loss of property and lives yearly. The main objective of this paper is to analyze the suitable land for settlement using Multi-Criteria Decision Analysis (MCDA) techniques. This model will help students, governmental sectors, researchers, and decision-makers to develop a general framework for urban and rural development. The inter-disciplinary methodology has been used, based on a combination of GIS and MCDA techniques. The process was conducted based on eight criteria, mainly DEM, Slope, Aspect, Proximity to Road, Proximity to Stream, Proximity from Settlement, Land Use type, and Proximity to Fault line which were prepared using ArcGIS. The AHP (Analytical Hierarchy Process) method was used to build weights for criteria, while WLC (weighted linear combination) approach was implemented to formulate suitability models. The study shows that only little area is favorable for settlement i.e. 3.43% (7.54 sq.km) is suitable for settlements, while 14.57% (32.04 sq.km) is moderately suitable, 56.55% (124.36 sq.km) area is less suitable and remaining 25.46% (55.99 sq.km) area is unsuitable for settlement.

Keywords: Analytical Hierarchy Process; Geographic Information System; Multi-Criteria Decision Analysis; Settlements; Suitability; Weighted Linear Combination

1. Introduction

Suitability analysis is a type of analysis used to determine the best place or site for something. Land suitability evaluation is regarded as a process for assessing the capacity or level of land that is suitable for a particular use by considering numerous criteria[1]. Researchers have been recently looking forward to rural settlement suitability. However, such suitability remains under-investigated and lacks attention from the government in terms of planning. As the Nepal government is planning to build cities along the mid-hill highway and Burtibang is among one of them we intend to find out a suitable location within the municipality boundary for settlement using MCDA techniques. We are performing the suitability analysis for rural settlements in the mountainous region where one of the main problems is outmigration from rural to urban areas. This trend of migration to urban areas tends to increase pollution and lack of space for settlement which leads to unmanaged and haphazard settlement patterns. This type of settlement pattern will ultimately increase the risk to the population residing in these places. So, nowadays studies and research have been done to find out the suitable location in the rural part of the country which will control population growth in an urban area. Suitability analysis for settlement in a rural area not only helps in maintaining rapid urbanization but also helps to utilize the vacant space in the rural area as well. After finding a suitable location for settlement different infrastructure and facilities can be built in these places which helps the people of rural areas to reside. Another burning problem country is facing is low annual agricultural products, i.e. yearly the production of agriculture products is in decreasing trend because most of the people want to reside in the urban area due to better employment opportunities, better health and education facilities, quality of life which ultimately leads to a decrease in agriculture practice in a rural area. Most of the agricultural land in rural is now vacant due to a lack of proper planning and management. So, if government performs research in a rural area about settlement and agriculture suitability it will help not only in the high production of agricultural products but also helps to stop the uncontrolled migration in an urban area.

The process of finding suitable sites for agriculture, settlement, or habitat all depends on different variables or criteria [2][3]. These criteria have different levels of importance and many techniques were used to determine the weights of the criteria. It has always remained

*Corresponding author. Tel.: +977- 986-60-10890,
E-mail address: karkimjp77@email.com

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the concern of researchers how to combine different datasets to form a single index of assessment since 1960 [4]. Wind and Saaty [5] first introduced the AHP and MCDA technique for suitability analysis. AHP calculates the weights of criteria using a pairwise comparison matrix based on local knowledge and expert opinions [6].

2. Materials and Method

2.1 Study Area

The study area for this research is Dhorpatan municipality which is located in Baglung district in Gandaki province of Nepal. It covers an area of 222.84sq. km and have a geographical extent between 28° 17' 59"N to 28° 28' 51" N Latitude and 83° 0' 16.96" E to 83° 18' 14.26" E longitude. Burtibang which is located in Dhorpatan municipality is one of the 10 proposed cities along the mid-hill highway project.

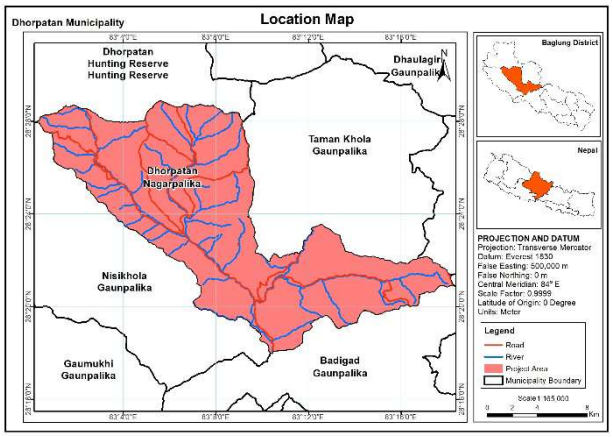

Figure 1: Study Area

2.2 Data Used

The study incorporates both primary and secondary sources of data. Primary data was collected from the field survey and some of them were analyzed in respective software. Secondary data were collected from documents, books, journals, conference papers, and web platforms via both government and private organizations. There are altogether 8 datasets used in this study categorized into four groups mainly Topographic factor which includes Elevation, Slope, and Aspect extracted from ASTER DEM of 30m resolution, Hydrological factor which includes Proximity to Stream which was calculated in ArcGIS using Euclidean distance, Geological factor include Proximity to Fault line which was also calculated in ArcGIS using Euclidean distance and Other factors which include Land use Land cover, Proximity to Road and Proximity to Settlement. The Source of the data used in this study is illustrated in the Table. 1

Table 1. Data Source

SN	Data	Sources
1	DEM	USGS
2	Fault Line	Department of Mines and Geology
3	Land Use Land Cover	Landsat
4	Stream, Road, and Settlement	Survey Department

2.3 Methodology

The interdisciplinary methodology was used based on a combination of MCDA and GIS capabilities. The process was conducted based on eight criteria, which were prepared using GIS. The AHP method was used to build weights for criteria, while the WLC approach was implemented to formulate suitability mapping. The detailed methodology is shown in Figure. 2

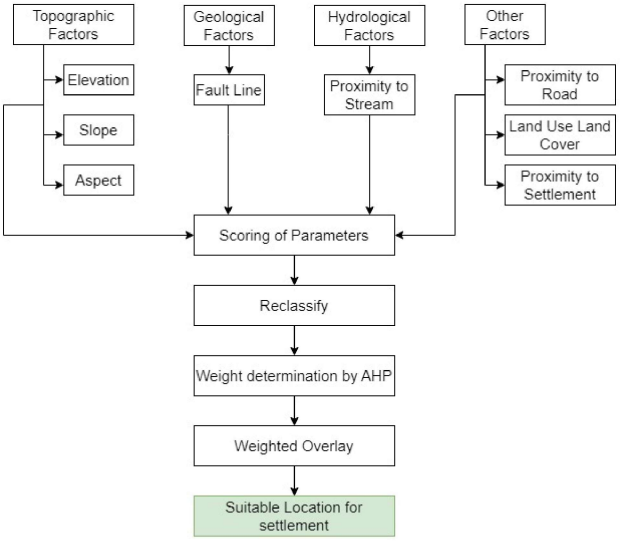

Figure 2: Flow chart of Methodology

The analytical hierarchy process is estimated by the consistency ratio (CR) which is measured by Eq. (1) This equation helps to identify the corrected logical contradiction of the pairwise comparison matrix established based on experience or expert judgment.

$$CR = CI / RI \quad (1)$$

$$CI = (\lambda_{max} - n)/(n-1) \quad (2)$$

where CI indicates the consistency index, RI indicates the random index, λ_{max} is the highest eigenvector of the computed matrix and n denotes the number of criteria. The weighted overlay analysis tool measures the suitability index for a pixel by multiplying the site suitability score and the weight for every pixel; the summation of

the results yields a suitability map using this formula shown in Eq. (3)

$$S = \sum w_i x_i \quad (3)$$

where S is the total suitability score, w_i is the weight of the selected site suitability factor i, and x_i is the assigned criterion score of site suitability factor i.

3. Results and Discussion

After the calculation of criteria weightage using pairwise comparison, each factor was converted to a raster layer. Then, a weighted overlay was performed in ArcGIS software and the final suitability layer was obtained as a result. This layer was then reclassified into four classes: Suitable, Moderately Suitable, Low Suitable, and Unsuitable. The results show that only little area is favorable for settlement i.e. 3.43% (7.54 sq. km) is suitable for settlements, while 14.57% (32.04 sq. km) is moderately suitable whereas 56.55% (124.36 sq. km) is low suitable and 25.46% (55.99 sq. km) area is more or less unfavorable for human settlement i.e. unsuitable.

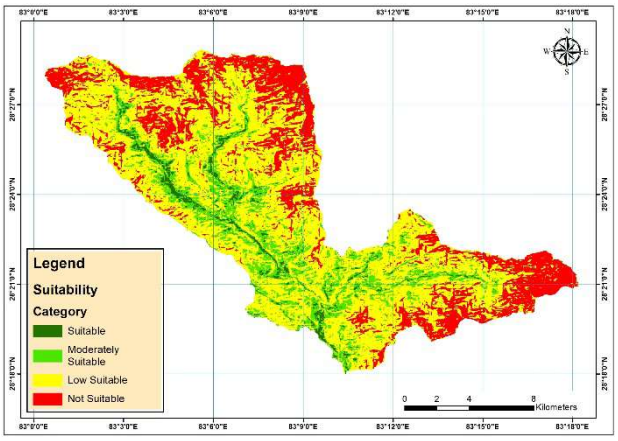

Figure 3: Suitability Map

4. Conclusions

Unplanned and haphazard urbanization has become a serious problem in recent decades. In search of better education, health, and other utilities people migrate from rural areas to urban areas. This type of migration leads to population growth in urban areas which ultimately leads to unmanaged settlement. So, to stop the rural migration government of Nepal is connecting the hilly area with the help of a transport network via the Mid-hill highway. Transportation is the basic factor that helps to establish other utility factors like education, health, job, and business. The government is also planning to establish 10 new cities along the Mid-hill highway to uplift the living standard of the local population and stop uncontrolled urbanization in the core city area. This study intends to find out a suitable location within the Dhorpatan municipality that helps in proper land use planning.

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