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GIS BASED LANDSLIDE SUSCEPTIBILITY MAPPING

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ABSTRACT
Spatial study based on fuzzy logic decision making system and GIS plays a vital role in landslide susceptibility mapping (LSM). A new approach of LSM using fuzzy set theory and Geospatial Data Abstraction Library (GDAL) is developed here. This approach provides us separate landslide susceptibility value for each location in study area represented by a pixel in LSM. The algorithm is applied over a Himalayan city named Hamirpur for analyzing landslides. Five major factors were considered here which are responsible for landslides as suggested by experts of the study area. Spatial data infrastructure is developed using dataset obtained from Indian Space Research Organization and National Remote Sensing Centre (India). Processing of spatial data is done by using GDAL so as to extract factor maps from the spatial data infrastructure. Fuzzy decision making system takes these factor maps as input simultaneously in pixel by pixel format and generates landslide susceptibility of the area represented by the pixels. In this manner landslide susceptibility map of whole study area is generated and result is validated with inventory developed using landslide data provided by Geological Survey of India. Result of the validation shows 80 % landslides shown in the inventory lie in high susceptible region of landslide susceptibility map generated by our algorithm using considered factors.

Keywords
Geospatial Data Abstraction Library, Landslide Susceptibility Mapping, Type-1 Fuzzy Logic

INTRODUCTION

Landslides comprises of all types of mass flow such as various types of rock fall, rock slides, debris slides, rock cum debris slides, wedge failure and rock slump. Such failures occur when combined effect of various factors results in stress exceeding the shear strength of the material at a location [7]. Landslide susceptibility mapping (LSM) is one of the most advance, reliable and accurate tool for analyzing and predicting destructions caused by one of the most hazardous natural dynamites, landslide prone areas, that can destroy life and property of human race on a very large scale [34]. LSM helps us in taking mitigation measures against these natural calamities, it also tells us about feasibility of slope failures in a region. It also provide susceptibilities, displayed geographically in maps and specify distribution of future slope-failure susceptibility spatially [33][34]. In order to make accurate and reasonable decision for designing reliable disaster management plans, LSM makes use of a multi-factor approach. Nature of data used to generate landslide susceptibility maps and approach of decision making analysis effects decisions to a great extent. Previous studies on landslides shows that topographic factors like slope, aspect, elevation, distance from road, and lineament has huge contribution in already occurred landslides. Information of slope angle, aspect of area and elevation of area can be obtained from digital elevation model (DEM) [2]. A lot of landslide susceptibility mapping systems and other geographic information applications are using DEM now days on large scale [2]. Information about factors like distance from road and lineament can be obtained from their shape files [11]. A shape file is a noncartographical way of storing factor values of geographical locations. Landslide susceptibility mapping requires reading and writing of data in spatial raster format. For this purpose we have used Geospatial Data Abstraction Library (GDAL). GDAL is open source library designed for reading, writing and transforming various spatial data formats like GTiff, GRASS, GIF, GTX etc. This library is widely used by many commercial and non-commercial geographic information based applications

RELATED WORK: A SURVEY

Survey says it might be 70 % and some other experts may say that it would be 75% or 68%. So, there is fuzziness in contribution of factors in landslide susceptibility of the area under study. It has been seen that there are two kind of

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fuzziness registered in most of the applications yet, they are linguist fuzziness and random fuzziness. Linguist fuzziness is expressed with help of words like "High susceptibility" [16]. Fuzzy set theory (FS) has been proved extremely helpful in making decisions in linguist fuzzy environment, whereas random fuzziness can be easily handled by probabilistic models. Fuzzy set theory was suggested by Zadeh in 1965 [1]. Since then many applications have been extensively using FS successfully in their decision making process. The fuzziness in landslide susceptibility can be expressed in linguistic words and thus FS can be very effectively applied to minimize effect of uncertainty in it. According to expert's knowledge values of all topographical factors which are suppose to be considered for landslide susceptibility mapping as well as susceptibility itself can be classified into words also known as linguistic variables and fuzzy sets. For example, all slope angles between 0o to 90o could be divided into words or fuzzy sets like "Very Unimportant", "Important", "Extremely Important", according to their impact on landslide susceptibility. Then using a rulebase designed with help of landslide experts, a decision could be made on susceptibility of the area, which is again a fuzzy set. Defuzzyfication would lead us to a certain and most expected value of landslide susceptibility in study area.Here all action units of face are combined to get different expressions. The success rate of this approach is 86.3%.

STUDY AREA

Our study area isa major city named Hamirpur in The Himalayan mountains range, having an area of 1,118Sq.km situated in the western part of Himachal Pradesh province of northern India (see Fig. 1). This city has elevation between 407 m and 1192 m above sea level and situated between 31°25′N and 31°52′N and between 76°18′E and 76°44′E. Major part of study area is covered with pine forest and mango trees and has major rivers flowing at its two ends.Temperature of this area varies between 15 ^{o}C to -1 ^{o}C in winters and 44 ^{o}C to 15 ^{o}C in summers and has average rainfall of 1200 mm. Steep slope, high elevation level of the area and very high average rainfall makes it highly susceptible for landslides. The area also have human population of 4,54,768. High susceptibility of this area for landslides makes extremely hazardous for a big population. The complicated geology of this area generates frequent landslides in locations like Jhalan, Dhenata, Malag, Bhota and Amned of Hamirpur district. According to inventory from Indian Space Research Organization (ISRO), Department of Space, Government of India, up to 2014, 50 landslides occurred in this region

APPLICATION OF GIS AND FUZZY SET THEORY

Landslides occur due to specific geographical conditions of an area**.** Our study area Hamirpur district is highly susceptible to landslides because of its very complex geographical condition with big mountains and heavy rainfall. For generating LSM of Hamirpur we consider five major factors, as suggested by geologists, responsible for landslides. These factors are as follows:- (a) Slope of the area, (b) Aspect of the area, (c) Elevation of the area, (d) Distance from road of the area, (e) Distance from lineament of the area. We performed this landslide susceptibility mapping in four stages, (a) development of spatial database, (b) creation of factor maps, for all considered factors responsible for landslide (c) calculation of landslide susceptibility of study area using fuzzy logic, (d) validating result with inventory of study area.

CONCLUSION AND FUTURE WORK

This paper proposes an innovative approach for calculating landslide susceptibility. We have considered major factors which could cause landslide as suggested by local experts of the study area. This approach makes assessment at each location which could be represented by a pixel in a factor map. The landslide susceptibility map produced with help of this approach proves that 80% of previously happened landslides occurred in high susceptible region according to considered factors. In future some more relevant factors like type of soil, plantation, amount of rainfall, curvature, minerals, distance from river, land use land cover (LULC) etc. can be considered in landslide susceptibility mapping.

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