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AN ASSESSMENT OF LANDSLIDE HAZARDS IN MUZAFFARABAD-AZAD JAMMU & KASHMIR USING GEOSPATIAL TECHNIQUES

MADIHA BATOOL[*], SAJID RASHID AHMAD[**], MUHAMMAD ASIF JAVED [***]

[*]College of Earth and Environmental Sciences University of the Punjab, Lahore-Pakistan

[*]Corresponding Author's e-mail: madhiaqwert@gmail.com

ABSTRACT

Landslides have been considered as one of the dangerous natural hazards faced by human beings. It damages the lives and property all over the World as well as in Pakistan in the landslide-prone areas. Particularly in South Asia, Pakistan, and Azad Jammu, and Kashmir the population living in hilly regions generally face this catastrophe. In most cases, landslides trigger in the rainy season particularly during the Monsoon period (July-Sept.). In addition to this, landslides may result from a variety of other anthropogenic and natural causative factors/processes. In the present study, a twelve square kilometer area in Muzaffarabad District along with the Neelum River Azad Jammu & Kashmir has been delineated as a case study area. The study is designed to delineate the landslide prone areas in the Muzaffarabad District of Azad Jammu & Kashmir and to highlight their causes and consequence. The choice of the study area is based on Muzaffarabad's vulnerability being a hilly area to landslides hazards and the consequent problem of the lives and property of the area. The Analytical Hierarchy manner (AHP) and Weighted Linear aggregate (WLC) strategies were employed to discover the landslide danger-affected sites by means of the usage of the GIS augmented through ancillary statistics. further, NASA's ASTER's digital Elevation model and high resolution (10 m) ALOS imageries have been used over the take a look at area of Muzaffarabad District. The AHP turned into used to calculate thing weights at the same time as WLC changed into computed for each landslide magnificence retaining in view its vulnerability. The consequences revealed that 14.99 percentage falls in a very excessive vulnerability region while 32.37, 31.97, 16.25, and 4.42 percent are categorized as excessive, mild, low, and very low vulnerability zones respectively inside the observe vicinity. In order to validate these results, the study suggests extensive field work in the area to have firsthand knowledge from the local population Present work can enhance our understanding in making landslide inventory which can reduce the risk and mitigate future loss due to landslides.

KEY WORDS: Muzaffarabad, Landslides, Digital Elevation Model, AHP, WLC, GIS Risk Zones

INTRODUCTION

A large downslope motion of regolith, debris, rock loads, soils, or a combination of all under the effect of gravitational force is known as a landslide. This phenomenon generally takes place in highlands and mountainous regions of the world and considered a primary geomorphic hazard and poses major loss to human lives and property. The frequency of landslide occurrence varies from place to place and region to region. As

stated earlier that the landslides bring greater loss to humanity, infrastructure, and natural resources in mountainous regions all over the world. These are also a major cause of disorder in business activities. In addition to the damage to infrastructure and sometimes brings serious human injury is enough to justify the negative impacts of landslide hazard (Sadaf, 2017). If we have beforehand information about landslide-prone areas then to some extent; all sorts of loss, as well as damage, can be reduced. In addition to this landslide, risk maps can be of greater use by the researchers working in natural hazards regions as it provide knowledge about the perceived effects of landslides.

The landslide hazards can be assessed through reliable datasets of satellite imaging methods as well as other ancillary data sources like meteorological and geological parameters along with fieldwork/household surveys. However, the most efficient analytical techniques and methods are generally related to remote sensing and various field study methods can help us to prepare land sliding hazard maps (Clerici et al., 2002 Michael, 2005 and Zubair, 2016). Prior to these avalanches hazard maps and inventories were prepared using cartographic and geospatial techniques (Danish et al., 2016).

Today, a number of landslide inventory maps have been generally is in use to identify its vulnerability. An investigation conducted by Saaty's Analytical Hierarchy Process (AHP) and its various approaches have been applied by many researchers to identify the landslide risk assessment in highland/mountain areas (Barredo et al., 2000; Mwasi, 2001; Nie et al., 2001; Yagi, 2003, and Ayalew et al., 2004). The composition, analysis, and assessment of landslide can be better judged through working on Analytic Hierarchy (AHP). (Dahal and Yamanaka, 2008). The geoscientists play a primary position in studying the Landslide danger Mapping and consequences may additionally range differently in exclusive scientific investigations. The semi-quantitative and multiplicity fashions are usually utilized in LULC landslide studies (Florence, 2018).

MATERIAL AND METHODS

Muzaffarabad, Azad Jammu, and Kashmir (AJK) have been considered as the study for the present research. The District of Muzaffarabad is the capital of AJK. while the location under research is positioned within the northern top terrain of Muzaffarabad district and lies among 34°37' to 34° 46' North latitudes and 73° 58'to 73° 71' East longitudes. The whole belt of landslide-prone areas covers 81 Sq.Km. of land area. The area spread over a 12 kilometers narrow belt running along the Neelum River with a buffer zone of about 3 kilometers. This region is considered as one of the active landslide-vulnerable areas of Kashmir and frequently cause damage to

infrastructure as well loss of human lives. Geographically it encompasses villages named Nuseri and Nushada along with Panjgran village where the boundary of the district terminates.

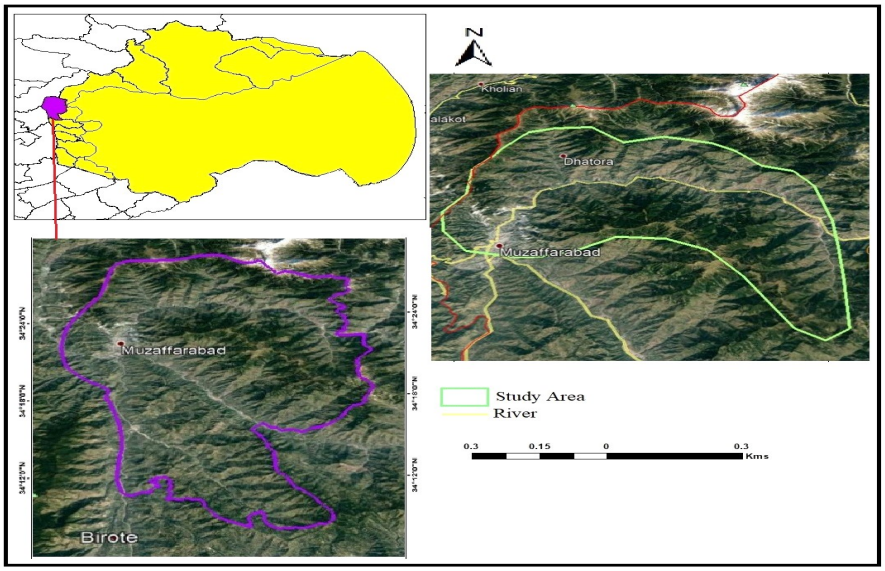

Fig. 1: Locations of District of Muzaffarabad and Key Study Sites.

Present study has been conducted to identify and highlight the factors, which are responsible in trigging the landslides havoc in the one of the most important region of Pakistan. The area under study is geo-strategically and financially important as it connects Azad Jammu and Kashmir with Rawalpindi. Therefore, this research has identified the causative and contributing factors of landslides in the Muzaffarabad District, Azad Jammu & Kashmir. The objective is to geospatial techniques (GIS and Remote Sensing) along with numerous other software to prepare landside vulnerability maps of the study sites. This integration of two geospatial technologies and the identification of susceptible landslide prone area along with related components have highlighted in Fig.1.

Further to explore and identify the techniques, skills, utilities, and potentials of Multicriteria Decision Making (MCDM) and Geographical Information System (GIS) for the purpose to identify the areas, which is generally affected due to landslides in the observed area-The Muzaffarabad District. With a view to taking a look at landslide hazard evaluation and to draw landslide maps, The parameters, which has been investigated for landslide hazard assessment and mapping are slopes, altitudes, land use and land cover (LULC), rainfall, and soils. In addition river network, geology and aspect of the region has been taken into consideration for preparing the maps. Further, landslide danger mapping is

executed through a Geographical records system (GIS), which is a computer-based machine and is able to handle such massive portions of spatial statistics from a ramification of assets to produce required maps (Tahir et al., 2011).

The Analytic Hierarchy procedure (WLC) has been each used to perceive and map the landslide-susceptible sites inside the examine place. a number of such maps were produced with the assist of GIS techniques (AHP) and Weighted Linear combination satellite remote sensing data.(Sajid Ali et al., 2018).

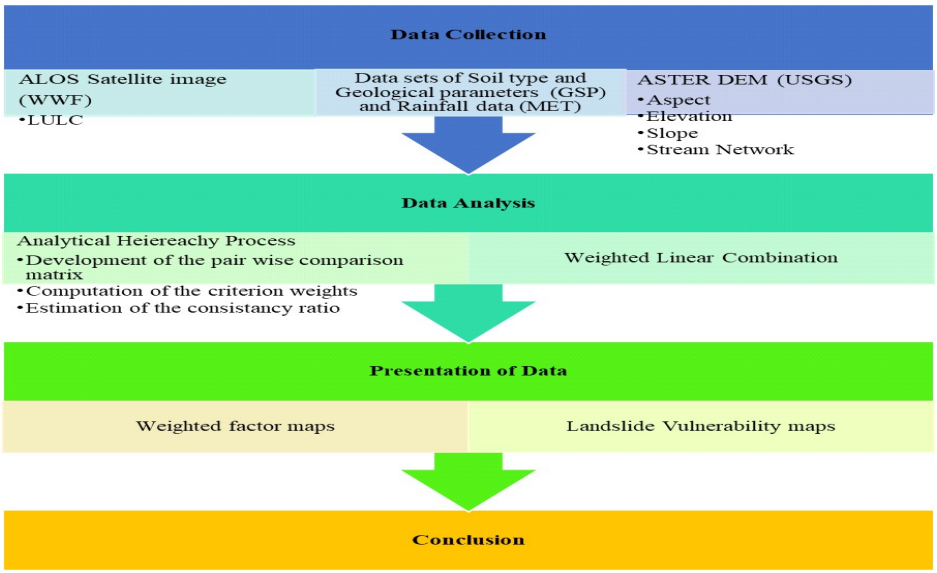

Fig. 2: Methodological Framework

As in the previous discussion, it has been stated that data used in the present research was collected from a number of non-governmental as well as from governmental departments and research organizations. In conclusion, Landsat images, Meteorological data, and scanned maps were obtained in the processed format. For further analysis, the collected maps were scanned and then digitized in an ArcGIS environment. It was important because to keep intact its vector layers and geographical grid references for a better analysis. All the Landsat digital data were recognized in different (LULC) classes by using a supervised classification algorithm in ERDAS Imagine.(Hawas and Shafique., 2019). The DEM (Digital Elevation Models) was prepared to take into account the factors such as aspect, altitude, stream networking, and slope of the study area. Since the rainfall data was in tabular format, therefore, the same has to be converted into maps and raster format using ArcGIS. For analytical reason, Arc GIS has been used on digitized vector maps in order to convert it to a

raster layout the usage of the vector conversion method. A 15 to 15-meter sizes pixel become set to create exceptional classes for photograph analysis. The output Landslide Sensitivity Maps has been superimposed (Akgun, 2008) to check the accuracy of the subsequent landslide maps. The Multi-standards Choice-Making (MCDM) strategies can facilitate and assist in decision-making processes for disaster management department, policymakers, city and regional planners and may be useful to other stakeholders for selection-making procedure.

Climate is an important factor, which causes land sliding in mountainous regions of the world as well as in Pakistan. An average annual rainfall of 1,511 mm is generally received by the area under study-Muzaffarabad while the average and mean monthly minimum and maximum temperatures during month of July remains around 23°C and 35°C while it is 3°C and 16°C in January respectively (Pakistan Meteorological Department, Govt. of Pakistan 2016).

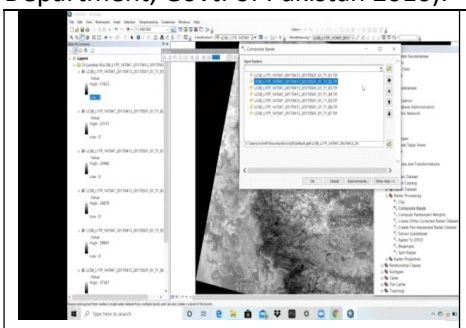

Fig.3 Processing of Band Composition

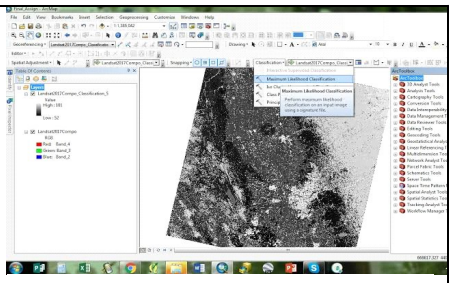

Fig. 4 Applying Supervised Classification

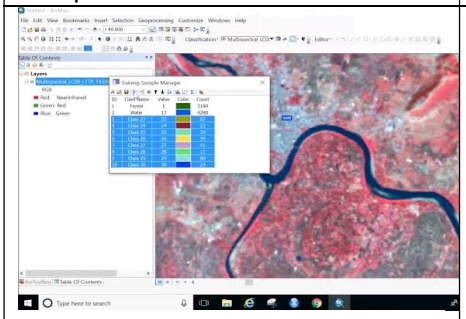

Fig.5 Making Signature Class

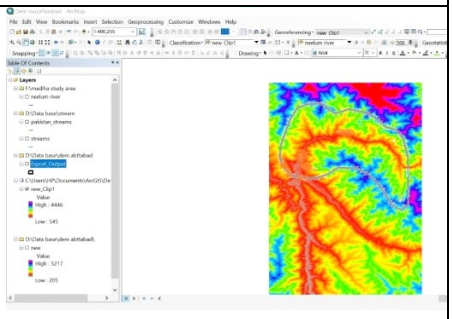

Fig. 6 Processing of Slope Map

As stated earlier, that in present work the DEMs have been the bases of the assessment and formulations of landslide hazard maps of the prone areas located in the landsides in Muzaffarabad-our research region. In future studies of this nature a DEM can be taken into considerations for getting maximum accuracy in assessment as well with a detail of the

trigging processes of landslide occurrence. Therefore, it can be employed in landslide prone mountainous regions of areas similar to present one. In conclusion, a Digital Elevation Model (DEM) can be taken into consideration as a beneficial generalization of the extent and character of landslide danger and assessment in any area.(Bakhtiar and Thomas., 2011). In terms of geological make up this area belongs to Murree Formation and the types of soils found and identified in the area by the Soil Survey of Pakistan are two main varieties of soils viz.; the combinations of rock and gravels,i.e.; brown forest type of soils, Podzols, and Looms kinds are common within the landslide prone regime. The ASTER platform have been used to download an ASTER 30m resolution digital elevation model from the free web. For the purpose, preparing landslide susceptibility and hazards maps the survey sheet no. 43F / 11 on a scale of 1: 50,000 prepared by the Pakistan Geological Survey have been consulted. This sheet has covered the complete area under investigation and maps were prepared accordingly.

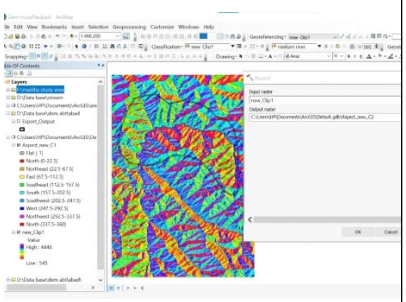

Fig.7 Processing of Aspect Map

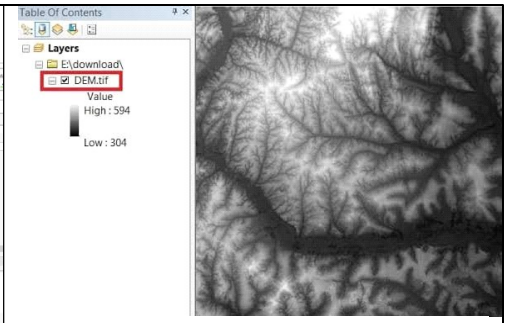

Fig.8. show the procedure for generating
sequences from DEM

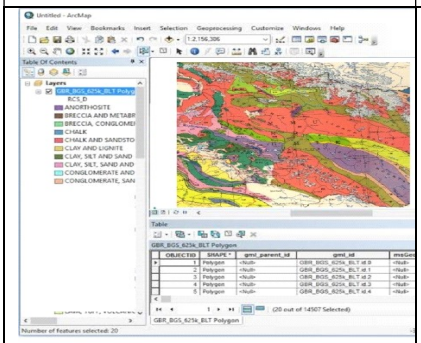

Fig.9 Processing of Geology Map

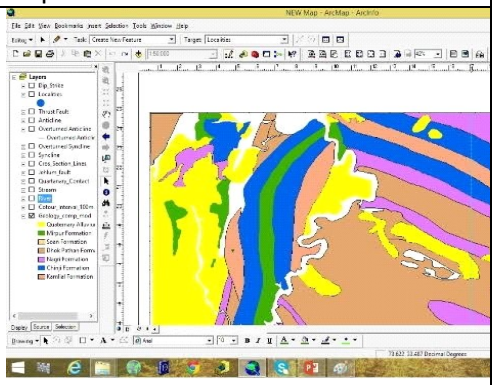

Fig.10(a) Processing of Soil Map

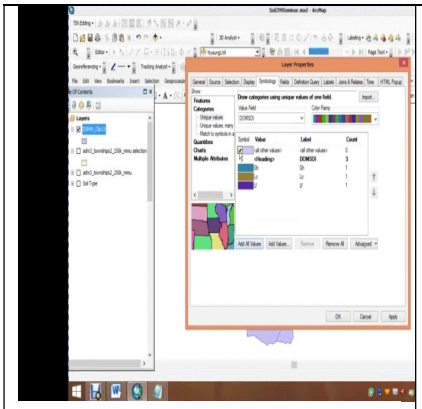

Fig.10 (b) Processing of Soil Map

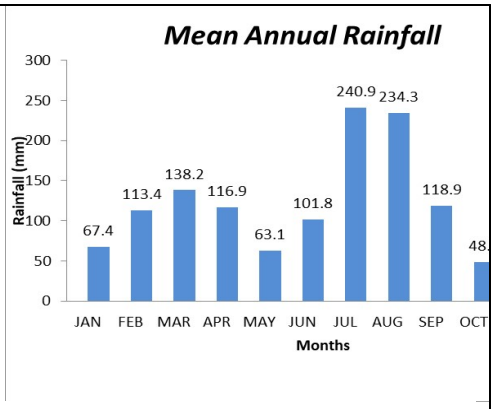

Fig.11 Mean Annual Rainfall in Muzaffarabad-AJK

An investigation and assessment to prepare LULC classified maps of the selected region, the same had been executed by using the ERDAS imagine 16.5 software programs over the satellite images of ALOS PALSAR platform. The training areas for the specific vegetation namely i.Conifer (thick) ii. Conifer(medium) iii. Confiner(thin) iv. herbs /shrubs v. bare soils vi. water and most importantly vii. the settlements had been recognized and analysed to infer consequences for this research work. The subsequent classes (categories) were taken from the satellite images earlier classified to be further analysed with the help of aerial photographs of the landslide suspected and prone sites. A total of three special buffer regions of fifty meters, one hundred meters, and one hundred fifty meters has been created. In Muzaffarabad -the selected region, we have identified four most important kinds of soils: (a) Gravel looms (reasonably deep) (b) Looms: massive (c) uncovered bedrock (d) a massive wide variety of sandy looms.The frequency ratio model was applied to identify the influential factors, which help in triggering of landslide, and distribution was made in different classes through the application of buffer zoning. In this research , eight triggering factors have been taken into consideration like altitude, geology, slope aspect, slope gradient, curvature, road network, drainage network and land use land cover were used for landslide susceptibility.(Ercanoglu and Gokceoglu., 2004).

RESULTS AND DISCUSSION

Existing literature has highlighted on the fact that landslide susceptibility has been widely researched all over the world. It has also exclusively received wide considerations during the last many decades. Particularly by the researchers working in the domain of geosciences. This is because of the fact that GIS, Remote Sensing techniques, geological, soil and

meteorological data has helped and played an important role in landslide hazard and its mitigation.

This section explains the landslide prone areas of Azad Jammu and Kashmir (Muzaffarabad) and preparation of hazard inventory maps. The susceptibility maps prepared during this study has identified and described the landslides prone areas of AJK, which is generally not available for the areas of Azad Jammu and Kashmir-Pakistan. This is the findings of this study that the landslide inventory and landslide susceptibility maps are an important segment of landslide mitigation measures. Similarly, other factors such as rainfall, elevation, weathering, erosion, geology, tectonics and numerous anthropogenic factors are directly or indirectly affect the occurrence of landslide in the study area-Muzaffarabad (AJK). In present study each elevation class as well as the region of landslide has been was using geospatial technologies in ArcGIS software. Then susceptibility map and related processing has been calculated and have been shown in Figs.3-14

An integration of numerous parameters, both spatial and temporal types of data and metadata, along with regional interlocked highlands, GIS, and Remote Sensing has been taken into consideration in those kinds of studies. This is mainly true when supported through geospatial techniques, which assist to record large quantity of data. The occurrence of landslide is closely linked with the geology of the region and this relationship cannot be denied in the assessment of landslide susceptibility and its mapping. This is because some of the rock structures are extremely prone to landslide. The geological maps of Muzaffarabad was developed using base map of Geological Survey of Pakistan. An Analytical Hierarchy Process was adopted to landslide assessment, and risk mapping keeping in view the element, elevation, slope, river network, soil, geology, LULC (four categories) and weights were considered in Google Earth and all of the parameters which have been utilized in making lithology and rainfall maps had been assigned accordingly (Sarkar et al., 2015). The Land Cover and Land Use (LULC) has been known to be a potent factor in landslide triggering factor for its occurrence because of the anthropogenic activities on unstable slope (Tirthankar, et al. 2019; Pareta, 2012). The magnitude, intensity and occurrence of landslides increased with human intervention particularly, road construction, cultivation and deforestation.

In study area, out of various causative factors, land cover and land use such as rangelands along with valley cultivation lands are more susceptible in trigging landslide as compared to level slopes and forested areas. The main factors responsible for dynamic changes in the LULC and anthropogenic activities are the role of nature. The ERDAS imagine software have been used in identification of seven major LULC training sites. All of these have been identified inside the study areas, and the task

was accomplished with the help of a supervised classification algorithm. Finally, a sum of 14 landslide susceptible zones were identified through Google Earth imagery. For landslide, susceptibility mapping eight landslide-triggering factors were selected and analysed in Muzaffarabad District based on existing literature. Each selected triggering factor in this study, plays a vital role in landslide susceptibility mapping and assessment. The landslides in the Muzaffarabad District were first identified and then risk maps were produced which were later validated with the help of AHP. The landslide susceptibility mapping has been the key finding of this research and the GIS techniques have been used to highlight prone hazard prone areas. The Monsson rainfall, weak lithology, unstable slopes and loses soil structure; seismic activity and anthropogenic activities are the main causative factors of net effect on loss of human lives and property in the area under study. For land slid risk assessment, mapping for the hilly region like AJK, a good planning as well as management of mitigation strategies are the need of the hour. This research suggests that the recurrent of landslide hazard phenomena and extreme climatic events are on the rise in region and that needs a proper monitoring by government to mitigate the adverse impacts of landslide hazard and to evolve preventive strategies for reducing impacts of landslides.

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