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A Conceptual Model for identifying Landslide risk: A case study Balakot, Pakistan

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Abstract: The developed models leave the ground of discussion for their accuracy, reliability and practicability for different school of thoughts. The traditional ways have been used in past to develop landslide risk models. As in this research, the conceptual model has been developed using various combined previous landslide risk algorithms, criteria and parameters. The hypothesis was also built initially based on the consideration of the topographic situations, geophysical properties and previous landslide records to develop this conceptual model. This model has utilized qualitative technique by assigning the different weight to the different parameters for developing different levels of risk. The weight assigned weight known as comparison matrix method remains subjective, so in this regard, the experts opinions and saaty scale of importance method has been used to cover the subjectivity of the selected criteria. The utilization of Geographical information systems (GIS) techniques and remotes using their various sub techniques have been applied for preparation of this conceptual model. It is assured that this type of developed composited algorithm, criteria conceptual model will assist to the different model developers for development for accurate, reliable, and implementable landslide risk models which can be helping for the different decision makers in the field during implementing them.

Keywords: Landslide risk, conceptual Model, composite parameters, Classification, sub setting, GIS,

1. INTRODUCTION

Disaster management models are based on the different techniques to recognize the different aspects of risk (TFQCDM/WADEM: 2002) The optimum methods are applied to cope up different directions of natural risk from landslides such as its recognition, predictions for future and incorporating the preventive measures which may reduce the probable risk from such probable phenomena (Dimitriadi and Dimitriadi 2007). The landslide risk is defined as expected number of fatalities, destruction of infrastructure at certain period of time. The various approaches such as qualitative, semi-quantitative and quantitative (Castellanos and Van Westen 2008), have been applied for measuring and evaluated landslide risk for future. In this regard, the different types of landslide risk models such as statistical (Dahal *et al.,* 2008), probabilistic, deterministic and heuristics (Aleotti and Chowdhury1999) have also been developed in past. Such approaches based models remained biased and indecisive complex and experimental Günther *et al.,* 2007). "In fact, these approaches need the combined and composited ideas based such dynamic efforts which may prove the fruitful, real and practical oriented landslide risk models for the decision makers. The combined effort require the utilization of new data, new parameters, and composite based landslide risk algorithms for developing such landslide risk models which may help for the sustainable and use planning to the various decision makers (Van Westen *et al.,* 2006),"The extreme need has been realized to develop such conceptual model for the landslide risk which may prove innovative, original, typical and adoptable for the decision makers based o the combination of overall traditional and new data based of the multi-tiered approaches.

This conceptual model has been developed based on the case study of Balakot, one of the destructed cities of northern Pakistan from earthquake based landslide disaster on 8 October 2005 with 7.6 Richter scale (Kamp, *et al.*,2008).

2. MATERIAL AND METHODS

This conceptual model needs the different steps such as;

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2.1 Hypothesis of research.

The hypothesis of this research comprises the various aspects as;

These types of models require multi-dimensional focuses to provide the corrective elucidation.

The various disasters contain different type of criteria so the parameters should be considered in that perspective.

The criteria have also been criticized as subjective so the mathematical supporting analysis should be practicised for the practical and reasonable criteria.

2.2 Study area

Balakot **(Fig.1)** located about 30km NE of epicenter Peiris, N., T., Rossetto, P., Burton, S., Mahmood, 2006.was one of the victim cities of northern Pakistan (**Fig.2)** affected by earthquake induced landslide disaster. It is covered with dense mountains and forest. This city is covered by seismic fault from Bagh to Balakot, in the Himalayan Mountain from the west direction ranging with main boundary thrust (MBT) (Pathier *et al.*, 2006).

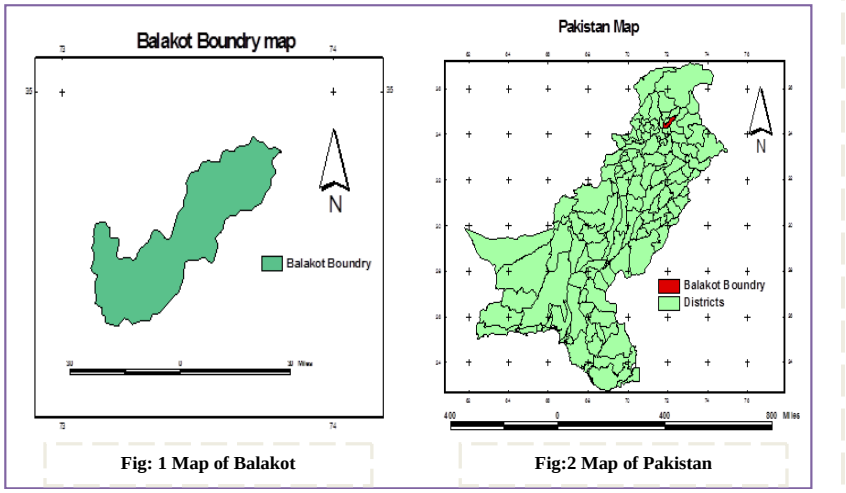

Fig: 1 Map of Balakot **Fig:2 Map of Pakistan**

2.3 Sub setting the Data Theme

This conceptual model needs to determine the different l topographic features of study area using one of the satellite data received on 16-09-2005 before the occurrence of phenomena **(as shown in Fig.3).** This satellite data posses the spatial resolution with 30m containing Path 150 and row 36 with datum WGS -84, UTM zone 43 N. The study area has been sub setted using remote sensing software **(as shown in Fig.04)**

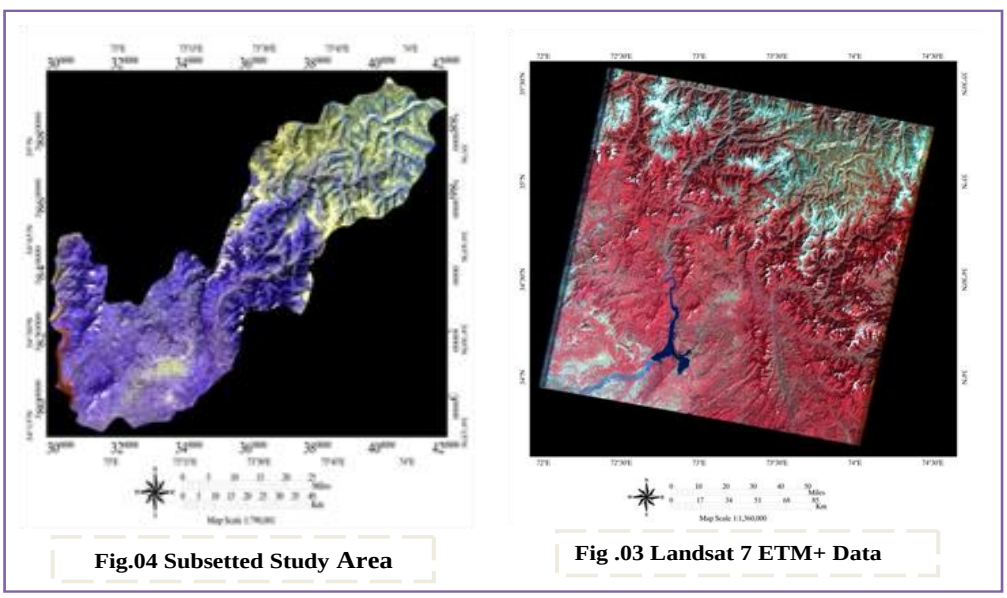

Fig.04 Subsetted Study Area **Fig .03 Landsat 7 ETM+ Data**

2.4 Classification of Data

The image was classified using supervised classification using remote sensing software to classify the various features of study area **(as shown in Fig.5.)**

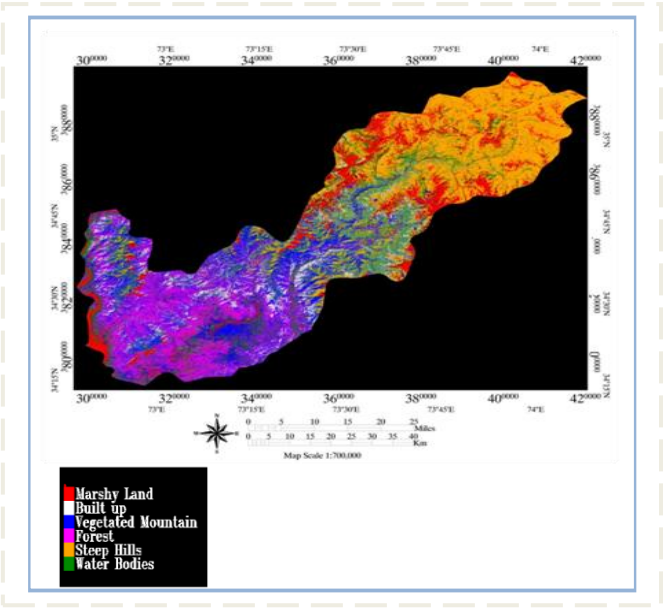

Fig: 05 Land use Map of Balakot

2.5 Methodology

This classified image contained five regions such as marshy land (in red color), built up (in white color) , vegetated mountain (in blue color) steep hills (in orange color) , forest (in cyan) and water bodies (in green color The built up system was located along the river. The catchment areas and marshy land appears to the steep of slopes which makes the soil shallow to be fragile and creates pore water pressure. The forest and vegetations lye on the lowland and appear less dense on the step of f the slopes. The built up system is along the river banks and the catchments area which is totally landslide prone situation.

This conceptual model utilizes the various detailed informative sources e.g. previous literature review by studying the different scenarios of occurred landslides and developed parameters in that connection, amalgation of different previous landslide risk criteria with their suggested algorithms and parameters, utilization of skills of potential scholars through studying the pervious case studies , discussing with local community for the landslide risk trend, triggering rate and occurred landslide events. After

The flow chart of research methodology has been given in Fig: 6.

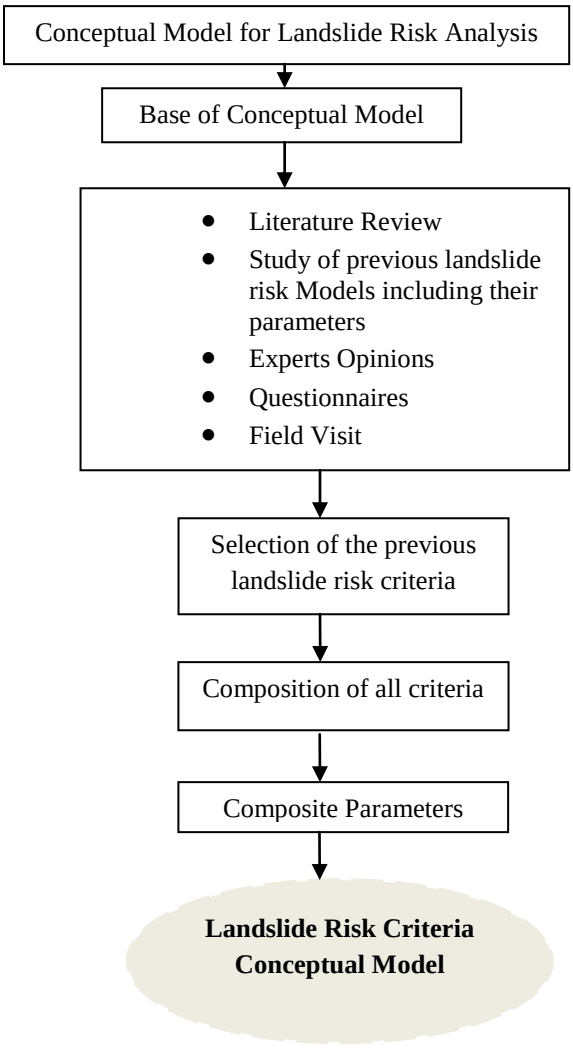

Fig: 6 Conceptual Model Methodology

developing the required parameters, it is suggested to develop the various categories of classes of the parameters so that Geographical Information system (GIS) may be utilized for analyzing to get the digital output of landslide risk model.

2.6. Previous Algorithms considered

The different algorithms developed in past as shown in **(Table 1),** were considered and the different criteria and the parameters were generated based on these previous landslide risk algorithms.

Table 1. Previous Algorithms Considered for developing landslide risk conceptual model

No	Algorithm	Developers
1	Rt=(E)(Rs)=(E)(H X V), As Rs=(H XV)	Varnes [11]
2	LPI = $\sum (R_i \times W_{ij})$	Sarkar [12])
3	Risk = $\sum H \sum(VA)$	Van westen [13]
4	VL = P[DL≥0/L], [0≤DL≥1]	Galli [14]
5	CL =VL, 0 ≤ (CL, VL) ≤1	Galli [14]
6	CL =P(S/HL) X P(T/S) X VL (L/T)	Galli [14]
5	HL= P (AL) X P (NL) X S	Gunther [15]
6	R = Hfr .Pop .Vul	Peduzzi [16]
7	n LHI =$\sum$weight $_{wi}$ X class rate I=1	Kouli [17]

3. RESULT

The conceptual model has been developed as shown in flow chart **(Fig.7)**.

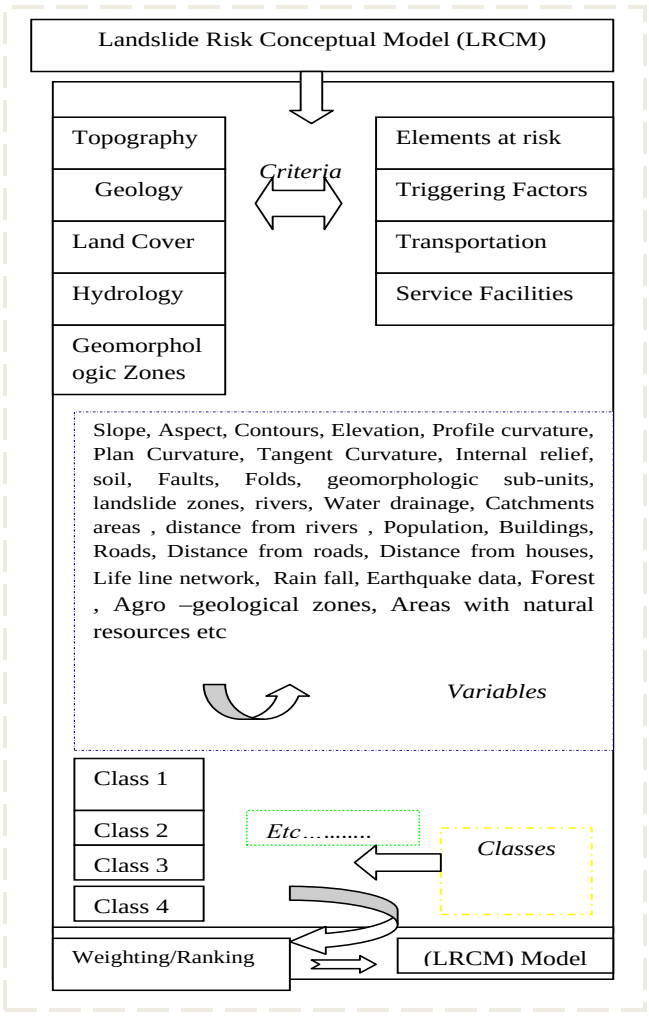

Fig.7 Conceptual model for identifying landslide risk

2.5 Combined parameter developed for conceptual model

The various previous research based utilized new and tradition parameters were combined and suggested to utilize in this conceptual model for development of landslide risk model. Those combined parameters areas; Slope, aspect, contours, elevation, profile curvature, plan curvature, internal relief, soil, tangent curvature, faults, folds, forest, agro-geological zones, areas within natural resources, rivers, water drainage, catchment areas, distance from rivers geomorphologic subunits, landslide zones, population, building, distance from roads, distance from houses, rain fall and earthquake data.

4. DISCUSSION

It has been observed that in past, neither any of the single type of risk algorithm has been taken as a basis for the development of landslide risk models which resulted the inaccuracy of such models during implementing in the field. This type of developed landslide risk conceptual model is a road map for developing various different landslide hazard, vulnerability, and risk models. Those developed different susceptibility models can be helping for the better land use planning, rehabilitation, sustainable development and various other positive benefits.

5. CONCLUSION

This conceptual model will help to the various academia and real life for developing landslide risk models in perspective of consideration of their accuracy, reliability and validity. This model is composite criteria based; qualitative based on utilization of the geo-information technologies practices such as remote sensing and geographical information systems (GIS) for developing landslide risk model. It is believed that this model will assist the different multidisciplinary people such as architects, city and regional planners, ecotourists and GIS modelers,

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