A REVIEW ON FLOOD RISK ASSESSMENT

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ABSTRACT-Flooding is considered as one of the most destructive events in many parts of the world in terms of occurrence and distribution, river flooding remains as a common disaster that has to be faced by the civilization in the flood plains. Due to the periodical happening and horrible impact that may be generated, Flood risk management is necessary to conduct. Risk assessment is a necessity for flood risk management. Practically, the majority of the decision-making requires that the risks and costs of all risk mitigation options are evaluated in quantified terms. As a result, a quantitative assessment of potential flood loss is very important, mainly for emergency planning and pre-disaster preparedness. The present review work primarily focuses on the assessment methodologies and an operational approach for assessing the risk of flood loss to the population, crops, housing, and the economy at different Scale's around the world. These techniques are based on hydro-meteorological, socio-economic and with the combination of those parameters in Geographic Information System (GIS) platform. Concluding that GIS platform appears to be most competent, as it is capable of integrating all the other techniques of flood risk assessment, providing plenty of evidence that the right combination of scientific understanding, experience, forecast and common sense can significantly reduce the risks posed by flood disasters.

KEYWORDS **Risk Assessment, Hazard, Vulnerability, GIS, and DEM.**

INTRODUCTION

For a society to develop in a sustainable manner, it has to cope with destabilizing influences such as natural disasters. (Burrell et al., 2007). Such catastrophes happen when an instinctive or man-made peril effects in human demise, damage or severe hardship, or harms open base, private property, land assets, or farming processing. Floods can result in threats to human health and wellbeing, adverse impacts on biological systems, and severe monetary misfortunes to people and to publicly accepted norms. Flooding is the most common of all environmental hazards and it regularly claims over 20,000 lives per year and badly affects 75 million people world-wide (Smith et al., 1996). Floods cause about one third of deaths, one third of injuries and one third of damage from natural disasters around the world. (Ologunorisa and Abawua., 2005). India, because of its land area, atmosphere, topography and great population, witnesses more fabulous effect of flood catastrophes. An investigation of flood calamities around the most recent 30 years indicates that about 40% of the flood occasions, 58% of expirations, 68% of the influenced inhabitants present and 48% of the monetary harms are reported from India. Around 40 million hectares (m ha) or practically one-eighth of Indian land range is flood-inclined. The average region influenced by flood yearly is about 7.57 m ha and the influenced product territory is about 3.5 m ha. The average misfortune in monetary terms is about Rs 13,000 million. On a normal the misfortune of human exists are about 1,595. (Sharma et al., 2012). Towards the development of Flood Risk Assessment using Hazard Profile, Vulnerability Data, Land use, Land cover Pattern, Population Data and High Resolution Digital Elevation Model Based on Remote Sensing and Gis Technique, Literature survey is carried out.

THEORETICAL CLARIFICATIONS

This subdivision elaborates the characters and elements influencing the assessment process by justifying the terminologies like Risk, Hazard and Vulnerability, which are keenly observed in the literatures and reports around the globe.

1) RISK

Risk is an integral part of life. Indeed, the Chinese word for risk "weji-ji" combines the characters meaning "opportunity/chance" and "danger" to imply that insecurity always involved some balance between profit and loss (Ologunorisa and Abawua., 2005). Risk can be related directly to the concept of disaster, agreed upon that it includes the total losses and damages that can be suffered after a natural hazard i.e. death and injured people, damage to property and interruption of activities. Risk implies a future probable condition, a function of the magnitude of the natural hazard and of the vulnerability of all the exposed elements in a determined moment. Additionally, these terms are used to question the ability of various structural and non-structural measures, which are applied for protection from these threats. (United Nations Commission for Human Settlements - UNCHS, 1981; Ologunorisa et al., 2005). Because risk cannot be completely eliminated, the only alternative is to manage it. Risk assessment is the initial step in risk management. (Ologunorisa and Abawua., 2005). In most part of the developed countries, a relation between risk assessment and management has been systematized, which allows the concerned areas that are safe from natural and human disasters. (Oh kim et al., 2012). Flood risk involves both the statistical probability of an event occurring and the scale of the potential consequences. It is a function and a product of hazard and vulnerability, i.e. the physical and statistical aspect of the actual flooding i.e. the exposure of people and assets to floods and the susceptibility of the elements at risk to suffer from flood damage. (Ologunorisa and Abawua., 2005; Apel et al., 2008; Samarasinghe et al., 2010). By definition of Flood Risk, Hydrometerlogical and Hydraulic investigations are carried out separately to define the hazard and the estimation of flood impact to define vulnerability later these parameters are combined for the final risk analysis, even can be linked with Gis-based risk model. Then degree of flood risk is calculated from historical data and expressed in terms of the expected frequency 10 year, 50 year or 100 year flood. (Apel et al., 2008; Samarasinghe et al., 2010; Zhou et al., 2012). Risk-oriented methods and risk analysis are gaining more and more attention in the fields of flood design and flood risk management since they allow us to evaluate the cost- effectiveness of mitigation measures and thus to optimize investments (U.S. Army Corps of Engineers, 1996; Apel et al., 2008). Flood risk assessment can be carried out using different parameters like Meteorological, Hydrological, Socio-Economic, Geographical Information System and Remote Sensing and by combination of these factors. (Ologunorisa and Abawua., 2005). Risk analysis quantifies the risks and thus enables insurance companies, municipalities and residents to prepare for disasters. (Apel et al., 2008; Ko Hsu., 2011). Evaluating depends on spatial specifications (e.g. area of interest, spatial resolution of data) and relies on an appropriate scale of the flood hazard and land-use maps. For both the hazard and vulnerability analysis a number of approaches and models of different complexity levels are available, and many of them were used in scientific as well as applied flood risk analysis and on different scales. Examples of flood risk analysis are available on municipal level, catchment level, on a national scale and European level (Dutta et al., 2006; Apel et al., 2008; Khan et al., 2010; Kandilioti et al., 2011).

2) HAZARD

Hazard is the probability that in a given time in a given region, and severe potentially damaging natural phenomena occurs that stimulate air, earth movements, which affect a given zone that may cause loss of life or initiate a failure mode. The initiating causes of a hazard may be either an external (e.g. earthquake, flood or human agency) or an internal (defective element of the system e.g. an embankment break) with the prospective to start a failure mode. Hazards can also classify as natural origin (e.g. excessive rainfalls, floods) or of man-made and technological nature (e.g. sabotage, deforestation, industrial site of chemical waste). The magnitude of the incident, the possibility of its occurrence and the extent of its impact can vary and, in some cases, be determined. (United Nations Commission for Human Settlements - UNCHS, 1981; Ologunorisa and Abawua., 2005). In simple words Hazard may be defined as a source of potential harm. (Or) A threat or condition that may cause loss of life or initiate any failure to the natural, modified or human systems. (International Strategy for Disaster Reduction-ISDR, 2004). Hazard analyses give an estimation of the extent and intensity of flood scenarios and associate an exceedance possibility to it. The usual process is to apply a flood frequency analysis to a given record of discharge data and to transform the discharge associated to defined return periods. Depending on the scale of the hazard or risk analysis, the complexity of models applied range from simple interpolation methods to sophisticated and spatially detailed models solving the shallow water equations in two dimensions. (Apel et al., 2004; Apel et al., 2008; Zhou et al., 2012; Camarasa et al., 2012).

3) VULNERABLITY

Vulnerability of any physical, structural or socio-economic element to a natural hazard is its probability of being spoiled, damaged or gone. Vulnerability is not static but must be measured as an active process, integrating changes and developments that alter and affect the probability of loss and damage of all exposed elements. (United Nations Commission for Human Settlements-UNCHS, 1981; Ologunorisa et al., 2005). In simple words “Vulnerability is a set of situation and processes resulting from physical, social, environmental and economical factors, which add to the receptiveness of a society to the blow of hazards”. (International Strategy for Disaster Reduction -ISDR, 2004). The assessment of vulnerability requires an ability to both identify and understand the susceptibility of elements at risk and in a broader sense of the society .The concept of vulnerability is used today by various disciplines, and hence, it is embedded in multiple disciplinary theories underpinning either a technical or a social origin of the concept and resulting in a range of paradigms for either a qualitative or quantitative assessment of vulnerability. A major challenge in vulnerability research is that ‘‘not only people are diverse, but also they are changing constantly, both as individuals and as groups. This constant change within the human system interacts with the physical system to make hazard, exposure, and vulnerability all quite dynamic’’(e.g. characteristics and driving forces of vulnerability change over time, certainly exceeding that time of the extreme event itself). (Fuchs et al., 2012). Vulnerability analysis is normally restricted to the estimation of detrimental effects caused by the floodwater like fatalities, business interruption or financial/economic losses. Frequently, vulnerability analysis focuses only on direct flood loss, which is estimated by damage or loss functions. Loss estimation can be performed on different scales from micro-scale to meso-scale. (Apel et al., 2008).

ASSESSMENT TECHNIQUES

In this section various techniques for assessment of flood risk, such as assessing meteorological parameters, hydrological parameters, socioeconomic factors, and combination of hydro meteorological and socioeconomic factors along with assessment based on geographical information system are explained.

1) METEOROLOGICAL AND HYDROLOGICAL PARAMETERS

Zhang et al (2002) after considering statistical monthly and daily precipitation data in AMeDAS (Automated Meteorological Data Acquisition System), operationalised by representing main factors with a set of scalar, measurable indicators and based on macro-zonation concept, the risk assessment model of flood damage caused by heavy rainfall is investigated by using weighted comprehensive analysis and Analytical hierarchy process, proving heavy rain frequency was larger than heavy rain intensity. Application of proposed methods has shown useful in assessment and zoning based analysis.

Khan et al (2010) used flood peak discharge data of river Indus in Pakistan, from 1942 to 2008, maximum flood was identified by normal, log-normal, and Weibull distribution and simulated data models, later different intensities were computed applying log-Pearson type III (LP3) distribution analysis, proving probabilistic approach to estimate maximum flood.

Camarasa et al (2011) Analyzed flooding by Natural hazards assessment using hydrogeomorphological methods and global exposure was assessment by combination of the economic value and human occupation of land. The procedure was based on the progressive combination of maps, using qualitative cross-tabulation techniques, to the Barranco del Carraixet and Rambla de Poyo floodplains, proving to be extremely efficient, simple, versatile and flexible in interpreting flood processes in intermittent flowing and highly torrential basins.

Zhou et al (2011) adopted an integrating approach by incorporating climate change impact assessment, flood inundation modeling, economic tool, and risk assessment, by step by step process of cost-benefit assessment of climate change adaptation measures for skibhus catchment, a pluvial region in Denmark and the frame work proved to be one of the useful methodology.

Kim et al (2012) Aimed to create a flood risk map for ungauged regions, which had inadequate flood damage data and other relevant data, the regional regression concept in statistical hydrology was introduced to the flood risk assessment with a series of two regression functions like flood damage and regional coefficients. Flood risk maps were created for the three metropolitan areas in South Korea, using flood vulnerability index (FVI), the comparison of the methodology with the existing methods revealed that the methodology adopted here could produce a statistically meaningful flood risk map.

2) SOCIO-ECONOMIC FACTORS

Kubal et al (2009) carries out Multi-criteria approach a novel method for Leipzig, Germany, which includes a specific urban type of economic, social and ecological flood risk criteria, which focused on population and susceptible groups, differentiated built-up land use classes, areas with social and health care and also ecological indicators such as recreational urban green spaces. These parameters are integrated using a multi-criteria decision rule based on an additive weighting procedure which is implemented into the software tool FloodCalc urban, using different weighting sets the most flood-prone areas were recognized, showing the ease of the approach.

Fernandez et al (2009) undergoes a Multi-criteria Decision Analysis (MCDA) for urban region in Tucuman Province, Argentina. Incorporating Parameters like distance to the drainage channel, topography, ground water table depth and urban land use and generated hazard maps and weighted linear combinations were applied. Error propagation method and global sensitivity analysis were carried out to assess the uncertainty, this method proved to be powerful method with good degree of accuracy.

Hsu at el (2011) developed a probabilistic model based on historical events in Taiwan. Rainfall event module, a hydraulic module, a vulnerability module, and an economic loss module were made and insurance portfolio data, flood maps, land-use and census maps, depth-damage curves, and historical rainfall events were incorporated together in a Monte Carlo simulation. Assessment was carried out on the policy level and the zone level. The results show estimation provides useful information for insurers, policymaker in for determining the flood protection capacity according to their tolerance of risk.

Wang at el (2011) used a semi-quantitative model and fuzzy analytic hierarchy process (FAHP) weighting approach for the Dongting Lake region, Hunan Province, Central China, considering spatial multi-criteria analysis (SMCA) techniques in a Geographic Information System (GIS). For the definition of indicator weights like drainage network, vegetation cover, triggering factors and topography, an analysis was performed in a raster environment. All weighted maps were overlaid and the flood risk index was then categorized. Proving the semi-quantitative model allows the incorporation of expert opinion and the use of group decision-making.

3) COMBINATION OF HYDRO-METEOROLOGICAL AND SOCIO-ECONOMIC FACTORS

Apel et al (2004) investigated process chain from rainfall, runoff generation and concentration in the catchment, flood routing in the river system, probable failure of flood protection measures, and inundation to economic damage by deterministic and spatially distributed models at different scales. The risk and uncertainty analysis in a Monte Carlo framework was developed based on the results of complex deterministic models to the Rhine downstream of Cologne in Germany. The Monte Carlo framework is hierarchically structured in two layers representing two different sources of insecurity, aleatory uncertainty (due to natural and anthropogenic variability) and epistemic uncertainty (due to incomplete knowledge of the system). Proving the model in the direction of calculating probabilities of occurrence for events of different magnitudes along with the predictable economic break in a target area to evaluate the economic risks, and to obtain insecurity limits associated.

Apel et al (2008) tested a number of combinations of models on a municipality in East Germany, Eilenburg. On the hazard side, the approaches/models chosen were (A) linear interpolation of gauge water levels and intersection with a digital elevation model (DEM), (B) a mixed 1D/2D hydraulic model with simplifying assumptions (LIS- FLOOD-FP) and (C) a Saint-Venant 2D zero-inertia hyperbolic hydraulic model considering the built environment and road and rail network. On the vulnerability side, the models used for the estimation of direct damage to residential buildings are in order of increasing complexity: (1) meso-scale stage-damage functions applied to CORINE land cover data, (2) the rule-based meso-scale model FLEMOps+ using census data on the municipal building stock and CORINE land cover data and (3) a rule-based micro-scale model applied to a detailed building inventory. And described that the 1D/2D hydraulic model in combination with the meso-scale flood loss model FLEMOps+ is the best compromise between data requirements, gave the best overall performances among other combinations.

Samarasinghe et al (2010) extracted flood extent from satellite images available for one in 50 year flood event occurred on June 2008 in Kalu-Ganga River, Sri Lanka. Then compared with the flood extent derived from the flood extent obtained for the 50-year rainfall using HEC-HMS and HEC-RAS. Base on the flood extent, They has developed, demonstrated and validated an information system for flood forecasting, planning and administrating using remote sensing data with the help of Flood Hazard Maps for different return periods (10, 20, 50 and 100 years), Assess the population vulnerability and physical vulnerability of the lowest administrative division subjected to floods, and using above outcome conduct a flood risk analysis was performed.

Kandilioti and Makropoulos (2011) created a GIS record of economic, social, and environmental criteria contributing. Three special multicriteria decision rules (Analytical Hierarchy Process, Weighted Linear Combination along with Ordered Weighting Averaging) were applied, to generate the general flood risk map of the Athens.IDRISI Andes GIS software was customized and used. The results obtained appear to be able to capture reality, as seen from the comparison with historical flood events. It is suggested that this method is applicable for the type of preliminary flood risk assessment that is required by the Floods Directive, and that it can be applied to relative large regions, while yielding results that are reliable enough to be used for screening purposes as the Directive requires. The method can easily be used to also account for long-term scenarios.

Diakakis et al (2011) in this study, Flood hazard is assessed in 10 municipalities of West Athens, with the use of a GIS-based methodology that exploits catchment morphometric characteristics to delineate flood hazard zones. Past flood events are reconstructed to provide better understanding of the flooding crisis in the area. Finally flood hazard was studied in combination with vulnerability to estimate flood risk spatial distribution. This approach does not give any quantitative expression hazard and risk; it certainly highlights and prioritizes the locations where actions have to be taken to mitigate risk. One of the advantages of the approach is its ability to produce results in short time and with low data and cost requirements, as it can function with commonly existing inputs like land use, geology and topography.

Masood and Takeuchi et al (2011) developed a flood hazard map for mid-eastern Dhaka by 1D hydrodynamic simulation on the basis of digital elevation model (DEM) data from Shuttle Radar Topography Mission and the hydrologic field-observed data for 32 years (1972–2004). Acquired DEM data were modified to represent the existing topography. The inundation simulation was carried out using hydrodynamic program HEC-RAS for flood of 100-year return period. A flood hazard map was prepared according to the simulation result using the software ArcGIS. Leading to the generation of risk map where risk was defined as the product of hazard and vulnerability.

Saini and Kaushik (2012) considered the flooding problem in the Ghaggar River basin, Guhla block Kaithal Haryana India, integrating the hydrological analysis with a Geographic Information System (GIS) to assess the risk and vulnerability based on multi-criteria assessment. RankSum method is used to calculate the weights of factors contribute to flood hazard. Environmental factors like hydrology, slope, soil type, drainage density, landform and land use/ land cover are limited to propose a Flood Risk Index (FRI). Study area shows extreme variability in terms of flood magnitude and frequency both spatially as well as temporally. Study has shown how flood hazard related information can be extracted from satellite imageries and synthesized with census data at village level to identify the land use that are exposed to different degree of flood risk, Integration of pre and post flood satellite imageries and local knowledge into mapping process can make local resident responsive and supportive, Gis mapping provide improved ways of presenting vulnerability and hazard risk that can be applied at local levels.

Sharma et al (2012) carried out an operation of generating flood hazard layer using 50 satellite datasets, together with optical and microwave data acquired during the flood season for the last 10-year period (1998–2007). And is incorporated with vulnerability index (land use/land cover, infrastructure and population data) and weightages are assigned to each group. Based on this, village flood risk index map for Nagaon district of Assam has been generated. Showing multi-temporal satellite datasets, integrated with GIS tools, are useful in identifying vulnerability of road and rail network, population and land use in the event of flood disaster and in calculating the flood risk index.

RESULTS AND DISCUSSION

Identifying and estimating the probable loss of elements at risk earlier to flooding has a significant impact on risk decisions making, mainly on disaster preparedness. Here, some of the techniques of flood risk assessment are reviewed. Which include hydro-meteorological specially those involving rainfall parameter and runoff data. Socio-economic factors, and a combination of hydro-meteorological parameters and socio-economic factors, the platform used for integration these aspects is Geographical Information System (GIS). Based on examples of the flood risk with different intensity provided, the fields of remote sensing and geographic information system (GIS) have greatly facilitated the process of flood mapping and flood risk assessment. It is clear that GIS has a great function to play in natural hazard management because natural hazards are multi dimensional and the spatial component is natural. The main advantage of using GIS for flood management is that it not only generates a image of flooding but also creates possibility to further analyze this product to estimated probable damage due to flood. Most of the investigations mentioned in this paper are heavily dependent on the availability of satellite data, which is not always guaranteed for the time of peak flood.

CONCLUSION

From the literature reviewed, it’s clear that the increasing population of our world is leading to the rising exposure of people and property to hazards of flooding. This declaration is in line with the findings of the research, which has confirmed that the population of people living along the riverbanks has increased over the years and has made them susceptible to the flooding. It is essential that human society adopt a risk management approach if there is to be harmonious co-existence with floods. In practical terms, the chance of flooding can never be eliminated entirely. However, the consequences of flooding can be mitigated by suitable behaviors and actions. The study concludes that the use of GIS technique should be encouraged in risk assessment of flooding, as it is capable of integrating the meteorological, hydrological and socio-economic variables. Successful flood risk management is based upon the active support of all on whom the effects of flooding may impact, those directly at risk, the civil authorities and the wider community.

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