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A REVIEW ON APPLICATIONS OF FLOOD RISK ASSESSMENT

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ABSTRACT

A disaster is a sudden occurring dreadful event which can disrupt the functioning of community or society and causes great loss of life and property. There are two types of disaster – Natural disaster and Man-made disaster. When disasters occur due to natural forces they are called natural disasters, over which man has hardly any control. Some common natural disasters are earthquakes, landslides floods, droughts, cyclones, etc. These disasters cause enormous loss of life and property. Floods are one of the most common natural disasters occurring in many parts of the world every year. Floods have been a recurrent phenomenon in India and cause huge losses to lives, properties, livelihood systems, infrastructure and public utilities. India's high risk and vulnerability are highlighted by the fact that 40 million hectares out of a geographical area of 3290 lakh hectares are prone to floods (Prafulla Kumar Panda, 2014). Floods occur due to heavy rainfall within a short duration of time in a particular region which causes the rivers and streams to overflow. But Floods are not always caused by heavy rainfall. They can result from other phenomena, like snowmelt, steep slopes, impermeable rock, too much wet and saturated soil, or compacted or dry soil. And, floods near to the coastal areas are increasing because of increase in global warming.

KEYWORDS: *Natural Disasters, Floods, Global Warming*

Article History

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INTRODUCTION

Flood Types

Floods are of several types such as River flood, Coastal flood, Storm Surge, Inland flood, Flash flood, and urban flood. River flooding occurs when water levels in rivers, lakes, and streams rise and overflow on to the surrounding banks, shores, and neighboring land. The water level rise could be due to excessive rain from tropical cyclones, snowmelt, or ice jams. In Coastal floods, simply the coast is flooded by the sea. The cause of such a surge is a severe storm. The storm wind pushes the water up and creates high waves. Heavy rainfall and lower elevation also play a factor in coastal water flooding up on land. Storm surge flooding happens during a storm, cyclone, or hurricane. It is a massive wave of water that sweeps on to land. Lastly, Storm surge flooding was severe in New Orleans during Hurricane Katrina in 2007. Inland flooding is the technical name for ordinary flooding that occurs in inland areas, hundreds of miles from the coast. It causes due to persistent rainfall, surface runoff, slow- moving tropical cyclones, rapid snowmelt, ice jams. Flash flood is the most destructive and can be fatal, as people are usually taken by surprise. There is usually no warning, no preparation and the impact can be very swift and devastating. It occurs within a very short time (2-6 hours) and usually causes because of Rain with a very high intensity, sudden Dam break or Snow melt. Flooding in urban areas can be caused by flash floods, or coastal floods, or river floods, but there is also a specific flood type that is called Urban flooding. It is generally caused due to lack of drainage in the urban area. High intensity rainfall can result in a flood as the city sewage system and draining canals do not have the necessary capacity to drain away the amount of rain that is falling.

Recent Flood Damage

Recently, Flood occurred in the region of Gujarat and Rajasthan in July 2017. According to the Indian meteorological department data, between July 1 and 28, Gujarat received 559.4 mm of rainfall, as against the average of 339.6 mm for the said period, representing an excess of 65%. The district of Banaskantha, Patan, Gandhinagar, Morbi, Surendranagar, Mehsana. and Sabarkantha received 267%, 208%, 189%, 174%, 172%, 130% and 115% respectively of their average rainfall for the same period (*Umarji, Vinay, 2017*). And at the same time, 2017 Northeast India floods are caused by overflowing of Brahmaputra River in the state of Assam in July 2017 affecting four Indian states: Assam, Arunachal Pradesh, Nagaland and Manipur. As of 14 July 2017, at least 85 people were dead as a result of the flooding and 4 lakh people have been affected and 500,000 have been homeless. Nearly 60 animals, mostly deer and wild boars, perished in the floods (*Al jazeera, 2017).* If we talk more about flood events in the same year, then 2017 Bihar flood occurred in August 2017 and it affected 19 districts of North Bihar causing of death of 514 people. According to the news from Times of India, NDTV, The Hindu and other various channels, It was saying that around 1.71 crore (17.1 million) people are hit by the flood. Over 8.5 lakh people have lost their homes, with Araria district alone accounting for 2.2 lakh homeless people (Bhattacharya, Aritra, 2017). And Bihar is India's most flood prone State, with 76% of the population in the north Bihar living under the recurring threat of flood devastation. This flood was a result of the sudden increase in water discharge due to torrential rain in the foothill of the Himalayas in Nepal and adjoining areas in Bihar between August 12 and 20 led to flash flood in various rivers (*sethi, Aman,sep.2017*).

Vulnerability and risk assessment into a coherent piece and gives an overview of recent literature related to flood risk assessment. Flooding is the most common of all environmental hazards and comes regularly every year. Whenever it comes, claims over the huge number of lives and adversely affects millions of the people worldwide. More than one-third of the world's land area is flooding prone which affecting around 82 percent of the world population. There are different types of the flood which occur either suddenly like dam failure or gradually like River flood, Urban flood. Suddenly occurring flood generally causes due to breaking down of dam, cyclones or storm surge and also rainfall. But River flood, Coastal flood, Urban flood and other gradually occurring floods causes due to heavy rainfall and less absorption of water on land which led to increasing in water level and flood occur.

Flood risk is a function and a product of hazard and vulnerability. Flood Hazard Assessment usually receives the most attention in process of assessing flood risk as it is based on flood probability scenarios in the areas where it will hit and strength of flood. Also, it provides flood hazard maps which can be used for estimating the danger to people due to flooding. Assessing vulnerability based on the set of conditions and processes resulting from physical, social, economic, and environmental factors, which increases the susceptibility of a community.

Flood Risk

As flood is a natural hazard, so we can't control it completely but the risk can be reduced by taking some measures. A risk is generally described as the uncertain product of a hazard and its potential loss (Crichton, 2002; Kron, 2005). Flood risk has been defined as a degree of the overall adverse effects of flooding. It incorporates the concepts of the threat to life and limb, the difficulty and danger of evacuating people and their possessions during a flood, the potential of damage to the structure and contents of buildings, social interruption, loss of production and damage to public property. Like other studies (Karim *et al*., 2005; Kron, 2005; Apel *et al*., 2009), Dang *et al*. (2010) define flood risk as a product of flood hazard and flood vulnerability, equation (1)

Flood Risk=Flood hazard X Flood vulnerability (1)

In this definition, we can say that flood vulnerability and its hazard are directly proportional to the level of flood risk. When the level of flood vulnerability ,as well as its hazard value ,will get higher than level of the flood risk will also get higher. Dang *et al*. (2010) suggest that flood risk assessment requires interdisciplinary approaches and studies. They specifically suggest that the potential flood risk can be reduced by decreasing the level of vulnerability, reducing the exposure value and by reducing the hazard. Mapping and prediction of flood hazards are an important aspects of flood risk assessment. Flood nature, intensity, and frequency of occurrence are better understood through mapping and simulating of both the already occurred and potential flood hazards. They are essentially used for assessment of the level of risk (knowing the affected people and properties), providing early warning in case of future reoccurrence and hydraulic design, especially for potential flood management and disaster risk reduction (Akinola adesuji komolafe, Suleiman adegboyega, Francis Omowonuola akinluyi, 2015).

Smith and Petley (2009) analyzed that risk is a statistical concept and probability refer to a negative event or condition which affect people, infrastructure and environment. For the last two decades advancement in the field of remote sensing and geographic information system (GIS) has greatly facilitated the operation of flood mapping and flood risk assessment. It is evident that GIS has a great role to play in natural hazard management because natural hazards are multi- dimensional and the spatial component is inherent (Coppock, 1995). The main advantage of using GIS for flood management is that it not only generates a visualization of flooding but also creates potential to further analyze this product to estimate probable damage due to flood (Hausmann *et al.*, 1998; Clark, 1998). Smith (1997) reviews the application of remote sensing for detecting river inundation, stage and discharge. Since then, the focus in this direction is shifting from flood boundary delineation to risk and damage assessment. Therefore, there is a need to review the current literature with a holistic view of dealing with various prospects and constraints of using the technology of remote sensing and GIS in flood management (Joy sanyal, X.X. LU, 2003). Our review presents recent development of flood assessment in some parts of the world using GIS and Remote Sensing. In particular. this paper draws attention to some of the issues associated with application of remote sensing in combating floods.

Global Scenario on Remote Sensing

Remote Sensing information is obtained from different sensors and platforms like satellite, and ground etc., are used for monitoring floods and assessment of flood. Along with the mapping of flood and assessing the damage, satellite data are also used for mapping post flood river boundary, flood control work, drainage mixed areas and then developing the flood hazard zone maps. The Synthetic Aperture Radar (SAR) can obtain observations of earth's surface on a regular basis and also SAR is able to identify the open water images. The Quantitative Precipitative Estimates (QPE) and the Quantitative Precipitation Forecasts (QPF) uses data as a source of information to the flash flood forecasts to provide warnings early to the communities. The Remote Sensing and Geographical Information System technology is significantly involved in the activities of flood management.

DECISION SUPPORT FOR FLOOD EVENT PREDICTION AND MONITORING

In this the development of Web GIS based decision support system for flood events is presented. The decision support system for flood prediction and monitoring that integrates hydrological modeling and CARIS GIS is developed. Here the study area taken for flood prediction and monitoring is the Saint John River in the Fredericton area (New Brunswick, Canada).

In 1973, the largest and best documented flood occurred between April and May in the Saint John River experienced its worst ever recorded flooding, resulting in economic losses of $31.9 million, and leaving one person dead. At the high level of the flood, private houses and public churches were flooded, and roads and bridges were damaged. Since 1973, other floods have left another three people dead and caused more than $68.9 million in damage (see figure 1)

Figure 1: Roads Flooded in Frederiction in 1973

The Saint John River lies in a broad arc across southeastern Quebec, northern Maine, and western New Brunswick. It extends from a point on the international boundary to the Bay of Fundy. It drains a total watershed area of 54 600 km2. The river is about 700 km long, and the total fall from its headwaters to the city of Saint John is about 482 m. The slope of river gradually decreases from about 1.5 meters per kilometer in the headwaters to 0.4 meters per kilometer in the reach above Fredericton. The study area of this research is the flood- prone area along a 90 km long section of the river from Fredericton. The Department of Environment Hydrology Centre is monitoring and predicting flood events along the Saint John River.

The Hydrology Centre team uses hydrologic modeling software to predict water levels for the next 48 hours along the lower Saint John River Valley by inputting climate data, weather forecast data, snow data, and flow data. Based on the water levels, it is hard for users to directly determine which houses, roads, and structures will be affected by the predicted flooding. To deal with this problem, it is necessary to interface the output of hydrological modeling to the Geographic Information System (GIS).

HYDROLOGICAL MODELLING

GIS has powerful tools that will allow the predicted flood elevations to be displayed as a map showing the extent of the flood inundation. Here they developed the Web GIS- based decision support system for flood prediction and monitoring and presented the methods for data integration, floodplain delineation, and online map interface.

This Web-based GIS model can dynamically display observed and predicted flood extent for decision- makers and the general public. In this project, they used CARIS GIS software to implement floodplain delineation.

CARIS (Computer Aided Resource Information System) develops and supports rigorous, technologically advanced geomatics software for managing spatial and non-spatial data. CARIS can be integrated with the hydrologic modeling to generate floodplain maps. With the robust computer tools and high accuracy Digital Terrain Model (DTM), automated floodplain delineation is achievable.

The design of this system allows real-time imagery of actual flooding conditions that can be overlaid on the base mapping and imagery, as well as overlays indicating 100-year flood extents. Map layers with transportation networks, hydrographic features, property boundaries, municipal infrastructure and contour lines can also be visualized.

The system utilizes a Dynamic Wave Operational model (DWOPER) (D. L. Fread, 1992, 1993) (D. L. Fread, J. M. Lewis, 1998) along with approximately 60 water level gauges in the New Brunswick portion of the river. DWOPER model is one dimensional routing model which was developed by the Hydraulic Research Laboratory of the United States National Weather Service to predict water levels for the next 48 hours along the lower Saint John River Valley.

The implementation of hydrological modeling, Digital Terrain Modeling, and GIS algorithm for floodplain delineation and therefore has very good flood prediction capabilities.

The Main Stages of the System of the Development Includes

- *Reconstruction of the DTM from elevation data,*
- *Floodplain delineation,*
- *Development of a Web-based interface for dynamic flood prediction monitoring,*
- *Mapping.*

The floodplain depth dataset is the primary output of this process. Therefore this project integrated the DWOPER hydraulic model with the CARIS GIS system to display real- time flood information in lower Saint John River valley. The research on this project provides the revised decision support system that results in the prevention, mitigation, response, and recovery from flood along the Saint John River.

FLOOD DISASTER RESPONSE AMD DECISION –MAKING SUPPORT SYSTEM BASED ON REMOTE SENSING AND GIS

China has frequently been hit by floods and suffered from flood disasters. To enhance the ability of disaster monitoring, precaution and emergency response decision-making support is the important task and requirement of disaster administration. HU Zhuowei et al. (2007) presented paper introducing the launch of small satellite constellation for the environment and disaster (HJ-1). The functions required to this system include a monitor, analysis, evaluation, precaution, salvation suggestion and so on. The background of this paper was the research on the application of HJ-1 small satellite constellation in the field of disaster mitigation. Taking the requirement of China civil affairs department and the future HJ-1 remote sensing data source into account, three key technologies about the development of flood disaster emergency response decision making support system were designed and developed.

By developing the prototype software based on the simulation data, the demonstrative application of key technologies in the integrative operational system was realized

Key Technologies

The Theme-Oriented Management and Service Technology for the Multi-Temporal Differ-Structural Spatial Data: The idea behind the development of this technology was embedding the operational spatial/non-spatial data processing module and the thematic information extraction module into the conventional geodatabase. Through this method, the data administration functions were integrated into the construction of the spatial database. It made the database has the characteristics of a thematic application, high performance and direct service for the operational work.

- **Disaster Risk Analysis and Loss Evaluation Technology Based on Object of Hazard Effect:** The existence of objects affected by natural disasters is the precondition of constituting a complete natural disaster system. So, Object of Hazard Effect is considered to be a core element of natural disaster risk analysis and loss evaluation.
- **Integrative Model Library and Operation Library for the Flood Disaster Emergency Response Decision-making Support:** In order to develop a standard extensible, updatable model library, HU Zhuowei et al. researched on the structure, the interface definition, the management module and the developing technologies of it considering the requirement of integration and running of operational system. Operation object was defined to organize, manage and trace the workflow of the flood disaster emergency response tasks.

The model library was abstracted as the following form:

M = <D, Q, P, A, R>

Where M is the model entity; D is the description of a model; Q is the problem needs to be solved; P is the parameter list; A is the algorithm applied and R is the result of the model runs.

In order to make this model as simple as a possible model is viewed as a black box with one layer nested by another. Inner layer tackles the algorithm problem. As a result, the model definition can be simplified to this form:

M = <D, P, R>

RUNNING MODES OF SYSTEM

In order to ensure the effective utilization of remote sensing data and realize all-day-night, all-weather monitor of disaster, the system should be developed to enhance the integrative ability of the flood disaster management and the decision making support. Viewing this, the running modes of the system were designed as follows.

- **Operation Mode**

The modules of Operational data processing and application were developed on the basis of simple integration method of RS, GIS technologies. A different module is designed in which one contains Image processing, Spatial Analysis, Cartography where another module has Data preparation, Image Dissolve, Disaster Analysis, and production. They can be integrated in one system and organized an operation object to serve for disaster environment.

- **B-D-A Phases Mode**

The Decision making support functions should be accessed before, during, and after (B-D-A) flood disaster. Before the occurrence of the flood disaster, analyze the monitored RS data, Hydrological data and other data periodically. Based on the regional disaster environment and historical disaster record, occurrence and risk of flood disaster can be predicted. During The occurrence of the flood disaster, the real-time RS data, hydrologica,l data and meteorological data can be analyzed by the system and withdraw route of people affected by adisaster, the transportation route salvation material, and so on. After the occurrence of the flood disaster, the relief of disaster people and the recovery of Disaster area will get support from the system.

- **Simulative Data Model**

By using the small satellite HJ-1,a prototype system is designed and developed for the ground integrative application. The HJ-1 platform will have 2 optical sensors and 1 Radar sensor in his “2+1” phase.

PROTOTYPE SYSTEM

The prototype system was built on the platform of ERDAS and ArcGIS, which are the two most famous softwares of RS and GIS. Powerful application development tools like Visual Basic, Visual C++ and Python were applied neatly to develop the integrative system (HU Z., GONG H.,2005),(LIU X., HU Z., GONG H.,2006). According to a model definition and using the above key technologies,the complex operational model developed synthetically. ERDAS take charge of RS data processing where ArcGIS was utilized to facilitate the construction of analysis models.

This software was divided into two parts: Professional edition and Operational edition. Professional edition can be used by an administrator to maintain the system, manage a database, model library or operation library. The Operational edition can be used by daily workers to access and execute the task in the working depend on the situation of a flood disaster.

The function hierarchy of prototype system depends on four levels: Level 1: the basic functions; Level 2: The model functions; Level 3: The operation functions; Level 4: the thematic application functions.

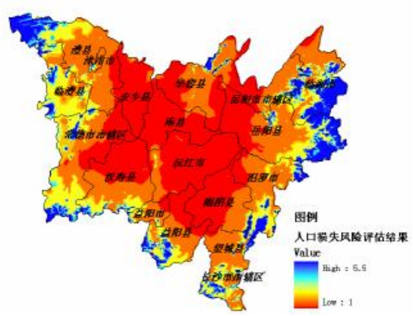

Figure 2: The Effect of the Prototype System

Finally, HU Zhuowei et al. (2007) cooperated with China National Disaster Reduction Center and accomplished the decision-making support system for the flood disaster emergency response. The system had the ability to store] massive data and provides multiple ways to query and search data. The prototype system had extensible modules about the flood disaster monitor, analysis, precaution, decision-making support for salvation and so on. And the effect of a prototype system is shown in figure 2.

A GIS FOR FLOOD RISK MANAGEMENT IN FLANDERS

Flanders, a region of north Belgium that extends from coastline inland, is located in the center of northwest Europe with bordering the North Sea. As Flanders is one of the most densely populated regions in the world, a solid water management policy is needed in order to mitigate the effects of this type of calamity.

In the past, the Flemish administration solved flood problem by draining water downstream as quickly as possible by heightening the dikes along the river banks. But, it leads to higher water levels and a higher flood risk downstream and water defence infrastructure can collapse and create more damage than if no flood defence infrastructure had existed. The new idea was a paradigm shift away from attempting to protect against high water levels to reducing damages caused by the water.

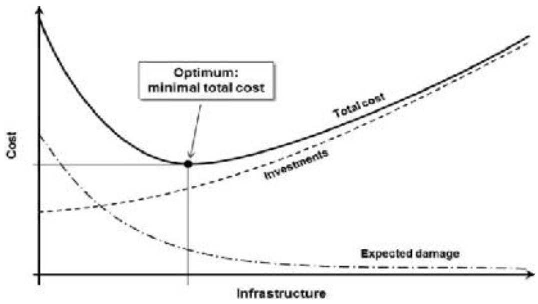

Figure 3: Economic Optimum in a Cost Benefit Analysis for Water Infrastructure

Figure 3 provides a graph of the new idea’s cost -benefit analysis, where a point has been placed on the “Total Cost” to illustrate the “Optimal Minimal total cost”. It shows lower the investment in flood defence infrastructure, the higher the expected costs for damage and vice versa.

In order to estimate and compare the benefits from each of different types of measures, a uniform risk analysis approach is necessary. In this context, several objectives were set by policymakers in the governmental note (Vanneuville et al. 2003) such as, the development of methodology used for the uniform calculation of damage and risk, use of this methodology to calculate change in flood risk and damage and a definition of data and software necessary for running the equations in a geographic information technology (GIT) environment.

To meet these goals, Flanders Hydraulics Research, in cooperation with the Department of Geography at Ghent University, developed a risk-based methodology to assess potential flood damage. This paper describes how risk-based-methodology was implemented via the assessment tool LATIS, providing different calculation performed. Also, it describes how flow velocity was modeled and how flood casualties are calculated.

OVERVIEW OF THE RISK-BASED METHODOLOGY

Flood risk studies in European countries are usually performed using the combination of probability and consequences (Verwaest et al. 2008). Several steps are required to calculate damage and risk (Vanneuville et al. 2005), as is shown in Figure 4.

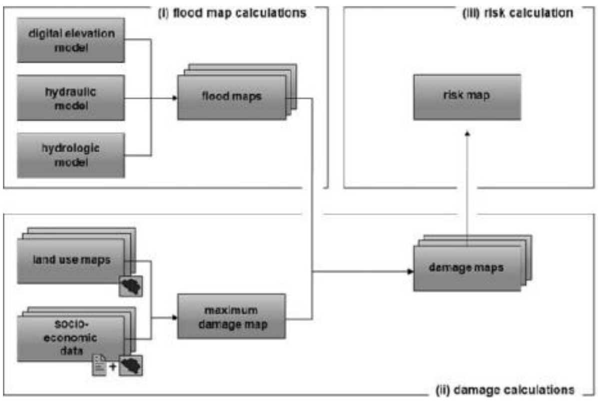

Figure 4: Framework for Risk Mapping (to be Read Counterclockwise, Starting at *Upper Left*)

- **Flood Map Calculation**

Before calculating damage and risk, it is necessary to estimate an area's flooding probability through statistical analysis of past water level and flow rates. First, the return period or average period of time in which a particular maximum water level and discharge may occur is calculated. Calculating probability occurrence is performed using composite hydrographs, which are synthetic hydrograph integrated from Quantity/Duration/Frequency (QDF) - relationships. QDF-relationship statistically links every river discharge with its duration and return period. Only one calculation is required for every return period, resulting in more rapid risk calculation models (Vaes et al. 2002). As stated above, flood maps are created using hydrological, hydraulic, and digital elevation models which shows maximum water levels and flooding extent. And, flow velocity and rise velocity can be obtained. If more historical data are available, flood maps for even longer return periods can be calculated.

- **Damage Calculation**

Here, Land-use information and socio-economic data are used to produce a maximum damage map. By combining the maximum damage map with the flood maps, expected damage for a given inundation can be calculated.

Different Types of Damages

Numerous definition of damage can be found in the disaster literature (e.g., Cochrane 2004). Financially, damage can be split into monetary (tangible) and non-monetary (intangible – including emotional) damage. Second, it is classified between internal and external damage. Internal damage is damage caused in the inundated zone itself, external damage occurs outside the inundated area. The risk methodology used here only considers monetary, internal, and direct/ indirect damage. Although several authors have performed flood risk assessment including non -monetary (Yates 1992; Lekuthai and Vongvisessomjai 2001; Simonovic and Carson 2003) and external damage (Penning-Rowsell et al. 2003; Van der Veen and Logtmeijer 2005).

Maximum Damage Map

Land use Information is needed to create a maximum damage map. Both CORINE land cover and small- scale land use map based on LANDSAT images with a resolution of 30 m per pixel are used to create overall land use map of Flanders. The combination of these data can classify different categories such as built-up areas, industrial grounds, crop lands, pastures, transport infrastructure and airports (Vanneuville et al. 2003). As this, resolution was insufficient to fulfill all needs, vector-based land use information such as road, railroad networks and location of highly valued buildings (e.g., hospital, school, churches, etc.) were integrated to socio-economic data. Socioeconomic data is calculated which includes an individual value of each household, factory or cropland, aggregated spatial data was used. Homes in residential areas have higher values than others. Similarly, Cropland in agricultural areas where fruits and vegetables are most important will carry a higher maximum damage value than others.

Calculating Damage Maps

Combine maximum damage map with the different flood maps to create maps of real flood damage suffered during each return period. To illustrate, five different damage functions are shown in Figure 5.

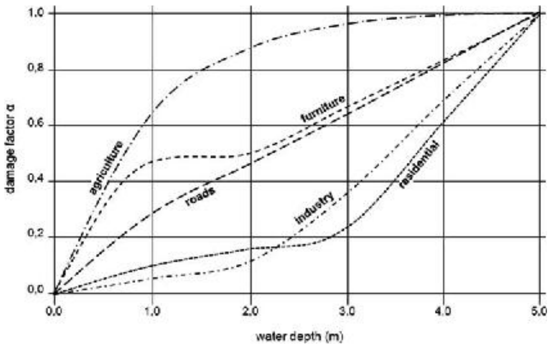

Figure 5: Damage Functions: Real Damage as a Function of Water Depth

The quantitative relationship reflected in these functions is based on Van de Sande and Corné (2001) and Vanneuville et al. (2003). The graph represents Water depth (X-axis) and the dependent damage factor (Y-axis). For example, a water depth of 3 m equals a damage factor of approximately 0.36 (36%) for the industry. The same water depth causes nearly 100% damage to agriculture. In a flood zone, the real damage caused by inundation at a certain water height can be calculated by summing all unique surface entities and combining water depth. Mathematically, this is described as:

$$S_w = \sum_{landusei} \alpha i * S_{i,\,max}$$

S_w : real damage in a zone

$S_{i,\,max}$: maximal damage in a land use class *i*

α_i : coefficient expressing the relationship between water depth and damage for land use class *i*.

Risk Calculation

In the final step, the different damage maps for each return period are combined into one risk map. The mathematical explanation of this procedure is explained in equations 1 and 2 :

$$R = \sum_{i=1}^{n} \frac{1}{i} (S_i - S_{i-1}) \ldots \quad (1)$$

Or

$$R = \frac{1}{1} S_1 + \frac{1}{2} (S_2 - S_1) + \frac{1}{3} (S_3 - S_2) + \ldots + \frac{1}{n} (S_n - S_{n-1}) \ldots \quad (2)$$

Where

R - risk

S_i - the damages related to a flood with a return period of i years

n - the highest return period

Implementation of the Methodology in a GIS

By using land use maps and flood maps, all steps to create risk maps are separated into submodels based on a raster GIS approach. Calculation time in raster GIS occur much more quickly; 90% of the over 400 computations were more optimally performed in a raster-based GIS (Burrough and McDonnel 1998). The model was initially implemented in IDRISI® software (developed by Clark Labs, Clark University, Massachusetts) for raster calculations for the development of LATIS. LATIS is a GIS application that guides the user through each step of the different damage and risk calculation. In 2007, Flanders Hydraulics Research, in cooperation with the Department of Geography at Gheni University developed a GIS tool named LATIS as a substitute for the model structure. The GUI (Graphical User Interface) of LATIS is built in the C#. NET programming language. The interface of LATIS is a simple windows application. The algorithms of the methodology are also implemented in C#. NET, but for the execution of the geospatial operations, LATIS still uses optimal computing capacity and built-in standard modules of IDRISI.

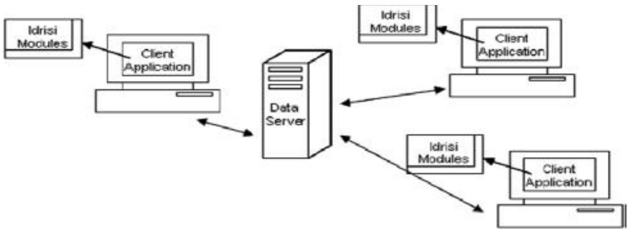

Figure 6: Overview of the LATIS Structure

This application performs the pre -processing of land use and socio-economic data and the user only has to input the flood maps. The data management system also records what data is used in an assessment so a specific risk calculation can easily be repeated. Development of *LATIS* now allows damage and risk maps in Flanders to be calculated in an efficient, uniform, and reproducible manner.

TECHNIQUES OF REMOTE SENSING AND GIS FOR FLOOD MONITORING AND DAMAGE ASSESSMENT: A CASE STUDY OF SINDH PROVINCE, PAKISTAN

In this project, the techniques for mapping flood extent and assessing flood damages have been developed which can be served as a guideline for Remote Sensing and Geographical Information System operations to improve the efficiency of flood disaster monitoring and damage assessment. The study area was taken for flood monitoring and damage assessment was Sindh Province in Pakistan where the flood caused by the Indus River. The study area is located in southern part of the country stretching about 579 km from north to south and 442 km from east to west with an area of 140915 km2 and lies between two monsoon—the southern monsoon from the Indian Ocean and the northeast or retreating monsoon, deflected towards it by the Himalayan mountains.

The flooding has been recorded and affecting the entire country since 1928 during the monsoon period between July and September and the country has experienced major floods during the years 1928, 1929, 1955, 1973, 1976, 1980, 1988, 1992 and 2010 (Solheim et al., 2001; Natalia Kussul et al., 2008). Floods in the Indus River Basin in Pakistan have claimed more damage to 7,000 lives; inundated zone was 7.7 million acres around and caused massive infrastructure and crop losses (Muhammad Shahzad Sardar et al., 2008). The flood in 2010 began in late July inundated Pakistan with approximately 60,000 km2, affected 15–20 million people along with the death toll close to 2000 (Mateeul-Haq et al., 2010; Wikipedia, 2010). The rains have been observed in Sindh leading to huge economic loss, damaging of ecological resources, food shortages and remaining the million people in starvation The average rainfall in Sindh province is 6 -7 inches that cause mainly during July and August.

Topographic maps are taken and used to extract different types of info-layers. The maps include administrative boundaries, rivers, lakes, roads, railway tracks, vegetated areas and other land use/land cover categories. TERRA and AQUA images of the required resolution were acquired and used as the input in mapping the flood- affected areas. Moderate Resolution Imaging Spectro-radiometer (MODIS) is used in the project for Flood Monitoring and Damage assessment. The MODIS images of the study area are taken from NASA. The District wise population density was used to estimate the affected people and the data are provided by Federal Bureau of Statistics, Pakistan (Statistical Bulletin, 2011). ENVI 4.5 and ArcGIS 9.3 are the software was for processing and analysis.

Flood monitoring using satellite data is an effective method to get a quick and precise overview of flooded areas. In this study, the detailed analysis had been carried out using Remote Sensing and GIS for identifying flood- affected areas along with land use/land cover. By using all the information and methodology, the cumulative and temporal flood extent maps were prepared.

FLOODS ASSESSMENT AND MONITORING USING REMOTE SENSING AND GIS

A flood is caused by heavy rain, snowmelt, or dam failures cause and defined as any relatively high water flow in any portion of a river or stream, and the water spreads over the flood- plain and generally becomes a hazard to society. As a result, floods are one of the greatest challenges to weather prediction. Due to the high degree of urbanization, the flooding can be extensive, resulting in a great amount of damage and loss of life and property. The floods are known by the one most common factor i.e., heavy rainfall. Improvement in rainfall measurements is being achieved by radar, rain gauges and remote sensing techniques to improve flood forecasting (Vicente and Scotfield, 1998). In the mountain areas, analyzing the risk of flood is associated with the data of erosion, slides, transport etc., whereas the flood is caused in plain areas mainly controlled by water flow.

Forms of Floods

- **River Floods:** Caused by winter and spring rains, snow melt
- **Coastal Floods:** Caused by winds and storms caused by Tsunamis
- **Urban Floods:** Caused by high degree of urbanization
- **Flash Floods:** Caused by excess rainfall, dam failure and sudden release of water

As per the Natural Disaster Survey Report on "The Great Flood of 1993," (Schofield and Achutani, 1994),

Flood Risk Map is of Two Types

- A detailed mapping approach which is required for hazard assessment for risk maps.
- A large scale approach with aim of identifying the areas that have highest risk.

There are the phases which can be taken for the flood.

Flood Preparedness Phase

This includes the Flood prone area or the Risk zone identification by the detailed mapping approach of the areas to estimate the earlier floods.

Flood Prevention Phase

Flood Monitoring

The Flood prevention phase states the flood monitoring which can be carried out through Remote Sensing using Hydrodynamic models.

HYDRODYNAMIC MODEL

Consists of factors like

- Land use
- Soil type
- DEM (Digital Elevation data)
- Soil Moisture
- Rainfall
- Base flow
- Static data

Flood Forecasting

The hydrologic models take an important role in forecasting the flood risk. These models give the predictions of flood which can help the emergency managers to develop plans in advance to an effective response to flood.

Response Phase

The Response Phase can be referred as the relief of flood and it refers to take the actions immediately after the flood. This is the most delicate management category and it includes the rescue operations and the safety of people and property.

Relief

Relief stage is the re-building of the damaged facilities and infrastructure. The medium resolution of the data can establish the extent of the flood damages and can be used to establish new flood boundaries. High-resolution data are suitable for pinpointing locations and the degree of damages and also can be used as reference maps to rebuild the bridges, roads, homes facilities.

CONCLUSIONS

Flooding is the most common of all environmental hazards and comes regularly every year. This review paper discusses five works of literature of flood assessment from different regions of this world. The review encompasses developing a GIS system to display near real time flood information in their area. This GIS system incorporates hydrologic and hydraulic models, landuse information and socio-economic data. The methodology used in their study has the capability to carry out rapid damage assessment. Their research provides the foundation for a revised decision support system that can result in improvements in the prevention, mitigation, response, and recovery from flood events.

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