



Review Paper

An ICT based Early Warning System for Flood Disasters in Pakistan

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Abstract

Pakistan is a developing country, like other developing countries Pakistan is facing so many kind problems. Natural disasters and terrorism are the major issues of Pakistan. Different types of natural disasters like earthquake, flood, drought, landslides and snow slides and glaciers melting are frequent disaster events in the region. 2005 Kashmir earthquake and 2010 flood was the mega destructive events with thousands of live losses and millions of dollars property damages. In sufficient coping capacity, pathetic communication and collaboration between different concerned departments, lack of community awareness, resources gathering and insufficient budgeting, lack of technology awareness, adoption, integration are the most common barriers in disaster management domain. Information and communication Technology (ICT) is the most adopting and growing technology now a days. ICT is playing most important role in enhancing human life activities as well as increasing efficiency and accuracy along with transparency and out of space and time limitations. ICT is also contributing its lions' share in the domain of disaster management. Various ICT based applications and services are available for disaster management. Floods are one of the most destructive disaster events in Pakistan their frequency and intensity is increasing in last decade. Unpredictable and heavy monsoon rainfalls and melting glaciers are the most common reasons for floods in Pakistan which resulting in massive live losses, large amount of internally displaced persons (IDPs), damages of agricultural land and crops as well as live stocks. There is an urgent need of flood disaster management system (FDMS) equipped with state of the art ICTs. Floods forecasting and predictions, early warning, flood monitoring, risk assessment and damage assessment are the open grounds for integrating ICTs. In this study we are trying to cover the role of ICTs in flood disaster management system all over the world. Identification of challenges and opportunities in terms of technology integration and adoption in the domain of FDMS in Pakistan, and proposing a ICT based Flood early warning system (FEWS) which is second face of the coin.

Keywords: Disaster management system, flood in Pakistan, ICT for flood disaster management systems, history of flood in Pakistan, flood 2010, flood early warning system (FEWS).

Introduction

Disaster is a new kind of threats for the whole world. Disasters do not distinguish between people, their affiliation, religion, sect, language, economy etc. they treated whole community in same manner and tries to destroy each and every thing. It is strong believe that disasters cannot be eliminated from the earth but people trying to manage them as efficiently as possible to minimize their losses and damages. Developed and developing countries are at the same target of natural and man induced disasters. Over the last 20 years the natural disaster occurrence frequency is increasing day by day. Global warming, changing weather pattern, rapid urbanization, pollution and industrialization are common factors that impact on natural disasters. Mostly Asian countries are developing countries. Social, Economical, Political, Geographical, Cultural, Educational, Legal, Technological and Institutional are the most common factors¹ that strongly influence on Disaster Management (DM) activities. The geographical location of south Asia makes this region's countries more vulnerable to

natural disasters. The South Asian countries like Afghanistan, Bangladesh, Pakistan, India, Sri Lanka, Nepal, Bhutan and Maldives many times demonstrates their deficiencies regarding disaster coping capacity. According to the United Nations International Strategy for Disaster Reduction (UNISDR) and the World Bank south Asian region's most frequent natural disasters are earthquake, flood, drought, landslide, cyclone and volcano hazards. These are many developing countries, trying to get strong institutional arrangement to handle emergency and disaster situation, disaster management mechanism is pathetic, lack of collaboration and communication between different DM responsible entities like Police, Fire brigade, Ambulance etc. these countries continuous struggling in prevention and better response to natural disasters in this regard strengthen disaster management activities is a keen focused area now a days.

Pakistan is one of the most vulnerable countries to natural disaster in south Asian region². Pakistan is continuously facing extraordinary natural and man induced disasters of great strength. 8 October 2005 Kashmir Earthquake and floods of

2010 are obvious examples of disaster events. As other developing countries, Pakistan is passing through the development phase of disaster resilience and disaster management institutional arrangements. Due to its inadequate disaster coping capacity, insufficient Disaster Management System (DMS), underprivileged community structure, poor awareness to disasters, lacking of training and exercises every time when a disaster occurs leaves its long term effects and impressions of losses and damages in the form of human casualties and property destruction. Geographically, Pakistan can be divided into three regions one is the northern highlands including K2, the second highest peak in the world, second is the Indus river plains, and third is Baluchistan plateau³.

Pakistan's Natural Disaster History: There is a long history of natural disaster events in Pakistan. Pakistan's geographical location exposes its more prone to different types of natural disaster like earthquake, landslides, floods etc. Pakistan is highly vulnerable to natural disasters and a big proportion of Pakistani people live in disaster risk area⁴. Disasters parallelized social and economical activities of the affected region. Local residents become victims and depending on external help for the fulfillment of their basic needs such as food, drinking water, medicines, residence, medical treatment etc. Thousands of people are displaced due to natural disasters. In Pakistan Internally Displaced Persons (IDPs)⁵ term is used for displaced people. According to International Displacement Monitoring Center (IDMC, 2012) in last five years around 19 Million people have been displaced from their residence by Earthquakes and around 5 Million by armed conflict in last seven years. In 2005 Kashmir earthquake displaced around 3.5 million people while in 2007 in around 300 thousand (3 Million) in Baluchistan. In 2010, 11 million people displaced due to Indus river flood and 2011 monsoon season with heavy rains around 4 million people were displaced from their residence. In the following table 1 demonstrate the number of disaster events and table 2 shows the number of deaths, injured and affected persons from 1935 to 2011 in various natural disaster in Pakistan. It is a well-built truth that poor country's peoples are the most affected community due to natural disasters like floods and earthquake as they have inadequate disaster management mechanism⁶, poor coping capacity and fewer resources.

Flood History of Pakistan: A natural incident covered land which is used by human beings for residence, farming, traveling, Business, sports, education etc. covered by huge amount of water which is normally not the actual place of this huge amount of water⁷. Floods are unfavorable event produce property damages, losses of lives and paralyzed human routine life activities. There are many types of floods Monsoon floods, Flash floods, Floods due to the breaches, urban floods and Coastal floods⁸.

Floods are not new destructive event for Pakistan. If we look at the Pakistan's disaster history we found number of dangerous flood events that was damaged Pakistan's assets in terms of

unbearable losses of crops, land and peoples. From 1947 to 2010 there are many dangerous floods. Following is the table that demonstrates the fact and figures of these events. Figure 1 shows the no. of fatalities in floods during 1950 to 2011 and figure 2 shows the no. of affected people in floods during 1950 to 2011. Following is the table that shows the floods history of Pakistan from 1935 to 2011.

Table-1
Pakistan Natural Disaster Events 1935 to 2011

Types of Disasters	No. of events
Floods	18
Earthquake	11
Wind Storm	11
Avalanche	3
Landslides and Floods	2
Cyclone	2
Drought	2
Heat Wave	2
Wind Storm tornado	2
Landslides	1
Cold Wave	1
Cyclone and Flood	1
Earthquake/Tsunami	1
Flash Floods	1
Influenza A (H1N1) Pandemic	1
Monsoon Rains	1
Rain and Snow Fall	1
Wind storm and Cyclone	1
Grand Total	62

Source: NDMA, PDMA, GBDMA, reliefweb

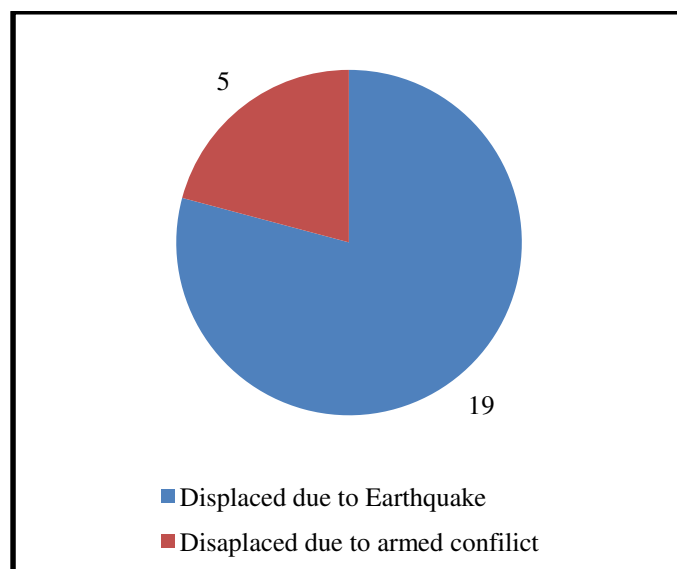


Figure-1
Displaced person in last five years (Source IDMC, 2012)

Table-2
Summary of death, Injured and Affected 1935 to 2011

Types of Disasters	Total Death	Total Injured	Total Affected
Floods	9,313.00	4,206.00	45,652,022.00
Rain and Snow Fall	1,116.00	666.00	7,000,000.00
Earthquake	138,653.00	87,020.00	4,650,000.00
Cyclone and Flood	330.00		2,500,000.00
Drought	200.00		2,200,000.00
Cyclone	500,231.00	155.00	657,000.00
Wind storm and Cyclone	450.00		400,000.00
Cold Wave	16.00		35,000.00
Landslides	200.00		8,000.00
Avalanche	149.00	81.00	3,633.00
Flash Floods			1,400.00
Landslides and Floods	100.00		300.00
Earthquake/Tsunami	4,000.00		
Heat Wave	1,250.00		
Influenza A (H1N1) Pandemic	29.00		
Monsoon Rains	112.00		
Wind Storm	10,908.00	458.00	
Wind Storm tornado	60.00	600.00	
Grand Total	667117	93186	63107355

Source: NDMA, PDMA,GBDMA, reliefweb

Table-3
Pakistan Flood History 1935 to 2011

Year	Name of Disaster	Geographical Province	Death	Affected	Damage/ Destroyed House	Area Affected	Crops Damaged	Cattle Head Perished/ Livestock
1950	Floods		2,900					
1973	Floods			4,800,000				
1976	Floods			5,566,000				
1978	Floods			2,246,000				
1988	Floods	Punjab, KPK, FATA, Gilgit Baltistan, Sindh	158	1,000,000				
1991	Floods	Balochistan			100			
1992	Floods	KP, Punjab	1,334	6,655,450	875,000	4,796,050		
1993	Floods	Punjab	15	261,295	667	798,315		
1994	Floods	Punjab, Sindh	316	840,000	84,000			11,000
1995	Floods	KPK, Sindh, Punjab, Balochistan	451	1,255,000	76,982	3	1.126 Million Acres	15,375
1996	Floods	Punjab	80	1,186,131			4.5 Million acres	
1998	Floods	Balochistan	1,000		4,000			20,000
2001	Floods	KPK/Punjab	210	400,000				
2003	Floods	Sindh/Balochistan	250	800,000	32,762			9,110
2005	Floods	KPK,sindh,	39	467,896	25,624			
2007	Cyclone and Flood	Balochistan/Sindh	330	2,500,000	88,344			
2008	Floods	KPK/Punjab	55	2,100,000	1,604			
2009	Flash Floods	Sindh, Balochistan, Punjab and KP		1,400				
2010	Floods	Balochistan, KP, Punjab, Sindh, Gilgit Baltistan	1,985	18,074,250	1,744,471	796,095		
2011	Floods	Balochistan,Sindh	520		1,604,406	6,763,454		116,529

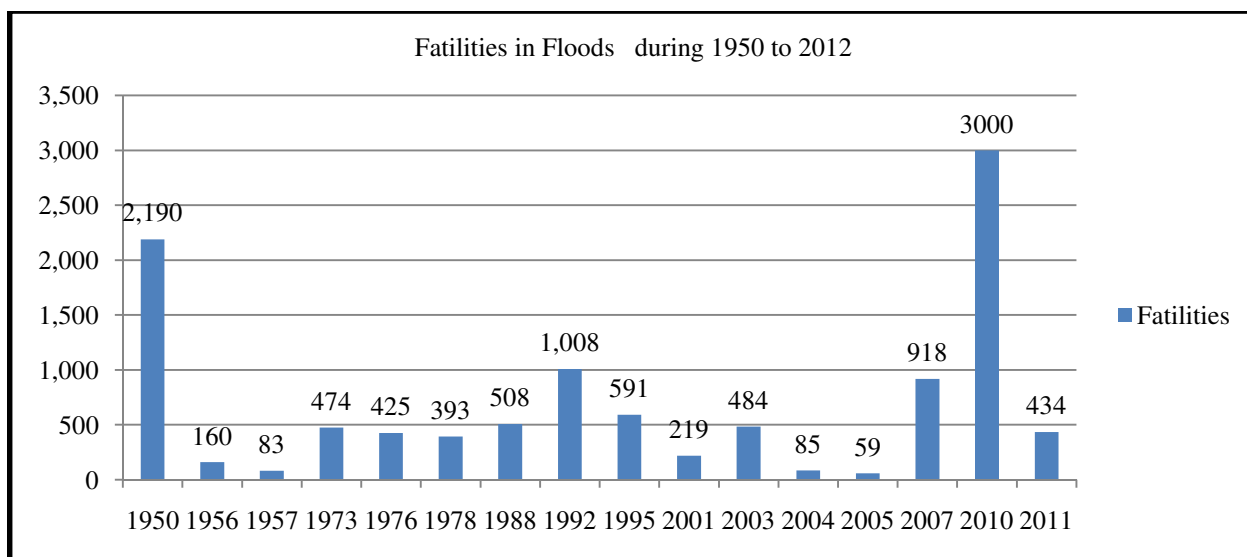


Figure-2
No of Fatalities in Floods (Data Source: pakistanweatherportal.com)

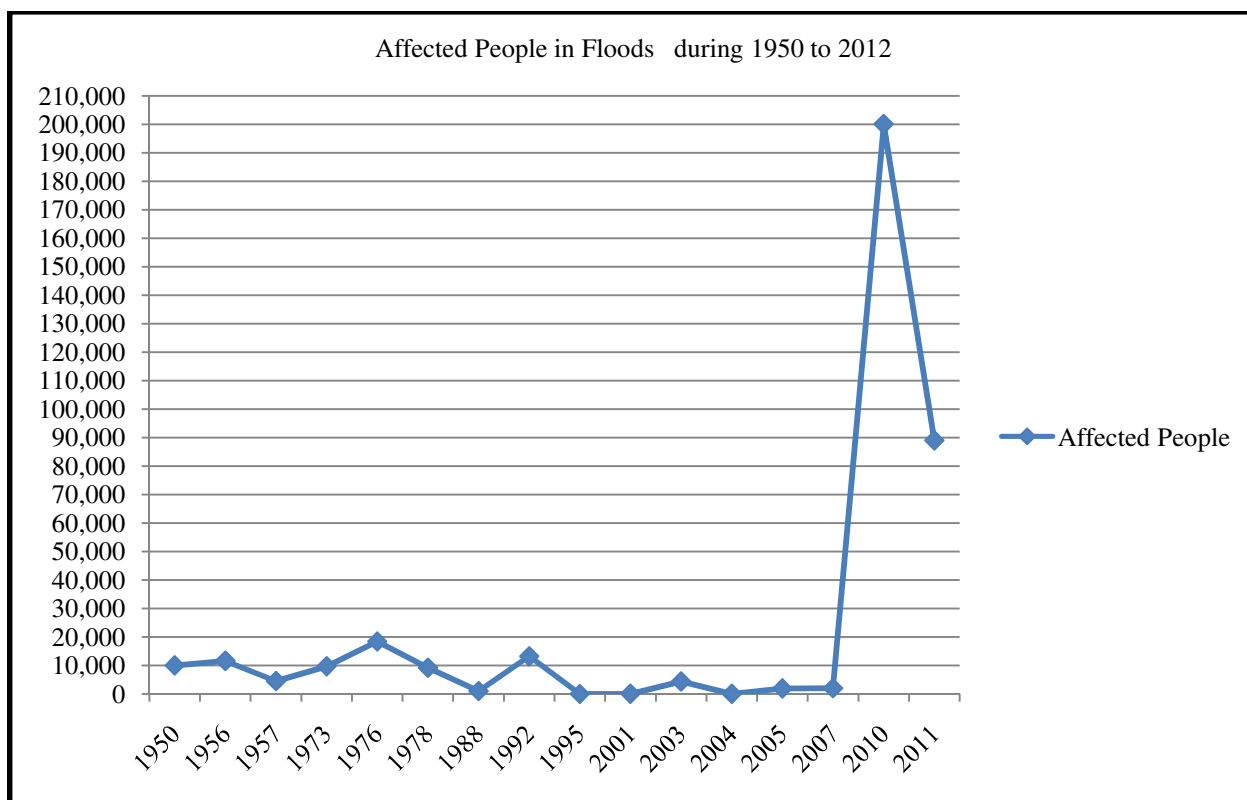


Figure-3
No. of Affected People in Floods (Data Source: pakistanweatherportal.com)

The July 2010 flood was the most intensive⁹ flood in the history of Pakistan as 20 million peoples were affected about 3000 killed, 1 million houses destroyed and no of IDPs was 10 million and approximately 796,095 square kilometers¹⁰ area was underwater.

Pakistan flood 2010: Causes of floods are generally heavy rainfall resulting in river overflow⁷, dam breaks¹¹, snow melt flows. In 2010 Pakistan was experienced worst flood of the history of the country. All most all the regions of Pakistan effected from this flood. Major cause of this flood was extraordinary rainfall hit Khyber-Pakhtunkhwa (KPK) and

Punjab province. The numbers of individual victims of this flood were more than the combined total victims of 2004 Indian Ocean tsunami, the 2005 Kashmir earthquake and the 2010 Haiti earthquake i.e. around 2000 persons died and 2 million people were affected¹².

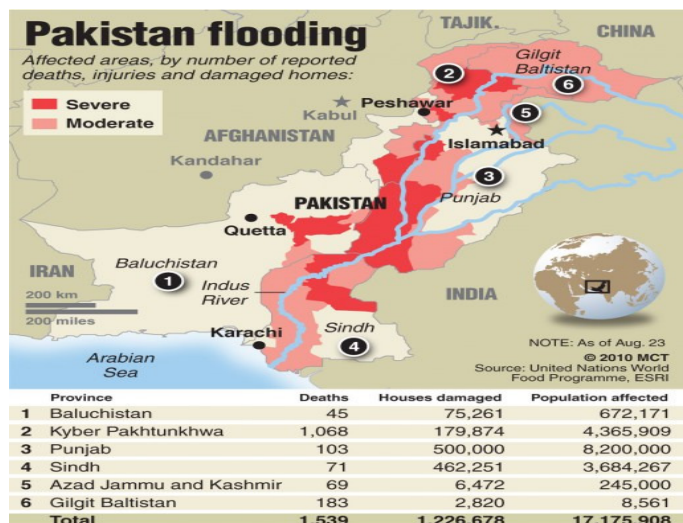


Figure-4

Pakistan Flood 2010 Affected area map (Source; Pakistan Metrological Department)

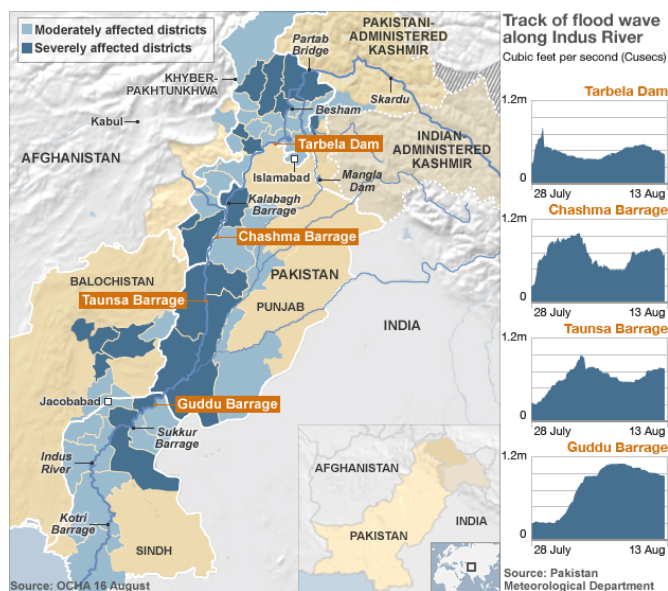


Figure-5

Pakistan Flood 2010 Affected area map (Source; United Nations World Food Programme)

According to BBC in 2010 Pakistan experienced record breaking rainfall resulting in worst flood of the history (80 years). According to the National Disaster Management Authority (NDMA) Pakistan, due to heavy flood along with landslides infrastructure is severely damaged, all most all the

villages are under water in affected areas and urban areas also seriously affected, 2 million homes, 400 miles of roads, 46 bridges, and railway lines were destroyed and thousands of acres of agricultural land and winter wheat crops which is Pakistan largest food crop, were damaged. On behalf of Pakistan Government's request Asian Development Bank (ADB) launched a Damage and Needs Assessment (DNA) exercise on August 16, 2010 to assess and quantify flood damage, losses and resulting needs¹³. A joint report of Asian Development Bank, Pakistan Government and World Bank is published on November 2010.

According to this report the overall recovery and reconstruction cost associated with the floods is estimated at approximately US\$ 8.74 billion to 10.85 billion, which includes estimated costs for relief, early recovery, and medium-to long-term reconstruction¹⁴. Following, table 4 demonstrates overall cost of the floods.



Figure-6

People wait to cross a flooded road in Bannu, northwestern Pakistan on Tuesday, Aug. 3, 2010 (Source:Sacbee.com)



Figure-7

Pakistani flood victims cross under a damage bridge following a flash flood in Medain, a town of Swat valley on August 2, 2010 (Source:Sacbee.com)

Table-4
Overall cost of the Flood (Data Source¹⁴)

Category	US \$ Million
Reconstruction	8915
Early Recovery	956
Relief	928
Relief/ Early Recovery	53

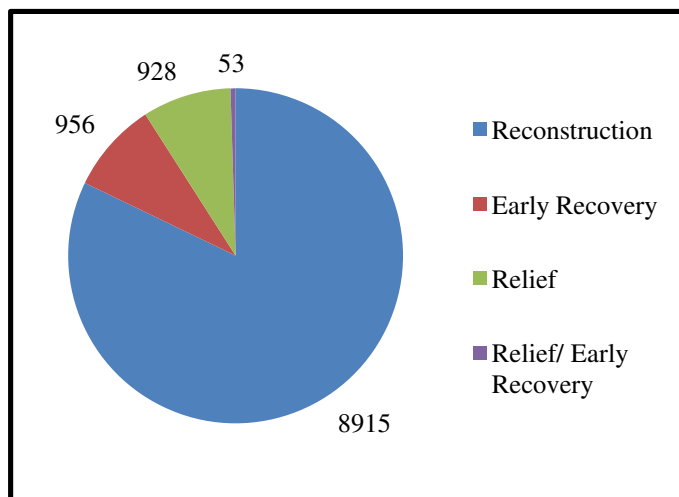


Figure-8
Overall Cost of Flood US \$ Millions (Data Source¹⁴)

Material and Methods

Pakistan's Flood Disaster Management System

Developed countries have established advanced and efficient flood management system¹⁵ that's why these countries minimize losses of flood in terms of live losses, property, agricultural area and livestock. In developed countries flood management system well planned stages of preparedness, rescue, relief, rehabilitation and reconstruction. Author emphasize on incorporation of appropriate town planning principle in Disaster Management System (DMS) and suggests that Disaster Risk Reduction (DRR) should be part of any plan at weather it is village or town planning or urban planning at each level (Federal, Regional, District and local or Community level) of administration or management of crisis or emergency situation. He point out deficiencies of Pakistan Flood DMS in context of lacking of town planning, DRR, absence of adequate use of technology. Pakistan's current flood management strategy¹⁶ are supposed to be acceptable before the flood 2010 but after consequences of 2010 flood are the evident prospect to re-examine and improvement of Pakistan's flood management strategy particularly in Sindh. There is an urgent need for building multipurpose water reservoirs not only for storing extra water due to heavy monsoon, glaciers melting etc. but for slowdown the water flow of, providing fast and secure channel for flood water to the sea and last but not least for power generation. Pakistan flood management strategy¹⁷ is emphasis on flood warnings, measurement of water level in the rivers, prediction

of flood and rescue and relief work in the affected area. Pakistan's Flood management strategy is exposing its deficiencies in terms of short-term planning, no prevention and preparedness just response, lack of environmental and sustainability concern. A report of National Disaster Management Authority (NDMA) Pakistan was published after calamitous flood of 2010 with the title of "Pakistan 2010 Flood Relief – Learning from Experience Observations and Opportunities", this study overview the strategic planning of NDMA and its collaborator organization and share their experience and lesson learned from the fold 2010. There are many recommendations presented in this study to strengthen the Disaster management mechanism and improving role of NDMA and their collaborators in Pakistan, Suggestion includes¹⁸: i. National Disaster Management act overview, redefining the role and responsibilities of NDMA, Provincial Disaster Management Authority (PDMA) and District Disaster Management Authority (DDMA). ii. NDMA leading role should be accepted by the Federal and Provincial Governments in major disaster situation for avoiding inconsistency. iii. Development of definite guidelines is needed for clarifying roles of disaster management authorities like Government Ministries or Departments, humanitarian organizations, military philanthropists, UN agencies, civil defense and donors. iv. Adequate funding for resource gathering should be provided to NDMA. v. All disaster management stockholders should be conducting a periodic meeting in peace time for building ownership and prepare to response any disaster. vi. Government officials should be nominated for training with collaboration of NDMA. vii. Provincial capacity development is needed for increase resource gathering, resource allocation, warehousing, personnel training, and focal-point functionality. viii. Identical reporting line should be adopted by the PDMA for avoiding divergent and inconsistent practices. PDMA should report to their corresponding Chief Minister or the Chief Secretary of the province. ix. Immediate establishment of a Joint Aviation Coordination Cell (JACC) is mandatory for responding future disaster; motivation of JACC is the 2005 Kashmir earthquake and flood 2010. x. An incident command system, Standard Operating Procedures for NDMA, a single reporting system development for effective monitoring and assist planning, single reporting format, autonomous of decision making, contingency plans for disasters, regular mock exercise, development of Disaster Risk Reduction (DRR) are critical.

FLOOD 2013: According to the NDMA the statistics for flood 2013 damages in all over the Pakistan are given in table-5.

ICT for Flood Disaster around the Globe: In an emergency situation like disaster events, effective communication and collaboration are the major issues. Responding emergency situations is not such an easy task. Responding efforts efficiency can be enhance by adopting ICT at the time of handling emergency situation like natural disaster management¹⁹. All most all the developed countries are extensively using ICT and ICT based applications for managing natural disaster.

Table-5
Flood 2013 Damages Statistics (Source: NDMA, 2013)

Province	Persons Died	Persons Injured	Persons Affected	Area Affected (Acres)	Crops Affected (Acres)	House Damaged		Village Affected	Relief Camps Established	Persons in Relief Camps
						Partially	fully			
PUNJAB	28	79	290306	396351	158580	1841	2250	534	43	1950
KPK	24	17	336	0	4279	708	149	15	0	0
SINDH	22	10	15000	0	0	1	0	15	1	850
BALUCHISTAN	16	2	0	0	0	0	0	28	0	0
FATA	12	0	0	0	0	0	0	0	0	0
AJ&K	4	5	0	0	0	98	1	0	0	0
GB	0	0	0	0	0	0	0	0	0	0
TOTAL	106	113	305642	396351	162859	2648	2400	592	44	2,800

Developing countries are trying to integrate ICT with disaster management scenario with facing some challenges like funding, awareness etc. The advancement in Information and Communication Technology in the form of INTERNET, GIS, Remote Sensing, Space Technology and Mobile Technology etc. can help a great deal in planning and implementation of disaster reduction measures. Natural disaster occurrence frequency and intensity is increasing day by day around the globe and becoming a big threat for the whole world. Among the various natural disasters floods are the most common natural disaster. Floods are disaster events resulting in great damages of agricultural land, live stocks, property and human lives. ICT is playing an increasing role in different stages of flood disaster management including forecasting and prediction, mitigation, early warning, response and rescue as well as rehabilitation. Potential ICTs which are widely using in flood disaster management are Remote Sensing²⁰, GIS²¹, Space Technology²², Wireless Sensors Networks²³, Satellite Technology²⁴, Mobile Technology²⁵ and Social Media²⁶.

A Flood Early Warning System²⁷ based on internet and sensors network is presented, using for monitoring data from various deployed sensor nodes. On the basis of captured data from sensors EWS calculate the probability of flood spreading also indicating the save passage for people from flood affected areas. Australia, like other developed countries fighting against natural disasters by incorporating latest technologies. Flood forecasting and early warning ICT based system²⁸ are being used from 1980 to 2010 in Bureau of Meteorology Australia. Flood forecasting, early warning and data collection in Australia varied from manual to state of the art ICT based services. These 24/7 ICTs system add great help in monitoring and forecasting flood disaster and preparing for better response for these destructive events. Risk assessment helps in proper policy making and planning likewise flood risk assessment is necessary for planning and policy making for a region which is vulnerable to

frequent floods. Flood risk assessment using GIS and remote sensing²⁹ with a case study of the city Gonaives, Haiti is presented as PhD dissertation. This report exhibits the use of GIS and remote sensing in combination with hydrological models for measure flood risk which can be helpful in proper conservation planning, policy making and supporting economic growth as well. In disaster management satellite imaging is widely used for monitoring and surveillance of land used, rivers levels, forest and deforestation etc. a study of Brahmaputra floods of June–July 2012, Assam, India²⁴ is presented, in this study satellite images are used for mining of disaster footprints and for evaluating impacts of disasters. Satellite technology both optical and radar are increasingly used in monitoring rock slides³⁰. Monitoring water resources³¹. Monitoring ocean currents³². Monitoring drought and vegetation³³ and flood and drought early warning, monitoring mapping, damage and risk assessment³⁴.

Mobile Technology (MT) is one the most popular, fastest growing and most adopting technology by human beings. MT is serving mankind in different domain like shopping, education, banking and finance, stock market, entertainment, transportation, public services as well as disaster management. There is a number of smart phone mobile based applications and services are available which are useful in disaster scenario including tracking of volunteers and resources, find out the most favorable path along the different geographic locations³⁵, incident reporting via SMS and mapping using social networks³⁶, reporting damages by using smart phone in form of photos, certificate and sketches for timely response³⁷, improve communication and collaboration of volunteers and rescuers during disaster for timely response³⁸, SMS based flood level monitoring systems, alarm or send SMS when water level reaches out of bonds³⁹. From the above mentioned work, it is clear that ICT, ICT based application and Services are widely used in natural disaster management scenario.

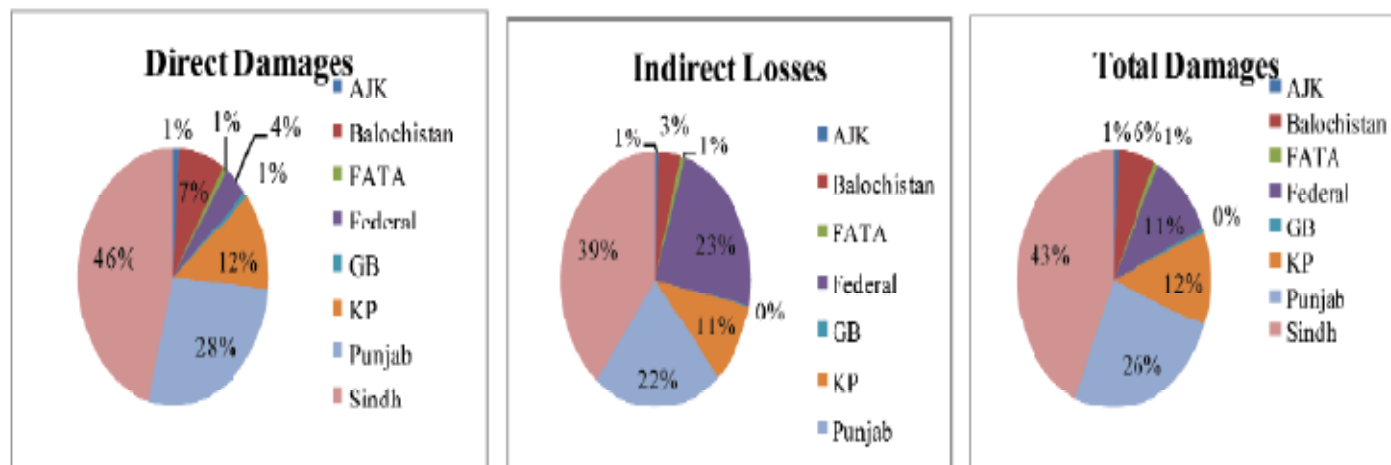


Figure-9
Geographical Distribution of Floods Damages (Source, DNA2010)

Results and Discussion

ICT for Flood Disaster in Pakistan: From the literature review and facts and figures regarding Pakistan's Flood it is obvious that floods are the major, cyclic and most destructive disaster event in the country. Losses of lives and damages of infrastructure, property, agricultural land, crops, live stocks, roads and railways are some of unbearable results. Compensation of these losses and damages can take many years and people of affected needs a long time (may be several years) to return back to their normal life in terms of conducting their social, economical and cultural activities. Coping and managing these types of giant disasters like Pakistan flood 2010, the affected country or region required great strength, effective planning and decision making, collaborative communication and collaboration, resources (human and machinery) and budget also. Some time the disaster event is greater than the coping capacity of the region so foreign help will require. Technology is playing a vital role in managing disasters in each and every stage of disaster management. Some examples of use of ICT in flood disaster management are discussed above in this study. Developing countries are using ICTs in their disaster management mechanism to boost their operations. Like other developing countries Pakistan is also facing political, economical, cultural, financial, geographical and technological challenges in terms of managing disaster scenario. Technology integration and adoption in DM domain are the most considerable issues.

After all of above arguments, discussion, results and consequences we are trying to mold the concentrations of the disaster management authorities (Like federal Government, Crisis management cell, NDMA etc) of Pakistan to incorporate and adopt technology in disaster management scenario, in its phases and stages at each level like in preparedness, mitigation, early warning, prediction, forecasting, rescue, relief and rehabilitation etc. Technologies enhance the operations of the

disaster management along with efficiency and accuracy as well as transparency Disaster Management System (DM) is a cyclic process and comprises on different stages and phases. Different operations and activities are performed in each DM stage. These activities and operations can be executed parallel, simultaneously or independently. Following is a figure shows stages and phases of DM.

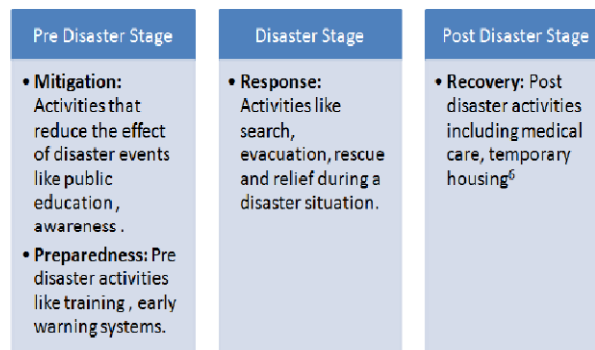


Figure-10
DM phases and Stages (Source: Shafiq and Ahsan, 2013)

Floods are predictable, every disaster management mechanism having some prediction and forecasting models for flood disaster. When a flood disaster like flood is predict a warning is issued to the flood disaster risk community to take some possible action for saving their lives and livelihoods. It is very practical situation. Like other countries Pakistan also having a National Crisis Management Cell have the responsibility for laying down the policies, plans and guidelines for disaster management. NDMA was established after 2005 Kashmir earthquake, under Chairmanship of Prime Minister of Pakistan. Pakistan Meteorological Department having flood early warning systems and several weather prediction models but their accuracy was a key issue. Pakistan flood forecasting and early warning system is flawed. To overcome these flaws after flood

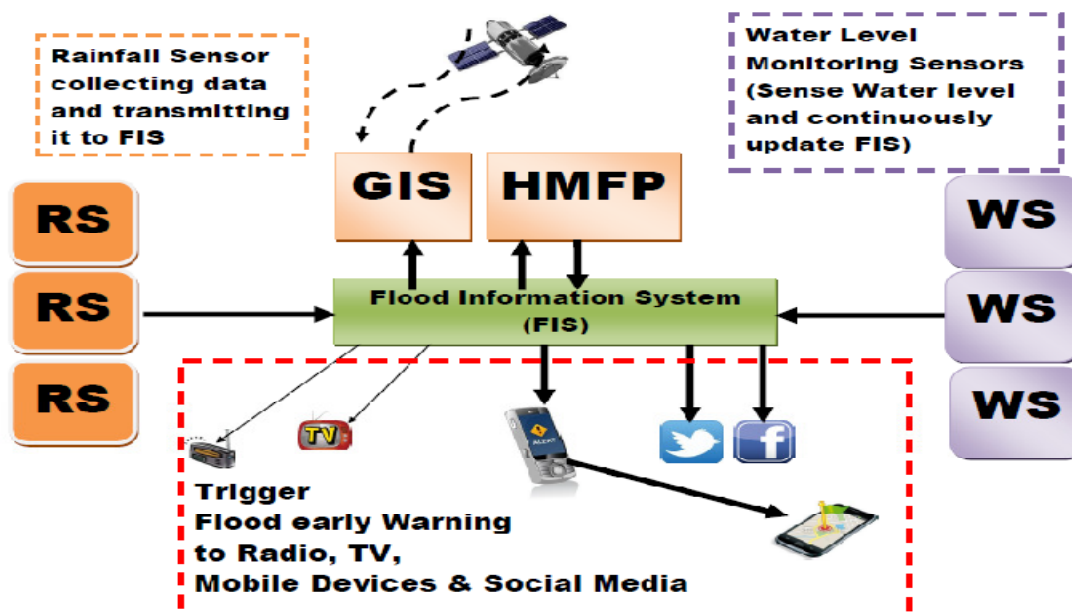
2010, the United Nations Educational, Scientific and Cultural Organization (UNESCO) approaches the Pakistan Government official for initiating a project “Strengthen Flood Forecasting and Management Capacity in Pakistan” with the objectives of i. To reduce the human and socioeconomic impacts of flooding in Pakistan, ii. To improve the social, economic, and ecological benefits of floods, and iii. To foster safer human settlements near flood plains.

This time Pakistan needs ICT⁴⁰ based flood early warning system. According to Musavi et al. an early warning system is a combination of various components⁴¹ like sensors and monitoring devices, communication links, alarm systems, computers⁴², servers and related software. These early warning systems are responsible for formulation of the warning, the issuance of the warning, and the reception of and response to the warning.

When an early warning for flood is issued, local community of the risk region trying to move some save place to save their lives, children and belongings too. This migration from risky area to save place creating a pathetic situation, everybody wants to move some save place as soon as possible to continue their routine life activities for providing bread and butter for their families. In this rush and pathetic situation nobody knows where is the save place and how long he goes to save their lives. To get ride off this sad situation we are suggesting to develop state of the art flood early warning system which is not only issuing warning alarms and messages but also directed to the people of vulnerable region that how far they go to save their lives with the help of SMS and GPS maps which are normally available in all smart phones.

The proposed flood early warning system is comprises of sensor nodes which are placed to observed rainfall and water level in the river, A central flood management center equipped with a state of the art ICTs and Flood Information System (FIS), which receives, store and process the data from the deployed nodes, A Geographical Information System (GIS), which is responsible for producing the GeoMaps of vulnerable region, satellite images of the effected region. Appropriate Hydrological models incorporating with FIS for predicting severity, intensity, time, location, expected land covers from the flooded water, amount of flooded water of expected flood.

Flood Early Warning Algorithm: i. Sensor nodes collect the data against defined parameters. ii. Sensor nodes disseminate collected data to the Flood Management Center (FMC). iii. FIS receives stores and process the data with the help of computer algorithms. iv. Hydrological Models are incorporating with FIS for prediction and forecasting. v. GIS collects the Maps of vulnerable region. vi. Satellite images are processed through computer algorithms. vii. Defined parameters are calculated and mapped on GPS maps. viii. GeoMaps are generated according to expected land covers and direction of flooded water. ix. Warning alarms and messages are broadcast to TV, Radio, Social Networks and Mobile Devices. x. Mobile user received Warning SMS with some predicted parameter details. xi. GPS labeled maps are also available on GPS enable devices like smart phones, xii. Peoples can navigate through these GPS maps towards save place. xiii. Necessary actions can take place by DM officials to avoid or minimize losses and damages. ivx. Processed information can be utilized in planning and development.



Key for figure 11: RS= rainfall Sensors, WS=Water level Sensors, HMFP=Hydrological Models for flood Prediction, FIS=Flood Information system, GIS=Geographical Information System.

Figure-11
Proposed Flood Early Warning System

Conclusion

Disasters resulting destruction indiscriminately, increasing frequency and intensity of natural disaster events mold the concentration of developed and developing countries towards strengthen their DMS and coping capacity against these unexpected events. Early warning is the most important activity for preventing disaster or minimizing losses of lives and property. ICTs is playing pivotal role in managing natural disaster like flood and earthquake. In this study we propose an ICT based Flood Early Warning System (FEWS), which can help community as well as disaster management authorities to prevent and minimizing losses against flood disaster. This system not only triggering early warnings also calculating the land cover from the expected flood and help the people and officials to point out the boundaries of region to be affected. Through use of Mobile technology people can easily get the early warning messages and by using GPS maps they can easily navigate towards the save place. Disaster management officials, rescuers and volunteers will also the beneficiaries of proposed system and can be used in rescue and relief works. This is the first version of the proposed model some improvements will also incorporate in future work to get the maximum advantage of the proposed solution.

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