DESIGN AND IMPLEMENTATION OF A WEB BASED GIS FOR FLOOD DISASTER MANAGEMENT: CASE STUDY OF NOWSHERA DISTRICT

By

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Registration No.2010-NUST- MSPhD-GIS-13

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Remote Sensing and GIS

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August, 2014

CERTIFICATE

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Design and Implementation of a web based GIS for flood disaster management: A Case Study of Nowshera District

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To my Parents, Sisters, Brothers

Teachers and sincere Friends, who helped me

and encouraged me in every step of

my life.

# ACKNOWLEDGEMENTS

“Thanks Almighty ALLAH” - Who bestowed upon me the power, courage and patience to complete this difficult tasks. It is ALLAH almighty the most benevolent gracious who help me in surmounting the obstacles on my way.

I expressed my heartfelt gratitude to my parents, family, brother and all lovable friends for their prayers, support and encouragement in every step of life.

I am greatly thankful to my advisor Dr. Javed Iqbal, Head of Department, Institute of GIS, School of Civil and Environmental Engineering, National University of Sciences and Technology in the selection, planning of the study and implementation of the study successfully. His cooperative support, encouragement, appreciation and technical support throughout the research work inspired me and I worked wholeheartedly to accomplish this useful task. Without his cooperation, encouragement and moral support, I would not have been able to accomplish this difficult task.

Last but not the least, I thank all staff members including Dr. Ali Tahir, Mr. Azmat Hayat Khan and Mr. Muahammad Ahsan Mahboob who encouraged, appreciated and helped me to accomplish my research work.

Fayaz Ali Shah

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LIST OF ABBRIVIATIONS

Abbreviation	Explanation
HEC RAS	Hydrologic Engineering Center River Analysis System
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
FATA	Federally Administered Tribal Areas
GIS	Geographic Information System
FFC	Federal Flood Commission
ADB	Asian Development Bank
WB	World Bank
DOS	Disk Operating System
FORTRAN	Formula Translating System
REST	Representational state transfer
ESRI	Environmental Sciences Research Institute
DEM	Digital Elevation Model
TIN	Triangulated Irregular Network
URL	Uniform Resource Locater
e.g	Exampli Gratia

Abstract

Natural disasters have been increasing worldwide in recent years, including floods, snow, and typhoons disasters. Flooding is the most frequent natural disaster in many countries and is increasingly a concern with climate change. The objective of this study is to develop a prototype version of a Web GIS-based disaster management system (WebGISDMS) using the HEC RAS Model and ArcGIS Server to enhance on-time operation. The selected study area comprised of 30 km of River Kabul and a 10 km tributary reach of Kalpani River. The data used include ASTER 30-m digital elevation model (DEM) downloaded from earthexploler.usgs.gov, flood discharge data were collected from irrigation department Peshawar, satellite imageries data of Landsat 30-m downloaded from glovis.usgs.gov, land use map generated from the classified image and assigned every Land use land cover class Manning's n values defined in HEC-RAS reference manual version 4.1. HEC-GeoRAS was used to develop the RAS layers including River Centerline, banks, flow paths, cross-sections, bridges, ineffective areas and blocked obstructions from Triangulated Irregular Network (TIN). The RAS layers were exported to HEC RAS where bridges data and flow data were also included to it for steady flow analysis. Finally the post processing of model was used to generate flood inundation map which shows the flood extent and depth in the study area. From ArcGIS desktop the resulted data were published and shared as a web services at ArcGIS Server. ArcGIS viewer for flex was used as a web mapping application for a web client application which can be accessed and used now in web browser.

Chapter-1

Introduction

One of a common natural disaster in the world is Flood, Which causes terrible damages to people's lives and properties. Flood becomes a disaster when it destructs the man-made environment, such as buildings, roads and crops etc.

The current study is focused on the influences and mechanism of floods in Kabul River during the unprecedented monsoon rains in 2010 in the districts of Nowshera. From this study one can find the different flood extent area with different discharge as well as the depth of flood plain area. To give everyone access to this spatial data, there is essential of distributed system through which all users may use these information's on right time. This distributed system is called Web GIS.

Requirement of Web GIS in Disaster management:

There should be centralized control system where the geospatial data are controlled centrally and every one can reach these data for spatial analysis.

The changes made by the server administrator in the map are reflected everywhere.

There is no need for GIS software with the users of using web GIS site, as well as no need for training in GIS software.

The present status of geospatial data is updated according from moment to moment and distributed the updated status to all users.

Web-based GIS play a vital role in this aspect to providing timely and right information to the concerned people and the emergency managers for taking necessary actions(Abdalla and Niall 2009).

Web-based GIS is a centrally managed and distributed computing design. It is directly required to make a plan for response phase of flood disaster management in order to reduce human losses and physical losses during flood disaster. Gathering relevant data from government departments, organizations and input this data in a GIS as a suitable tool to process and analyze it, can help managers to make a better conclusion during and just after of a flood. One important need for any disaster management effort is to have the spatial information accessible to a larger group of people, in a fast, easy and cost-effective manner. The use of GIS on the web can help a lot in achieving these objectives(Hsu, Wu et al. 2005).

1.1 Floods in Pakistan

Pakistan experienced extraordinary rains in the middle of July, 2010, which it continued until September, 2010. The result was floods without precedents which affect to the whole length of the country. The floods have been evaluated to be the worst from 1929, there are 20 million persons they have affected due to the floods of 2010. Also, in the affected areas, the sudden floods and landslides provoked by the rains caused severe damages to the infrastructure. Finished villages have been washed, centers of urban have been flooded, houses have been beaten in, and thousands of hectares of cultivation and the agricultural lands have been damaged by major soil erosion it happens in some areas of the alluvial flatness.

The floods produce almost every year the events to themselves in Pakistan. From its creation, Pakistan has suffered serious floods in 1950, 1956, 1957, 1973, 1976, 1978, 1988, 1992 and 2010, which caused enormous economic and human losses. The floods of different magnitudes took place between 1922 and 2010 in Punjab, Sindh and Khyber Pakhtunkhwa. The sudden floods damaged the mountainous areas of Khyber Pakhtunkhwa, FATA, Gilgit Baltistán and Punjab(Hashmi, Siddiqui et al. 2012).

PDMA evaluated that more than 1,056 persons turn out to be hurt and 3,820,173 person affected in Khyber Pakhtunkhwa and 11,581,875 entire of affected in Pakistan as a result by the floods, more than the combined whole of the individuals affected by the tsunami of 2004, the earthquake of Kashmir of 2005. The Table 1.1 shows the whole of damages in all the provinces of Pakistan.

During the last sixty three years of the history of Pakistan, the entire losses of the floods are enormous. The floods have taken lives of more than 8,700 persons. In Pakistan it goes direct damages to the infrastructure, the cultivation, the public services and the urban and rural property. Table 1.2 shows the history of the floods and the caused damages during the course of the history of Pakistan(Tariq and van de Giesen 2012).

In July, 2010 the floods of the monsoon struck almost the whole country. The strong record rains in many regions of the country have been established out of the rivers and the sudden floods to give place to big number of deaths, the large-scale displacement of persons and damages to the property. The 2010 flood takes life of approximately 1,539 persons in the whole country. The entire population affected was approximately 17,176,908. About 1,226,678 houses were destroyed or damaged(Kronstadt 2010).

Historical floods of Pakistan from 1950 to 2010. The table 1.2 shows damages to property, lives lost and the number of villages affected. The damages are adjusted to 2002 price level.

1.1.1 Damage and Needs Assessment

National Disaster Management Authority (NDMA) published in their report that the rains/floods 2010 affected over 20 million people. For the assessment of these floods, Asian Development Bank (ADB) and World Bank (WB) were requested by the Government of Pakistan for leading the Damage and Needs Assessment (DNA). The DNA evaluates magnitude of the damages and of the needs for rehabilitation and reconstruction of the goods and damaged infrastructures and the restoration of the means of life and the economic productivity The targets of the DNA it is to do the arrangement of the reinforcements foreseen for the way to the reconstruction after the long-term floods, the planning of the recovery, organization and programming.

With base in the DNA report, the entire cost estimated for the recovery and the reconstruction associated with the flooded area is of approximately US an $ 8740 million to 10850 million, which includes the costs estimated for the early recovery, the help and a half to long-term reconstructions.

With regard to the financial costs of the DNA it has been generated against three categories of evaluation, which are

The **direct damage** refers to the entire monetary value of the goods or partially destroyed, like the social infrastructure, physically and economically immediately after a disaster. Whenever it is possible, the goods direct damage is evaluated in as it was the condition, that is to say, to its book cost.

The **indirect losses** are the losses of income and it contains both the change of the flow of goods and services and other economic flows and the increase of expenses, reduction of the production and decrease of income, which arise from the direct damages to the production capacity and the social and economic infrastructure.

The **reconstruction costs** measure the reconstruction extension lost assets and the restoration of the lost services. In general, it was polled to that the substitution cost with an additional costs to construct again more intelligently (Hicks and Burton 2010).

1.1.2 Key Lessons Learnt from Flood Response 2010

The exceptional intensity and long period of the rains, the resulting flooding clearly overcome national, provincial and local disaster/flood management capacities, mostly at the district level.

Partial implementation of already prepared for national response and emergency plans, disaster preparedness effected by the limitations of existing early warning arrangements down to community level, emergency response mechanisms and structural mitigation.

There are lacked disaster preparedness awareness to the affected communities, sensitization and training regarding localized hazard and flood risk reduction, emergency preparedness and response functions mostly essential for populations situated within flood plain areas (Polastro, Nagrah et al. 2011).

Table 1.1. Province wise damages.

Province/State	Deaths	Injured	Houses Damaged	Affected Population
Baluchistan	45	98	75,261	312,774
Khyber Pakhtunkhwa	1,070	1,056	179,910	3,820,173
Punjab	103	350	500,000	8,200,000
Sindh	72	680	462,251	2,269,846
Azad Jammu & Kashmir	69	83	6,472	245,000
Gilgit Baltistan	183	60	2,820	8,516
Total	**1,542**	**2,327**	**1,227,858**	**11,581,875**

Table 1.2. Historical floods of Pakistan from 1950 to 2010.

Year	Direct Losses (Rupees in Millions)		No. of Deaths	Affected Villages
	Unadjusted	Adjusted		
1950	199.8	11,282	2,190	10,000
1956	155.5	7,356	160	11,609
1957	152	6,958	83	11,609
1973	5,137	118,684	474	9,719
1976	5,880	80,504	425	18,390
1978	4,478	51,489	393	9,199
1988	6,879	25,630	508	1,000
1992	34,751	69,580	1,008	13,208
1995	6,125	8,698	591	6,852
2001	450	450	219	50
2003	5,175	5,175,00	484	4,376
2004	15	15	85	47
2005	Not available	59	1,931	
2006	Not available	541	2,477	
2007	Not available	586	6498	
2008	Not available	157	800	
2009	Not available	99	89	
2010	819,381	819,381	1961	14,316
Total	888,778.8	1,205,202.00	10,023	115,059

1.2 Causes of Floods in Pakistan

It is generally known that complete prevention of floods is physically impossible but flood safety and management is possible and is very important requirement. The human life and property can be secured from floods by adoption of proper planning policies. In general, rivers are flooded due to the heavy concentrated rainfall in the monsoon period in its catchment area, which is occasionally higher by snow melting in summer period. The source of monsoon is Bay of Bengal (India) currents and its resultant depression causes heavy showers in the foothills of Himalayan range, furthermore the Arabian Sea weather system is increased and also affected from the Mediterranean Sea (Westerly Wave) which seldom generates devastating floods in the major rivers of the Indus System. Sometimes landslide form natural dams or falls movement irregularly causes huge floods. The large cyclic disparity in rives discharges further exacerbate the river course and its morphology. The adjacent low elevated areas near the banks of large rivers in Pakistan inundate both the communication services and irrigation channels. In Indus Basin upper portion, the floodwater regularly returns to the river after decrease the water level. Though, the lower part of Indus River experiences flood of extended periods because river is flowing at higher elevation than the adjacent lands and overflowed water doesn't return to the river again. Due to this phenomenon the duration and losses of flood largely extend.

The discharge volume of Barrages and Bridges construct on Indus, Ravi and Chinab Rivers has been found to be inadequate during enormously high floods, this increase flood on upstream part which results in cracks in banks of rivers. Sometimes for the safety of main barrages, settlements and other essential structures the flood embankments have to be broken intentionally at pre-selected location(Khan, Iqbal et al. 2011).

1.3 Floods in Khyber Pakhtunkhwa (KPK)

Monsoon floods in July 2010 are the worst floods in KP since 1929. The KP affected severely due to 2010 floods caused by the unexpected Monsoon heavy rains from July 27 to July 30, 2010. The historical flood caused major losses to life, crops, houses and infrastructure, which were seriously damaged due to flooding in Rivers Kabul, Swat and Panjkora.

The 25 districts in KP were hit by 2010 flood and more than 400,000 people were affected. Charsadda, Swat, Nowshera, D.I. Khan, Tank, Upper and lower Dir are the districts severely hit by flood. The rain received in 24 hours was between 100-290 mm which was the peak documented rainfall in last 35years in the region. More than 20 villages were affected and 5,000 houses were inundated. In Swat more than thousand homes were inundated and in D.I. Khan 23 villages were affected due to flood(Ahmad, Kazmi et al. 2011).

In the last decade, enhance the efficiency and visualization of basin and river modeling through the integration of GIS with flood studies. HEC-RAS is a most significant hydraulic model which has a good GIS integration by means of an ArcGIS extension recognized as HEC-GeoRAS. The HEC-GeoRAS is a set tool, services and techniques for processing geospatial data in ArcGIS (US Army Corps of Engineers, 2009). The HEC-GeoRAS software supports in the preparation of geometric data for importing into HEC-RAS and processing simulation result exported from HEC-RAS to HEC-GeoRAS (Ackerman 2002).

1.4 HEC-RAS Model

HEC-RAS is a type of hydraulic model formed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers allows performing one-dimensional steady flow, unsteady flow, sediment transport/mobile bed computations, and water temperature modeling. The HCE produce the HEC-2 model in 1964, the model was established to support hydraulic engineers in the analysis of stream channels and floodplain delineation. The HEC-2 model quickly turned out to be the standard stream hydraulic analysis program, and its capabilities were increased. The model was launched to perform weir, bridge, and culvert analysis. Primarily the HEC-2 model was run on mainframe computers and can also work in DOS mode on personal computer(Brunner 1995).

Windows-based software was greatly used in 1990's. This trend also followed by HEC and released a Windows-compatible version of HEC-2. The model was named Hydrologic Engineering Center River Analysis System (HEC-RAS). The graphical user interface (GUI) was developed in Visual Basic programming language for the HEC-RAS model and in FORTRAN the flow computation algorithms working on the backend was programmed, most of which were resulting from HEC-2 model(Yang, Townsend et al. 2006).

1.4.1 General Philosophy of HEC-RAS Model

HEC-RAS model is basically an integrated system of software, which is developed for interactive utilization in a multi-tasking and multi-user environment. The model consists of GUI. The model has separate hydraulic analysis part and has the capability of storage and managing of data. It also provides the graphics and reporting abilities to the users(Ackerman, Evans et al. 2000).

The HEC-RAS Model covered four components for performing one-dimensional river analysis: (1) steady flow water surface profile calculation (2) Simulation of unsteady flows (3) water quality analysis and (4) Sediment transport analysis. The main factor is that entire four units utilize the representation of geometric data, common geometric and hydraulic calculation routines. The model also consists of various hydraulic design functions apart from the four river analysis techniques that can be evoked once the essential water surface profiles are produced(Merwade 2010).

The HEC-RAS model has the proficiency to implement subcritical, supercritical, and mixed-flow regimes for a single river reach, streams comprising of complete channels network and also for dendritic stream systems. The model can also be valuable in floodplain management and flood insurance studies(Ackerman 2005).

1.4.2 HEC-RAS Parameters

HEC-RAS Model requires some input parameter of water flow and stream channel geometry for hydraulic analysis. These input parameters are used to generate a series of cross-sections along the stream channel and floodplain. The places of stream banks are identified in every cross-section. There are three parts of each cross-section, i.e. main channel, right floodway, and left floodway as given in figure. HEC-RAS model is divided in such way, because of variation in hydraulic parameters. The witted perimeter and surface roughness in the floodway is much higher as compared to the main channel. Thus, resistance forces between the channel bed and water have a huge effect in flow resistance in the floodway, leading to lower values of Manning coefficient. As a result the flow velocity and transmission are significantly higher in the main channel as compared in the floodway (Ackerman, Jensen et al. 2009).

1.5 Web GIS

Web GIS is a new pattern for delivering GIS capabilities and is at the Esri center of strategic direction for applying GIS as a platform. Maps on the web provide a new paradigm for how people everywhere access and use geographic information. They use GIS maps on their desktops, the web, on tablets, and smart phones to apply advanced geographic information for a sophisticated range of activities(Abdalla and Niall 2009).

Web GIS naturally brings Geospatial information into the hands of people. People expect to be able to use maps from modern consumer devices such as smartphones and tablets, simple web browsers, or directly implanted in the tools they generally use such as Microsoft Office. Web GIS provides the functionalities to easily build and share maps that work seamlessly across different devices and form factors maps that work everywhere (Abdalla 2009).

Web GIS reduces the need to create custom applications. The wide variety of ready to use applications and application templates included with Web GIS let modify simple and to the point user experiences to let people get the work done quickly and automatically.

Web GIS provides a platform to integrate GIS with other business systems applications. In fact Web GIS is based on simple protocols like REST and other proven web standards so effectively insert GIS into existing business enterprise systems. The systems that plug and play with the web GIS delivered through ArcGIS are IBM Cognos, MicroStrategy, or SAP(Mansourian, Rajabifard et al. 2006).

Web GIS enables cross organizational association, facilitating communication and optimizing the use of information throughout organizations. For example, Web GIS makes existing tools that anyone can use to easily get data into a map, analyze it, and properly present it to communicate knowledge. The emphasis of web GIS is on everyone, as opposed to a few. The maps you create can be kept private, or immediately shared with a group of peers or the public at large to interact with your maps using their chosen client application. The web GIS opens the door for creating a participatory environment where GIS tools are made more accessible and flexible for everyone(Weiser and Zipf 2007).

Web GIS allows organizations to properly manage all their geographic data. At the heart of Web GIS is a map-centric content management system, which provides support to organize, secure, and facilitate access to geographic information products. This central component refers to here as the ‘ArcGIS portal,’ represents a common access for geospatial information in an organization. It all maps directories for easy discovery, allows for defining rules as to who can access which data, map, GIS application etc. The portal is a central component of embracing Web GIS(Abdalla and Niall 2009).

1.7 ArcGIS Server

Organization that manages geographic information, faced with the challenges of sharing collection of geographic information with people inside organization as well as outside of organization. ArcGIS Server enables these organizations for sharing GIS resources, such as maps, with user community, whether they are sitting in the same office using ArcGIS Desktop or sitting across the country retrieving and observing maps over the Internet.

ArcGIS Server provides the facility to share GIS resources across an enterprise and across the internet. GIS resources are the maps, globes, address locators, geodatabases, and tools that needed to be shared with others. To share these resources by first hosting them on ArcGIS Server system, or GIS server, and then allowing client applications to use and interact with the GIS resources. The key advantages of sharing GIS resources on a GIS server are the same as distribution of any data through any kind of server technology the data is centrally managed, supports multiple users, and delivers clients with the most up-to-date information. (Source: ESRI)

1.8 ArcGIS Viewer for Flex

ArcGIS Viewer for Flex provides a smart, intuitive framework for looking at and interacting with maps. It is a configurable web application that allows us to easily build in just a few minutes our own custom mapping application, with no programming required.

The steps which are required for building a map application are

- In first step from Esri’s extensive basemap collection choose a basemap.
- Adding the operational map layers to the basemaps.
- Apply some basic functions to the operational layers through widget tab.
- Adding our personalized title, logo, and color themes through design tab.
- Extend the viewer according to map map behaviors, functionality, and layouts.

Figure 1.3 shows how a web map was developed in ArcGIS Viewer for flex. It contains five tabs that are Maps, Widgets, Layout, Design and Preview.

1.9 Statement of the Problem

- There is no centralized database for flood discharge data in Pakistan.
- Data duplication: same data of same area is stored in different organization with different format.
- It is very difficult to access right information like discharge, depth and extent of flood at right time.

1.10 Objectives

The first objective was to generate flood inundation map for Nowshera district which include the extent of flood with different discharge and depth in the floodplain area. The second objective is to develop a web GIS for inundation maps.

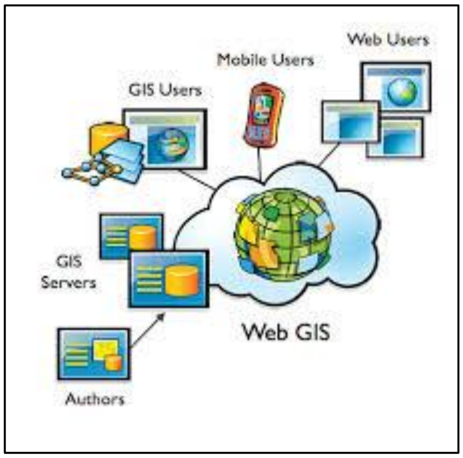


Figure1.1. WebGIS Architecture.

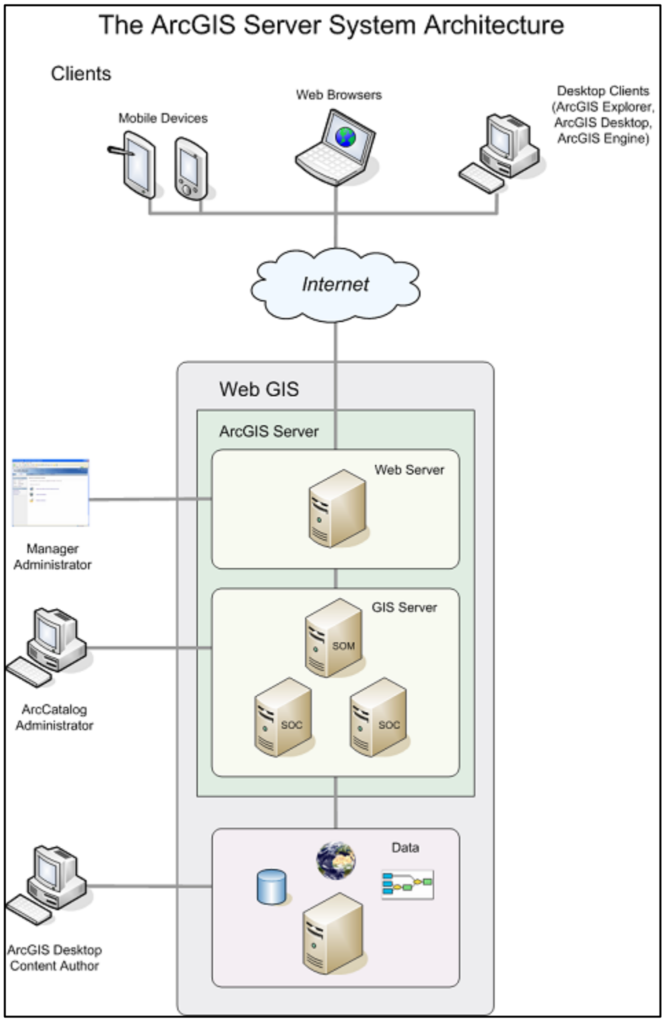


Figure 1.2. ArcGIS Server Architecture.

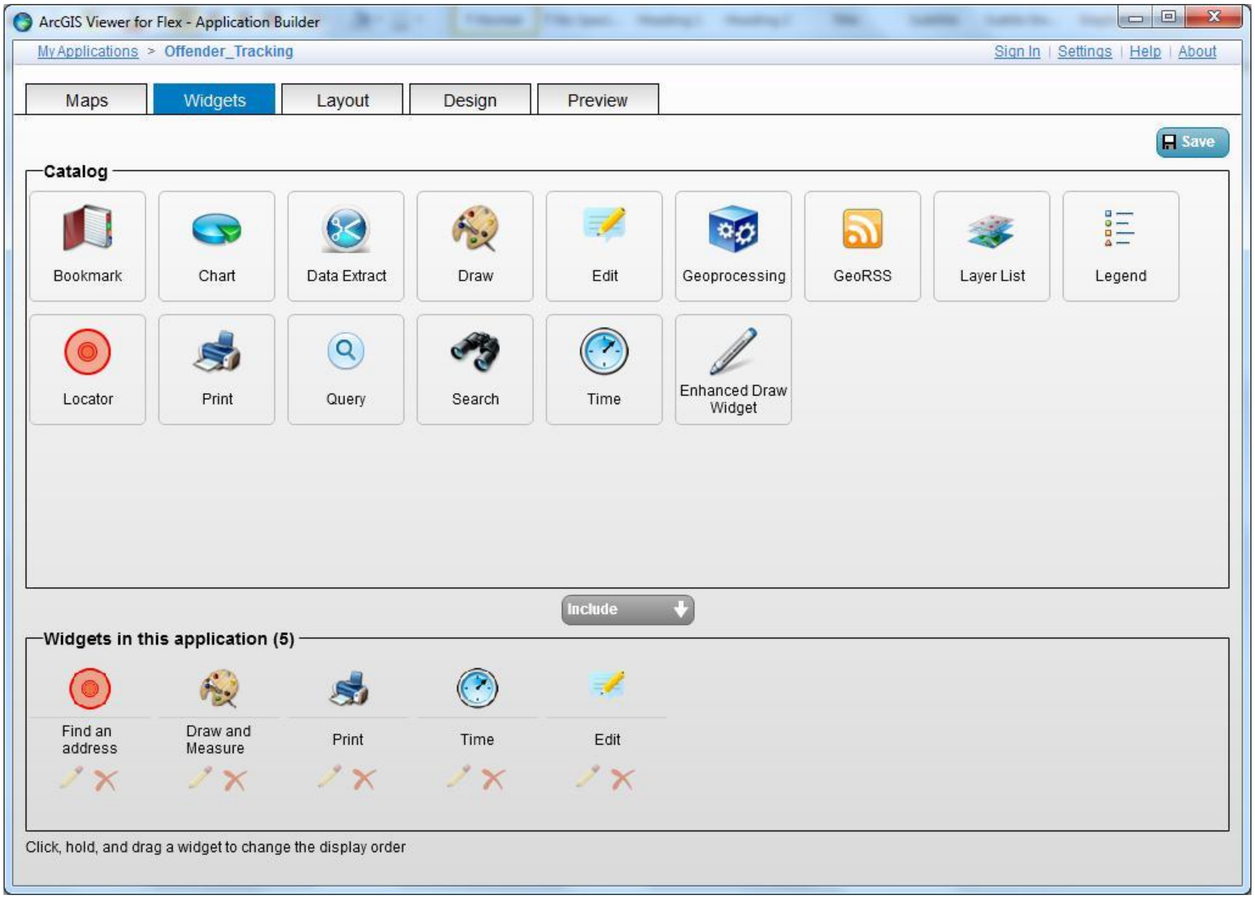


Figure1.3. ArcGIS Viewer for Flex -Application builder.

Chapter-2

Materials and Methods

2.1 Study Area

Nowshera known locally as Nowkhaar is the chief city of Nowshera District in the Khyber Pakhtunkhwa Province of Pakistan.

The study area comprised of 30 km reach of Kabul River and 10 km reach of its tributary river Kalpani. The selected study site extends from 33°57' 0" to 34°06'30" North latitude and from 71°57'0" to 72°12'30" East longitude (Figure 2.1).

2.2 Methodology

This study was in two phases, first was data preparation regarding flood inundation maps and second was to publish flood inundation maps on web. In the first step the flood discharge records were collected from Irrigation Department Peshawar for the year 2010. Field survey was conducted for collecting spatial locations of Bridges, Schools and Hospitals through handheld GPS. Landsat image were classified to get the land use /land cover map and assigned the manning's 'n' value to its classes. I used HEC GeoRAS to get the River Geometry from Satellite Data and DEM, Then using HEC-RAS model to generate water surface profile from River Geometry and Flood Discharge data and from the exported data HEC GeoRAS generated flood inundation maps. I published the flood inundation maps from ArcGIS desktop to ArcGIS server, apache tomcat was used as a bridge, and made a web GIS application in ArcGIS Viewer for Flex to access the data from server in web browser.

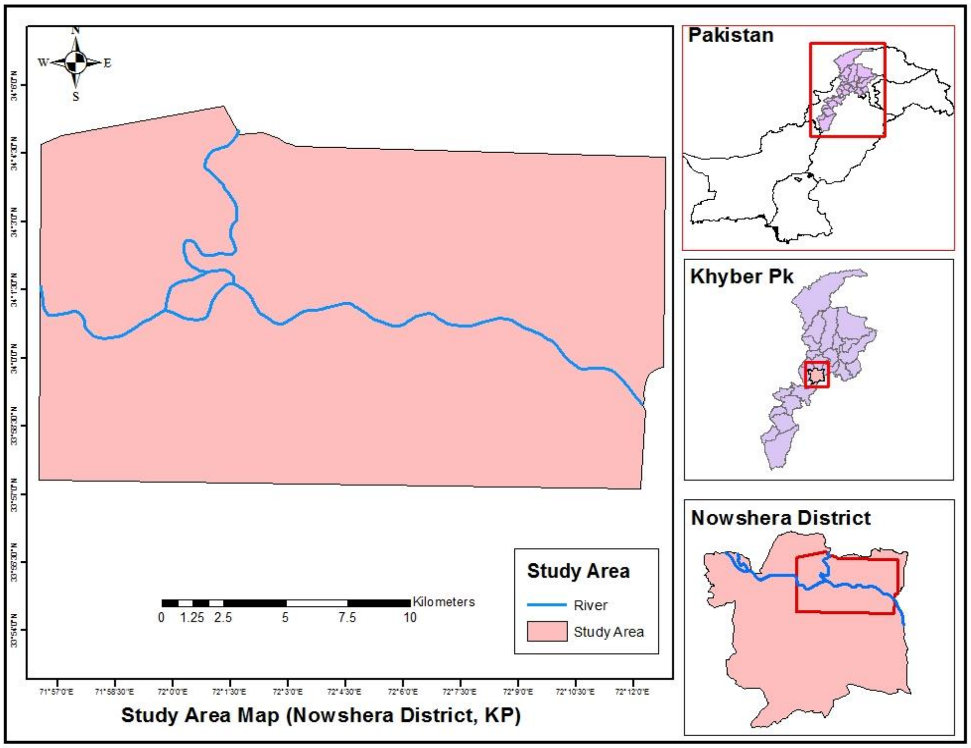


Figure2.1. Study area map Nowshera District along river Kabul and Kalpani.

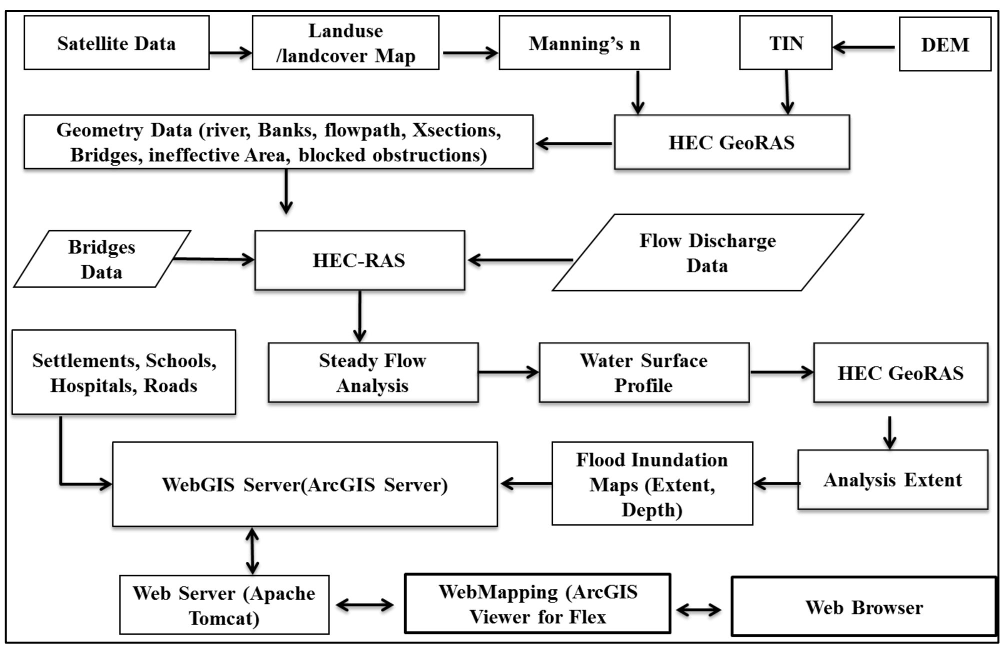


Figure2.2. Methodology flowchart for web GIS for flood disaster management.

2.3 Tools

Table2.1. Tools type its key features and sources.

Tools	Key features	Source
Erdas Imagine	Image Classification	Academic license
HEC GeoRAS	Geometry and flood plain mapping	Open Source
HEC RAS	Water surface	Open Source
ArcGIS 10.2	Geospatial analysis and management	Academic license
ArcGIS Server 10.2	GIS Services	Academic license
Apache Tomcat	Web Services	Open Source
ArcGIS Viewer for Flex	Web Mapping Application	Open Source

2.4 Data

Table2.2. Data type and its sources.

Data Type	Specification	Source
Landsat satellite data	30 m resolution	http://glovis.usgs.gov
DEM	Aster 30 m Resolution	http://earthexplorer.usgs.gov.com
Discharge data	River Discharge	Irrigation Department, Peshawar
Bridges, Schools, Hospitals data	Spatial location	Survey

2.4.1 Satellite Imagery

Satellite imagery is considered to be the best means of collecting significant information about the flood situation. It provides up-to-date information as compared to the published maps. In flood situation satellite imagery is used for the identification of flood extent. In this study, Landsat satellite imagery with spatial resolution of 30m of 2010 was downloaded from http://glovis.usgs.gov web site. The Landsat satellite image is given in figure 2.3. It was used for extracting flood extent and flood depth as shown in Figure 2.3& Figure 2.4.

2.4.2 River Discharge Data

The discharge data is one of the essential parameter required to HEC-RAS model for the generation of water surface profiles. A number of gauge stations located at different sites on Kabul River and its tributaries. The Kabul River discharge is recorded at Pirsabak gauge station.

The discharge of Kalpani river is recorded at Chawkay bridge gauge station Risalpur. The Peak discharge and daily discharge data of 2010 flood seasons were collected from Irrigation department Peshawar.

2.4.3 Land Cover/ Land Use Data

Satellite image of Landsat TM having special resolution of 30m was used to extract the landcover/landuse information by performing supervised classification in ERDAS Imagine 9.2 software. The classified image was converted from Raster to polygon by using conversion tool in arc toolbox. The shape file landcover/landuse classes i.e. barren land, built up area, vegetation and water were assigned Manning's n values defined in Chow's book "Open-Cannel Hydraulics" (Te Chow 1959).

2.4.4 Digital Elevation Model (DEM)

One of a most important factor for flood modeling was surface elevation data. ASTER 30m Digital Elevation Model (DEM) downloaded from a website http://earthexplorer.usgs.com for this study area. The study area was extracted by extraction tool in spatial analyst tool and transformed to projected coordinate system by project raster tool in projection and transformation tool of data management tool. The DEM was converted to TIN by Raster to TIN conversion tool in 3D analyst tool of arc toolbox.

2.5 HEC RAS and HEC GeoRAS Process

HEC-RAS and HEC-GeoRAS models involved three steps i.e. 1) pre-processing of data 2) Models execution and 3) post-processing of the data.

2.5.1 Data Pre-Processing

In this step the study area Rivers (Kabul River 30 km and Kalpani River 10 km) reaches geometric database was developed. The pre-processing operations were made with the help of ArcGIS embedded HEC-GeoRAS model. HEC-GeoRAS was used to create a file of river geometric data for import into HEC-RAS. The DEM (figure 2.4) is most important parameter required for the HEC-GeoRAS Model and was used in the form of TIN (figure 2.5). ASTER 30m DEM was converted into TIN using ArcGIS 3D Analyst. The Geometric data was created in the form of RAS layers. The RAS layers include Stream Centerline, Flow Paths Centerline, Main Channel

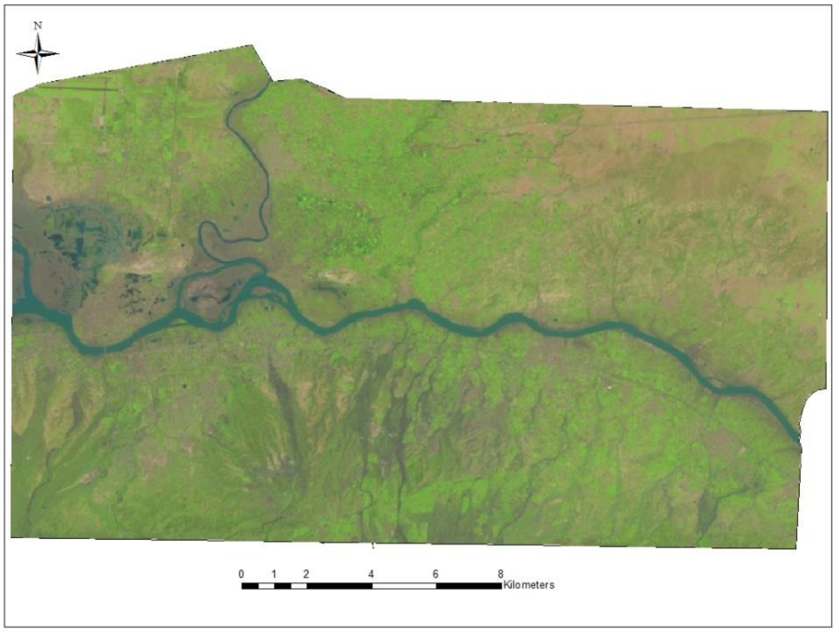


Figure2.3. Study area Landsat satellite image.

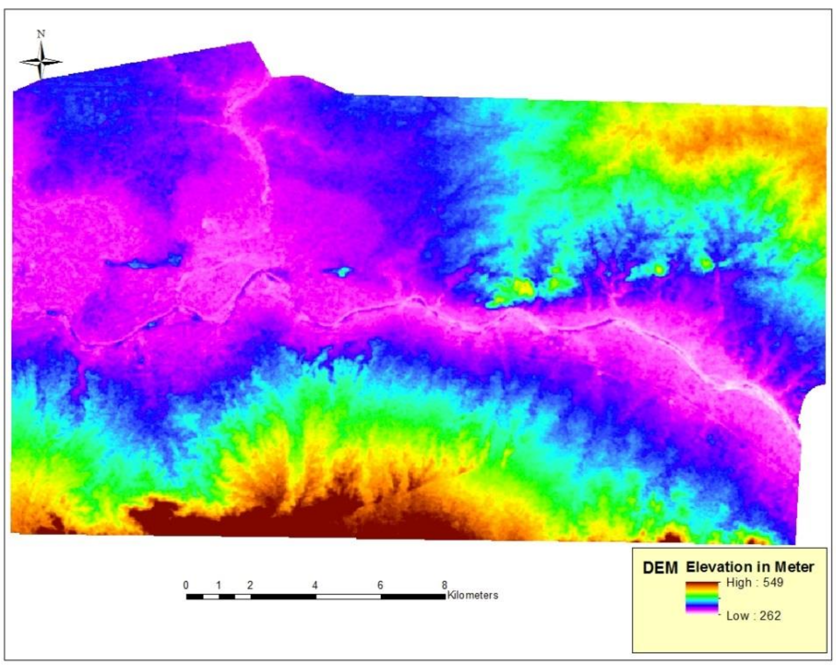


Figure2.4. Digital Elevation Model of Nowshera near to Kabul river of resolution 30m, downloaded from http://earthexplorer.usgs.gov.com

Banks, Cross-Section Cut Lines and the Land use (Manning's n values). RAS layers (figure 2.5) were digitized one by one and there attributes i.e., topology, length/stations, Manning's n values and elevations were assigned according to the layers requirements. Six reaches of both the rivers were digitized which include Kabul River Upper, Lower reaches, split sections and River Kalpani reach. Total of 200 cross-sections were digitized on three reaches. Each cross-section intersected Stream Centerline, Main Channel Banks, and Flow Paths Centerline. The cross sections of coverage on both sides of the channel show the maximum possible flood. After creating the rivers geometric database the RAS GIS import file (RASImport.sdf) was generated.

2.5.2 Model Execution

The purpose of this phase was the preparation of the flood extent and depth maps for July and August 2010. The peak flood discharge data for the flood seasons of 2010 were chosen for flood analysis. Boundary conditions of rivers for the upstream and downstream were selected in terms of water levels corresponding input peak discharge for the selected two gauge stations. Steady flow analysis technique was used for July and August 2010.

The HEC- RAS model is specially designed for hydraulic modeling and simulation. Basically it is selected to perform a simulation dimensional steady flow of flooding. The geometric data performed with the aid of HEC- GeoRAS was provided to the HEC- RAS steady flow model analysis as shown in figure 2.6. Different discharge data of July and August 2010 was selected for steady flow simulation. The

Discharges at Nowshera Bridge gauge station was used for Kabul River upper reach and the discharge recorded at Chawkay gauge Station at Risalpur was used for Kalpani River (figure2.8). Bridges data were included to the geometry data (figure 2.7). The model was run successfully for steady flow simulation. The steady flow analysis provided the water surfaces profile at each cross section (figure 2.9). The extent of flooded area was shown by 3D profile (figure 2.10). The HEC-RAS steady flood simulation data was exported again into ArcGIS supported format for the generation of flood inundation mapping.

2.5.3 Post Processing

The post-processing step is the last step of the hydraulic modeling. At this stage, the model can be visualized and the final design can be generated maps. The data exported from HEC -RAS model was imported into ArcGIS with the help of HEC- GeoRAS. The HEC- GeoRAS provides facilities flooded areas of cartography and visualization to the user. The GIS analysis was performed.

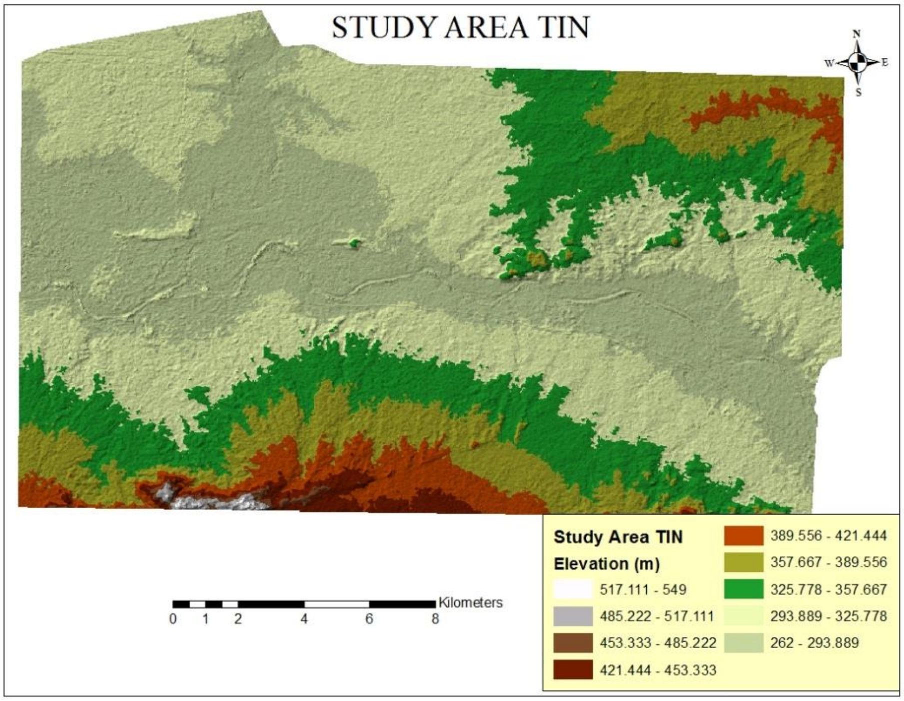


Figure2.5. Triangulated irregular network (TIN)

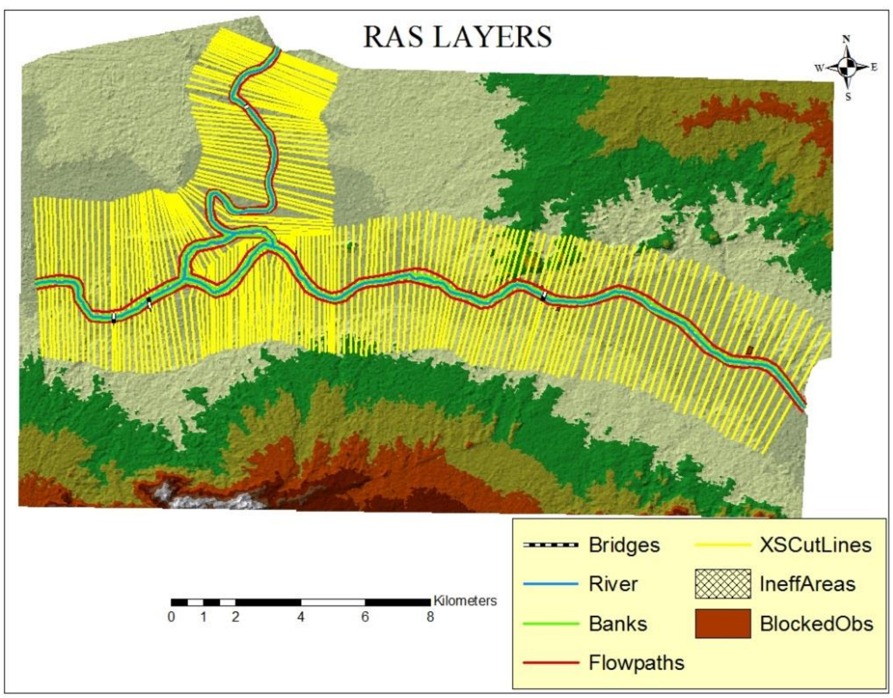


Figure2.6. RAS layers (River, River Banks, Flow Paths and Cross-Sections etc.).

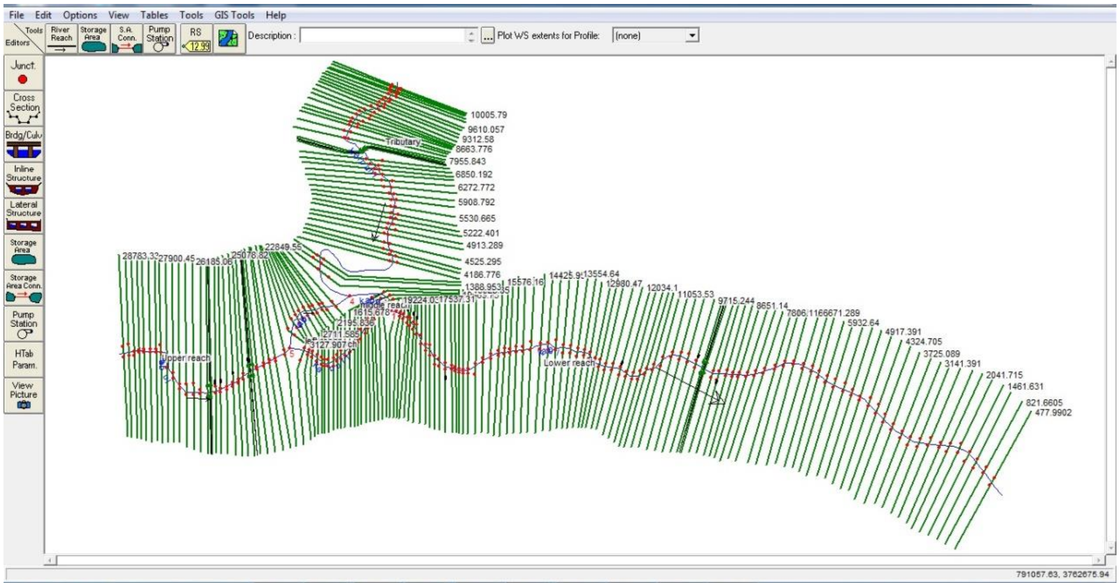


Figure2.7. RAS geometry imported into HEC-RAS model. The flow directions of river reaches are shown by arrows.

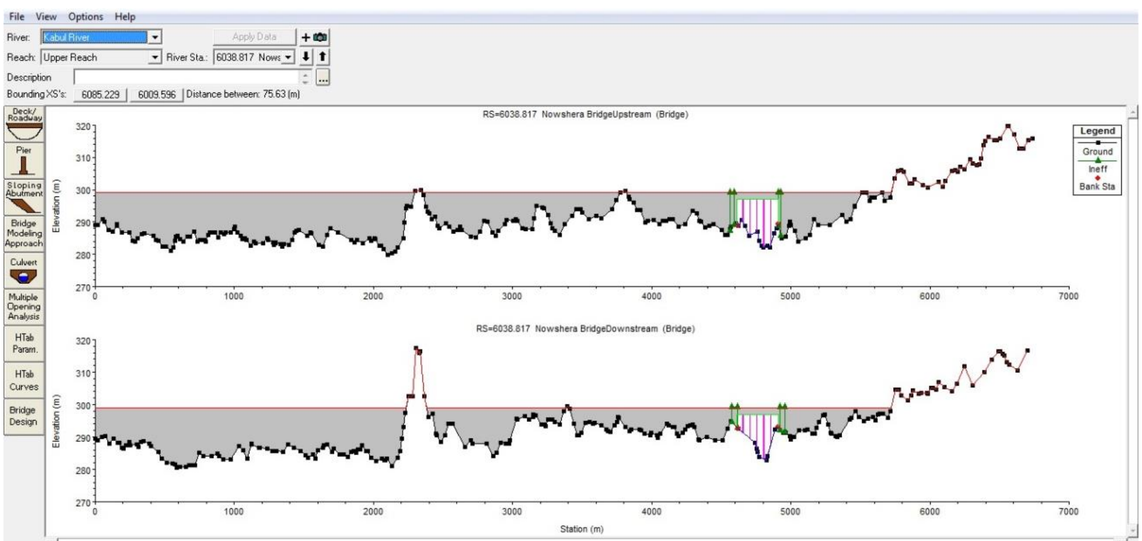
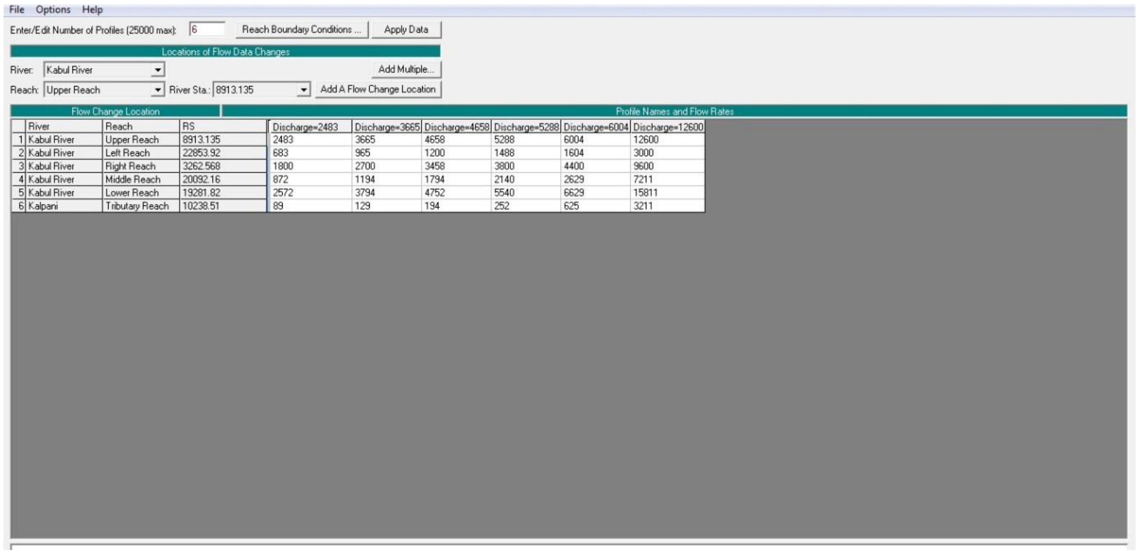


Figure2.8. Bridge data of Nowshera bridge on Kabul river upper reach.



	River	Reach	RS	Discharge=2483	Discharge=3665	Discharge=4658	Discharge=5288	Discharge=6004	Discharge=12600
1	Kabul River	Upper Reach	8913.135	2483	3665	4658	5288	6004	12600
2	Kabul River	Left Reach	22853.92	683	965	1200	1488	1604	3000
3	Kabul River	Right Reach	3262.568	1800	2700	3458	3800	4400	9600
4	Kabul River	Middle Reach	20092.16	872	1194	1794	2140	2629	7211
5	Kabul River	Lower Reach	19281.82	2572	3794	4752	5540	6629	15811
6	Kalpani	Tributary Reach	10238.51	89	129	194	252	625	3211

Figure2.9. Steady flow discharge data of Kabul and Kalpani river.

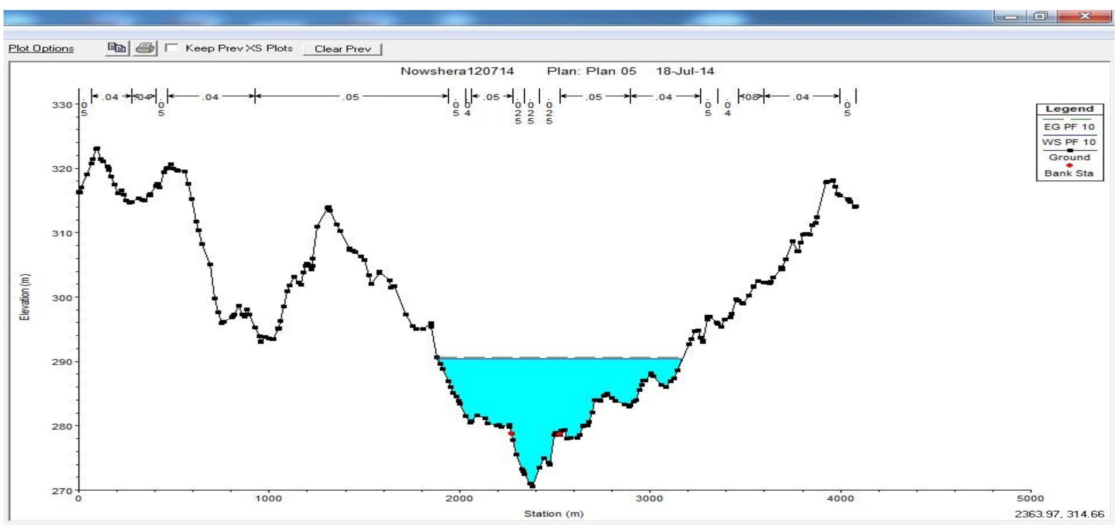


Figure2.10. Water surface profile at cross section taken on Kabul river lower reach.

Water surface profile shows the water level of 2010 flood event.

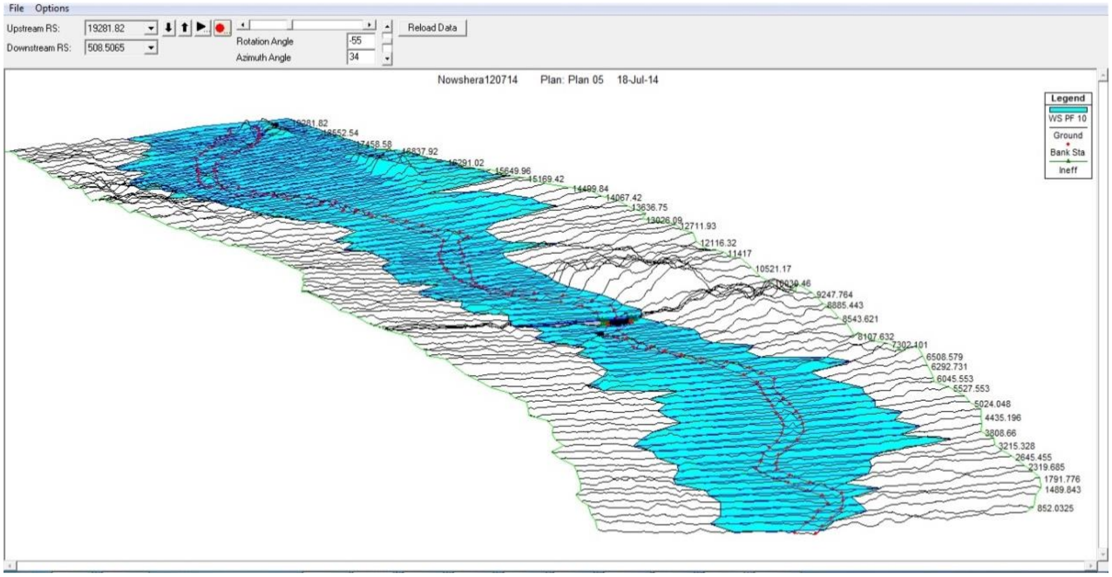


Figure2.11. x-y-z perspective profile of River Kabul lower reach of flood event 2010.

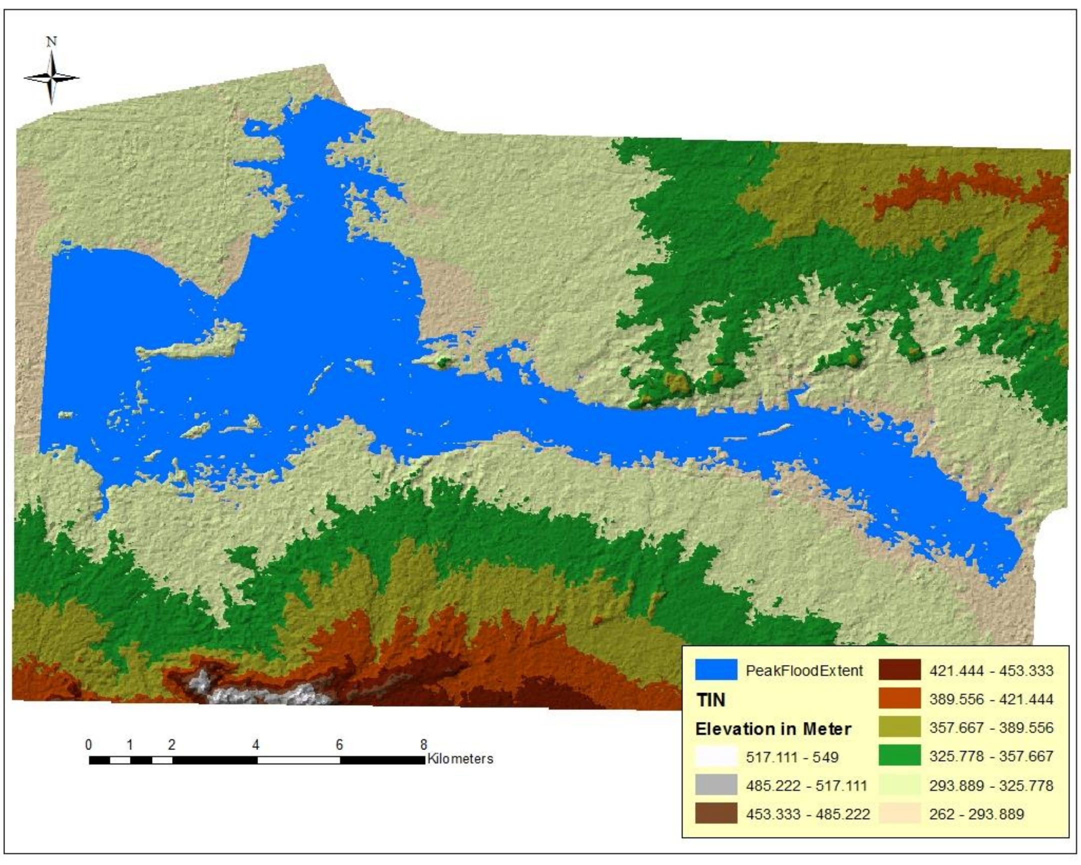


Figure2.12. Peak Flood Extent at Kabul and Kalpani River on 29th July, 2010.

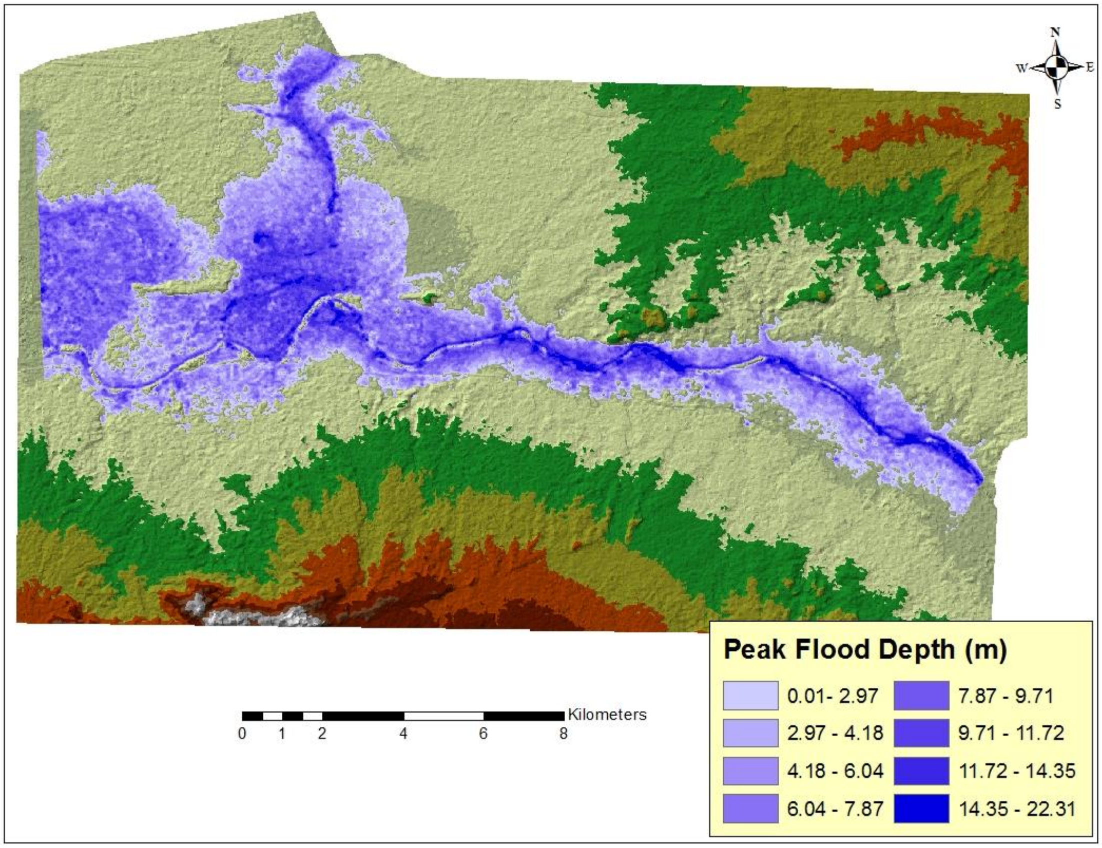


Figure2.13. Peak Flood Depth at Kabul and Kalpani River on 29th July, 2010.

Chapter-3

Results and Discussions

3.1 2010 Flood Analysis

In July 2010 Kabul River was flooded due to the severe monsoon rain and inundated the low laying areas near to Kabul River. The different discharge of flood in July and August was used in HEC-RAS Model for different water surface profile calculation. The peak discharge at Pirsabaq gauge station and Chawkay gauge station was 12,600 cms and 3211 cms on 29^{th} July, 2010. The resulted inundated area was 74.59 sqkm in the study area. In HEC-RAS model, the Manning's *n* value is the roughness parameter which is very important for the computation of water surface profiles (Cook, 2008). The selection of suitable Manning's *n* value for the riverbed and floodplain is very important to the accuracy of the generated water surface profiles (HEC, 2010). According to HEC RAS 4.1 reference mannual, the Manning's *n* values were assigned to the landuse map as shown in table 3.1.

The Steady flow simulation was calculated by using the different discharges of Kabul River and Kalpani River to get the different inundated areas. The different inundated areas calculated with HEC-GeoRAS model was shown in figure 3.1.

3.2 Development of Web-GIS

To distribute the flood inundated maps on internet we developed a Web GIS Application. All the layers that is flood extent maps, flood depth map, Schools, Hopitals, Roads, Cross Sections and Banks Points was published in ArcGIS Server as a dynamic layer which are accessible through uniform resource locater. The following steps are required for Web GIS development.

3.2.1 Layer Services

Before going to publish a layer, check there services like symbology, time and query as if the layer have time series data that change property of a layer according to time we should check time enabling option and time slider that will show the map characteristics with different time period in ArcGIS Desktop 10.2.

3.2.2 Publishing Service

After allotting the services steps the different layers are ready for publishing their services on Arc GIS Server 10.1 for web based activities. Figure 3.2 shows service ready for publishing. The connection to ArcGIS Server must be established before going to publish a map services from ArcGIS desktop through Arc Catalog or ArcGIS Server Manager. If the server is down the required services will be not published. The metadata, input output parameter should also be provided here to each layer for Geo processing services such as query and searching. Figure 3.3 represents the connections and the directory where the web service must be placed.

3.2.3 Utilizing Service

After publishing the services it is available for further utilization using URL as shown in Figure 3.4, which shows the service name, URL, and other information. All the attributes and related information can be viewed and any user can view or query the layer through URL it can query in ArcGIS Desktop. Each layer is represented by a unique ID, which starts from layer id zero and so on.

3.3 Presentation Tier / Client Side View

The presentation tier or client side view of the application is explained below which shows all the layers functionalities. End user can view this web GIS application through URL. Figure 3.5 shows the front view of the application.

3.4 Base Layers and Operational Layers

These are two important layers type while only one base layer will be active at any time. Operational layers are over laid on the Base map which is like a container; it might be Google layer or satellite imagery. From different types of base maps only one can be active at a time, as shown in Figure 3.6. Operational layers are over laid on base map and any operation can be performed on it. At a time more than one operational layer can be active. Operational layer transparency can be increased or decreased according to the requirements of the application. The layers sequence can be moved up and down accordingly in the application. Figure 3.7 shows operational layers here is school layer, hospital layer, road layer, settlement layer, peak flood depth and different flood extent etc.

3.5 Bookmark Widget

Widget is a graphical user interface which display information of an area and provide a specific way for user to interact with the application. Bookmarks are used to view the required area of interest through a shortcuts way.

Figure 3.8 represents bookmarks with the name Khyber Pakhtunkhwa and Nowshera and show the minimum x, y and maximum x, y coordinates.

```
<configuration label="Nowshera">
   <bookmarks><bookmark      name="Khyber      Pakhtunkhwa">7699227.54916518
3625377.225405699
         8258196.249608866 4435028.803813384</bookmark>
      <bookmark      name="Nowshera">7978100.403160751      4001218.0934838145
8046007.059089269
         4059340.809791836</bookmark>
   </bookmarks></configuration>
```

3.6 Layer List Widget

The Layer List widget provides ArcGIS Viewer for Flex application end users with the ability to turn map layers on and off accordingly. Operational layers listed in the viewer application main configuration file appear in the widget. It contains School layer, Hospital layer, Road layer, flood extent and flood depth layers shown in figure 3.9. With a mouse click the flooded extent area can be find as well as the depth of flooded water shown in figure 3.10.

3.7 Legend Widget

A legend conveys the meaning of the symbols used to represent features on the map to a map reader. The Legend widget provides a dynamic legend for the ArcGIS Viewer for Flex and automatically updates if the visibility of a layer or sub layer changes. Figure 3.13 represent legend widget.

Table 3.1. Table shows the Manning's *n* values of land use classes.

Landuse Classes	**Manning's n**
Settlements	0.08
Barren Land	0.04
Vegetation	0.05
Water	0.025

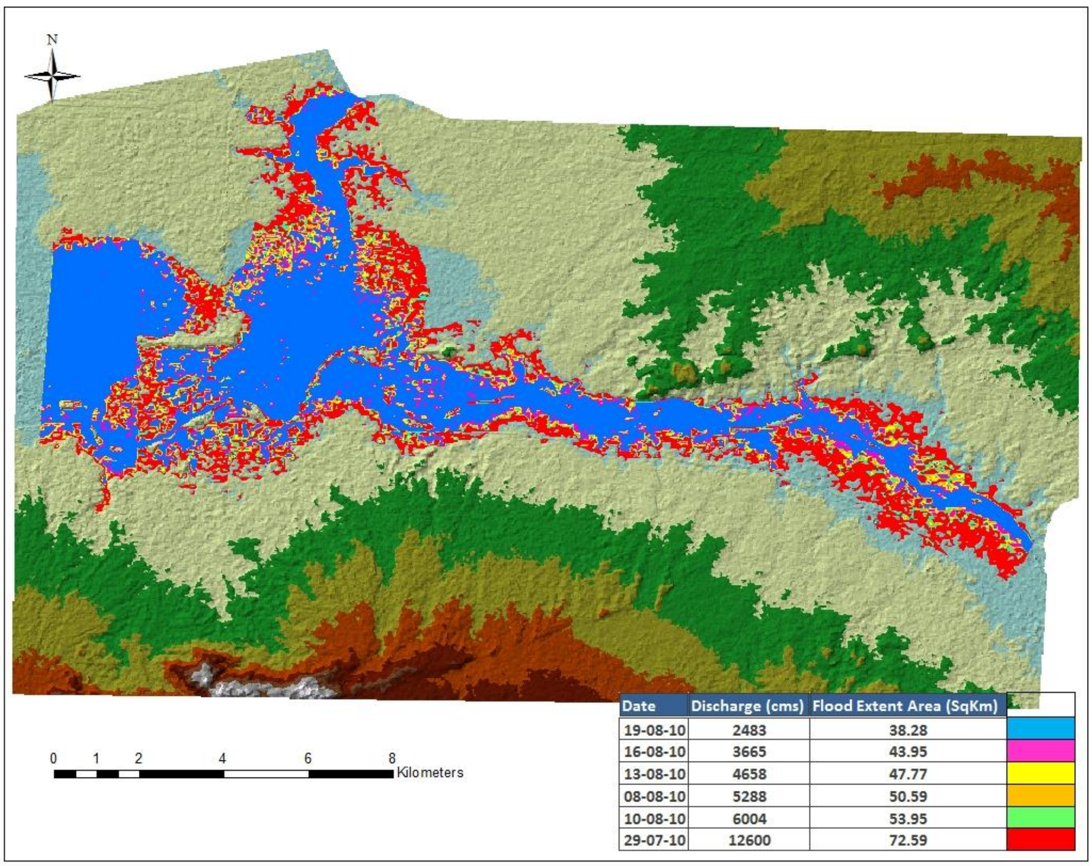


Figure3.1. Flood inundation map with different flow discharge.

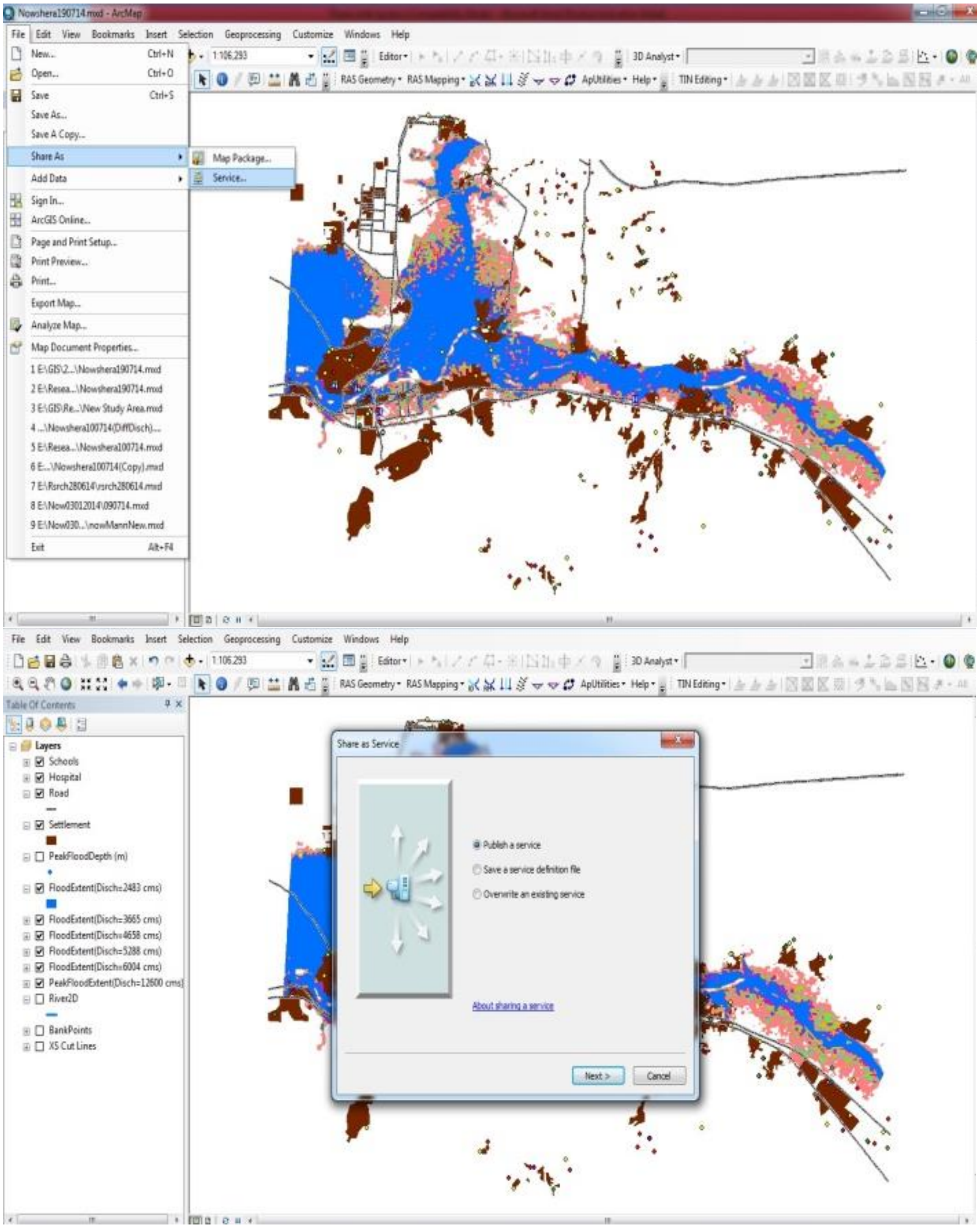


Figure3.2. Services ready for publishing.

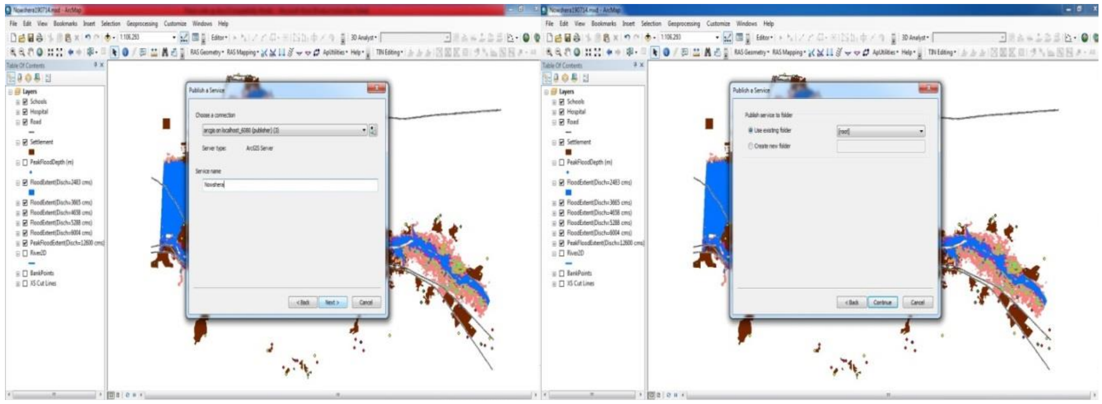


Figure3.3. Connection and directory.

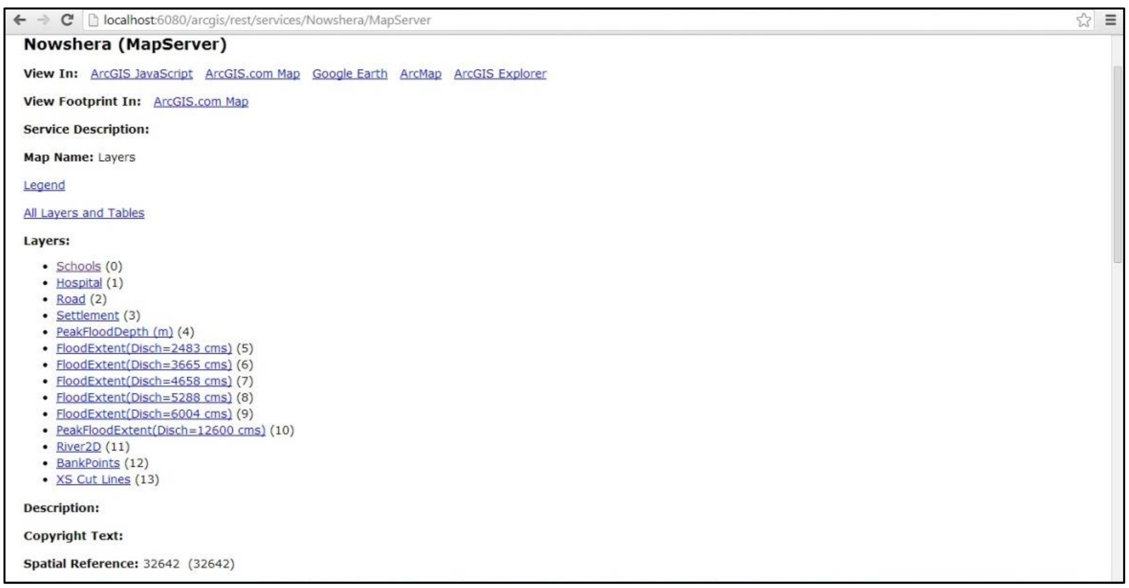


Figure3.4. Utilizing services.

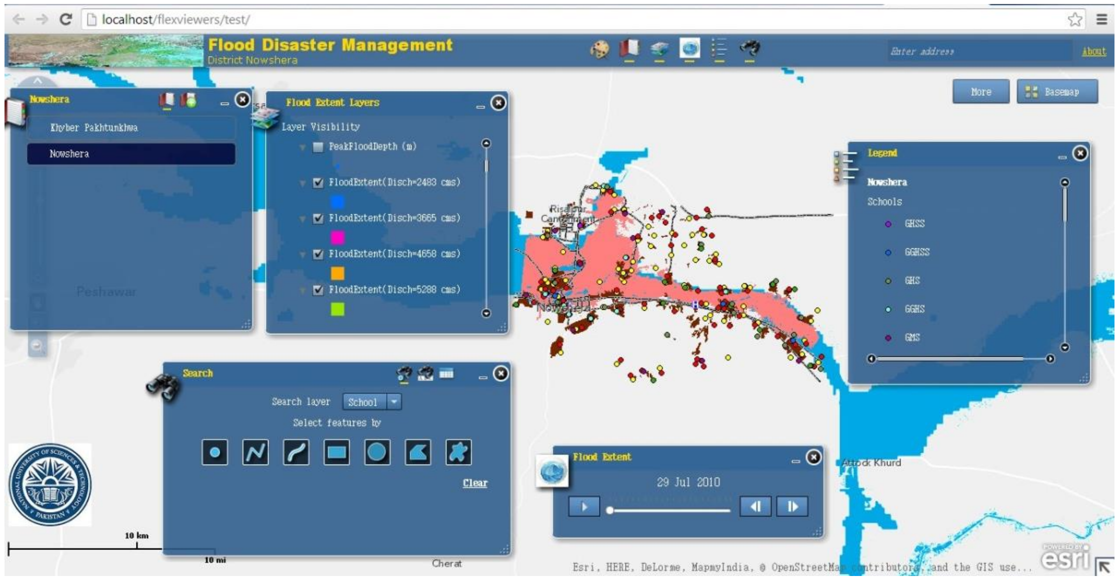


Figure3.5. Front view of application.

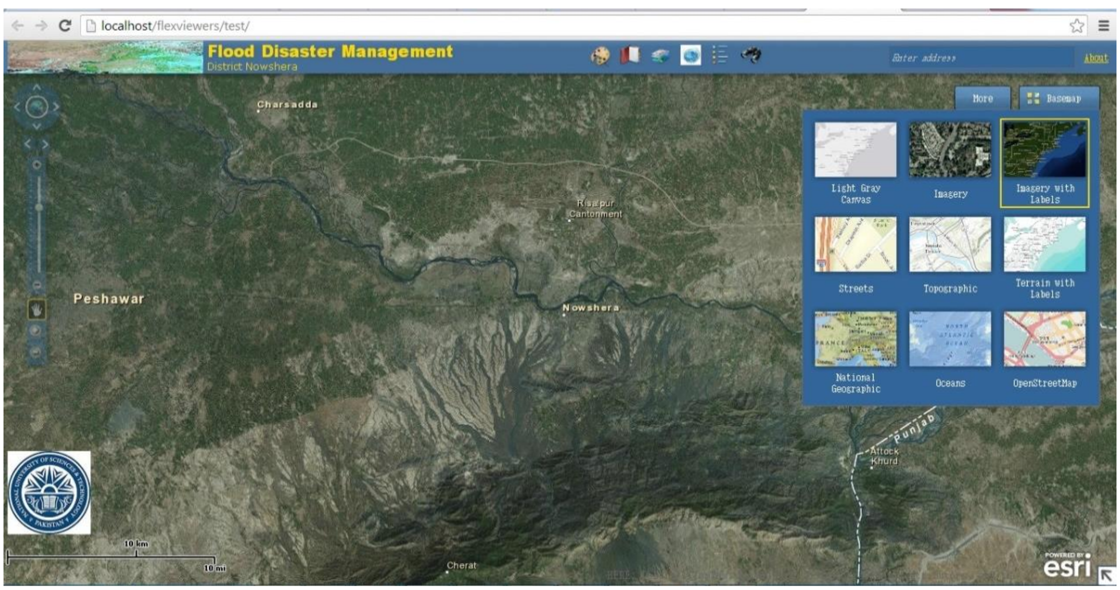


Figure3.6 Base map layer.

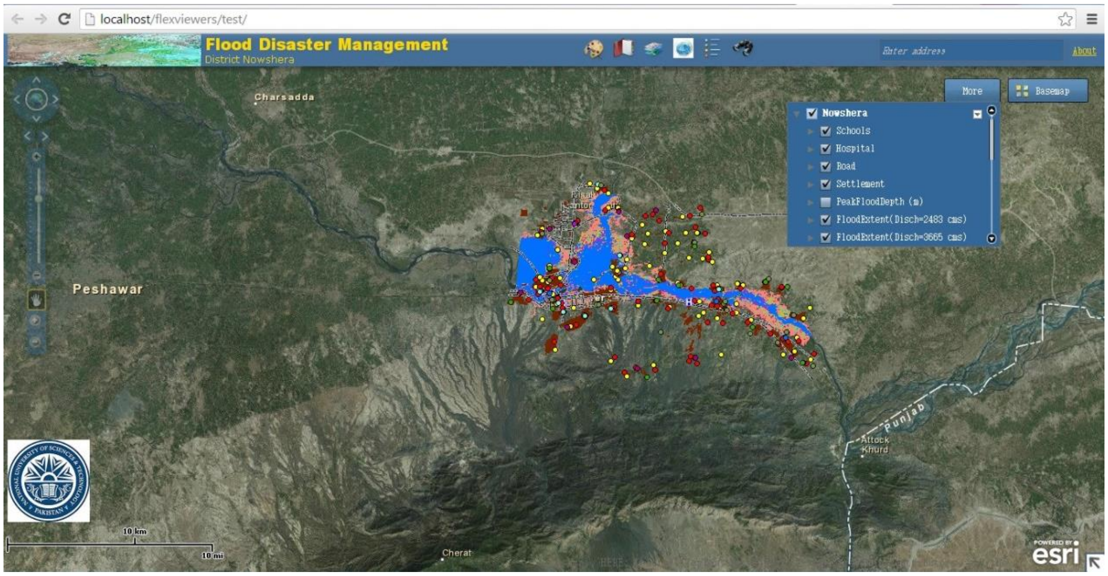


Figure3.7. Operational layers.

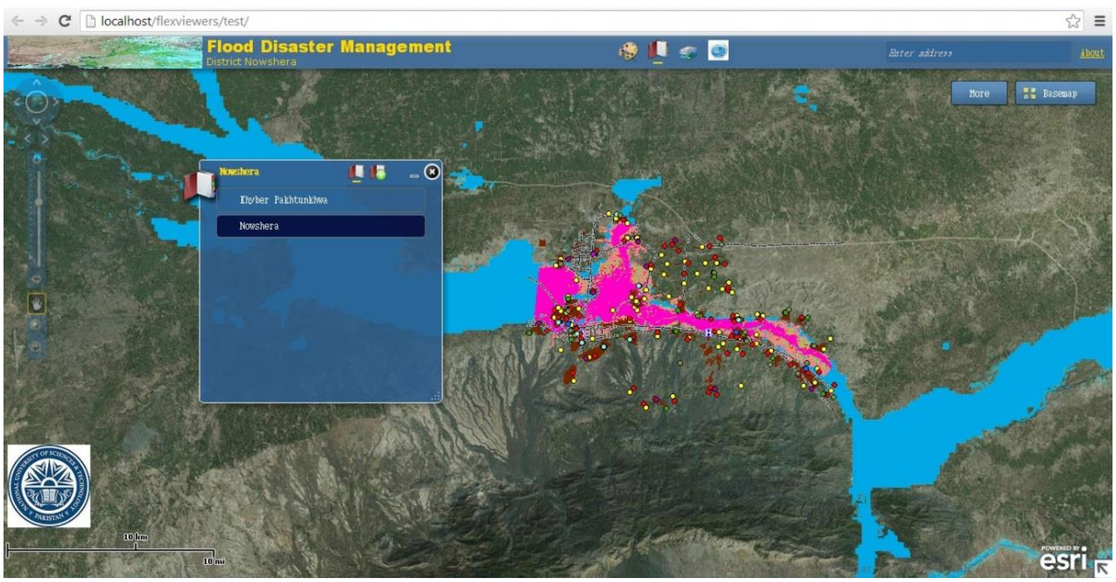


Figure3.8. Book mark widget.

3.8 Time Widget

The Time widget defines time-related properties and applies them to the map in the ArcGIS Viewer for Flex.it work with time enabling data published from ArcGIS server as either a feature or dynamic service, which requires ArcGIS desktop 10.2. All layers referenced in the application configuration file that have temporal data, will then follow the time properties defined by the Time widget (Figure 3.11), enabling them to be displayed in the web application.

3.9 Drawing and Measure Widget

This widget is very useful for the drawing and measurement at client side, which can also show us the area and perimeter of the specific area. Different types of drawing can be performed on it. In this widget the users can change the measurement units as well as labeling functionality is available in this widget according to the requirement of the users. Figure 3.12 shows the draw and measurement widget.

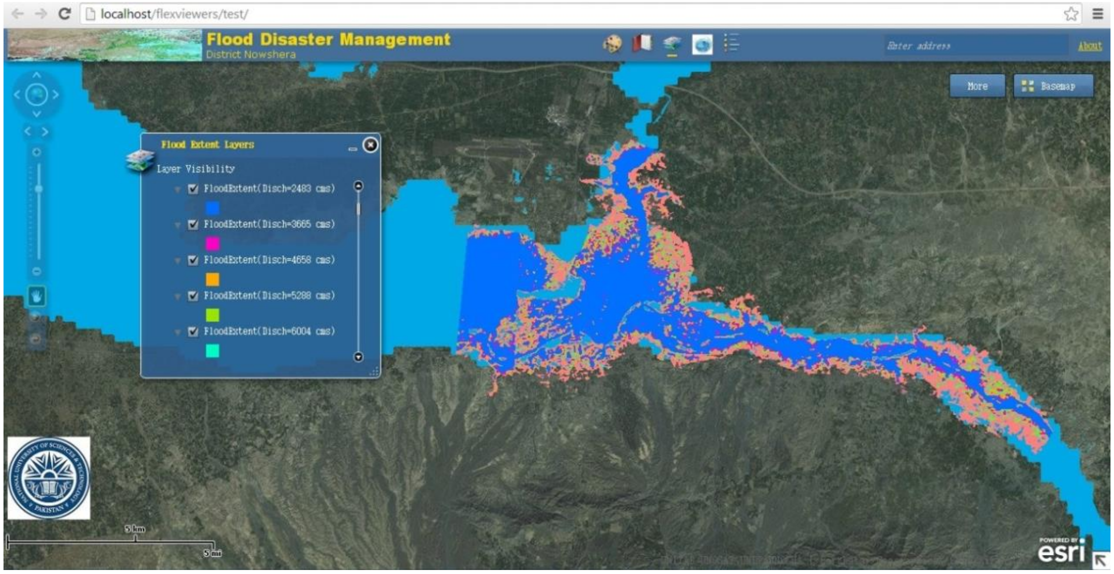


Figure3.9. Layer list widget.

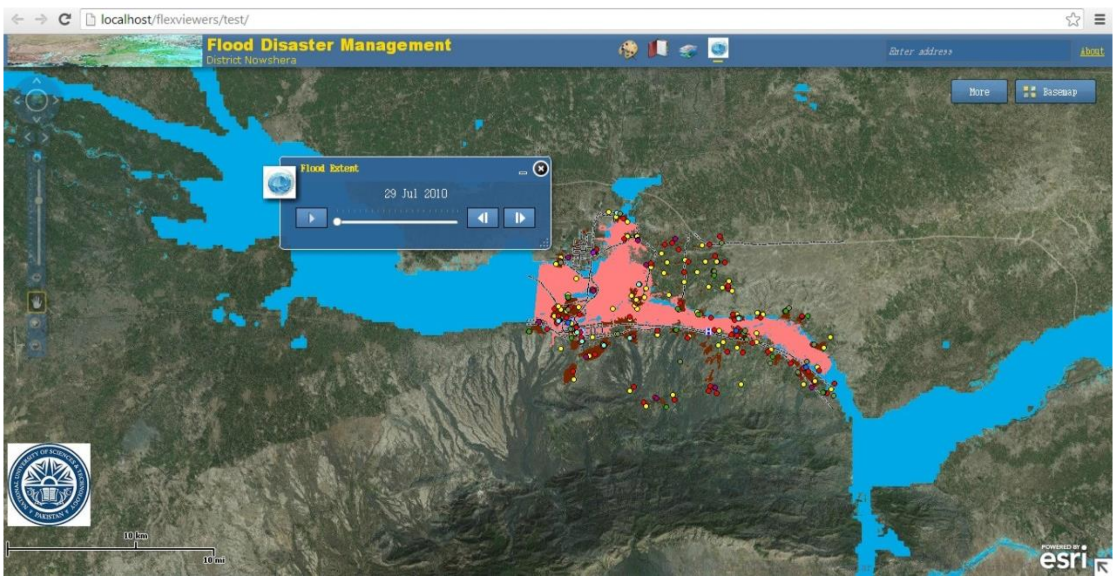


Figure3.11. Time slider.

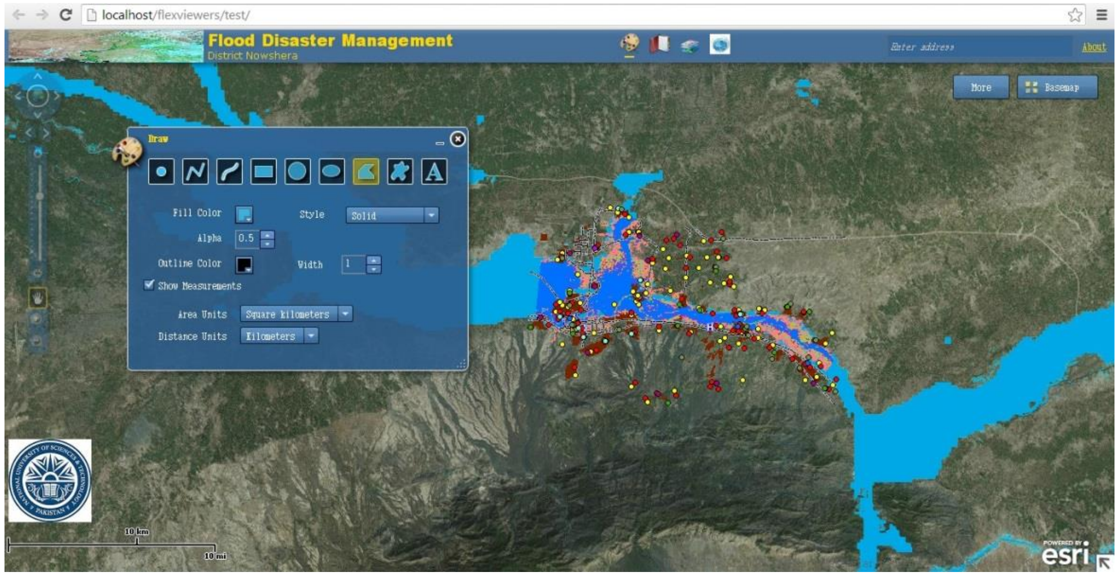


Figure3.12. Drawing and measure widget.

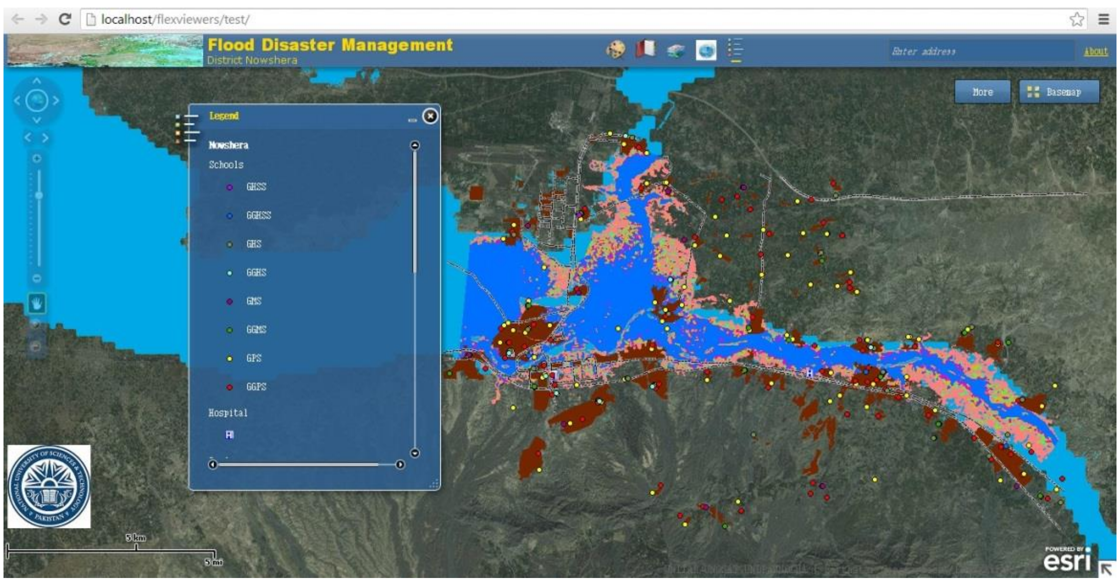


Figure3.13. Legend widget.

Chapter-4

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

Population growth is increasing rapidly near to Kabul river and there is no planning for urban sprawl. The settlements are highly in risk due to heavy monsoon rain. To achieve one of the aim of this research using the best model HEC-GeoRAS for defining flood extent and flood depth in the study area to expose the flooded area with low flood discharge to high flood discharge. The study also exposed the basic facilities (schools, hospitals, roads) that will be affected from the flood disaster in this area.

Another main achievement of this research was to distribute information about flood disaster and its extent in the study area through Web GIS. A quick searching of flooded area, flooded basic facilities and printing functionality have been delivered through Web-GIS. Any client/organization can find the floodplain area with different flood discharge and flood depth in floodplain area which is very important for better decision during flood time and in future for urban planning.

4.2 RECOMMENDATIONS

An early warning system Web GIS should be implemented in flood related organizations which inform the people live near to Kabul river about the extent of flood and its depth. They should focus high flooded area to provide rescue operations at right time to right people.

There should be a centralized database for flow discharge data. Same area data exists at different organizations in different format which increase their efforts and waste their time to get this data.it will be easier to organize, edit, update and backup of the data in centralized database.

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