BE CIVIL ENGINEERING
PROJECT REPORT

EARLY FLOOD WARNING SYSTEM AT RIVER SWAT WITH SPECIAL EMPHASIS ON DISTRICT KHAWAZAKHELA

Project submitted in partial fulfillment of the requirements for the degree of

BE Civil Engineering

SUBMITTED BY

GC HAMMAD ASGHAR	**NUST201439219BMCE10114F**
GC USAMA BIN SAMEE	**NUST201439208BMCE10114F**
GC MUHAMMAD BILAL	**NUST201439209BMCE10114F**
GC TANZEEL UR REHMAN	**NUST201439221BMCE10114F**
GC GULRAIZ	**NUST201439223BMCE10114F**

MILITARY COLLEGE OF ENGINEERING
NATIONAL UNIVERSITY OF SCIENCES & TECHNOLOGY
RISALPUR CAMPUS, PAKISTAN

(2018)

This to certify that the

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Has been accepted towards the partial fulfillment of the requirements for

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Lt Col Khurram Sattar Khan
Syndicate Advisor

Maj Dr. Naeem
Syndicate Co-Advisor

DEDICATION

This thesis is dedicated to our country, in general, and the people of SWAT, in specific. Our parents and friends without whose prayers and well-wishing we wouldn't have gained the potential to finish this. Most importantly, our educators and mentors for their valuable time and guidance.

ACKNOWLEDGEMENT

All thanks and praise to Allah Almighty.

We are appreciative to Almighty Allah for giving us opportunity and assets to finish our examination work. We are enormously obliged to the general population without whom it would not have been composed. Our most profound appreciation goes to our regarded educators especially our guides Sir Khurram Sattar and Sir Naeem who have dependably been an image of support and motivation to us and was the main thrust behind this exploration. He contributed assets thoughts and his gathering of our thoughts and proposals has dependably been amazingly promising. Through his praiseworthy direction and authority, we could accomplish the goal of this exploration. Unique on account of our folks for their endless love and petitions. To the individuals who somehow contributed in this examination, your thoughtfulness implies a great deal to us.

ABSTRACT

Flood warning has been an important issue for Pakistan. In this study we considered district Khavazakhela KPK. We used GIS techniques for this purpose. i.e. Global Mapper, ARC-GIS, Hec-HMS. . The objective of this study was to develop a flow model for Khuvazakhela, for this purpose we processed the DEM of Khavazakhela, took FAO soil data. We developed landcover on ERDAS IMAGINE and created the CN Grid. The main theme of the project is to enlighten the significance of GIS based approach in the field of hydrology and disaster management.

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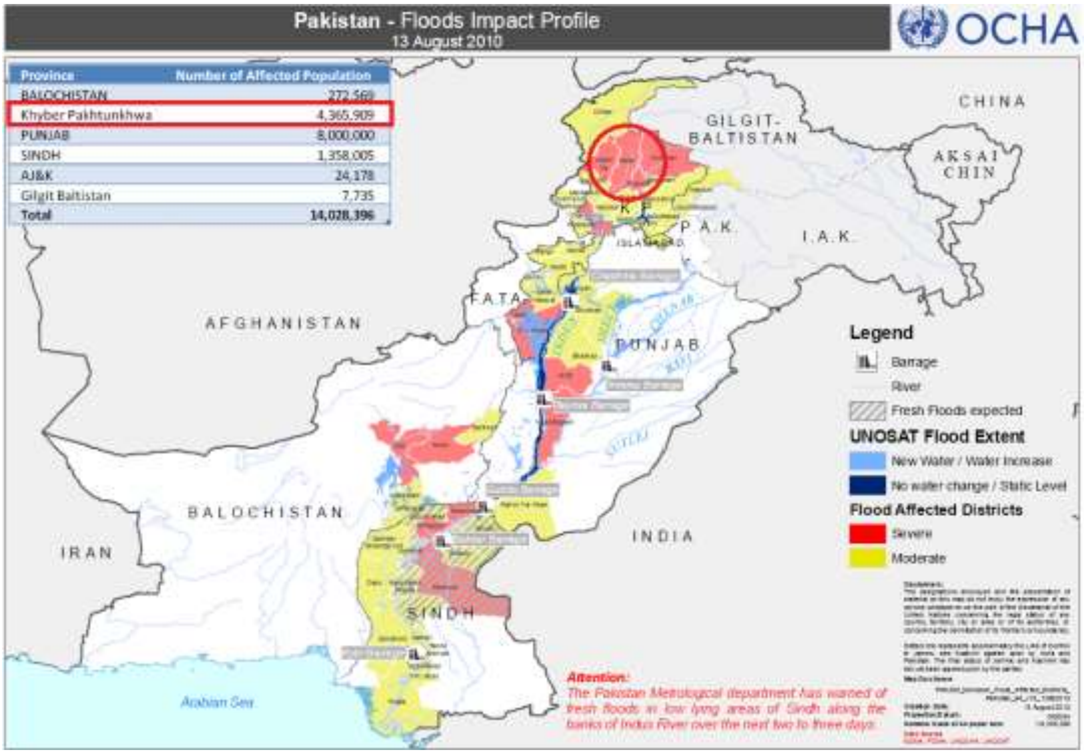
<u>Chapter 1: Introduction</u>

1.1Background

Swat is a district in KPK province. 2010 floods brought destruction and huge losses all over the Pakistan due to heavy monsoon. It affected the Indus river basin, almost 20 percent of Pakistan total land area was affected badly. 20 million people were affected and the death toll is about 2000. Floods also resulted in destruction of property, infrastructure loss, livestock losses are also included. So the Early Flood warning system at River Swat district is a dire need of the hour to prevent from major losses against such catastrophes.

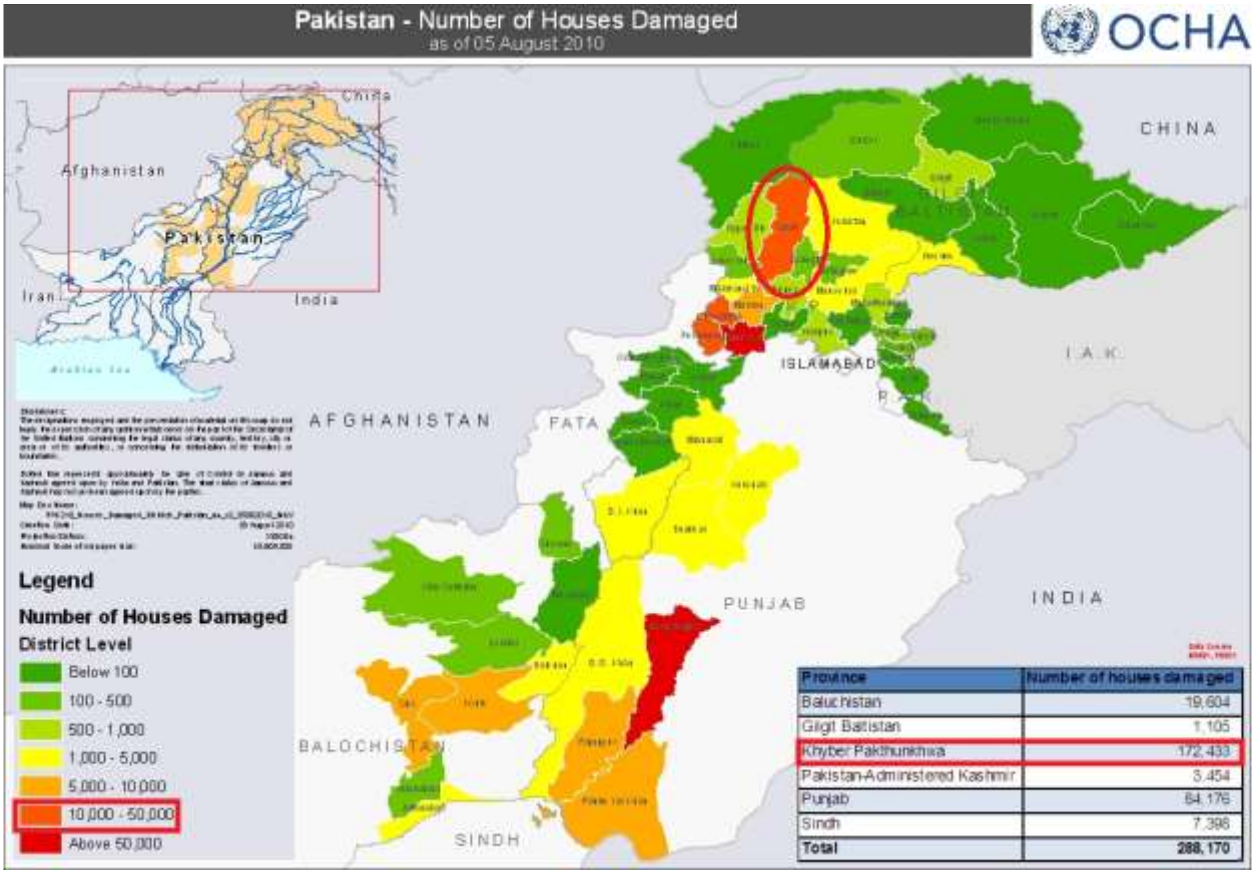
1.2 Importance of Hydrology in Subject Area

Pakistan, almost every year, is hit by many Flash Floods which cause the lives of many innocents. Death toll is significant and many catastrophes as such. All this is due to poor water management. The flood in 2010 affected millions of people across the country. SWAT division itself lies amongst the highest flood hazard prone regions and district Khawazakhela (area under consideration) has been in a limelight of such topic. Undertaking these facts into consideration, hydrology of this region becomes an important study. Establishment of an early flood warning system is thus, a vital and preliminary work of today and future.



1.3History of Floods in Subject Area

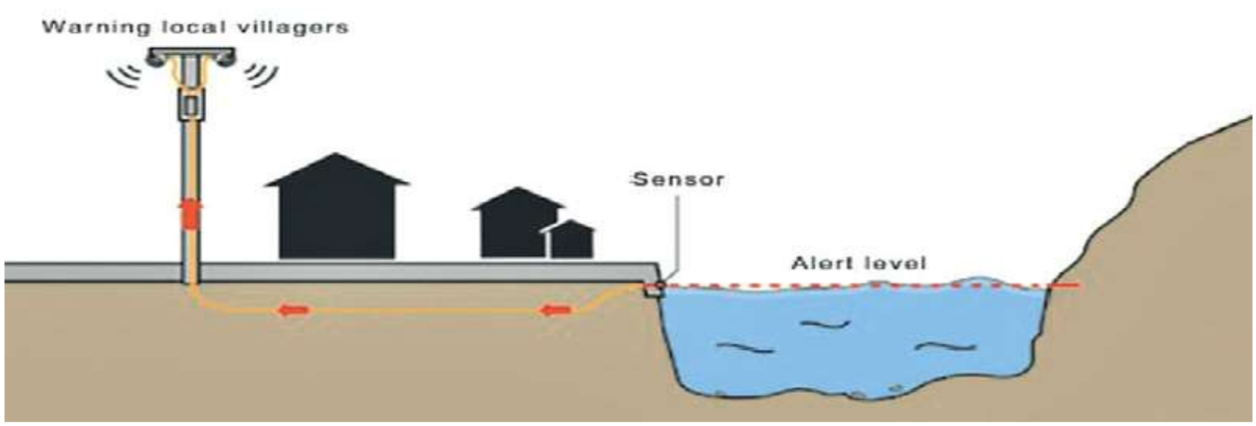
Woods specialists say that where the deodar (Cedrus deodara) develops, the rainstorm doesn't typically go, yet in the event that it arrives, it brings only destruction. It all happened back in the late July of 2010, when swat and its adjoining areas were hit by the flood of the worst kind. All the areas from Kalam and Utror to Landakey were adversely affected, leaving only the traces of destruction everywhere. There was no admonishing of the surges in Swat, as the catastrophe administration instrument was for all intents and purposes dead at that point. It has been exactly eight years since the flood, and still some of the areas of Swat-Kohistan portion are not re-built. The kalaam swat road is still in a very poor condition, it should have been repaired considering the tourism attraction toward Bahrain, kalam and utror valleys.


Pakistan - Number of Houses Damaged
as of 05 August 2010
OCHA
China
Afghanistan
Pakistan
Iran
India
CHINA
AFGHANISTAN
FATA
ISLAMABAD
I.A.K.
PUNJAB
INDIA
BALOCHISTAN
SINDH
Legend
Number of Houses Damaged
District Level
Below 100
100 - 500
500 - 1,000
1,000 - 5,000
5,000 - 10,000
10,000 - 50,000
Above 50,000
Province | Number of houses damaged
Baluchistan | 19,604
Gilgit Baltistan | 1,105
Khyber Pakhtunkhwa | 172,433
Pakistan-Administered Kashmir | 3,454
Punjab | 84,176
Sindh | 7,398
Total | 288,170

1.4 Importance of an Early Warning System

Floods and landslides have been posing damages to the several areas of Swat from past few years. According to the report of Pakistan meteorological department, 399 houses were damaged and 116 people got killed during monsoon of the year 2017 because of the floods and landslides caused by them. The national disaster management authority (NDMA) of Pakistan has been looking up for early flood warning system to avoid any disaster causing damage to the vegetation, health, bridges and property of the people of Swat. Floods can be extremely disastrous. They cause vulnerable damage to the flood prone areas. So, it's important to arm these communities with the flood warning programs to avoid turning them into a disaster.

The difference between survival and disaster can be made through an integrated community based flood warning system, which will be implemented by the communities themselves. Today, according to the national disaster management authority of Pakistan, many areas of district Swat are in need of flood warning systems.

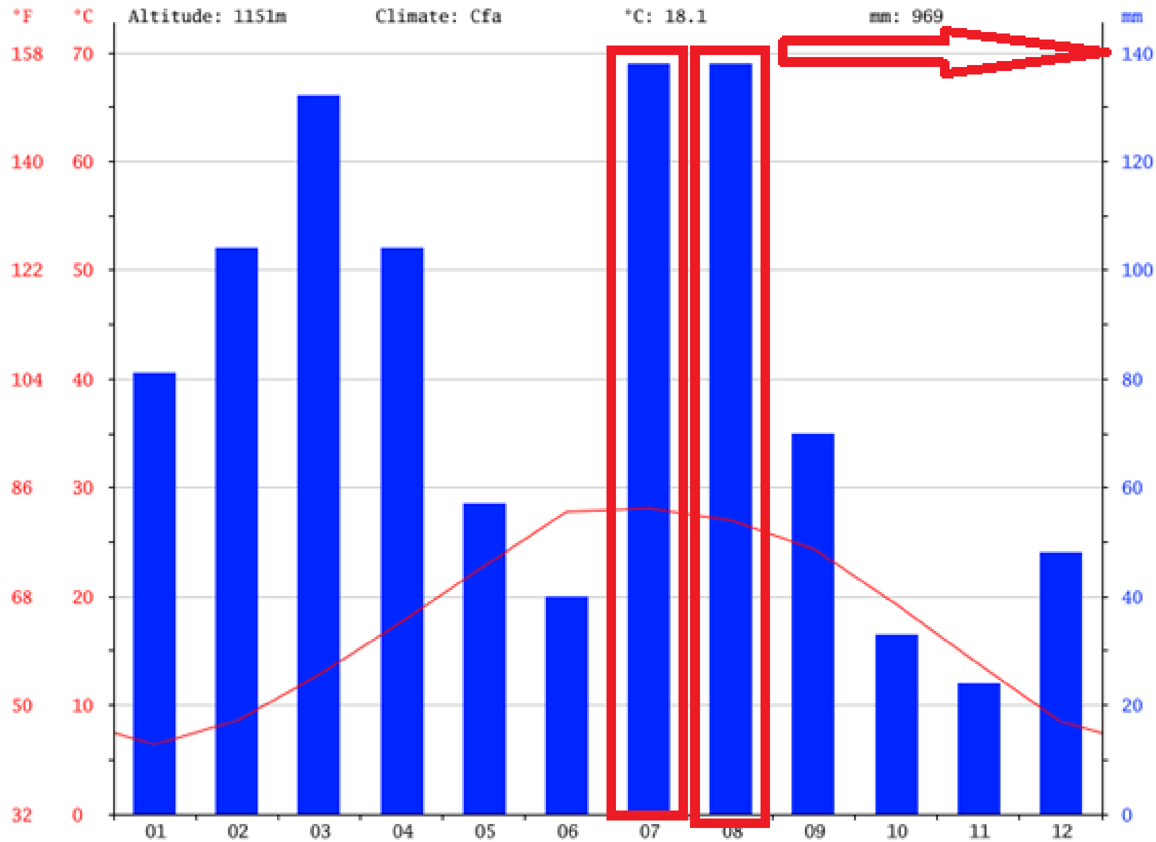


1.5 Area under Consideration

The area of our study lies in Khyber Pakhtunkhwa Province, Pakistan. District Khawazakhela. Khavazakhela is tehsil of Swat district in KPK. Its coordinates are 34.9371° N, 72.4687° E. its elevation is 1,151 m. following are the wards of tehsil Khavazakhela: Shalpin, Shin, Kotanai, Miandam, Khavazakhela, Fatehpur and Jano.

Khawazakhela is having mild and temperate climate. Under the Koppen climate classification Khawazakhela features a humid subtropical climate. Some of the facts and figures are as follows;

- Average temperature 18.1 degree Celsius
- Annual precipitation 969 mm
- Driest month precipitation 24 mm i.e. November
- Wettest month precipitation 138 mm i.e. July



1.6 Problem Statement

Floods can overwhelm a village in a matter of moments. But with an early flood warning system, vulnerable communities can be equipped with information and preparation it takes to keep a threat from turning into a tragedy. So, developing an early flood warning system for district Khuwazakhela is todays necessity keeping in view the flood history at the site (2010 floods specifically).

1.7Research Questions

- How effective is using GIS based technology in managing the drainage of storm water surface run-off?

- How effective is using GIS based technology in managing the drainage of storm water surface run-off?
- What can be the remedial measures for the critical areas?

1.8 Scope and Objectives:

The scope of this research study is to develop an Early Flood warning system at River Swat using GIS based modelling approach. The objectives of the project of early flood warning system are listed as under:

- To delineate Watersheds and Stream-network for study area.
- To prepare a Land cover Map.
- To process soil data and Land use data.
- To generate Curve Number Grid
- To generate Flood Inundation Polygon

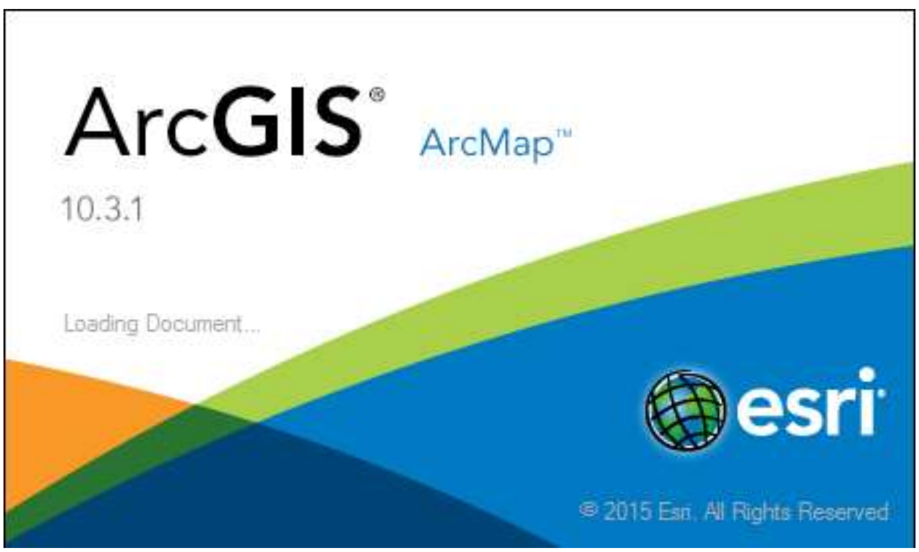
1.9 Overview of the Softwares Used

1.9.1 Global Mapper

Global Mapper is an easy and user friendly software for processing of very low level tasks to more complex problems in 2D and 3D.

1.9.2 Arc GIS 10.3.1

ArcGIS is a very integrated and comprehensive software used for analysis and classification of geographical data acquired from various sources. It includes many extensions that are used in this project like HEC geo HMS, Arc Hydro tools.



1.9.2.1 HEC Geo HMS

HEC Geo HMS is the extension used for generation of parameters required for HEC HMS like CN Grid and is a part of HEC HMS which is the main software used for simulation of hydrological processes.

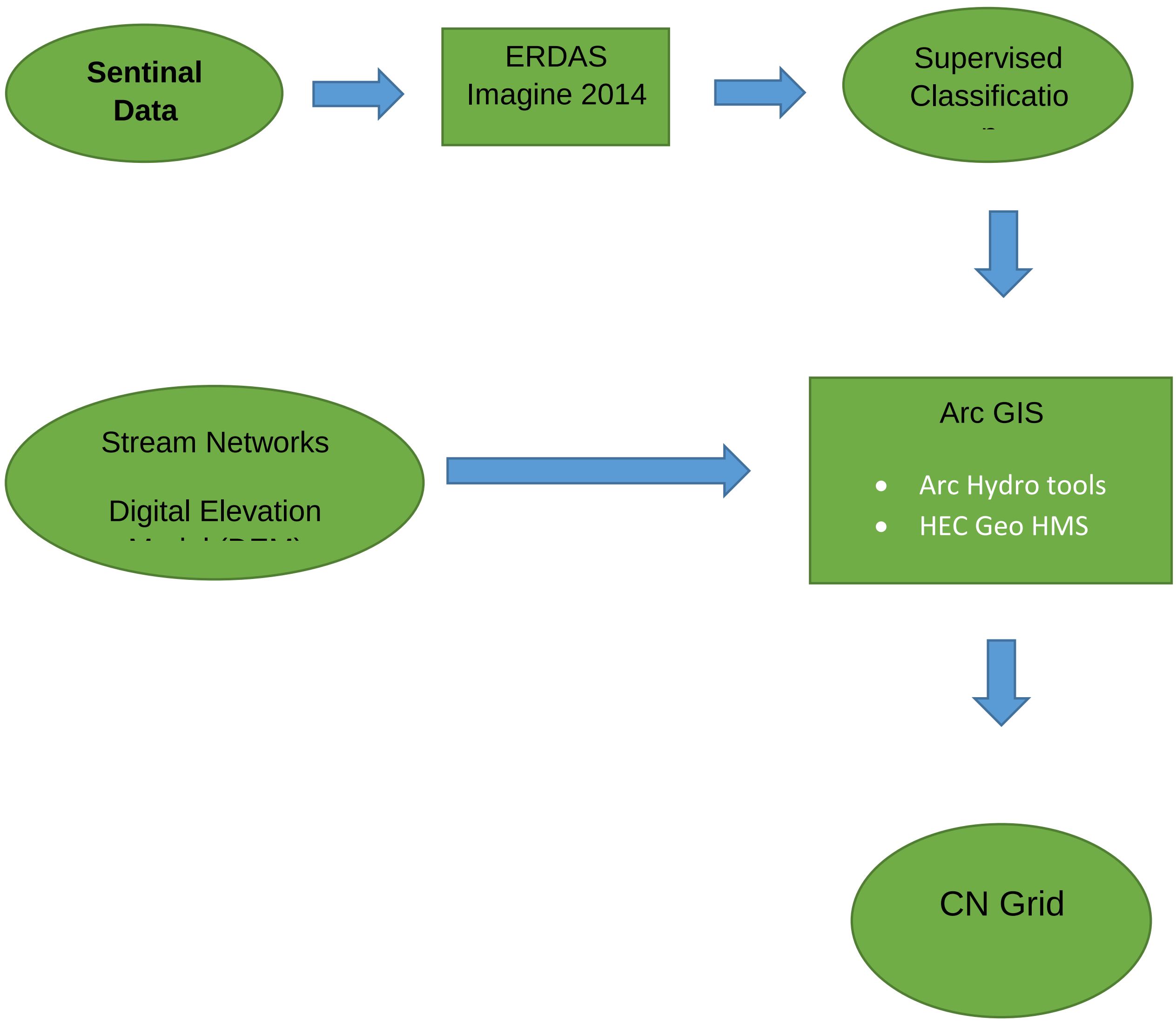
1.9.2.2 Arc Hydro Tools

Arc Hydro Tools are tools that are an extension of Arc GIS that is used for delineation of watersheds and stream networks, they need to be separately downloaded from internet.

1.9.3 Erdas Imagine 2014

Erdas is a software used for processing Satellite Imagery, it can process vector data, geo spatial data, hyper spectral imagery and LiDAR data managed from different sources. It is a raster based remote sensing software that is specifically designed for extraction of information from images.

2.0 <u>Relationship of Software with Project Data</u>



CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In the present era GIS is responsible for real time monitoring of damages and assessment of natural calamities specially floods. With geographic information system flood prone areas i.e. critical areas be identified timely. By using GIS approach information is basically stored as database for demarcation of hazardous areas and then disaster management is carried on for mitigation purposes of those affected areas.

2.2 Significance of Flood Forecasting

With early warning losses can be reduced significantly. The purpose of flood forecasting is to anticipate the magnitude of coming danger/hazard and component of time period which the authorities can provide to their masses for the sake of shifting to safe regions and take relative measures to reduce the losses as per the possibility. This concept is quite old ,initially it was introduced a long time ago when an individual sitting across the bank of river observed that due to high discharge of river and significant amount of seasonal rainfall the level of the river may rise to a threatening degree and may bring huge losses to his community and locality, but in engineering and official terms first flood forecasting service was started at France for river Siene in 1830. Similarly an official commission was set up for the said cause in Germany (1890). Basic theme of these efforts is to provide timely rescue for the reduction of losses.

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2.3 Geographical Information System

Geo spatial information system is the system which helps us procure, store, display and control various forms and types of geographical data. The plus point is that this added data or stats are identifiable with the same geospatial referencing system used before. GIS has different levels of operating. Firstly, Geographic Information Systems technology is used for computer map making. Then comes the usage of spatial and other analysis methods which are required to compute the geographic information. This is considered one of the biggest advantages of GIS over other analyzing soft wares. The final step is the usage of information that is derived from analysis. (ESRI, 2012)

2.4 Application of GIS and Remote Sensing in Flood Management

The recent advancements in Geographic Information Systems (GIS) and Remote Sensing have improved real time monitoring, early warning and damage assessment of flood disasters in short period of time. They both assist in identifying flood prone areas so the people are timely communicated. Remote Sensing helps in flood management in following ways

- Generation of general flood model.
- Detailed Mapping for hazard assessments and for usage in different hydrological models.

Briefly stating GIS and Remote sensing techniques have so far contributed in:

- Flood Plain Zoning
- Flood Inundation Mapping
- River morphological studies

2.4.1 Flood Plain Zoning

For regulation of flood plain development activities and policy decisions by means of non-structural flood control planning of the flood plain, flood hazard zone mapping can be used. At the end flood hazard map is generated as output. Inputs include satellite data and hydrological data.

2.4.2 Flood Inundation Mapping

Information is necessary for flood mapping during the flooding and flood plain mapping after the flood diminishes. Remote sensing provides synoptic view of flood-affected areas at regular intervals for progressions and regressions of flood inundation in short time which helps us in planning and organization of relief operations effectively. Implications of this mapping include;

- identification of worst flood affected areas
- Defining spatial extent of flood inundation.
- assessing damages
- Planning relief operations
- Evaluation of flood impact on ecosystem

2.4.3 River Morphological Studies

Morphological studies of the river tells us the structure of river and its form i.e. geometry of the channel and its configuration and it also deals with the form of bed of the river. Morphological studies based on satellite remote sensing are useful in following areas:

- Identification of changes in the course of river over a period of time.
- In studying the effectiveness of flood dealing structural methods.

2.5 Terms used in the project

2.5.1 Average Annual Precipitation

The measure of precipitation that a specific area gets is controlled by various factors beforehand examined in this part. These incorporate the normal temperature for a territory, the most extreme vapor restrict, the mugginess, the area of unmistakable land developments, for example, mountains, the nearness to seas, the measure of wind, and so on. The measure of precipitation that a territory gets is alluded to as that zone's normal yearly precipitation.

An area with a moderately low normal yearly precipitation would be somewhat devastate. Little water implies that there will be less life. These territories are frequently called deserts.

Zones with high normal yearly precipitation are lavish and clamoring with life. These territories are frequently alluded to as rain woodlands. A large portion of the Earth's surface gets a normal yearly precipitation that untruths somewhere close to these two extremes.

2.5.2 Design Storm

In rundown, precipitation can be characterized as a power, for the most part a steady force just like the case for the sound strategy, or as a hyetograph where the profundity is related with a transient dispersion. The Natural Resource Conservation Service (NRCS), once in the past the SCS, has characterized some common outline storms for different districts of the United States. These conveyances are dimensionless top to bottom, however for the most part 24 hours long. They show the distinctions among run of the mill storms where 1) precipitation starts with a shorter time of higher power towards the center and decreases, 2) a generally consistent force all through, or 3) a high force storm where a large portion of the precipitation happens over a moderately little term. The movements underneath represent these distinctions.

2.5.3 Storm Water

Storm water is the water that begins because of the precipitation occasion and furthermore amid the dissolving of ice or snow. This water can dissipate and stay on the off chance that it is on surface and can splash into the dirt too. Slanting surface may cause the tempest water to run-off and fall in a stream or other downstream supply. Vegetation in the method for streaming water cause obstruction in its stream and frame a brief store. Developed regions don't bolster adsorption, retention or capacity. This causes high stream rates which can form into surges. This may likewise cause water contamination.

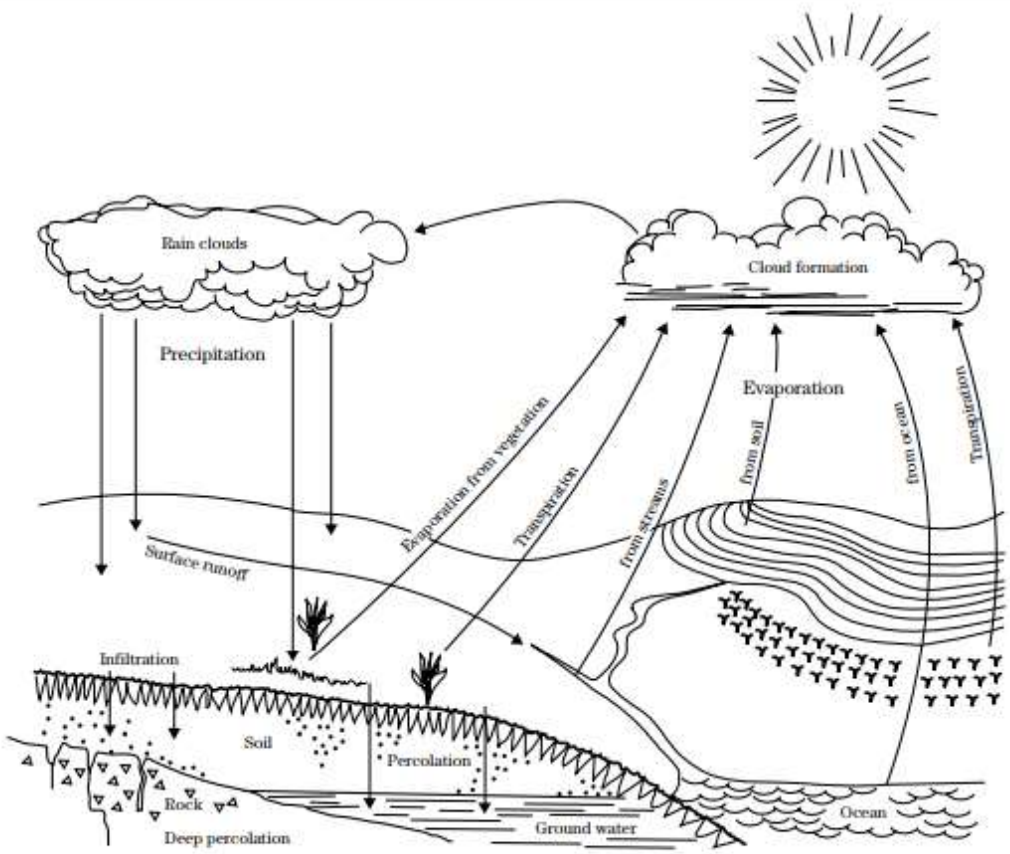
2.5.4 100 Year storm

There are comparable arrangements for 100-year surge occasions. The term 100-year surge is utilized as a part of an endeavor to streamline the meaning of a surge that factually has a 1-percent possibility of happening in any given year.[2] The genuine number of years between surges of any given size can shift on the grounds that the atmosphere normally differs after some time. Vast surges or rain occasions can happen in progressive or almost progressive years.[3] It ought to be noticed that few out of every odd 100-year precipitation occasion prompts a 100-year surge. Nearby conditions may take into account a less extreme tempest to prompt serious flooding.

2.5.5 Surface Run-off

Surface run-off is water, from rain, snowmelt, or different sources that streams over the land surface, and is a noteworthy segment of the water cycle.

Spillover that happens on surfaces before achieving a channel is likewise called overland flow. A land zone which produces overflow depleting to a typical point is known as a watershed. At the point when spillover streams along the ground, it can get soil contaminants, for example, oil, pesticides, or manures that progress toward becoming discharge or overland flow. Urbanization expands surface overflow, by making more impenetrable surfaces, for example, asphalt and structures don't permit permeation of the dilute through the dirt to the aquifer. It is rather constrained straightforwardly into streams, where disintegration and siltation can be significant issues, notwithstanding when flooding isn't. Expanded spillover decreases groundwater energize, in this way bringing down the water table and exacerbating dry seasons, particularly for ranchers and other people who rely upon water wells.



2.5.5.1 Factors affecting Surface run-off

They include;

A. Atmosphere factors:

1. Forms of Precipitation:

It has incredible impact on the overflow. E.g. A precipitation which happens as precipitation begins promptly as surface spillover relying on precipitation power while precipitation as snow does not bring about surface overflow.

2. Precipitation Concentration:

On the off chance that the precipitation force is more prominent than invasion rate of soil then overflow begins instantly after precipitation. In this manner high forces of precipitation yield higher overflow.

3. Time Span of Rainfall:

It is specifically identified with the volume of spillover because penetration rate of soil diminishes with length of precipitation. In this way medium power precipitation even outcomes in significant measure of overflow if length is longer.

4. Precipitation Dispersal:

Overflow from a watershed depends particularly on the circulation of precipitation. It is additionally communicated as "circulation coefficient" mean proportion of greatest precipitation at a point to the mean precipitation of watershed. Therefore, close outlet of watershed spillover will be more.

B Physiographic Factors:

1. Magnitude of Watershed:

An extensive watershed sets aside longer time for depleting the overflow to outlet than littler watershed and tight clamp versa.

2. State of the Watershed:

Spillover is extraordinarily influenced by state of watershed. State of watershed is for the most part communicated by the expression "shape factor" and "minimization coefficient".

Shape Factor = Ratio of normal width to pivotal length of watershed

= B/1 or A/1/1 = An/I2

Smallness Coefficient:

Proportion off edge of watershed to periphery of circle whose region is equivalent to region of watershed

Two kinds of shape:

Fun shape [tends to deliver higher overflow exceptionally early]

Greenery shape [tend to delivered less runoff].

3. Slant of Watershed:

It has complex impact. It controls the season of overland stream and time of centralization of precipitation. E.g. messy watershed brings about more prominent spillover because of more prominent overflow speed and the other way around.

4. Introduction of Watershed:

This influences the dissipation and transpiration misfortunes from the zone. The north or south introduction, influences the season of dissolving of gathered snow.

5. Land Use:

Land utilize and arrive administration hones have awesome impact on the overflow yield. E.g. a zone with timberland cover or thick layer of mulch of leaves and grasses contribute less spillover since water is assimilated more into soil.

6. Soil dampness:

Extent of overflow yield relies on the underlying dampness exhibit in soil at the season of precipitation. In the event that the rain happens after a long drought then penetration rate is all the more, consequently it contributes less overflow. 7. Soil write:

In filtration rate shift with sort of soil. So spillover is awesome influenced by soil write.

8. Topographic attributes:

It incorporates those topographic highlights which influences the spillover. Undulate land has more prominent overflow than level land since spillover water gets extra vitality [velocity] because of slant and brief period to infill rate.

9. Seepage Density:

It is characterized as the proportion of the aggregate direct length [L] in the watershed to add up to watershed zone [A]. More noteworthy waste thickness gives more overflow

Seepage thickness = L/A

Or on the other hand

Variables Affecting Runoff

The different elements which influence the spillover from a seepage bowl rely on the accompanying attributes.

1. Precipitation qualities:

a. Kind of tempest and season

b. Force

c. Term

d. Arial Distribution

e. Recurrence

f. Precursor precipitation

g. Heading of tempest development

2. Metrological elements:

a. Temperature,

b. Mugginess

c. Wind speed

d. Weight contrast

3. Watershed Factor:

a. Estimate

b. Shape

c. Height

d. Geology

e. Topography [Soil type]

f. Land utilize [vegetation], Orientation

g. Sort of seepage organize

h. Proximate to sea and mountain run

4. Capacity Characteristics:

a. Dejections

b. Lakes, lakes and pools.

c. Stream

d. Channels.

e. Check dams in gorges

f. Upstream supplies or tanks.

2.5.5.2 Methods to calculate run-off

- Time of Concentration Method
- Rational Method
- Curve Number Method

We've used curve number method so we will explain only that section.

The curve number method is basically a relation between rain volume and runoff volume (how much is the precipitation and how much is the runoff). It is specifically used for rural areas and other methods have been developed for estimation of peak runoff. The basic equation is

$$Q = \frac{(P - I_a)^2}{P - I_a + S}$$

Where

Q: runoff depth (to get volume, multiply by watershed area) in inches

P: rainfall depth in inches

I_a: Initial Abstraction in inches

S: Watershed storage in inches

2.5.5.3 Factors that determine Curve Number are

- Hydrological Soil Group
- Cover Type
- Treatment Hydrologic Condition
- Antecedent Run-off Condition
- The flow spreads over pervious area or directly enters drainage

2.6 Hydrological Soil Groups

Soils were originally classified into four groups based upon the following factors

- Soil in non-frozen form
- Soil surface that is bare
- Peak swelling of expansive clays
- Entry and conduction of water (thoroughly wet)

An important point to be taken into consideration right now is that while designating the hydrological soil groups, slope of the soil surface was not taken into account. The four groups are as follows:

Based on NRCS soil is divided into four hydrological soil groups.

Group A	Low Runoff
Group B	Moderate Runoff
Group C	High Runoff
Group D	Very High Runoff

Group A: (Low Runoff, High Infiltration)

When these soils are thoroughly wet, they have low run-off potential and water is transmitted freely through the soil. They've typically more than 90% sand or gravel and less than 10% clay textures. Saturated hydraulic conductivity of all layers of these soils exceeds 40.0mm per second (5.67in/hr.) and the depth to water table is greater than 24 inches.

Group B: (Moderate Runoff, Moderate Infiltration)

When thoroughly wet these soils have moderately low runoff potential and the water transmitted through them is unimpeded. They've typically between 10-20% Clay and 50-90% Sand with the texture loamy sand or sandy loam. Hydraulic Conductivity in the least transmissive layer between the surface and 50cm is between 1.42in/hr. to 5.67in/hr.

Group C: High Runoff, Low Infiltration

Soils in this category have moderately high runoff potential in their wettest state and transmission through the soil is somewhat restricted. They've soils typically having 20-40% Clay and less than 50% sand with loam, silt loam, sandy clay loam, clay loam and silty clay loam textures. The conductivity in saturated form in least transmissive layer between surface and 50cm is between 0.14in/hr. to 1.42in/hr.

Group D: Very High Runoff, Very Low Infiltration

When completely wet these soils have high runoff potential and the water movement through the soil is very restricted. They've typically greater than 40% Clay less than 50% sand and have clayey textures. They also have high shrink swell potential in some areas. Soils with depth to a water impermeable layer less than 50cm and with water table within 60cm of the surface are included in this group. The saturated hydraulic conductivity in the least transmissive soil layer is less than or equal to 0.14in/hr.

Table 7–1 Criteria for assignment of hydrologic soil groups when a water impermeable layer exists at a depth between 50 and 100 centimeters [20 and 40 inches]

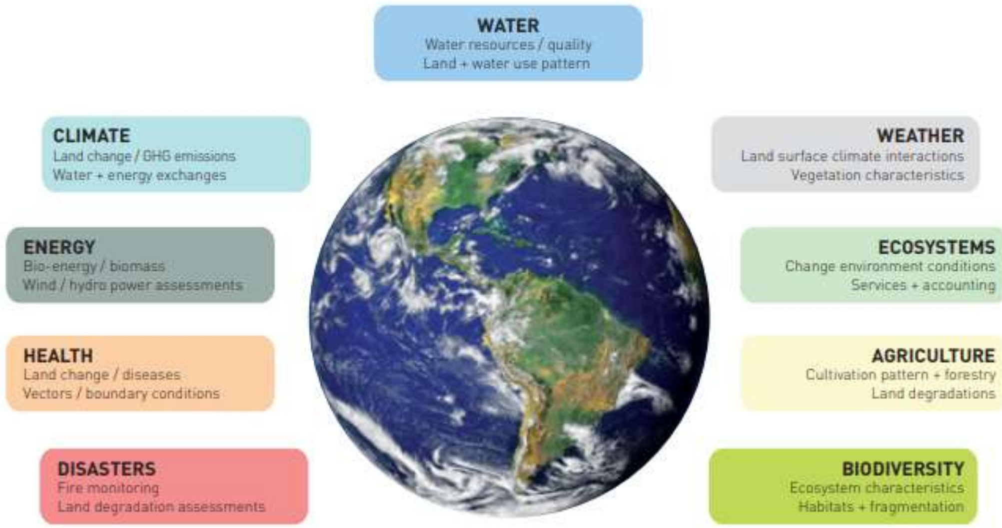
Soil property	Hydrologic soil group A	Hydrologic soil group B	Hydrologic soil group C	Hydrologic soil group D
Saturated hydraulic conductivity of the least transmissive layer	>40.0 μm/s (>5.67 in/h)	≤40.0 to >10.0 μm/s (≤5.67 to >1.42 in/h)	≤10.0 to >1.0 μm/s (≤1.42 to >0.14 in/h)	≤1.0 μm/s (≤0.14 in/h)
	and	and	and	and/or
Depth to water impermeable layer	50 to 100 cm [20 to 40 in]	50 to 100 cm [20 to 40 in]	50 to 100 cm [20 to 40 in]	<50 cm [<20 in]
	and	and	and	and/or
Depth to high water table	60 to 100 cm [24 to 40 in]	60 to 100 cm [24 to 40 in]	60 to 100 cm [24 to 40 in]	<60 cm [<24 in]

Table 7–2 Criteria for assignment of hydrologic soil groups when any water impermeable layer exists at a depth greater than 100 centimeters [40 inches]

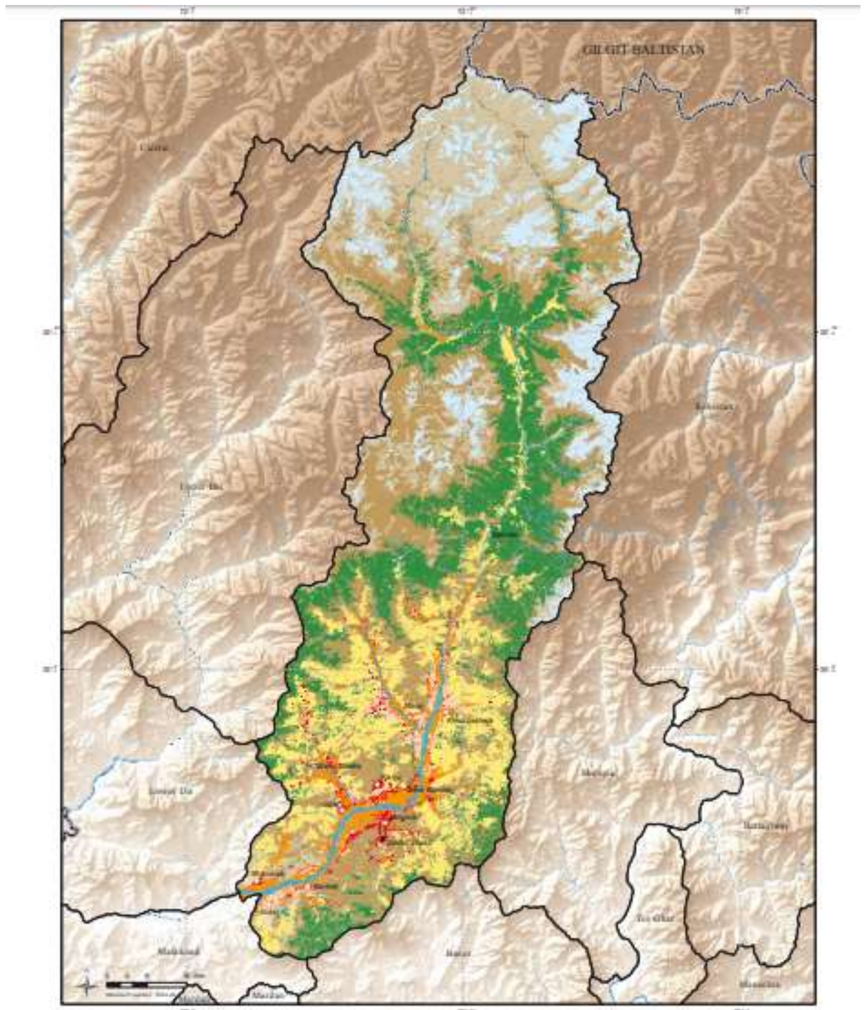
Soil property	Hydrologic soil group A	Hydrologic soil group B	Hydrologic soil group C	Hydrologic soil group D
Saturated hydraulic conductivity of the least transmissive layer	>10 μm/s (>1.42 in/h)	≤10.0 to >4.0 μm/s (≤1.42 to >57 in/h)	≤4.0 to >0.40 μm/s (≤0.57 to >0.06 in/h)	≤0.40 μm/s (≤0.06 in/h)
	and	and	and	and/or
Depth to water impermeable layer	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]
	and	and	and	and/or
Depth to high water table	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]

2.7 Cover Type

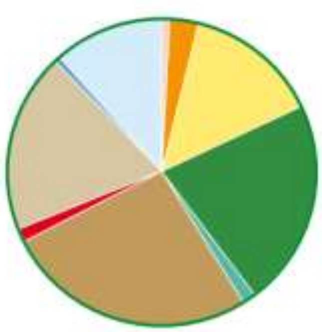
Land cover can be defined as the the physical entities i.e. wetlands, woodlands, horticulture, water that exist on the earth's surface. It can be determined by analysis of aerial and satellite imagery which then provides information to understand the landscape at present time, to observe change these maps for different years are needed. It is helpful in many ways e.g. it can help asses urban growth, water quality issues, sea level rise, tracking of wetland losses and many more.



Land cover observations and Geo societal benefits



LAND COVER IN PERCENTAGE



DISTRIBUTION OF LAND COVER IN THE DISTRICT

Legend	km²	%
Orchards	49.64	0.9
Crop Irrigated	5.99	0.1
Crop Marginal and Irrigated Saline	0.00	0.0
Crop in Flood Plain	170.78	3.2
Crop Rainfed	758.34	14.1
Forest - Natural Trees and Mangroves	1,171.22	21.7
Natural Vegetation in Wet Areas	62.26	1.2
Range Lands - Natural Shrubs and Herbs	1,429.09	26.5
Built-up	77.31	1.4
Bare Areas	0.00	0.0
Bare Areas with Sparse Natural Vegetation	1,015.03	18.8
Wet Areas	38.45	0.7
Snow and Glaciers	613.84	11.4
Grand Total	**5,391.95**	

2.8 SUMMARY of inputs of HEC HMS

The inputs for HEC HMS display are as per the following:

1. CN (Currve Number) Grid,
2. Storm Distribution Curve,
3. Design Storm.

2.8.1 Design Storm (Total Storm)

The outline storm for the bowls are chosen as the pinnacle storm at any point recorded in that specific bowl. The accessible record was of Peshawar and Saidu Sharif whose pinnacle recorded rain were 261 mm 183mm separately. We have three bowls being referred to which are Kabul tributary 1, Kabul tributary 2 and Swat tributary 3 bowls. For Kabul Basins we have considered the outline storm estimations of Peshawar though for Swat estimations of Saidu Sharif were considered. This has been done in light of the fact that Kabul Tributaries lie in the region of Peshawar and Swat Tributary lie in the region of Saidu Sharif.

2.8.2 Time Distribution Storm Distribution Curve

24 hour max precipitation information has been considered. SCS type 2 curve was utilized to deduce the given storm information after each 1 hr interim as specified in segment 4.2.5.

2.8.3 Curve Number Grid

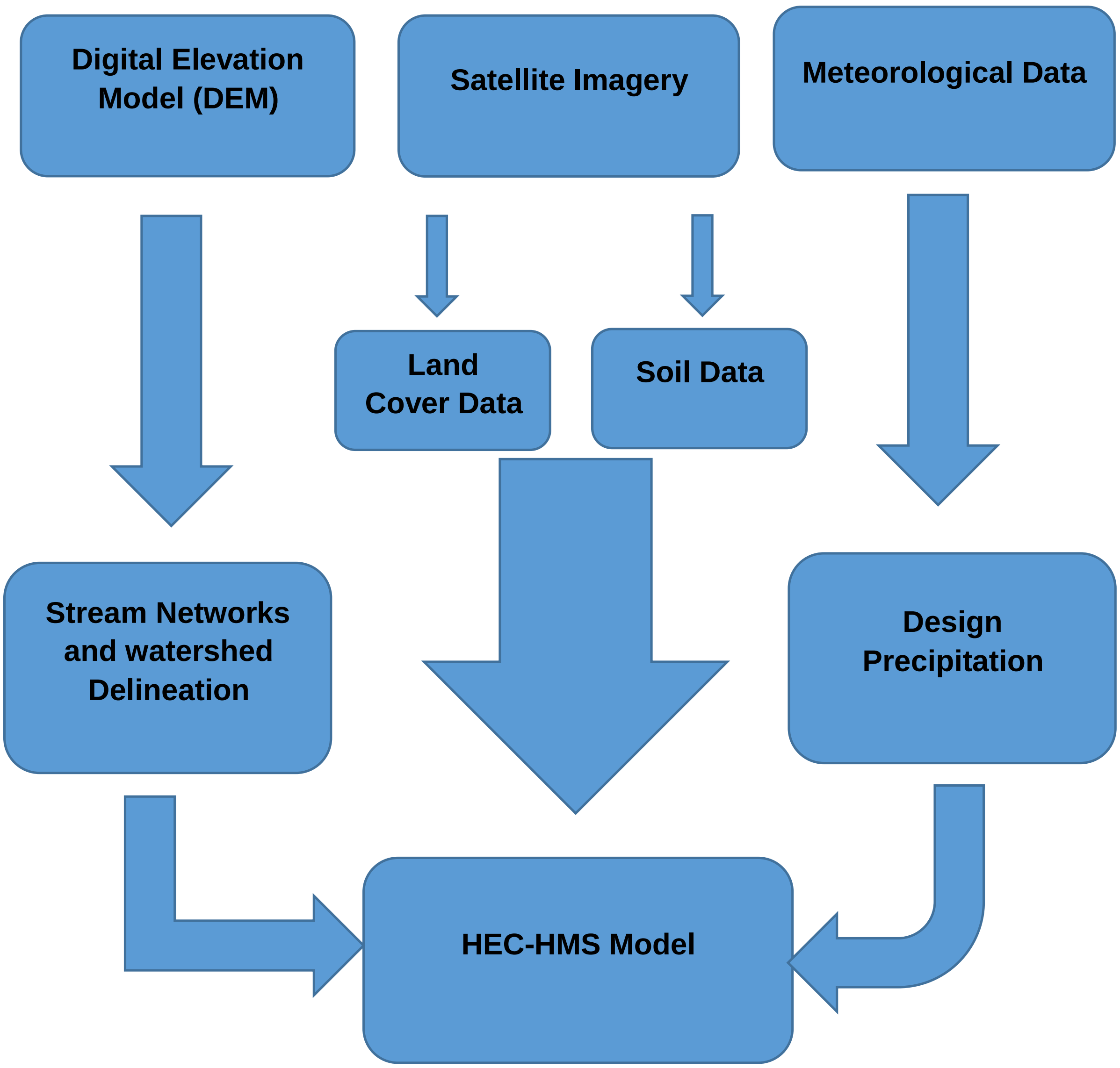
CN Grid was created utilizing HEC Geo HMS which is an Arc GIS expansion. The CN Grid points of interest have been beforehand clarified in section 3.

Chapter 3 METHODOLOGY

Introduction

The process of generation of a HEC-HMS model for early flood warning consists of the following steps:

- Brainstorming the process
- Data Collection
- Creation of Watersheds and Stream-Network Delineation
- Acquisition and Processing Land Cover Map
- Acquisition and Processing Soil Data
- Generation of CN Grid using HEC-GeoHMS
- Creation of HMS Model
- Running and Analysis of Generated Results


Digital Elevation Model (DEM)
Satellite Imagery
Meteorological Data
Land Cover Data
Soil Data
Stream Networks and watershed Delineation
Design Precipitation
HEC-HMS Model

3.1 Brainstorming the process

The initial step in any activity is the brainstorming i.e. what is our objective how are we going to achieve those objectives and after completion of the process what is going to be the outcome of the whole effort. It's a random thought process that needs to be noted down and further refined for easy and successful completion of Project.

3.2 Data collection

It is the most time consuming part of the project as it requires a lot of resources and effort and it is not obtained from a single source. Sometimes it is in raw form and needs processing other times it may be in soft from and needs conversion to hard copies. It can be available on internet or occasionally one has to visit specific departments physically to get access to it.

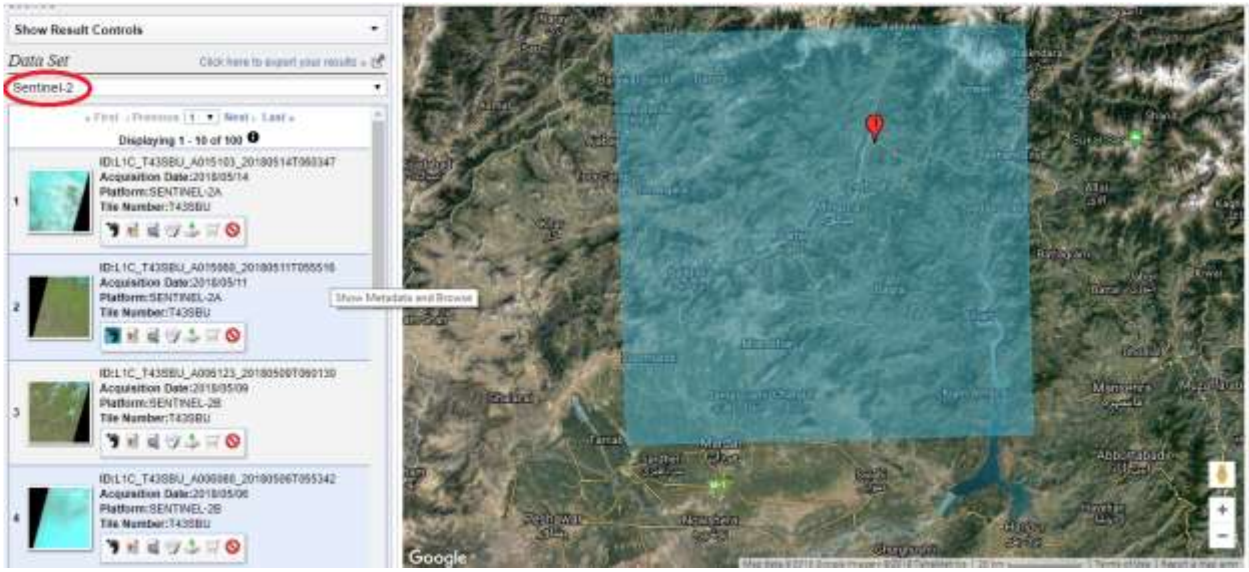
3.2.1 Rainfall Data

Precipitation data is an input parameter for HEC-HMS, which is further managed keeping in view our area of interest. As in Pakistan there are not gauging stations installed in every area so we have to manage and decide between which of the installed gauging stations our area falls. The main source for getting this data is Pakistan Metrological Department. We'll be considering Meteorological observatories of Saidu Sharif, Kalam and Malam Jabba for convenience which are installed at an elevation of 961m, 2103.01m and 2590.67m respectively.

IT is a specific database that speaks to the alleviation of a surface between purposes of known rise. By introducing referred to rise information from sources, for example, ground reviews and photogrammetric information catch, a rectangular computerized height display network can be made.

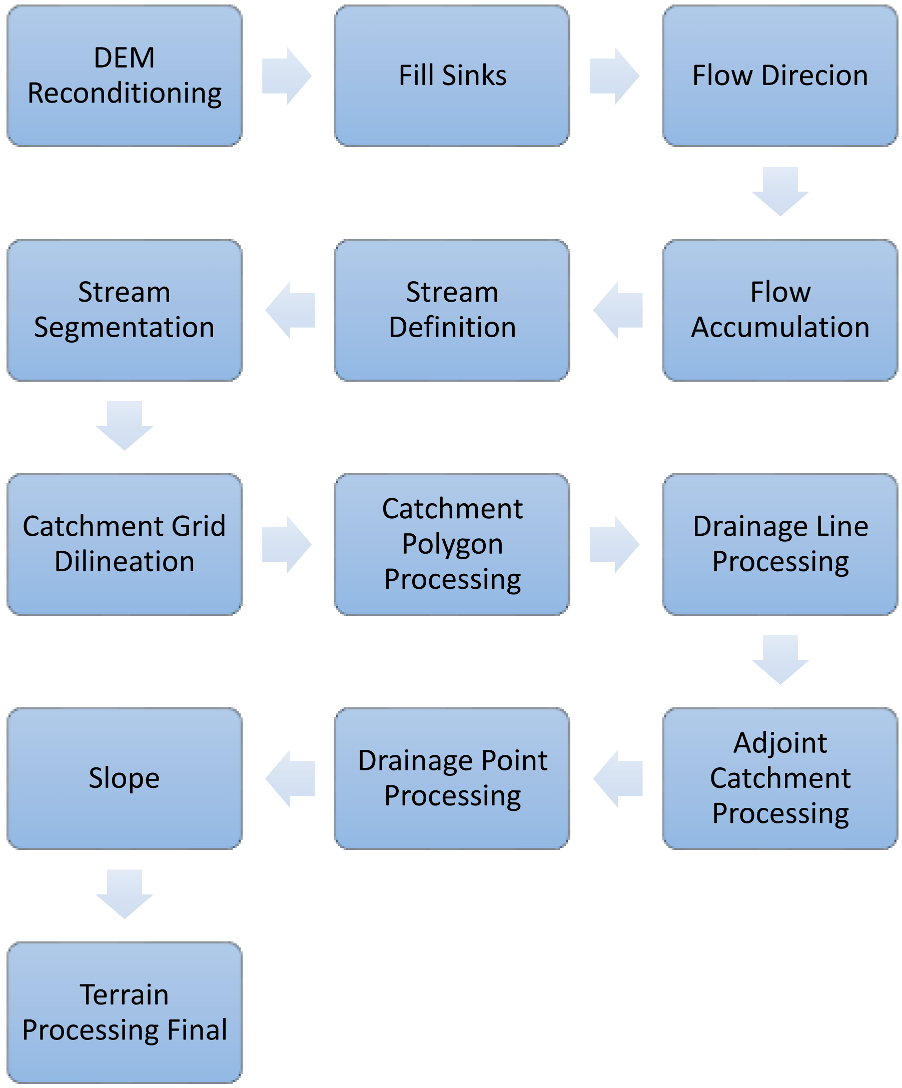
3.2.3 Land Cover Map and Soil Data

These are used in calculation of SCS Curve Number Grid which is further an input for HEC-HMS. Sentinel 2 data was used which is a tool for detection of changes, forest monitoring and has proved to be effective tool for disaster risk reduction.

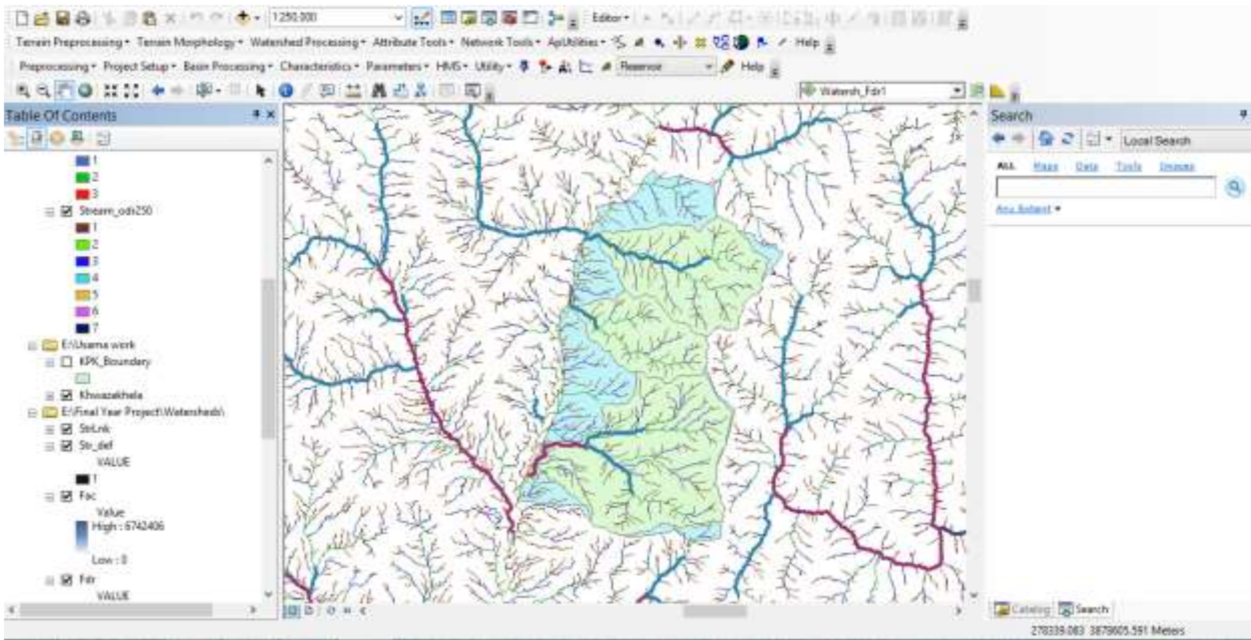


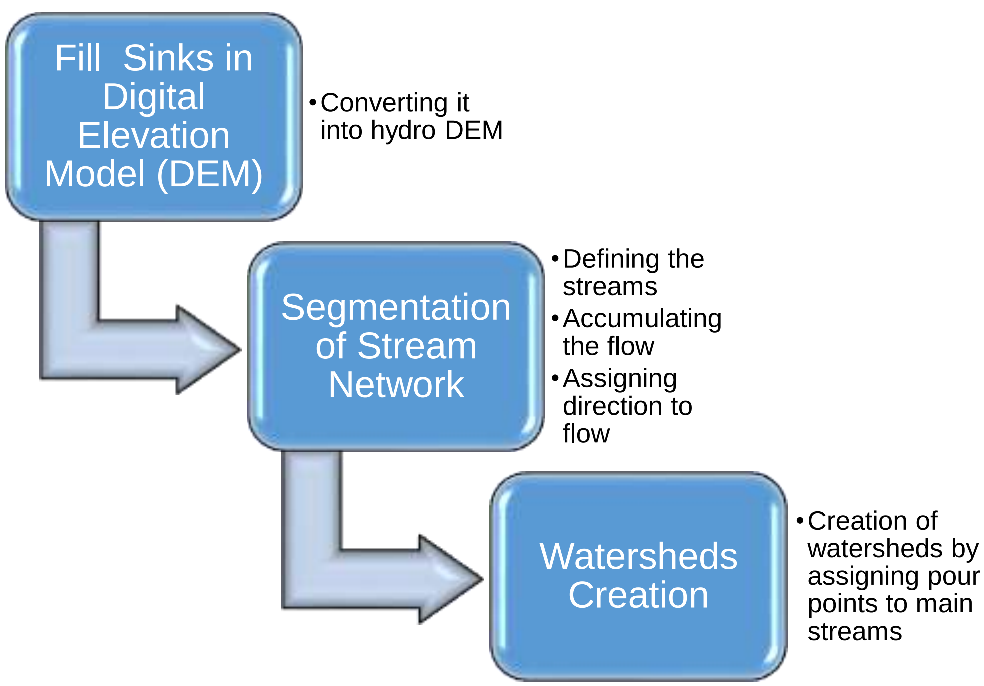
3.3 Creation of Watersheds and Drainage Network

The process of creating watersheds and drainage lines delineation is carried out in Arc-GIS using the Arc Hydro Tools. Shape files of the focus area, boundaries and stream networks were the inputs for this process. It is a long time consuming process from filling the acquired Digital Elevation Model (DEM) , featuring streams , assigning order and direction , Linking streams , Defining Streams , Accumulating Flow and assigning water pour points. Three Watersheds were created keeping in the view the boundary of Khawazakhela and main stream networks.



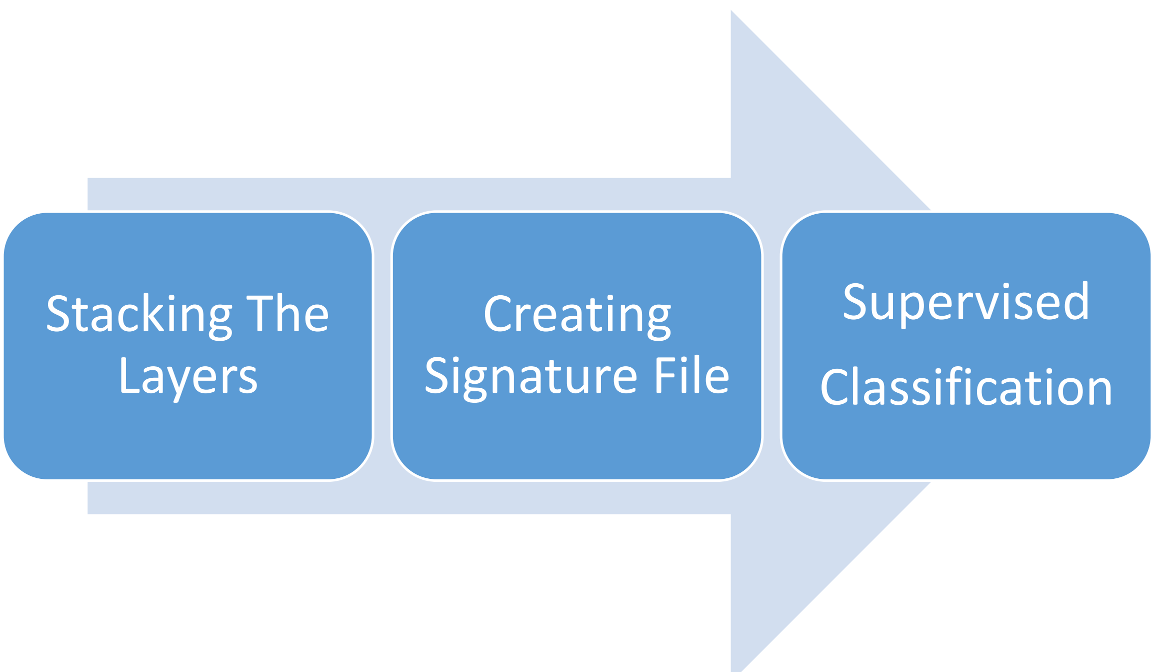
Flow Chart of Watershed Delineation process using Arc Hydro Tools



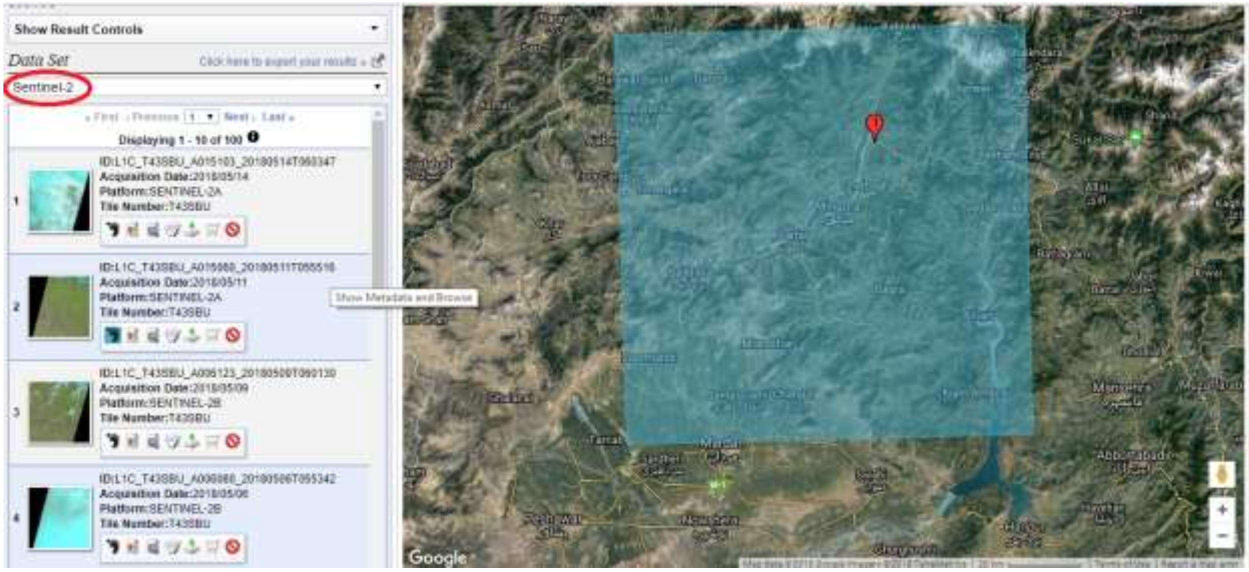

Fill Sinks in Digital Elevation Model (DEM)
•Converting it into hydro DEM
Segmentation of Stream Network
•Defining the streams
•Accumulating the flow
•Assigning direction to flow
Watersheds Creation
•Creation of watersheds by assigning pour points to main streams

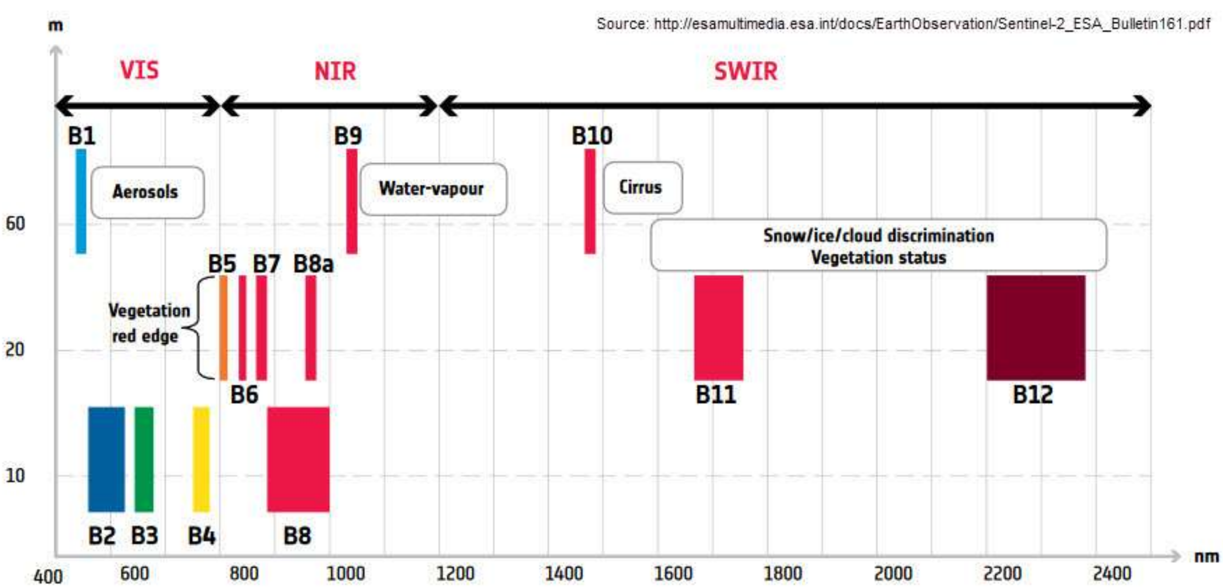
3.4 Processing of Land Cover Data

The land cover data downloaded from USGS Earth Explorer is in raw form which needs further clarification which is carried out in Erdas Imagine 2014 using the classification Tools. Supervised Classification of Sentinal 2 data was carried out with lowest cloud cover. Sentinal 2 has 13 spectral bands out of which 10 were used in this processed as the three left were Aerosols, water vapors and cirrus. The process starts with stacking the layers required in their sequential order, creating a signature file resulting in supervised classification of the imagery.



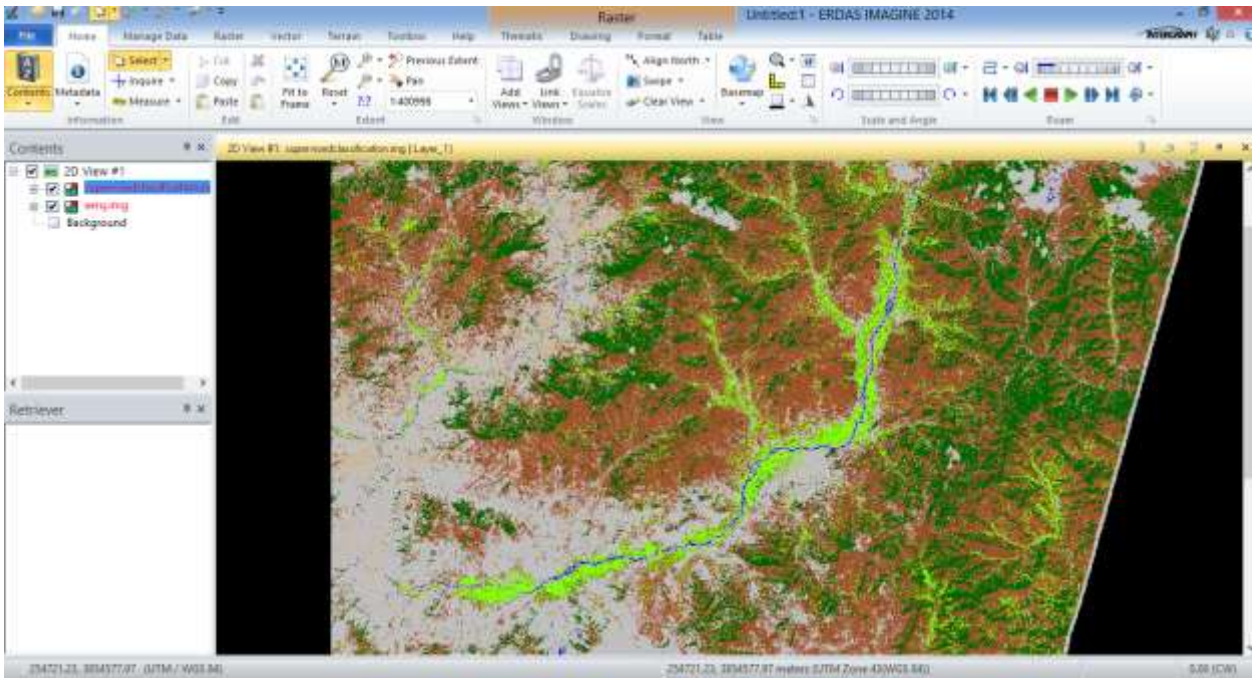
Stacking the Required Layers

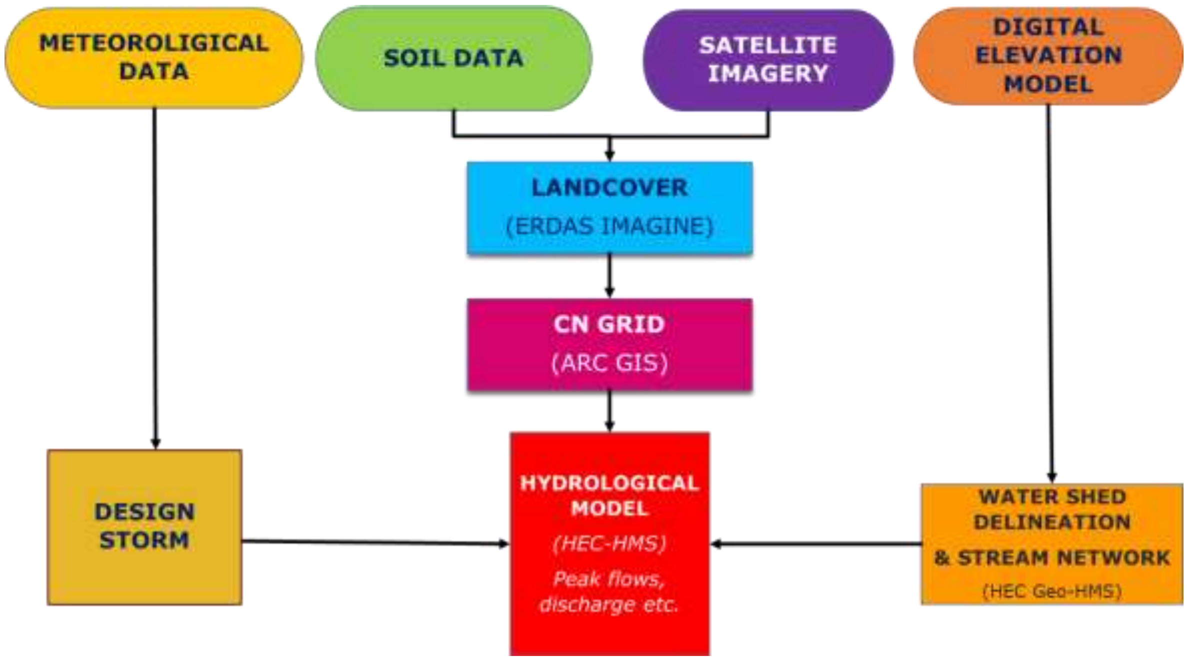




↑ Spatial resolution versus wavelength: Sentinel-2's span of 13 spectral bands, from the visible and the near-infrared to the shortwave infrared at different spatial resolutions ranging from 10 to 60 m on the ground, takes land monitoring to an unprecedented level

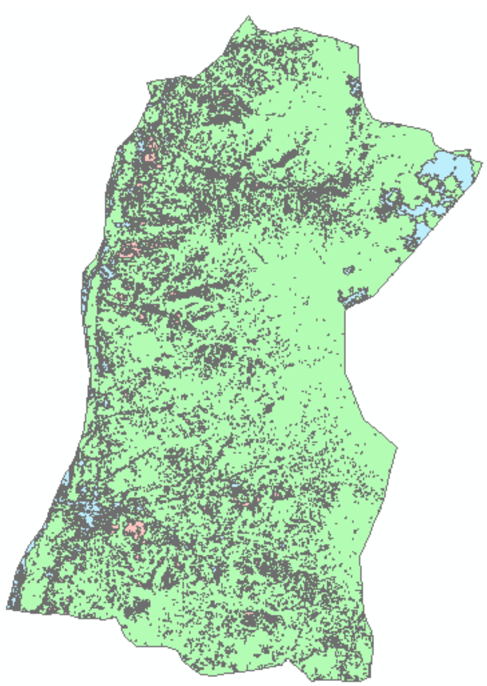
Generating Signature Files and Performing supervised Classification.



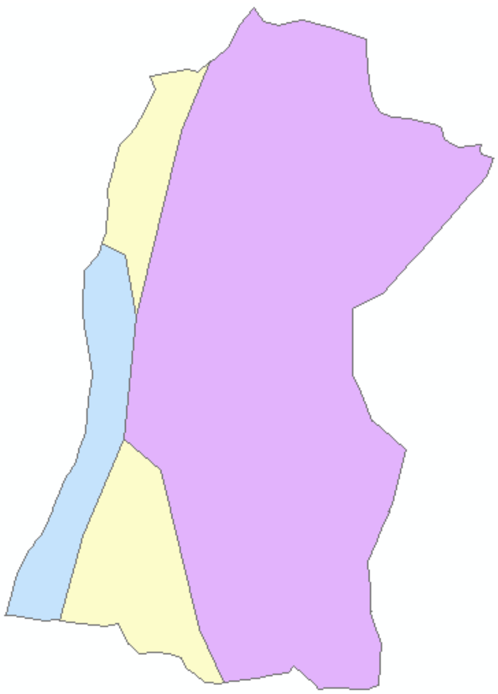


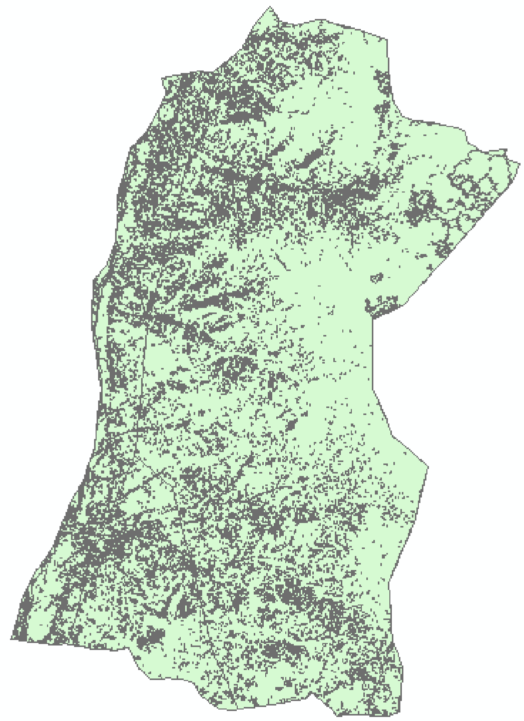
Flow Chart of the process

Union of Soil and Landover Data



Land use Data

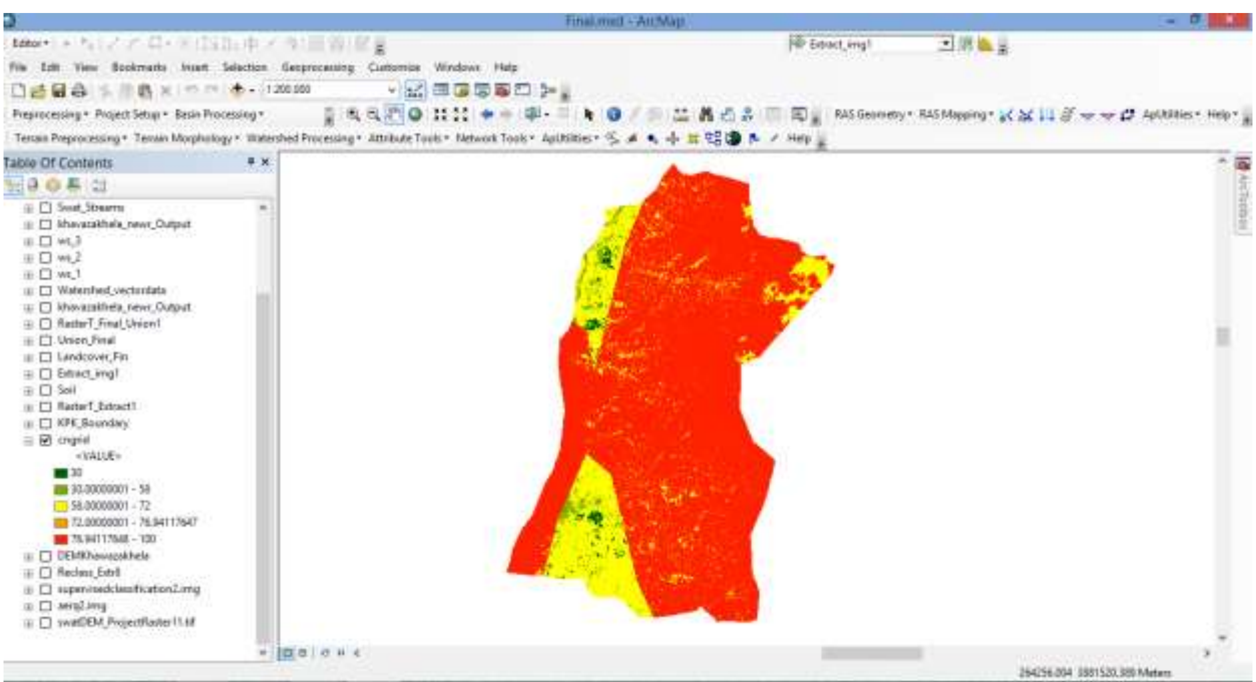




Soil data

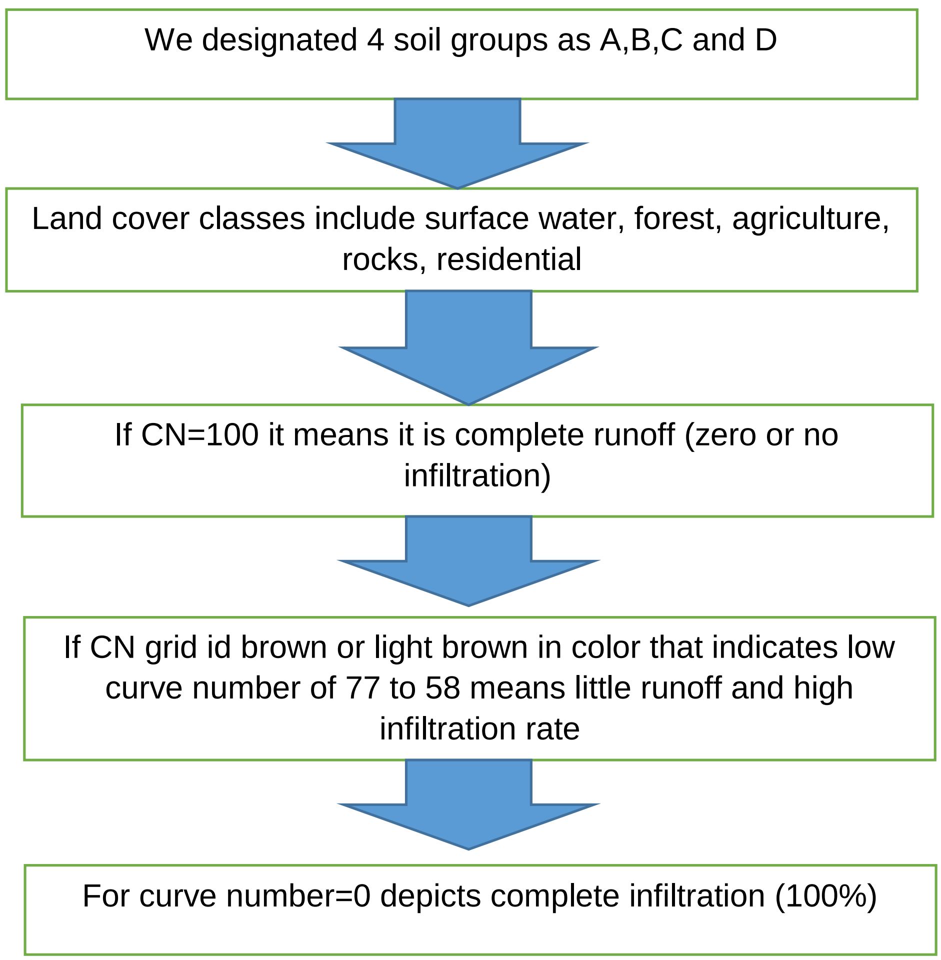
Union of soil and land use data

Generation of CN Grid

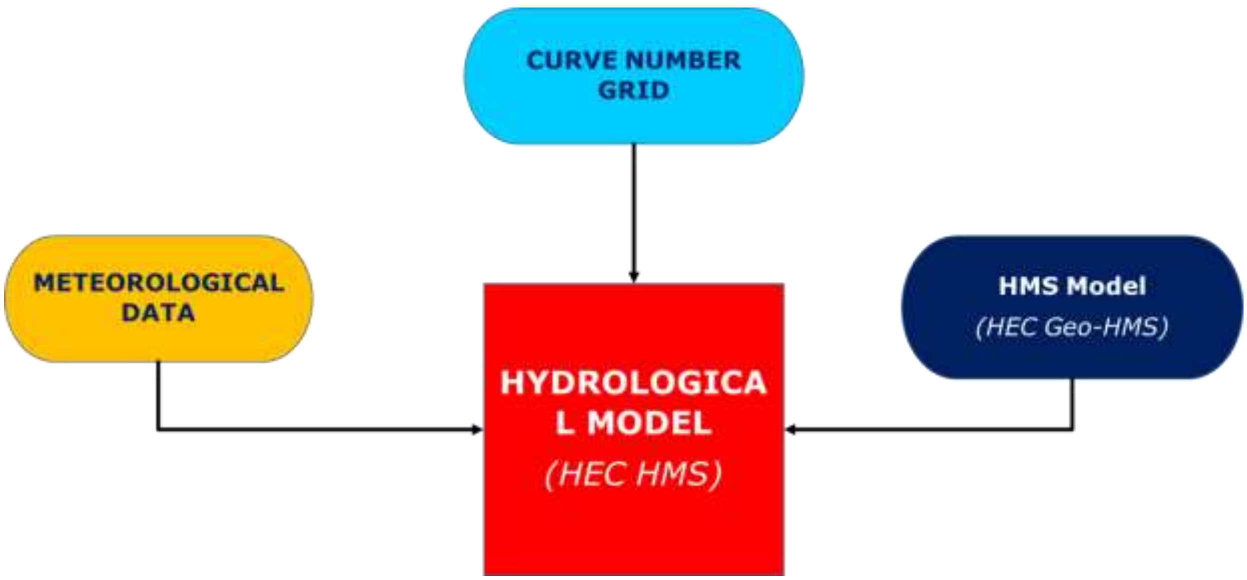


The values of CN Grid

GIS in combination with HEC-GEOHMS provides an accurate and reliable source for developing CN grid. Curve number can be generated by using Soil Data and Land Cover data and integrating them along with the digital elevation model of the subject area. CN grid is difficult to generate without the help of GIS.



Inputs for generation of Hydrological Model



3.5 METEOROLOGICAL DATA

Meteorological data was obtained from Pakistan Meteorological Department Zonal office Peshawar for the gauging station Kalaam. This was used as an input in hydrological model.

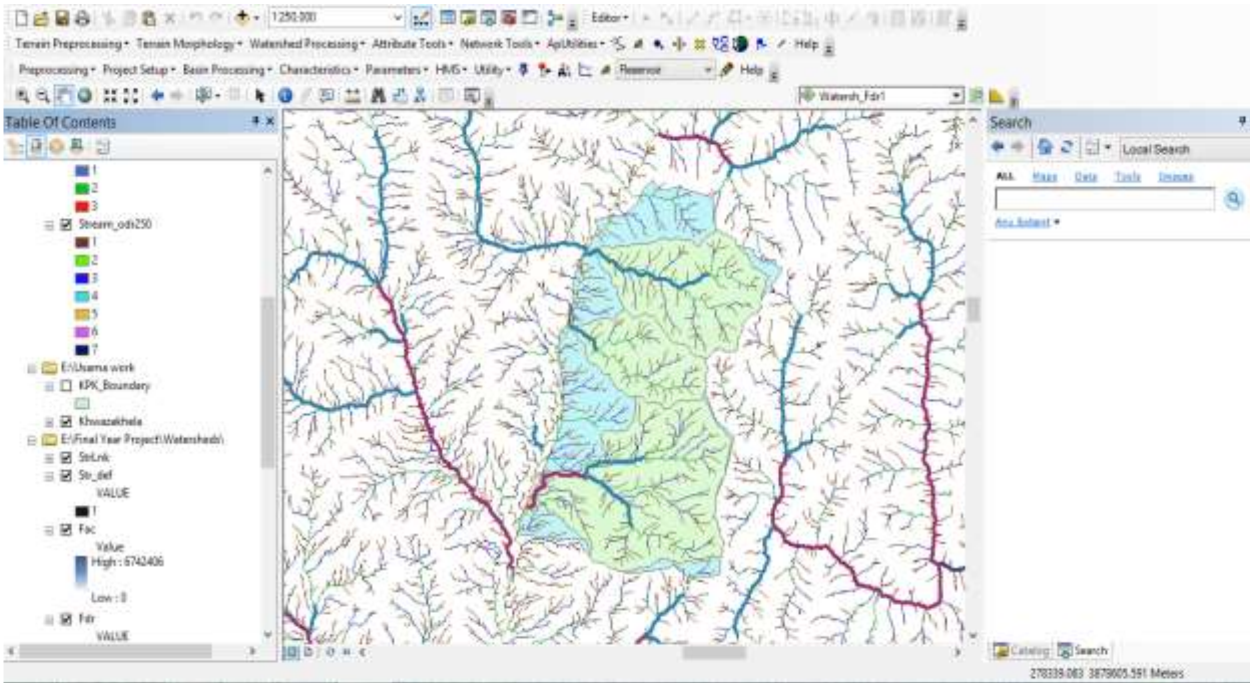
DESIGN STORM

Year	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC
2003	52	472.6	151.6	219	141.9	54.6	238.6	187.3	96.9	13.8	112.8	57.4
2004	162.4	77.7	46.2	172.2	62.5	162.5	270.5	204.3	125.2	379.5	6.4	110.2
2005	187.7	257.8	211	160.3	133.5	32.5	290.4	157.4	44.5	90	61	0
2006	272.5	134.7	117.9	86.5	52.4	108.5	300	380.8	69.3	29.9	123.2	146
2007	19.2	222	257.9	76	138.4	136.5	157	78	136	41.5	0	44.6
2008	228.7	137.6	21.2	213.8	83	81.1	290.4	338.2	71.1	32	83.6	131.5
2009	198.4	154.6	58.9	111.2	55.7	67.8	275.7	322.4	66.6	37.1	70.5	123.9
2010	213.3	158.2	62.6	128.4	44.6	98.8	329.7	302.1	85	45.2	91.4	133.8
2011	38	285.6	123	193.3	40.5	95	217	165	220	86.5	36	15.2
Monthly Avg	**152.5**	**211.2**	**116.7**	**151.2**	**83.6**	**93.0**	**263.3**	**237.3**	**101.6**	**83.9**	**65.0**	**84.7**

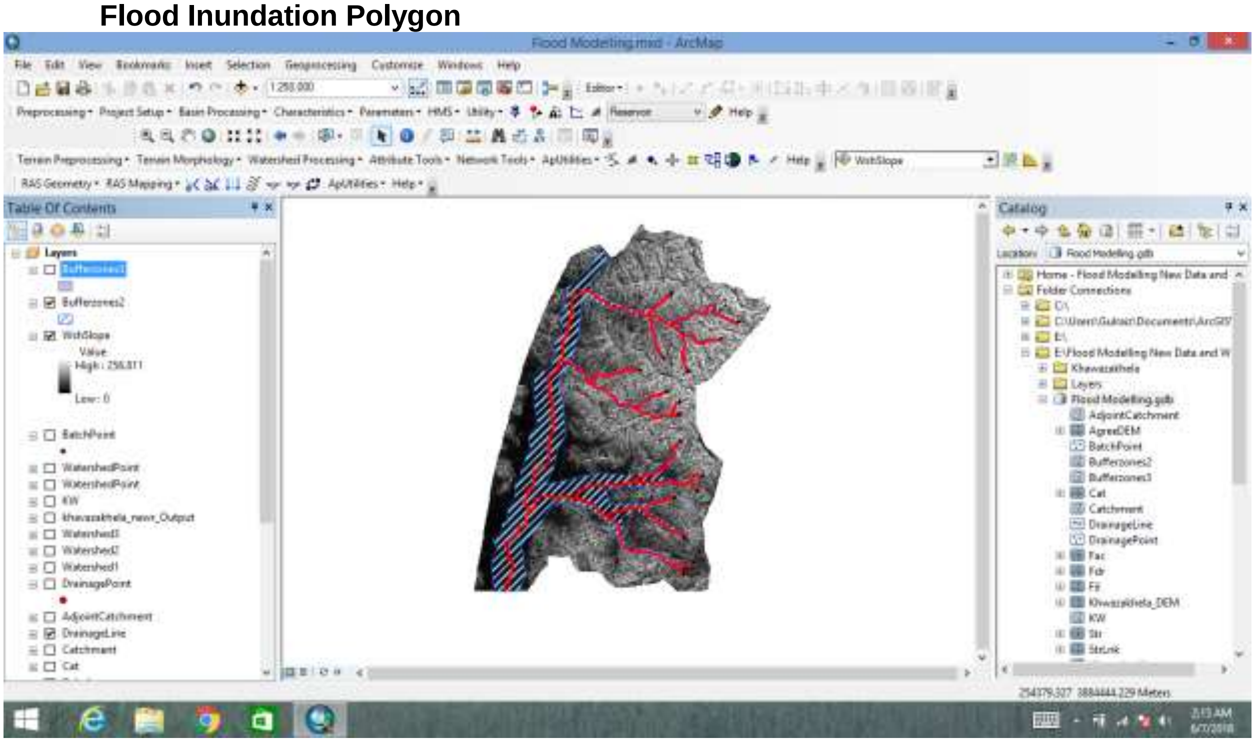
CHAPTER 4: RESULTS AND CONCLUSIONS

4.1 Results

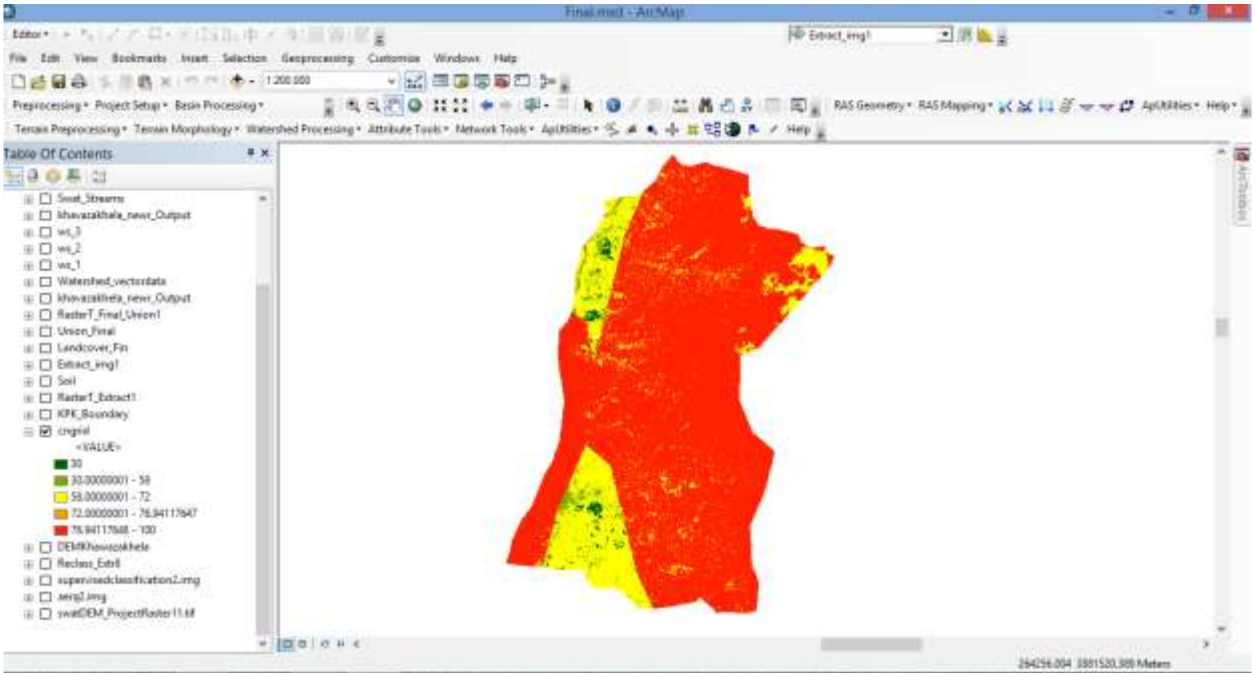
Generation of Watersheds



Flood Inundation Polygon



Curve Number Grid



4.2 CONCLUSIONS

- **GIS – Excellent Runoff modelling tool.**

GIS or Geographic Information System is an excellent map modeling technology that provides the person to create and interact with maps and its data in a variety of ways. This technology enables a person to use hydrological data or any other data the way it requires and best fits for runoff modeling.

- **Computations of Maximum Peak flows can be achieved by integration of Soil Data, Land cover, DEM.**

By acquiring the soil data from FAO soil data base and incorporating land cover data in addition to the DEM attained in the first place, decryption of inputs are organized and worked upon to get the CN Grid.

CN Grid, as earlier mentioned, ranges from 30-100 and indicates the areas with soil in accordance to water infiltrations characteristic. (Low Water Infiltration (Green color) **30 – 100** (Red color) High Water Infiltration)

- **Accurate and Convenient means of Large Study Areas, which is physically cumbersome.**

Enabling the user to work on bigger and large areas without any difficulty or obstruction. Prior to this technology, people had to go on ground and had to take accurate measures physically, which in case of large study areas was not possible. This has been made available and easily accessible with just a click of a button. GIS enables the person to conveniently work upon areas without the restriction of any size.

4.2 RECOMMENDATIONS

- **GIS based, software modeling approach for installation of cross drainage structures**

In comparison to rational approaches and methods geographic information system software, modeling and mapping tools provide the most suitable alternative for the design of cross drainage structures i.e. drainage culverts, bridges, dams, gabion walls etc. by providing us with the demarcation of critical areas (flood prone areas, landslide hazardous areas , whatever type of problem we are encountering)

The upper hand in this approach is that it provides the researcher with the real time discharge data, precipitation information, satellite imagery, storm data, rocks data, and latest land cover map of respective area of interest (study area).

- **Future Implications**

  Using the techniques and Methodology adopted in this study, Analysis and Modelling of larger areas can easily be done for calamity prone areas.

  - Flood Level Analysis using HEC-RAS and HEC-HMS
  - Adaptation of GIS based techniques for Numerous Hydrological Problems

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