Flood Water Management in Daraban Watershed by using GIS and Remote Sensing

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BAF

(1) Floods

(2) Perenial water

بسم الله الرحمن الرحيم

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FINAL APPROVAL

It is certified that we have read the thesis submitted by Ms Barira Haider 212- FBAS/MSES/F14 and it is our judgment that this project is of sufficient standard to warrant its acceptance by the International Islamic University, Islamabad for the M S Degree in Environmental Sciences

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DEDICATION

This thesis is dedicated to my parents, whose words of encouragement and pushes for tenacity holds me up. I will always appreciate all they have done.

DECLARATION

I hereby declare that the work present in the following thesis is my own effort, except where otherwise acknowledged and that the report is my own composition No part of this thesis has been previously presented for any other degree

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CONTENT

ACKNOWLEDGMENT

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LIST OF ABBREVIATIONS

Acronym	Abbreviations
AHP	Analytical Hierarchy Process
DEM	Digital Elevation Model
GIS	Geographic Information System
GPS	Global Positioning System
RS	Remote Sensing
HEC-RAS	Hydrologic Engineering Centers River Analysis System

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Abstract

This study focuses on developing strategies for crop production, use and storage of water in order to manage the heavy flood flows in Daraban Watershed D I Khan In this research, eleven factors were considered for the flood management mapping slope, aspect, elevation, drainage, accumulation, soil, annual rainfall, rainfall volume, runoff, classification of daraban Catchment, and land cover of Daraban Command Landuse/landcover map of Daraban Command area is prepared in order to examine how to control the flood flows **47%** of the area of Daraban Command is bare soil which needs to be developed by the proper use flood water **26%** area is rangeland which can be managed more efficiently by controlling this flows Rainfall volume is calculated by multiplying area into mean of rainfall **24.1mcm**^{3} is the total volume of water which is managed **6.266mcm**^{3} runoff is generated from **24.1mcm**^{3} Data for other factors were acquired from freely available sources The results showed that a large area of bare soil is being destroyed by heavy flood every year It is resulted that if bare soil area is developed by wheat it can give the income of **2602, 273 08rs** every year If wheat is grown over the area of **60%**, it can use **8.8mcm**^{3} water which can reduce the flood flows It is resulted that if a reservoir of **8ft and 7acers** is developed, it can store **5.8mcm**^{3} of water which can be further used for fishing and other purposes This study gives the best strategies to develop a beautiful land through controlling heavy floods

Chapter 01
Introduction

Pakistan is an agriculture country situated in arid and semi-arid region As 90% Pakistan's agriculture is dependent upon irrigation so agriculture is linked with water availability Pakistan is highly vulnerable to weather related disaster The country has increasingly suffering from recurring cycles of droughts followed by enormous floods Either there is lack of precipitation which leads to droughts, crop failure, famines, or there is immense heavy rainfall leading towards floods Flood is the overflow of water from river that submerge the previously dry land under water

Watershed is all the land which transmit water, dissolved salts and sediments to a major river through systems of drains Watershed is also known as drainage basin and catchment area Essentially a watershed is define as water area which contributes runoff to common point Watershed could be classified into a number of groups that is size, drainage, shape and land use pattern depending upon the mode of classification

Watershed management is been seen as a major component for conservation of soil, water and vegetation cover, rural communities standards improvement and better environmental conditions

Improving the overall productivity, controlling floods and reducing erosion is known as Watershed management

Flooding in rivers are mainly caused by heavy rainfall in monsoon which is sometime aggravated by snowmelt The flow rate exceed the river channel capacity Our country is one of the most flood prone countries Fist factor is the melting of snow cover and the second factor is related with heavy rainfall in monsoon (Arsalan et al , 2013)

Flood results in serious economic, social and environmental effects Ultimately floods causes life loss, damage to cropping pattern, destruction of infrastructure and irrigation

Pakistan has faced several floods throughout its history by heavy rainfall or sudden release by India The country has faced massive floods every year in some provinces and districts Some devastating floods in the history of Pakistan were 1950, 1973, 1976, 1988, 1992 and 2010 (Annual Flood Report 2010)

During the past 60 years, Pakistan has suffered a cumulative financial loss of 30 billion US$ The total financial loss from 1950 to 2009 was 20 billion US $, around 8,887 people lost their lives, damaged villages were 109,822 and an area of 407,132 km^2 was affected The floods of 2010 collectively caused the damage of 10 billion US $, about 2,000 people lost their lives, in addition, 17553 settlements were destroyed and as a whole 160, 000 km^2 area was effect (Annual Flood report 2010)

Land cover is a general term used to describe what is present or what covers the earth surface It shows how much of an area is covered with forest, agricultural land, barren land, water bodies, buildings etc Land cover includes where we live, where we do business, how we travel and all physical components of ecosystems e g residential areas, commercial, agricultural or forest areas, roads, biodiversity habitats, deserts, glaciers, rivers etc Land use means the use of land for utilization and which is devoted to human activities (Barredo and Engelen, 2010)

Natural land cover does not include built up or man-made environment Land cover can influence weather and climate, and soil and water chemistry Natural resource management depends on the accurate land cover data about a particular region for planning and monitoring

Land cover maps are used to manage and monitor endangered species of plants and animals, urban sprawl, land use, deforestation, river patterns, range lands, crop lands, wetlands, disasters and other changes in land cover overtime This is important to gather all the data and facts to observe the change and to prepare land cover maps then give options for the management of natural resources (XiaoMei and RongQing, 1999) Land cover change detection is essential to study or deduce the effects of any natural phenomenon or disaster on ecological system By estimating the land cover or land use change, the damage to environment and infrastructure can be estimated Similarly, we can analyze the flood induced land cover change in any effected region by Remote Sensing

Remote Sensing is the science and art of identifying, measuring and analyzing the characteristics of the objects without actually being in contact with them (Maini and Agrawal, 2011) Energy emitted and reflected from object is recorded and then interpreted and processed to get the required information about that particular object This information is then used for further analysis

Satellite Remote Sensing is an evolving technology with a potential to estimate and monitor the effects of any catastrophe Flooding and flood induced land cover and land use change can be detected using satellite imageries Satellite images are processed by using different softwares to delineate flood water and changes in land cover (Vogelmann et al , 1998) Temporal analysis of the satellite images of any area is done to detect the change Remotely sensed data is more cost effective and accurate for assessment and analysis of different areas

Moreover, Digital Elevation Models (DEMs) can be used for elevation watershed analysis of any area through which we can estimate the pattern and accumulation of water flow and identify the basins These topographic skeletons are used to automatically map the stream channel and divide networks of a watershed (Rabus et al , 2003)

Remote sensing can be integrated with GIS technology to classify and map both land use and land cover to identify patterns and understand processes that underlie observed patterns (Lillesand et al , 2004) Assessing land cover change is important for future planning The main purpose study all the characteristics are to monitor land change developments, investigate and giving different strategies for the management of the consequences of change, and define future schemes for change Land cover change is associated with climate and helps to predict the climatic patterns

1.1. Irrigation system in Daraban Zam

1. Irrigation from Perennials water(Kala Pani)
2. By overflow (Chhal)

1.1.1. Perennial water

Perennial water flows throughout the year, from which land of Daraban area is irrigated Tand and Vichobi are cultivations done in Daraban In tand cultivation all the fields are required to be divided in small plots and strips same as well cultivation Is is always carried out near the head of stream The Vichobi cultivation is resembles the ordinary hill torrent cultivation In Vichobi cultivation all the fields are required to be filled with water which is then soaked and after all these ploughing is allow in the field It gives less trouble, but requires more water In Perennial water, all inputs are provided by the owner The distribution of crop is 3 1 between land owner and tenant respectively

1.1.2. Irrigation by overflow (Chhal)

Besides the regular irrigation from dams there is irrigation by overflow, when a torrent is full that the water will flow into the Khulas without dams, all villagers are at liberty to use this water, whether there dams have been cut or not

1.2. GENERAL TENANCY PATRONS

1.2.1. Flood Irrigation

Before 1950, resident were used to pay 7th share of his crop after equally distribution After 1950, they legally protected and set distribution in the ratio of 2 3 between Land Owner and tenant respectively However, the tenant is responsible to construct band, land preparation, irrigation, seed, harvesting for which a share has been given in excess

Heavy rains in catchments area of Daraban watershed results in heavy flood flows in Balochistan, Afghanistan, Suleiman Range, Shirani Hills and Bhittani Range

According to a research study by Dewan et al , (2007), GIS data can be used to analyze flood event using synthetic aperture radar Flood affected frequencies and flood depth from satellite imageries They have calculated Elevation, land cover classification, geomorphic division and drainage network data were generated from remote sensing Flood hazard maps were prepared by using land cover, geomorphology and elevation heights for flood affected frequencies and flood water depths It was concluded in their study that major portion of Dhaka was comprised moderate to high hazard zone 8 4% portion was found to be the least vulnerable to potential flood hazard 28% portion of Dhaka was found within very high hazard zone In this study comprehensive strategies for flood water management and land use planning were proposed

A study was found in which inundation maps were generated by using hydrodynamic model HEC-RAS and HEC-GeoRAS extensions of ArcGIS9 2 Optimal flood depth for crop production using statistical analysis was calculated Volume of water above the flood depth was calculated by using GIS model According to their study 1 85msl was optimal flood depth and suggested to produce boro because farmer get more return from Boro variety (A M zaman and A U Khan , 2012)

Spatial analysis for flood control was done by using environmental modeling Flood data for the events to 2009 was gathered in north of Iran and usng GIS data for physiography division, land cover classification, elevation, drainage network, and population density and environmental parameter modeling A framework was developed for flood control and working on landuse planning through GIS and remote sensing results (Alireza g et Al , 2011)

To control floods and for some extreme condition events systematic approach was studies by using hydrological model for river flows Bostanlı river basin basin was examined, which has been affected by severe flood condition for many years HEC-HMA and HEC-RAS modeling tools were used, both integrated with GIS functions for spatial operations A dam with suitable construction would have positive impacts for potential flood control measures and it decreased the flood peaks of 68 8 and 158 7m3/s to 65 5 and 150 7m3/s when dam is in operation (Gulay O et Al , 2010)

Flood control strategies were adopted in the river basin based on European floods Six factor were analyzed for the spatial distribution of the hazardous area Flow accumulation, slope, land use, rainfall intensity, geology and elevation map were generated Targeted area was divided into five different zones according to flood hazard ranging from very low to very high Maps generated for flood hazard area identified those area and settlements which were in high flood risk zone (Nektarios N et al , 2011)

A study found with focus on delineation of catchments and flood hazard maps for the vulnerable areas Flood depth is taken as crucial prepare flood hazard maps and a digital elevation model (DEM) is used to estimate flood depth from remote sensing data The accuracy of flood estimation depends on the resolution of the DEM Study presents areview of application of remote sensing and GIS in flood management specially to develop countries of Asia (Sanayal, J and lu, x x, 2004)

Many locations can be used for water storage along the 80km long reach of the Tisza river in Yugosolavia between the town Becej and the Hungarian border By data base landuse was calculated and considered five locations for retention basins Each location had the capacity of 21 and 140 million cubic meter, and flooded area were calculated as 235 to 2829 hectares (J Miodrag, et all 2009)

Assessment of flood hazards was done by developing maps for eastern Dhaka Hydrodynamic simulation was used on the basis of DEM (digital elevation model) Inundation was conducted by using 1D hydrodynamic program HEC-RAS for flood of 100 years return period The results showed that maximum depth was 7 55m and it affected 50% area of the total area Flood hazards map were prepared using ArcGIS to assess the flood risk of targeted area (Masood M, Takeuchi K, 2011)

A study describes the causes and damages by 2010 flash flood Interviews and surveys were conducted to analyze the physical and economic damages of the targeted area Dir valley Land cover maps were developed by using GIS Buffer analysis was used to assess the affects and flood damages It was resulted that upper zone of the targeted area was badly affected with maximum house damages This study was useful for the attention of disaster management to take steps for reduction of flood risks and enhancing the retention capability of watershed (Khan A, et al, 2016)

A study on land cover mapping using remote sensing and GIS techniques was carried in sub Carpathians area of Prahova country Applications of remote sensing, GIS and cartography were used for the accurate results of land cover of the area where land cover features were complicated in configuration Supervised classification was done from Landsat OLI image with currently available land cover model Land cover features were extracted from two land cover models i e CORINE land cover and GlobeLand30 Final maps were prepared at different scales for the comparison of land cover categories Rmona M , et al , (2016)

A case study on management of flood flows using GIS for crop production risk management was carried in agriculture area of Shariatpur It was analyzed that when the two rivers Padma and Meghna in Shariatpur face peak floods flows events, the district face destruction Study provides a strategy for managing flood water for crop production risk management Hydrodynamic model HEC-RAS and HEC-GeoRS extension of ArcGIS9 2 were used to prepare the maps Statistical analysis was used for flood depth calculation GIS model of ArcGIS9 2 was used to calculate the volume of water above the optimal flood depth and gave strategies for flood management for crop production Results showed that flood depth was 1 85m, where they can grow boro If it is suggested to grow aman, it would face about 200 ton/yr loss Baky, A A , et all (2012)

1.3. Objectives

- Study landuse/landcover status of catchment and command areas of Daraban using GIS and remote sensing
- Assess flood water potential in the daraban watershed using satellite data
- Proposed strategies for effective management of flood water for agriculture and domestic use

Chapter 02
Methodology

2.0 Materials and Methods

2.1. Study area description

The Daraban watershed is situated across Khora river (Daraban Zam) about 13km from Daraban Town and 69km from D I Khan city in Khyber Pakhtoonkhwa Province (KPK). Location of Daraban Zam is shown in figure 2 1

Location of Major Zams in D.I Khan and Tank Rod Kohi Areas, NWFP

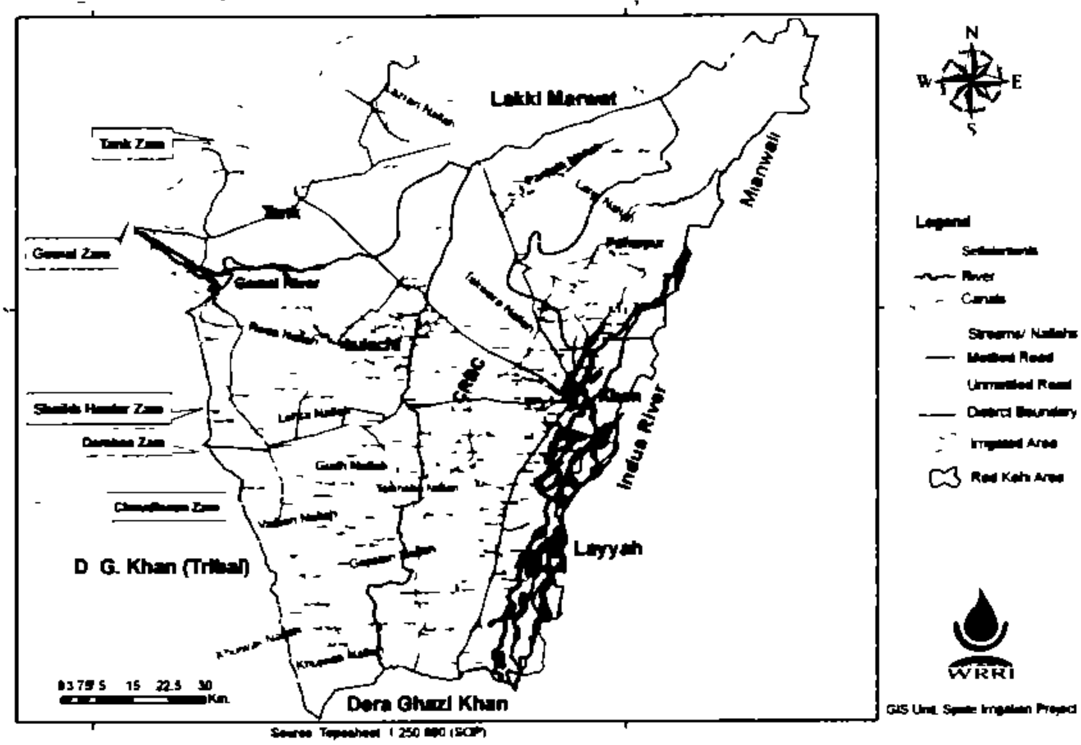


Figure 2.1 Location of Daraban Zam in D.I.Khan area.

Daraban command area is extended over an area of about 490 sq km with longitude 70 2011 and latitude 31 744 It has a mean length of about 45 km in SE direction. Thus well connected with other parts of the country The elevation in the command area ranges between 180 to 417 meters above mean sea level (masl) The elevation increases gradually from the flood plain in the east towards mountainous area in the west Daraban is now considered as a tehsil It was the part of tehsil Kulachi before devolution plan Miankhels, Michen khel and Shirani Baloch are the main tribes of Zam Some of the general information about Daraban Zam is

- Total Population 44,903
- Total villages 62
- Total households 6,539
- Union councils 3 (Daraban, Musazai, Gara-isa Khan)

The water of Zam is used for irrigation and other purpose such as drinking The water of the Zam is furthure categorized into flood water also known as Buga pani and perennial water that is also called askala pani The flood water in the zam originates from high mountains of the Sulieman mountains in the west The catchment area of Daraban watershed is about 410 sq miles while cultivable command area is about 32,000 acres The extent of the catchment area is shown in Figure 2

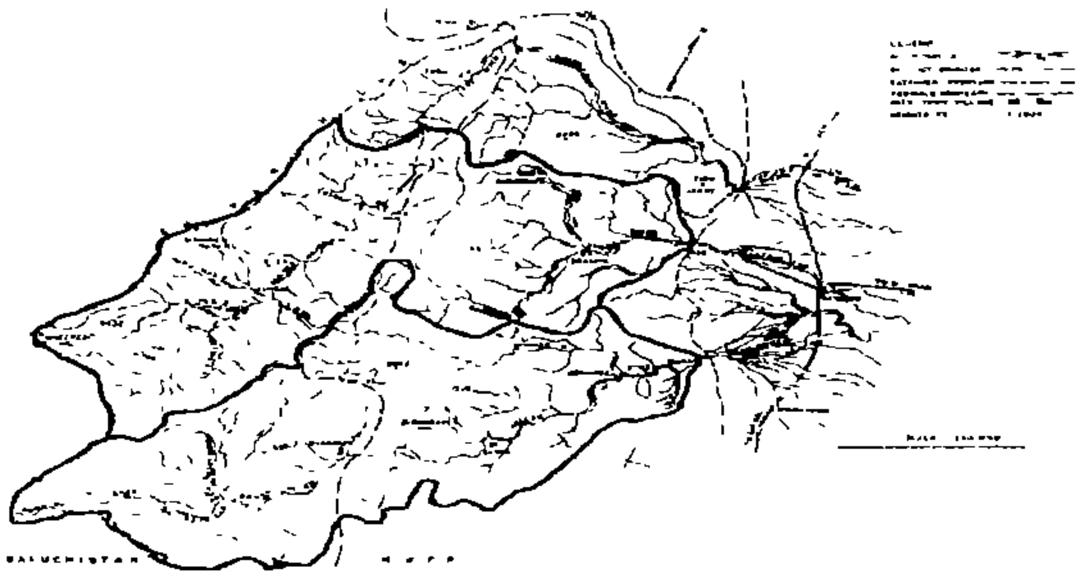
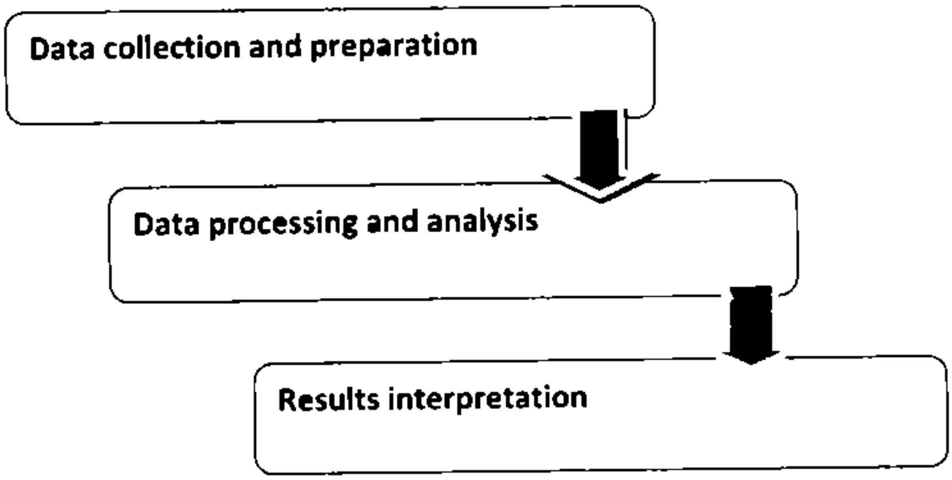


Figure 2 2 Extent of Daraban watershed

Land, forest and livestock are natural resources for the people of Daraban Zam Farmers of Daraban Zam mainly depends upon livestock and also keep this as stand by for their livelihood Agriculture production in Daraban demands labour both men and women February to March are the timings of flood for winter crops including sorghum, millet and mellon While July to August is the time for full flood in monsoon for summer crops i e wheat and Gram

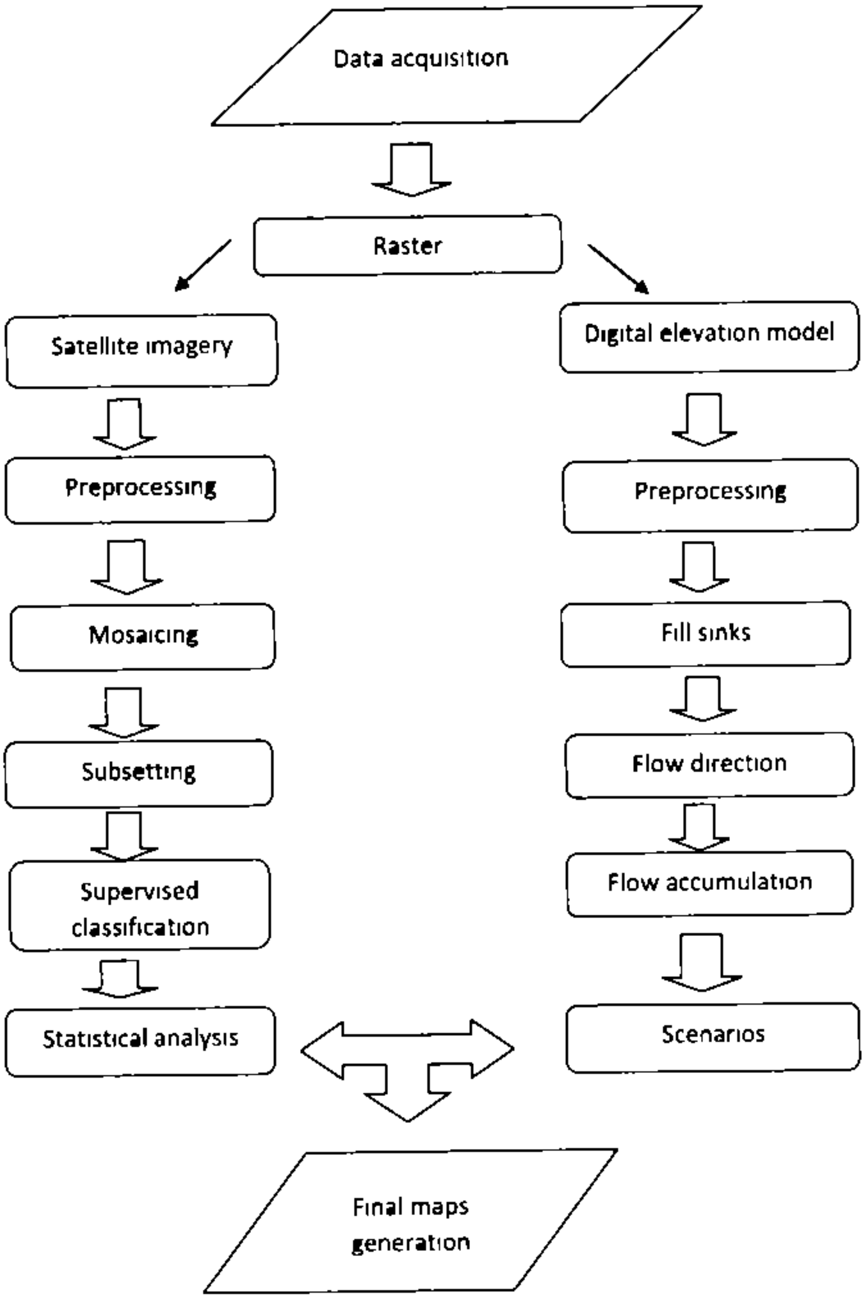
Before 1970 Daraban zam had thick forests that were surrounded near all the waterways and covered all the highlands area Due to cutting of trees for selling purpose Daraban Zam has depleted all forests very quickly Due to cutting Peeloo is finished in the zam area



Landsat 8, shutter radar topography mission digital elevation model were used for the study

Seven spectral bands are considered in Landsat images with a spatial resolution of 30 meters for bands 1 to 5 and 7

Software used in this study included ERDAS imagine 9 2 and ArcMap 10 1 These softwares are quick efficient and have best functionalities for handling satellite imageries and generating maps



2.3 Flow chart of Flood Management mapping

2.2 Data Acquisition

Classified map of Daraban Command area was prepared to develop different scenarios according to the area and other relevant maps including slope, aspect, elevation, drainage network, flow accumulation, soil, rainfall and runoff

2.2.1 Drainage Network

Drainage network was prepared by overlaying on DEM of 30m resolution Flow direction was determined from high elevation to low elevation

2 2.2 Slope

Slope was extracted from DEM 30m resolution, acquired from USGS earth explorer Classes of slope were assigned as gentle, moderate, medium, steep and very steep

2.2.3 Aspect

Slope map was prepared form DEM 30m resolution and divided into nine classes i e flat, north, northeast, east, southeast South, southwest, west, northwest, north

2.2.4 Mosaicing

This is used for overlaying digital images It is the combination of several images to form one large radio-metrically stable image so that the boundaries between the original images are not seen As the study area did not fit in one tile two tiles were downloaded and mosaicing was done to create a single image

2.2.5 Sub setting

Study are was extracted from a large are to perform quality anaylsis Area was clipped and analysis was specifically performed on the subsetted area Area of daraban watershed was extracted from the mosaiced image by using the shapefile of daraban

2.2.6 Supervised classification

Supervised classification technique was applied for landuse/land-cover changes Five classes were made for analysis of Daraban command area i e rocks, rangelands, irrigated are, bare soil and tree cover Four classes were made for the analysis of Daraban Catchment are i e vegetation, rangelands, exposed rocks and bare soil Classification was processed by comparing each pixel with various signatures which was assigned to the class whose signature came closest

2.2.7 Scenarios

Various water management scenarios were developed for the proper use of land in Daraban command area Various strategies were developed in order to use the total volume of water for bare soil, crops and other usage

Chapter 03
Results

3.0 Results and discussion

3.1 Catchment delineation

A watershed is the area that gives flow of water to a common channel's concentrated drainage It can be a part of major watershed and can also cover smaller watershed, called sub-basin or catchments SRTM DEM was required to determine flow direction, flow accumulation, and to delineate the catchments of the study area

3.2 Flow accumulation

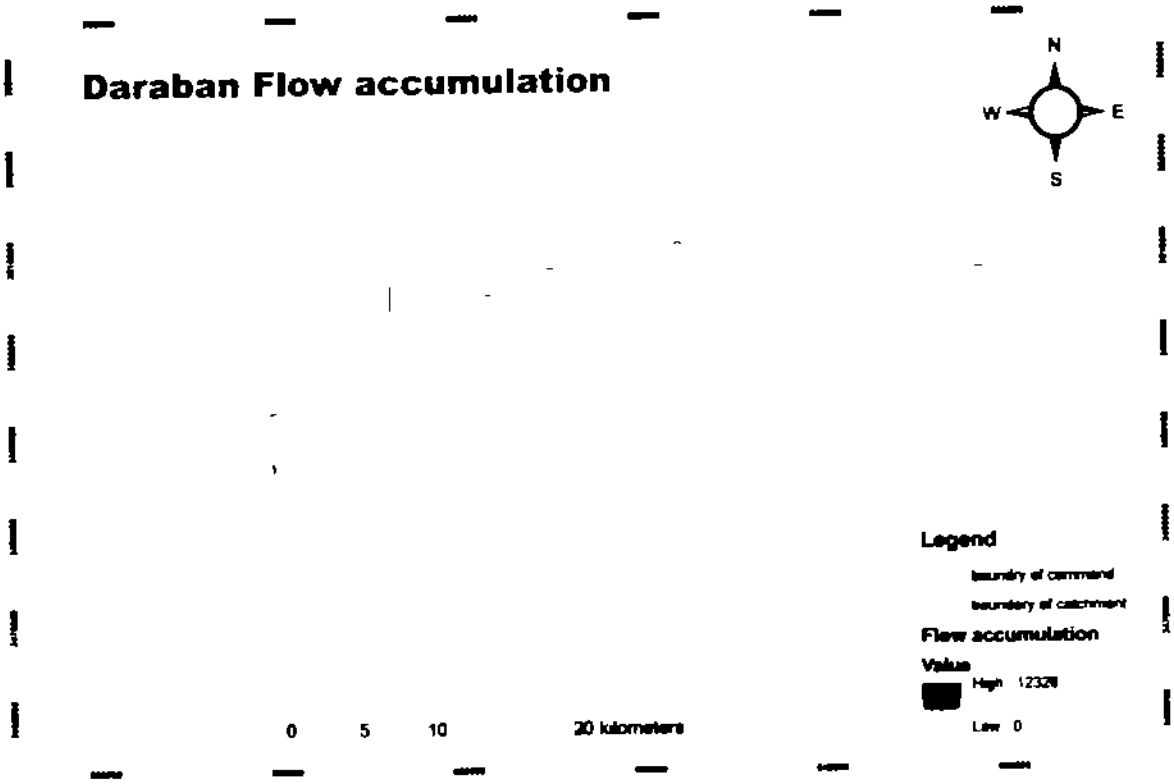


Figure 1 2 Flow Accumulation map of the study area

3.3 Topography elevation

Digital elevation model of 30m resolution was used to determine the elevation of the study area The results showed that the highest peak in the study area has an elevation of 3000m while the lowest peak in the study area was 182m which is flat area.

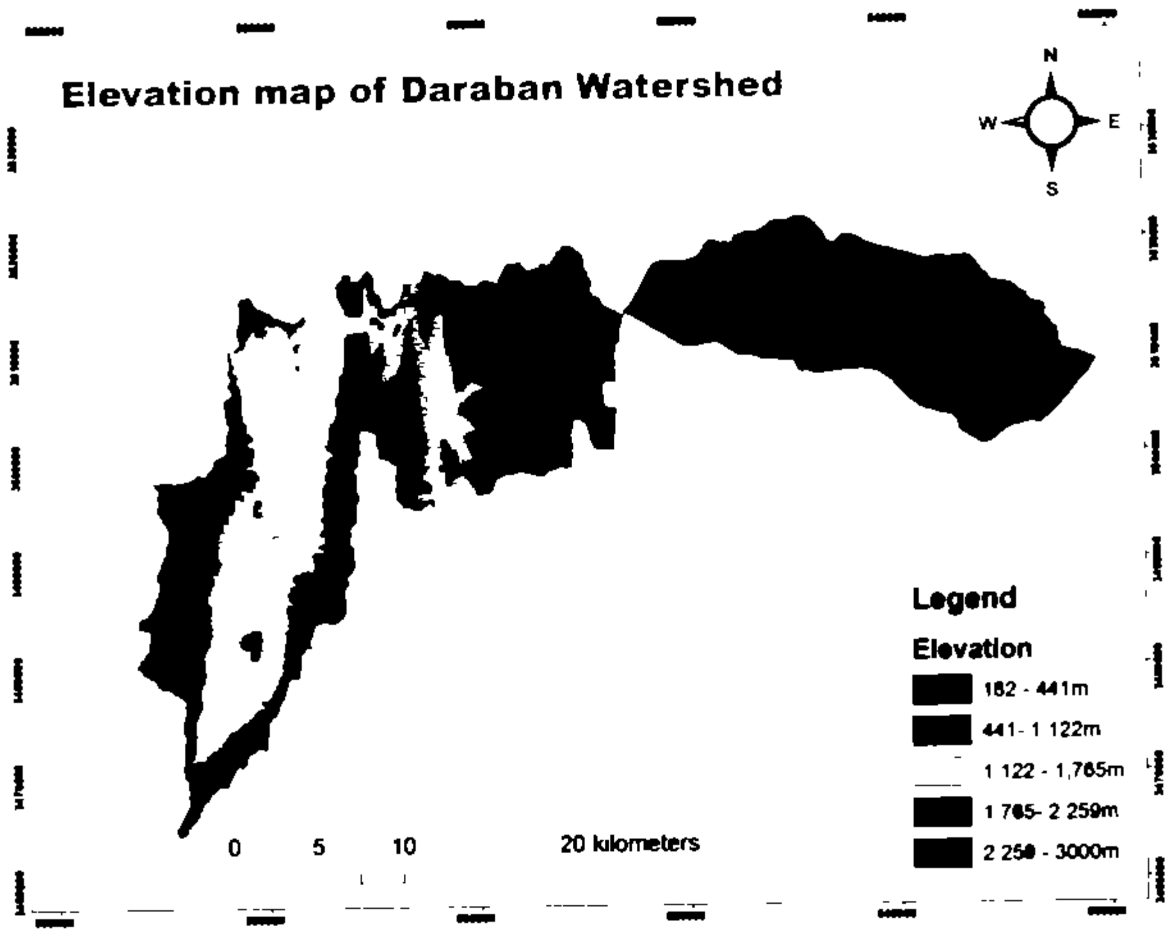


Figure 3 3 elevation map of the study area

3.4 Slope

By using ASTER DEM values of slope were also calculated The output shows that command area of Daraban watershed is completely flat while catchment area of Daraban has the higest value of slope is 72 1m

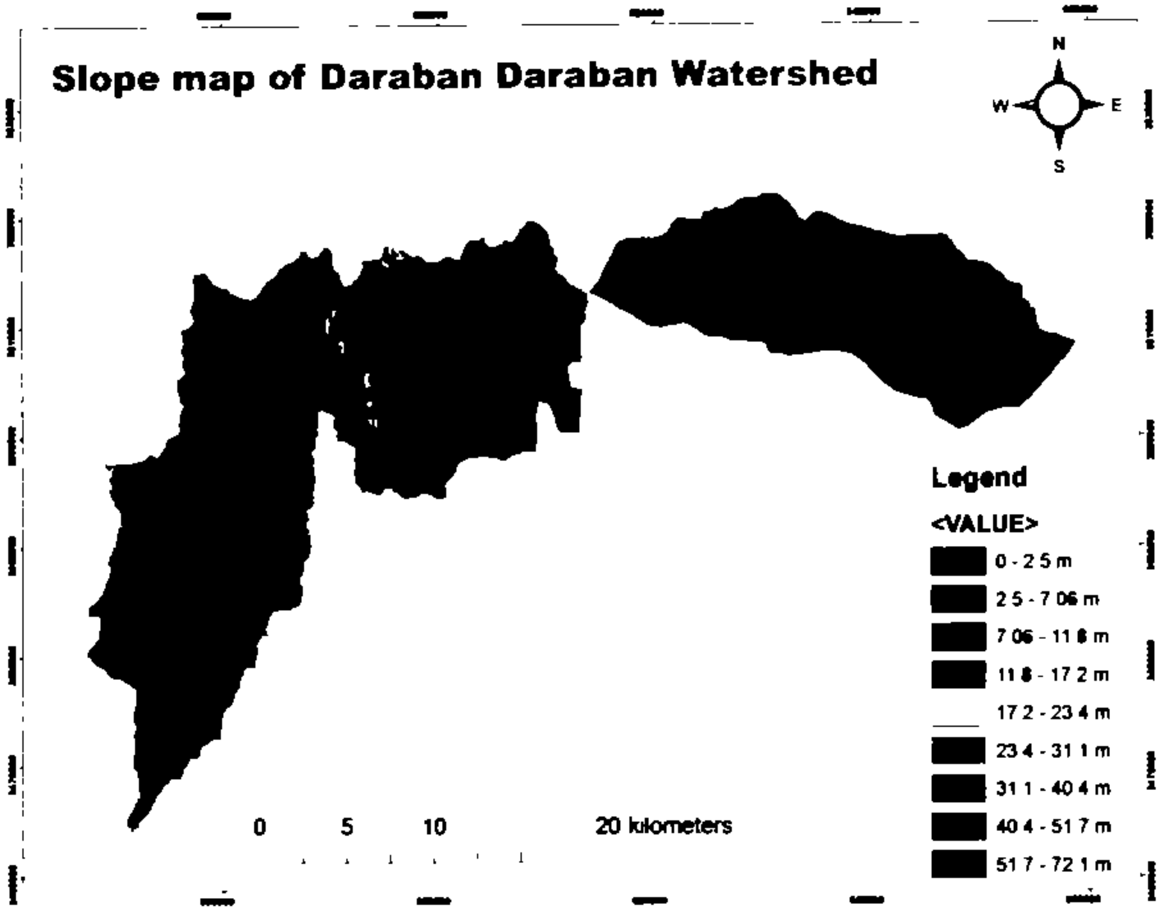


Figure 3.4 slope map of Daraban Watershed

Slope values were assigned diverse classes based upon the degree of preference

0-7	Gentle
7-17	Moderate
17-31	Medium
31-51	Steep
>51	Very steep

Table 3 1 classes of slope

3.5 Aspect

Aspect is the tool to find out the path of the hill It is measured clock wise in the units from north to again north Plane areas having no down-slope track are given a value of -1 The aspect of the area was produced using Spatial Analyst tool of ARCGIS

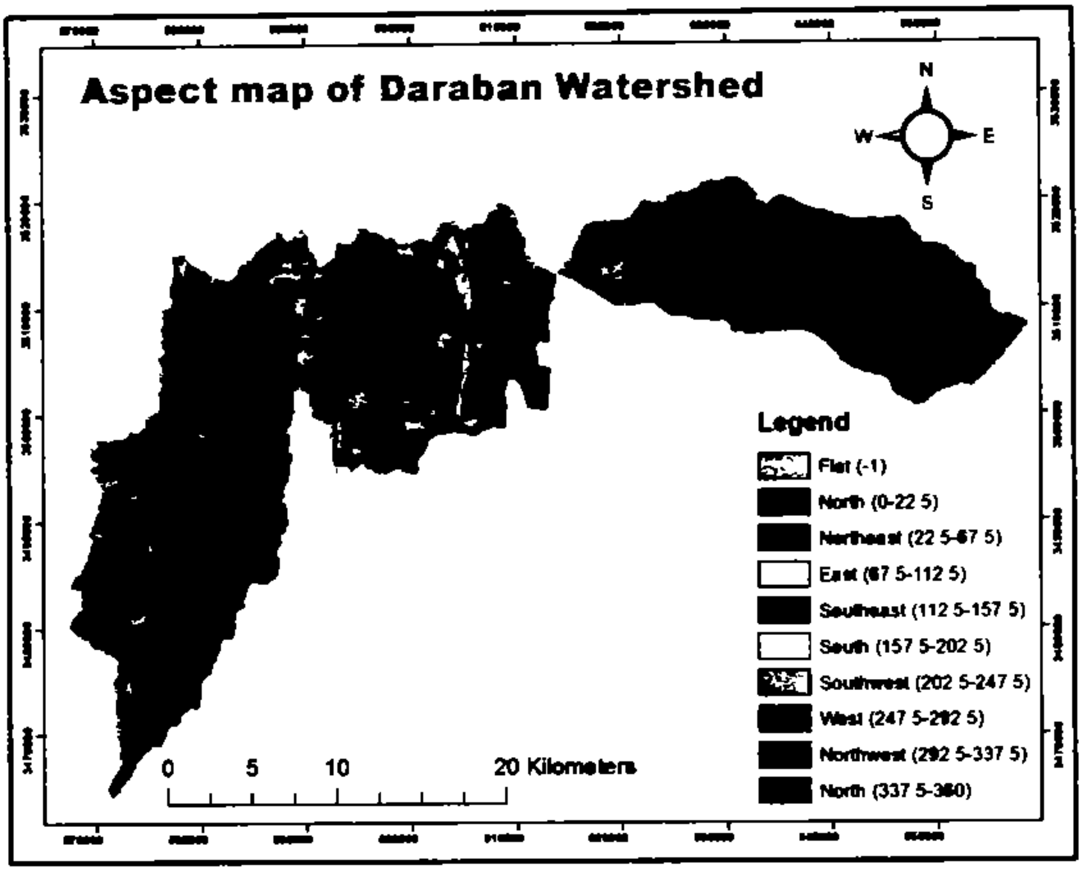


Figure 3 5 Aspect of the study area

3.6 Soil

Command area of Daraban has six different types of soils

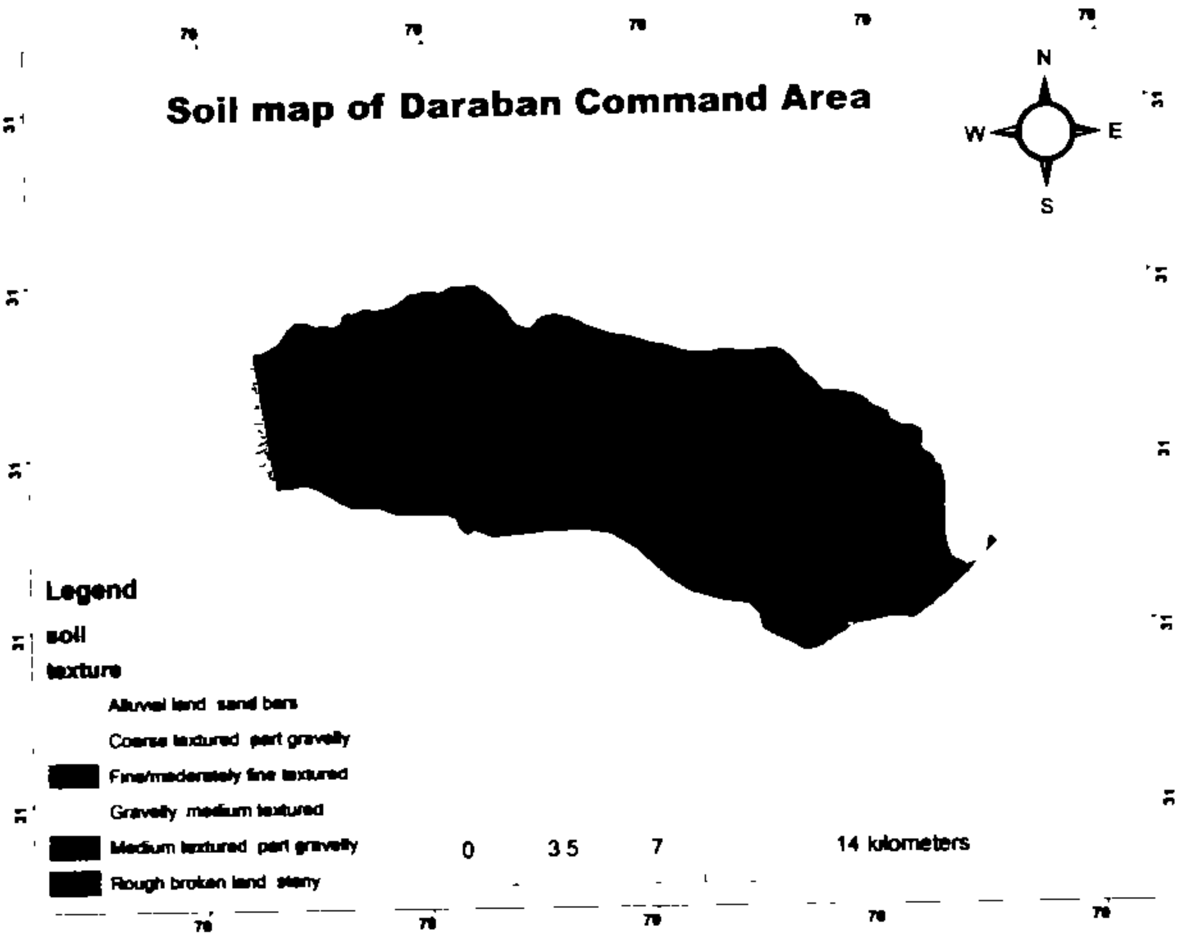


Figure3.6 Soil map of Daraban Command area

Type of soil	Area(hectares)
Gravelly, medium textured	3670 539
Medium textured, part gravelly	21025 93
Fine/moderately fine textured	3512 105
Coarse textured, part gravelly	160 4304
Rough broken land, stony	19810 29
Alluvial land, sand bars	780 6395
Total	48959 93

Table 3.2 soil types of Daraban Command area

3.7 Rainfall

Rainfall data obtained from national agriculture research center Islamabad Minimum rainfall recorded was 150mm in command area of Daraban watershed while maximum rainfall recorded was 970mm in catchment of Daraban watershed It shows that there is minimum rainfall in Daraban Command area and maximum rainfall in daraban catchment area which destroy the Command area By finding annual rainfall we can estimate that how much water of volume and runoff is generated in this area so that it can be managed properly

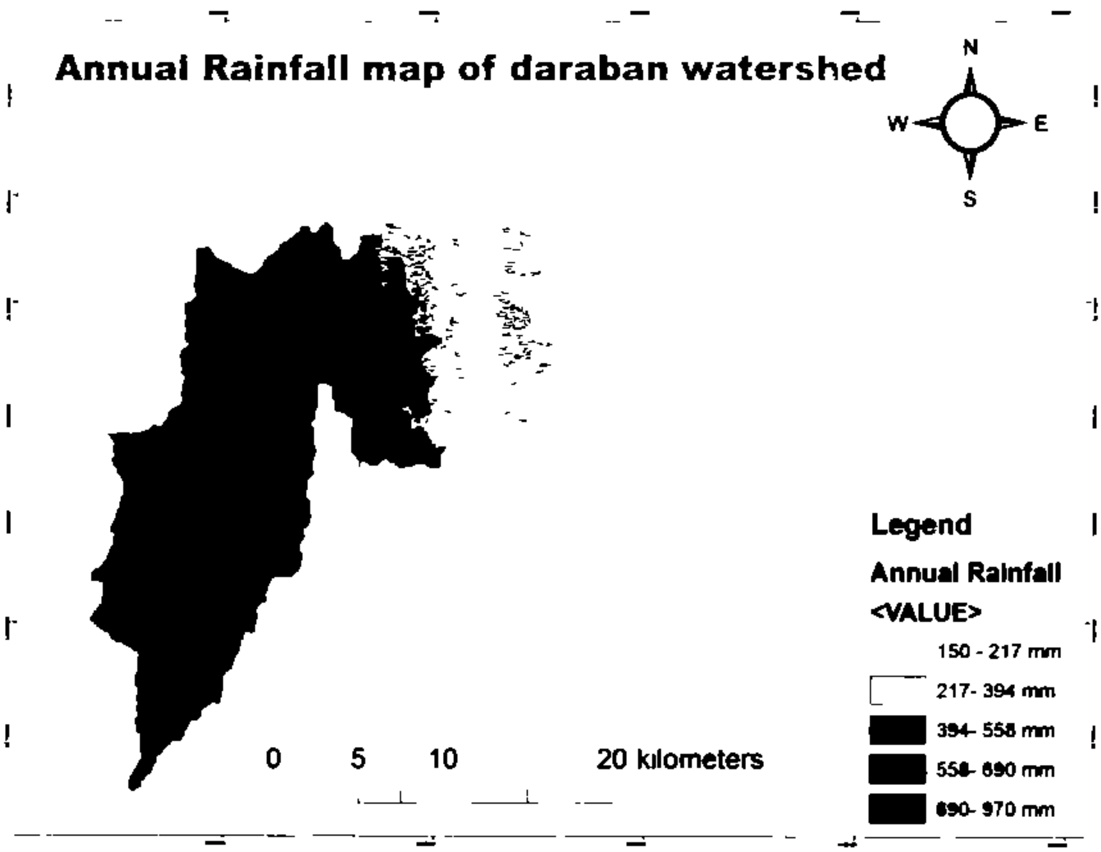


Figure 3.7 annual rain fall map of study area

3.9 Rainfall volume

Minimum rainfall volume calculated in the catchment of Daraban watershed 1,577 cubic meter while maximum volume was 7,859 cubic meter

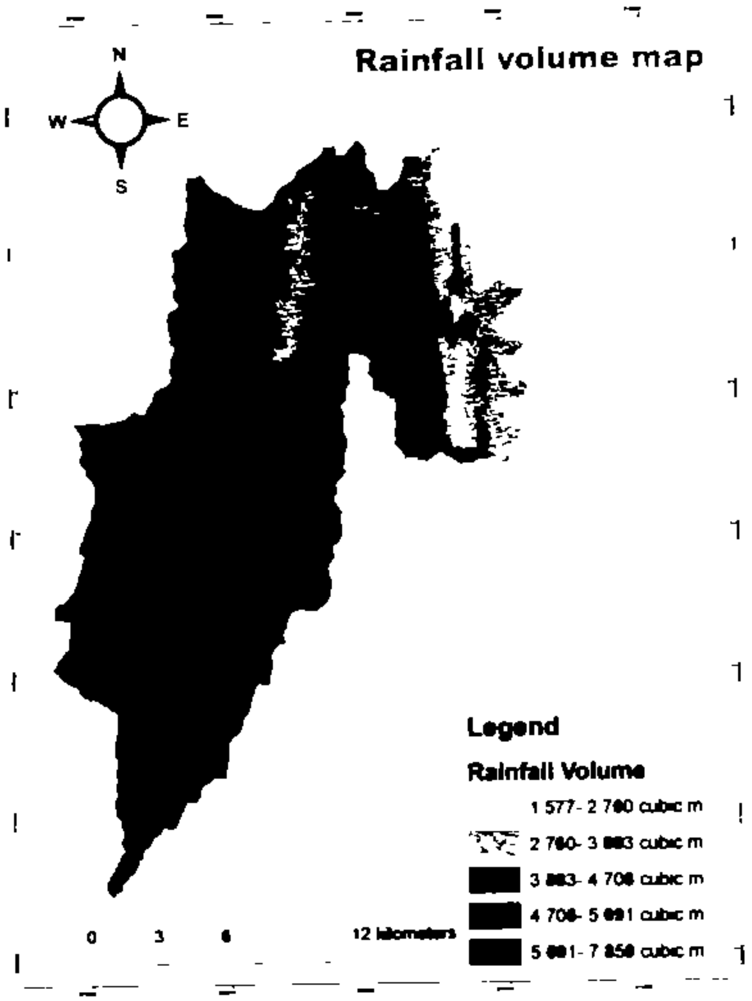


Figure 3 8 Rain fall volume of the Catchment area of Daraban

3.10 Runoff

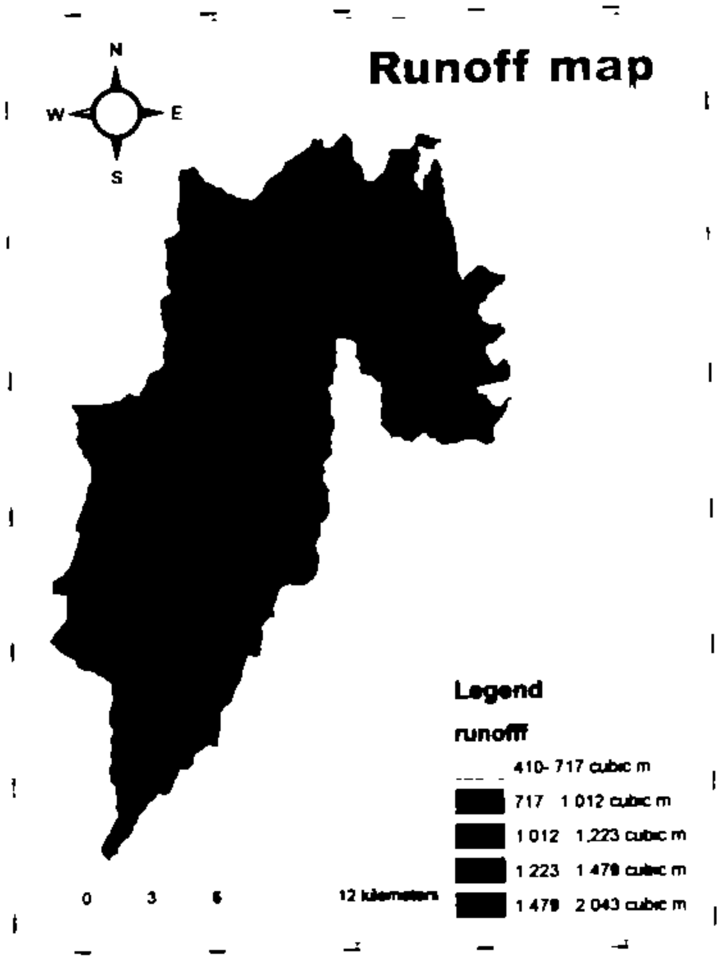


Figure 3.9 Runoff map of Daraban Catchment area

3.11 Land cover

LANDSAT 8 ETM+ was used for the land cover classification of the study area Five different classes were taken for the classification of daraban command area i e rocks, ranglands, irrigated area, bare soil and tree cover

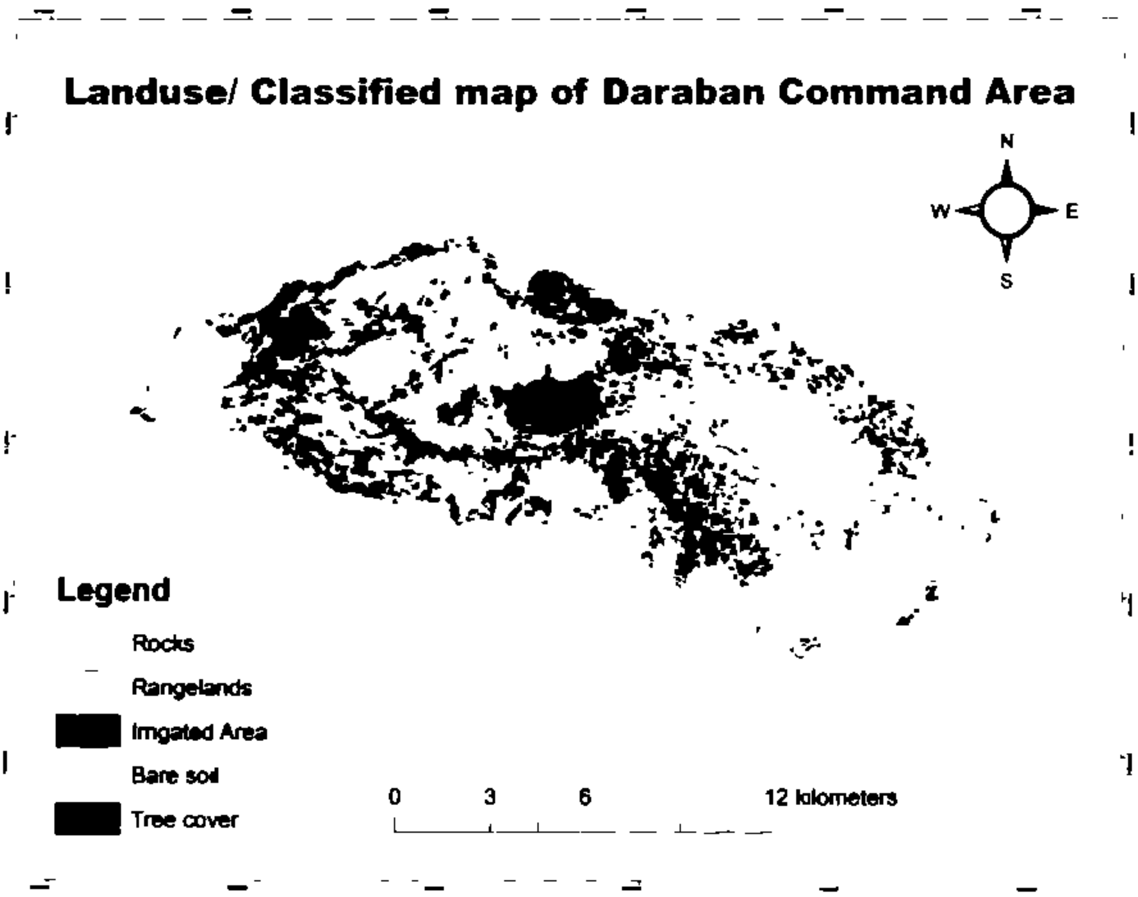
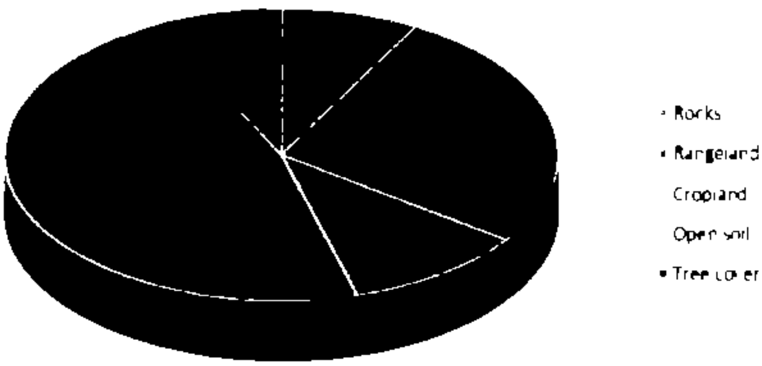


Figure 3 10 Landuse map of Daraban Command area

Classified map of Daraban watershed of year 2014 showed that major area is covered by bare soil and makes up-to 47% of the entire area. Another major area is rangelands covering 26% of the total area while crop land covers the area of 10% Rocks covers the area of 8% while trees are only have 7% of the whole area

Percentage of Landuse map of Command area of Daraban



Graph 3 1 Landuse classes

3.12 Land cover of Daraban Catchment

LANDSAT 8 ETM+ was used for the land cover classification of the study area Four different classes were taken for the classification of Daraban catchment area i e vegetation, rangelands, exposed rocks and bare soil.

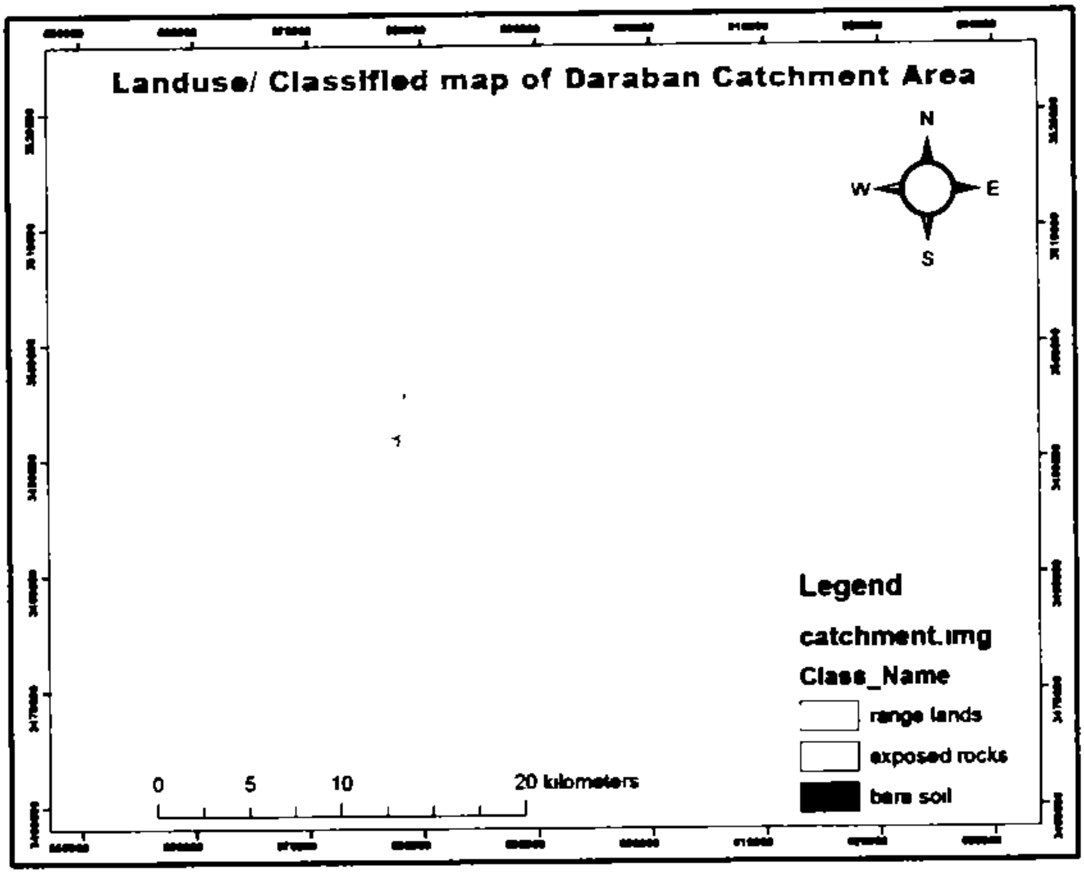


Figure 3.11 Landuse map of Daraban Catchment

Chapter 04
Discussion

4.0. Water management strategies

Landuse has a great influence on rain fall and runoff process Total area of Daraban watershed is 48946 23hec from which a large area is required to develop It is estimated that developing different useful scenarios can help in the development of bare soil of Daraban Command area

4.1. Volume

Volume of Daraban Catchment is determined by multiplying area to mean of rainfall

Area * mean of rainfall

48946 23(493 71) = 24, 165536 9/ 1000000

Volume = **24.1mcm^3**

4.2. Runoff

Runoff is resulted by multiplying the volume into runoff co-efficient 0 26 that is estimated by findings of Suleman range by Nespark

24 1 (0 26) = 6 266 mcm^3

4.3. Land cover

Classification results shows five different classes for Daraban command area which needs to be managed from flood damages It is resulted that area of bare soil in Daraban Command area is 23037 12km2 that is 47% of the total area, range land is 13138 2km2 that is 26%, while crop land is of 5226 21 km2 which is 10% of the total area

4.4. Full area of bare soil for wheat

Wheat is the most important grown crop in the field of agriculture in Pakistan Production of Wheat gives strength to our economy Full area of bare soil in Daraban Command area is 23037 12 hectare which needs to be developed for crop production

Water requirement of Wheat = 400mm

400/1000 = 0 4 m = 0 064m^3

Open soil area = 23037 12 hectare

23037 12/100 = 230 37km^2 = 230,371,200m

230,371,200 (0 064) = 1473756 8 m^3

1473756 8/1000, 000 = 14 7 mcm^3

It is estimated that if we grow wheat on full area of bare soil then 14 7mcm3 volume of water is used from 24 1mcm^3

Yield of wheat 2013-2014 = 2824kg/hec

Yield (area of bare soil)

2824 / 23037 12hec =

65056,826 9 / 1000 = 65056 82 tons

Price of wheat (production of wheat)

40 (65056 82) = **2602,273.08 income**

It is resulted that production of wheat on full area of bear soil can give 2602, 273 08rs income per year

4.5. 60% area for wheat

60% area of bare soil = 13822 27 hec

13822 27(1000) = 138222700m

Wheat requirement = 400mm = 0 064m

Area (wheat requirement)

138222700(0 064) = 8846252 8 / 1000000 = 8 8mcm^3

4.6. Establishment of a reservoir

A reservoir of 8ft and 7acers can be developed for proper storage of water and fishing

8ft = 2 438m

7acers = 24281 km^2 = 2 42m

2 438m (2 42m) = 5 899m^2

2 899/1000, 000 = 5 8mcm^3

These reservoirs can also be used for fishing and other purpose

4.7. Water use for Crop land

Crops of Pakistan are playing an important role in economy of Pakistan It is resulted that area of crop land in Daraban Command area is 5226 21hec which requires sufficient water for them

Area of crop land = 5226 21hec

5226 21(100) = 52260 21km^2

522660 21 (1000000) = 3344653 44

3344653 44/1000000 = 3 34mcm^3

It is resulted that from 24 1mcm^3 water, 3 34mcm^3 volume of water can be used for crop land

4.8. Water use for natural needs

Out of 24 1mcm^3 of water 2mcm^3 water can be used for natural needs and vegetation

Chapter 05
Conclusion

5. Conclusion

- This study is useful to manage the flood flows in flood pron area
- This is concluded that Daraban command area can give more strength to economy if we grow crops from flood water The storage of flood water is useful for future crop production
- The suggested method was applied to Daraban watershed in order to control the flood hazard areas and to manage the flood for crop production
- Concrete dams or ponds can be constructed through which integrated natural resource management can be done (fish farming, duck farming, small vegetable beds)
- Flash flood area can be stabilized through watershed management practices (check-dams, bio check dams, plantation)
- It is recommended to agriculture department to maximize the benefits from these short live flooding through above mentioned strategies

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