FLOOD CHALLENGES IN BALOCHISTAN: TURNING THREATS INTO OPPORTUNITIES

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Certification

This is to certify that **Syed Ihsan Shah, 19CE51** and **Shabab Ahmed, 19CE30** have successfully completed the final project **Flood Challenges In Balochistan: Turning Threats Into Opportunities**, at the **Balochistan University of Engineering and Technology Khuzdar**, to fulfill the partial requirement of the degree **B.E Civil Engineering**.

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FLOOD CHALLENGES IN BALOCHISTAN: TURNING THREATS INTO OPPORTUNITIES

Sustainable Development Goals

(Please tick the relevant SDG(s) linked with FYDP)

SDG No	Description of SDG	SDG No	Description of SDG
SDG 1	No Poverty ✓	SDG 9	Industry, Innovation, and Infrastructure
SDG 2	Zero Hunger ✓	SDG 10	Reduced Inequalities
SDG 3	Good Health and Well ‘’’’’’’’Being ✓	SDG 11	Sustainable Cities and Communities
SDG 4	Quality Education	SDG 12	Responsible Consumption and Production
SDG 5	Gender Equality	SDG 13	Climate Change
SDG 6	Clean Water and Sanitation	SDG 14	Life Below Water ✓
SDG 7	Affordable and Clean Energy	SDG 15	Life on Land
SDG 8	Decent Work and Economic Growth ✓	SDG 16	Peace, Justice and Strong Institutions
		SDG 17	Partnerships for the Goals

Range of Complex Problem Solving			
	Attribute	**Complex Problem**	
1	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues.	✓
2	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.	
3	Depth of knowledge required	Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach.	✓
4	Familiarity of issues	Involve infrequently encountered issues	
5	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering.	
6	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.	✓
7	Consequences	Have significant consequences in a range of contexts.	✓
8	Interdependence	Are high level problems including many component parts or sub-problems	
Range of Complex Problem Activities			
	Attribute	**Complex Activities**	
1	Range of resources	Involve the use of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technolo'gies).	✓
2	Level of interaction	Require resolution of significant problems arising from interactions between wide ranging and conflicting technical, engineering or other issues.	
3	Innovation	Involve creative use of engineering principles and research-based knowledge in novel ways.	✓
4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation.	✓
5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches.	✓

FLOOD CHALLENGES IN BALOCHISTAN: TURNING THREATS INTO OPPORTUNITIES

Abstract

The largest province of Pakistan, Balochistan, is vulnerable to flooding because of its geographic location and climate. Balochistan has seen frequent flooding, which has seriously damaged the region's infrastructure, agriculture, livestock, and people. Not only do these floods threaten the province's socioeconomic advancement, but they also provide the administration with difficulties in terms of disaster relief and management. Therefore, the issue statement is how to address flood challenges in Balochistan and turn them into best opportunities. The 8247 km^2 area of Balochistan were affected by the flood in 2022. The 2037809 acres of the total landmass of Balochistan province were flooded in 2022. The 4972 km^2 cultivated land was affected by the flood in 2022. The 1228531 acres of the total cultivated land of Balochistan province was inundated in 2022. The experts highly responded that the dams are the beneficent for the localities. The experts responded highly that the dams are the best solution for recharging the groundwater. The survey reveals that the dams are very helpful in those areas where the water table is too low. The survey reveals that that the construction of dams is also beneficent in agricultural sector of Balochistan. The experts agreed that the construction of the small dams is also effective in mitigating the drought challenges.

Keywords: livestock; socioeconomic advancement; groundwater

Undertaking

I certify that the project Flood Challenges In Balochistan: Turning Threats Into Opportunities is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/ referred.

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We are also thankful to our friends and families whose silent support led us to complete our project.

Table of Contents

List of Tables

List of Figures

List of Acronyms

GIS	Geographic Information System
KPK	Khyber PakhtunKhuwa
GLOF	Glacial Lake Outburst Floods
PMD	Pakistan Meteorological Departmen

FLOOD CHALLENGES IN BALOCHISTAN: TURNING THREATS INTO OPPORTUNITIES

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Flooding is globally a major natural hazard. Floods result in property and life loss and poor economic development. Floods always cause a huge loss of human lives, properties, cattle and livestock. The flood destructs the roads and other physical assets. The floods of 2010 did the same in Pakistan. The economy is still striving to recover the damages. The areas which affected during the floods of 2010 are still lacking behind in socioeconomics and educational terms than the areas which were not affected at that time. Though it is not possible to prevent the occurrence of floods, but their negative impacts could be minimized considerably through proper planning and effective preparation. The vulnerability to floods could be reduced by accurate and timely prediction (Forecasting and Warning) and by impact-reducing measures. Naseerabad is also adversely affected by floods. Naseerabad faces flooding problem almost every year in the recent past. Floods cause huge loss of infrastructure, life and land. In Blochistan especially, in Naseerabad division, poor management of water resources and lack of effective water policy have led to flooding problem. Hydrological modeling tool in GIS application is broadly utilized instrument for helping with risk management. Remote detecting information, alongside expanded goals from satellite stages and GIS applications, makes these advancements controlled to improve an effect on land resource management initiatives involved in monitoring and mapping for future projection.

The flood impact is one of the worst disasters in the world. More than half of the global flood damage occurred in Asia. The cause of the flood is due to natural factors, such as heavy rain, high floods, and high tides. Factors such as blocking rivers or aggravating drainage channels, improper land use and deforestation.

There are many types of floods like Riverine floods generally take place as a result of intense monsoon (summer) rainfall in the catchments. In the history of Pakistan, the 2010 super flood was the most devastating riverine flood which caused huge life and financial loss. Agriculture sector (crops, livestock and fisheries) suffered the highest damage caused by 2010 super flood. The 2013 and 2014 riverine floods also caused huge life and property loss.

The flash floods of huge magnitude and short duration take place in natural streams due to heavy monsoon rainfall (torrential rain) in hilly and semi-hilly areas. Flashfloods are difficult to predict and also have the short warning lead times. In Pakistan, flash floods occur along the mountainous regions adjoining the Indus River Basin, Kashmir, Gilgit-Baltistan, KPK, Balochistan and South Punjab. The flash flood of 2011 caused a human life loss of more than 500 lives. The 2011 floods had severely impacted the agriculture sector, with damages to crops, livestock and fisheries. The total estimated loss was US$ 1840.31 million. Sindh suffered most with 94% and Balochistan with 6% of total agriculture sector damage.

GLOF (Glacial Lake Outburst Floods) take place as a result of collapse of the glacial lakes. Such floods pose an increasing threat to mountainous regions in northern Pakistan. Three people were killed and over 300,000 people stranded in Chitral, KPK, due to a Glacial Lake Outburst Flood in July 2015. “The glaciers of the HKH (Himalayan Karakorum Hindu Kush) region in Pakistan are retreating due to global warming. As a result of glaciers retreat, glacial lakes develop behind glacial deposits rupture and release huge volume of water within few hours causing devastating flooding called as GLOF. GLOF causes severe socioeconomic damages in the HKH region of Pakistan. The ICIMOD (International Centre for Integrated Mountain Development) has identified and mapped 5218 glaciers having 2,420 lakes in Pakistan. About 52 lakes have a potential GLOF threat with occurrence frequency of once every 3-10 years. In HKH region, about 35 GLOFs have been reported during the past 200 years.

Coastal flooding in coastal areas takes place due to cyclones generated by the storm surges induced by wind in the Arabian Sea. In Pakistan, coastal floods occur due to cyclones in the coastal regions of Balochistan and Sindh during the months of May, June.

Flooding in the main cities and the towns takes place due to cloud burst, heavy monsoon rains or cyclones. In Pakistan, vulnerability of urban flooding has also increased. In recent years, Karachi, Lahore and Rawalpindi in Punjab, Karachi and Hyderabad in Sindh and Peshawar in KPK have faced severe flooding problem.

1.2 HISTORY OF FLOODS IN PAKISTAN

FLOOD CHALLENGES IN BALOCHISTAN: TURNING THREATS INTO OPPORTUNITIES

The years of 2010, 2011, 2012 and 2013, 2017 and 2022 witnessed the worst floods in the history of Pakistan, damaging crops, infrastructure, and settlements. This resulted in a significant loss of livestock while causing an unimaginable and prolonged suffering amongst the affected population. The summer rainfall in Pakistan is generally during the periods of July to September. Monsoons from the Bay of Bengal are the main source of these rains. However, the mid-latitude westerly disturbances sometimes also contribute to the summer rainfalls. There is a well-marked monsoon season from July to mid-September in which the majority of the country receives rainfall. The floods, flash floods and torrential rains from the hills are a phenomenon of common occurrence in Pakistan, usually during a monsoon. These episodes, on occasions, are largely detrimental to the economy, damaging crops, settlements, households, infrastructure and exterminating livestock and other valuable assets.

The monsoon season in 2010 started with a normal tempo until mid-July. The devastating rain started around 18 July and ended on 10 September. The largest amount of rain was received from 28 to 29 July, 2010. Another intense rainfall system was observed between 5-9 August. The rainfall systems during July and August were due to the interaction of a monsoon and mid-latitude westerlies. The Rainfall data is collected across the country by meteorological stations operated by Pakistan Metrological Department (PMD).'

There are five large rivers that flow through the country from north to south, namely the mighty Indus and its tributaries i.e. Jhelum, Chenab, Ravi and Sutlej. The initial outburst started from River Swat, causing damage in the Swat valley during the last week of July. The Indus River breached its embankments upstream of Taunsa Barrage in Punjab and at Tori/ Ghauspur of Sukkur Barrage. Large areas were subject to flooding by the breaches of the river embankments; additionally caused by flash floods and torrential rain in the catchments of rivers and creeks. In total, 6 million ha of geographic area was inundated in Pakistan. The affected cultivated area was 3.3 million ha; consequently, 2.3 million ha of crops were destroyed.

The monsoon of 2011 was manifested by remarkably high rainfall in South Asia. In Pakistan, there was wide spread rain. However, the major thrust of rainfall was in the Sindh province, where cumulative rainfall varied from 400 mm to a little over 1299 mm. These rains inundated large areas in Sindh and other provinces causing damage to crops, infrastructure and human settlements. The combined consequence of these detriments was a severely disrupted national economy.

FLOOD CHALLENGES IN BALOCHISTAN: TURNING THREATS INTO OPPORTUNITIES

The monsoon in 2012 was late; it started in August and intensified during the month of September. During the first half of September, wide spread rains were experienced throughout the country, this severely affected the areas of Punjab, Sindh and Balochistan. Between 9 and 11 September, Jacobaabad, Larkana, Sukkur, Thatta and Tharparkar in the Sindh region received heavy rains, resulting in rainfall inundations. In Punjab, Rahim Yar Khan, Sahiwal, Okara, Jehlum, Mandi Bahaudin, DG Khan and Rajanpur experienced an extensive and continuous down pour from 8 to 12 and then 19 to 23 September. Balochistan, Naseerabad and Jafarabad also received heavy rains resulting in hill torrents in the Suleman Range. Heavy rains affected Southern Punjab, Sindh and Balochistan with almost 24 to 26 hours of continuous rain, which affected thousands of people with the vast majority left displaced. Several deaths, injuries and damaged property were reported. Pakistan suffered the worst floods in its history back-to-back in 2010 and 2011. According to the National Disaster Management Authority (NDMA), the Floods in 2010 affected an area proportional to one fifth of the country, claiming over 2000 lives and injuring 3000 people. Flash floods and landslides triggered by monsoon rains caused severe damage to the infrastructure in the affected areas. Entire villages were washed away, urban centers were flooded, homes were destroyed, and thousands of acres of crops and agricultural lands were damaged with major soil erosion occurring in some areas. The 1.04 million cusecs (measuring the flow rate of 1 cubic foot per second) of water flowing from north to south through the provinces of Punjab and Sindh have broken the century-old record of 0.9 million cusecs experienced in the flooding of 1901.

In mid-June 2022, at the beginning of monsoon season, heavy rains began flooding areas of Pakistan. Estimates range from double to several times the normal monsoon rainfall. By late August, flooding had worsened to historic and catastrophic levels, reportedly affecting more than 33 million people, injuring nearly 13,000 and killing more than 1,600. With more than one-third of the country reportedly submerged, housing, infrastructure, and livelihoods are negatively affected, and agricultural losses appear to be extensive.

1.3 GIS AND USE OF GIS IN FINDING OF FLOOD PRONE AREAS

Chen (1998) defined GIS is the software system for gathering, preparing and investigating spatial topographical data. It is a basic instrument for big business association, private structures and government division for adopting proactive strategies and settles on significant choices broadly and universally. The principal GIS created by Canadian researcher in 1960's it has been produced for over 40 years. In 1980s, GIS is utilized in created nations to develop spatial information bases.

GIS has been producing for over 40 years. This product innovation is firmly identified with the advancement of geological science. According to (Lawal (2011), described that GIS has grown to be interesting and outstanding software that control the flood threats along with risk zone estimations of geographical areas. This is the reason it is one of the powerful tools to create a flood risk map. In the early period, the improvement of GIS was principally relied upon the advancement and application of remote sensing, ariel photography, as well as computer-aided design (CAD). With the quick advancement of Management Information System (MIS) and Internet innovation, GIS has grown powerfully in the nation as of late. Geographic Information Systems (GIS) are effectually used to imagine the degree of flooding and furthermore to break down the guideline of flood to deliver metropolitan flood harm assessment maps and urban flood hazard map. GIS in mix with distant detecting (RS) strategies are an efficient device for examination, remembering for recognizing flood hazard zones and flood impacts on immersed zones. Remote sensing and GIS in combination is an efficient tool for analysis, including in identifying flood impacts and flood zones on flooded areas (Sarker 2011). Remote sensing saves both time and manpower in the data collection and data analysis of topographical and geo-morphological data. Rainwater management through GIS maps provides a tool to enrich living conditions in cities and to extend water availability for the various needs such as landscaping, gardening, cleaning and emergency response. GIS and hydrology methods works together for great results and to estimate the flood profile of flood prone areas. GIS data is ordinarily established on two classes, property information and spatial data.

1.4 PROBLEM STATEMENT

The largest province of Pakistan, Balochistan, is vulnerable to flooding because of its geographic location and climate. Balochistan has seen frequent flooding, which has seriously damaged the region’s infrastructure, agriculture, livestock, and people. Not only do these floods threaten the province’s socioeconomic advancement, but they also provide the administration with difficulties in terms of disaster relief and management. These floods frequently result in fatalities, destruction of infrastructure, and interruption of economic activity, which causes poverty and unemployment. Therefore, the issue statement is how to address flood challenges in Balochistan and turn them into best opportunities. The aim of this study is to increase capacity for resilience and to advance sustainable development in the face of the state’s persistent flood problems.

1.5 AIMS AND OBJECTIVES

The aim of this study is to comprehensively understand the challenges posed by floods and transform them into opportunities for effective utilization. This research is specifically focused on the Balochistan. The main objectives of this study are as follows:

- To analyze the past historic data of floods with Geographic Information System.
- To evaluate the role of small dams to mitigate the flood related challenges/risks in the region.
- To investigate the best possible solutions to manipulate the threats present by floodwaters into opportunities.

1.6 PROJECT SCOPE

The scope of the project "Flood Challenges in Balochistan: Turning Threats into Opportunities" encompasses the comprehensive assessment, management, and mitigation of flood-related issues in the Balochistan. The primary objective is to transform the challenges posed by flooding into opportunities for sustainable development, resilience, and improved quality of life for the local population.

1.7 PROJECT STUDY LINKAGE WITH SUSTAINABLE DEVELOPMENT GOALS

This project study helps to achieve the sustainable development goals which are set by the United Nation. The United Nation and worlds developed and under developing countries set the target to achieve the sustainable development goals in 2030. This project study will help to achieve the sustainable development goals which are as under:

- No poverty (SDG-1)
- Zero hunger (SDG- 2)
- Good health and well-being (SDG- 3)
- Decent work and economic growth (SDG- 8)
- Life below water (SDG- 14)

CHAPTER 2

REVIEW OF LITERATURE

Bhutto (2022) reported that the monsoon season of 2022 highly destructed the lives, livestock, crops in Balochistan and Sindh.

Haq *et al*. (2012) studied that the 2010, 2011, and 2022 floods in Pakistan affected approximately 55–60 million people with over 3500 deaths. The floods in 2011 inundated over 21,000 km^2 area, displaced 5.9 million people and damaged 1500 km of the road network, 382 km of railway tracks, 500 km^2 of forests and over 16,000 km^2 of agricultural land. The 2012 floods inundated 13,157 km^2 of the area in 22 districts of Pakistan damaging 2950 km^2 of agricultural land, 1681 km of the road network, and 110 km of railway track.

European Parliament Council (2007) stated that the Floods are natural phenomena which cannot be prevented; nevertheless, some human activities contribute to an increase in the likelihood and adverse impacts of flood events.

National Disaster Management Authority (2022) reported that there have been at least 12,867 people injured and 1,717 causalities due to the floods – a 27 percent increase in less than two months. As more areas have been assessed since September, damage reports have doubled, with more than 2 million houses, 13,115 kilometers of roads and 436 bridges reported as damaged. Livestock, a critical source of sustenance and livelihoods, has also been heavily impacted, with more than 1 million killed.

Muhammad Aslam (2018) reviewed that literature analysis on flood management in Pakistan is provided in this electronic version. A wide range of flood management-related subjects are covered in the review, including the country's existing disaster management situation, Pakistan's difficulties managing floods, and Pakistan's chances for effective and long-lasting flood management. The assessment also looks at the government's response to recent flood disasters, emphasizing the requirement for better flood policies and laws, and it highlights the cutting-edge flood control strategies being used in Pakistan. The assessment also emphasizes the significance of flood forecasting and early warning systems, better land use planning, and increased investment in infrastructure for flood management. The assessment offers suggestions for efficient and long-lasting flood control in Pakistan, such as the requirement for better coordination between government agencies, elevated public participation and awareness, and the application of contemporary technologies. The evaluation, taken as a whole, offers a thorough overview of flood management in Pakistan and emphasizes the necessity of ongoing efforts to advance flood control in the nation.

Muhammad Shahzad Iqbal *et. al* (2014) that the study reveals that the how floods affect Pakistan's economy and the policy alternatives available to lessen their consequences. According to the study, floods significantly increase the loss of human life, property, cattle, and animals, as well as the destruction of roads and other physical assets. Due to its extensive reliance on agriculture, Pakistan's economy is particularly susceptible to the consequences of flooding. In order to lessen the impact of floods on vulnerable communities, the study recommends a number of policy options that the government can implement, such as creating a disaster management fund, setting up a reliable early warning system, constructing neighborhood health centers, and erecting specific barriers to prevent water from entering cities and villages. The study finds that Pakistan's sustainable growth depends on having efficient flood management regulations.

Kainat Ali *et. al* (2020) reviewed the development of GIS-based hydrological modeling-based rainwater flood prediction models. The evaluation, which includes 50 publications, uses hydrological modelling to identify areas for future research on flood-prone locations. The discussion portion of the paper highlights the significance of various stakeholders in assessing flood-prone locations and recommends using more thorough views and objective research methodologies in future studies. The report highlights how GIS technology has aided in our understanding of urban flooding caused by rain and hydrology. Overall, the literature review offers a thorough summary of the state of the art of GIS-based urban flood modelling research.

Xianwei Wang *et. al* (2018) studied that the management of water resources and the evaluation of flood risk, geographic information systems (GIS) and remote sensing have become indispensable instruments. An overview of remote sensing and GIS applications in these disciplines is given in this literature study. The assessment emphasizes the importance of managing flood risk and water resources and shows the potential advantages of combining remote sensing and GIS technologies. The management of water resources, including water quality monitoring, hydrological modelling, and groundwater evaluation, makes use of a number of remote sensing techniques, including satellite images, LiDAR, and radar-based data collecting. It is also covered how to integrate GIS and remote sensing to estimate flood risk using techniques like flood mapping, floodplain delineation, and flood forecasting. The paper includes a number of case studies that demonstrate the effective use of remote sensing and GIS in managing water resources and managing flood risks, as well as the methodology used and the results obtained. Along with recommendations for next research and technology developments, the difficulties and limitations of these technologies are discussed. The significance of remote sensing and GIS in managing water resources and flood risk is highlighted in this literature review's conclusion, along with the opportunity for continued development in this interdisciplinary topic.

Youjie Jin *et. al* (2022) examines that the application of geometrics-based flood loss assessment in an eastern city of China. Geometrics, including remote sensing, Geographic Information Systems (GIS), and global positioning systems (GPS), is a valuable tool for assessing flood risks and estimating potential losses. The review discusses methodologies such as flood extent mapping, vulnerability analysis, and damage estimation using remote sensing and GIS techniques. It explores the integration of spatial data from satellite imagery, topographic maps, socio-economic data, and field surveys. Case studies from the eastern city of China highlight the application of geometrics in flood loss assessment and its outcomes in terms of flood risk characterization and loss estimation. The review addresses challenges including data availability, accuracy, uncertainty, and the need for integrating socio-economic factors. Future research directions focus on incorporating advanced technologies, standardizing methodologies, and promoting data sharing and collaboration. In conclusion, this review emphasizes the significance of geometrics for flood loss assessment and its potential to enhance flood risk management strategies in the specific context of an eastern city in China

Ijaz Ahmed *et. al* (2002) studied that the literature offers a thorough overview of relevant studies and research that have been done in the areas of flood management, characterization, and vulnerability assessments. It offers citations to numerous papers and books that aid in understanding these subjects. In order to control floods effectively, the review emphasizes the value of combining 2D hydrodynamic modelling with remote sensing (RS) and geographic information systems (GIS). It also underscores how important it is to take climate change and its effects on flood risks into account. The evaluation recognizes the financial assistance provided by Pakistan's Higher Education Commission for the study covered in the PDF file. It also says that data, models, or code are accessible upon justifiable request from the appropriate author. The Punjab Irrigation Department provided the information required for the authors' research, for which they are grateful. The review's conclusion states that the writers have no financial ties to their own work that could conflict with it. Overall, the literature review shows the state of the art and knowledge gaps in the field of flood management and vulnerability analysis and serves as a strong foundation for the study presented in the PDF file.

Emmanuel Opolot (2013) said that the literature review offers a thorough synopsis of the most recent developments in the use of remote sensing and geographic information systems (GIS) for flood management. It includes all phases of flood management, including those that occur prior to, during, and following a flood. The review highlights several types of floods and contemporary flood management approaches. Additionally, it presents case examples that show how GIS and RS are used in flood control. The paper emphasizes the interdisciplinary approach to flood control and the value of RS approaches in gaining access to spatial data, especially in physically impossible locations. It also goes over how GIS techniques make it easier to gather data, analyses it, run queries, and show information in an organized manner. The review aims to advance knowledge of possible RS and GIS uses in flood management, particularly in developing nations where their adoption has been sparse.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 RESEARCH METHODOLOGY

geographic information systems (GIS) are computer-based tools used to store, visualize, analyze, and interpret geographic data. Geographic data (also called spatial, or geospatial data) identifies the geographic location of features. These data include anything that can be associated with a location on the globe, or more simply anything that can be mapped. For example, roads, country boundaries, and address are all types of spatial data.

GIS technology is a crucial part of spatial data infrastructure, which the White House defines as “the technology, policies, standards, human resources, and related activities necessary to acquire, process, distribute, use, maintain, and preserve spatial data.”

GIS can use any information that includes location. The location can be expressed in many different ways, such as latitude and longitude, address, or ZIP code.

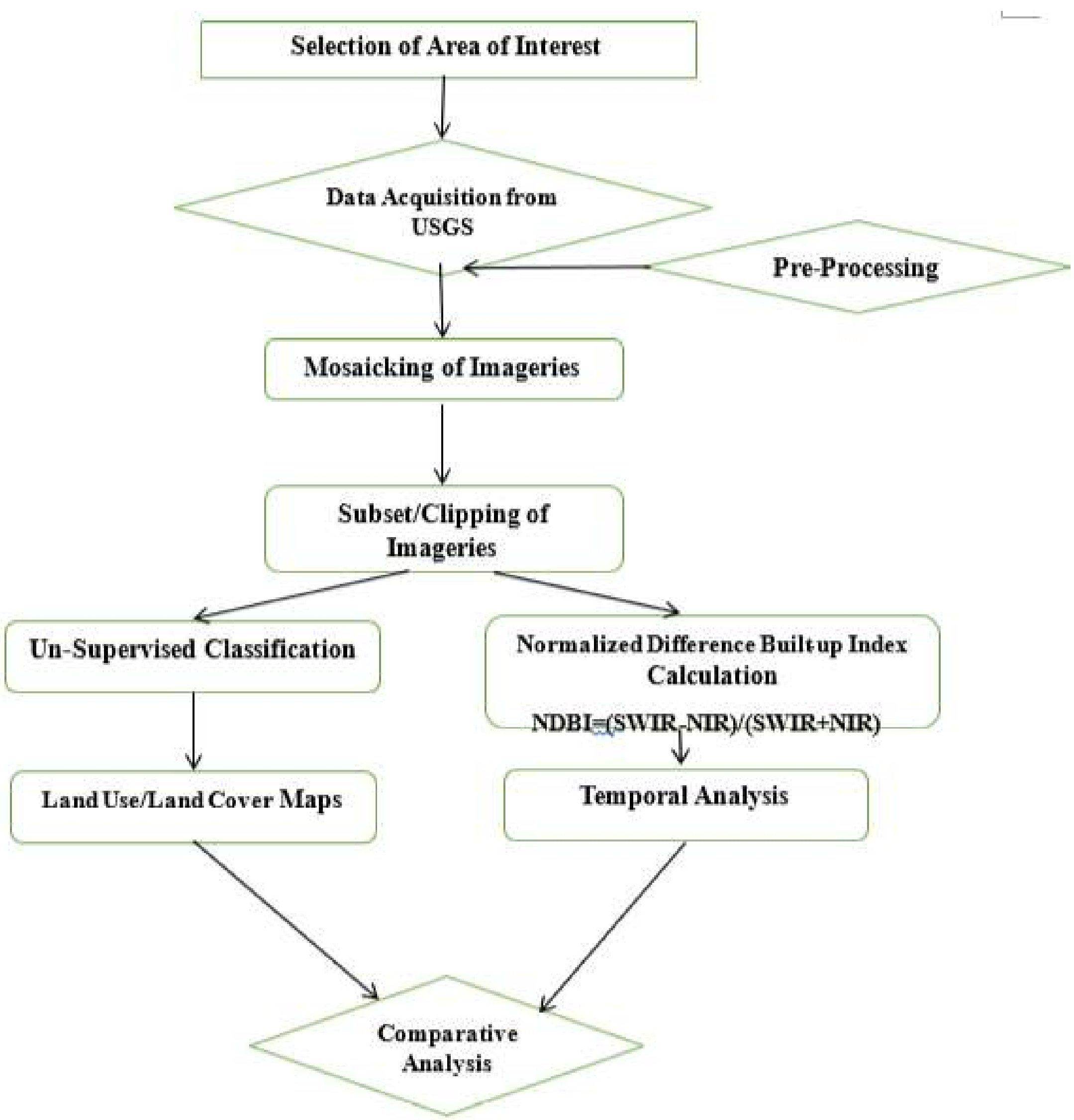
With GIS technology, people can compare the locations of different things in order to discover how they relate to each other. For example, using GIS, a single map could include sites that produce pollution, such as factories, and sites that are sensitive to pollution, such as wetlands and rivers. Such a map would help people determine where water supplies are most at risk.

The Landsat data will be downloaded free of cost from the website of United States Geological Survey (USGS) acquired by National Aeronautics and Space Administration (NASA) (earthexplorer.usgs.gov).

Table 3.1: Landsat Acquisition Data

S No	*Month*	*Duration (dates)*	*Year*	*Data Acquisition*
1	***August***	***1-31***	***2022***	***Sentinel 1 and Sentinel 2***

Further setting has been performed in ArcGIS desktop software for extract the study area by using "Extract by Mask Tool". The flow chart of proposed methodology is as under:



3.1.1 Selection of area of interest

The study area should be your area of coverage that is, your case study. Introducing information from other areas or region will have no significance on the subject matter, hence your primary focus would be on the area your research is covering.

3.1.2 Data acquisition from USGS

A data acquisition system (or DAS or DAQ) converts physical conditions into digital form, for further storage and analysis.

For a particular data set which cannot be find through internet or Science Data Catalog. USGS Science Information Services website is useful to initiate a live Web chat with a Science Information Specialist.

3.1.3 Pre processing

Any type of processing performed on raw data to prepare it for another data processing procedure. Data preparation and filtering steps can take considerable amount of processing time. Examples of data preprocessing include cleaning, instance selection, normalization, one hot encoding, transformation, feature extraction and selection, etc. The product of data preprocessing is the final training set. Data preprocessing is essential before its actual use. Data preprocessing is the concept of changing the raw data into a clean data set. The dataset is preprocessed in order to check missing values, noisy data, and other inconsistencies before executing it to the algorithm.

3.1.4 Mosaicking of imagery

Image mosaicking is the construction of a large orthoimage by splicing multiple orthoimages which have overlaps between each other. It is an important part of remote sensing imagery production. Mosaicking is blending together of several arbitrarily shaped images to form one large radiometrically balanced image so that the boundaries between the original images are not seen. In a nutshell, image mosaicking is the process of merging two or more images with overlapping areas into a single view with an indistinguishable seamline (Burt and Adelson, 1983). Image mosaic is a technique that combines several images with overlapping parts (the images may be obtained at different times, different viewing angles or by different sensors) into a large-scale seamless high-resolution image.

3.1.5 Clipping of imagery

In the Image Analysis Toolbar, highlight the new clipped raster the tool creates. Save the new clipped image by clicking the export button. Choose the location and name of the file that you want to save. You can also change the cell size and the format of the clipped raster.

3.1.6 Normalized Difference Vegetation Index calculation.

The Normalized Difference Vegetation Index (NDVI) uses the NIR and SWIR bands to emphasize manufactured built-up areas. It is ratio based to mitigate the effects of terrain illumination differences as well as atmospheric effects.

NDVI = (SWIR – NIR) / (SWIR + NIR)

3.1.7 Un-supervised classification

Where you let the computer decide, which classes are present in your image based on statistical differences in the spectral characteristics of pixels.

There are four main steps:

1. Load and display the Kupang bay imagery.
2. Conduct our unsupervised classification.
3. Reclassify our unsupervised classes to land cover classes.
4. View area statistics.

Unsupervised classification (commonly referred to as clustering) is an effective method of partitioning remote sensor image data in multispectral feature space and extracting land cover information.

Compared to supervised classification, unsupervised classification normally requires a minimal amount of initial input from the analyst. This is because clustering does not normally require training data.

3.1.8 Land use/land cover maps

Land Use / Land Cover (LULC) generally refers to the categorization or classification of human activities and natural elements on the landscape within a specific time frame based on established scientific and statistical methods of analysis of appropriate source materials.

GIS allows for a rapid, low-impact, low-budget macro and micro analysis of an area of interest. Furthermore, GIS allows us to visualize the land from miles above, and see it with digital eyes that capture what the human eye cannot.

3.1.9 Temporal data

Temporal data represents a state in time, such as the land-use patterns of Naseerabad division in 2022 or rainfall in Quetta on July 1, 2022. This data comes from many sources, ranging from manual data entry to data collected using observational sensors or generated from simulation models.

Temporal Geographic Information System (GIS) is an emerging capability in GIS for integrating temporal data with location and attribute data. Temporal data specifically refers to times or dates, enabling temporal visualization and ultimately temporal analysis.

3.1.10 Comparative analysis.

Comparative analysis refers to the comparison of two or more processes, documents, data sets or other objects. Pattern analysis, filtering and decision-tree analytics are forms of comparative analysis.

3.2 QUESTIONNAIRE BASED SURVEY ABOUT THE ROLE OF DAMS

The second objective of this study is to evaluate the role of dams to mitigate flood related challenges in Balochistan. The Questionnaire was developed which is as shown below to achieve the second objective of this study. The survey was conducted out in various governmental departments like Irrigation Department, Agriculture and On Farm Water Management which are directly linked to not only mitigate the flood disasters but also store the flood water for agriculture and basic needs of livelihoods of the region.

FLOOD CHALLENGES IN BALOCHISTAN: TURNING THREATS INTO OPPORTUNITIES

Basic Details Table

Basic Details	
Department	
Name	
Qualification	
PEC Registration No.	
Position	
Experience	
Contact No.	
Email Address	
Field of Major Experience	☐ Irrigation ☐ Agriculture/ Agricultural Engineer ☐ Other (Please Specify)
(A) TYPE OF ORGANIZATION (Please Tick the appropriate Type)	
Government	☐
Non-Governmental Organization	☐
Other (State)	☐

Signature: ________________________ Date: ____________________

Questionnaire Survey Form

NOTE: VL (VERY LOW), L (LOW), A (AVERAGE), H (HIGH) and VH (VERY HIGH)

S. No.	Factors	Relevant Questions	Remarks / Ratings				
			VL	L	A	H	VH
01	**Height of the dam**	Is the height of dam plays an important role to mitigate the effects of flash flood?	○	○	○	○	○
02	**Storage capacity of the dam**	The storage capacity of dam is capable to carry the maximum flash flood water?	○	○	○	○	○
03	**Route of the flash flooding**	Should the dam be constructed at the route of natural flood?	○	○	○	○	○
04	**Potential benefits of the dam**	Is there any benefit of the dam for the localities?	○	○	○	○	○
05	**Impact on environment**	Is the construction of dam has good environmental impacts?	○	○	○	○	○
06	**Impact on groundwater recharge**	Is there any impact on groundwater recharge due to construction of dams?	○	○	○	○	○
07	**Impact on agriculture**	Is the construction of dam has good impact on agriculture?	○	○	○	○	○

08	**Capability of dam to mitigate flash flood**	Are dams capable to mitigate flash flood?	○	○	○	○	○
09	**Economical construction of the dam**	Is the dam being economical w.r.t construction cost?	○	○	○	○	○
10	**Recreational and Environmental impact**	Is there any good impact on recreational and environmental activities?	○	○	○	○	○
11	**Specific types of dams**	The type of dam has been constructed in flash flood areas are mitigate the effects of flash flood or not?	○	○	○	○	○
12	**Sustainability of dams**	The dam will able to sustain against the flash floods?	○	○	○	○	○
13	**Long-term solutions for flash floods**	The temporary and permanent dams are the best solutions to counter the flash floods?	○	○	○	○	○
14	**Potential risks for relying on dams**	Is there any serious destruction for livelihoods while relying on the dams?	○	○	○	○	○
15	**Protection from drowning and damages from floods**	Are the dams being capable to protect the destructions which happens during the flash floods?	○	○	○	○	○
16	**Drought mitigation**	Are the dams being capable to mitigate the drought?	○	○	○	○	○
17	**Source of renewable energy**	Are the dams being capable to produce the renewable energy?	○	○	○	○	○
18	**Socio-economic development**	Are the dams being best source of socio-economic development?	○	○	○	○	○

19	**Impact on water quality**	The construction of dams in particular area helps to improve the quality of water?	○	○	○	○	○
20	**Effects on Aquatic ecosystem**	The dams are best source to protect the aquatic ecosystem?	○	○	○	○	○

CHAPTER 4

RESULTS AND DISCUSSION

4.1 FLOOD EXTENT IN BALOCHISTAN

The total area of Balochistan is 347667 km^2 about of which 8247 km^2 were affected by the flood in 2022. The 2037809 acres of the total landmass of Balochistan province were flooded in 2022 according to the calculations of raster data. The flood extent of 2022 in Balochistan is as shown in figure below:

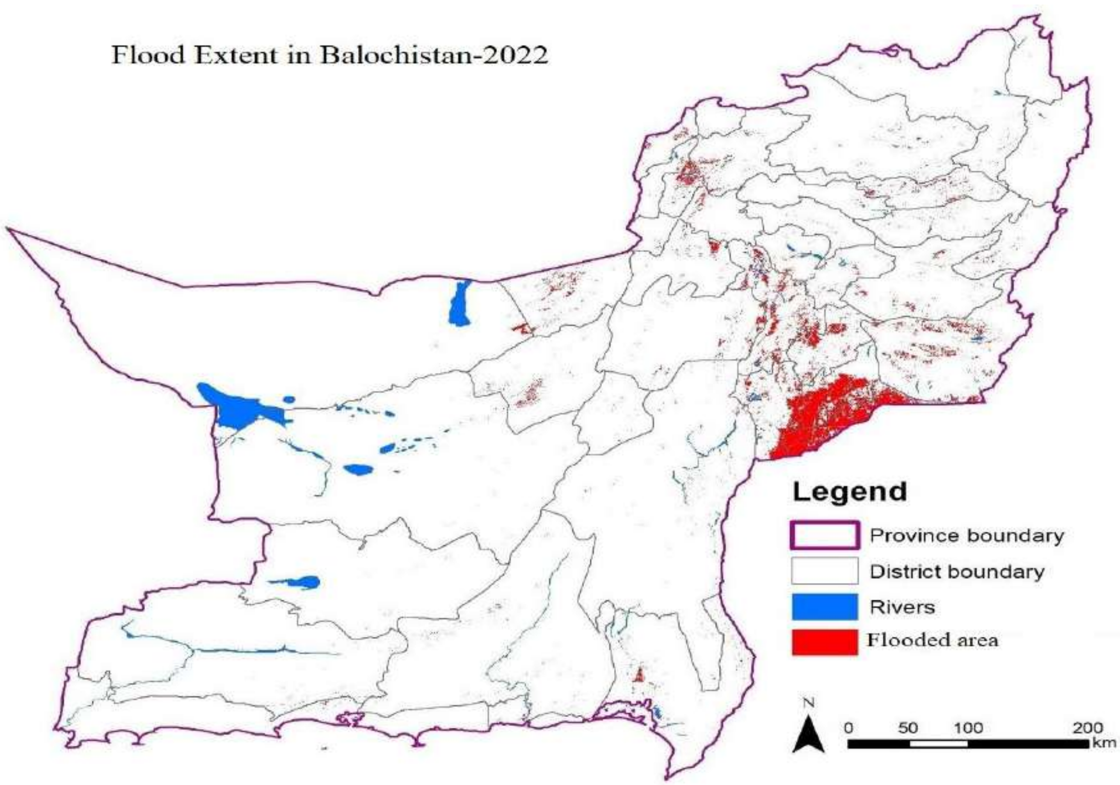


Fig. 4.1: The flood extent of Balochistan 2022

According to the figure 4.1, the five districts of Balochistan were highly affected in 2022 flood.

Table 4.1: Highly affected districts of Balochistan

S No	Districts	Area (km^2)	Percentage (%)
1	Nasirabad	1545	48

2	**Jaffarabad**	**1455**	**86**
3	**Jhal Magsi**	**840**	**22**
4	**Bolan**	**731**	**14**
5	**Dera Bugti**	**653**	**06**

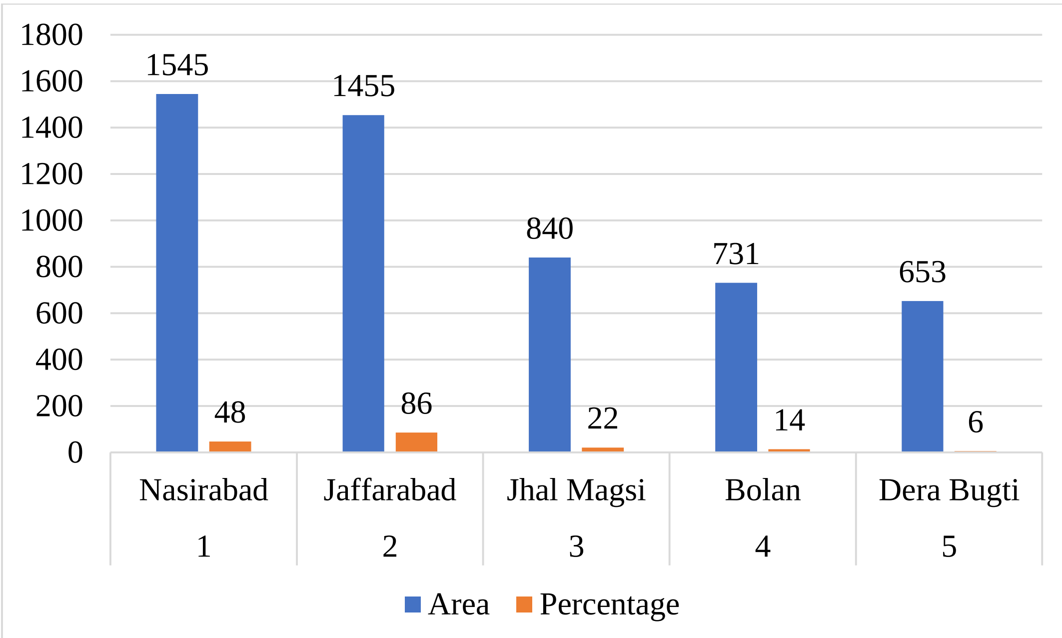


Fig. 4.2: Highly flood affected districts of Balochistan

4.2 AFFECTED CULTIVATED LAND OF BALOCHISTAN

The total cultivated land of Balochistan is 33750 km^2 about of which 4972 km^2 was affected by the flood in 2022. The 1228531 acres of the total cultivated land of Balochistan province was inundated in 2022 according to the calculations of raster data. The inundated cultivated area of Balochistan during flooding of 2022 is as shown in figure below:

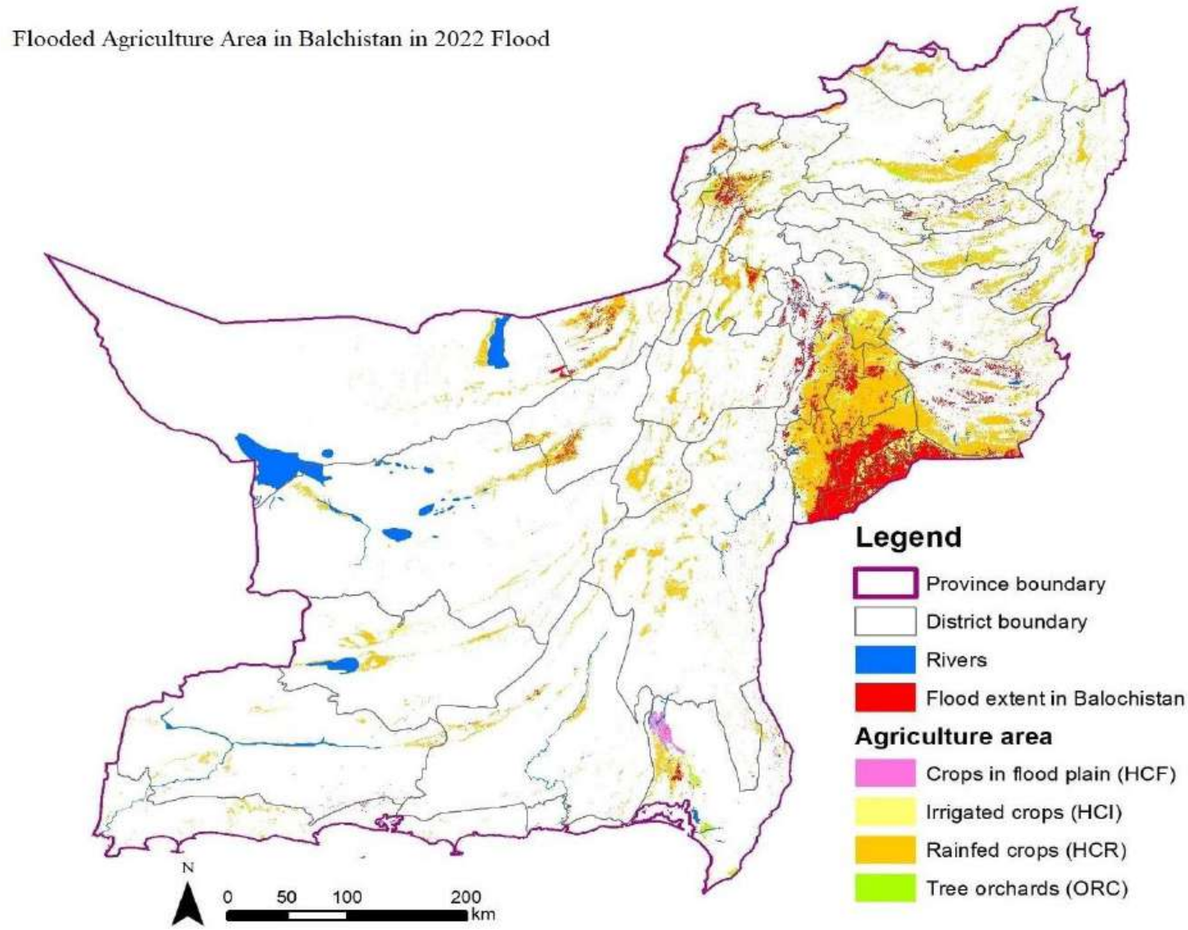


fig. 4.3: Affected cultivated land of Balochistan during flooding of 2022

According to the figure 4.3, the five districts of Balochistan were highly affected in terms of cultivated land in 2022 flooding.

Table 4.2: Affected cultivated land

S No	Districts	Area (km2)	Percentage (%)
1	Jaffarabad	1737	77
2	Nasirabad	1622	48
3	Jhal Magsi	448	15
4	Sibbi	178	07

5	**Bolan**	**170**	**05**

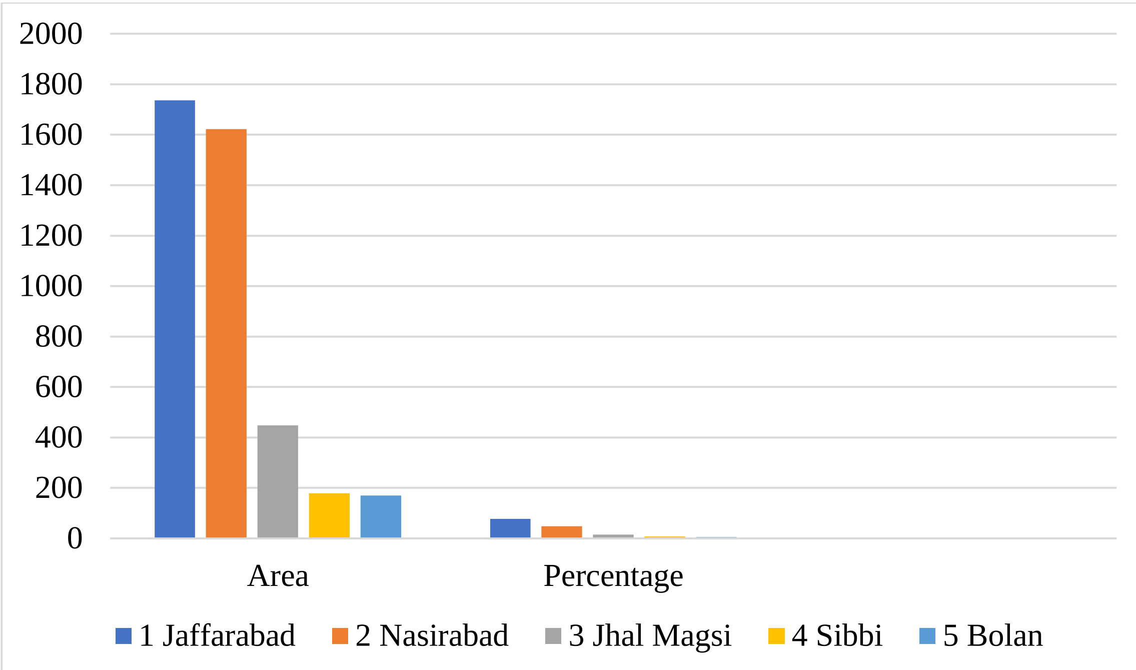


Fig. 4.4: Most affected cultivated land of Balochistan during flooding of 2022

4.3 **ROLE OF DAMS TO MITIGATE FLOOD**

The factors as shown in the fig. 4.4, that the experts highly responded that the dams are the beneficent for the localities. Meanwhile the experts responded highly that the dams are the best solution for recharging the groundwater. Furthermore, the survey reveals that the dams are very helpful in those areas where the water table is too low.

Additionally, the survey reveals that that the construction of dams is also beneficent in agricultural sector of Balochistan. Furthermore, the experts agreed that the construction of the small dams are also effective in mitigating the drought challenges.

The research study highly tells that the dams are the best source to protect the aquatic ecosystem. Moreover, the survey reveals that the construction of the dams in particular area helps to improve the quality of water. Additionally, the dams are capable to sustain against the floods. The dams are also helpful in enhancing the recreational and environmental impacts.

Among the twenty-two experts, only two experts disagreed from the factor that the dams are the long-term solutions to mitigate the flash flood.

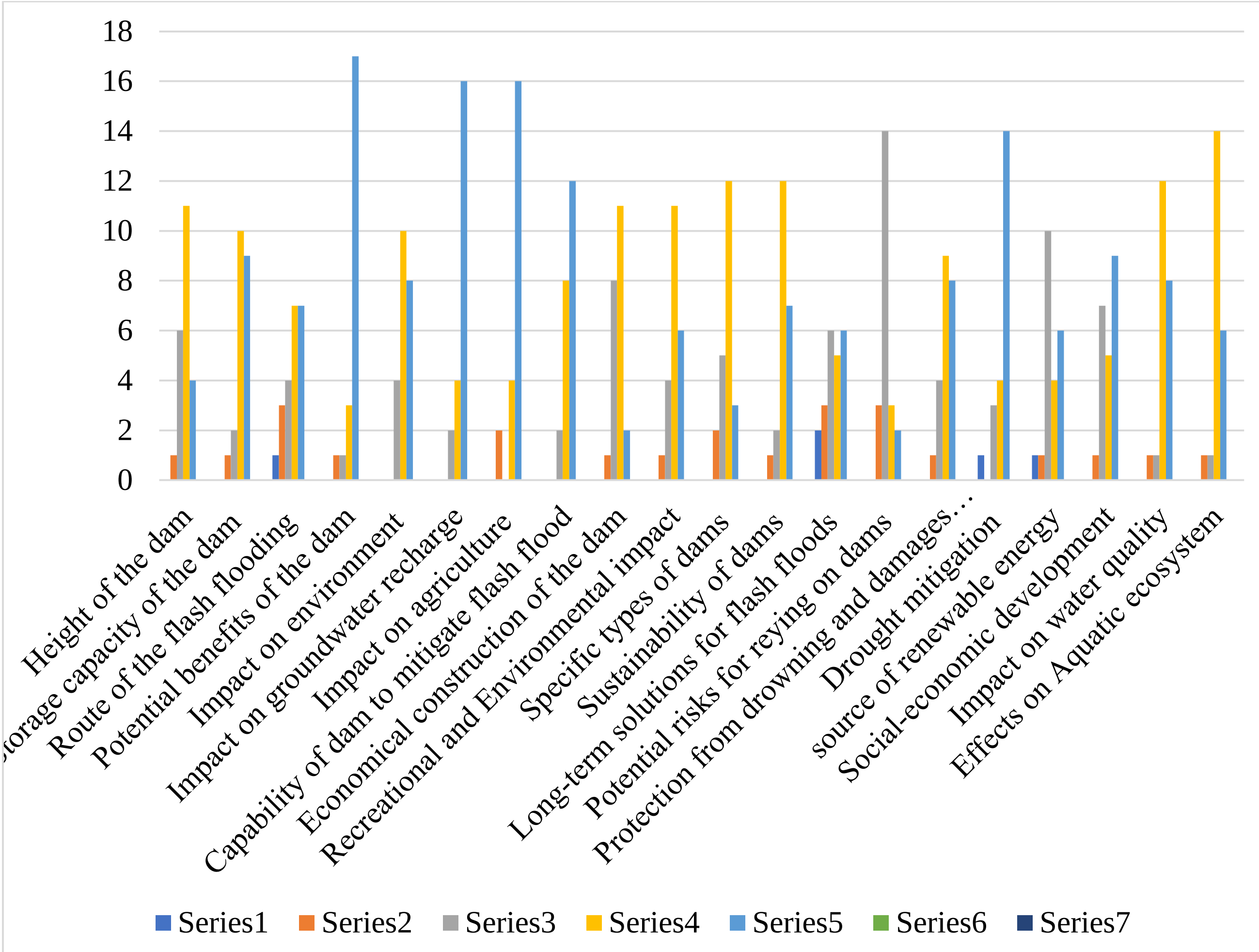


Fig. 4.5: Questionnaire responses about the *role of dams to mitigate flood*

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study was carried out to analyze the pre historic floods with Geographic Information System. Secondly to evaluate the role of small dams to mitigate the flood related challenges/risks in the province and to investigate the best possible solutions to manipulate the threats present by floodwaters into opportunities. The following conclusions are revealed:

- *The 8247 km^2 area of Balochistan were affected by the flood in 2022. The 2037809 acres of the total landmass of Balochistan province were flooded in 2022.*
- *The 4972 km^2 cultivated land was affected by the flood in 2022. The 1228531 acres of the total cultivated land of Balochistan province was inundated in 2022.*
- *The experts highly responded that the dams are the beneficent for the localities.*
- *The experts responded highly that the dams are the best solution for recharging the groundwater.*
- *The survey reveals that the dams are very helpful in those areas where the water table is too low.*
- *The survey reveals that that the construction of dams is also beneficent in agricultural sector of Balochistan.*
- *The experts agreed that the construction of the small dams is also effective in mitigating the drought challenges.*

In this study, main objectives of the study have been obtained. Mostly the experts responded the dams are helpful to improve the quality of water, protect the aquatic ecosystem, environmental and recreational activities.

5.2 RECOMMENDATIONS

Based on this research study, further studies that can be carried out in future are as follows:

- Flood and flood management in Balochistan Pakistan.
- A review of flood management: From flood control to flood resilience.

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