FEASIBILITY SUDY OF INDLAND WATERWAY ON KABUL RIVER

Final Year Project Thesis UG-2018

Submitted By

CAPT SHAHZAD ASLAM (SYN LDR)	**-**	**PA-55169**
CAPT SUFIAN ZAFAR	**-**	**PA-55395**
CAPT MUSTAFA YAWAR	**-**	**PA-55294**
CAPT MUHAMMAD AMAN	**-**	**PA-54599**
CAPT ABDUL QADDUS	**-**	**PA-54787**

In Partial Fulfilment of the Requirements for the

Degree of BACHELOR'S OF

CIVIL ENGINEERING

MILITARY COLLEGE OF ENGINEERING (MCE), NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY (NUST) ISLAMABAD, PAKISTAN (2022)

This is to certify that the Final Year project

FEASIBILTY STUDY OF INLAND WATERWAY ON KABUL RIVER

Submitted by

CAPT SHAHZAD ASLAM (SYN LDR)	**-**	**CMS-281066**
CAPT SUFIAN ZAFAR	**-**	**CMS-281123**
CAPT MUSTAFA YAWAR	**-**	**CMS-281118**
CAPT MUHAMMAD AMAN	**-**	**CMS-281049**
CAPT ABDUL QADDUS	**-**	**CMS-281058**

has been accepted towards the requirements
for the undergraduate degree
in

CIVIL ENGINEERING

____

LEC HANNAN
Military College of Engineering (MCE)
National University of Science and Technology (NUST), Islamabad, Pakistan

DEDICATION

DEDICATED TO OUR BELOVED PARENTS, TEACHERS AND OUR MOTHERLAND, PAKISTAN

FEASIBILITY STUDY OF INLAND WATERWAY ON KABUL RIVER

DECLARATION

It is hereby declared that all the work carried out for this thesis was performed by us and it has not been submitted by any institution, in whole or in part in any previous application for a degree. Any references to the work done by any other person, University or material used from other publications have been appropriately cited.

ACKNOWLEDGEMENTS

First of all we thank ALLAH ALMIGHTY who enabled us to complete our degree leading to the culmination point of in the form this project. It is with great pleasure and profound feelings of obligation that we thank Lec Hanan (our syndicate supervisor), for his genuine concern, advice, invaluable guidance, and enthusiastic encouragement throughout our research work. We are profoundly indebted to him. We would like to thank our peers who gave us their opinions and fruitful advice which helped us during the project work. Lastly, we would like to thank all the researchers out there whose publications we have consulted for the completion of this project.

ABSTRACT

According to a recent National Highway Authority report, Pakistan's trade volume will expand by more than fourfold by 2025. The country's current transportation infrastructure development trajectory indicates that highways and motorways will account for most of this volume. According to existing research, inland waterways can transport 70 and 16 times more freight than highways and railroads, respectively. In addition, waterways are 700/70 times safer than roads/railroads in terms of accidents, 5/3 times more fuel efficient, and 11/1.5 times less polluting. As a result, inland waterways constitute an apparent mode of transportation in both developed and developing countries.

Despite the presence of many rivers, Pakistan lacks this means of transportation. In this study, the potential of inland water transportation on Kabul River was studied, and it was discovered that it is technically feasible and can be socioeconomically sustainable if executed in a methodical phase-by-phase manner.

Title **Page**

List of Figures

Figure Description **Page**

List of Tables

Table Description **Page**

CHAPTER 1

INTRODUCTION

Chapter 1: Introduction

1.1 General

Pakistan, with over 200 million individuals, every year produces a total domestic transport stack of around 239 billion passenger kilometers and 153-billion-ton kilometers. Domestic exchange accounts for different rural and industrial items transported between provinces. This stack of household and Worldwide trade is supported by a 9,574 km long National Interstate and Motorway network constituting only 3.65% of the entire Road network but carrying 91% of the national passenger activity and 96% of the cargo. Present cargo density on our streets is about 170 billion tons/km which is anticipated to extend to 600 billion ton/km by 2025 in case no modern roads are included to the network. It will take a 350 percent increase in road length just to maintain the existing density. With an average cost of over $3 million per kilometer for a highway, a budget of around $100 billion is required just to maintain current trade volume density – not to mention that 170 billion tonnes per kilometer already indicates an overburdened road network – and $100 billion spent on road networks alone within the next eight years for Pakistan's feeble economy appears difficult (Ahmed, Mehdi, Baig and Arsalan, 2022).

1.2 Problem Statement

Pakistan's road freight density is predicted to increase from 170 billion tonnes per kilometer to 600 billion tonnes per kilometer. A massive investment in road infrastructure is necessary to match a three-fold increase in transport load per kilometer. To just sustain the existing freight density on roadways, more than $100 billion in road infrastructure is necessary. Due to the country's current economic difficulties, it is difficult to invest such large sums in road infrastructure. As a result, an alternate option that is both cost-effective and more capacious than highways must be investigated.

1.3 Objectives of Project

This study investigates the potential of developing inland waterway on Kabul River to meet rising transportation demand and proposes a plan to make it happen. The major objectives of our study are:

- Investigate the viability of inland transportation on Kabul River in Pakistan
- Examine the implications of developing inland navigation
- Suggestions for inland navigation development

1.4 Scope of Work

This research will investigate the technical feasibility of building inland waterways in Pakistan to meet current and future transportation load demands. For the planned initial phase of the project, the economic comparisons drawn, and conceptual designs offered only cover major components. This research is intended to be used as a decision-making aid and does not include specific engineering or economic analyses for inland waterway.

River Kabul has been selected for research because of following reasons:

- Ease in data collection owing to be in reach
- Importance of River Kabul for this region especially Peshawar
- Importance of River Kabul for military activities/ training
- It's a pilot project and we had to start from either River Kabul or River Indus
- It is easier to investigate River Kabul navigation potential as it is shorter in length than River Indus (in Pakistan)

CHAPTER 2

LITERATURE REVIEW

Chapter 2: Literature Review

This chapter discusses the comparison between domestic modes of freight transport, a historical perspective of inland navigation in the world and few examples of the current waterways of the world.

2.1 Comparisons of Different Modes of Transportation

Every mode of transportation has distinct characteristics, considering the type of commodity, size of shipment, the distance, the cost, the urgency. Roads provide wider access, while waterways are limited to very few axes, rail tends to be limited to trunk lines and the air is limited to airports only. Comparisons between them are highlighted as following:

2.1.1 Cargo Capacity

Table 2.1 Cargo Capacity of Modes of Transportation

Mode (unit)	Dry(tons)	Liquid(gallons)
Barge	1750	1555000
Rail car	110	33870
Large semi-trailer	25	7865

This table illustrates the cargo capacity of different modes of transportation in terms of dry weight and liquid state of the material. In terms of dry freight, the barge can carry a freight of 1750 tons while the railcar and semi-trailer can carry only 110 tons and 25 tons respectively. Here it shows that the heavy freights are more suitable to be shipped by sea efficiently and conveniently (Sahin et al., 2009).

2.1.2 Energy Efficiency

The energy efficiency of different modes of transportation including shipping, number of miles of one ton can be carried out per gallon of fuel (Usón et al., 2011).

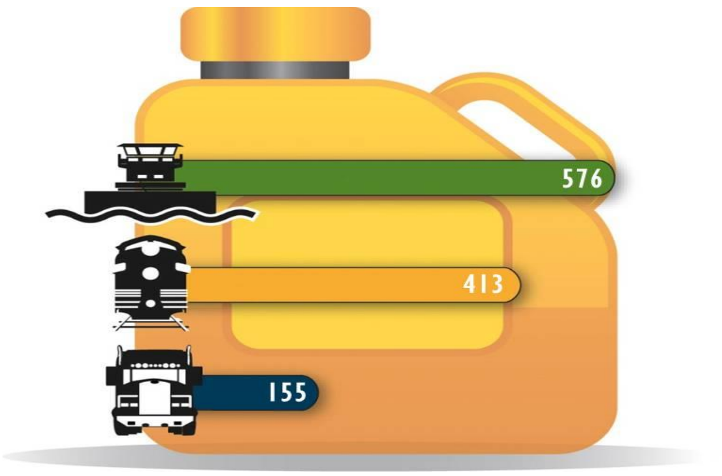

Figure 2.1 Energy Efficiency of Modes of Transportation

2.1.3 Global CO2 Emissions

Following table reveals that the road mode of transportation is the highest contributor in the emission of CO2 around the globe while rail mode is the least. (Cadarso et al., 2010)

Table 2.2 CO2 Emissions of Modes of Transportation

Mode	%		Total (out of 100%)
	Passenger	**Freight**	
Road	45.1	29.4	74.5
Air	81(of 11.6%)	19(of 11.6%)	11.6
Sea	-	10.6	10.6
Rail	-	1	1
Others(pipeline)	-	2.2	2.2

2.1.4 Green House Gas Emissions

The transportation sector is one of the major contributors to anthropogenic U.S. greenhouse gas (GHG) emissions. According to the Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2019 (the national inventory that the U.S. prepares annually under the United Nations Framework Convention on Climate Change), transportation accounted for the largest portion (29%) of total U.S. GHG emissions in 2019. Cars, trucks, commercial aircraft, and railroads, among other sources, all contribute to transportation end-use sector emissions. Following table shows the percentage of Green House Gas emission by different mode of transportation. It shows that the sea and rail mode of transportation are the least affective while the road mode is the most affective. (Sperling & Salon, 2002)

Table 2.3 Green House Gas Emissions of Modes of Transportation

Mode	%
Road vehicles	82
Aircrafts	10
Rails	2
Ships and Boats	2
Others	5

2.2 Historical Outlook of Inland Navigation

Inland route includes stream direction, i.e., water level administration and a rectifying and developing of the most channels, in this way changing riparian and benthic territories. (Effects of Recreation and Commercial Shipping, 2009). It is a more feasible transport alternative for merchandise and travelers, it too pulls in examination from national specialists to guarantee expanded security and natural obligation. (Beyer, 2018)

- **Development Prior to 1800.** The Romans were the primary to construct conduits within the Netherlands. Around the starting of the common period, they assigned the Rhine – at slightest, what is known nowadays as the Oude Rijn – the northern border of their domain. To permit them to move their troops around rapidly, they built the Corbulo and Drusus canals. The Corbulo canal, or Fossa Corbulo, connected the Maas and Rhine rivers behind the coastal hills. Unearthings have appeared that this conduit was some 13 m wide and 2 to 3 m profound at Voorburg. Within the east of the nation, the Drusus canal connected the Rhine and the Gelderse IJssel. Its exact course is obscure. (Knight et al., 2022)
- **19^{th} Century in Netherlands.** The nineteenth century was a period of radical political and technological change. After the defeat of Napoleon the allies decided to merge the Netherlands and Belgium into one kingdom, and to make the Rhine an international, toll-free river. This was officially confirmed in the 1868 Convention of Mannheim. The Central Commission for Navigation on the Rhine (CCNR), established in Strasbourg, was given the task of

guaranteeing the free, safe navigation of the Rhine. King William I tried to forge a single nation of the Netherlands and Belgium by building canals, particularly in the period 1815-1830. It is likely he was inspired by the canals of Britain during his time in exile there. Canals built in this period include the Willemsvaart (Groningen-Assen), the Zederik Canal (Amsterdam-Rhine), the Apeldoorn Canal, the Zuid-Willemsvaart (as an alternative to the unreliable river Maas), as well as several canals in Belgium, including the Brussels-Charleroi Canal which played a particularly important role in transporting coal. (Radmilovic & Dragovic, 2007)

- **20th Century.** The twentieth century saw a sharp turn within the tide. In financial terms, the introductory years of the unused century spoken to a continuation of the previous one. Then came the Primary World War, followed by a brief financial restoration and after that the Great Misery of the 1930s, the Moment World War and the Cold War. At long last, there was a huge growth in success within the 1960s. The to begin with mechanized vessels came into utilize within the early twentieth century. After the Moment World War steam ships were quickly supplanted by mechanized ships, and the final wooden cruising ships vanished. This all driven to a major extension in scale, especially after thrust freight boats were presented in 1957. (Beyer, 2018)
- **Inland Navigation in a Nutshell.** This portrayal of the advancement of inland route vessels has concluded the following:
  - Inland route vessels are most suited to bulk transport
  - The appearance of the inner combustion motor and radar made inland route vessels a greatly effective mode of transport
  - The normal vessel measure has developed hugely over a long time, and there's no prospect of a conclusion to this trend
  - Recreational route accounts for a huge extent of activity on numerous waterways

2.2.1 Indus River

Indus River and its tributaries rising from the north join many main towns of Afghanistan, Pakistan, and India with the Arabian Sea. Historically, the capability of connecting main commercial enterprise centres of sub-continent with the ocean thru inland navigation in Indus has existed because the instances of British Raj (Abbas, 2016). In order to govern Sindh, Punjab, fortify their have an impact on withinside the northwest and Afghanistan, and, counter any chance from Russians, the British knew that manipulate on river Indus could be vital. British, therefore, legal a complete survey of river Indus to get admission to its navigational capability. They determined out that the river changed into now no longer as clean and as appropriate for navigation due to the moving nature of the river and issues in delta (Council et al., 2001).

- **Indus Flotilla.** In 1835, the primary ever steam vessel named "Indus" was cruised within the Stream Indus. In 1843, two more steamers named "Planet" and "Satellite" took portion within the British Military Operations related with the success of Sindh territory (Aitken, 1907) From 1852 onwards a fortnightly postal mail benefit was begun between Karachi and Multan utilizing the over specified flotilla vessels. In 1859, another flotilla was organized which afterward got to be to be known as Indus Steam Flotilla. Its constitution was to coordinate with the Railroads between Karachi and Kotri. As profundity of water channel was very shallow in Indus Delta, the terminal of Indus Flotilla was positioned at a little city called 'Jhirk'. At Jhirk, cargo was transported to Indus Flotilla steamers, which took it upstream to Multan and Kalabagh in Northern Punjab/NWFP (Tehsin & Nasir, 2019).
- In 1859, a Railroad Line was opened from Karachi harbor to display day Gizri Stream and it decreased the cargo travel of little pontoons by a few kilometers. In 1861, after the Karachi-Kotri railroad interface opened, the steamer terminal at Jhirk misplaced its significance as all the major cargo was moved to Kotri on rail (Tehsin & Nasir, 2019).
- By 1862, Indus Flotilla Steamers were running all the up to Makhad in Indus and their Punjab operation was called Punjab Flotilla for a whereas. Around same year, the Indus Naval force was canceled and its 2 steamers were given over to the Indus Flotilla Company (Tehsin & Nasir, 2019).
- By 1865, Railroad Line had associated Multan with Delhi by means of Lahore and Amritsar. Due to wastefulness, the Indus Flotilla Company was amalgamated with the Railroads and its administration was exchanged to Lahore.

- In 1878, Karachi was associated to Lahore by means of railroads and Indus Flotilla misplaced its significance as the fundamental implies of communication, in this way canceled in 1882-83 (Tehsin & Nasir, 2019).
- **Rise of Irrigation and demise of Inland Navigation in Indus.** Officers of East India Company had imagined Indus as an Indian Mississippi/Hudson for steam ships navigating the fresh waters. Indus flotilla had operated between Kotri and Multan carrying goods and passengers. And, although, proposals were put up for intercity linkage canals through the Indus, the British engineers saw more economic potential in building irrigation canals on the model of Ganges (Albinia, 2010). While development of railways took care of inland transportation needs, the rivers were diverted into irrigation canals to transform the river basin into what is now known as the largest contiguous irrigation system of the world – IBIS (Indus Basin Irrigation System). The problems posed by the delta only worsened as the development of canal irrigation networks continued to expand. Finally, the large dams under Indus Basin Treaty almost sealed the fate of an inland water way through Indus (Abbas, 2016). Historically inland waterways have played a significant role in trade, commerce and regional integration. The potential of Indus River in this regard has existed in past but never fully exploited. This potential still exists; hence, it is worth exploring this potential in the present day scenario (Tehsin & Nasir, 2019).

2.3 Waterways of the World

The following paragraph discuss various navigable rivers in World.

- **Mekong River.** Mekong River with a length of 4909 km runs through China, Myanmar, Laos, Thailand, Cambodia, and Vietnam forms major trade route between China and South East Asia. With average discharge of 16,000 m^3/s and varying depth of up to 90m navigation of the river is divided between upper and lower Mekong. with the "upper" part of the river defined as the stretch north of the Khone Falls in southern Laos and the "lower" part as the stretch below these falls. From the tripoint of China, Myanmar and Laos the river flows southwest and forms the border of Burma and Laos for about 100 km (62 miles) until it arrives at the tripoint of Burma, Laos, and Thailand. This is also the point of confluence between the Ruak River (which follows the Thai-Burma border) and the Mekong. The area of this tripoint is sometimes termed the Golden Triangle. The river is navigable by seagoing vessels as far as Phnom Penh, the capital of Cambodia, a distance of 550 km but they are prevented from going much further upstream by numerous sandbanks and rapids. Main cargo transported between Thailand's Chiang Saen and China is mostly the refined petroleum products from Bangkok, which is 32% of the throughput. According to the MRC Council Study's assessment, economic gains from the navigation sector increased by $69 billion by 2014, a ten-fold increase over the past 24 years (Zumerchik & Danver, 2010).

Figure 2.2 Inland Waterway use of Mekong River

- **Congo River.** Congo River has a length of 2700 kms which runs mainly through the Democratic Republic of Congo forms one of the main river transportation systems in Africa. With an average discharge of 40000 m^3/s and average depth between 5 – 15 m. Its tributaries form one of the best networks of waterways on Earth. Out of 9320 mi of navigable route, 8390 mi fall in Congo whereas 930 mi are route on navigable lakes. Water traffic is interrupted by various falls and rapids which divides the river into 6 navigable reaches. About 40 % of Inland traffic moves over navigable waterways. Rail lines bypass the unnavigable stretches making the inland transportation possible (Zumerchik & Danver, 2010).

Figure 2.3 Congo River

- **Nile River.** The Nile is a major north-flowing river in northeastern Africa. It flows into the Mediterranean Sea. About 4130 mil long, its drainage basin covers eleven countries: Tanzania, Uganda, Rwanda, Burundi, the Democratic Republic of the Congo, Kenya, Ethiopia, Eritrea, South Sudan, Republic of the Sudan, and Egypt. Maritime transport is most dominant modes of transport for moving freight between the Nile Countries and Global Market. Egypt which has 2450 kms of coast line on Mediterranean and Red Sea has the most developed maritime system.9 out of 11 Riparian Countries have navigable water bodies and a total of 72 navigable ports between them, with Egypt and Uganda having highest number (Zumerchik & Danver, 2010).

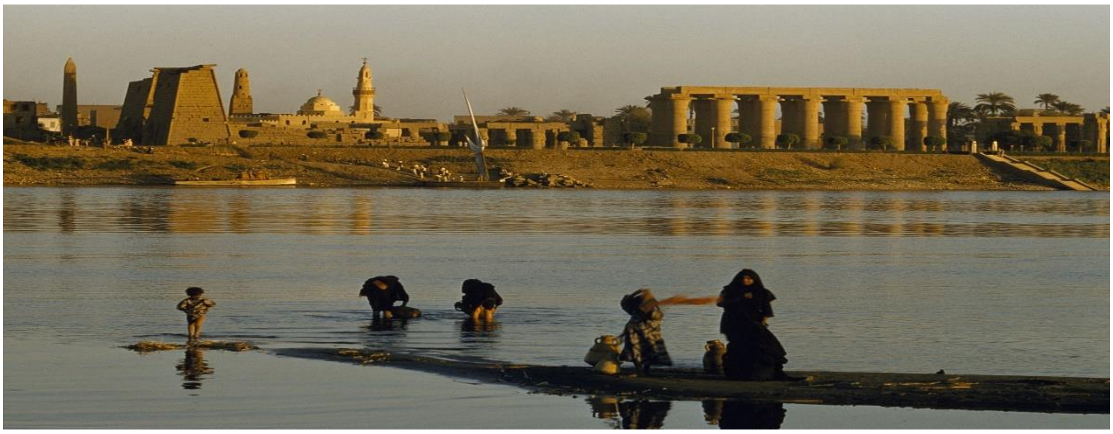

Figure 2.4 Nile River

- **Mississippi River.** Mississippi River is one of the largest drainage systems in North American continent. It is also an outstanding system of inland waterways, consisting of 25000 mi of navigable rivers and canals, of which 12000 mi is commercial waterways and carrying 600 million tons of domestic freight each year. This amounts to 16 % of intercity freight movement in Country each year. Waterways transport about 60 % of Americas grain export, 22 % of domestic petroleum products and 20 % of coal used in electricity generation. This system of waterways is managed by US Army Corps of Engineers with project depth of between 2.7m and 3.7m to accommodate barge transportation (Zumerchik & Danver, 2010).

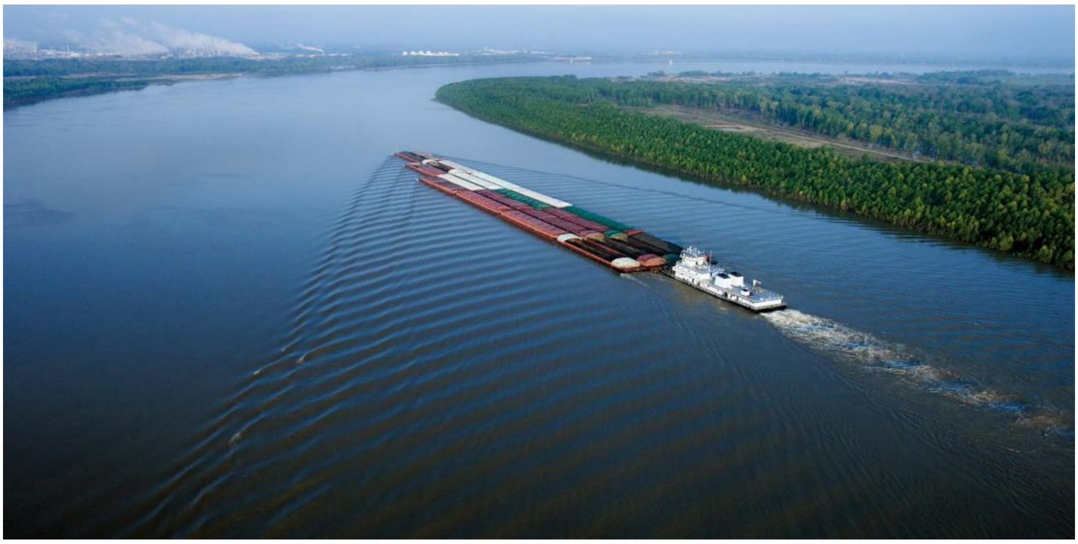

Figure 2.5 Mississippi River

CHAPTER 3

METHODOLOGY

Chapter 3: Methodology

3.1 Introduction

According to the conclusions of the literature review, inland navigation was once practiced on the Indus River. Throughout history, numerous people have emphasized the river Indus's potential for navigation. In addition, there are examples of inland waterways, one each from underdeveloped, developed, and advanced navigation has been discussed. It has been proved that inland navigation existed in the Indus Valley in the past and is now employed by developing and poor economies around the world.

The research approach has been created in such a way that it meets the study objectives outlined in Chapter 1. The approach is described in depth in the following paragraphs under research design.

3.2 Research Design

This research takes an exploratory approach to determining the feasibility of using the river Kabul for inland navigation. The viability of navigation in the river Kabul was investigated using both secondary and primary data sources. The suggested implementation approach, potential system impacts, conclusions drawn, and recommendations for future research are then presented. The following is a step-by-step description and explanation of the individual steps in order.

3.3 Literature Review

The first step was to do a literature review to better grasp the notion of inland navigation and its advantages over other types of transportation. The evaluation focused mostly on research that included a statistical comparison of three types of transportation: roads, trains, and inland waterways. The research looked at cargo carrying capacity, fuel efficiency, safety, and emissions from several forms of domestic freight transportation.

The history of inland navigation was explored next. The geographical relevance, construction tactics, socio-economic and political motives for construction, historical usage, and impacts of the above inland navigation canal systems were all investigated in the literature. Following the study of inland navigation, the literature on the history of the Indus River in terms of navigation was investigated. The establishment, expansion, and eventually the circumstances that contributed to the demise of the Indus Flotilla were all examined in this area of the literature assessment.

The utilization of inland rivers around the world was the subject of the following section of the literature review. It was designed to look at the evidence of inland navigation's existence and efficacy in other economies throughout the world, as well as to suggest the feasibility of navigation in the river Kabul by comparing hydrological, economic, and spatial stretches.

3.4 River Kabul and Its Navigational Potential

This aspect of the research is divided into two parts. The first is primarily a literature review of the Kabul River's previous hydrological status. It also goes through the history of hydrological changes and the causes that have influenced them over the last 150 years. The current state of the Indus and its navigational possibilities were briefly reviewed in the second section.

3.5 Implementation Approach

The recommendations for planning and implementing an inland waterway system are provided in this portion of the study.

3.6 Potential Impacts

This section of the study elaborates on the potential impacts of inland waterways based on the suggested implementation approach. It has been discussed how inland waterways have the potential to enhance the country's socioeconomic situation. Other potential implications that have been addressed include technological, industrial, and agricultural impacts, as well as their internalities for long-term development goals.

CHAPTER 4

HYDROLOGICAL STUDY

Chapter 4: Hydrological Study

4.1 Historical Background

The Kabul River originates in Afghanistan, flows through Afghanistan for about 350 km, and then flows into Pakistan north of the Khyber Pass. It will then travel 140 km through Khyber Pakhtunkhwa in the Peshawar, Charsadda and Nowshera districts, eventually joining the Indus River near the city of Khairabad in the Nowshera district. There are four major tributaries in Afghanistan, and the main tributary in Pakistan is the Swat River.

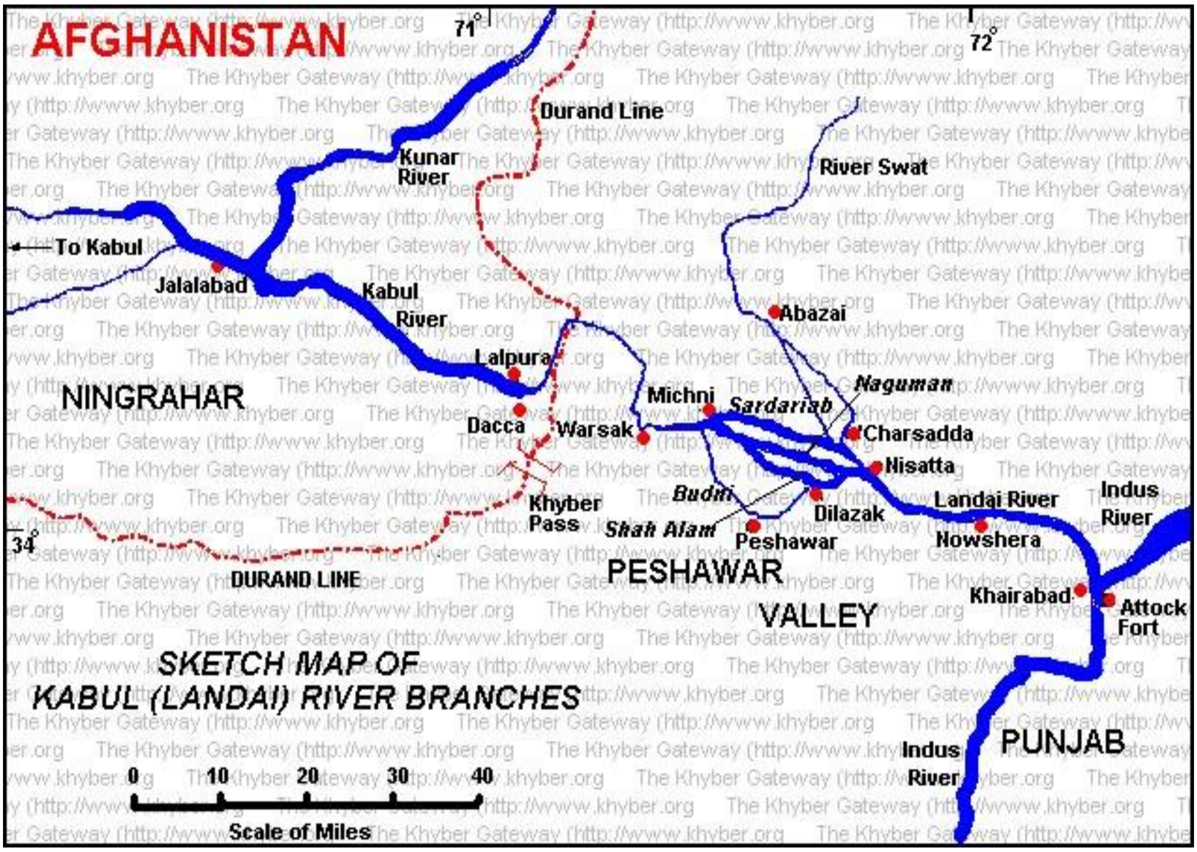

Figure 4.1 Kabul River Branches

The Kabul and Indus rivers meet near the city of Khairabad. The high waters of the two rivers are synchronized, causing very high flood conditions downstream of the confluence. In the last week of July 2010 and the beginning of August, Khyber Pakhtunkhwa (KPK) was hit by very heavy rainfall. The Pakistan Meteorological Bureau reports that it rained 9,000 millimeters a week. This is 10 times the amount of rain that Pakistan normally receives in a year. As a result, rain spills caused unprecedented floods on the Kabul River, which spilled its embankments, flooded large areas and disrupted life and property. The town of Nowshera was hit hardest. About 40% of the Nowshera Army Supply Corps colony and neighborhood were flooded, with thousands of acres of farmland and urban areas in more than 29 villages.

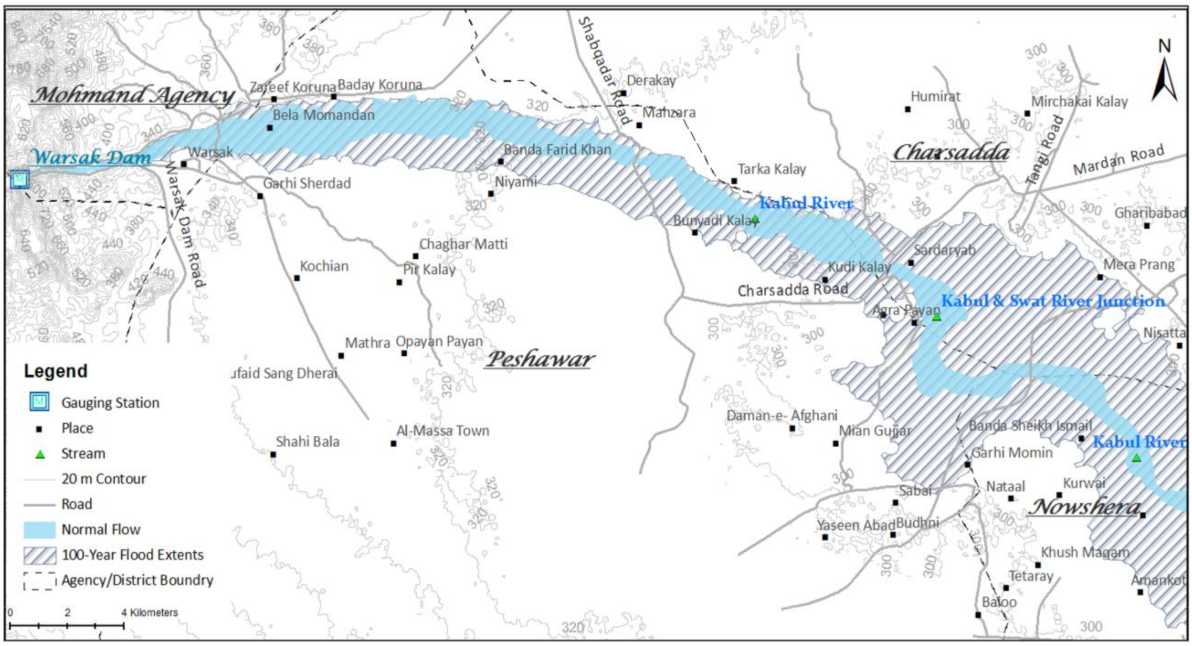

Figure 4.2 100-year floodplain map for the Kabul River in Peshawar, Charsadda, and Nowshera districts

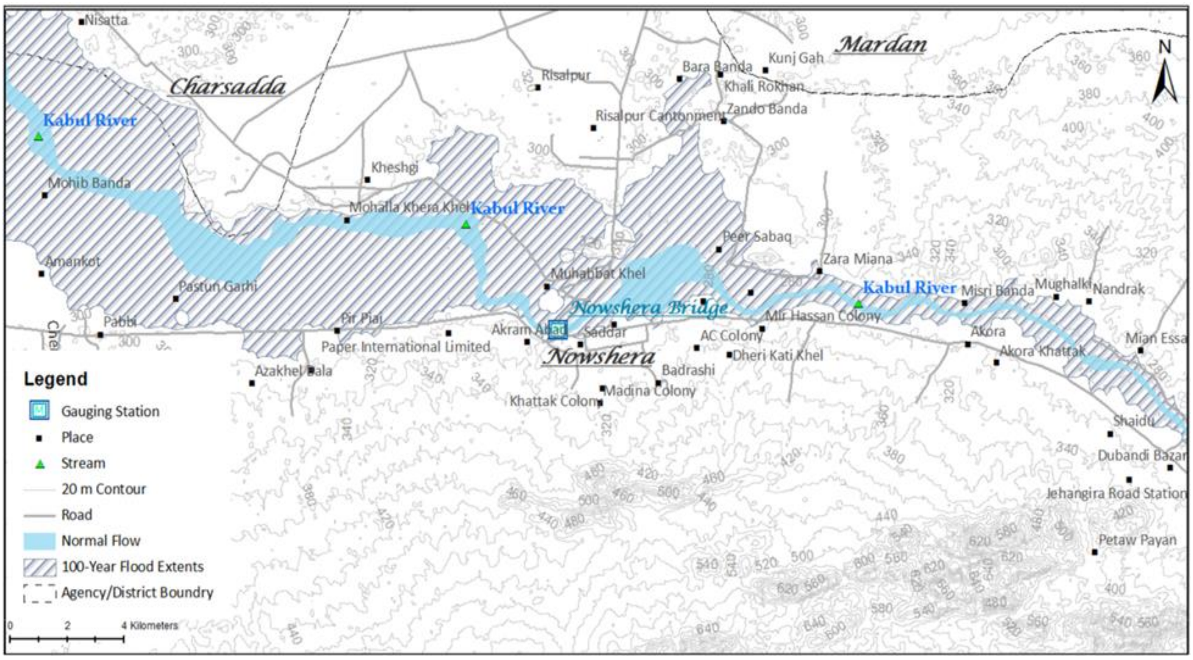

Figure 4.3 100-year floodplain map for the Kabul River in Charsadda and Nowshera district

During the floods the irrigation and drainage network and the flood protection works in the province of the Khyber Pakhtunkhwa (KPK) were extensively damaged. As the flood waters receded it became imperative that the disrupted irrigation channels were immediately restored on priority to save irrigated agriculture from further damages besides carrying out restoration of the damaged flood protection works and other infrastructure on fast-track basis in view of the limited available closure period. The Irrigation Department KPK took cognizance of the prevailing situation and assigned the task of carrying out restoration of the flood damaged works to the Flood Damages Restoration Directorate of the Department. The task also envisaged Master Planning for the construction of new flood protection works after a comprehensive study of the post flood river conditions and the hydrology to obviate the recurrence of such flood devastations in future.

4.2 Current Situation of Kabul and Its Navigation Potential

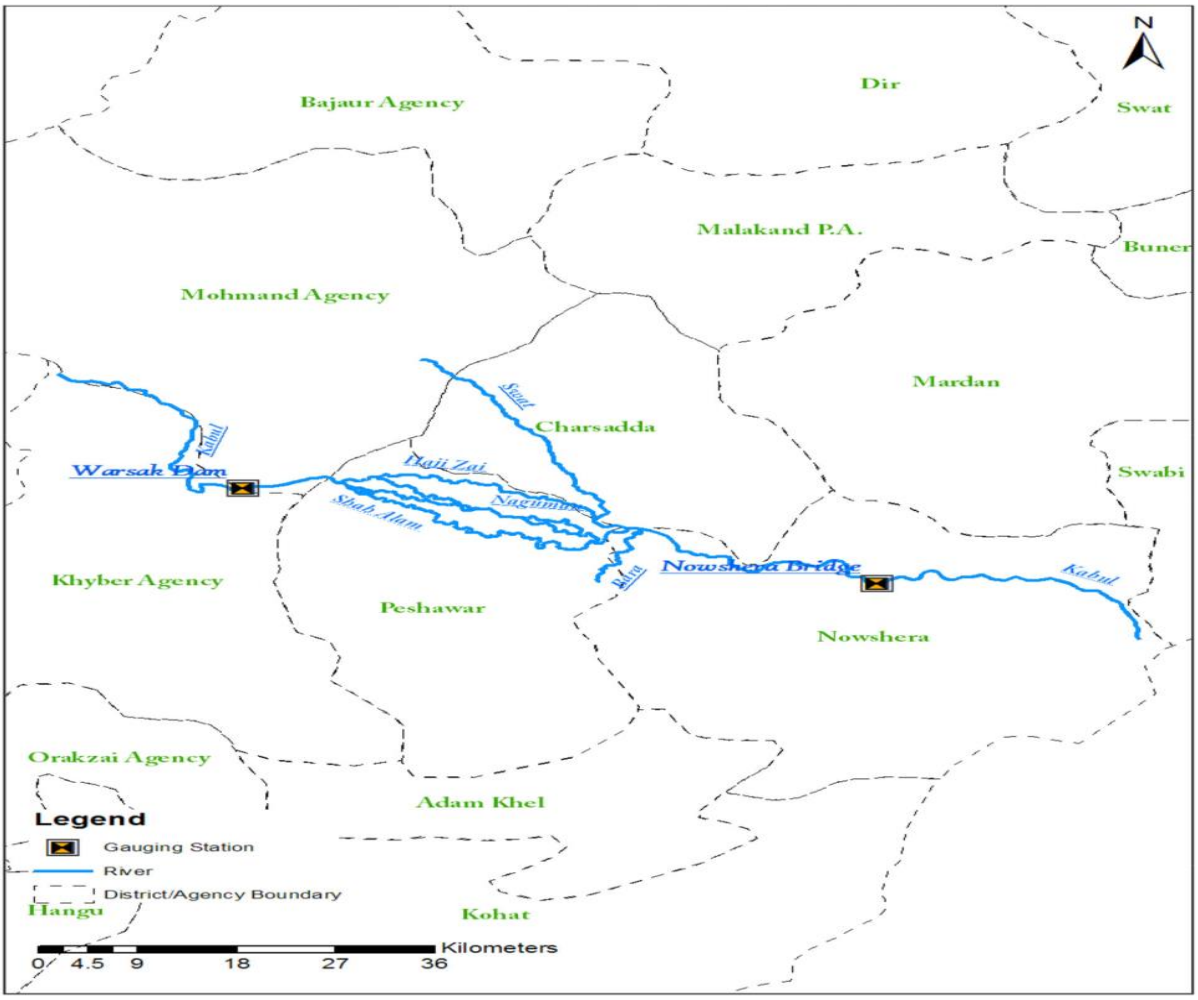

Figure 4.4 Kabul River Flow Pattern

The Kabul Waterway is the project's principal river. Khiali River and Jindi River join from the left, while Bara River joins from the right, beside offshoot streams of the main river, Naguman and Shahalam, which split at an upper contour and reunite in the lower reach. The Kabul River flows for 140 kilometres through Peshawar, Charsadda, and Nowshera districts in Khyber Pakhtunkhwa province, before emptying into the Indus near Khairabad, district Nowshera.

4.3 Hydrological Study

The goal of this research by Irrigation department was to calculate flood levels in the Kabul River at Nowshera Bridge for various return durations. A statistical analysis of related historic meteorological data and discharge data from the Kabul River system was conducted for this aim. The following subsections provide more information on the study.

4.3.1 Discharge Data

Flow data for the Kabul River are available at Warsak and Nowshera. In January 1960, SWHP and WAPDA installed a flow meter on the Nowshera Bridge (longitude 710 58` 50 inches, latitude 340 00` 25 inches) on the Kabul River in Nowshera. Daily water levels are recorded, and low current measurements are taken by the competent authority.

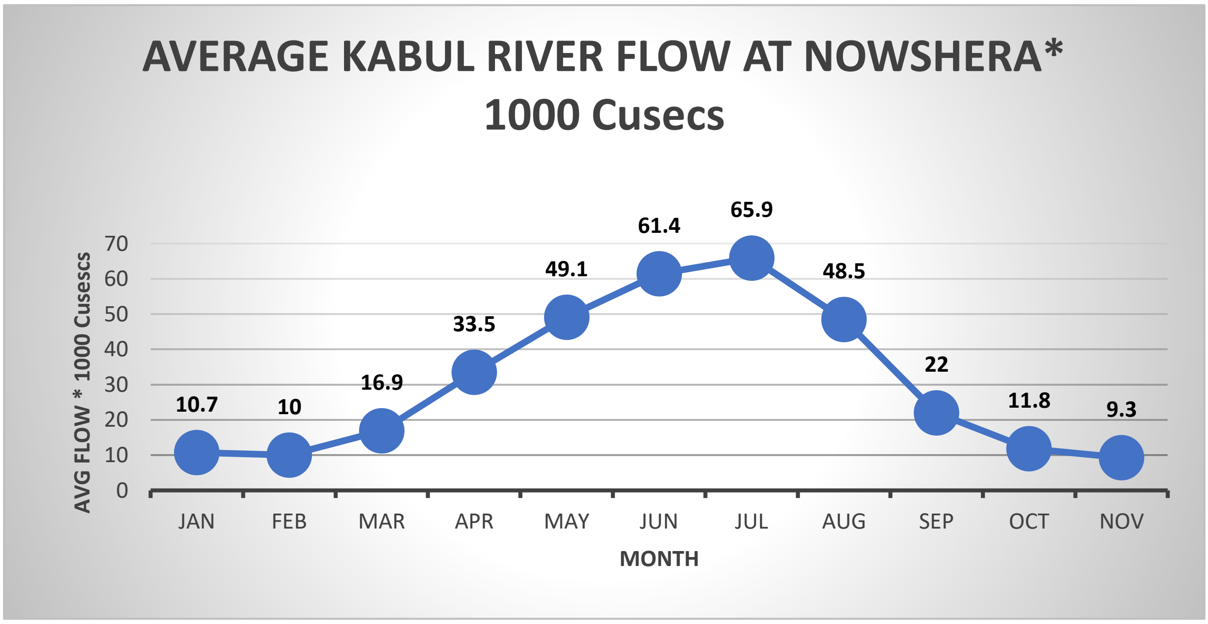

Figure 4.5 Average Kabul River Flow at Nowshera

4.3.2 Flood Data Collection

Peak discharge data from the Kabul River in Nowshera is collected by WAPDA's Surface Hydrological Project (SWHP). The observed data vary from a minimum of 50,377 cubic feet to a maximum of 450,000 cubic feet with a skewness factor of 4.17. Momentary Peak Discharge Data from the Kabul River near Warsak is collected by WAPDA, Momentary Warsak Division, Surface Hydrology Project (SWHP). The observed data vary from a minimum of 38,160 cubic feet to a maximum of 159,700 cubic feet.

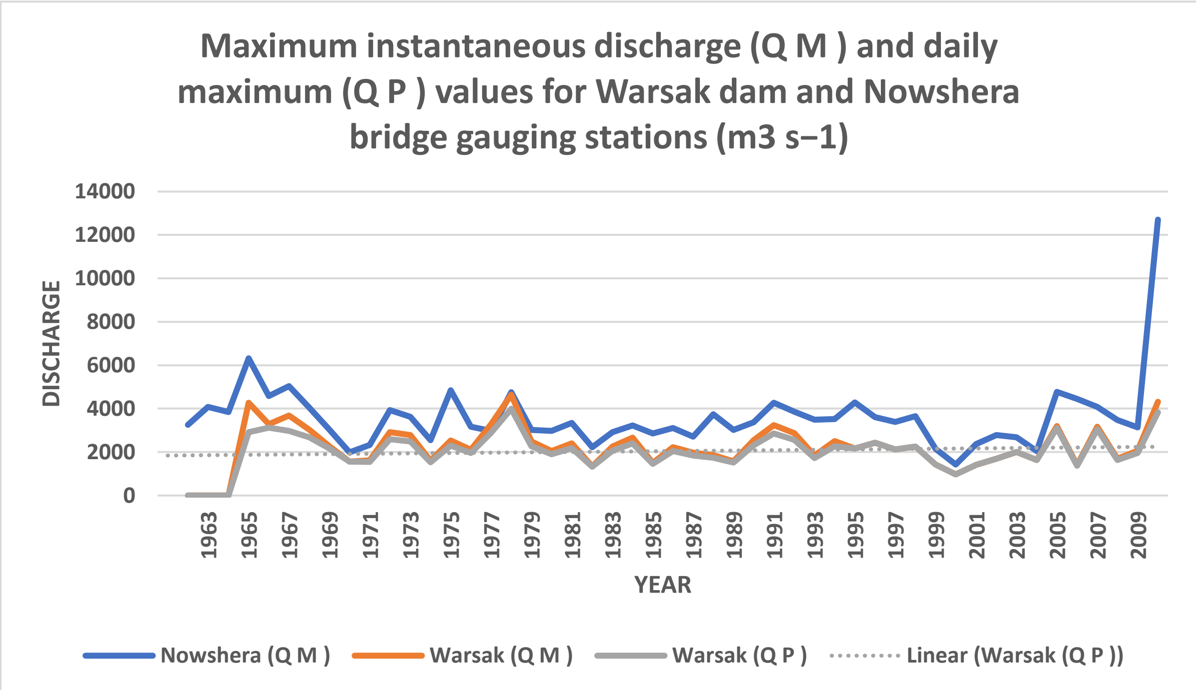

Figure 4.6 Maximum Instantaneous and Maximum Daily Discharge

4.3.3 Rainfall Data

Daily precipitation data for Peshawar and Risalpur is collected by the Lahore Meteorological Authority. The average monthly rainfall in Peshawar varies from 0.47 inches to 3.02 inches, while the average annual rainfall over the corresponding period is 18.87 inches. The average monthly rainfall in Risalpur varies from 0.51 inches to 5.26 inches, while the average annual rainfall over the corresponding period is 26.85 inches.

4.3.4 Temperature Data

Monthly temperature data for Peshawar is collected by the Lahore Meteorological Bureau. The data show that the average maximum temperature varies from 18 degrees Celsius to 41 degrees Celsius, while the average minimum temperature varies between 2 degrees Celsius and 27 degrees Celsius.

4.4 Hydrological Modifications in the Kabul

River Course and Meandering Pattern section of Master Planning Report carried out by Irrigation department reveals that there have been no major changes in the river course except some erosion taking place on the concave sides of the meanders at certain locations and the river follows a stable course. The Irrigation Department has constructed several stone studs to check the river erosion and save the loss of precious agricultural lands.

The river belt in this reach is well defined and cannot be encroached upon to accommodate the meandering of the river under wide winter and summer discharge variations. It is not conducive to construct long spurs for training the river course and the technique of stone studs having appropriate lengths can be adopted for the purpose whenever required.

4.5 Current Hydrological State of river Kabul and Its Navigation Potential

River flow forecasting is important for water resources management, environmental protection, navigation, flood control, draught protection, reservoirs management and water allocation.

- The total Kabul River inflow received at the Pakistan Border in a year is about 19.35 BCM of which 9.44 BCM (49%) is contributed from Afghanistan through Kabul River while 9.91 BCM (51%) is contributed through Chitral River. After the joining of Swat River and Kalpani Nullah inside Pakistan, the mean accumulative inflow of Kabul River received every year at Nowshera is 26.23 BCM, i.e., 5.23 BCM in October to March and 21 BCM in April to September.

- The annual (1977–2015) mean river inflow of 26.23 BCM with a range of 13.77 to 42.2 BCM and standard deviation of 6.026 BCM reveals no significant fluctuation in the transboundary mean annual inflow. The fluctuation in highest and lowest annual river inflows can be attributed to climatic variability or droughts in the last 39 years.
- The stream flow pattern shows that the mean monthly inflow of Kabul River at Nowshera starts increasing in March/April and peaks (4.94 BCM) in June/July (International Union for Conservation of Nature, 2014).
- According to the data collected to obtain the actual prism of the river/stream at the appropriate distances by means of sounding for the stream and total station for the dry portion, shows the bed level, surface level and maximum flood level. The minimum bed level is 861.57 ft, figure 4.7.

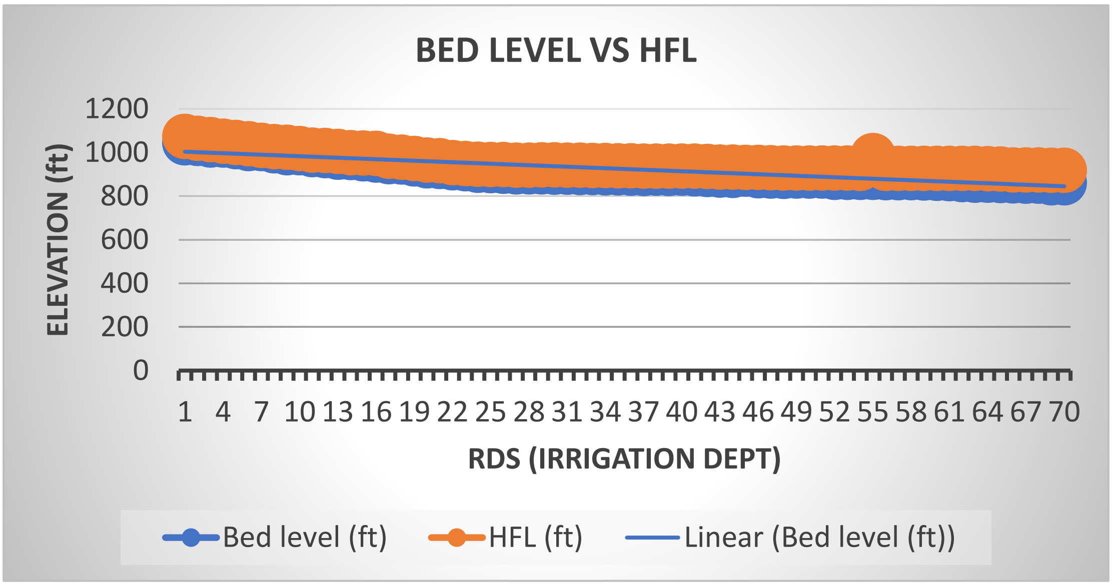

Figure 4.7 Bed Level Vs HFL of Kabul River

- Water bodies were extracted from the classified images of respective years and overlaid on one another to analyze the temporal changes in the river course in last 30 years. Significant changes in the Kabul River course were noted at two different locations, which are identified in fig 4.8. These changes might be due to anthropogenic activities or due to artificial floods created by opening, during the flood season, of the spillway gates of Warsak Dam, which is constructed on Kabul River about 30 km upstream of Peshawar.

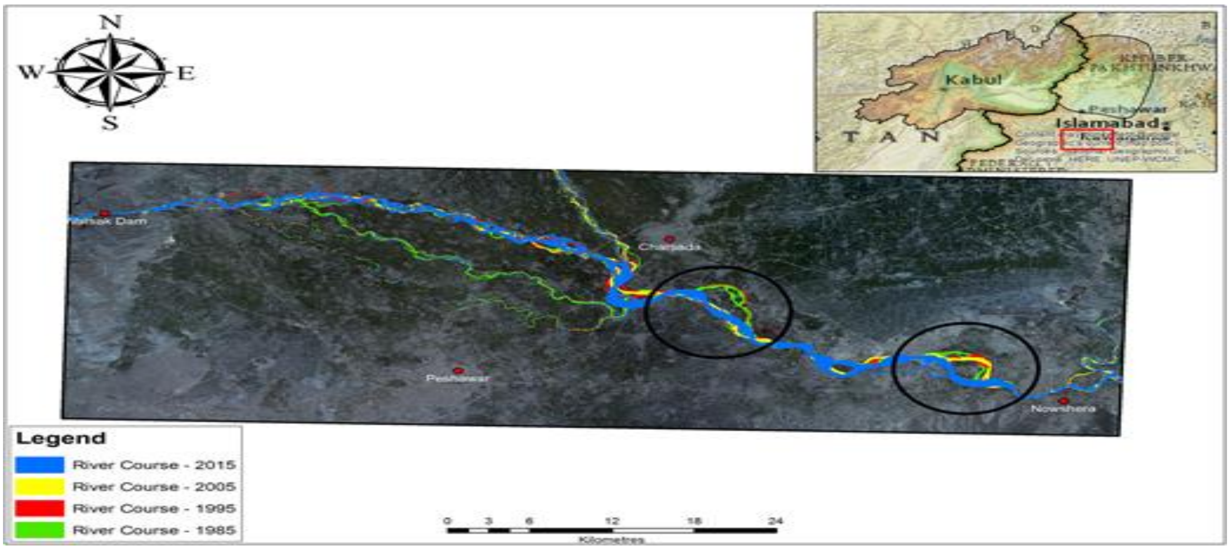

Figure 4.8 Kabul River in Different Time Periods

4.6 Conclusions

The above discussion shows that:

- The river course indicates no major changes which goes in favor of Kabul river being good for navigation.
- Minimum bed level is 861.57 ft with flow level as 918 ft which is greater than 4m (13.12 ft) required for navigational purposes as per European Standard for Inland waterways.
- Floods of 2010 were due to heavy Monsoon rainfall which started from 27th July and prolonged till the month of August made the rivers surge and overflow causing havoc in the target area. These rainfall systems in July-August were due to interaction of Monsoon and mid-latitude Westerlies (winds blowing from the west to the east steering extratropical cyclones). This is not a frequent phenomenon as there is difference in rainfall between 2010 and the long-term average for the region.
- Moreover, the current hydrological state of Kabul River indicates good inflow of water which also makes it suitable for navigation.

CHAPTER 5

KABUL DELTA

Chapter 5: Kabul Delta

5.1 Introduction

For the viability of an inland waterway, it is required to assess the availability of water in the river. Global Surface Water Explorer, developed by the European Commission's Joint Research Centre (EU JRC), provides a global surface water database for analyzing water availability. It provides remote sensing data on the presence and availability of surface water in this vital area. Water occurrence, water occurrence change intensity, water seasonality (from 2014-2015), and water transitions (from first to last year) are discussed in the following paragraphs from 1984 to 2015.

5.2 Kabul Delta

5.2.1 Water Occurrence

Water occurrence represents where the water surface appeared, between 1984 and 2015. The graphic depicts both intra-annual and inter-annual water availability. The frequency of water presence is measured by water occurrence. Figures depict the presence of surface water in the river section under investigation. Permanent water surfaces are depicted in blue, while locations where water appears only occasionally are depicted in pink to purple (0% < occurrence < 100%). The lighter colors denote locations where water is less likely to occur.

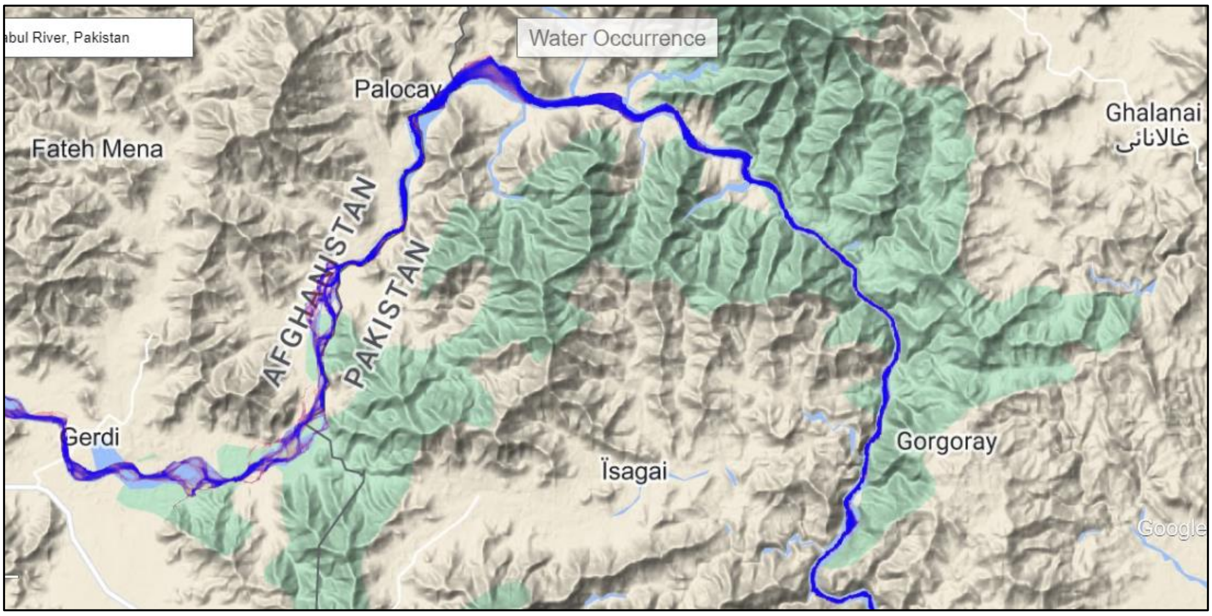

Figure 5.1 Water Occurrence Path Of Kabul River

In the box section of below figure we can see that river is dominated by blue colour which represents a relatively wider and permanent flow section of the river. This implies that the water in this section is mostly permanent and occurs all-round the year. In the section highlighted by small circles the paler shades dominate representing that the occurrence of water is not permanent in this part of the channel.

Figure 5.2 Water Occurrence Path Of Kabul River

5.2.2 Water Occurrence Change Intensity

The water occurrence change intensity imagery depicts where surface water levels have risen, fallen, or remained constant. The intensity of colour represents the degree of change. Green denotes an increase in surface water, red denotes a reduction, and black denotes places where there has been no substantial change in water occurrence between 1984 and 2015. The presence of water in the river has not changed considerably during the last 32 years, as seen in Figure.

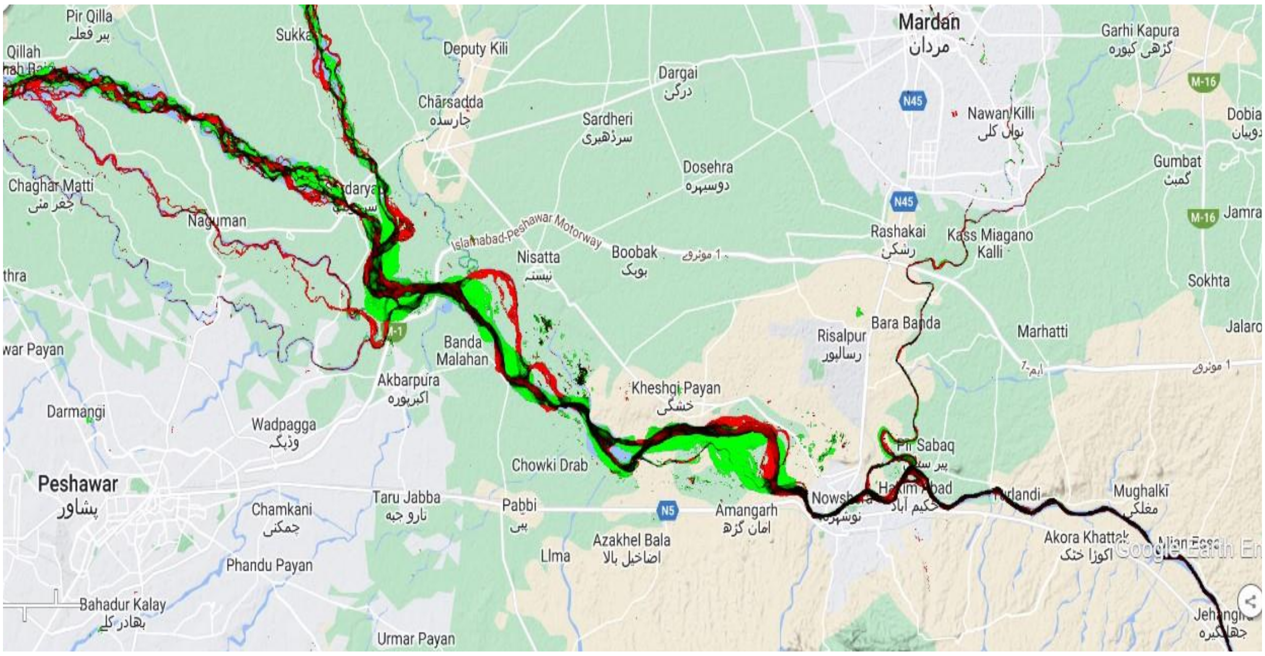

Figure 5.3 Water Occurrence Change Intensity of Kabul River

5.2.3 Water Seasonality

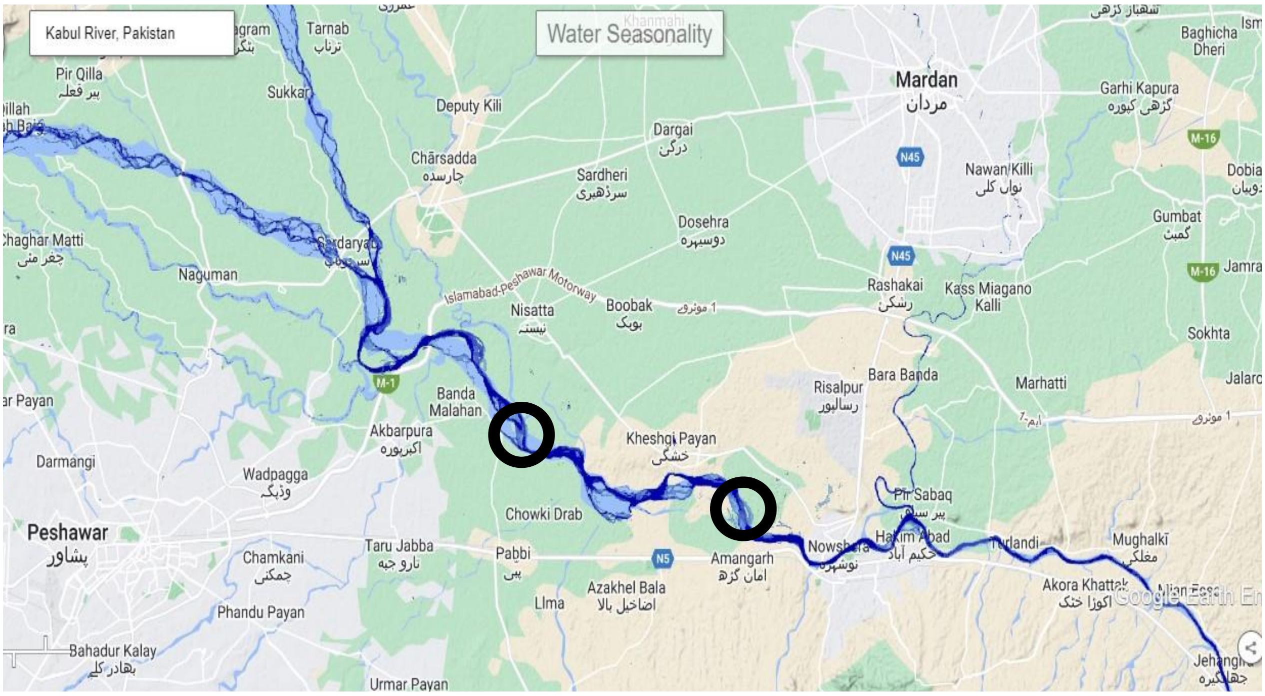

Figure 5.4 Water Seasonality of Kabul River

The intra-annual presence of water in the river channel is measured by water seasonality. It depicts the intra-annual behavior of water bodies, distinguishing "permanent" from "seasonal" water bodies. Permanent water is depicted in blue, whereas seasonal water is depicted in lighter blue (data is scaled from 1 month to 12 months per year). Figure depicts water seasonality, indicating that the river reach is mostly permanent. There are a few stretches of the river where the seasonality index is around "6," indicating water scarcity throughout parts of the 2014-2015 year.

5.2.4 Annual Water Recurrence

It represents the number of times water returns from one year to the next (as a percentage). It is possible to distinguish between areas that are flooded on an episodic basis (variant of orange) and those that are flooded on a regular basis (blue). Figure shows that areas are are flooded on regular basis as blue color dominates the river path.

Figure 5.5 Annual Water Occurrence of Kabul River

5.3 Results

The water occurrence, water occurrence change intensity, water seasonality and annual water recurrence imagery of the river show that water availability is overall good. However, there are some sections and few patches highlighted in the imagery where flow is comparatively less. It is important to note that some distance before Nowshera till Khairabad the imagery shows increased availability of water.

CHAPTER 6

PRESENT BOATING SYSTEM

Chapter 6: Present Boating System on Kabul River

6.1 Introduction

Boat is a watercraft that is designed to work in shallow waters and have huge maneuverability advantages as large ships. Traditionally people use to differentiate boats from ships on their size. There are different types of boats used world widely than one can possibly imagine but generally boat can be classified in to 3 main categories and more than 15 subcategories. Three main categories of boats are as following:-

- Unpowered Boats
- Motor Boats
- Sail Boat

These categories are sub divided in to further sub categories which are as following:-

- Fishing Boats or Trawlers
- Tug Boats
- Deck Boats
- Life Boats
- Sail Boats
- Cuddy Boats
- The Pontoon's or Pontoon type Boats
- Ferry Boats
- House Boats
- Bay boats
- Bow rider Boats
- Convertible fishing Boats
- Dual console Boats
- Inflatable Boats
- Utility Boat

These are the boat types used world widely for inland transportation depending upon usage and purposes (Khuram et al., 2014).

6.2 Present Boating System on Kabul River

In river Kabul few of sub categories boats are used at various places depending upon usage and purposes which are as following:-

- Fishing
- Recreation
- Rescue
- Emergency Operations

Few of the types of present boating system available in river Kabul will be defined in detail with few characteristics which are as following:-

6.2.1 Fishing Boats or Trawlers

Boats that can be used with some handheld fishing gears. Traditionally a fishing boat is used to be a wooden hull structure made from simple tools. These are used to catch fishes in fresh and sea waters. Further these small scale boats are commonly used in fresh and salt waters for low scale or recreational fishing. These small boats are designed to give better maneuverability, comfort and help while catching fishes. In river Kabul these are used at various places for the purpose of recreation and fishing and owned by old traditional boaters who were related to boating business for many years (Khuram et al., 2014).

Figure 6.1 Fishing Boats

6.2.2 Tug Boats

These small boats whose main job is to help maneuver large boats/Bridging Equipment even in congested areas. The main advantage of tug boats over other boats is its high power to weigh ration and great maneuverability and 3-4 HP four stroke diesel engine is used. These are manly held with Pakistan Army Engineer Corp and used for bridging exercises near Akora Khattak.

Figure 6.2 Tugboats Used By Military

6.2.3 Life Boats

A life boat are these rigid hulled inflatable small boats used for rescue and search operations during emergency conditions. These boats are generally used to carry passengers to safe places; and these boats hold all basic necessary from tools to first Aid and signaling equipment. These are mostly held with Rescue 1122 and Pakistan Army and used in flooding or any emergency to rescue the people and save their life in any calamity.

Figure 6.3 Life Boats for Rescue

6.2.4 Inflatable Boats

Inflatable boats are light and constructed of tubes filled with pressurized air. These can be made of any three materials PVC, Hypalen, and Polyethylene usually 6 to 14 feet in length they may or do not have aluminum floor bed. These boats have an outward motor for propulsion which is installed separately once fully charged with pressurized air. These boats are used for rescue operations, emergency services, river rafting and solo fishing. Suitable for shallow water and easy to deflate and store (Khuram et al., 2014).

These boats are held by Rescue 1122 and Pakistan Army used for rescue, emergency services and held by KPK tourism department for recreational activities such as rowing competitions.

Figure 6.4 Inflatable Boats Used By Rescue Workers

6.2.5 Utility Boats

Utility boats are the most basic yet powerful boat idle for fresh water. Made to last in tough conditions it is usually made with aluminum. This is used mostly where the water is calm or shallow. This flat bottomed vessels can range between 12-20 feet in length. Its features are open hull construction with 2-3 sitting bench idle for fishing and local recreation. These boats are simple, inexpensive and is east to maintain (Khuram et al., 2014). These boats are held by Pakistan Army and Rescue 1122.

Figure 6.5 Utility Boats

CHAPTER 7

IMPLEMENTATION APPROACH

Chapter 7: Implementation Approach

7.1 Introduction

The availability of sufficient water in Kabul River, which encourage inland shipping, have already been mentioned. However, development of still canals can be used to bypass impediments such as bridges, barrages, and dams, as well as to resolve difficulties of low draft availability. According to the Mississippi inland navigation model, the projected still canals can have a minimum depth of 9-12 feet. Furthermore, canals can be created to connect the trade and commerce centers on both sides of the river, giving these centers direct access to the major Navigation Channel. Inland navigation may be difficult due to steep slopes in the upper stages of the Kabul River and its tributaries. Inland travel is possible with the use of a well-designed system of locking gates that can accommodate steep slopes.

7.2 Using Solar Energy and Electric Engine Powered Barges

Port-Liner, a Dutch business, planned to launch an electric barge and charging station system powered by renewable energy in 2018. To make loading and unloading easier, the barge is intended to carry battery packs within 20-foot shipping containers. When it arrives at the shipping terminal, it may either swap empty batteries for fully charged ones or plug in to charge the batteries directly (Peters, 2018). It is possible to power the inland shipping system with solar energy using this broader knowledge base and today's cutting-edge technology of solar barges. The plan may only allow electric motors to be used to power barges, ferries, and other vessels when solar charging facilities are installed at inland ports. This would make the entire system more ecologically friendly and sustainable. Furthermore, the transportation costs of electric powered barge engines would reduce inland towing prices down dramatically compared to diesel engines. This, in turn, would provide a financial cushion as well as a reduction in the system's carbon footprint (Shafique, 2018).

7.3 Inland Port Cities

The notion of sustainability can be used to build inland port cities that may emerge because of developing Indus inland navigation. Solar energy as a source of power for the ports could be considered. Charging stations for electric barges can recharge batteries by changing out empty cells for fully charged ones. Inland port facilities may be constructed to provide enough handling capacity for the various types and quantities of cargo that the port is expected to handle. Regulations may be enacted to limit land use through zoning rules to maximize cargo processing and industrial units as close as feasible to the port.

Road and rail infrastructure might be built to provide access to farmers and industry, allowing for smooth port operations. Solar power could be used as part of an energy solution for towns and local industries.

7.4 Safety and Reliability

The most up-to-date technology and logistics should be used. As a result, river navigation can be portrayed as a safe and dependable mode of transportation. Because the business will be the first on the river, it will be able to demonstrate the most up-to-date navigational equipment and logistical improvements. This could open up a market for newly developed technologies that are having trouble finding a place in existing established inland navigation systems around the world. Ships and barges used for inland navigation, for example, are powered by fossil fuels. In order to service large ships and barges, infrastructure and logistics have emerged.

The Kabul inland waterway system can take use of this potential and adapt to current river navigation trends. This will not only help to build local industries and infrastructure, but it will also result in the production of qualified individuals who are familiar with the application and operation of cutting-edge technology.

7.5 Federal Administration of Water

The constitution's 18th amendment has relegated water resource management to the provinces. As a result, political power has influenced the projects and regulations executed across multiple provinces, resulting in inter-provincial water conflicts. Water resource management might be separated from political influence and handled by a single organization made up of professionals from various sectors to fully execute the inland navigation system.

To begin, the project's initial phase might be from Khiali below Warsak to Nowshera, and it would not require the consent of several province governments as required by the constitution's 18th amendment. The project's initial phase can portray inland navigation as a revenue-generating business with strong economic prospects for all provinces, resulting in a win-win situation for all. This could motivate others provinces to make inland navigation easier and eventually expand into Punjab and Sindh.

7.6 Involvement of Stakeholders

It is critical to identify and address the needs and concerns of all stakeholders who may be affected directly or indirectly by the proposed inland waterway's implementation. The population of port cities, existing enterprises, and other stakeholders are among these stakeholders. It may not be possible to maximize the benefits of the proposed system for local communities without this.

7.7 Minimum Navigation Channel Requirements:

` The European Standard for Inland Waterways of International Importance has established Class IV as the minimum standard for waterways of international importance (Shafique, 2018). Class IV Minimum Navigation Channel Requirements are:

• Draught = 2.5 – 2.8 m

• Length of Motor Vessels and Barges = 95 – 110 m

• Beam of Motor Vessels and Barges = 11.4 m

• Tonnage = 1500 – 3000 tons

• Minimum Radius of bends in navigable channel = 360 m

• Minimum total depth of navigable channel = 4.0 m

7.8 Electric Barges for Transport

The latest available technology, as stated in the implementation approach, may be used in the initial phase for its reliability and societal acceptance. As a result, the projected electric barges from the Dutch company Port Liner might be used. Following are the key characteristics of the proposed electric barge (Shafique, 2018).

- Length: 110 m
- Beam: 11.4 m

- Four Battery Boxes capable of 35 hours of autonomous driving
- 270 container capacity
- Compatible with Class IV specifications
- Zero Emission Transport
- Cost per unit 4 million USD

Figure 7.1 Electric Barge

7.9 Channel Design

The proposed Channel cross-section conforming to European Class IV specification is shown in Figure. The channel cross-section has been proposed for allowing two-lane traffic of barges on the navigation channel. Following are the design characteristics of the channel cross-section:

- Total depth of navigable channel = 4.0 m
- Draught provision = 2.8 m
- Navigable Channel Width = 90 m
- Minimum radius of bends = 360 m (PRŠIĆ, 2011)

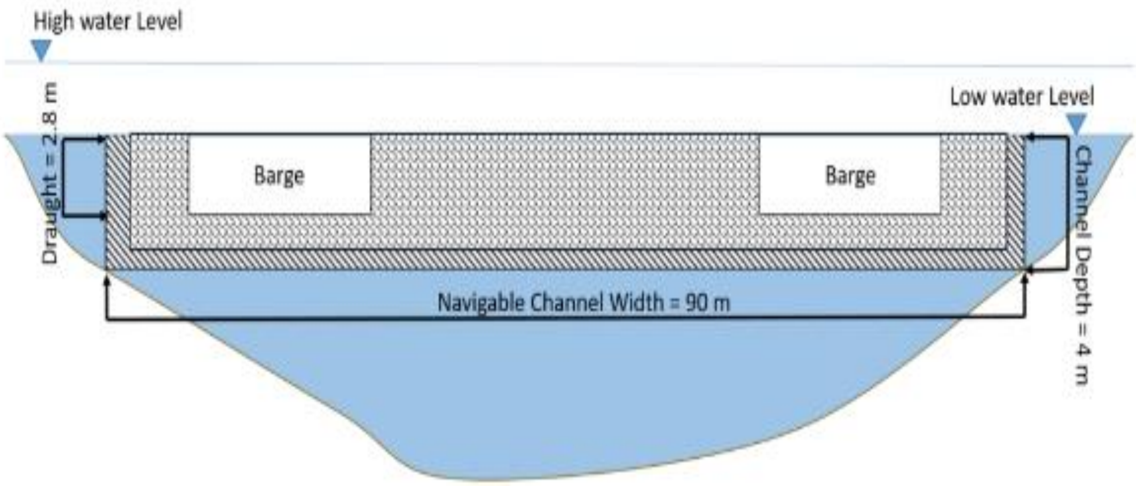

Figure 7.2 Inland Waterway Channel Design

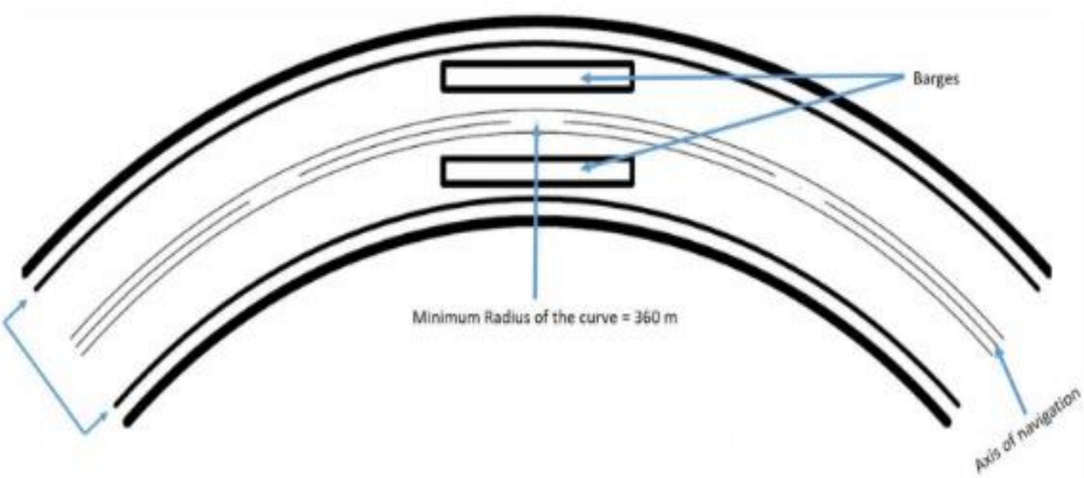

Figure 7.3 Minimum Radius Of Curve

This conceptual design is recommended to be executed so that navigation in the channel can be done even when the water level is low. Detailed design based on the local characteristics of the river at different reaches of the project could be done for this purpose.

7.10 Block Plan for Major Components of Inland Port

A conceptual block plan of major components of inland port to be established may consist of:

- Harbour facilitating cargo transfer
- Residential Area for Port Employees

- Solar Power Park for power generation
- Recharging and maintaining Electric Barge Battery Packs at solar power park facility
- Power Production for Industrial, Residential and Harbour
- Rail/Road Access to Industrial Area, Solar Park and Harbour
- Road Access to Residential Area

The block layout depicts a concept in which the industrial facility is located as close as possible to the Harbour facility. This allows raw materials and processed goods to be transported between the harbour and industry over a short distance, using both rail and road transportation services (Shafique, 2018).

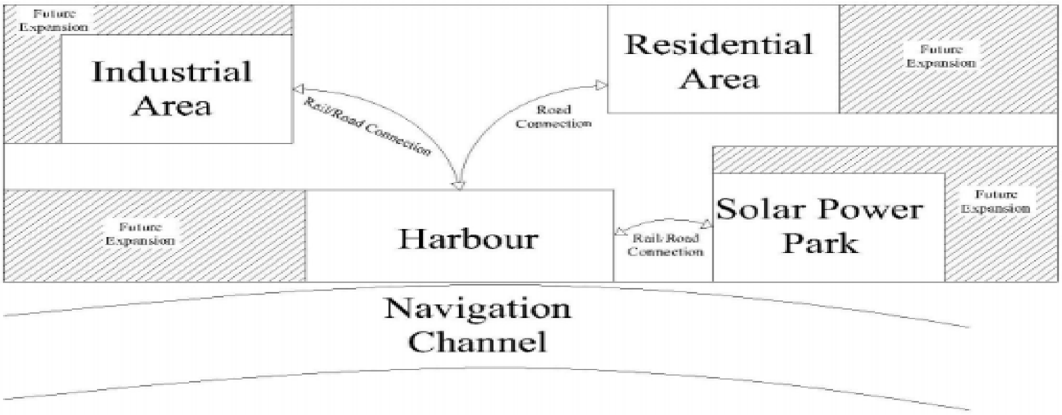

Figure 7.4 Block Layout of Harbour for Inland Waterway

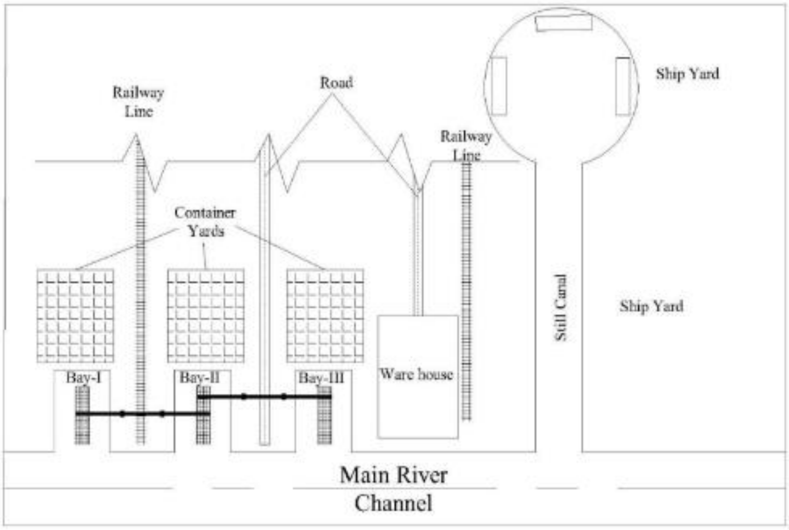

Figure 7.5 Layout of Channel for Inland Waterway

7.11 Calculation Regarding Inland Waterway Economy

In the design considerations, the selected annual cargo handling capacity of river Kabul is considered 7 million tons. The Inland Waterway channel from Warsak Dam to Karimabad has total navigable distance of 95 km. An equivalent road infrastructure consists of Grand Trunk Road whose length is about 105 km. The infrastructure costs for every ton-km for both inland waterways and roads have been taken from report titled “The Future of Freight Transport and Inland Navigation in Europe” (The Power of Inland Navigation the Future of Freight Transport and Inland Navigation in Europe, 2013).

7.11.1 Costs Estimated

Following is break down of the costs estimated by the study:

Table 7.1 Infrastructure and External Cost per ton-km for Roads and Inland Water Way

Type of Cost	Mode of Transport	Value
Infrastructure Cost (Construction and Maintenance)	Roads	$ 0.59 per ton-km
	Inland Shipping	$ 0.95 per ton-km
External Cost (Safety, nuisance etc)	Roads	$ 2.24 per ton-km
	Inland Shipping	$ 0.12 per ton-km

For using the cost provided in Table, the calculation for ton-km is given:

Table 7.2 Calculation for Ton-Km

Inland Shipping	Road Equivalent
Length of Inland Waterway = 95 km Cargo Load = 7 million tons Ton-km = 665000000 Total infrastructure cost = $ 0.63 Billion(@ $0.95 per ton-km) Total External Cost = $79.8 Million(@ $0.12 per ton-km)	Road Length = 105 km Cargo Load = 7 million tons Ton-km = 735000000 Total infrastructure cost = $0.43 Billion (@ $0.59 per ton-km) Total External Cost = $ 1.64 Billion (@ $ 2.24 per ton-km)

Total Infrastructure and External Costs for Inland Water Way Vs Equivalent Road Infrastructure from Warsak Dam to Karimabad

Table 7.3 Total Infrastructure and External Costs for Inland Water Way Vs Equivalent Road Infrastructure

Costs	Inland Waterway	Equivalent Road Infrastructure
Total Infrastructure Cost (Construction & Maintenance)	$ 0.63 Billion	$ 0.43 Billion
Total External Cost (Safety, Nuisance, emissions etc.)	$ 79.8 Million	$ 1.64 Billion

7.11.2 Annual Savings

The following paragraphs include the assumptions and calculations which are involved in determining the annual savings in comparison with equivalent road infrastructure from Warsak Dam to Karimabad.

Total cargo under consideration = 7 million tons

Equivalent TEUs = 325,000

Table 7.4 Annual Savings for Inland Water Way Vs Equivalent Road Infrastructure

Inland Waterway	Equivalent Road Infrastructure
Length of route = 95 km Annual Fuel requirement = 0 (Use of Electric Barge) Assuming uniform to and fro movement of cargo in Kabul River No. of barge trips required = 325,000 TEUs/270 (@ 270 TEU per barge) = 1200 barge trips (Peters & Adele, 2018) Assuming the speed limit for proposed electric barge to be 10 knots (Marine Department, 2000) 10 knots = 18.5 km/hr Travel Time for one barge trip = 95/18.5 = 5.13 hours approx. Total Travel time for 1200 barge trips = 6156 hours Considering annual maintenance cost per km for waterways = $ 31,000/km/year (Christa, Sys, Vane , Islander, & Thiery, 2011) Total Annual Maintenance Cost = 31,000 x 95 = $ 2.9 million	Length of route = 105 km = 65.24 miles Ton-miles moved per gallon of fuel = 150 (Kruse, Jeffery, & Leslie, 2017) Total ton-miles = 7,000,000 x 65.24 = 456680000 Annual Fuel Requirement = 456680000/150 = 3044533.3 Gallons = 11508336 liters ≈ 11.5 million liters Fuel Cost per liter (Diesel) = $ 0.77 (144.15 Pkr) Annual Fuel Cost = $ 0.77 x 11500000 = $ 8.85 million Assuming movement of cargo to and from the Kabul River No. of trucks trips required = 325,000 TEUs/2 (@ 2 containers per truck) = 162,500 truck trips Assuming speed limit for truck traffic to be 100 km/hr Travel time for one trip = 105/100 = 1.05 hours Total Travel time for 162,500 trips = 170625 hours Value of one hour of transit time for cargo on trucks = $ 31 per hour (Oregon Department of Transportation , 2014) Assuming annual maintenance cost per km for roads = $ 41,000 (Christa, Sys, Vane , Islander, & Thiery, 2011) Total Annual Maintenance Cost =$ 41,000 x 105 = $ 4.3 million

7.11.3 Calculating Savings

Annual Fuel Requirement for Inland Waterway Transportation is zero

Annual Fuel cost saving = $ 8.85 million

Annual cargo transit time saving = 170625 – 6156 = 164469 hours

Annual cost saving of cargo transit time = 164469 x 31 = $ 5.09 million

Annual maintenance cost saving = 4.3-2.9 = $ 1.4 million

7.11.4 Summary

Table 7.5 Annual Savings and Cost Summary for Inland Water Way Vs Equivalent Road Infrastructure

Saving	Value (million USD)
Annual Fuel Cost Saving	8.85
Annual Cargo Cost Saving	5.09
Annual Maintenance Cost Saving	1.4
Total Saving	15.3

7.12 Efficacy of Electric Barge Against River Flow

Electric Barge by PortLiner has been designed for ports of Amsterdam and Rotterdam. River Amsterdam average current is about 2.5 m/s average. On the other hand current of river Kabul increases after April every year and maximum current is in range of 2.5 to 3 m/s. Average flow is about 250 cumecs as depicted in fig 7.6. Average flow at Amsterdam is 2200 cumecs with lowest 800 cumecs as depicted in fig 7.7. The data indicates that electric barge will be appropriate to be used in River Kabul.

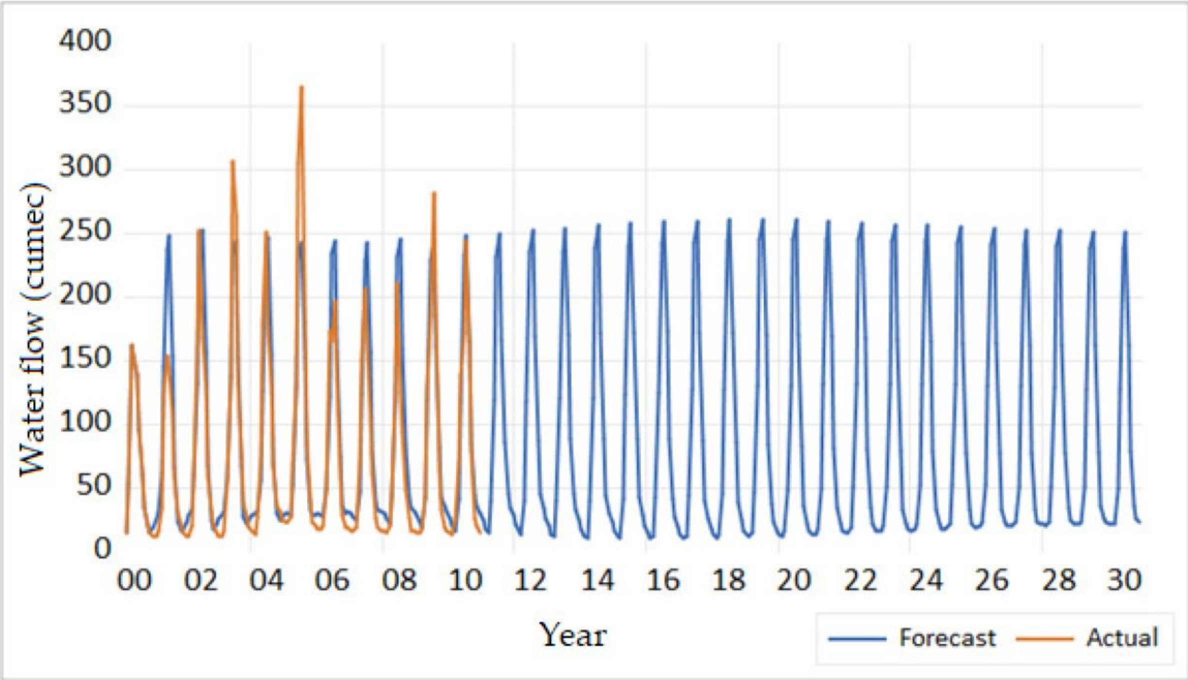

Figure 7.6 Forecasted and Actual Waterflow in Kabul River

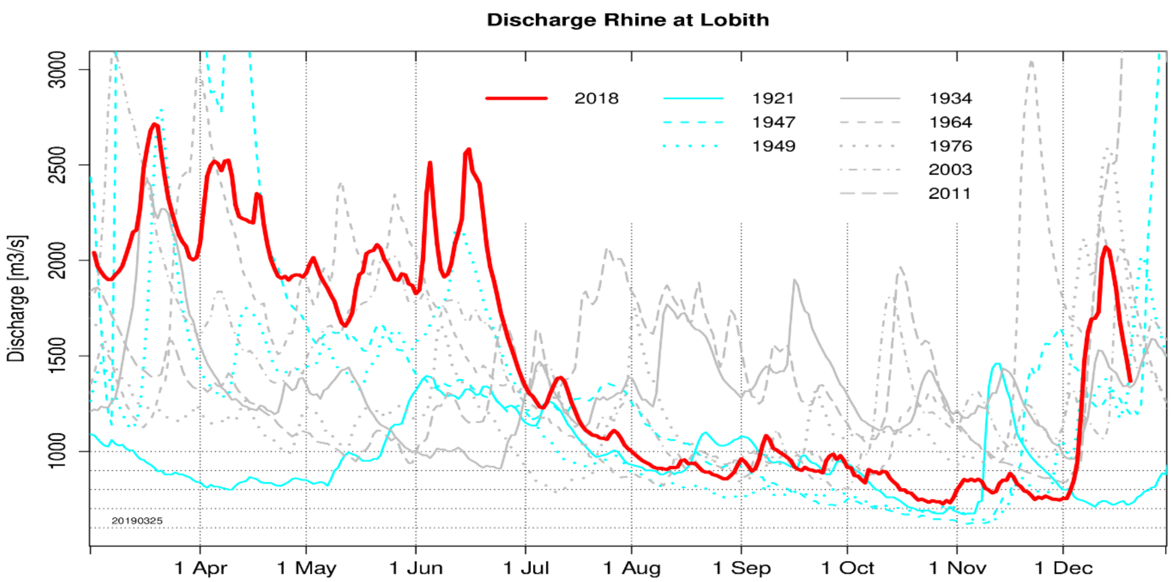

Figure 7.7 Waterflow at Rhine River

CHAPTER 8

POTENTIAL IMPACTS

Chapter 8: Potential Impacts of Inland Waterway

When properly executed, inland navigation can have far-reaching consequences on a national and regional scale. The impacts of an inland navigation system are discussed in the following paragraphs (van Lier & Macharis, 2014).

8.1 Political Impact

A centrally administered water resource management body, devoid of political influence, can offer coherence and sustainability to future water resource management solutions, according to the proposed implementation approach. Because inland navigation has the potential to be a win-win situation for all provinces, it can serve as a tool for inter-provincial harmony and dispute resolution in terms of resource benefit sharing.

8.2 Technological Impact

If built with cutting-edge technology, the inland waterway might become a viable market for cutting-edge equipment and logistics created around the world. It has the ability to contribute information and skills to the local supporting industry, as well as produce competent workers who can handle logistics. Adopting solar energy for inland ports and barges can have a positive impact on the local community and companies by dispelling the myth that solar energy is unreliable. A socio-technical trigger like this can result in a para-time shift, enhancing social acceptability of solar energy as a source of power. When the native industry for solar power and electric engines develops, it has the potential to modernize road transportation by gradually phasing in the use of electric vehicles while gradually phasing out the use of conventional combustion engines.

8.3 Environmental Impact

Electric barge transportation and related infrastructure can help to minimize carbon emissions. Water's inherent value can add to the value of real estate built around inter-city connection canals that support navigation, promote eco-tourism, and pump large quantities of money into the local and national economies.

8.4 Economic Impact

Strong and more stable macroeconomic conditions can be achieved through healthy politics, inter-provincial unity, an open market for cutting-edge technology, improved law and order, and rising agriculture and industry. This could make the country more appealing to foreign commercial investment. As a result, the developed economy has the potential to reintroduce businesses that have slowly relocated to the Middle East over the last few decades.

When canals are adequately landscaped, they can offer opportunities for high-value real estate development along the water's edge. Within a rich environment, inland marinas, floating motels, and cruises can draw a large number of tourists from all over the world. The emergence of corporate centres around the region can aid in the distribution of wealth and resources more evenly among the population.

8.5 Sustainable Development Goals

The inland canal system has the potential to create job possibilities and raise the standard of living in inchoate areas. Increasing per capita incomes as a result of increased economic activity can help the country get out of poverty. The economic benefits of inland transportation can encourage the use of efficient irrigation practices, resulting in increased agricultural productivity and lower staple food costs, bringing them within the purchasing power of the poor. Inland rivers have the ability to help in the circulation of wealth within inchoate areas' local economies. This can encourage healthy habits and provide access to basic health care, as well as improve the native population's socioeconomic well-being.

The potential development of rural places can aid in the improvement of educational infrastructure, resulting in higher educational quality for the native people. Similarly, social acceptance of contemporary technology and the expansion of domestic industries can help to encourage vocational training and the development of trained workers for industry. Domestic industries such as food processing, packaging, and hospitality, which have the potential to grow along the rivers, can generate employment and revenue. As a result, less fortunate and uneducated women can contribute to the region's socioeconomic prosperity on par with their male counterparts.

The creation of uniformly distributed corporate centres across the region can lead to a more uniform distribution of wealth and resources. People in impoverished communities can afford decent drinking water and sanitation facilities if they have more money in their pockets. The country's current energy crisis has limited the supply of energy to less developed areas, which are experiencing long outages. In addition, the cost of energy use per unit has risen dramatically in recent years. This has made housing unaffordable for a large percentage of the disadvantaged people. Promoting the usage of solar energy in the proposed inland navigation system could help to develop a market for solar energy solutions. This will have an indirect benefit for the poor population, as they will be able to maintain an affordable and clean supply of energy for household and industrial usage.

Pakistan has the potential to develop into an open market for high-tech firms. Increased job and business opportunities may eventually make modern technology indigenous. The innovative potential of young minds can be exploited, resulting in an increase in demand for answers to the country's current issues. Port cities with sustainable infrastructure can attract processing companies, increasing the value of current raw material exports. Implementing the inland waterway in its entirety can raise society awareness of the necessity of a sustainable environment, healthy lifestyles, good waste management, and responsible natural resource usage for home and industrial purposes. Increased knowledge can lead to a social shift toward green energy, environmentally sound waste management, efficient natural resource use, and a reduction in reliance on fossil fuels.

The level of synergy and long-term sustainability that can be realized through the development of Inland waterways is unimaginable. The discussed possible implications demonstrate that this system may be used not just as a mode of transportation, but also to support economic growth and political stability on a national and regional scale.

CHAPTER 9

CONCLUSIONS & WAY FORWARD

Chapter 9: Conclusions & Way Forward

9.1 Obstacles

Although navigation in the Kabul is technically feasible, the following obstacles may prevent it from being used to its highest output.

- Barrages and bridges presenting obstacles across the river channel. The structural solutions to negotiate these obstacles would increase the cost of developing inland navigation
- Irrigation inefficiency forces 136 BCM out the river to serve the agricultural needs. Some of this water can be returned to the river by adopting efficient irrigation practices.
- Intermittent flow in the river may pose a problem. However, to manage small amount of water in still canals may not be too difficult, given that the river is naturally a perennial river.
- 18th amendment in the constitution makes water resource management a provincial matter. However, basin-scale navigation requires one central authority controlling the resource.

9.2 Limitations

This research investigated the technical feasibility of inland navigation in the Kabul River as well as the potential consequences. The study's goal is to create a decision-making tool that may be utilized for future planning and detailed design of inland navigation in Pakistan. The extensive investigation of river cross-sections was not possible due to the lack of available data on river soundings and the study's limited scope. As a result, the conceptual designs and economic evaluations are estimates that have been made to establish a reasonable comparison and the system's economic benefits.

9.3 Conclusions

- The river course indicates no major changes which goes in favor of Kabul River being good for navigation.
- Minimum bed level is 861.57 ft with flow level as 918 ft which is greater than 4m (13.12 ft) required navigational as per European Standard for Inland waterways.
- Floods of 2010 were due to heavy Monsoon rainfall which started from 27th July and prolonged till the month of August made the rivers surge and overflow causing havoc in the target area. These rainfall systems in July-August were due to interaction of Monsoon and mid-latitude Westerlies (winds blowing from the west to the east steering extratropical cyclones). This is not a frequent phenomenon as there is difference in rainfall between 2010 and the long-term average for the region.
- Moreover, the current hydrological state of Kabul River indicates good inflow of water which also makes it suitable for navigation.
- The water occurrence in the river delta from 1984 to 2015 shows that the water surface availability in major portions of the river is good and a wider permanent flow is available throughout the year which is sufficient for inland use of the river during the entire year. However, there are very few locations where the water surface does not remain permanent and fluctuates during the seasonal changes which are comparatively negligible considering the inland capability.
- During the last 32 years of studying the water occurrence change intensity in the river delta it has been observed that there is no considerable change in the water occurrence which depicts the permanent water surface availability for the inland use of the river.
- The water seasonality measures the presence of water surface during different seasons throughout the year. Study finds that the water surface remains permanent through entire reach however few stretches exist along the reach where water scarcity was observed during the 2014-2015 study.
- Inland waterway, according to research, can haul more freight and is times more fuel efficient than roads/rail.
- The Inland Waterway's potential impacts can help to reform inter-provincial politics, aid technical progress, boost agriculture and industry, strengthen local

and national economies, improve socio-economic conditions, and bring peace and prosperity. Furthermore, increased international competitiveness because of lower transportation costs may open new markets for agricultural products. These changes may enable Pakistan to contribute to the accomplishment of the Sustainable Development Goals (SDGs).

9.4 Way Forward

- To accommodate growing freight density on the roadways, a $100 billion investment in road infrastructure is necessary. For Pakistan's weak economy, this is difficult to manage. At the same time, research reveals that inland towing can transport more freight and uses less fuel than roads and rail. An inland waterway built on a 3,000-kilometer network of the Indus River and its tributaries could be a viable answer for the country's future transportation needs.
- The funding approach for implementing the system could be based on a public-private collaboration, reducing the government's investment responsibility.
- At the federal level, legislative measures might be made to make water resource management the duty of a central body of experts.
- Prior to the implementation of the inland waterways scheme, a strong institutional structure can be built. This institutional framework will oversee zoning rules, flood-protection zones, construction phase monitoring and evaluation, taxation and tariffs for barge traffic and companies, and policing, among other things. The resulting rules and policies can then be enforced in their entirety to prevent future unplanned and uncontrolled development.
- The lack of online databases is a major roadblock for academic and corporate research in a variety of sectors across the country. WAPDA and IRSA, for example, should create online databases that are open to the general public. Such easily available data would aid the scientific community in filling knowledge gaps in diverse domains' literature.

References

- Ahmed, A., Mehdi, M., Baig, M. and Arsalan, M., 2022. The Assessment of Sustainability of Freight Transportation in Pakistan. Iranian Journal of Science and Technology, Transactions of Civil Engineering, 46(3), pp.2593-2608.
- Sahin, B., Yilmaz, H., Ust, Y., Guneri, A. F., & Gulsun, B. (2009). An approach for analysing transportation costs and a case study. European Journal of Operational Research, 193(1), 1–11. https://doi.org/10.1016/j.ejor.2007.10.030
- Usón, A. A., Capilla, A. V., Bribián, I. Z., Scarpellini, S., & Sastresa, E. L. (2011). Energy efficiency in transport and mobility from an eco-efficiency viewpoint. Energy, 36(4), 1916–1923. https://doi.org/10.1016/j.energy.2010.05.002
- Cadarso, M.-Á., López, L.-A., Gómez, N., & Tobarra, M.-Á. (2010). CO2 emissions of international freight transport and offshoring: Measurement and allocation. Ecological Economics, 69(8), 1682–1694. https://doi.org/10.1016/j.ecolecon.2010.03.019
- Sperling, D., & Salon, D. (2002). Transportation in Developing Countries: An Overview of Greenhouse Gas Reduction Strategies. Escholarship.org. https://escholarship.org/uc/item/0cg1r4nq
- Beyer, A. (2018). Inland waterways, transport corridors and urban waterfronts. Www.econstor.eu. https://www.econstor.eu/handle/10419/194084
- Knight, S., Witzke, E., & White, K. (2022). Inland Waterway Transportation. Women in Infrastructure, 199–240. https://doi.org/10.1007/978-3-030-92821-6_10
- Radmilovic, Z., & Dragovic, B. (2007). The Inland Navigation In Europe: Basic Facts, Advantages and Disadvantages. Journal of Maritime Research, 4(2), 31–46. https://www.jmr.unican.es/index.php/jmr/article/view/85
- Beyer, A. (2018). Inland waterways, transport corridors and urban waterfronts. Www.econstor.eu. https://www.econstor.eu/handle/10419/194084
- Council, N. R., Board, T. R., Studies, D. on E. and L., Board, W. S. and T., & Study, C. to R. the U. M. R.-I. W. N. S. F. (2001). Inland Navigation System Planning: The Upper Mississippi River-Illinois Waterway. In Google Books. National Academies Press. https://books.google.com.pk/books?hl=en&lr=&id=fav6EP6LxscC&oi=fnd&pg=PA1&dq=+inland+navigation+on+indus&ots=W7L3W4hhzM&sig=x8iAuRBYjfX8HUME7mUvPXZzgBw&redir_esc=y#v=onepage&q&f=false
- Tehsin, M., & Nasir, heikh I. (2019). Inland Water Transport in Pakistan: Limits and Prospects. Global Social Sciences Review, IV(I), 441–448. https://doi.org/10.31703/gssr.2019(iv-i).57
- Zumerchik, J., & Danver, S. L. (2010). Seas and Waterways of the World: An Encyclopedia of History, Uses, and Issues. In Google Books. ABC-CLIO. https://books.google.com.pk/books?hl=en&lr=&id=IBKoUXrF5p0C&oi=fnd&pg=PP1&dq=waterways+of+world&ots=RLzVqev6Oc&sig=wHzaoEof6HIQsXz62qy8Nnzw_aA&redir_esc=y#v=onepage&q=waterways%20of%20world&f=false • Khuram, I., Ahmad, N., Jan, S., & Barinova, S. (2014). Freshwater green algal biofouling of boats in the Kabul River, Pakistan. Oceanological and Hydrobiological Studies, 43(4), 329–336. https://doi.org/10.2478/s13545-014-0150-y
- Shafique, S. (2018). Analysis of Transportation Potential of Rivers in Pakistan. ICSDC Conference Proceedings Volume-I. https://www.academia.edu/39127352/Analysis_of_Transportation_Potential_of_Rivers_in_Pakistan
- The power of inland navigation The future of freight transport and inland navigation in Europe. (2013). https://www.edinna.eu/wp-content/uploads/2017/08/140410-the_power_of_inland_navigation_2013.pdf

- van Lier, T., & Macharis, C. (2014). Assessing the environmental impact of inland waterway transport using a life-cycle assessment approach: The case of Flanders. Research in Transportation Business & Management, 12, 29–40. https://doi.org/10.1016/j.rtbm.2014.08.003