

Unravelling the Obstacles: Hindrances Affecting the Natural Flow of the Indus River, Causing Heavy Floods in Sindh - Empowering Decision Making through Mapping of Satellite Images and GIS

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ABSTRACT

In this research, one can identify the underlying factors of the barriers (natural or manmade) that lead to floods, loss of human life, destruction of crops, infrastructures and displacement of human beings. The River Indus in Pakistan has witnessed two major floods in the last decade in 2010 and 2022. These floods have caused rampant devastation, where the human and natural aspects play a crucial part in the intensity of such disasters. The impacts have been loss of life, displacement of communities, destruction of infrastructure, and long-term economic and environmental degradation. The majority of the damage and loss of lives occurred between Sukkur and the Dadu-Moro Bridge, which was getting more susceptible with human intrusion and bad planning. There are two Flood Protection Bunds (levees) along the river. These levees are developed to control the flood water especially during the monsoon. The success of these levees is however hampered by human encroachment and also by deposition of natural sediment in the river bed. As there is little space between the levees with illegal settlements and other natural obstructions, the floodwaters become constricted resulting in breakages and overflows. These problems will need to be solved by a mixture of policy implementation, redesign of the infrastructure and riverbed management to recover the natural capacity and flow of the River Indus.

Keywords: Obstacles, Indus River, Floods, Sindh, Satellite, GIS.

INTRODUCTION

One of the longest and most important rivers in Asia, the Indus River has centuries-long been the lifeblood of Pakistan. The river is formed by the Tibet mountain plateau, flowing through India and Pakistan and emptying itself in the Arabian Sea, the Indus River provides a large and diverse ecosystem, sustaining millions of people, and being a key source of agriculture, industry, and domestic water (Inam,

A., et, al 2007). But over the past decades, its natural flow has been more and more disturbed by man-made and natural barriers, with the devastating results, most prominently, the frequent and disastrous floods in Sindh. (Haider, S., et,al 2025). The Indus has historically influenced and cultivated Sindh, which has suffered its rage as well. The river, which was once revered as a means of livelihood and wealth, in recent years, has become the bringer of doom during the monsoon season. The frequency and severity of floods in Sindh have become frighteningly frequent and severe, displacing millions of people, destroying infrastructure, destroying crops, and claiming lives (Khan, A., 2025).

Historical Context

The River Indus has traditionally been seasonal due to the melting of glaciers and monsoon rainfall. The river has historically been prone to natural floods, which were even useful as they replenished agricultural lands with fertile silt (Clift, P. D., and Guedes, J. D. A., 2021). Civilizations such as the Indus Valley Civilization were successful due to close association to the floods of the river (Noor, N., et, al,2025).

Nevertheless, the natural flow and tide of the river was blocked with the growth of human settlements and the introduction of modern engineering into the river in the 20th century. Construction of large dams like Tarbela and Mangla, extensive system of barrages and canals were put in place to regulate the stream of water and to aid irrigation (Tarar, R. N. (2006). Although these processes increased agricultural production and hydro power, they had a fundamental effect on the dynamics of the river particularly to the downstream areas such as Sindh.

The net result of such interventions over the years has been the degradation of the river system resilience to seasonal peaks. Settlement and agricultural growth have encroached on the natural floodplains which served as buffers during high-flow times. Channels have become silted down as the flow velocity has slowed down and numerous embankments, rather than saving communities, have become hard barriers to the water to trap it in populated communities when the river overflows. Simply put, the Indus taming systems have ensured some of the areas are more susceptible to its fury.

The 2010 super floods and the disastrous monsoon of 2022 vividly remind about the Sindh crisis (Hassan, B., et, al 2025). The mere amount of water in either event and the lack of infrastructural readiness resulted in unparalleled destruction.

Scope and Purpose of the Study: This paper aims at making a multi-dimensional analysis of the barrier that interfere with the natural flow of the Indus River with a special emphasis to the role of such barriers in causing heavy flooding in Sindh. It will look at the infrastructural aspects such as barrages and embankments; the environmental aspects such as deforestation, sedimentation and climate change and the governance aspects such as poor planning, lack of synchronization between provinces and the outdated water management policies.

It is not just about finding problems but to know how they are interrelated and provide information about how they can be solved sustainably. Flooding in Sindh does not necessitate the emergency efforts but necessitates a radical reconsideration of the Indus River management on the whole of the course (Arshad, E. M.,et, al, 2025). Long-term mitigation will only be attained by restoring some semblance of the natural flow and functionality of the river, in addition to increasing resilience in the susceptible areas.

The Hindrances

The Indus River is the lifeline of Pakistan, which has determined its geography, history and economy. This is clear nowhere than in Sindh where the waters of the river have given birth to civilization and generations have made a living. But over the past few decades, the river has turned into a matter of growing alarm, especially during the monsoon, when the river has regularly caused extensive destruction in Sindh. The barrage between Sukkur and the Dadu Moro Bridge is one of the most susceptible areas as it is one of the most exposed parts of the river to floods because of various natural and artificial impediments that hinder the natural course of the river (Shah, S. et, al, 2020).

Some of the major Obstacles to the Natural Flow.

There are a number of critical barriers in this portion of the study area that are factors contributing to the frequent flooding:

1. **Sedimentation and Siltation:** The riverbed has over the years been deposited with sediment which has drastically decreased the depth and carrying capacity of the River Indus. The upper reaches are trapped by upstream dams, so much of the sediment is deposited in the lower reaches. This predisposes the river to flooding during normal rainfall.
2. **Weak and Breached Embankments:** River protective bunds are either weak, old fashioned or not properly maintained. These embankments are easy to break in the case of high flows, which occurred in 2010 (Oberhagemann, K., et al, 2020).
3. **Intrusion into Floodplains:** Agricultural activities and rural settlements have invaded the natural floodplain of the river. These buildings do not only block the flow but also augment the harm of floods when the waters recover these spaces.
4. **The historic paths:** When natural drainage pathways such as Dhands (natural depressions) and old riverine ways are closed or abandoned, excess water is not able to flow out in a safe manner. This leads to floodwaters stagnation, which results in long-term waterlogging and damages (Barrocu, G., & Eslamian, S., 2022).
5. **Infrastructure:** Larkana-Khairpur Bridge is located between the Sukkur to Dadu-Moro Bridge and the natural width of the river is 12.4 kilometers (between levees). The bridge was constructed in December 2009, which is only 1.2 kilometers long, and is the main cause for storing the flood water before the bridge. This structure, was a cause of the devastation of the flood of 2010 at study.

The irrigation system of Sindh has its century-old world-famous irrigation system in the Sindh Province which uses 14 major canals originated by the Gudu, Sukkur as well as Kotri barrages. The Sukkur barrage is experiencing water shortage since the past ten years (Chandio, N. N., et, al. 2023).

Flood 2025 and Slit Deposition.

Flood of 2025 left a substantial amount of sediments, being formed in the eastern area. Since the floods originated in this area, they took a long time to pass on and big amounts of silt were mixed in the flowing

water. This led to the flood water having a high sediment load, which was deposited later along the river system. Field observations have shown conclusively that the river and irrigation canals beds have significantly been silted with sediments that were carried by the flood water. This sedimentation has decreased depth and carrying capacity of these channels that influence the flow and general river health.

Climate of the Sindh Province

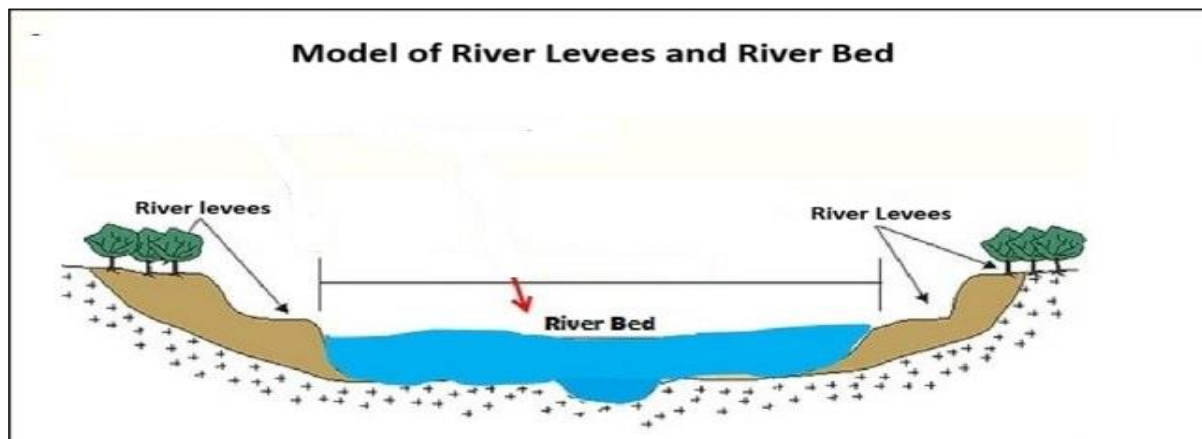
The climate in Sindh is mainly arid and semi-arid with a hot summer, mild winter and low rainfall per year. The area is in a subtropical area and it is largely affected by desert and monsoon weather patterns. Summers are very hot, with temperatures in inland cities such as Jacobabad, Qamber-Shahdadkot, Dadu and Sukkur frequently exceeding 113°F (Abbas, F., et, al, 2018). Temperatures in coastal regions like Karachi are however relatively moderate because of the closeness to the Arabian Sea but the weather may feel oppressive because of the high humidity. The monsoon usually sets in during July and extends to September and provides a lot of needed rainfall, but the quantity and distribution of the rain may vary considerably between years. Sindh has been receiving less rainfall in most years, resulting in the drought condition, particularly in the Thar Desert.

The winter in Sindh, between November and February is usually dry and light. The range of temperatures in this season is between 50o F and 77o F, hence the most favorable season in the province. During winter, there is very little rainfall and clear sky is very prevalent. It is occasionally cold in the province, particularly in the north where the cold waves are temporary. (2019).

The Study area (Sukkur to Dadu-Moro Bridge)

The study area consists of three administrative divisions and five districts, starting from Lloyd Barrage, Sukkur, to Dadu-Moro Bridge (Pul). The total length of the area is 157-kilometer-long belt along the two banks (Flood Protective Bunds) of river Indus as in fig.1.

Fig.1. Model of River Levees and River Bed



Source: Vieira. L, 2019

The area of between banks known as “Kachho” in Sindhi Language. The thousand-years-old alluvial soil was deposited in the Kachho, the flood plain. It comprises the alluvial plain that is deposited by the Indus and is fertile in the areas near the river as well as the canal systems. The riverine forests are also included, which sustain biodiversity, grazing, and wood production, but are also prone to seasonal flooding and are also affected by the dynamics of the Indus River flow (which has effects on agriculture, land-use, and flood risk).

Gravity/slope of Sindh

The Indus River is one of the mightiest rivers in the world. It is uneven in width with minimum at 5.5 Kilometers below the Sukkur Barrage, 12.46 kilometers before the Larkana-Khairpur Bridge, 5.6 kilometers before the Dadu-Moro Bridge. The river is 6.8 kilometers wide on average. In fact, 6.8 kilometers is sufficient to drain out flood water.

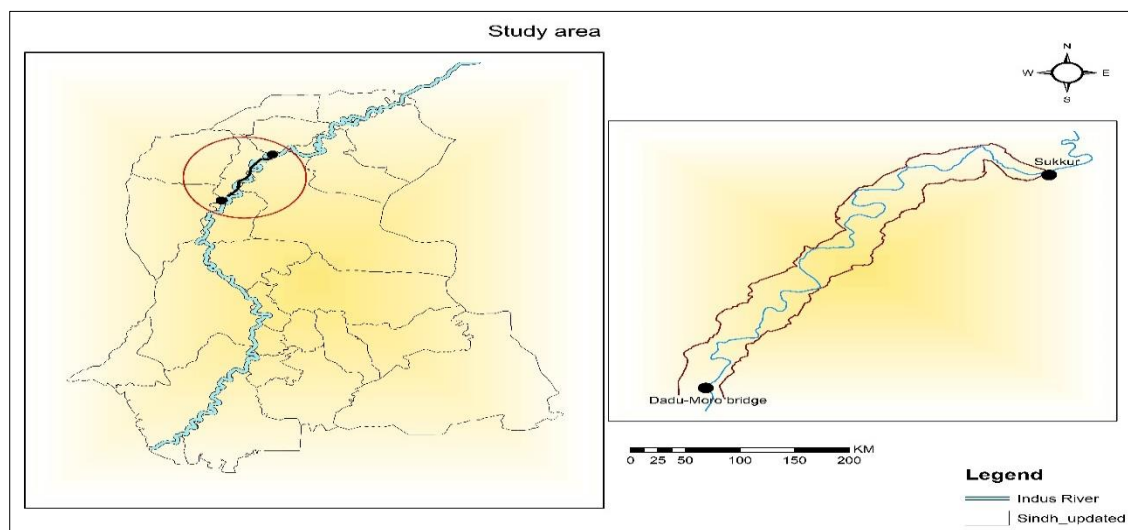
The slope (gravity) of Sindh is 0.5 feet per Kilometer. Guddu is 550 kilometers aerial distance to the Arabian Sea. The Guddu natural gravity/slope is 275 feet above sea level. The Indus Delta (near the Arabian Sea) is 0 (zero) feet above the sea level; thus, the Natural gravity of Sindh is blessed to drain out the flood water of the Indus River easily as revealed in fig 2b.

On either side of the River Indus (between Sukkur and Dadu Moro Bridge are barriers to form obstacles in the flood water. In the flood season, water flow increased 6th times more than normal flow. The Unravelling obstacles created hindrances of flood water, which is the main cause of flooding in Sindh.

Fig. 2: figure 2a explained the study area in the map of the Sindh, figure 2b explained the study area from Sukkur to Dadu-Moro bridge.

(a)

(b)



Source: author, 2025

Hydrological Importance

Sukkur, located in Upper Sindh, is situated at a strategic point along the Indus River, where the channel narrows due to rocky outcrops. This natural constriction facilitated the construction of the Sukkur Barrage (Lloyd Barrage) in 1932, one of the largest irrigation control systems in South Asia (Stephen, D. (2013). Downstream from Sukkur, the river widens, creating extensive floodplains as it approaches Dadu District, located west of the river corridor and influenced by runoff from the Kirthar mountain range.

RESEARCH METHODOLOGY

Research Methodology explains the research design, and data to be used in the research. It involves field surveys, GIS mapping to determine riverine obstacles. The information was processed to comprehend the trends in floods and the effects of natural and anthropogenic influence.

This design allows the scientific, imaging-based explanation of obstacles to the river flow and incorporates the human ideas that are applicable to management and planning. The research Project mixed research Methodology is:

A: Quantitative analysis, the Quantitative analysis comprised of satellite images and river morphology.

Satellite images, get multi-temporal satellite images to locate impediments.

Landsat (5, 7, 8, 9) River bed morphology (30m resolution)

B: Field visits, and expert interviews, and document analysis formed qualitative assessments.

Field survey:

The field survey was carried out between the Sukkur (Starting point) and the Dadu-Moro Bridge (wind-up point). The research sought to draw attention to the barriers in the map with coordinates. The survey started from the Right Bank of the River Indus, then the left bank of the River Indus. There were eleven barriers identified in the research field of the river such as sediments and settlement.

RESULTS

Eleven barriers were recorded during the field study. The barriers are constantly introducing a barrier to the flood water, that obstacles are introducing a decreasement of speed and velocity of flood water. Two types of obstacles were pointed out i.e. natural and man-made obstacles.

Identification of obstacles:

The Documentation of hindrances/obstacles was separated into:

1. Identification and size of each obstacle

2. Where obstacles are on in the maps.
3. Area covered by obstacles

The identification of every barrier occasioned by the floods along the Indus River is very crucial. Near the bridge, natural barriers are located. The table 1 indicates the identified obstacles. This is also very essential to determine the nature, type and area of covered by each obstacle. To illustrate, there is a natural barrier, which has occupied an area of 6563 sq. meters along the Larkana-Khairpur Bridge.

Table.1. location, nature and size of each obstacle.

S.No.	Location of obstacle	Name of obstacle	Area (sq: km)	Nature of the obstacle
1	27°40'14.22"N 68°29'51.88"E	Homes	0.5 sq.km	Man-Made
2	27°38'30.56"N 68°26'32.84"E	Home	Single house	Man-Made
3	27°39'36.08"N 68°24'25.87"E	Settlement	2.84 sq. kms	Man-Made
4	27°33'27.02"N 68°20'25.41"E	Settlement	5.16 sq. kms	Man-made
5	27°30'53.69"N 68°20'8.46"E	Homes	0.035 sq. kms	Man-made
6	27°29'26.88"N 68°16'36.13"E	Settlement	6.27 sq. kms	Man-made
7	27°23'18.88"N 68°16'35.01"E	Settlement	2.78 sq. kms	Man-made
8	27°26'11.95"N 68°17'9.22"E	Houses	1.5 sq. kms	Man-made
9	27°25'33.87"N 68°17'1.78"E	sediment	2.78 sq. kms	Natural

10	27°25'21.58"N 68°17'6.89"E.	Bridge	1.2 km long	Man-made
11	27°18'27.77"N 68° 9'42.06"E	Dispersed settlement	31.3 sq. kms	Man-made
12	26°43'3.51"N 67°53'35.88"E	Bridge	1.19	Man-made

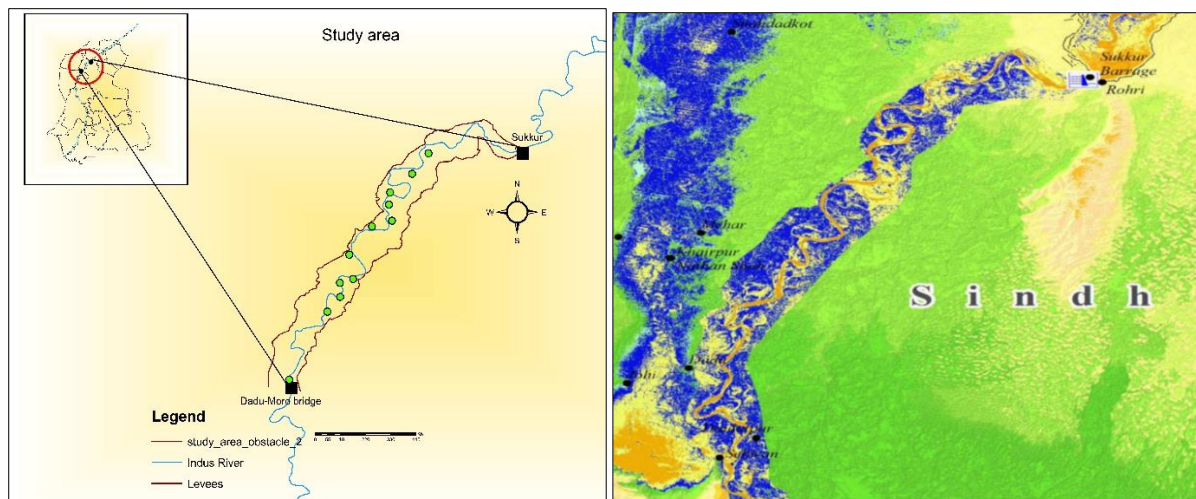
Obstacle 1: This obstacle is on the left levee and near the riverbed, stretching towards the coordinates 27o4014.22iN to 68o2951.88iE. The barrier is a house that is located near the banks of the river. Moreover, there is a group of houses located in the area of the S-shaped-curve of the river. These structures located on the riverbank can be dangerous during the high-water flow such as erosion, flooding, and damage of property can occur. Human settlements near the river channel are more likely to be vulnerable and can inhibit the natural flow, impacting the river dynamics and local safety.

Obstacle 2: This obstacle is a single house, which looks like a farmhouse, deep in the forest, on the riverbed. Geographically, it is situated at 27°38'30.56"N, 68°26'32.84"E. The building stands on the levee of the river, which is active, on the left. It is positioned close to the riverbed which puts it at a risk of floods, erosion and possible damages during the high flow seasons.

Fig. 3a reveals the positions of the barriers in between the two levees on the riverbed. *Fig. 3b* shows that the water in floods has filled the whole space in between the levees. Consequently, the area intruded upon is entirely covered with floodwater.

(3a)

(3b)



Source: author 2025 and (Naeem, B., et, al. 2021).

Obstacle 3: This obstacle consists of a village located at 27°39'36.08"N, 68°24'25.87"E. It has a size of 2.84 sq. km and is located on the right levee adjacent to the riverbed. Its location near the river makes it more susceptible to floods and could influence the natural flow and river processes.

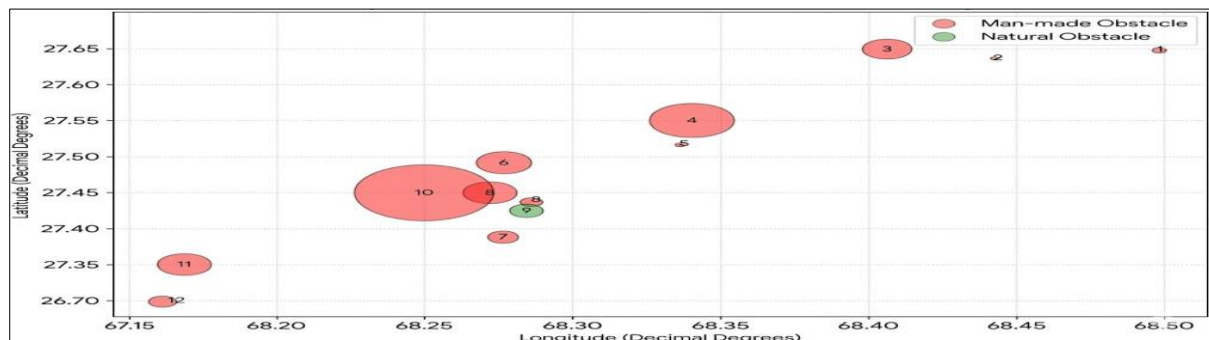
Obstacle 4: It is a medium village in the left levee of the Indus River. Geographically, it lies at 27°33'27.02"N and 68°20'25.41"E. The village is located on 5.16 square kilometers and serves as a barrier to the river path.

Obstacle 5: This obstacle is a village on the approximate position of 27°30'53.69N and 68°20'8.46 E. The barrier has an area of 0.035979 square kilometers and is located along the left levee of the Indus River. It is located very near the main stream of the river meaning that the settlement is located close to the active river channel. At high-flow periods, the village might be susceptible to floods and other hazards related to the river due to the location of the village.

Obstacle 6: This obstacle is a village located at 27°29'26.88"N and 68°16'36.13"E. It is located near the riverbed; the village occupying a space of 6.27 square kilometers and being located on the right levee of the Indus River. The settlement is also a form of obstruction that is due to its location, which helps in causing hindrances in the natural flow.

Obstacle 7: The obstacle is a village located at 27°23'18.88"N and 68°16'35.01"E. It is an area of approximately 2.78 square kilometers located on the right embankment of the river Indus. Its position next to the river adds to the impediments in the natural circulation of floodwaters.

Fig. 4. Geospatial distribution of obstacles



Obstacle 8: This obstacle is a village with 1.5 square kilometers area, situated at 27 26 11.95 N 68 17 9.22 E. It lies on the left bank of the Indus River, near the Larkana-Khairpur Bridge and it might be in a position that limits the natural discharge of floods.

Obstacle 9: This is a significant natural barrier which is found on the river bed. It is situated between the coordinates 27o2449.73N and 68o1721.08E, and occupies an area of 2.78 square kilometers. It is situated near the Larkana-Khairpur Bridge, which it greatly affects the natural and continuous passage of river water. This barrier is important because of its location and size in changing the hydraulic behavior of the river especially at high discharge rates. This obstacle has created the water pressure over the bridge.

Fig.5. Picture and satellite image of obstacle 9.



Obstacle 10:

It is an artificial village comprising of a row of houses along the left bank of the Indus River in the proximity of $27^{\circ}18'27.77''$ N and $68^{\circ}09'42.06''$ E. The settlement is approximately 31.3 square kilometers and a major impediment, thus, leading to floodwater obstruction during a flood season.

Obstacle 11:

This is among the biggest impediments and a primary reason behind flooding in the region. The Larkana-Sukkur Bridge hinders the natural course of floods between Sukkur and the bridge. Geographically, the structure is located between $27^{\circ}25'21.58''$ N and $68^{\circ}17'6.89''$ E. Prior to the bridge, the width of the Indus River is about 12.5 km which is wide enough to allow floodwater to move without any difficulty. The bridge is however only 1.2 km long which limits water flow. The construction of the road to the bridge has blocked two channels of ancient rivers between the Razi-Dero Flood Protective Bund and the bridge.

Obstacle 12: The Dadu-Moro Bridge spans 1.19 km, connecting Dadu to Moro. However, the river narrows significantly here from its 5.6 km width between the levees. This structural bottleneck acts as a major hindrance to hydraulic flow. Consequently, floodwaters are unable to pass efficiently, causing them to pool and remain stagnant upstream. This constriction increases the risk of levee breaches and prolonged inundation in the surrounding areas during heavy monsoon seasons.

Finding: The study finds out that the eleven obstacles are known to be in existence, which create hindrances, and that the hindrances are leading to flooding, and cause the destruction of socio-economic in this area. Agriculturally rich and densely populated areas around Dadu, Sukkur, Khairpur Mirs, Larkana and Noushero Feroze are densely inhabited. In case of floods, thousands of people are forced to move out, crops are lost and it affects local economies. The destruction is not just short term, but also protracted because stagnant water causes soil fertility.

RECOMMENDATIONS

There are two categories of obstacles i.e., natural obstacles and man-made obstacles as shown below:

Natural obstacles: Natural obstacles are the issues of the departments concerned because the problem is connected with both management and irrigation engineering. Thus, to manage floods and to design rivers, it is important to know the pattern of sediment transportation and deposition in the River Indus. To mitigate the effects of floods and to make the river and canal systems sustainable in the long-term, regular desilting, enhanced watershed management upstream, and continuous monitoring of the river morphology are required.

Man-Made obstacles: These obstacles also pertain to the Irrigation, Agriculture Department and the district governments. Settlement between the two levees is adding to the risk of flooding. Hence, the advice is that policy makers should think of migrating people in the riverine regions to safer places.

In addition, it is also proposed that the ancient and new blocked river channels, blocked by the construction of road linking Larkana and Khairpur should also be opened. These natural river channels would enable the passage of the floodwater more effectively and also relieve the pressure on the main river flow, same as the blocked river channels near the Dadu-Moro Bridge should be reopened through the construction of small bridges.

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