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Research Article

Measures of Flood Management and Policy Implication in Kosi River Basin (North Bihar) – An Approach to Disaster Risk Reduction.

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ABSTRACT

High flood occurrences are growing more often despite a general decrease in precipitation in the Kosi River basin of North Bihar. The river's capacity for destruction resulted from the massive volumes of water it carried down from the Himalayas, which were heavy with silt, sand, and kankar. Inadequate maintenance rendered the embankments that India and Nepal had constructed to direct the river course, unable to resist the power of the floodwaters. The finding suggests that the various social, economic and cultural impacts are identical in the region due to recurrent floods in the Kosi River basin. During the recent events of flooding events in the area, Supaul, Purnea, and Madhepura districts were the most affected districts in the region, in which surging water swamped 1,000 square kilometres of farmlands, destroying large areas under crops. The present paper is a modest attempt to analyse the impact of floods on the lives of the people in the Kosi region.

Keywords: Kosi River basin, Flood Hazard, People and Community, North Bihar, Himalaya.

1. Introduction

Flood is one of the most frequent (United Nations, 2015) and extensive natural hazard responsible for most damage and loss of life (WBGU 1999). Floods also seem to have a spatial implication on their victims, imparting a fear of consequences that often surpass their actual impacts. It also has grave secondary effects on society, its economy, and agriculture. A flood occurs when water overflows (due to meteorological or geophysical causes) or soaks the surface land that is usually dry in normal conditions. There are few places on Earth's surface where people do not need to be worried about overflowing or flooding on Earth's surface. A flood can be defined as a spatiotemporal submergence of a flood plain (area prone to floods) by water outside its circumference (FLOOD site-Consortium 2005; cf. Munich Re 1997). Damage by flood hazards to the community, society or infrastructure depends on the vulnerability of exposed elements in flood-prone areas. The term 'vulnerability' can be defined as an integral characteristic of these elements (vulnerable), determining their potential to be harmed (Sarewitz et al., 2003). It can also be seen as a phenomenon that arises from the interplay between vulnerability and societal worth (FLOOD site-Consortium 2005) and is manifested through both direct and indirect impacts on society (Messner and Meyer., 2007). Unlike societal value, which exists independently of risk, susceptibility (the condition of being vulnerable in an individual, group, or community) reflects the process through which damage occurs (Penning Rowsell et al. 2005). The Koshi River is dynamic, as evidenced by its regular change of paleocourses (lateral shifting), and recurrent flood, "piggyback" thrusting segments, extensive bank erosion along the bank line, neotectonic tilting, and sedimentological alteration in its watershed. (Nepal et al. 2014; Ghatak et al. 2012; Rahman 2011; Jain and Sinha 2005; Nakayama and Ulak 1999; Sinha, 1998). However, there is a finite quantity of deposits in the Nepalese Himalayas, proving that rainfall is not the only factor in erosion. (Andermanna et. al., 2012). Geological and recent climatic changes have influenced the geomorphic variability in the floodplain. (Sinha et. al., 2005). Flood-fed alluviation presents a problem for the riparian region of Koshi (Hooning., 2011). This system is demarcated by channel shifting and overflow deposits that have a direct impact on the community in the region (Ghatak et al., 2012).

The rapid growth of population, climate change intensification and expansion of socio-economic activities in flood-prone areas (flood plains) have all been identified as the key drivers of increased future flood damages and losses (Alfieri et al., 2016; Kundzewicz et al., 2014; Revi et al., 2014; Vitousek et al., 2017).
The Kosi River Basin of North Bihar is a hotspot for several natural disasters due to its complex geophysical setup. The river originates from the northern Himalaya and transverses through wide areas of northern Bihar before joining the River Ganga. Such physio-climatic transformations, demographic concentration in riparian regions, and the Indian Monsoon play a significant role in the flow dynamics of the Koshi River, which results in devastating floods during the summer monsoon. According to the National Disaster Management Authority (NDMA), the northern Plain of Bihar is one of the most susceptible flood-prone areas in India. Along with recurring floods, the regular shifting of river courses has resulted in massive bankline erosion in the region. Every year, the recurring floods and bankline erosion affect thousands of villages in the basin, resulting in massive stress on the socio-economic lives of the millions of riparian communities.

2. Study Area

The present study is based on the Koshi River basin of north Bihar. The River Koshi is a transboundary river which originates in Tibet and flows through the Himalayas in Nepal. It enters into the plains of India in Bihar and eventually merges into the River Ganga near Kursela (Katihar, Bihar). In Bihar, the river basin is spread across 16 districts of the state, viz. Purbi Champaran, Muzaffarpur, Sitamarhi, Sheohar, Madhubani, Darbhanga, Samastipur, Khagaria, Saharsa, Begusarai, Supaul, Madhepura, Araria, Katihar, Purnia and Bhagalpur. Nepal surrounds the Kosi Basin on the North; Paschim Champaran, Gopalganj and Saran districts of Bihar on the west; Vaisali, Patna, Lakhisarai, Munger and Banka districts of Bihar and state of Jharkhand on the south; and Kishanganj district of Bihar and state of West Bengal on the east.

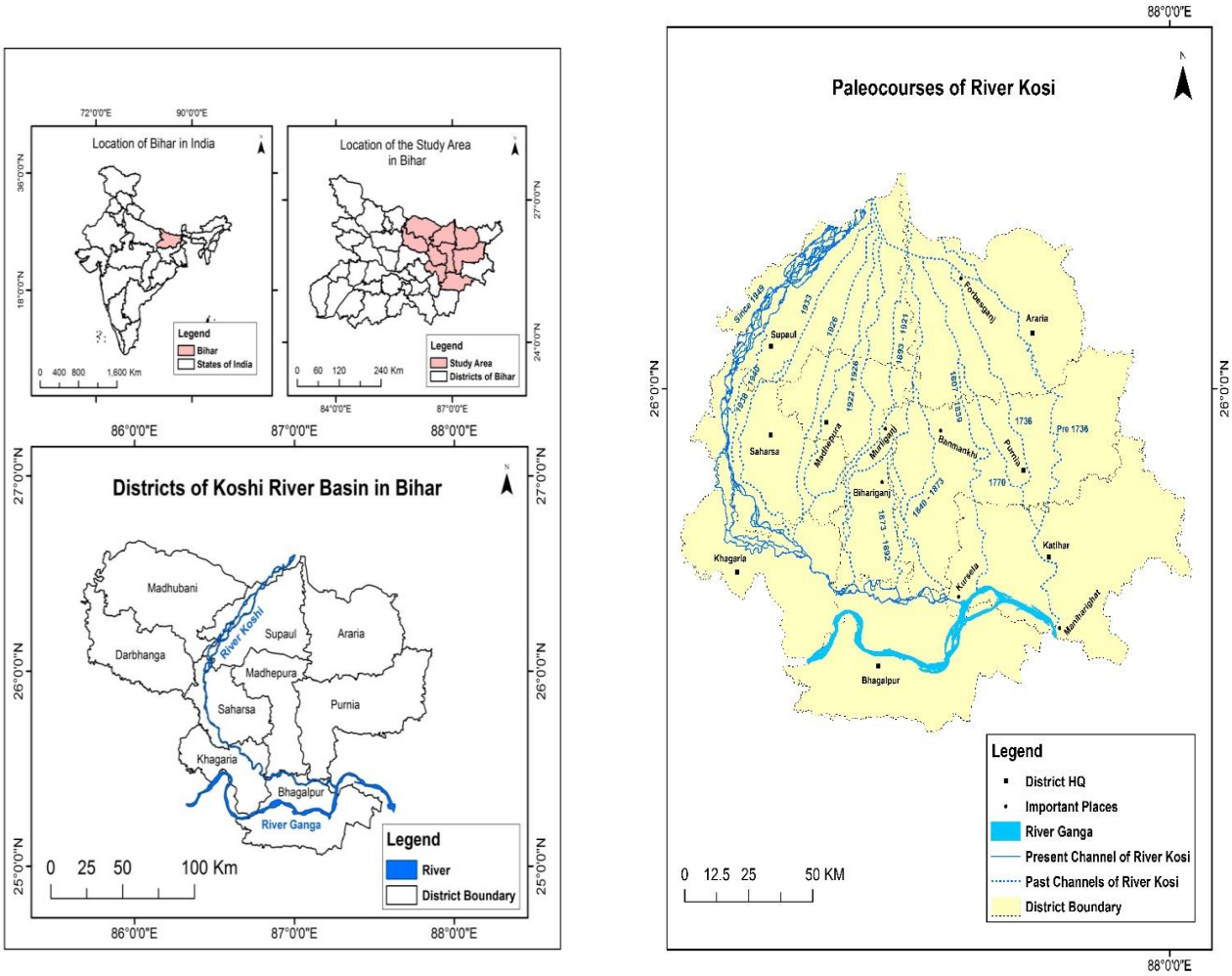

Fig. 1: Location of the study area and Paleocourses of the River Kosi in North Bihar.
Source: Prepared after Gole and Chitale., (1966), and Prakash. V. et. al., (2020).

3. Methodology

The sources of data include both primary as well as secondary sources. In this research, primary data were gathered using semi-structured questionnaires and in-person interviews. The purposive sampling technique has been used

to select the representative samples from selected villages in the districts of Kosi River Basin, North Bihar. Apart from that, the participatory observation method has also been used to understand the implications of flood and riverbank erosion on the residents of the region. Both qualitative and quantitative techniques have been used to interpret the data. Secondary data have been used extensively in the present study. In secondary data, the conventional data sources include reports and records of WRD reports, Census of India, NFHS, National Disaster Management Authority (NDMA), State Disaster Management Authority (Bihar), Non-conventional or geospatial data like Landsat imageries (MSS, TM, ETM+, and OLI), Digital Elevation Model (SRTM) have been obtained from the website of United States.

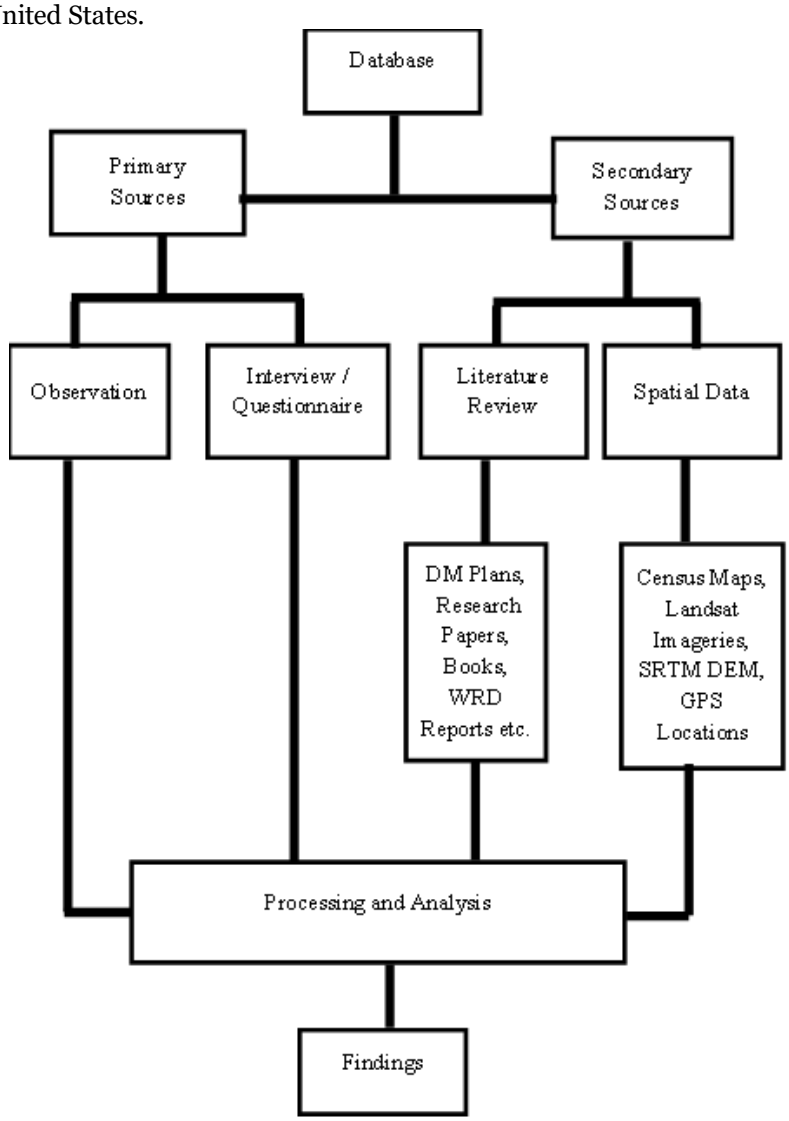

Fig. 2: Flow-chart of methodology of the study.

4. Analysis and Findings

4.1 Flood Hazard in the National Policy Framework

As per the Disaster Management Act of 2005, the term 'Disaster' signifies a catastrophe, mishap or calamity and severe disruption of normal functioning of life in an area, emerging from either natural or anthropogenic causes or by accident or human negligence, which translates into a substantial loss of life (human and animal), damage to infrastructure and property, degradation of the natural or built environment, and human suffering at a large magnitude that the community or society of the affected area could not cope with that. The National Disaster Management Plan (2016) of India aims to make the Nation a disaster-resilient society through disaster risk reduction, which emphasizes minimizing the physical, social, economic and environmental vulnerabilities of communities or Society. The plan has been based on the guidelines and recommendations prescribed under the Sendai Framework (2015-2030) for disaster risk reduction (DRR). However, prior to 2005, various national policies on flood management had been enacted and implemented in the country, but most of them needed inter-department mental cooperation. Some of the past policies have been discussed below.

4.2 The National Water Policy of 1987

The National Water Policy of 1987 recognizes the importance of the Kosi River and calls for the development and management of water resources in the river basin in an integrated and coordinated manner. The National

Water Policy of 1987 provides a comprehensive framework (guidelines) for the development (infrastructural or non-infrastructural) and management of water resources in India, including the Kosi River basin. The policy emphasizes the need for integrated and coordinated management of water resources, efficient use of water, participation of local communities and stakeholders, and inter-state cooperation and coordination.

4.3 The National Flood Policy of 1988

It is another critical policy document that outlines the framework for flood management in India. The policy recognizes that floods are a recurring natural calamity or hazard in the country's flood plains. It also identified that the Kosi River basin is particularly vulnerable to floods due to its geography, climate, and topographic set up. The policy emphasizes the need for a comprehensive approach to flood management (Pre-disaster, during a disaster and post-disaster), which includes structural and non-structural measures. The National Flood Policy of 1988 provides a comprehensive framework for flood management in India, including the Kosi River basin. The policy also emphasizes inter-state cooperation and coordination and integrated management of water resources to mitigate the impacts of floods in the region that are prone to them.

5. State Response to Policy Implementation

5.1 Bihar State Disaster Management Plan of 2008

In 2008, the Government of Bihar prepared the final state disaster management plan called the 'Bihar State Disaster Management Plan of 2008'. This plan outlines the strategies and actions to be taken for disaster management in Bihar, including floods in the Koshi River Basin. The Bihar State Disaster Management Plan of 2008 is an important policy document that outlines the framework for disaster management in Bihar, including the Kosi River basin. The plan emphasizes the need for interdisciplinary, multi-disciplinary, and multi-sectoral approaches to disaster management, including both structural and non-structural measures, indigenous methods of disaster preparedness, mitigation, and community-based disaster preparedness and response.

5.2 Koshi River Basin Management Plan (2010)

The Koshi River Basin Management Plan is a comprehensive document that provides guidelines and recommendations for sustainable management of the Koshi River Basin, which is one of the significant river systems in the Himalayan region. The plan was prepared in 2010 by the Koshi Basin Programme, which is a joint initiative of the International Centre for Integrated Mountain Development (ICIMOD) and the Governments of China, India, and Nepal. The Koshi River Basin comprises an area of 88,000 square kilometres (approx.) and is home to around 40 million people.

Key recommendations of the plan include:

- Strengthening institutions and governance mechanisms for water resource management in the basin.
- Promoting the use of water-efficient technologies in agriculture and other sectors.
- Enhancing the capacity of communities to manage water resources sustainably.
- Promoting the use of renewable energy sources such as hydropower.
- Developing and implementing strategies to reduce the impacts of natural disasters such as floods and landslides.

Overall, the Koshi River Basin Management Plan is an important document that provides a roadmap for sustainable development in the region. However, its implementation requires the cooperation and commitment of all stakeholders, including governments, communities, and the private sector.

5.3 Koshi Flood Management Program (2018)

The Koshi Flood Management Program (KFMP) is a comprehensive flood management initiative undertaken by the Government of Nepal in partnership with the World Bank. The program was launched in 2018 with the aim of reducing the vulnerability of communities living in the Koshi River Basin to flooding. The Koshi River begins in Tibet and travels through Nepal and Bihar (in India), making it one of the major tributaries of the Ganges River. The river is known for its frequent (recurring in nature) and severe floods, which cause serious disruption in the normal functioning of life along with extensive damage to infrastructure and livelihoods among the communities residing in and around the region prone to flood. The KFMP focuses on improving the flood management infrastructure, strengthening early warning systems, and enhancing community resilience to flooding. The Disaster Management Authority of Bihar has proposed a future plan to prepare a comprehensive spatial analysis of various disasters and their associated risks in the state. Thus, due to the lack of such spatial analysis, the present study tries to prepare a spatial analysis of flood mitigation measures in the state's Kosi Basin districts. It will not only give a general understanding of the spatial distribution of the existing management strategies in the state but also give the overall effectiveness of those measures.

6. Assessment of Flood Hazard Management in Koshi Basin Districts

In the present study, an attempt has been made to assess the effectiveness of existing flood management measures in the Kosi Basin districts. For that, six variables have been selected, viz. Embankments, Water Level

Gauging Stations, Flood Shelters, Medical Facilities, Road Network and Distribution of Population. The selected variables have been discussed below:

6.1 Embankments

After the floods in the Kosi River in Aug 2008, which breached the Kosi Eastern Afflux Embankment from 11.37 Km to 13.60 Km at 13km upriver of the Kosi Barrage and 8 km north of the India-Nepal border, the Water Resources Department, Government of Bihar, took up several significant initiatives and projects under the Bihar Kosi Flood Recovery Project. The Embankment Asset Management System (EAMS) for Koshi River, with the assistance of the World Bank, is one of the major projects amongst them. It has helped develop the infrastructural building of embankments along the banks of Koshi.

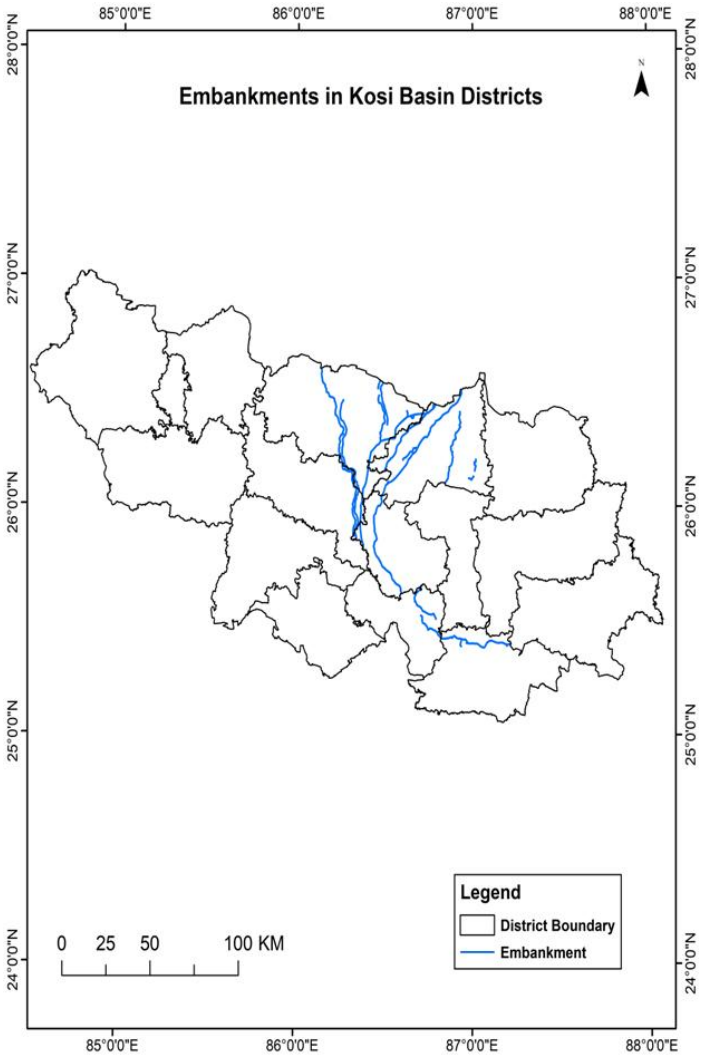

Fig.3: Embankments in Kosi River basin (North Bihar).
Source: Prepared after the Water Resource Department (2015).

Table 1: List of Embankments in Kosi Basin Districts

Sl. Nu.	Name of the Embankment	River	Jurisdiction	Length
1	Eastern afflux embankment at u/s of Koshi Barrage	Koshi	CE, WRD, Birpur	32 km
2	Western afflux embankment at u/s of Koshi Barrage	Koshi	CE, WRD, Birpur	12 km
3	New Nepal Embankment (Above EAB)	Koshi	CE, WRD, Birpur	15 km
4	Koshi embankment (Eastern)	Koshi	CE, WRD, Birpur	125 km
5	Koshi embankment (Western)	Koshi	CE, WRD, Birpur	47 km
6	Nirmali Ghoghrdia	Koshi	CE, WRD, Birpur	8.5 km
7	Ghoghrdiha Ghoghepur Embankment.	Koshi	CE, WRD, Birpur	54 km
8	Sikrahatta – Majhari Low Embankment.	Koshi	CE, WRD, Birpur	18 km
9	Sikrahatta – Majhari Low Embankment (Extended)	Koshi	CE, WRD, Birpur	21.5 km
10	Tiljuga Embankment (left and right)	Tiljuga	CE, WRD, Birpur	25 km
11	Bhutahi Balan Embankment (left and right)	Bhutahi Balan	CE, WRD, Samastipur	54.70 km
12	Badlaghat – Nagarpara Embankment	Koshi	CE, WRD, Samastipur	35.65 km

13	Nagarpara – Narayanpur Embankment	Koshi	CE, WRD, Bhagalpur	31.0 km
14	Tirmuhani – Kursela Enmbankment	Koshi	CE, WRD, Bhagalpur	28.0 km
15	Kamala Balan (Left Bank) Embankment	Kamala Balan	CE, WRD, Samastipur	103.0 km
16	Kamala Balan (Right Bank) Embankment	Kamala Balan	CE, WRD, Samastipur	96.5 km
Total Length (A)				**706.85 km**
17	Jamindari Bunds			
	i) Telhar	Kosi	CE, WRD, Samastipur	17.50 km
	ii) Chorhli	Kosi	CE, WRD, Samastipur	13.50 km
	iii) Lagma-Bharpura	Kosi	CE, WRD, Samastipur	3 km
	iv) Baltara	Kosi	CE, WRD, Samastipur	3.50 km
	v) Bagjan	Kosi	CE, WRD, Bhagalpur	10 km
	vi) Mahadev ring bund	Kosi	CE, WRD, Birpur	3.70 km
Total Length (B)				**51.20 km**
Total Length (A+B)				**758.05 km**

Source: after WRD reports (2015).

6.2 Automatic Water Level Gauging Stations

The Kosi River Basin has several automatic water level gauge stations at various locations, which help monitor the water level at the Kosi River. The following Figure (4) shows the spatial distribution of water level gauging stations in the basin.

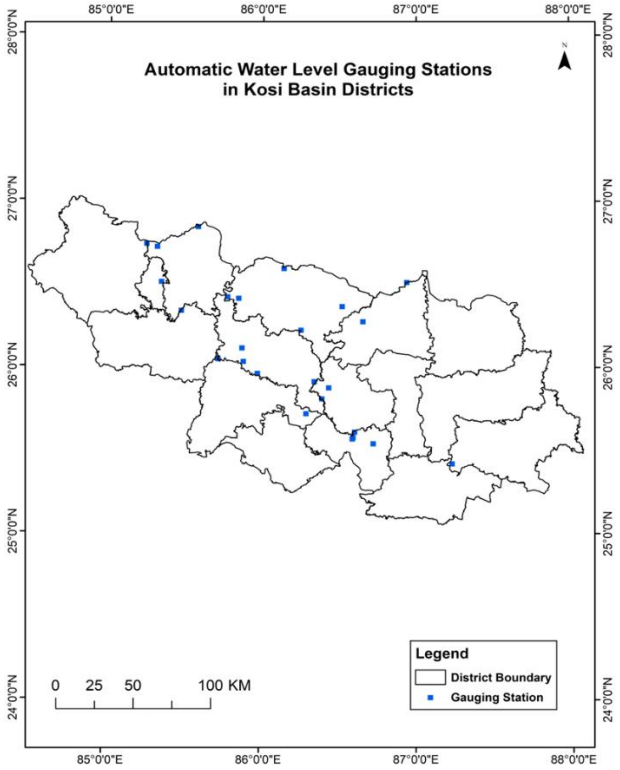

Fig. 4: Automatic Water Level Gauging Stations in Kosi Basin Districts (North Bihar).
Source: Prepared after the Water Resource Department data (2015).

6.3 Flood Shelters/ Relief Camps

During the Kosi Flood of 2014, the government set up several relief camps (21 in Supaul, 28 in Saharsa, 22 in Khagaria, 2 each in Madhepura and Bhagalpur districts and 1 in Madhubani districts). These temporary shelters and camps were constructed in a higher place to move highly vulnerable people to a less susceptible area only for the duration of the flood. Several NDRF have been deployed for relief work in flood prone area. The existing flood shelters and relief camps have been shown in Fig. 5.

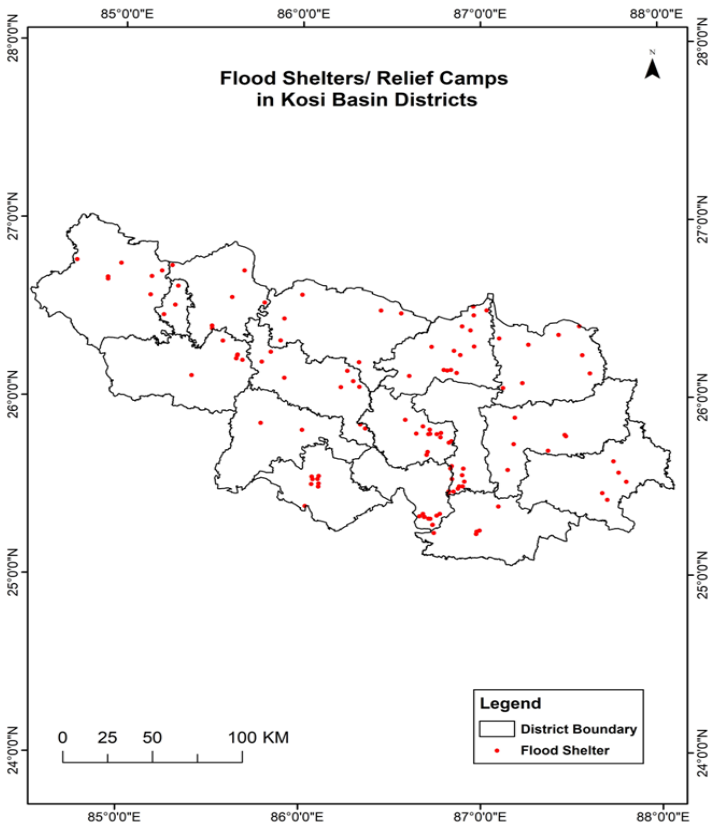

Fig. 5: Flood Shelters and Camps in Kosi Basin Districts (North Bihar).
Source: Prepared after the Water Resource Department data (2015).

6.4 Medical Facilities

Though the medical facilities in the districts of the Kosi River basin need to be better equipped, there are sizeable numbers of PHCs, CHCs, and District hospitals available in the region (Fig 6).

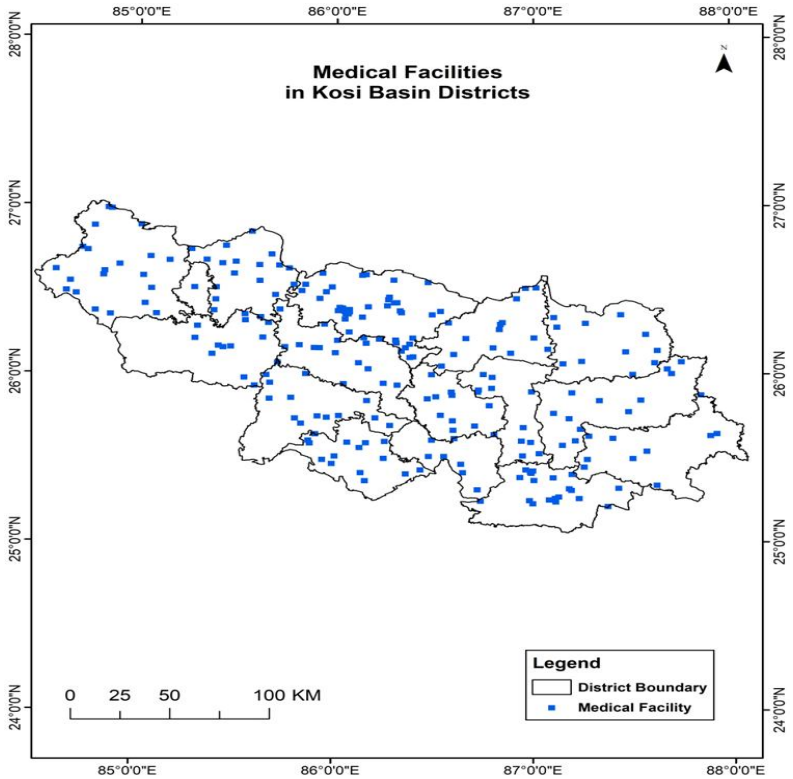

Fig. 6: Medical Facilities in Kosi Basin Districts (North Bihar).
Source: Prepared from NFHS data (2021).

6.5 Road Network

The northern part of Bihar vis-a-vis the Koshi basin region serves as a significant transit zone, which plays a major role in linking the northeastern states of India with a major part of the Nation. This is a key region that facilitates several transportation facilities with a massive network of railways and roadways. Major national highways (NH) which cross this region are: NH 2, NH 19, NH 28, 28A, 28B, NH 30, 30A, NH 31, NH 57, 57A, NH 77, NH 80, NH 81, NH 82, NH 83, NH 84, NH 85, NH 98, NH 101, NH 102, NH 103, NH 104, NH 105, NH 106, NH 107 and NH 110. The East-West corridor runs through the Muzaffarpur-Madhepura-Darbhanga-Purnia cities of Bihar (Fig.7).

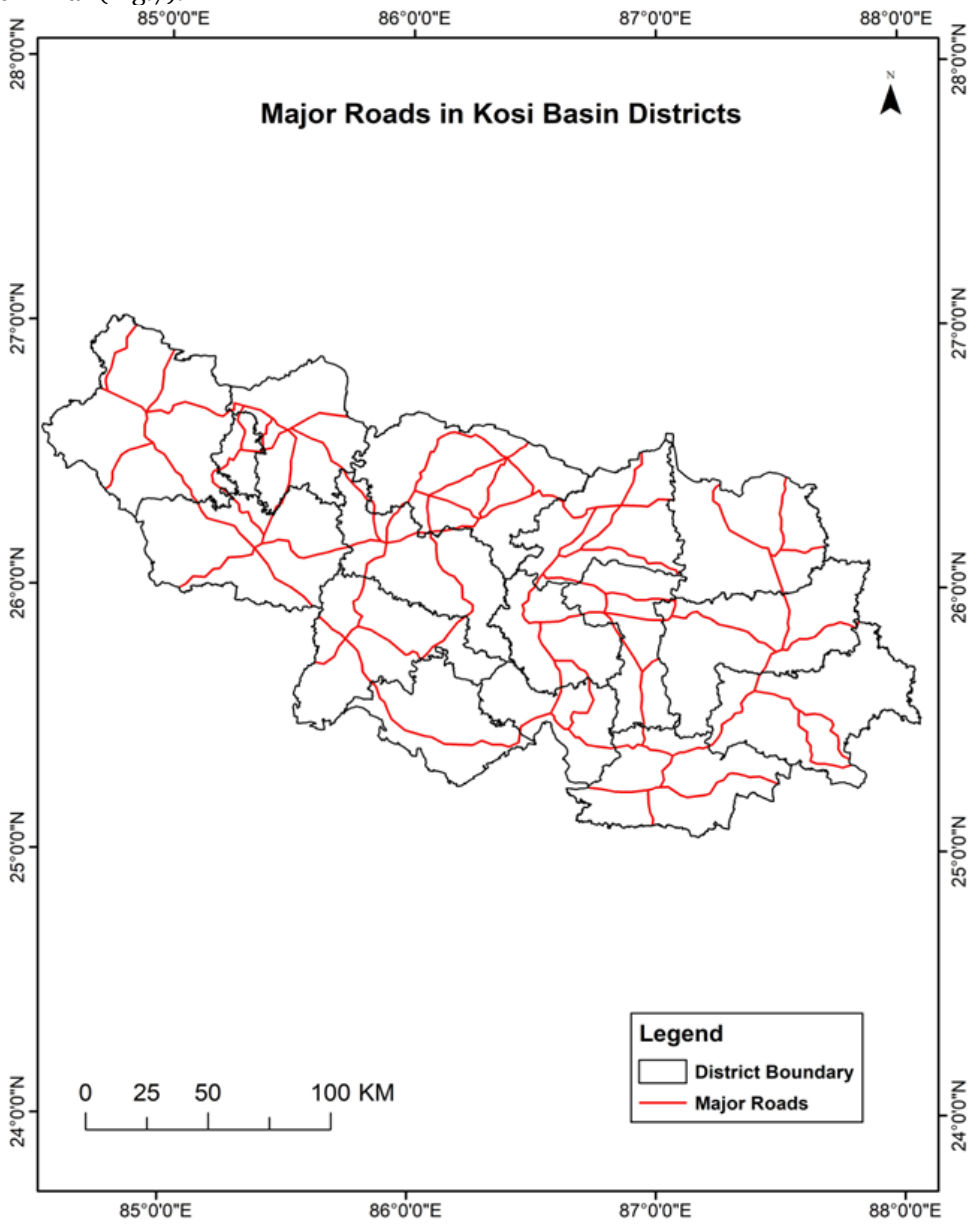

Fig. 7: Road Network in Kosi Basin Districts (North Bihar)
Source: Google Earth Imagery.

6.6 Spatial Distribution of Population

The spatial distribution of the population is highly essential for disaster management agencies while preparing disaster management plans. It gives microscopic details about the various population clusters. In the present study, the Kosi Basin districts have been classified into ten density clusters (Fig.8).

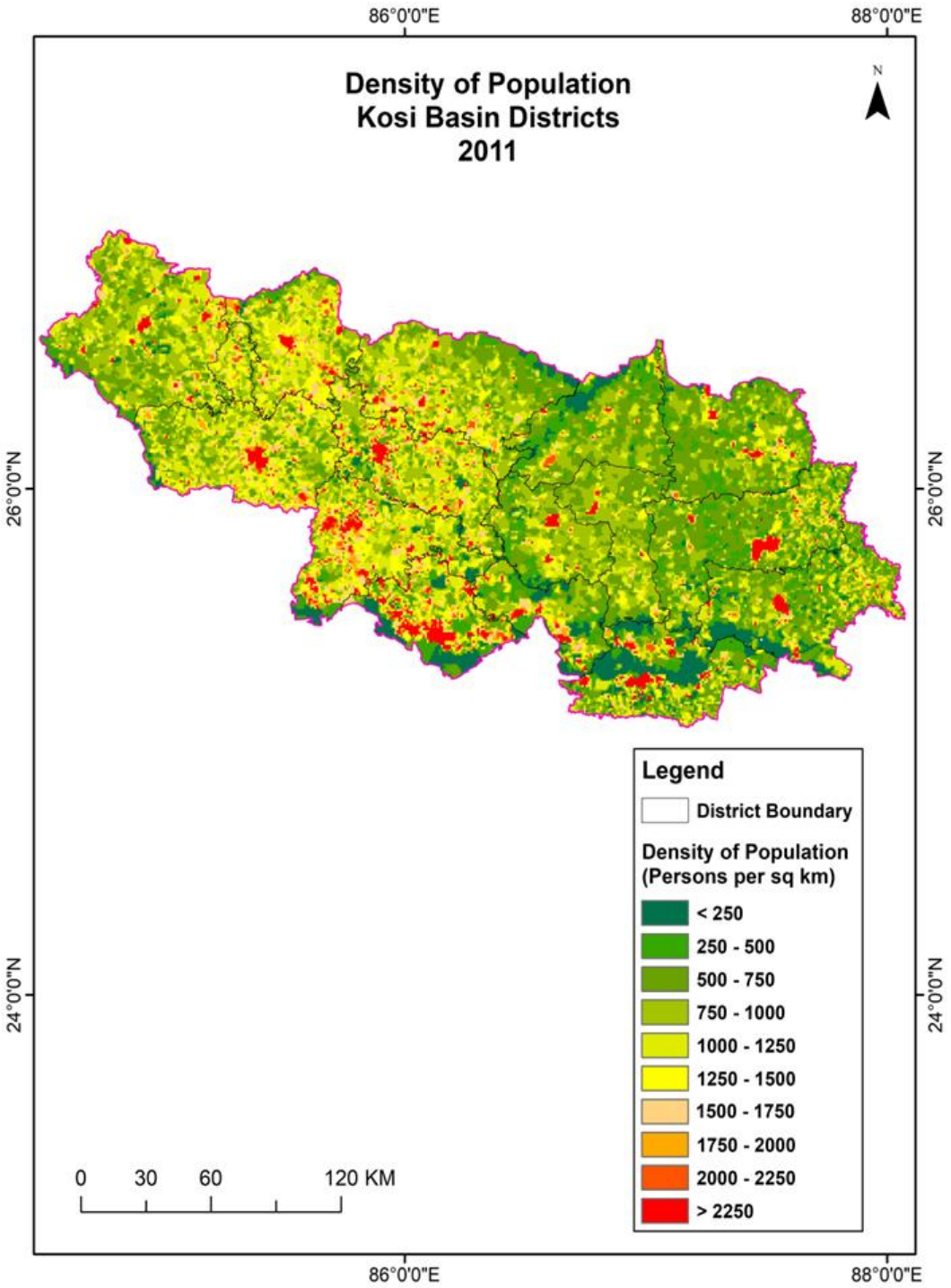

Fig. 8: Road Network in Kosi Basin Districts (North Bihar).
Source: Prepared after the USGS data

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6.7 Assessment of Flood Management Measures in Kosi Basin

The existing literature has observed that flood management measures are not satisfactory in the Kosi basin. A similar result has also been observed from the present analysis. The analysis has shown that among the districts, Supaul, Madhepura, Sheohar, Bhagalpur, and Madhubani have performed relatively better in flood management indicators, while Samatipur, Katihar, and Begusarai have performed poorly (Fig.9).

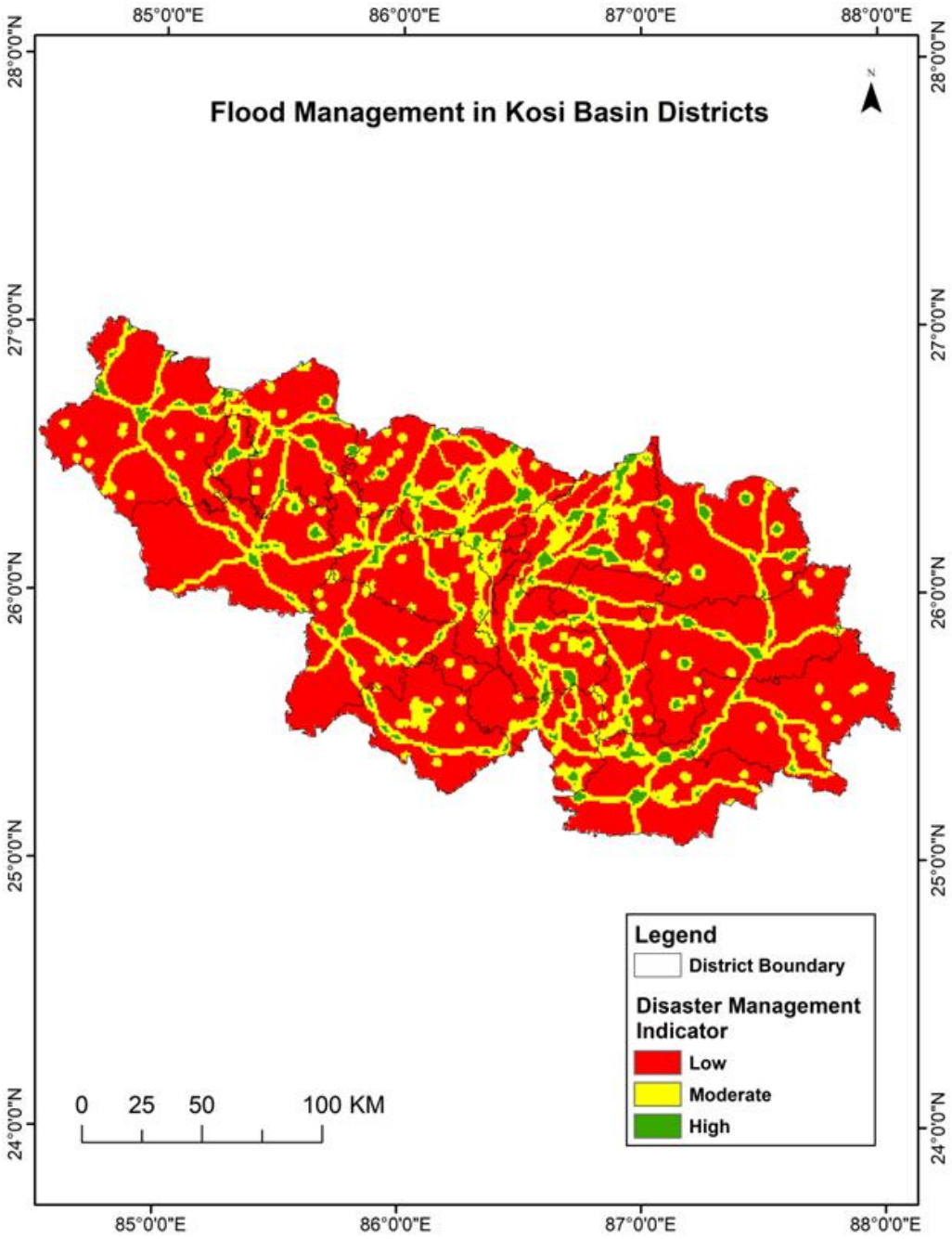

Fig. 9: Flood Management in Kosi Basin Districts (North Bihar).
Source: Prepared by the researcher from secondary data.

7. Rehabilitation Measures in Kosi Basin

The community residing in the riparian area of river Koshi was forced to face several issues such as damage (infrastructural, agricultural), loss of lives during a flood, displacement, lack of basic amenities such as drinking water and food during the flood and suffering from various diseases after the flood. The promises made by several governments still need to be fulfilled properly. Failure to implement the objectives of the Koshi project negatively impacted the lives of those living in the flood-prone region of the Koshi project made lives worse in the flood-prone area of the Koshi River basin.

Due to the slow process of resettlement and its funding, very few families have opted to shift to the rehabilitation areas during floods in the Koshi basin. By 1970, only 6,650 no. of families had been resettled in higher elevation areas. As per the Lok Lekha Committee (Bihar Legislative Assembly), from 1958 to 1962, around 12,000 families were selected for the residential zone beyond embankments in the region and were paid around Rs 17 lakhs as the first instalment for housing. There is a need to implement comprehensive measures to tackle the massive floods in the Koshi basin in Bihar.

8. Conclusion

The study finds that, despite the fact of being one of the utmost flood-prone areas in the country, the government of Bihar needs to address the issues of flooding and cope with its multi-dimensional implications on the society in the Koshi basin. The government's indifference on the way to flood management is evident from the fact that in spite of the formulation of the state disaster management plan in 2008, the state has yet to prepare a comprehensive disaster management report for the state. The district disaster management report needs to be prepared with a district disaster management plan. Apart from that, the existing measures of flood management are found to be insufficient in the present study. There is a need for the inclusion of indigenous techniques and framing an integrated approach to reduce the risks of flood hazards along the Koshi river basin in Bihar. Thus, there is an urgent need for an integrated disaster management plan that can address the perennial issue of flooding among riparian communities in the Kosi Basin.

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