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**Research Article**

# Kosi River- The Sorrow of Bihar Affecting Livelihood Impact Zone of the River with the help of Geospatial Approaches: A Geographical Analysis

MITU KUMARI* AND ANOOP KUMAR SINGH

*University Department of Geography, Pataliputra University, Patna-800020, Bihar*

**ABSTRACT**

This study has addressed a river the principles and practical features of large- and meso-scale changes to the upper braided reach of the Kosi River. It focuses on third-generation issues connected to soil erosion and sedimentation in the districts of Darbhnaga, Madhubani, Supaul, Saharsa, Madhepura, Araria, Purnea, Katihar, Khagaria, and Northern Bhagalpur in Bihar. The study aims to classify land in lower Kosi basin region based on cropping and land utilization patterns, as western anabranches (An anabranch is a section of a river or stream that diverges from the main channel and then re-enters at a later point. It is typically formed by a change in the natural course of the waterway.) deteriorated due to basin shifting. The river, which experienced significant sedimentation due to flood and continues eroding for past thirty years due to shrinking of agricultural land, possibly due to continuous change in the land scenario, which has brought land utilization. For example, the highest area under double cropping systems has been reduce about more than 65 % area in the study area. The Lower Kosi basin's largest area is 18.5% under Supaul district, followed by Madhepura, Saharsa, and Madhubani. Medium range is 7.3%-8.3% under Darbhanga, Araria, Purnea, and Khagaria. This study aims to identify areas in the lower Kosi basin that need conservation efforts to counteract economic losses. Another objective of the study is to investigate livelihood losses and distribution throughout the basin. The conservation priority levels will help plan future conservation efforts. The geospatial approaches can be applied to similar river basins with appropriate calibration and validation. Soil conservation is a challenging issue due to land use and land cover changes, which impact soil erosion and environmental deterioration.

**Key words:** River shifting, Shifting pattern, Cropping pattern, Agri-economic losses, Livelihood loses, and Geospatial visualization

## Introduction

Numerous studies which have made in the past address the fundamental ideas and useful aspects of large- and meso-scale modifications to the upper braided reach of the Kosi River (Omer *et al*., 2022). This, it seems, was one of the causes of land use change. In this work, an effort has been made to provide an explanation for the changes in agricultural practices and economic issues brought on by Kosi basin after 30 years (Adhikari *et al*., 2019). The river has been found to be shifting and shrinking as a result of the changed land categories anabranches after the construction of the Lower Kosi basin (Makaske, 2001). The rivers shifting can consider as catastrophic natural events (Subash *et al*., 2011). For example, floods brought on by higher seasonal rainfall or droughts caused by monsoon instability, which have apparent consequences in flood prone areas of Lower Kosi region (Subash *et al*., 2011). The effects of river

*Corresponding author,
Email: mitukumari1411@gmail.com

shift in plain area locations are more visible, therefore there are more immediate consequences on farmers' livelihoods (Bhatta *et al*., 2015). The rising frequency and intensity of floods has a substantial impact on risks to human lives, property, societal structures, and values with severe repercussions on primary livelihood (Afjal *et al*., 2012; Ahmed *et al*., 2024). Designing and developing more sensible and focused adaptation strategies to support household's capacity to enhance their livelihoods and resilience will be required to develop understanding of household's perspectives on river shifting, their current coping mechanisms, land use patterns, and the critical variables influencing farmers (Baniya *et al*., 2023; Sahani *et al*., 2023). At present, macroscopic research results in related fields are relatively rich, but typical survey analyses based on households are relatively rare, and micro-positive research based on comparisons of farmers in different affected regions is even more rare (Roy *et al*., 2024; Jodhani *et al*., 2024; Sarkar, 2024). This paper explores the discrepancy between river-shifting disasters and land resources operation in diûerent areas of the Lower Kosi region of Bihar with a goal of detecting its impacts on rural household livelihoods in terms of both livelihood improvement ability and disaster pliability.

## Materials and Methods

The data for land evaluation and its change system at farm level were obtained from an inclusive survey of 1200 households with the support of schedule during 2022-23. The sample design adopted for the study was purposive stratified random sampling having three stages. The first stage was selected from the district moderately or least effected. Among badly affected Saharsa and Supaul, moderate affected districts are Madhepura, Khagaria and less affected districts are Araria, Madhubani, Darbhanga, Purnia, part of Katihar and Bhagalpur. For selections of villages limit for spatial ranges as limit up to 5 Km as first order, 6-10 Km in Second order and third order as 11-20 Km were classified into high, medium and low effected. For each selected stratum villages 50 percentage highly effected and rest of the percentage districts among moderate and less affected villages. In this way 4 blocks from badly affected blocks and a total of 16 villages from the district were selected. Under the selection of moderate affected 4 village and less affected 8 village for household survey. The second stage consisted of selecting households from these 18 villages. This was also done with the help of stratified random sampling technique. In this case, the criteria for judging the stratum were the farm size categories. From each farm size categories, 150 households were selected randomly. In this way from badly affected village 600 households were selected randomly followed by 400 household in moderate affected village and 200 household in less affected villages. Thus, a total of 1200 households were surveyed in the study area (Fig.1). For getting accurate information, the farmers' households were visited frequently. A questionnaire was designed to collect the relevant information. Sufficient care was taken to make the questionnaire

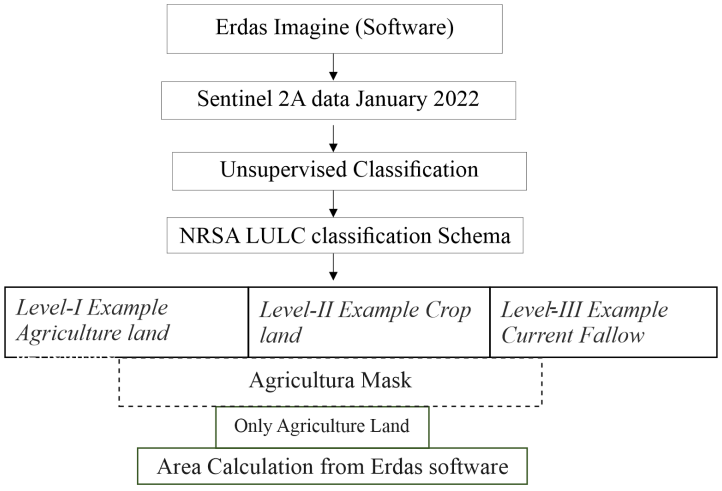


**Fig. 1.** Detailed methodology for LULC classification

communicable to the respondents. In this paper secondary data were used as spatial data in satellite form and its info high resolution data 2007 to 2019 and Sentinel 2A images for 2023 (Mandal *et al*., 2014) were collected from the https://scihub.copernicus.eu/dhus/#/home for the monitoring of LULC and Agriculture land utilization. The goal of the current study is to determine how land use and land clarity affect the concentration of various land types and how this reflects changes in river course in basin areas. High resolution Sentinel 2A satellite data from 2022–2024 is used in the study. Strategies used as:

To classify the images, (Erdas Imagine, 2015) software were utilized. Unsupervised classification methods were used to do the multispectral classification. Until previously, each land use class had homogeneous locations in the picture. Then, for every class, multivariate statistical parameters were collected, such as means, standard deviation, covariance matrices, correlation matrices, etc. In percentage datasets, classification was done independently for area. In the current study, the geospatial approach in Arc GIS software is used to publish maps, such as economic losses and economic index maps, using GPS data and farmer survey data.

A total of 12 scenes from different days of the year were used for the classification of land use from google earth and agriculture cropping pattern derived from remote sensing process (Mandal *et al*., 2019, 2020). Large height fluctuations, intricate habitats, several ecosystem types, a variety of land cover types, and clear regional variances are all present in the watershed. It is considered as one of the world's most sensitive areas to global disaster (Ghosh *et al*., 2023). The main industry in this area is agriculture, although the amount of arable land available is scarce and distributed unevenly. Furthermore, the agricultural yield is mostly dependent on natural circumstances and is produced using antiquated farming techniques. The majority of farmers in the area rely only on agriculture for their livelihoods, and poverty is common in this region.

## Result and Discussion

### *Land use and Land cover classification*

On the basis of the NRSA Hyderabad Considering the land use and land cover schema develop in this paper and using high spatial resolution of remote sensing data, reference to other land cover system results combined with the study area and its distribution as part of districts of Some part of the area is under cultivated and it comprises almost 55.2 percent of the total area. 16.3% area is covered by plantation and settlement covers the 15.6 percent of the total area. Around 5.8% area is covered by water bodies while forest cover the 1.3% out of whole Bihar (Fig. 2 and Table 1).

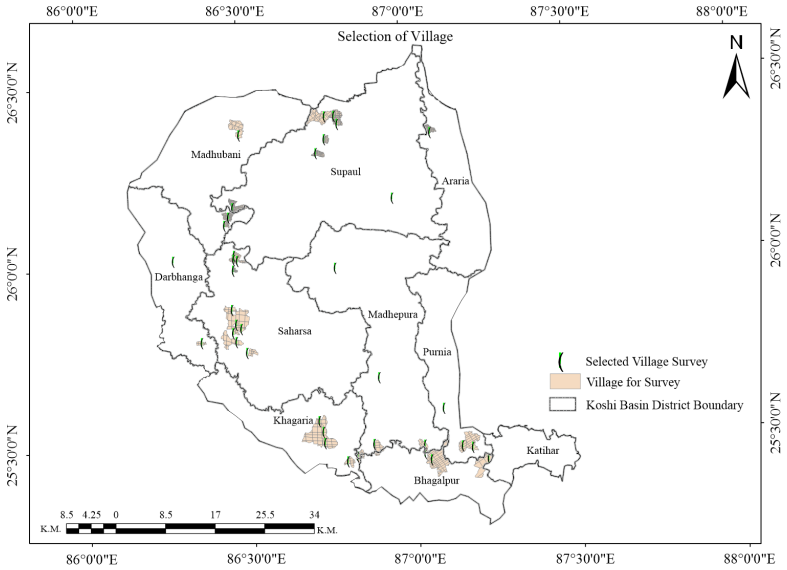


**Fig. 2.** Selection of Village for Survey

**Table 1.** Land Use and Land Cover of the Kosi river basin

| LU/LC category | Area in Percentage |
|---|---|
| River | 2.3 |
| Water bodies | 5.8 |
| Plantation | 16.3 |
| Forest | 1.3 |
| Agriculture land | 55.2 |
| Settlement | 15.6 |
| Diara/Grass | 3.2 |

Authors own calculation: Sentinel 2A

### *Time series analysis of Kosi shifting*

The Kosi River's behaviour, which are commonly referred to as "avulsive" movements, have been extensively observed by earlier researchers. Over the past 200 years, there has been a favoured westward flow of 150 km (Gole and Chitale, 1966; Wells and Dorr, 1987). The break at the eastern afflux bund at Kusaha in Nepal, 12 km upstream of the Kosi barrage, caused the Kosi River to move by around 120 km eastward in August 2008, in contrast to the river's predominately westward motion over the previous 200 years.

The Kosi River, known for its dynamic regime and high sediment load, has been a problematic river due to recurrent flooding and frequent course changes. In 2009, a massive avulsion in Nepal and north Bihar inundated a large area. It has long been considered as a troublesome river due to repeated and substantial floods and frequent changes in its courses (Sinha, 2008). The avulsed channel reoccupied the one of the prehistoric channels of the Kosi river and the flow of the river diverted into the new course. In recent years, a vast section of Nepal and north Bihar was submerged by what has been called one of the largest avulsions in any large river system worldwide (Sinha, 2009). Landsat, Modis, and Sentinel data, as well as multi-year data, were used to analyze the current study (Fig. 4 & 5).

### *Agriculture Land Utilization*

According to the image processing results the largest area in the Lower Kosi basin under agriculture is in Supaul district (18.5%) followed by Madhepura 18.2, Saharsa 14.1 and 11.3 percent under the Madhubani district (Fig. 3). Comparably, the medium range comes areas under the districts of Darbhanga, Araria, Purnea, and Khagaria is 7.3% to 8.3%. On

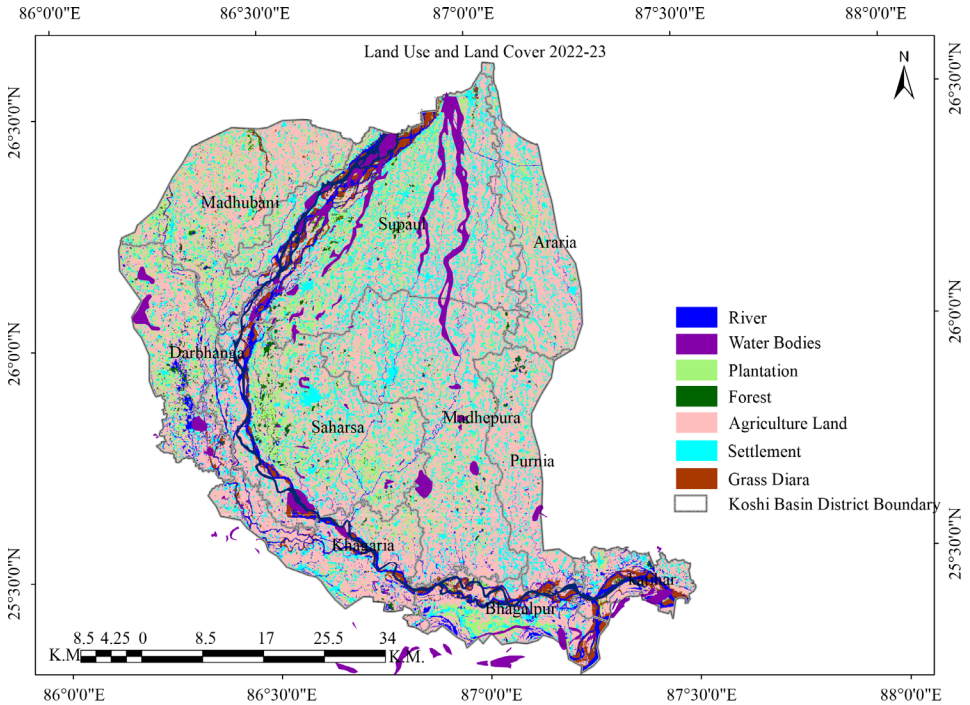


**Fig. 3.** Land Use and Lan Cover during 2022-23

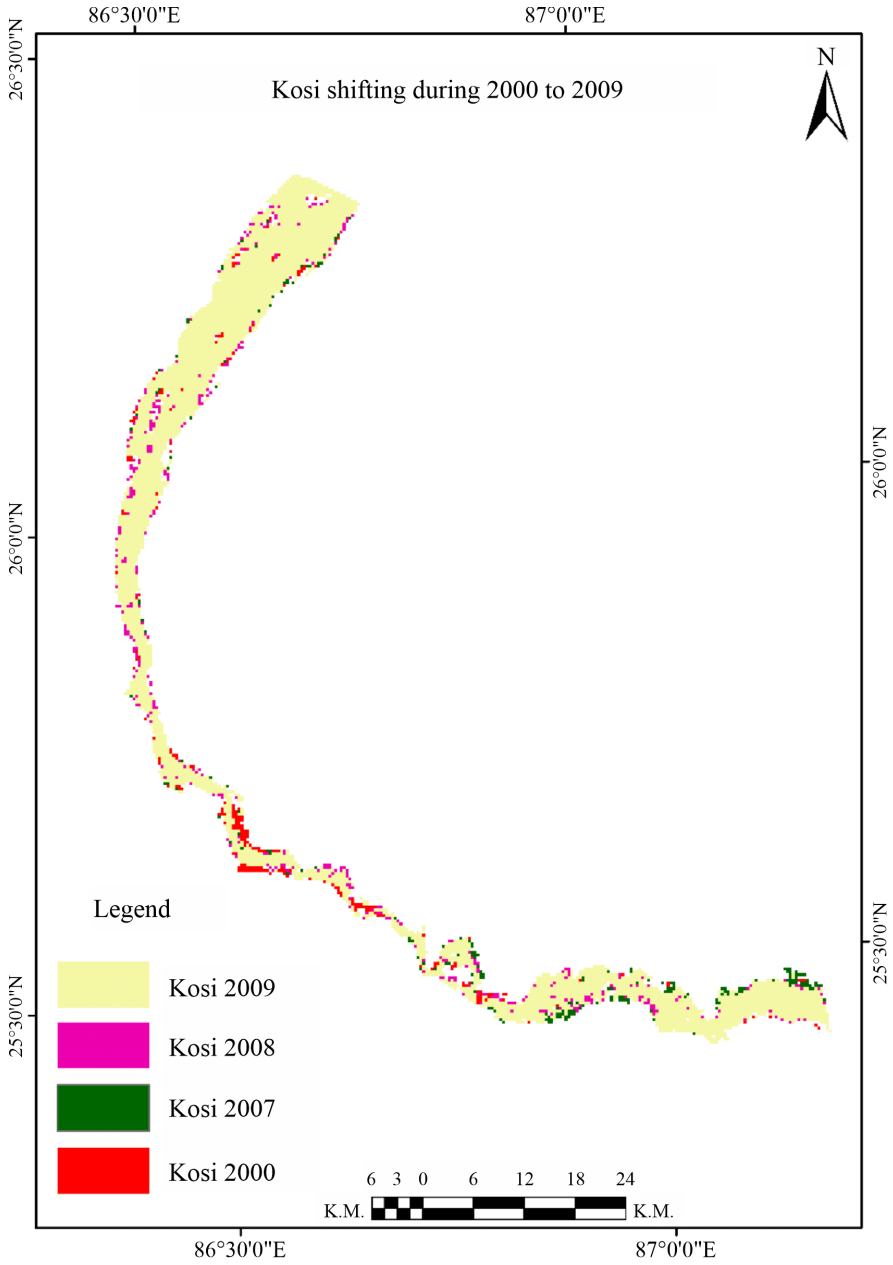


**Fig. 4.** Kosi river shifting during 2000-2009 to 2022-23

the other hand, the beneath is in Katihar and Bhagalpur (Table 2).

### *Land Utilization Analysis based on farmer's practice*

Analysis using Kharif, Rabi and Zaid season data and cropping systems analysis derived from Sentinel 2 A data during 2022-23 reveal that the highest area under double cropping systems about more thar 65 % area in the study area. Rice -Maize cropping systems is followed by single cropping system and Lowest area under triple cropping systems. Cropping pattern and practices of farmers change due to river shifting factors were analysed using 1200 farmers opinion and farmers' perceptions. From Selected GPS field, samples of maize, rice, pulses during kharif season and maize, mustard, potato, pulses, wheat during rabi season plus jute,

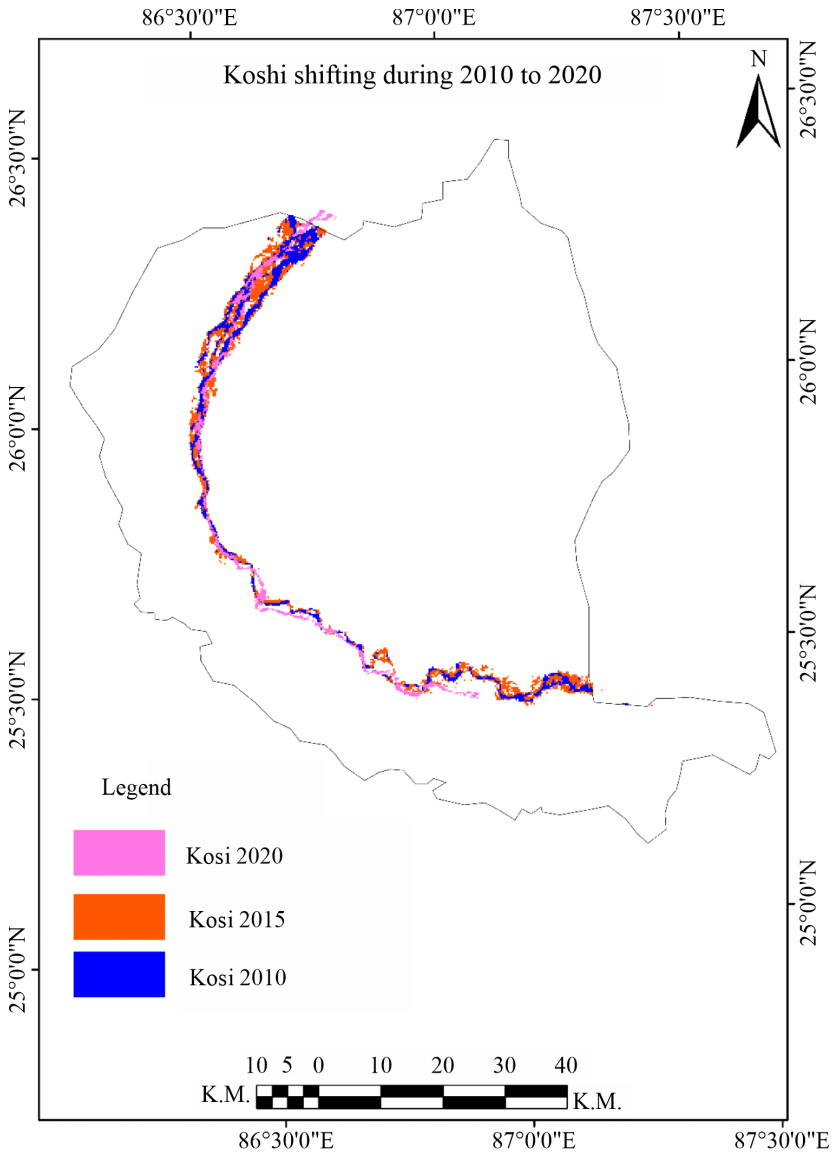


**Fig. 5.** Kosi river shifting during 2010- 2020

**Table 2.** District wise agriculture area in Kosi basin from Sentinel 2A data

| Districts | Agriculture area in percentage |
|---|---|
| Araria | 7.5 |
| Bhagalpur | 4.6 |
| Darbhanga | 7.3 |
| Katihar | 2.7 |
| Khagaria | 8.3 |
| Madhepura | 18.2 |
| Madhubani | 11.3 |
| Purnea | 7.5 |
| Sarahsa | 14.1 |
| Supaul | 18.5 |

maize, pulses, rice during zaid season were taken. The study area was divided into three crop based economic classes, from very low to extremely high, based on the estimated input and output crop-based farming. The southern area of the basin was less erodible and the central area highly erodible. The differences in erosion levels between the northern, central, and southern parts of the study area are mainly due to topography (Derakhshan *et al*., 2020). In a comparable manner the research area's southern regions are classified as low economy areas based on crop-related economic indicators. Khagharia, a portion of Saharsa, a southern portion of Madhepura,

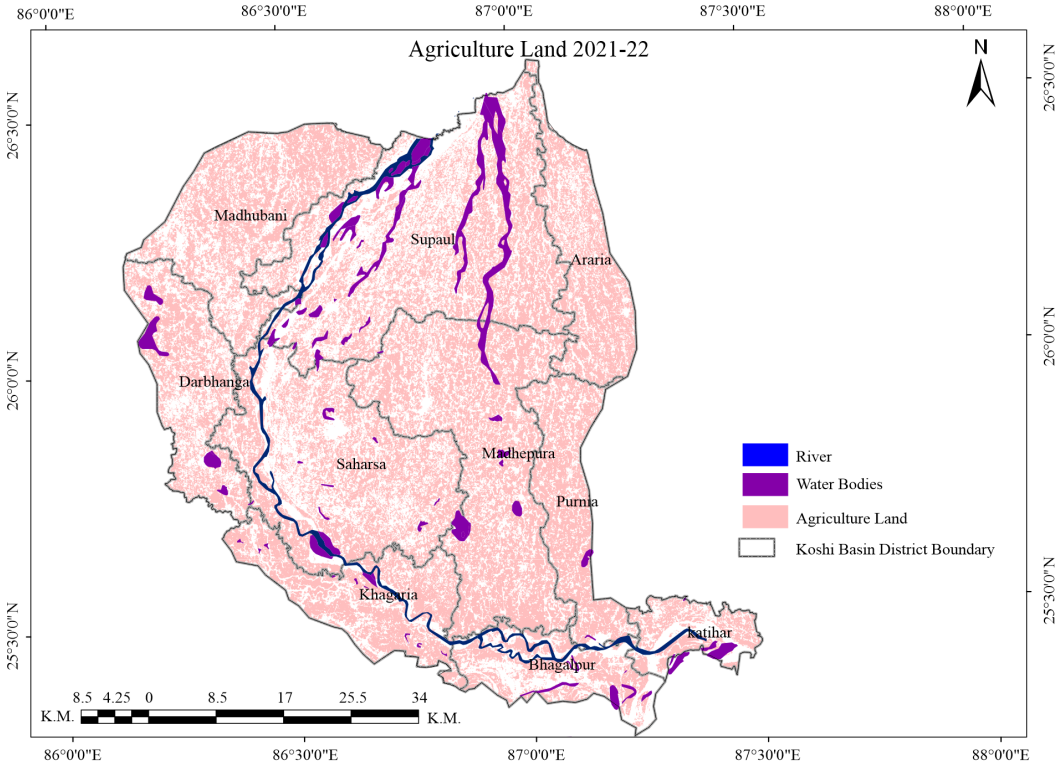


**Fig. 6.** Agriculture Land in Lower Kosi basin

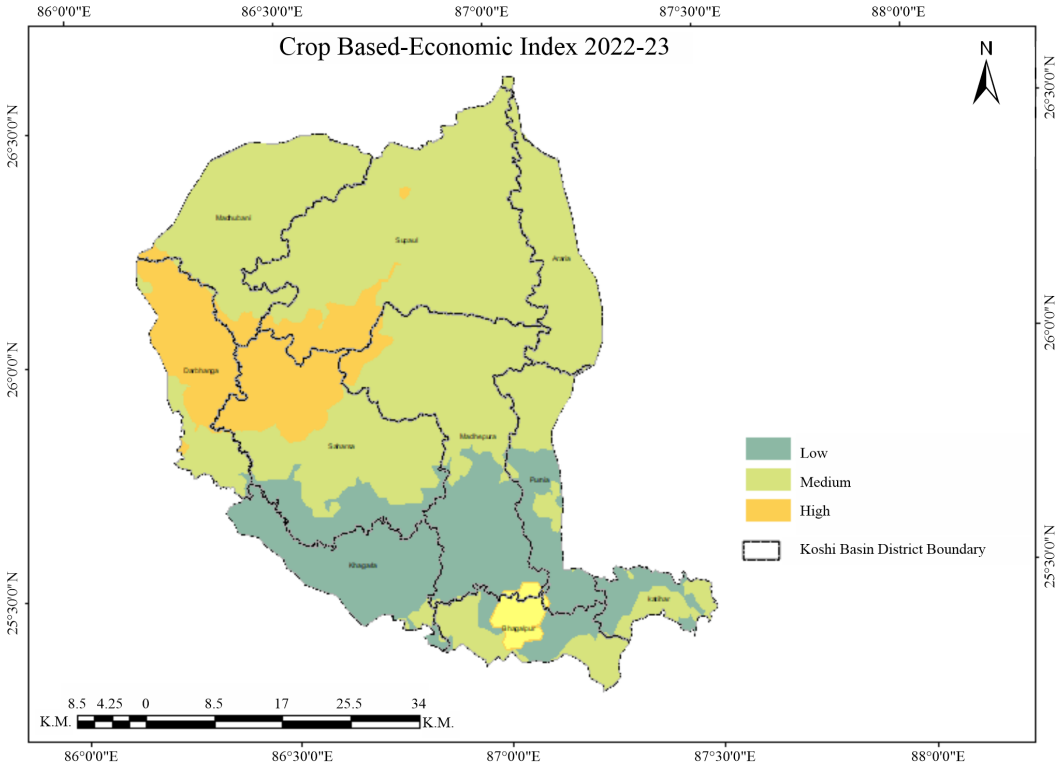


**Fig. 7.** Spatial visualization of crop based economic losses during 2022-23

**Table 3.** District wise farmers practices during 2022-23

| District | Farmers perception (Area in Percentage) | | | | |
|---|---|---|---|---|---|
| | Kharif | Rabi | Zaid | Double Cropping | Triple Cropping |
| Araria | 13.3 | 26.6 | 6.6 | 40 | 13 |
| Bhagalpur | 23.3 | 26.6 | 13.3 | 26.6 | 10 |
| Darbhanga | 13.3 | 10 | 0 | 43 | 33.3 |
| Katihar | 31 | 40 | 9 | 12 | 8 |
| Khagaria | 25 | 17.3 | 9.16 | 32.3 | 15.8 |
| Madhepura | 23.3 | 16.6 | 6.6 | 37.3 | 16.5 |
| Madhubani | 13.3 | 10 | 20 | 40 | 16.6 |
| Purnea | 28 | 40 | 9 | 12 | 12 |
| Sarahsa | 30 | 17.08 | 9.16 | 33.3 | 10.8 |
| Supaul | 22.9 | 25.6 | 16.16 | 21.6 | 13.6 |

and a few regions of Katihar and Purnea came next (Table 3). The areas in the very low erosion class were mainly located at the lower elevations which includes part of Araria, some part of Madhepura and Purnea (Fig. 4). The Soil conservation represents a complex biophysical, social, and economic challenge. Soil erosion is linked both to environmental degradation and to inappropriate land use practices, and is strongly affected by land use and land cover change. For example, clearing of forest land for agriculture and infrastructure development.

### *Crop based economic losses Index*

The economic losses due to river shifting in the study area were estimated from survey data and result reveal that three crop based economic classes, from very low to extremely high, based on the estimated input and output crop-based farming. The southern area of the basin was less erodible, and the central area highly erodible. Similarly southern parts of the study area are spatially under low economic area as per crop based economic losses index. This is followed by Khagharia, Part of Saharsa, soutrhrtn part of Madhepura and some parts of Katihar and Purnia (Fig. 8). The areas in the very low economic losses class were mainly located at the lower elevations where the terrain is relatively flat such as part of Araria, some part of Madhepura and Purnia.

$Y_{EC} = Q_i X_{PC}$

$Y_{EC} = Qi \times {}_{PC}$

where $Y_{EC}$ Agriculture economic losses, Qi is production and PC = current price of corresponding crops

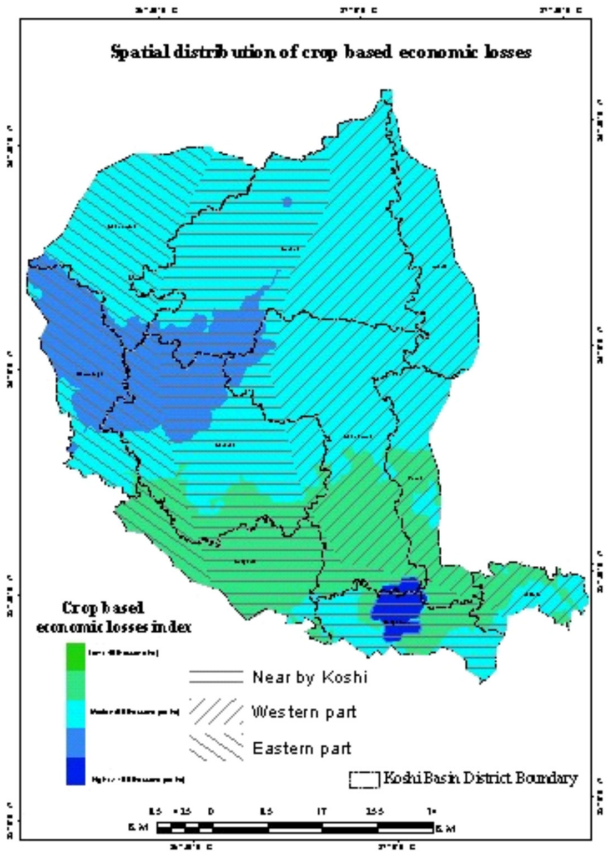


**Fig. 8.** Spatial distribution of Crop based economic losses in Lower Kosi basin

## Conclusions

The findings provided here demonstrate that employing remotely sensed data and automated land cover analysis, a modelling approach known as the crop based economic losses, can be used to create a comprehensive spatial assessment of the distribution of risk of losses over an entire basin. At the basin level, field-based measurement is not a feasible option; the results provide the best substitute. It is possible that conservation priorities provide a helpful benchmark for decision-making for governmental bodies. It is anticipated that the conservation priority levels determined by this study will identify places that are most likely to need actions to counteract further economic losses, making it easier to plan future conservation efforts in the Lower Kosi basin. It is anticipated that the conservation priority levels determined by this analysis will indicate which areas are most likely to need action to counteract additional economic losses. It is anticipated that these sites will be dispersed over the basin. The model can be applied to river basins that are similar to this in the other region with the appropriate calibration and validation. Land use and land cover changes, such as the clearing of forest area for agricultural and infrastructure development, have a significant impact on soil erosion and are linked to both unsuitable land use practices and environmental deterioration.

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