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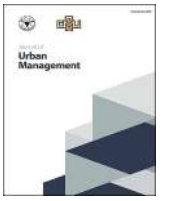

Case Report

Assessing industrial linkage and strategic locations for sustainable economic development: A case study in North Corridor of Bangladesh

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ABSTRACT

Industrialization is a key driver of economic development. Despite its potential in northern Bangladesh, especially in Kamarkhanda upazila, the region faces challenges like underutilized resources, unorganized industries, and a lack of strategic planning. Tools such as forward and backward linkages and economic zones remain underexploited. Moreover, natural hazards like floods are often ignored in zoning decisions. This study aims to identify suitable industries and safe locations for sustainable industrial growth, incorporating industry linkages and disaster risk factors such as floods and earthquakes. An Input-Output model was applied to analyze industry linkages, and a GIS-based Multi-Criteria Decision Analysis (MCDA) was used to select optimal industrial sites. Data were collected through 400 household surveys based on the Yamane formula and questionnaires from 51 industries by purposive sampling as there was no data available on the government website. The Analytical Hierarchy Process (AHP) was used to assign weights to criteria such as proximity to growth centers, markets, roads, slope, elevation, and precipitation. Findings show dairy farms have a 99.8 % backward linkage with agriculture, while rice mills and Shitalpati industries have 49.7 %, largely dependent on imports. Suitable economic zones were identified near the Dhaka-Sirajgonj highway and railway lines, as well as outside flood-prone and earthquake-risk zones. These findings support future master plans and informed policymaking for sustainable industrial development.

1. Introduction

Industrialization has been the major force driving economic growth and modernization, dramatically transforming societies ever since it launched a century ago with the British Industrial Revolution in the late eighteenth century (Acemoglu, 2012). In many developing countries, industrialization became a transformational force; it lifted millions out of poverty, created jobs, and brought about sustained economic growth (UNIDO, 2024). This industrialization wave began with the First Industrial Revolution in England between 1750 and 1760 and marked a major historical transition from agrarian to industrialized economies. The process has since progressed through many technical and sociological changes at a global level (Jiang, 2024).

Industrialization has driven economic expansion worldwide, although its benefits have been unevenly distributed. In East Asia, countries like China and South Korea exemplify how rapid industrial growth can fuel urban development. China's industrial boom in the 1980s, driven by major investments in infrastructure, human capital, and proactive government policies, transformed not only its

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economy but also its urban landscape, leading to the rise of megacities and improved urban infrastructure (Kniivilä, n.d.). Industrialization encourages urban development by attracting workers to cities, which drives population growth and increases demand for housing, transportation, education, and healthcare services. The formation of backward and forward linkages, as described by Hirschman (1958), stimulates local enterprise growth and encourages innovation, further diversifying and strengthening urban economies. While emerging economies often face hurdles such as inadequate infrastructure and weak planning systems (Bamber & Fernandez-Stark, 2019), strategic industrial zoning can address these issues. For example, the Gujarat International Finance Tec-City (GIFT) in India showcases how industrial zones can concentrate investment, enhance logistical efficiency, and catalyze the urbanization process by integrating local industries into broader national and global supply chains. Additionally, reverse linkages provide local suppliers with opportunities and incentives, creating industrial ecosystems that support sustainable urban growth (Gereffi & Fernandez-Stark, 2011). Thus, industrialization not only drives economic development but also serves as a key engine for urban transformation.

In Bangladesh, industrialization has been recognized as one of the most important processes of transformative change. The government has constantly appreciated the role that industrialization can play in fostering economic development and reducing poverty, starting from the First Five-Year Plan, which emphasized the development of the manufacturing sector. Through the years, the policies relating to industrialization in Bangladesh have been couched in broader socio-economic goals, including policy formulation, poverty reduction, and the search for sustainable development (Akinrebio, 2024). Nonetheless, industrialization has not occurred uniformly; instead, cities like Dhaka and Chittagong have been curved out as the major industrial centers. This concentration has exacerbated regional inequalities and strained urban infrastructure (Rahaman et al., 2023).

A strong backward linkage is as important as a forward linkage in making the necessary industrial development for Bangladesh. Indeed, industries are related as the linkages materialize at every stage; overdependence on imports diminishes, and naturally, this factor fortifies national domestic economies (Bamber & Fernandez-Stark, 2019). The textile industry of Bangladesh is one of the very good examples showing strong backward linkages, especially through the purchase of raw materials—cotton—by the local producers themselves. This not only improves the financial situation for rural agriculture but also meets the needs of the urban production sectors (Rubel, 2023). Nonetheless, barriers like useless commercial enlargement and environmental decline underscore the need for strategic zoning to capitalize on the advantages of industrialization at the same time as assuaging its terrible effects (Sarkar, 2004).

When considering all factors, the North Corridor, especially the Sirajganj district in Bangladesh, acts as a significant driver for equitable industrial growth across the region. In light of the location on main transport corridors and along the Jamuna River, combining a logistical advantage with an economic opportunity in tackling the constraints of poverty, underdevelopment of resources, and inadequacy of infrastructure, accordingly, by strategically using zoning, this area is well-positioned to encourage dispersed industrial growth with lesser burdening of cities and integration of local economies with national and international value chains. The establishment of industrial zones in this corridor has the potential to greatly enhance both forward and backward linkages. This development would enable local industries to supply raw materials to national and international markets while also fostering local demand for goods and services (Sarkar, 2004). This strategy has the potential to enhance the inclusion of less developed areas within the national economy, foster regional fairness, and advance sustainable growth.

This investigation aims to examine the impact of strategic zoning on promoting economic growth in the North Corridor of Bangladesh. The analysis of possible backward and forward connections, combined with an investigation of zoning strategies, aims to produce practical recommendations designed to improve industrial interdependence and promote regional equity. This study aims to deliver significant insights regarding the dependence on local and intra-regional industries, serving as both a catalyst and a framework for the successful incorporation of zoning strategies into master or development plans. The study investigated the interlinking of the existing industries in the region and determinable types of industries for growth, and it assessed suitable locations for these industries with consideration for natural disasters, among a range of multi-criteria factors in the area.

2. Literature review

2.1. Empirical study

The establishment of industrial links was examined with a focus on industrial development as well as inter- and intra-regional connections. The majority of studies employed input-output models. Employing the I-O model, Haque (2005) investigated economic disparities across six regions in Bangladesh. Haque employed I-O analysis to propose strategies aimed at enhancing productivity and investment in developing countries. The latter has employed the I-O model to emphasize Ethiopia's connections and contend that economic advancement necessitates increased investments. The two studies aimed to highlight the significance of I-O models in regional economic planning; however, they were constrained by data limitations. Haque (2005) utilized secondary data sourced from the Bangladesh Bureau of Statistics, while Tesafa (2014) gathered data from 38 sectors, which presented ambiguous demand estimates. They neglected rural and route connectivity in favor of metropolitan cities. Haque (2005) stated that an I-O table may incorporate sectoral methods into planning and policymaking by describing the economic dynamics of a specific region for a certain time. This method is valuable, although few people have studied I-O analysis at the micro level since 2005. Recent research has shown that backward and forward connections may help explain industry interdependencies and guide sustainable economic strategy. According to Chen and Suk (2023), China's coal sector supports upstream industries via backward linkages and influences downstream industries through forward linkages. Claus examined New Zealand's economy and found that wholesale commerce and air transport were extensively integrated into production networks due to the hub's massive backward and forward links (Kim et al., 2022). expanded this work to examine Korea-ASEAN-5 manufacturing sector interdependencies, stating that such links are crucial to regional economic

development and diversification. It implies backward and forward links, with primary movers informing the upstream and downstream growth of major sectors. Thus, it might make industrial zoning and policy choices more practical and persist longer. Hossain and Dewan (2015) studied land zoning in densely populated Bangladesh. Rapid development, urbanization, and population increase are straining limited land resources, they argue. The authors insist on using remote sensing and GIS data to assist judgments.

The decision in suitable economic zones is required, especially in disaster-prone areas, on the premise of very careful analysis of factors for which the combination of GIS with MCDA is a very effective technique. Land suitability analysis determines places for industrial setup and helps balance between economic benefit and environmental constraints. For example, the case studies conducted in Cox's Bazar, Bangladesh, highlight the contribution that land use planning can play in safeguarding sensitive ecological sites toward the fulfillment of sustainability at large (Khatun, 2014). The case studies conducted on Khulna City depict quite poignantly that the selection of industrial sites forms the very core of sustainable growth in urban areas (Haque et al., 2021). In those cases, AHP and GIS-based MCDA were employed to integrate factors such as proximity to water bodies, temperature, land use compatibility, and transport connectivity in developing suitability maps that would guide industrial planning toward sustainability.

In this respect, MCDA using GIS has evolved as a vital tool in land-use planning and site selection for industry, structuring several factors such as proximity to resources, climate adaptability, and accessibility. Such a method, applied with weighted criteria or threshold-based analyses, can successfully categorize and rank choices of location (Greene et al., 2011). showed the strengths in using this technique, citing how GIS-MCDA brings together various stakeholder points of view and displays them in a visual format, with added transparency via sensitivity analysis of spatial data. More recent works continue to include environmental considerations, especially those related to natural disasters, within plans for economic zones. Fuzzy AHP has been widely used in land use suitability analyses, considering slope and elevation parameters and proximity to critical habitats during disaster situations. Its application in Cox's Bazar tried to balance ecological sensitivity with vulnerability to natural hazards.

AHP and one of its extensions, Fuzzy AHP, are among the diverse tools commonly adopted for land suitability analysis. Weighing of criteria is thus performed in accordance with expert judgments. AHP's pairwise comparison method ensures that factors such as economic viability, environmental impact, and disaster risk are weighted in the right proportion, while Fuzzy AHP does the job by incorporating ambiguity in expert assessments (Park et al., 2020). This feature is much needed in analyzing areas that are uncertain or in disasters. Planning an industrial zone falls under the goals of sustainable development; specifically, Goal 9 aims at enabling resilient infrastructure and sustainable industrialization (United Nations, 2015). Careful site selection not only reduces environmental impact but can also enhance the resilience of regional economies to climatic hazards. For example, studies in Khulna City have shown that compliance with the sustainable site selection criteria leads to regional economic stability and resilience–a signal of advantages accrued to strategic industrial development in consistency with SDGs.

2.2. Review of the environmental impact assessment report

The proposed Sirajganj Economic Zone is spread over an area of 1041.43 acres in Syedabad Union of Sirajganj Sadar Upazila, Northern Bangladesh (EQMS company, 2021). It covers three mouzas, which are Khasbarshimul, Pansona, and Chakboyra of Sirajganj Sadar, and Belchuti and Barbera Kharia of Belkuchi Upazila. First and foremost, the Economic Zone on the west bank of the Jamuna River close to Bangabandhu Bridge will increase the connectivity of this region, acting as a connecting point between Dhaka and Northern Bangladesh. As cited in the ESIA Draft Report prepared by Sirajganj Economic Zone Limited, the proximity of the site to a char of the Jamuna River at a distance of only 2.6 km makes it fall within a flood hazard zone and thus be very vulnerable in case of seasonal flooding The infrastructure and sustainability risks can be identified in the severe flood of 2024: flood risks when water levels reached 37 and 17 cm above the danger mark at Jamuna's Sirajganj Hard Point, BDnews24, July 12, 2024. Kafi and Babel (2022) present the flood zone of Sirajganj as very diversified: Sirajganj Sadar is representative of a high-risk category flood area, while Belkuchi stands at a moderate risk category, hence putting additional importance on robust flood management and infrastructure resilience for sustainable operations within this zone.

2.3. Theories on clustered industrial development and location selection for industry

The framework embeds the concepts of cluster theory, multi-criteria decision analysis, and value chain analysis in a search for optimum development of economic zones. Each component adds a unique value to the understanding of how industry linkages, spatial planning, and economic performance assessments work together in the provision of sustainable industrial ecosystems.

2.3.1. Cluster theory

Cluster theory has been conceptualized by Alfred Marshall (1920) and later elaborated by Porter 1990. A cluster is defined as a geographical concentration of interrelated businesses in an economic zone. Clusters are networks of independent yet interdependent companies that achieve, through mutual availability of resources, infrastructure, and knowledge, a competitive advantage (Porter, 2000). Clustering allows for sophisticated competition that "emphasizes innovation rather than cost-cutting imitation" and enables "flexible, rapid responses to market needs" (Bucifal, 2008). This theory underlines the role of location in forming an integrated network of value-added production chains and points to agglomerations as providing economic resilience through efficient resource allocation and industry synergies.

2.3.2. Multi-criteria decision analysis (MCDA)

MCDA will be of paramount importance in complex decision support through the structuring and evaluation of a number of factors

influencing economic zone development. MCDA provides, according to Langemeyer et al. (2016), methodologies that allow stakeholders to evaluate and subsequently rank alternatives based on quantifiable performance metrics and stakeholder preferences. The structured process of MCDA allows planners to balance competing interests, explore trade-offs, and make transparent, robust decisions. The methods of AHP and multi-attribute utility theory in MCDA provide the means to consider a broad range of criteria, including but not limited to environmental impact and economic viability, and social consequences toward the goals of sustainable development.

2.3.3. Value chain analysis

Value chain analysis, put forward by Porter (1985), is an analytical technique by which activities in an industry can be analyzed and optimized. It helps to identify cost drivers and points of competitive differentiation by structuring activities into primary and support functions that add value (Woudstra & Powell, 1989). Assessing the interrelated activities within an economic zone, the value chain analysis becomes an approach showing how firms within a cluster gain advantages from pooled resources, infrastructures, and cooperative linkages. This allows policymakers to appreciate how the linkages in an industry can unfold both upstream and downstream, where value addition and sustainable growth can potentially be realized. At the industry-wide level, value chain analysis has also been used to explore the cooperative and competitive relationships that shape economic performance and resilience in clusters (Walters & Rainbird, 2007).

Integration of theoretical components puts together this framework, which postulates that optimized clusters through value chain linkage and MCDA are able to create sustainable development in economic zones. Cluster theory undergirds both the spatial and operational synergy of industries, while value chain analysis shows a way to value creation and competitive advantage; MCDA enhances decision-making by incorporating multiple criteria with a view to balance and sustainability in industrial development. Together, these theories offer a systematic means to help plan and evaluate economic zones, which would otherwise contribute to or foster resilient and sustainable economic ecosystems.

2.4. Review of historical disaster impacts

Natural disasters, especially floods, have long plagued the Sirajganj district. According to Baki et al. (2015), there have been significant floods in 1949, 1956, 1961, 1962, 1966, 1967, 1974, 1979, 1987, 1988, 1996, 1998, 2002, 2004, 2007, and 2008. The city was twice flooded to a depth of almost seven feet, making the 2007 flood the most destructive of these (ICLEI – Local Governments for Sustainability South Asia, 2016). Compared to the devastating 1988 flood, floodwaters increased even more in 2010 (ICLEI – Local Governments for Sustainability South Asia, 2016).

More recently, the district was inundated with about 500 villages, and over 100,000 people were left stranded by the 2016 flood, which was caused by heavy rainfall and upstream water inflow. In 2020, a widespread national flood crisis affected over 3.3 million people across 21 districts, including Sirajganj (BWDB, 2025). Sirajganj Sadar's water level as of June 19, 2025, was 9.85 m, lower than the highest level ever recorded in history, which was 14.70 m. This underscores the continued necessity of flood risk monitoring and adaptive infrastructure planning (BWDB, 2025).

2.5. Research gap

The industrial sector is a major component of Bangladesh's economic structure, as it contributes significantly to GDP growth, employment generation, and export earnings (World Bank, n.d.). However, to date, there is still a large gap in the studies that have explored the interindustry relationships with regard to both forward and backward linkages, especially at the upazila level, using the Input-Output (I-O) model. Most of the available body of scholarly literature, quite notably with emphasis on research conducted by Hoque (2005) and Huq and Ichihashi (2023), underlines mostly the stratified structure of sectors based on their respective contributions. Such a focus has led to a serious dearth of extensive quantitative linkage studies at the micro-regional level. Such a lack of in-depth investigation is particularly concerning given that industrial zoning—a vital strategy for achieving equitable regional development—has not been adequately explored. Most of the previous studies on zoning, like the one by Hoque (2005), have been conducted primarily for residential sectors and have failed to include crucial aspects such as disaster resilience, the benefits of rural markets, and the economies of scale associated with industrial clustering. The lack of comprehensive zoning studies presents significant challenges for policymakers in setting up sustainable and disaster-resilient economic zones. This paper tries to fill this gap by conducting a detailed analysis of industrial linkages and zoning approaches at the upazila level (the lowest administrative unit in Bangladesh), with special emphasis on sustainability and resilience within the country's context of industrial planning.

3. Study area profile

Sirajganj is a district in Bangladesh's North West Rajshahi Division, known for its breathtaking natural beauty, rich culture, and heritage, including the residence of Rabindranath Tagore. It is often called the gateway to Uttar Pradesh. Landmarks like the Jamuna Bridge, the Jamuna River, and the Korotoa Canal further add to the beauty of the region, which in turn facilitates economic growth.

There are nine subdivisions in the district, one of which is Kamar Khand. The boundaries of the subdivision are Belkuchi, Ullahpara, Sirajganj Sadar, and Raiganj. Regarding Kamarkhanda, Sirajganj, Bangladesh, the coordinates are around 24° 23′ 5″ N, 89° 40′ 43″ E (see Fig. 1). Though Kamarkhanda is the smallest sub-district, with an area of 90.80 square kilometers, it has a population of 138,645 with 31,961 households (BBS, 2011). About 12–14 km from the Yamuna River, the Kamar stretch is particularly vulnerable to natural hazards, especially floods and riverbank erosion. The main industries of the area are small and medium-scale industries, traditional

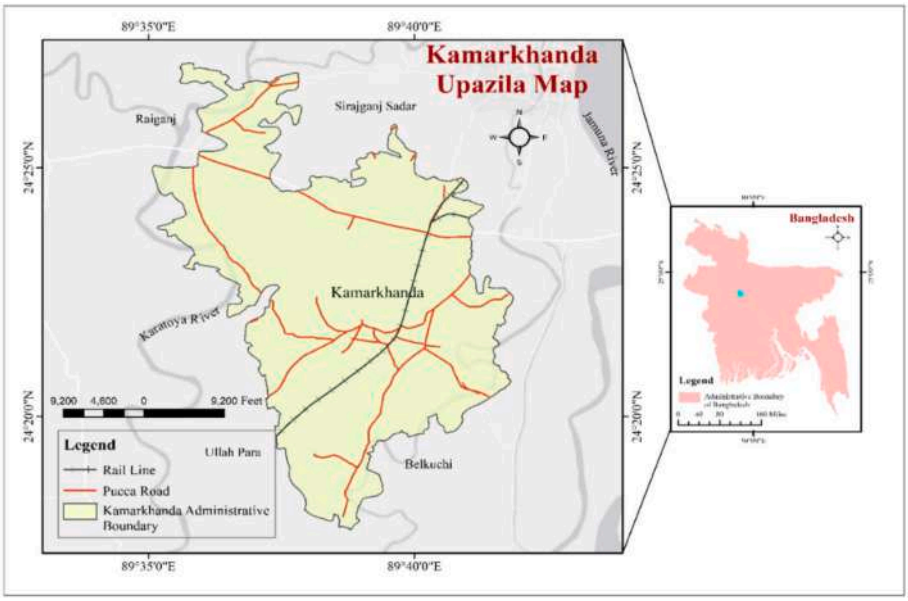

Fig. 1. Kamarkhanda Upazila map (study area).
Source: Authors' drawing

craftsmanship of Shital Pati, a kind of mat, and jute. There is a considerable tract of agricultural land, but that is not adequate to meet the local demands. Located near the Yamuna River, a great source of water and transportation, plays a significant role in economic activity and development.

4. Materials and methods

4.1. Data sources

Data collection involved two distinct types of questionnaire surveys: one targeted households within the defined study area, while the other focused on manufacturing industries. The questionnaires are validated by consulting with experts. The information collected from these two survey tools is employed in performing the Input-Output analysis. A secondary data analysis was conducted utilizing GIS techniques that incorporated a combination of criteria. The data required for this study were collected from various sources, including USGS, LGED, and the Upazila map of Kamarkhanda Upazila.

4.2. Sample size determination

4.2.1. Sampling method

Data were collected from the selected study area using two different sampling techniques. The stratified random sampling method was used in the household survey conducted for Kamarkhanda Upazila. In this method, an equal number of samples was chosen from each of the four unions in order to represent the variation in the different regions properly. The purposive sampling method was used for the industrial survey. This approach allowed for the identification of industries that best fit the detailed criteria relevant to the study's objectives, despite the absence of a detailed list of industries.

4.2.2. Sample size

When the population size is known, the Yamane formula for sample size determination is most suitable in research. In 1967, the formula emerged as the most straightforward and dependable method for extracting samples from a large population. The formula is: (Kayes et al., 2025; Sultana & Hasan, 2023; Yamane, 1967)

$$n = \frac{N}{1 + Ne^2} \tag{1}$$

Here, ***n*** refers to the sample size, which is defined as the number of individuals or units to be drawn from the population for the study. ***N*** is the population of the study area, meaning the whole group out of which the sample is to be drawn. The variable ***e*** is the margin of error, representing the permissible difference between the sample result and the true population parameter. Typically, this would be at 0.05 for a 95 % confidence level, meaning there would be a 95 % likelihood that the sample would represent the population within the error margin stated. This formula thus ensures that the sample size is sufficient to yield valid and reliable research results.

According to BBS (2011), the population size of Kamarkhanda Upazila is 31961. As the most recent census data is not currently available, census data from 2011 was collected. So-

$$n = \frac{31961}{1 + \left(31961 * 0.05^2\right)} = 395 \text{ for household survey}$$

For the questionnaire survey in industrial, there is no specified data on industries; for that, the sample was collected as much as possible with variety.

4.3. Methods of data analysis

4.3.1. Input-output model (IO model)

Table 1 in Input – Output analysis is basically a matrix that make easy to understand the flow in input of raw materials and output of products and final demand and value-added section as well. It is very important when writing to set the target date, generally taken as one year, and to decide which industries of the domestic economy are to be written about (Yoomi et al., 2022).

The basic structure of the input-output table, as presented in Table 1, can be prepared separately for the identification of forward linkages and backward linkages. The various elements of the table are arranged both vertically and horizontally. The vertical columns refer to the inputs of raw materials in quantity or monetary terms, besides value-added components or operating costs such as wages, electricity, taxes, etc. Unlike the columns, however, the horizontal rows represent outputs from one industry to another, final demand, and export, also in quantity or monetary terms. Final demand across the horizontal rows shall include such elements as subsidies and household expenditure that relate to the specific industries. The last row would represent the total input calculated by summing up values in each column. While the last column gives the total output, found by adding up the entries in its row.

For forward linkage (Tesafa, 2014)

$$L_{ij} = \frac{FLi,j}{\sum_{j=1}^{n} FLi,j} \tag{2}$$

In equation (2), Li,j denotes the coefficient for each cell, and $FL_{i,j}$ is the output value from the ith industry to the jth industry. Here, $\sum_{j=1}^{n} FLi,j$ represents the total output produced from the ith industry.

For backward linkage (Tesafa, 2014)

$$L_{ij} = \frac{BLi,j}{\sum_{j=1}^{n} BLi,j} \tag{3}$$

In equation (3), Li,j denotes the coefficient for each cell, and $BL_{i,j}$ is the input value from the ith industry to the jth industry. Here, $\sum_{j=1}^{n} BLi,j$ represents the total input taken from the ith industry.

Limitations of the I-O model: The I-O paradigm is inherently static; it presumes a constant input-output connection and fails to include temporal dynamics. Furthermore, the model requires comprehensive and precise data, which may be difficult and expensive to acquire.

4.3.2. Multi-criteria decision analysis (MCDA)

For both economic zone selection and flood hazard area identification, which is a variable of economic zone selection criteria, the

Table 1
Basic structure of the IO model.

Input from:		Output to:							
		Intermediate Use				Final Demand			Total Output
		Industry 1	Industry 2	Industry 3	…….….	Industry n	Household consumption	Government consumption	
Intermediate Use	Industry 1 Industry 2 Industry 3 …. …. …… Industry n								
Value Added	Wages Taxes Import								
Total Input									

Note: IO stands for Input Output.
Source: Glasson, 1974; Guo et al., 2012

MCDA method has been applied. Coupling the use of GIS with MCDA makes the judgments of decision makers flexible and more precise (Nigusse & Adhanom, 2019; Yahaya et al., 2010).

Each variable in the identification of economic zones and flood hazard mapping holds a different influence and importance. Assigning different weights to each variable is, therefore, necessary in analysis. Many researchers use expert opinions solely for the derivation of these weights, but this study used the AHP method.

4.3.2.1. Identification of weight for the criteria: analytic hierarchy process (AHP). One of the most popular MCDA methods for solving multi-criteria problems, very useful in the GIS-based analysis developed by Thomas L. Saaty in 1980, is the AHP method. It has been used in this study to assign weights to different spatial criteria that helped in demarcating economic zones and flood-prone areas. It ensures that decisions are made according to expert judgment but also considers spatial issues. Three experts were selected for this study, who were professors and assistant professors with expertise in research, GIS, and previous work experience on AHP.

The traditional AHP method was utilized instead of Fuzzy AHP because the expert responses were clear and consistent using numerical pairwise comparisons. There was no significant uncertainty or vagueness that required fuzzy logic. AHP also allowed for straightforward interpretation in identifying suitable industrial sites. However, I recognize the value of Fuzzy AHP and may consider it in future studies where expert judgment is more uncertain.

4.4. Methodological steps

A methodological flowchart expresses how guidelines should be followed step by step throughout the whole process so that one reaches the ultimate goal of the analysis. A well-developed flowchart means that the process is clear and transparent, reducing the possibility that an error occurred or causes major hindrances along the way due to missteps. Fig. 2 show the methodological flowchart developed for this study:

5. Analysis and findings

5.1. Demographics of the household

The various categories of specific expenditures were collected through a household survey in order to determine the final demand for forward and backward linkages. Table 2 shows the average annual spending in Bangladeshi Taka for 400 households across different categories. The highest expenditure is on food and beverages, estimated at 84,627 BDT, while rice comes second at 36,138 BDT, both being important items of everyday consumption. On the other side, Oil and Dairy Products spending amount to 11,206.2 BDT and 9270.9 BDT, respectively. Then there is Textiles at 12,336 BDT, Sanitation spends of 5329.5 BDT show the increasing importance in spends, and others consist of the remaining miscellaneous spent at 8457 BDT. This gives the division an emphasis on how much households' spending relates to edible foodstuffs, while their share of necessities is relatively less compared to other expenditure types.

For industrial location identification, factors such as labor wages, condition of existing industries, and utilities like electricity, and the condition of roads play a crucial role. Additionally, understanding the knowledge and access to these resources is important. Table 3 presents the condition of the road in the Likert scale, the existence of industry in binary (yes/no) units, average daily electricity availability, and daily wages of labor, calculated based on the responses from a sample of 400 respondents.

Table 3 determinants for identification of industrial location based on the responses of 400 participants. The average daily wage of labor is 487.5 BDT, while the average number of hours of electricity availability per day in the studied region is 20.11 hours. In terms of road conditions for the transportation of goods, the majority of respondents assessed them as Good (70.5 %) and Very Good (11.5 %). A smaller portion rated the conditions as Normal (9 %), Bad (3 %), or Very Bad (6 %). Furthermore, 29 % of participants acknowledged the existence of industries in the region, whereas 71 % reported the absence of such industries.

5.2. Forward and backward linkage

Data for the analysis of forward and backward links was acquired from 51 manufacturing enterprises via questionnaires. The collected information included input sources, end product markets, input costs, and revenue specifics. Furthermore, data from 395 homes were gathered to facilitate the computation of household demand. The information on government subsidy data was gathered through the KII from Upazila Poverty Alleviation Officers and also used in the final computation of demand.

5.2.1. Backward linkage of existing industries

Backward and forward links are important for economic development, and economic zones contribute a great deal to their enhancement. No individual industrial sector can adequately drive the economic growth of the entire region. Consequently, it is essential to pinpoint sectors that exhibit both weak and strong backward and forward links within the research domain. The IO model was subsequently applied to the aforementioned problem, and the results, as illustrated in Tables 4 and 5, provide valuable insights for policy implications concerning sustainable economic growth.

Table 4 illustrates the backward connections of industries, including dairy farming, rice milling, chicken farming, and textiles (e.g., towel manufacturing). Notwithstanding the area's little size and the restricted quantity and diversity of enterprises, the region has

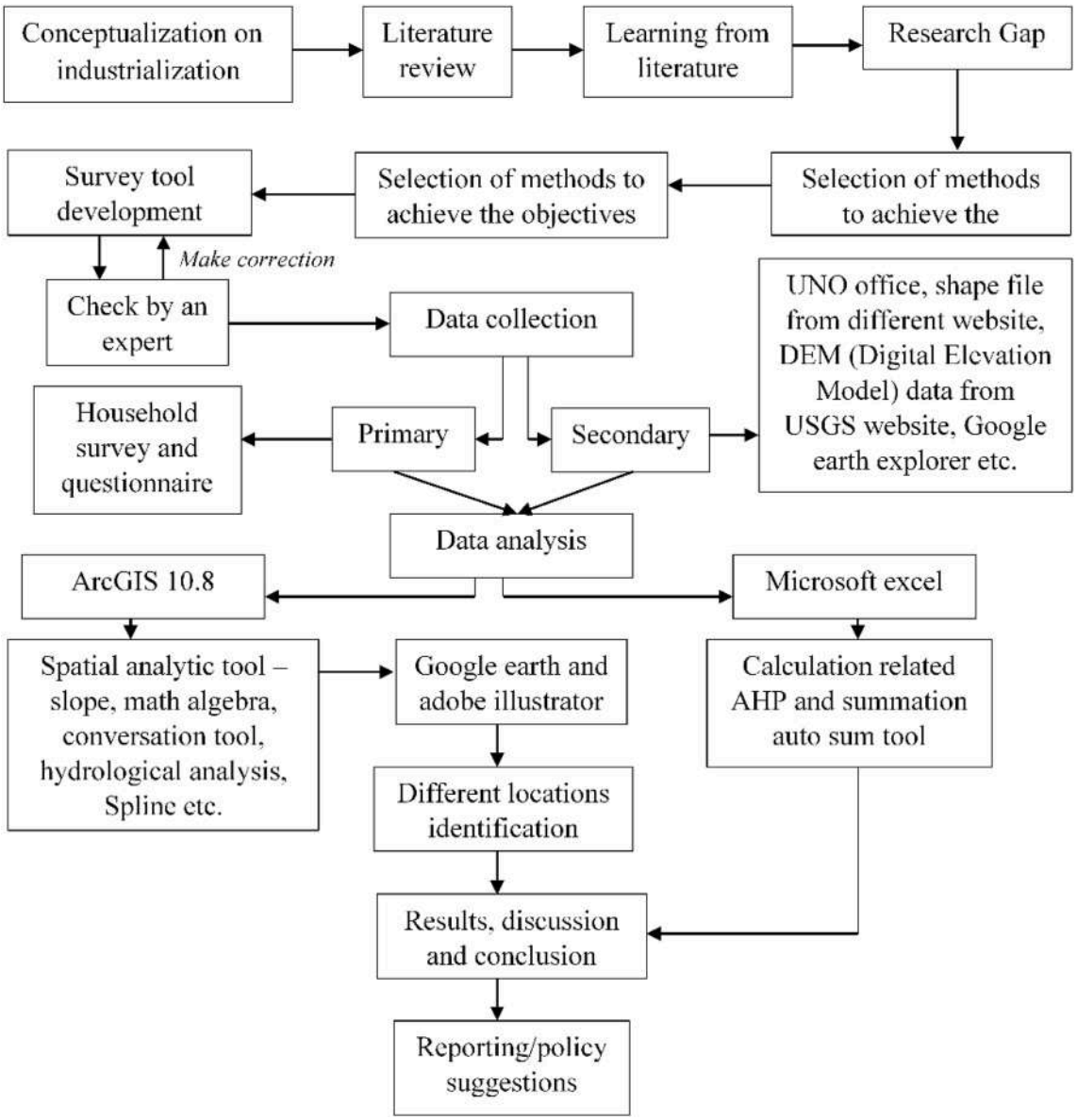

Fig. 2. Methodological steps.

Table 2
Average yearly expenditure in different categories.

Category	Average yearly expenditure in BDT (sample 400)
Food and Beverage	84627
Dairy product	9270.9
Oil	11206.2
Rice	36138
Sanitation	5329.5
Textile	12336
Others	8457

Note: BDT stand for Bangladeshi Taka.
Source: Field survey, 2024

considerable promise. The agriculture sector supplies 99.8 % of the inputs for dairy production, with a mere 0.2 % sourced from other sectors and no reliance on imports. This signifies a strong backward connection, implying that the development of industries associated

Table 3
Key influential factor for industrial establishment.

Criteria	Result
The average wages of labor in the study area	487.5 BDT
The average hour of having of electricity in the study area	20.11 hours
Road conditions for transporting goods to the market	Very bad (6 %) Bad (3 %) Normal (9 %) Good (70.5 %) Very good (11.5 %)
Availability of industry in the study area	Yes (29 %) No (71 %)

Note: BDT stand for Bangladeshi Taka.
Source: Field survey, 2024

Table 4
Backward linkage of the industries.

Backward Linkage				
	Agricultural	Industrial	Service	Import
Dairy farm	0.998	0.002	0	0
Industry	0.497	0.006	0	0.497
Poultry farm	0.591	0.409	0	0
Textile	0	0.588	0	0.412

Source: Authors' calculation, 2024

with dairy products will be both sustainable and efficient. Rice mills are the primary contributors to the local economy, although Sithal Pati has cultural and social significance for the community. Rice mills rely on the agricultural sector for 49.7 % of their inputs, with a mere 0.6 % sourced from the industrial sector, while 49.7 % of their inputs are imported from the Natore district, indicating poor regional backward linkages. These industries have promise, since rice mills demonstrate a 59.1 % contribution from agriculture and 40.9 % from the industrial sector, with no reliance on imports.

In the industrial subsector of making towels, 58.8 % relies on the industrial sector for its inputs, and 41.2 % on imports, while the major import locations are Narayanganj and Dhaka. Thus, high transport costs increase the expenses due to huge reliance on imports, reducing overall efficiency in the end. It is essential for policies to focus on fostering local industries that supply inputs for rice mills and textiles, thereby strengthening backward linkages and decreasing dependency on imports. Supporting dairy product enterprises will strengthen the robust agricultural link, fostering sustainable development. Furthermore, enhancing the organization and resource distribution for Sithal Pati production could elevate its cultural and economic importance. The region exhibits significant potential for ongoing economic advancement by concentrating industrial development on improving both backward and forward linkages.

5.2.2. Forward linkage of existing industries

Table 5 shows the forward linkage of the selected industries-dairy farming, rice milling, chicken farming, and textiles (towel manufacturing)-to agriculture, industry, meat processing, services, and final demand. The forward linkage of the dairy farms to the service sector is very high, reaching about 74.6 %, while their products are highly used as an input in services such as distribution or retail, though they also contribute 13.9 % to meat processing and only 8.4 % to final demand.

This may facilitate the advancement of retail chains, delivery systems, and food services, while enhancing the overall economy through interconnected opportunities across various sectors. The industrial sector, which includes rice mills and Shital Pati, demonstrates a strong connection to services, with a linkage rate of 97.9 %. This illustrates the significant reliance of services on this sector for its service-oriented functions, whereas the connection with agriculture, meat processing, or final demand is minimal at 0.4 %. Strong forward linkages to the service sector from rice mills and Shital Pati enforce logistics and retail growth. The rice mills contribute to improving rice distribution in Dhaka, while the Shital Pati promotes retail and cultural events to maintain tradition. This promotes

Table 5
Forward linkage of the industries.

Backward Linkage					
	Agricultural	Industrial	Meat processing	Service	Final Demand
Dairy farm	0	0.031	0.139	0.746	0.084
Industry	0	0.016	0	0.979	0.004
Poultry farm	0	0.604	0.151	0.031	0.213
Textile	0	0.109	0	0.81	0.08

Source: Authors' calculation, 2024

commerce, preserves cultural heritage, and bolsters the economy. The forward linkage to industry is very high for poultry farms at 60.4 %, showing their great role in industrial processing. They further contribute a lot to meat processing at 15.1 % and final demand at 21.3 %, while their backward linkages to services are limited, at 3.1 %. In addition, service-related activities are dominated by the towel manufacturing sector, accounting for as high as 81 %, indicative of its importance to retail. On the other hand, its contributions to the total industry are 10.9 % and to final demand, 8 %. These would tend to suggest that sectors such as dairy and poultry have avenues of diversification into meat processing and further downstream into the consumer market, while sectors such as textiles may seek alternative avenues in an attempt to enhance value added and thereby move towards integration into final demand. The textile and industries group is more export-oriented, while the dairy and poultry farms have more of their produce being marketed locally. This will help develop the local sectors into downstream industries, strengthen their links to final demand, and thus promote economic growth, especially in less-developed areas like Sirajganj.

5.3. Economic zone identification

5.3.1. Result from Analytic Hierarchy Process (AHP)

Within the framework of the Multi-Criteria Decision study (MCDA), two matrices were made for the study: one to judge the weight for economic zone identification and the other to define flood hazard zones. Table 6 illustrates the pairwise comparison matrix used for the identification of flood danger areas. The study encompasses six criteria, with the Random Index (RI) established at 1.24 and the Consistency Ratio (CR) computed at 0.046 (4.6 %), which is within the permissible limit of 10 %. This verifies that the pairwise evaluations are coherent and appropriate for determining the weights.

The pairwise comparison matrix yielded the weights presented in Table 7, which the GIS analysis then used.

The results indicate that elevation got the maximum weight of 45.56 %, followed by distance from the river at 22.24 %. The weights applied were as follows: slope 12.51 %, flow length 9.3 %, Land Use/Land Cover (LULC) 5.7 %, and precipitation 4.6 %. The weights, obtained by methodical computation, indicate the relative significance of each criterion in the flood danger study.

Similarly, Table 8 represents the pairwise comparison matrix to determine the weight of the criteria selected for economic zone identification. In Table 8, the Consistency Ratio (CR) is 0.062 or 6.2 % again this percentage is below the 10 % highlighting the consistency of the matrix to determine the weights. The Random Index (RI) was taken 1.120 because the number of criteria was 5.

The pairwise comparison matrix yielded the weights presented in Table 9, which the GIS analysis then used.

The results indicate that distance from rural market got the maximum weight of 48.81 %, followed by Land Use Land Cover (LULC) at 22.24 %. The weights applied were as follows: slope 13.594 %, distance from shelter and educational institution 8.971 %, and distance from growth centre 4.628 %. The weights, obtained by methodical computation, indicate the relative significance of each criterion in the flood danger study.

5.3.2. Flood hazard areas identification

Six key criteria were used in order to find the flood hazard areas and to place the economic zone in a safe location. Elevation data (DEM) was downloaded from the USGS website, and the rest of the criteria were prepared using different tools in ArcGIS. The precipitation data were interpolated using the Inverse Distance Weighted (IDW) interpolation tool. The slope surface was obtained from

Table 6
Pairwise comparison matrix for determining weights in flood hazard analysis.

No of variables	1	2	3	4	5	6	λ_{max}	CI	RI	CR
Variables	Elevation	Slope	LULC	Precipitation	River Distance	Flow length				
Elevation	1	5	7	7	3	5	2.282	0.056	1.24	0.046
Slope	0.2	1	3	3	0.333	2				
LULC	0.143	0.333	1	2	0.2	0.5				
Precipitation	0.143	0.333	0.5	1	0.333	0.333				
River Distance	0.333	3	5	3	1	3				
Flow length	0.2	0.5	2	3	0.333	1				

Note: λ_{max} = maximum eigenvalue, CI = Consistency Index, RI = Random Index, CR = Consistency Ratio, LULC= Land Use Land Cover.
Source: Author's calculation, 2024

Table 7
Weight for analysis in ArcGIS.

Variables	Elevation	Slope	LULC	Precipitation	River Distance	Flow length	Weight	Percentage	ArcGIS
Elevation	0.495	0.492	0.378	0.368	0.577	0.423	2.733	0.456	45.556
Slope	0.099	00.98	0.162	0.158	0.064	0.169	0.751	0.125	12.51
LULC	0.071	0.033	0.054	0.105	0.038	0.042	0.344	0.057	5.726
Precipitation	0.071	0.033	0.027	0.053	0.064	0.028	0.275	0.046	4.591
River Distance	0.165	0.295	0.27	0.158	0.192	0.254	1.334	0.222	22.236
Flow length	0.099	0.049	0.108	158	0.064	0.085	0.563	0.094	9.381

Source: Authors' calculation, 2024

Table 8
Pairwise comparison matrix for determining weights in economic zone analysis.

No of variables	1	2	3	4	5	λ_{max}	CI	RI	CR
Variables	Growth centre	Rural market	LULC	Slope	Shelter and educational institutions				
Growth centre	1	0.143	0.2	0.333	0.333	5.276	0.069	1.12	0.062
Rural market	7	1	3	5	5				
LULC	5	0.333	1	3	3				
Slope	3	0.2	0.333	1	3				
Shelter and educational institutions	3	0.2	0.333	0.333	1				

Note: λ_{max} = maximum eigenvalue, CI = Consistency Index, RI = Random Index, CR = Consistency Ratio, LULC= Land Use Land Cover.
Source: Authors' calculation, 2024

Table 9
Weight for analysis in ArcGIS.

Variables	Growth centre	Rural market	LULC	Slope	Shelter and educational institutions	Weight	Percentage	ArcGIS
Growth centre	0.053	0.076	0.041	0.034	0.027	0.231	0.046	4.628
Rural market	0.368	0.533	0.616	0.517	0.405	2.11	0.488	48.81
LULC	0.263	0.178	0.205	0.31	0.243	1.2	0.24	23.998
Slope	0.158	0.107	0.068	0.103	0.243	0.38	0.136	13.594
Shelter and educational institutions	0.158	0.107	0.068	0.034	0.081	0.449	0.09	8.971

Source: Authors' calculation, 2024

the Slope tool, and river distance and flow length were produced from hydrological analysis. These criteria/variables of the flood hazard analysis are presented in Fig. 3.

After reclassifying the criteria, all layers were combined using the weights derived from the Analytical Hierarchy Process (AHP) method, as presented in Table 9. The combination was performed using the following equation:

Combined layers = (Reclassified DEM * 45.556 + Reclassified River Distance * 22.236 + Reclassified Slope * 12.510 + Reclassified Flow Length * 9.381 + Reclassified LULC * 5.726 + Reclassified Precipitation * 4.591).

After combining the layers, the flood hazard areas were categorized into five distinct classes based on their level of risk. The categorized results are presented in Fig. 4.

This result was further utilized in the economic zone identification process to exclude locations that fall within high to very high flood-prone areas.

5.3.3. Delineation of economic zone

The chosen criteria for the analysis are in both vector and raster data types. Based on the pairwise comparison matrices shown in Tables 6 and 7, five criteria were originally selected for the study (see Fig. 5). The definitive set of criteria comprises nine factors. The supplementary criteria—namely, flood danger zones, places extremely susceptible to earthquakes, distance from the Dhaka-Sirajganj Highway, and closeness to the railway line—are used towards the conclusion of the research to refine the selection of the most appropriate locations among all potential sites. Fig. 6 below presents a thorough summary of all the criteria.

After the reclassification process, all the layers are combined with the help of the weight determined in Table 9 by the AHP method and the equation below:

Combined layers = (Reclassified Growth Center * 4.628 + Reclassified Rural Market * 48.810 + Reclassified LULC * 23.998 + Reclassified Slope * 13.594 + Reclassified Shelter and Educational Institution * 8.971).

After combining all the layers, the potential locations were identified and represented in raster data format. The results are presented in Fig. 6.

The final output must be in vector format. The cell values were first transformed into integer numbers to do this. Subsequently, the Con tool, the Majority tool, and the Raster to Polygon tool from the Conversion toolbox were used to delineate all potential places in polygonal format. The sites were further refined using the 'Select by Attribute' tool to preserve those situated within 1 km of a highway and 5 km of a railway line. The conclusive findings are shown in Fig. 7.

The chosen places must be secure from natural calamities, namely, floods and earthquakes. To do this, further research was performed by juxtaposing the selected places with flood danger zones (Fig. 4) and a map indicating seismic susceptibility. The seismic hazard map was generated with historical data and contour lines, employing the Spline tool from the ArcGIS toolkit. The conclusive outcomes of this investigation are shown in Figs. 8 and 9.

The marked regions are classified as moderate to low flood danger zones, as shown by the cell colors ranging from deep green to yellow, with certain exceptions. The comparison indicates that this area is the most appropriate identified so far for the formation of an economic zone.

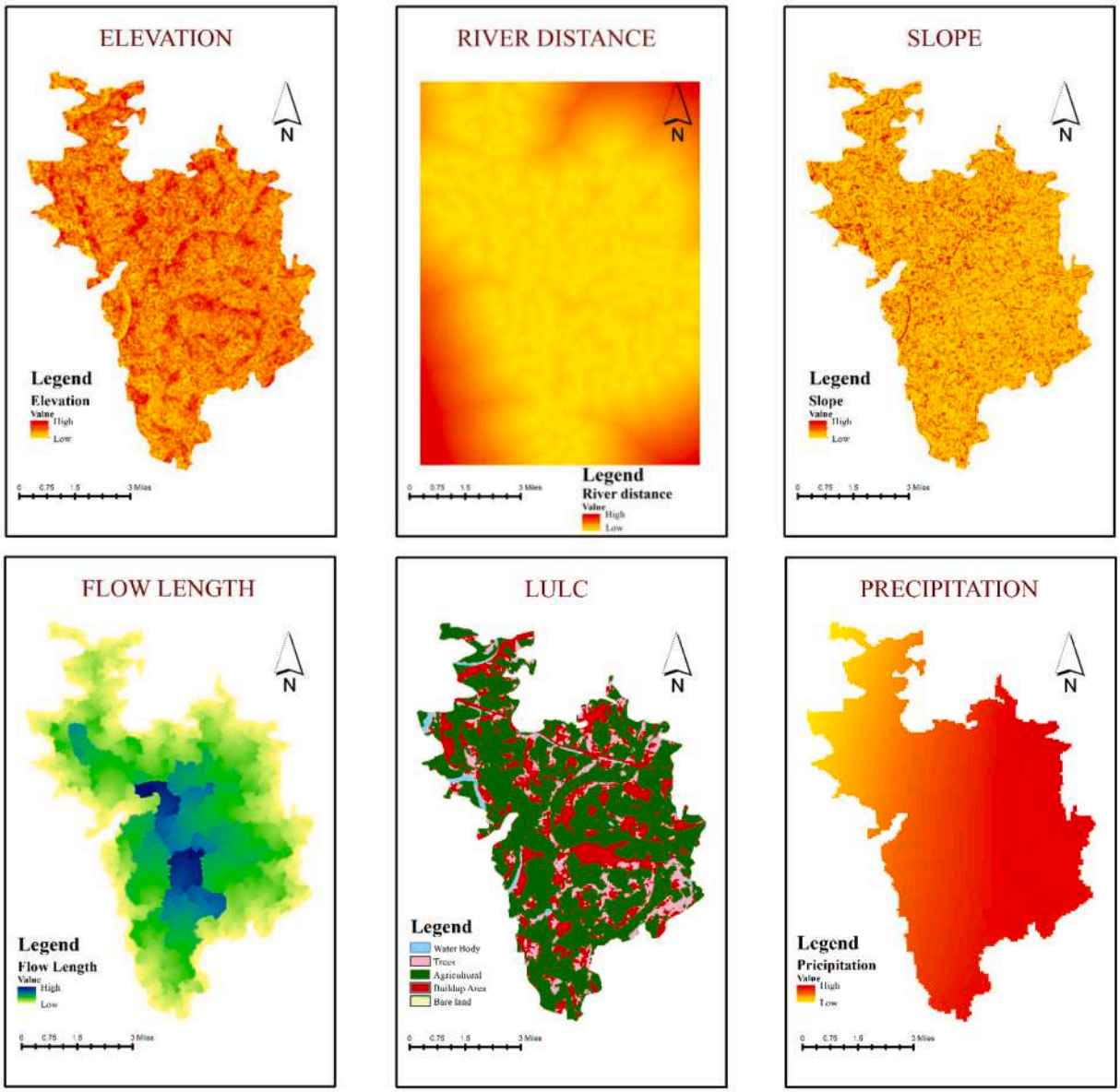

Fig. 3. Criteria selected for flood hazard areas identification.
Source: Authors' drawing, 2024

Fig. 9 clearly indicates that the selected area is minimally prone to earthquakes. So, the final result of the analysis and the suitable location for the economic zone are presented in Fig. 10. The exact location of the area is **24° 23′ 46″ N** latitude and **89° 38' 26" E longitude**.

5.3.3.1. Why is this location suitable?. The selected site offers numerous advantages to the establishment of an economic zone. It is strategically located near major transport routes, which will promote the easy flow of raw materials and end products, thus acting as a driver for connectivity. The area is also protected from the natural disasters faced by the district for the greater part, hence, a safe environment for development. The proximity to a power station guarantees a constant and reliable supply of electricity, which is essential in industries. The site lies close to Sirajganj Sadar Upazila, the major district town in northern Bangladesh, hence raising its accessibility and regional importance. Also, the community about the traditional craftsmanship "Sitalphati" has articulated quite some needs for infrastructural support, which might become very easily realizable given the proximity of the settlement to the site. Further details are provided in the insights from the FGD.

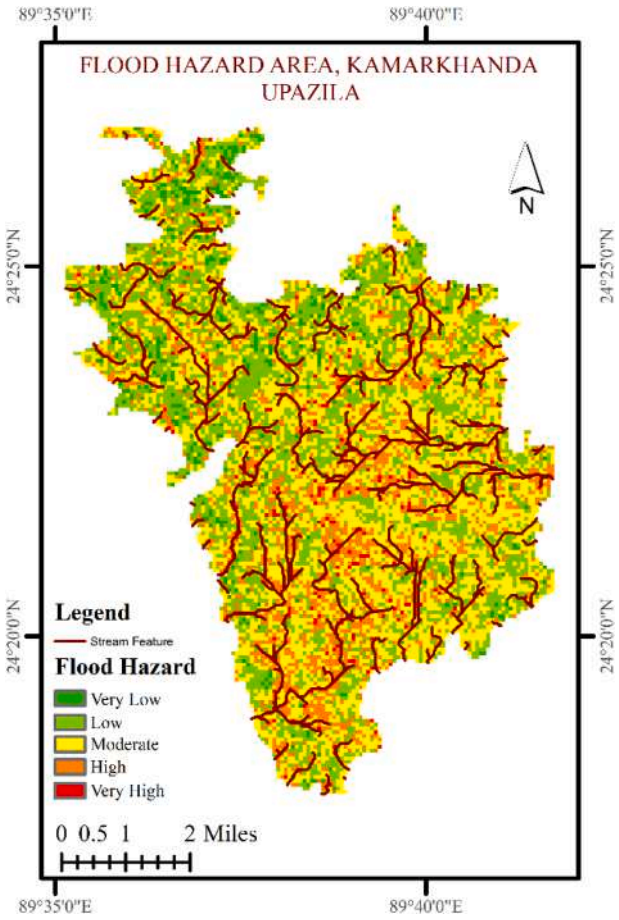

Fig. 4. Flood hazard areas of Kamarkhanda Upazila, Sirajganj.
Source: Authors' drawing, 2024

5.4. Insights from FGDs on Shitalpati Crafting

An FGD was performed in July 2024 in the Jawoil Union of Kamarkhanda Upazila, Sirajganj District, to gather information on the socio-economic characteristics, challenges, and opportunities of families producing Shital Pati. This skill is integral to the cultural legacy of Bangladesh, functioning as both a livelihood and a manifestation of identity. The dialogue included 8–10 family members from families engaged in Shital Pati production, who offered significant perspectives on their livelihoods, the obstacles they encounter, and their ambitions for safeguarding and augmenting this traditional legacy.

5.4.1. Shital Pati production overview

Among the diversified range of the rich cultural heritage of the country of Bangladesh, Shital Pati is one of the artisanal products, which are hand-woven mats made from the stems of the Murta plant. The tradition of craftsmanship flows, from generation to generation. At present, some 55–60 families of Jawoil Union are engaged in the production of Shital Pati, where Murta plants grown locally serve as their primary raw material. This craft is authentic, as Murta plants are used because of their origin, and at the same time, visitors will be contributing to sustainable practices locally.

5.4.2. Economic conditions of the artist's household

The income of households involved in the production of Shital Pati varies, with most families earning a modest monthly income of up to 8000 BDT. A small number of 8–10 households earn between 15,000 and 16,000 BDT per month. This is very likely due to differences in the scale of production and market availability. Besides this, the earnings also foreshadow substantial financial challenges that most of the households face, given that the average loan burden is 50,000 BDT. This debt inhibits their ability to invest in the expansion of their operations or the betterment of their craft and threatens the economic viability and continuation of this heritage craft.

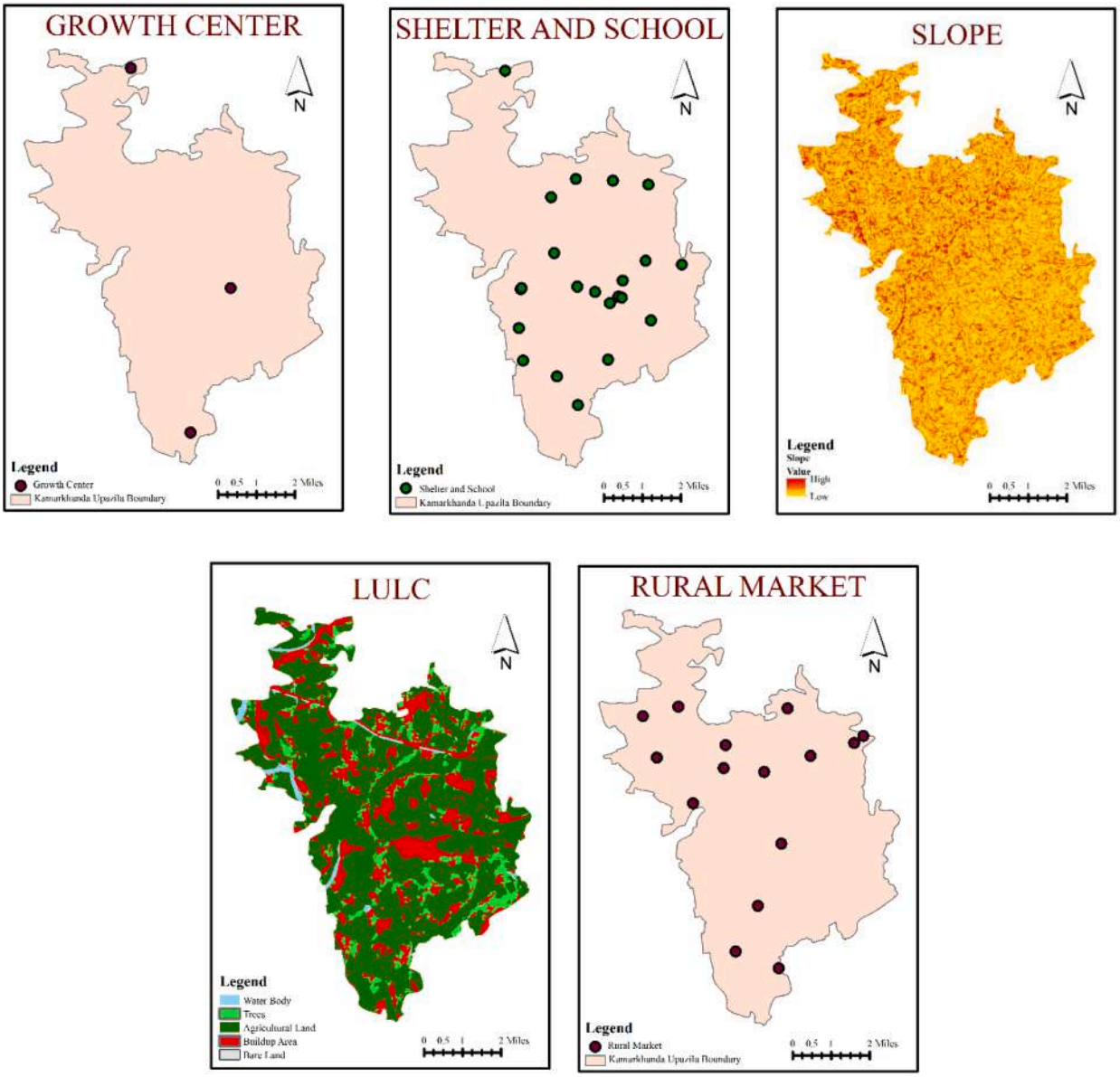

Fig. 5. Criteria selected for economic zone identification.
Source: Authors' drawing, 2024

5.4.3. Challenges identified

The participants identified a number of challenges that have prejudiced the sustainability of Shital Pati production and the preservation of their cultural heritage.

a. The poor infrastructure is one challenge: bad transport and lack of proper storage mean the products are often damaged, reducing their quality and marketability. It reduces the income, an essential factor in sustaining such heritage, but also somewhat undermines the effort of the artisan in maintaining the high standards associated with their heritage.
b. Constraints on production: Due to a lack of decent production facilities, working under very bad conditions becomes inescapable for artisans. This degrades not only the quality of the product but also, more importantly, impinges on transmission to future generations of the traditional technique.
c. Regulatory Barriers: The artisans showed interest in getting trade licenses to operate their businesses formally. Having trade licenses would greatly expand the market and formalize one's craft as a known economic activity. However, going through the bureaucracy involved in this regulatory environment is problematic for small-scale artisans.

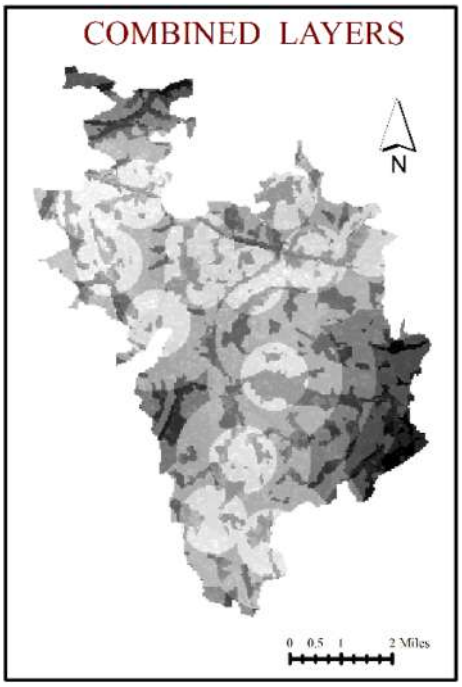

Fig. 6. Possible location in raster format.
Source: Authors' drawing, 2024

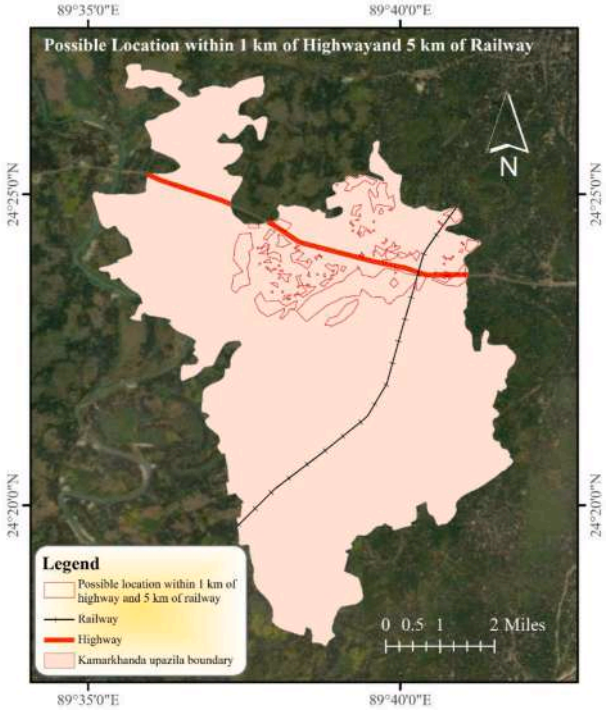

Fig. 7. Possible locations for economic zone.
Source: Authors' drawing, 2024

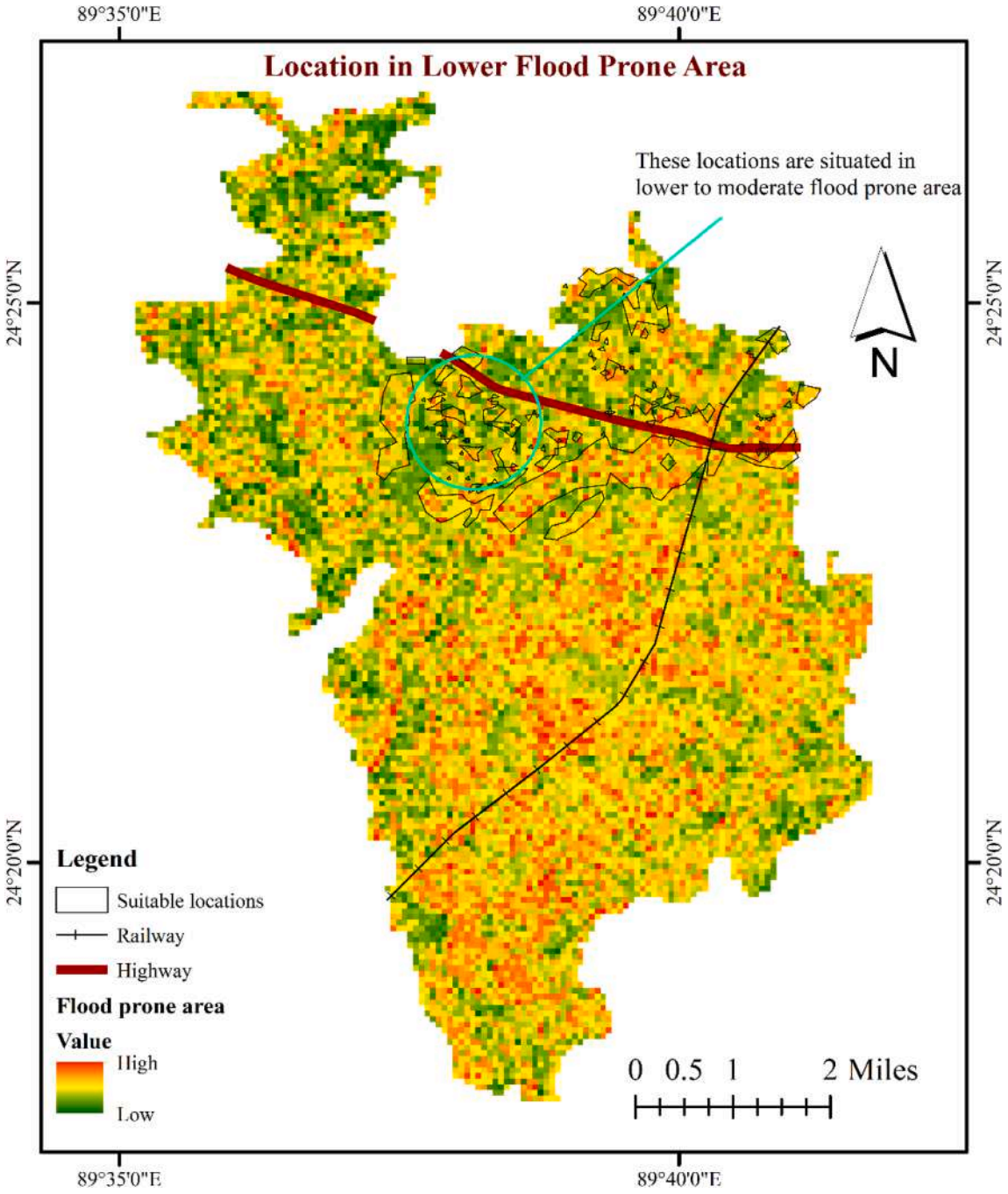

Fig. 8. Locations with lower to moderate flood prone.
Source: Authors' drawing, 2024

5.4.4. The Murta plant: A pillar of cultural heritage

Murta plant is grown in the wetlands and marshy lands of Bangladesh; Jawoil Union is a part of it. Hence, it is part of the core importance in the production of Shital Pati. So, it would be a source of great pride for the artisans using local raw materials like Murta, and these ingredients are imperative to maintain the authenticity and quality of Shital Pati. Sustainability of this plant is important for the economic sustenance of the artisans and preserving the cultural practices associated with Shital Pati production. Participants expressed concern over the over-exploitation of the Murta plant and environmental changes that might affect sustainability. All the usual practices must also be maintained so that the sustainability of the plant is based on unshakeable grounds.

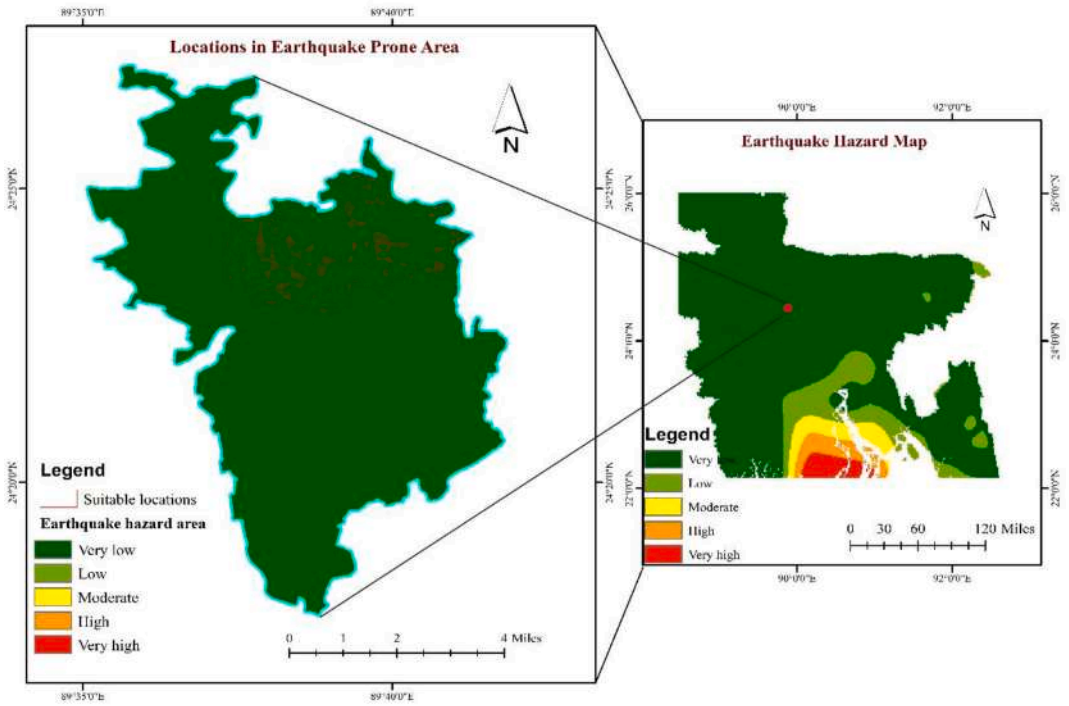

Fig. 9. Earthquake scenario of the selected area.
Source: Authors' drawing, 2024

Fig. 10. Proposed economic zone.
Source: Authors' drawing, 2024

5.4.5. Community feedback and key action areas

a. Participants, therefore, based their interests on interventions that would work toward addressing their challenges in this area, as it would preserve the cultural heritage attached to Shital Pati production. The major recommendations are as follows:
b. Infrastructure Development: Facilities for transportation and storage to maintain the quality of Shital Pati so that this heritage craft is able to continue in its functioning.
c. Access to Finance: Other than access, support through low-interest loans would minimize the burden of debt on artisans to reinvest their resources into the trade.
d. Upscaling of skills and heritage conservation: The skill development training programs will be aimed at enhancing and upscaling the skills of artisans, product quality development, and inculcating forward-and-reverse linkages in passing the tradition on to the next generation. This heritage will be extended to heritage conservation, given the cultural value associated with Shital Pati.
e. Sustainable management of the resource: Murta-growing that ensures sustainability so that it is continually available through generations, thus conserving the cultural tradition around Shital Pati.
f. Ease of Doing Business: The facility of a trade license would empower the artisans to formalize their operation and trade in wider markets with state acknowledgement of the practice of their craft. This is one important regulatory basis for ensuring the economic viability and cultural sustainability of Shital Pati production.

6. Discussion

Huq and Ichihashi (2023) highlighted that in the context of Bangladesh's business development, the national economic system is significantly reliant on the fabric and food sectors, which are intricately linked. An illustrative instance of control within the employment sector is the situation in Sirajganj District, which has a long-standing history in handloom fabric production. However, according to Pande (2022), the sector continued to face many problems in its value chain. According to Benarjee (2018), the poultry industry in the district is not left behind in having its challenges, mainly owing to the increase in feed costs. The food and textile-related industries are highly present in the current study area. However, similar to Sirajganj, the current study also depicts the fragile nature of industrial linkages. This indeed points out that the challenges in developing proper backward and forward linkages might hamper the overall economic growth and stability of these sectors in the study area. These sectors are vital to the local employment structure, but insufficient interlinkages between the industries have led to underachievement in comprehensive industrial development and poverty reduction in the area studied. Therefore, these findings confirm the results of other studies suggesting that policies that encourage industrial linkages and resolve sector-specific problems should be adopted.

Apart from these linkage-related issues, infrastructure resilience is still a crucial component of sustainable industrial development, especially in areas like Sirajganj that are prone to disasters. Because of the region's frequent flooding, implementing resilient infrastructure measures like raising factory buildings above known flood levels and adding a suitable drainage system can greatly lessen production and logistics disruptions brought on by disasters. Long-term economic stability is aided by these actions, which not only protect industrial assets but also guarantee business continuity during severe weather conditions.

Frick et al. (2018) assert that farmers often pursue economical sites while remaining near major urban centers. The closeness to substantial markets and established industrialization markedly improves the efficacy of economic zones. Correspondingly, the results of this research reveal that the suggested economic zone is situated outside the Sirajganj Sadar Upazila in a more cost-effective and affordable region. This area will serve markets in Tangail, Natore, Bogura, Pabna, and further places. Consequently, in accordance with the results and criteria emphasized by Frick et al. (2018), the suggested economic zone in this research has the potential for sustainability and economic development enhancement.

Pabna, Rajshahi and Sirajganj districts are famous for their traditional and technical loom weaving. Dependence on imported raw materials from Dhaka, Narayanganj and Ghazipur increases transportation costs, consequently increasing cost of goods and reducing profitability. This represents a significant barrier to economic advancement in these areas. The creation of the planned economic zone, together with its ancillary businesses, would decrease transportation expenses and enhance profit margins, thereby mitigating these economic difficulties.

The Ishwardi Export Processing Zone (EPZ), founded in 2001, has garnered significant international investment from nations like South Korea, India, Japan, and China (Wikipedia, n.d.). The EPZ mostly manufactures footwear, leather products, clothing, and other export-oriented commodities, making a substantial contribution to the local economy (Wikipedia, n.d.). The planned economic zone in this research and the Ishwardi EPZ are situated in neighboring districts within the northern area, which is anticipated to foster inter-regional industrial connections. This industrial chain would enhance the interconnections between the northern areas (Pabna, Sirajganj, Natore, Bogura, Rajshahi, and Kushtia) and significant economic centers like Dhaka, Narayanganj, Gazipur, and Tangail. The planned economic zone aims to improve supply chain efficiency, encourage regional economic integration, and support industrial development and sustainability in the northern area and beyond by developing inter-regional links.

6.1. Policy recommendations

The identified area should be included in the ongoing master plan as an industrial zone to provide structured support for growth. That will encourage the agglomeration of interconnected industries, suppliers, and easy access to economic activities of the local community, ultimately increasing forward and backward linkages and contributing to broader economic development. Shital Pati-making industries aren't large-scale businesses in every part of the country, but they are very important to the culture and

consistent demand among the people. As a result, there is a risk that this industry may be overlooked when it comes to land allocation within industrial zones. For that reason, provision of specific land allocation, subsidy, low-interest loans, and infrastructure development to the Sithal Pati-making community in order to strengthen their activities. Lastly, making regulations to promote small and medium-scale industry development in order to develop forward and backward linkages. For example, industries that process dairy products and meat can be established and promoted, enabling local producers to supply their products to these industries and generate greater profits through strong forward linkages.

7. Conclusion and recommendations

It can thus make significant contributions to regional development in respect of industrial and economic activities. This study underlines that, for sustainable growth, there should be strong forward and backward industrial linkages, along with the agglomeration of industries. However, the study area lacks these strong industrial linkages. The textile industry, Sithal Pati, dairy farming, and poultry farming are some of the industries that show much potential for development. Above all, supporting industry development and infrastructure, training of manpower, and other strategic interventions need to be nurtured to allow this potential to bloom. For such a thing, the establishment of a sustainable economic zone was emphasized to facilitate these industries' becoming powerful enough to bring liaisons between each other. This study shows that using cutting-edge tools such as remote sensing data, GIS data, information about natural disasters, and on-site Environmental Impact Assessments, or EIAs, is a very important part of the selection process in these economic zones.

7.1. Limitations of the study

The application of multi-criteria decision analysis and analytic hierarchy Process methods may not highlight possible land conflict cases, which could be complex during land acquisition. Furthermore, some of the highlighted locations involve existing settlements, which implies that relocation would be quite costly. These could be reduced through proactive initiatives on the part of the government and its strategic planning.

7.2. Further areas of research

Strategies that promote women's contribution to economic activities. In addition, there is a need to explore community-based industrial networks where women can work from their homes for a better solution to develop industrial linkages. These considerations will go further toward sustainable regional development and inclusive economic growth. And also need to explore the Social Impact of the Economic zone establishment.

CRediT authorship contribution statement

Abu Nayem Md. Kayes: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Md. Ashrafuzzaman Pramanik:** Writing – review & editing, Validation, Supervision, Resources. **Rabeya Sultana Mim:** Writing – original draft, Data curation.

Ethics statement

Ethics approval was obtained from the Chairman of the Department of Urban and Regional Planning, Pabna University of Science and Technology (Ethics Committee). In addition, the participants provided their informed consent to participate in this study.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jum.2025.08.003.

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