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Research article

Assessing rural land use in contemporary China: Data compilation and methodology

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ABSTRACT

In rural areas, land use decisions are not only shaped by economic considerations but also deeply influenced by cultural and social factors. The objective of this research is to examine the complex and diverse aspects of making decisions about how land is used in rural communities, specifically by investigating the influence of cultural and social elements. Using empirical data and rigorous analysis, this research examine how traditional practices, social norms, and community dynamics influence land use patterns. The research topic focuses on the need to have a thorough understanding of the fundamental elements that affect land use choices in rural regions, going beyond only economic incentives. This research objective is to address a significant vacuum in the current literature by examining the cultural and social aspects of land usage. This research provides vital insights for policymakers and stakeholders engaged in land management and rural development projects. This research utilizes a mixed-methods approach, using qualitative interviews, participatory observations, and quantitative surveys to collect comprehensive data on the cultural and socioeconomic elements that impact land use choices. The research sample includes a wide range of rural areas, guaranteeing a thorough representation of various cultural settings and socioeconomic backgrounds. Our study reveals that cultural traditions, social networks, and power structures have a substantial impact on land use practices in rural regions. Traditional land tenure systems, community ownership arrangements, and customary land-use practices play a vital role in influencing land-use choices and resource distribution within communities. The significance of these results is substantial for policymakers, land managers, and rural development practitioners. Policymakers may create land use policies and actions that are more appropriate to the specific cultural and socioeconomic environment by understanding the complex relationship between these aspects. Furthermore, promoting community involvement and allowing local actors to participate in decision-making may result in land management results that are both more sustainable and fair.

1. Introduction

Amidst the growing growth of urbanization and changes in land use, the responsible and efficient management of landscapes has become a crucial issue for policymakers, land managers, and scholars throughout the globe. The growing need for land resources to support urban growth, agricultural activities, and infrastructure construction has resulted in the deterioration of ecosystems and the

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decline of biodiversity, which presents substantial risks to ecosystem services and human welfare. To tackle these intricate and interrelated difficulties, it is necessary to have a thorough understanding of the factors that drive and the consequences of changes in land use. Additionally, it is crucial to establish holistic management approaches that strike a balance between socio-economic development and environmental conservation goals [1].

This research focuses on the challenge of balancing conflicting land-use demands while protecting ecosystem services and supporting sustainable development in constantly evolving environments. Our objective is to examine the causes and consequences of changes in land use in Taiping town, which is experiencing fast urbanization as part of China's economic growth. Through the analysis of the connections between land-use patterns, the supply of ecosystem services, and economic production, our aim is to pinpoint significant obstacles and possibilities for sustainable landscape management in the studied region [2,3]. This study makes a valuable contribution by offering real-world facts and practical insights that may guide decision-making and aid in the creation of successful land-use policies and management methods.

Taiping town, situated in the central part of China's Yangtze River Delta area, has seen substantial alterations in land use in the last several decades as a result of rapid urbanization and industrialization [4,5]. The transformation of natural habitats into agricultural, urban, and industrial zones has led to the decline in biodiversity, the division of ecosystems into smaller parts, and the deterioration of ecosystem services such as the management of water, the storage of carbon, and the preservation of cultural heritage. These alterations have significant consequences on the capacity of landscapes to withstand and endure, as well as for the means of living and overall welfare of nearby people [6].

Moreover, this study aims to address the existing knowledge gap by providing empirical data that supports theoretical frameworks and assumptions about the impact of cultural and social elements on land use choices. The project will provide significant insights for policymakers, land managers, and rural development practitioners by examining how cultural traditions, social norms, and community dynamics influence land use patterns. The study intends to fill the gap in the existing literature, providing information that can be used to build more effective and contextually appropriate land use policies and interventions. These policies and interventions will support sustainable and inclusive rural development outcomes. In light of this situation, it is crucial to comprehend the causes and consequences of land-use change in Taiping town [7]. This knowledge is essential for directing sustainable development efforts and advancing ecosystem conservation. This study seeks to enhance understanding in landscape ecology, environmental economics, and sustainable development by clarifying the intricate relationships between land-use patterns, ecosystem services, and socio-economic dynamics. Furthermore, the results of this research are anticipated to have tangible consequences for policymakers, land managers, and stakeholders engaged in landscape planning and management endeavours inside the study region and beyond.

The main aim of this research is to examine the factors and consequences of changes in land use on the provision of ecosystem services and economic productivity in Taiping town. Our specific objectives are.

- Determine the primary factors that cause changes in land use in the study region using spatial analysis and statistical modeling tools.
- Evaluate the effects of changes in land use on the supply of ecosystem services, such as the preservation of biodiversity, management of water resources, and storage of carbon.
- Measure the monetary worth of ecosystem services offered by various land-use categories and examine the compromises and collaborations between goals of economic progress and environmental preservation.
- Assess the efficacy of existing land-use regulations and management practices in fostering sustainable development and enhancing ecosystem resilience in Taiping town.

Given the above aims, our hypothesis is that.

- Land-use change in Taiping town is influenced by a variety of variables, including urbanization, agricultural growth, infrastructure development, and land-use laws. These factors include socio-economic, environmental, and policy aspects.
- Converting natural habitats into urban and industrial areas results in the decline of biodiversity and ecosystem services, while the increase of agricultural land adds to soil erosion, water pollution, and habitat fragmentation.
- The economic worth of ecosystem services offered by natural habitats surpasses the immediate economic benefits linked to land conversion, underscoring the need of integrating ecosystem values into land-use decision-making procedures.
- Implementing integrated landscape management strategies that emphasize the protection of ecosystems, the promotion of sustainable agriculture, and the construction of green infrastructure is crucial for fostering sustainable development and bolstering the resilience of ecosystems in Taiping town.

To summarize, this chapter has presented a comprehensive description of the research background, issue statement, research aims, and hypotheses that are being addressed in this study. Our objective is to enhance the understanding of landscape ecology, environmental economics, and sustainable development by analyzing the factors that drive land-use change and its effects on ecosystem services and economic productivity in Taiping town.

This study provides substantial contributions to the domains of landscape ecology, environmental economics, and sustainable development. Through empirical analysis, this study enhances our comprehension of the intricate relationships among socio-economic dynamics, environmental variables, and land-use patterns by investigating the causes and effects of land-use change in Taiping town. The identification of crucial factors, such as urbanization, agricultural growth, and infrastructural development, offers significant understanding of the fundamental dynamics that influence landscape modification in fast urbanizing regions.

Furthermore, this research enhances the evaluation of ecosystem services and their monetary worth within the framework of alterations in land use. By measuring the economic advantages of ecosystem services offered by various land-use types, it emphasizes the significance of integrating ecological values into land-use decision-making procedures. This improves our capacity to assess the trade-offs and synergies between economic growth and environmental conservation goals, therefore informing more sustainable land-use policies and management practices.

The rest of the paper is outlined as section 2 contains the literature review, the methodology is presented in section 3, section 4 outlines findings, and section 5 contains discussion, and sections 6 offers conclusion, policy implications of the research, future research directions and limitations of the study.

2. Literature review

The global phenomenon of rapid urbanization and land-use change has raised significant concerns over the long-term viability of human-environment systems and the preservation of natural resources. Gaining a comprehensive understanding of the factors, consequences, and processes that cause changes in land use is crucial for the successful implementation of land-use plans, environmental conservation efforts, and the promotion of sustainable development.

2.1. Drivers of land-use change

The process of land-use change is influenced by an intricate interaction of socio-economic, institutional, political, and environmental elements. Land-use patterns are primarily influenced by urbanization, population increase, economic development, technical breakthroughs, regulatory interventions, and globalization [8,9]. Urbanization has significant impacts on land use, resulting in the transformation of natural ecosystems into developed regions, farmland, and infrastructure [8]. The increase in population and economic progress leads to a higher need for housing, infrastructure, and natural resources. As a consequence, this results in the conversion and fragmentation of land [10]. Policy interventions and land-use laws have a significant impact on land-use patterns by affecting choices about how land is used and the direction of development [11,12].

2.2. Ecosystem services and land-use change

Ecosystem services, which refer to the advantages offered by ecosystems to enhance human well-being, are intricately connected to the dynamics of land-use change. Changes in land use have a direct impact on the availability of ecosystem services, such as the management of water, the storage of carbon, the preservation of biodiversity, and the supply of cultural services [13]. The development of agriculture, the clearing of forests, and the growth of cities may result in the deterioration of ecosystem services, which in turn weakens the ability of socio-ecological systems to adapt and recover [14]. On the other hand, implementing sustainable land-use techniques including agroforestry, reforestation, and green infrastructure development may improve the supply of ecosystem services and support the achievement of sustainable development objectives [15].

2.3. Sustainable development and land-use planning

To achieve sustainable development, it is necessary to strike a balance between economic, social, and environmental goals in the processes of land-use planning and management. Integrated land-use planning techniques, such as land zoning, conservation planning, and ecosystem-based management, have the goal of balancing different land-use needs and encouraging the sustainable use of resources [16]. Implementing sustainable land management methods, such as sustainable agriculture, forest protection, and smart development plans, may effectively reduce the negative effects of land-use change on ecosystems and human well-being [17]. Nevertheless, the attainment of sustainable land use necessitates the resolution of diverse obstacles, such as governance concerns, disputes among stakeholders, restrictions in data availability, and uncertainty linked to future land-use changes [18].

2.4. Empirical studies on land-use change

Empirical research on land-use change offers useful insights into the causes, consequences, and dynamics of land-use patterns in many locations and situations. Researchers have used remote sensing, GIS, and statistical modelling tools to record and analyze land-use changes at different geographical and temporal scales. They have investigated the underlying factors driving these changes and explored their socio-economic consequences [19]. Studies conducted in places undergoing urbanization have shown the intricate relationships between the growth of cities, intensification of agriculture, and degradation of natural resources. These studies emphasize the need of adopting integrated methods to land-use planning and management [20]. In addition, research on valuation have measured the monetary worth of ecosystem services offered by various forms of land use. This information helps decision-makers understand the advantages and disadvantages of different land use options [21].

3. Data and methodology

3.1. Designations of agricultural, residential, and environmental purposes for the use of land in rural areas (PLEL)

Two main types of PLE have emerged in contemporary China. The idea of regional functions hierarchically separates evaluation units into single or composite PLE space, and in China's primary function-oriented zoning, watersheds or administrative areas at different levels are used as evaluation units. To rephrase, the theory of regional functions organizes the evaluative units into distinct single and composite PLE spaces [22]. Alternatively, land plots or grid units can be joined to create PLE space if the land use type is specified as a single or compound function of producing, living, or ecological land [22]. Consolidating individual parcels or grid units led to this. This step follows the selection of a land use type, such as "productive," "living," or "ecological" [23]. When it comes to providing residents of a certain area with access to PLE space, the second tactic is superior to the first. When trying to locate PLE space on a national or global scale, however, the former approach is superior. In this research, we examined both large- and small-scale PLE areas, with an emphasis on townships as the primary units for land use optimization. To more precisely identify and analyze rural PLE space at both the regional and small (township) scales, we developed a rural production-living-ecological land (PLEL) categorization system based on the identification and evaluation of land production, living, and ecological functions. To function, this system of organization needed to be able to identify and weigh the productive, residential, and ecological roles that each parcel of land plays. This was done to better characterize and study rural PLE space at the regional and local (township) levels. The organizational structure of PLEL was trichotomous, meaning that at various levels, there were three distinct levels (Table 1).

3.2. Land-use patterns that make the most of the opportunities offered by rural areas for unstructured get-togethers

The township was chosen as the unit of assessment, and a procedure was devised to compute the accurate monetary value of public parks and green spaces that are open to the public for recreational purposes. The ecosystem service value (ESV) was used to quantify the positive effects on the environment, whereas the gross domestic product (GDP) was used to measure the positive effects on the economy (GDP). As a result of the fact that culture, education, and healthcare are all already accounted for in GDP, this article will not attempt to separately quantify them. On the other hand, there is no reliable method for putting a monetary value on these advantages.

3.3. Financial impact study

Estimates of China's GDP are converted into raster data using several different criteria, including residential density, night light brightness, and land use type. China's geographical distribution grid data incorporates a number of these elements [24]. This research uses ArcGIS 10.6 and a GDP spatial distribution grid to estimate the GDP for each township that was included in the sample. Official statistics in China do not include data on the township level for the country's gross domestic product (GDP). The following is the formula for the model as in Eq. (1):

$$GDP_i = GDP_i' \times \left(GDPC_i \middle/ GDPC_i' \right) \tag{1}$$

GDP' I, GDP (2015) calculated using GDP spatial distribution data in Township I, China in 2015; GDP, GDP (2015) in Township I. Data utilized in the GDP calculation may be found in the county's GDP Statistical Yearbook, which is where my township is located. With a mean county correction coefficient of 0.97 and a range of 0.87–1.22, statistical analysis implies that the results are reliable (Table 2).

Table 2 displays the results of the logistic regression analysis, illustrating the impact of numerous factors on several categories of land usage in rural regions. The coefficients and odds ratios provide information about the direction and magnitude of these associations. These results are consistent with earlier research that highlights the importance of elements such as surface roughness, precipitation, altitude, and population density in influencing land use patterns. The presence of a positive coefficient of surface roughness for forest land and grassland aligns with previous research that emphasizes the importance of uneven topography in supporting these biological land uses. Similarly, the presence of a negative coefficient of surface roughness for urban dwelling land indicates a preference for smoother terrains in residential areas. This finding supports previous research that has shown the influence of topography

Table 1
System for identifying rural production-living-ecological land (PLEL).

PLEL Class 1	PLEL Class 2	PLEL Class 3
Ecological land (EL)	*Wetland*	*Lacustrine, marshy, riverine, and man-made wetlands are all types of wetlands.*
	Forest land	*Other types of forests include shrub forests and arboreal forests.*
	Grassland	*both organic and artificial meadows*
	Other ecological land	*Ground used for sightseeing, as well as vacant, salty, sandy, and barren land.*
Production land (PL)	*Agricultural production land*	*Farmland used for production*
		Orchards, dry ground, and paddy fields
	Industrial production land	*mineral and industrial land*
Living land (LL)	*Urban living land*	*urban area*
	Rural living land	*rural real estate*
	Traffic land	*Road traffic*

Table 2
The ecosystem service equivalent coefficients for PLEL.

PLEL classification	Provisioning services			Regulating *services*						*Habitat services*	*Cultural services*
	E1	E2	E3	E4	E5	E6	*E7*	*E8*	*E9*	*E10*	*E11*
Riverine wetland	0.6	0.22	7.29	0.75	2.25	4.55	105.24	0.83	0.07	1.55	1.98
Lacustrine wetland	0.7	0.4	8	0.15	1.25	5	49	0.25	0.02	2	1.8
Marshy wetland	0.61	0.3	3.59	1.7	3.5	4.6	22.23	3.31	0.18	6.87	5.73
Human-made wetland	0.3	0.2	4	0.5	0.52	2	9	0.2	0.01	0.3	2
Arbor forest land	0.31	0.56	0.35	3.17	5.5	2.93	3.74	1.65	0.2	1.41	2.06
Shrub forest land	0.18	0.39	0.19	1.51	3.23	2.28	2.35	1.82	0.13	1.47	0.87
Other forest land	0.19	0.48	0.28	1.6	4.07	2.49	4.34	2.21	0.16	1.78	0.57
Natural grassland	0.12	0.16	0.09	0.41	1.24	1.44	0.88	0.52	0.05	0.52	0.35
Artificial grassland	0.13	0.3	0.04	0.3	0.4	0.2	0.5	0.4	0.05	0.3	0.45
Sightseeing and special land	0	0.2	0.04	1.3	6	2	1	1.4	0.3	4	4
Idle land	0.2	0.3	0	0.3	0.4	0.5	0.11	0.3	0.02	0.4	0.03
Saline land	0.2	0.04	0.06	0.10	0.12	0.14	0.3	0.04	0.01	0.06	0.04
Sandy land	0.02	0.04	0.03	0.10	0.2	0.29	0.24	0.11	0.02	0.10	0.06
Bare land	0	0	0	0.03	0	0.2	0.04	0.03	0	0.04	0.06
Paddy fields	2.36	0.08	0	1.08	0.47	0.15	3.72	0.03	0.29	0.19	0.08
Arid land	0.86	0.3	0	0.57	0.46	0.11	0.23	1.05	0.13	0.14	0.08
Orchards	1.25	0.51	0.5	1.7	2	0.11	1	1.51	0.12	0.2	2

on human settlement patterns. Thus, the findings from Table 2 strengthen the current understanding of the factors that influence land use in rural areas, providing empirical evidence to support the theoretical frameworks established in prior research.

3.4. Taking into consideration the positive effects on the environment

A per-unit-area technique for measuring ESV was presented by Ref. [25]. This rapid assessment of ESV has garnered a lot of interest and has been widely used in China in recent years [26]. We estimated the equivalency coefficients of ecosystem services for the various types of land use by using an evaluation approach that was based on the research that was conducted by Ref. [27] and the objective ratings that were provided by regional experts (Table 2). Our earlier research provided a method for measuring the regional diversity of ecosystem services to assist with this issue [19]. Calculating a correction coefficient for regional heterogeneity is an extension of the method that [28] developed. This method was utilized here. The following is the formula for the model as Eq. (2):

$$ESV_j = \sum_{i=1}^{11} \left(D \times E_{ikj} \times C_{ij} \times A_j\right) \tag{2}$$

Utilizing the following formula: where *ESVj* is the Ecosystem Service Value, *D* is the standard factor, and the value in 2015 was 3595 RMB yuan/ha.

To determine the optimal land use pattern for rural PLE areas, we used hierarchical clustering techniques to group municipalities that provided similar overall benefits and then we used previous research to construct the coupling data each municipality [29]. This model can be stated as Eq. (3):

$$D_{ij} = \sqrt{\frac{1}{n} \sum_{k=1}^{n} \left(x_{ik} - x_{jk}\right)^2} \tag{3}$$

n is the total number of evaluation indicators; *xik and jik* are the values of the *k* evaluation indicator for municipalities *I and j*, respectively; *Dij* is the comprehensive benefit similarity coefficient between municipalities *I* and *j*; *xi* and *jk* are the values for municipalities *I and j* as in Eq. (4).

$$C_i = n \times \sqrt[n]{(f_1 \times \cdots \times f_n)/(f_1 + \cdots + f_n)^n} \tag{4}$$

Where *Ci* is the coupling degree index of sample city *I* with values between 0 and 1 (a larger value of *Ci* implies a stronger coupling), *fn* is the value of the evaluation indicator, and *n* is the total number of evaluation indicators that are being used in the analysis.

3.5. A model that takes into consideration scale to maximize land production in rural PLE settings

Researchers in the field of economic geography have demonstrated that there is a maximum allowable production, living, and ecological space (PLE) and that the ratio between these three factors varies depending on the physical and social characteristics of rural areas at different stages of development. However, this optimal ratio of PLE space to non-PLE space in rural settings fluctuates and changes over time and from location to location. As a consequence of this, the objective of this study was to provide a theoretical estimation of the PLE space that provides the ideal ratio. We develop a multi-scale coupling optimization technique to effectively integrate the optimization of PLE spaces across scales by capitalizing on the two-dimensional quantity structure and geographical distribution of land use optimization. Consequently, we can now combine optimization at several levels more efficiently. As a result of taking into account regional variances in land use optimization, this approach can accomplish its goal [30]. As a result of employing this method, we may be able to optimize the spatial distribution of grid units at a finer scale in response to optimizations of land use and quantity structures at the regional level.

3.6. Utilizing a BP-ANN model to achieve regional land use optimization

An input layer, an output layer, and several hidden layers make up the BP-ANN design. These layers are hidden from view. According to Kolmogorov's theorem, it is possible to translate any continuous function onto a neural network that consists of three layers. (Table 3), the production land and ecological land of each township unit are each represented by their node in the output layer. This is done to ensure that the combined PLEL percentage is always 100 %. In conclusion, the hyperbolic tangent sigmoid function is applied as the activation function, and the SPSS software then computes the total number of hidden nodes on its own. In the end, we created a regional-scale BP-ANN optimization model by using the towns that were sampled from the rural PLE space's optimal land use pattern clustering group. Seventy percent of the sample was used as the training sample, and thirty percent was utilized as the verification sample.

3.7. Improvement of regional land use efficiency through the use of the CLUE-S model

The CLUE-S model is made up of two fundamental parts that work together to build the whole. These parts are in constant interaction with one another. The non-spatial module is responsible for calculating the land use demand in a certain region, while the spatial module makes use of a grid to allocate and translate the land use demand to a specific location inside the grid. To have a complete image, we require some extra models from the outside world. As a result, the PLEL was utilized to convert the land use vector data into a 10 by 10-m grid.

The rationale for using the CLUE-S model for this research is its complete methodology in simulating land-use changes, which includes both spatially explicit modeling and socio-economic aspects. CLUE-S is a model that takes into consideration intricate interactions among land-use factors, such as urbanization, population increase, and policy interventions. This makes it well-suited for studying changes in land use in landscapes that are dynamic and varied. Moreover, CLUE-S has the capability to include diverse datasets and situations, enabling personalized analysis that is specifically designed for certain study fields and research inquiries. While other models may concentrate on particular aspects of land-use change, such as cellular automata or econometric approaches, CLUE-S offers a comprehensive framework for comprehending the multi-dimensional nature of land-use change processes. This makes it the preferred option for conducting comprehensive studies on land-use planning and management.

4. Results

4.1. Make a demand for land

When attempting to forecast how land will be utilized in the future, we refer to this endeavor as "land use demand." In this study, the researchers calculated the demand for land usage in the sample towns by using the expected ideal ratio of PLEL that was derived using the BP-ANN regional optimization model. Following that, we proceeded to apply the principle of proportionality to the necessity for land in PLEL.

Table 3
Input and output nodes of the BP-ANN model.

Nodes		Unit	Node meaning
Type	Name		
Input nodes (X_n)	*Geographic conditions (X_1)*	*m*	*The distance above the county level between the sample townships and the closest city*
	Longitude (X_2)	*m*	*The distance above the county level between the sample townships and the closest city*
	Latitude (X_3)	*m*	*The projected ordinate of the sample townships' geometric center*
	Altitude (X_4)	*m*	*The typical elevation of the sample townships*
	Relative height (X_5)	*m*	*The variation in elevation between the highest and lowest points in the sample townships*
	Surface roughness (X_6)		*The average surface roughness of the sample townships, measured as the ratio of surface area to predicted area*
	Population density (X_7)	*Person/km^2*	*The proportion of each township's total land area to its population*
	GDP per unit area (X_8)	*10^4 yuan/km^2*	*The GDP to total area ratio for the sample townships*
	ESV per unit area (X_9)	*10^4 yuan/km^2*	*The ratio of the ESV (Ecosystem Services Value) of the sample townships to the total land area*
Output nodes (Y_s)	*Production land ratio (Y_1)*	*%*	*The proportion of the production land area of the sample townships to the total land area*
	Ecological land ratio (Y_2)	*%*	*The percentage of ecological land area to total land area in the sample townships*

4.2. A firm grasp on the root drives

Essential parts of the CLUE-S paradigm must be located near one another for the system to work properly. This was accomplished by zeroing in on the ten elements of Table 2 that did not contribute to the formation of regional spatial patterns and ignoring the remaining two hundred and ten. These 10 criteria were altitude, slope, surface roughness, yearly precipitation, land production capacity, proximity to major roads and cities, distance to significant rivers and densely populated areas, and GDP distribution.

4.3. Conditions that are amenable to the alteration of land use

The land use conversion rule is presented in the form of a matrix that outlines the various land categories and indicates which of those classifications can be converted into others. Because it was found that all of the various types of land could be swapped out for one another, the value of the land use conversion rule matrix was set to 1. The amount of labor that is required to switch from one kind of land use to another is quantified by a concept known as the "elasticity of land use conversion." The CLUE-S model was calibrated using a value of 0 for the land use type elastic parameter. As the elasticity coefficient increases, there is a corresponding decrease in the ease with which one type of land can transform into another type. Table 4 provides a quantitative breakdown of the elasticity coefficients of various land uses in the study area based on an analysis of historical data and the opinions of local experts.

The probability of geographical distribution is taken into consideration. The CLUE-S model makes its predictions on the geographic distribution by analyzing the statistical link that exists between the prevalence of various land use categories and the various driving factors. An SPSS logistic regression model was utilized to provide projections regarding the upcoming PLEL case occurrences. The following is the formula for the model:

Type I PLEL likelihood is recorded along with grid unit Pi, explanatory variable Xn, constant term 0, the partial regression coefficient of Xn, and n. As the exogenous variable (Ind) changes, so does the dependent variable (Exp). When Exp is less than 1, the probability does not change no matter what the value of the independent variable is. When Exp = 1, however, the likelihood changes regardless of the value of the independent variable. Any inputs that do not materially affect the output are quickly thrown out of the model [31]. The ROC analysis confirmed the findings of the logistic regression. When the ROC value is close to 1, the model's predictions are highly reliable; when it's close to 0.5, the model's interpretations aren't very reliable (Table 3).

To achieve the goal of optimizing the land use pattern in the study region, it will be essential to allocate ecological land and production land wisely, as well as to adjust the structural link between the two types of land (Table 4).

Table 4 displays the need for PLE (Public Land Expansion) space in rural parts of Taiping, illustrating the necessary land area for various land use classifications. The proportions emphasize the significance of ecological land, with agricultural producing land and urban dwelling land following suit. These results align with prior research emphasizing the crucial need of ecological conservation in rural areas, particularly in mountainous locations like as Taiping. The substantial amount of agricultural land highlights the continued significance of agricultural operations notwithstanding the rise of urbanization. Furthermore, the limited space designated for industrial production land corresponds with research that supports the use of sustainable land management methods to reduce environmental deterioration in rural regions. Hence, the findings shown in Table 5 confirm the need of implementing well-balanced land use policies that give priority to ecological protection while simultaneously maintaining agricultural livelihoods in rural areas.

Table 5 displays the findings of a thorough investigation that groups towns into different categories based on economic and ecological characteristics. Group 3 is distinguished by having the greatest GDP *per* unit area and GDP *per capita*, which suggests a more robust economic performance when compared to Groups 1 and 2. In contrast, Group 2 has the greatest ESV (ecosystem service value) *per* unit area and *per capita*, emphasizing its better ecological value. According to the coupling degree index, Group 2 exhibits the highest level of integration between economic and ecological advantages, highlighting the need of implementing balanced development plans. These results support prior research that recommends combining economic and ecological elements in land management to achieve sustainable development.

4.4. Maximizing regional land productivity using BP-ANN

Training data comprising optimal land use patterns were used to develop and implement a BP-ANN optimization model for land use. Forty-four of these cities were used as examples in the training data. The model's hidden layer consisted of three nodes: two neuron nodes and one deviation node. The model's astonishingly high forecast accuracy (88.9 %) demonstrates its outstanding dependability. As a predictor variable, surface roughness (0.2475) is more important than latitude (0.1936), altitude (0.1796), relative height (0.11274), longitude (0.11064), economic surplus value *per* unit area (0.0552), population density (0.0465), and gross domestic product *per* unit area (0.0465) in SPSS 24. (0.0286). (0.0152). The 215 sample towns' data was used to train a BP-ANN model that then predicted the optimal production, residential, and ecological land uses for each community. It was also anticipated what the best uses

Table 4
Elasticities of the various PLEL types.

*PLEL classificati **on***	Wetland	Forest land	Grassland	Other ecological land	*Agricultural production land*	Industrial production land	*Urban living land*	*Rural living land*	Traffic land
Elasticity coefficient	*0.7*	*0.5*	*0.4*	*0.3*	*0.4*	0.8	*0.7*	*0.6*	*0.10*

Table 5
Results of a thorough benefit cluster analysis.

Cluster group	Group 1	Group 2	Group 3
Number of sample towns	*112*	*42*	*53*
GDP per unit area (10^4 yuan/km^2)	*16.64*	*15.54*	*48.67*
ESV per unit area (10^4 yuan/km^2)	*2.14*	*6.86*	*2.87*
GDP per capita (10^4 yuan/person)	*2.80*	*3.46*	*7.73*
ESV per capita (10^4 yuan/person)	*0.63*	*1.34*	*0.73*
Total GDP (10^8 yuan)	*5.57*	*7.5*	*16.09*
Total ESV (10^8 yuan)	*1.51*	*3.65*	*1.75*
Coupling degree index	*0.59*	*0.72*	*0.49*

of land would be in each municipality. This was the case despite an increase in the total amount of protected land. Inhabitable land decreased by 3–5% in the south and west, and increased by 1–2 percent in the center and north, for a net shift of 1 % worldwide. The degree of land use mismatch present during the study was positively connected with the best adjustment range in most circumstances. The BP-ANN model can be used to detect and optimize the land use pattern of rural PLE space at the regional level. The model produced reliable and fair predictions, and it was shown that the degree of imbalance correlated with the size of the change in land use structure adjustment. The hypothesis was tested, and the model passed with flying colors.

4.5. The CLUE-S model is used to find the best possible use of land in a given area

The BP-ANN model determined that in the city of Taiping, the percentages of production land, residential land, and ecological land could be increased from 88.17 %, 6.25 %, and 5.58 %–62.92 %, 7.83 %, and 29.25 %, respectively. Because of this, we were able to determine the CLUE-S-related land-use needs of Taiping (Table 5). What this means is that it is possible to make reliable predictions of the spatial distribution of various land uses. Urban habitation (0.916) was more productive than traffic land (0.885) was more productive than another ecological land (0.804) was more productive than industrial production (0.779) was more productive than forest habitation (0.726) was more productive than wetland habitation (0.711) was more productive than agricultural habitation (0.647) was more productive than grassland habitation (0.62) was more productive than rural habitation (0.62). (0.611. Topography, climate, elevation, slope, accessibility, population density, and agricultural potential all played a role in shaping land use patterns in rural PLE areas (as measured by the odds ratio and logistic regression coefficient). To thrive, wetlands needed a rough surface and lots of rain, but altitude and slope were bad for them. A combination of surface roughness and slope favored forested land, but high population density had the opposite effect. Surface roughness and slope had favorable effects on grassland, but precipitation had negative consequences. Surface roughness, precipitation, and altitude all benefited land used for industrial production, whereas population density and land production capacity favored land used for agricultural production. A favorable land slope benefited industrial output whereas height, precipitation, and separation from major roadways benefited agricultural productivity. Livable land in urban areas was negatively impacted by surface roughness, road distance, rainfall, and altitude, while livable land in rural areas was positively impacted by rainfall and population density. The surface's height and roughness hampered vehicular travel. Both elevation and surface roughness reduced urban useable land (Table 6).

Table 6 presents the geographical distribution of several land use categories in the rural regions of Taiping town, emphasizing the changes in the proportions of each sector. Forest land had a significant growth of 18.27 %, suggesting promising endeavors in ecological protection. In contrast, the amount of land used for agricultural production declined by 22.25 %, indicating a transition away from intensive agricultural methods. These results support earlier research that promotes sustainable land management methods that emphasize ecological preservation and maximize agricultural yield in rural regions. Furthermore, the negligible alterations in the land areas dedicated to industrial and urban living suggest a consistent pattern of growth in these industries.

The logistic regression findings of the driving factors investigated using the CLUE-S model are shown in Table 7. Altitude, slope, surface roughness, and precipitation have substantial effects on various land use categories. Higher surface roughness has a favorable impact on industrial production land but has a detrimental impact on urban dwelling land. These results support prior research that emphasizes the significance of geographical and climatic variables in influencing land use patterns. Moreover, the noteworthy coefficient values for each driver highlight their importance in deciding land allocation methods, highlighting the need for comprehensive spatial planning techniques that integrate environmental and socioeconomic factors.

The land use transfer matrix analysis has mostly focused on optimizing Taiping's land use pattern in light of the change in

Table 6
The Taiping town's need for PLE space in rural areas.

PLEL classification	Wetland	Forest land	Grassland	Other ecological land	Agricultural production land	Industrial production land	Urban living land	Rural living land	Traffic land
Area (hm^2)	*295.23*	*1144.56*	*240.67*	*0.00*	*3653.45*	*1.58*	*42.56*	*382.74*	*15.32*
Proportion change (%)	*2.45*	*18.27*	*2.75*	*0.00*	*−22.25*	*0.00*	*0.16*	*1.46*	*0.07*

Table 7
Results of the driving factors in the CLUE-S model using logistic regression.

Driver		Altitude	Slope	Surface roughness	Annual average precipitation	Land production potential	Road distance	City distance	River distance	Population density	GDP	Constant	ROC
Wetland	*β*	*−0.009030*	*−0.011558*	*1.477895*	*0.001781*	*−0.00007*		*−0.000027*	*−0.000274*	*−0.000578*	*−0.000037*	*−1.026494*	*0.711*
	Exp (β)	*0.991011*	*0.988509*	*4.383706*	*1.001783*	*0.99993*		*0.999973*	*0.999726*	*0.999422*	*0.999963*		
Forest land	*β*	*0.001919*	*0.010103*	*0.768814*		*−0.000187*	*0.00021*	*0.000024*	*0.000083*	*−0.002644*	*0.000494*	*−2.049125*	*0.726*
	Exp (β)	*1.001915*	*1.010154*	*2.157207*		*0.999813*	*1.00021*	*1.000024*	*1.000083*	*0.997359*	*1.000494*		
Grassland	*β*	*0.000389*	*0.008323*	*0.53273*	*−0.005215*	*0.000028*	*0.000224*	*0.000013*	*−0.000034*	*0.000729*		*−2.125707*	*0.62*
	Exp (β)	*1.000389*	*1.008358*	*1.703576*	*0.994798*	*1.000028*	*1.000224*	*1.000013*	*0.999966*	*1.000729*			
Other ecological land	*β*	*−0.003354*	*0.005466*		*0.019127*	*0.000133*	*0.00035*	*−0.000014*	*0.000032*	*0.004394*	*−0.001117*	*−25.580989*	*0.804*
	Exp (β)	*0.996631*	*1.005481*		*1.019311*	*1.000133*	*1.00035*	*0.999986*	*1.000032*	*1.004404*	*0.998884*		
Agricultural production land	*β*	*0.00012*	*−0.002347*	*−1.26613*	*−0.001185*	*0.000159*	*−0.000119*	*−0.000004*	*−0.000017*	*0.001874*	*−0.000324*	*1.826247*	*0.647*
	Exp (β)	*1.00032*	*0.997655*	*0.28192*	*0.998816*	*1.000159*	*0.999881*	*0.999996*	*0.999983*	*1.001876*	*0.999676*		
Industrial production land	*β*	*−0.004108*	*0.004534*		*−0.004007*	*−0.000364*	*−0.001438*	*−0.000059*	*−0.000061*	*−0.000483*	*−0.000174*	*3.987978*	*0.779*
	Exp (β)	*0.995810*	*1.004544*		*0.996001*	*0.999636*	*0.998563*	*0.999941*	*0.999939*	*0.999518*	*0.999826*		
Urban living land	*β*	*−0.00337*		*−1.343769*	*−0.001685*	*−0.000184*	*−0.006442*	*−0.000068*	*−0.000184*	*0.000721*	*−0.000075*	*3.472517*	*0.916*
	Exp (β)	*0.996540*		*0.260861*	*0.998316*	*0.999816*	*0.993579*	*0.999932*	*0.999816*	*1.000721*	*0.999925*		
Rural living land	*β*	*−0.001145*		*−0.902975*	*0.002962*	*0.000077*	*−0.00013*	*−0.000016*	*−0.000006*	*0.001153*	*−0.000168*	*−4.995866*	*0.611*
	Exp (β)	*0.998849*		*0.405362*	*1.002966*	*1.000077*	*0.99987*	*0.999984*	*0.999994*	*1.001154*	*0.999832*		
Traffic land	*β*	*−0.000662*	*0.005556*	*−0.826851*	*−0.008503*	*−0.000103*	*−0.004427*	*−0.000034*	*−0.000073*	*−0.002595*	*0.000413*	*7.672008*	*0.885*
	Exp (β)	*0.999339*	*1.005572*	*0.437425*	*0.991533*	*0.999897*	*0.995583*	*0.9999*					

ecological and productive land. Agricultural production land (APL) was converted into all other categories of land use that saw a gain in the area because of the increased elasticity coefficient and the reduced area of the ecological and living land. A contributing factor was probably the higher elasticity coefficient seen in areas with a wide range of ecological and physiological conditions. Subsequently, the CLUE-S method was used to convert low-potential agricultural land with poor topographical qualities into ecological land. That was done without putting agriculturally productive areas at risk. These improvements pave the way for a more rational local land use structure, which in turn aids in the preservation of regional soil, the purification of regional water, and other ecological tasks.

5. Discussion

Using a comprehensive method of benefits evaluation, we discovered that the land use benefit in a mountainous region in Southwest China is very variable and unevenly distributed, as is common for such regions. This finding is consistent with those of investigations done both nationally and in Sichuan [32]. It is unlikely that the total benefits will precisely reflect the ideally dispersed level of land use in township units, given that the average ratio of ESV to GDP in the study towns was just 0.27. To determine the best method for land development, this paper makes use of a coupling degree index. Results from a Pearson's correlation study provided further support for the identification results by showing a significant relationship between land use structure and benefits. The complete benefit coupling degree index was negatively correlated (−0.369), positively correlated (−0.323), and negatively correlated (0.439) with productive land, populated land, and ecological land percentages respectively. All of these numbers were unquestionably not equal to zero (p 0.01).

The methodology used in this study, however, provides a more satisfactory explanation of why Further, the heterogeneity correction method is used in this work to adjust for the fact that the value of ecosystem services varies considerably across geographic locations. The method is very dependent on a set of factors and models, which limits its applicability. The ensuing research will further develop the model used to account for heterogeneity. To increase crop yields, the authors of this piece merge the BP-ANN and CLUE-S models. Its original purpose was to enhance the consistency of functional regions across scales and to optimize land use quantitatively. Planning land usage more effectively in China's rural areas is also covered. First, we showed that the factors affecting land use distribution are stable over space and time. Unlike the distribution of ecological land, which is primarily influenced by topography, the distribution of production land is primarily influenced by cropland and soil quality. The topographic setting plays a significant role in determining the ideal site for any given land use. Because these findings are in line with those of national-scale research [33],it is clear that the influencing components chosen for this study are particularly trustworthy for improving land use on medium and small scales. Evidence from all over the world shows that land use changes have profound scale effects and regional variances. When adapting this methodology for usage in other regions, researchers will need to consider several factors before settling on a final model.

Furthermore, the BPANN model's capability to capture the complex nonlinear relationship between land use and the factors affecting it can result in an optimal land use structure that satisfies the practical needs of regional food security and ecosystem services. The accuracy of the BP-ANN model could be enhanced with the help of additional studies using a larger data set of cities. The ecological conditions of the analyzed region have changed little, and the model relies on fewer local parameters. The model could benefit from additional regional indicators. These hints can be gleaned from studies conducted in different ecosystems. These results corroborate previous research showing that the CLUE-S model successfully altered a landscape pattern dominated by agriculturally productive land by introducing more diversity and balance. This conclusion is consistent with the available evidence. There is also a mistake in the article's forecast of habitable terrain. This is because social norms and laws have a more pervasive effect in close-knit communities.

As a result, optimization of the residential environment can be used to apply resident behavior models, leading to more accurate simulations [34]. Integrating land use optimization findings into a national spatial planning framework is made possible through the use of spatial function zoning. The major functions and compound functional space outlined in the "Land Spatial Planning of Sichuan Province (2020–2035)" were utilized to categorize the study region, which was then used to identify the study's geographic distribution. Listed below are some recommendations on how the government of China's mountainous southwest might better put its land to use. Ample space for storing and handling food is essential for preventing contamination. Better protection and development of cultivated land resources, as well as rigorous adherence to the Cultivated Land Protection Red Line policy, are crucial for achieving maximum agricultural output. Limiting the spread of risky industrial endeavors is also crucial. Housing is given high priority in urban planning and industrial expansion because of its importance to the local economy and population density. Urbanization and intensive

Table 8
Comparison of the PLEL in Taiping's landscape pattern index.

Landscape pattern index	Before	After	Landscape pattern index	Before	After
NP (n)	*586*	*3180*	*SPLIT*	*1.2984*	*2.8439*
PD (n/100 hm^2)	*10.0628*	*54.6072*	*PR*	*8*	*8*
LPI	*87.7567*	*58.6232*	*PRD (n/100 hm^2)*	*0.1374*	*0.1374*
TE (m)	*569,803*	*884,290*	*SHDI*	*0.526*	*1.1284*
ED (m/hm^2)	*97.847*	*151.851*	*SIDI*	*0.2181*	*0.5528*
LSI	*18.667*	*31.741*	*MSIDI*	*0.2461*	*0.8047*
FRAC	*1.4007*	*1.3646*	*SHEI*	*0.253*	*0.5427*
CONTAG	*67.7101*	*64.6797*	*SIEI*	*0.1497*	*0.6717*
IJI	*40.4179*	*67.197*	*MSIEI*	*0.1167*	*0.777*
DIVISION	*0.1166*	*0.6494*	*AI*	*97.7699*	*90.1614*

land use must be rigorously regulated to safeguard ecologically sensitive areas. This can only be achieved with the use of a correct approach and well-defined boundaries. No expense may be too great to ensure the continued survival of the upper Yangtze River's rich biological diversity. Ecosystem services can only be kept stable through measures like the strict implementation of the Ecological Protection Red Line policy, the management of development and building activities, the gradual adjustment of the industrial structure, the conversion of farmland to forests, and the restoration of ecological systems. Functional properties of varying types can be found in the enormous compound functional space. Major objectives of regional function optimization include coordinating economic and ecological growth and building a land use structure that strikes a healthy (Table 8).

Table 8 presents a comparison of the landscape pattern index (LPI) of Taiping before and after the implementation of adjustments in PLEL. The LPI after the intervention demonstrates a noteworthy improvement, suggesting a landscape that is more varied and environmentally sustainable. Metrics such as Shannon's Diversity Index (SHDI) and Simpson's Diversity Index (SIDI) show significant increases, indicating a greater variety of species and improved ecological health in the area. These results are consistent with other research that highlights the beneficial impacts of landscape design interventions on the preservation of biodiversity and the resilience of ecosystems. The significant rise in Effective Mesh Size (TE) also signifies enhanced landscape connectivity, facilitating species migration and ecological usefulness.

Cultural and social elements are crucial in determining land use choices in rural regions, often having a substantial impact on local habits and preferences. A significant cultural element is the long-established land use methods that are profoundly rooted in the rural communities. These behaviors often originate from ancient conventions, beliefs, and indigenous knowledge systems that have been transmitted over generations. For instance, in agricultural communities, land is often seen not just as a means for economic profit, but also as a representation of one's identity and ancestral legacy. Therefore, cultural norms related to agricultural techniques, land tenure systems, and community ownership arrangements have a significant impact on choices about land usage. Resistance to change may occur when planned alterations in land use clash with deeply rooted cultural traditions, underscoring the need of being sensitive and working together in decision-making processes.

The interactions and relationships among individuals in rural communities are also crucial in influencing the choices made about the usage of land. The allocation of land and resources may be greatly influenced by social cohesiveness, community networks, and power structures. In tightly-knit rural communities, decision-making is often influenced by either consensus-building procedures or hierarchical leadership systems. The influence of prominent local leaders or landowners may significantly impact choices about the allocation of land use, resulting in inequalities in the distribution of resources. Furthermore, the adoption of certain land use techniques may be influenced by societal norms and ideals related to land stewardship, environmental protection, and sustainability. Communities that have deep cultural connections to the land often give high importance to conservation initiatives and sustainable farming methods in order to save natural resources for future generations. Comprehending these cultural and social variables is crucial in formulating efficient land use policies and actions that are in line with local values and encourage community involvement and empowerment.

6. Conclusion and policy implication

This research offers unique insights into the intricate relationship between land-use patterns, ecological services, and economic growth in Taiping town. By conducting a thorough examination of geographical data and using advanced statistical modeling approaches, we have successfully determined the main factors that contribute to changes in the landscape. Additionally, we have measured the effects of these changes on the supply of ecosystem services and economic output. The implications of our results are significant for policymakers, land managers, and academics who are working towards the attainment of sustainable development objectives in landscapes that are undergoing fast changes.

A key discovery from our research is the substantial influence of land-use alteration on the patterns of ecosystem service behavior and economic results. We have seen a distinct trade-off between the transformation of natural habitats into agricultural and urban areas and the decrease in the values of ecosystem services, specifically in relation to the preservation of biodiversity, management of water, and storage of carbon. These results emphasize the immediate need for proactive land-use planning techniques that give priority to the preservation and rehabilitation of crucial natural habitats while still allowing urbanization and infrastructural expansion.

Moreover, our study emphasizes the significance of taking into account the socio-economic backdrop and local community dynamics when making decisions about landscape management. Community participation and participatory techniques are crucial for guaranteeing the effectiveness and long-term viability of conservation initiatives, while also promoting social fairness and adaptability. It is crucial for policymakers to give high importance to investing in green infrastructure projects and ecosystem-based adaptation measures. These investments will help improve the ability of ecosystems to withstand and recover from the negative impacts of climate change.

Our work highlights the significance of integrated landscape management techniques in addressing conflicting land-use demands and protecting ecosystem services, with important implications for policy. Policymakers should engage in cooperative efforts with local stakeholders to formulate and execute land-use plans that accurately represent the community's requirements and ambitions, while also guaranteeing the responsible use of natural resources. Furthermore, it is crucial to have strong monitoring and evaluation systems in place to monitor changes in the health of ecosystems and socio-economic indicators. These systems are necessary to implement adaptive management techniques effectively.

In the future, there are several opportunities for additional study that may expand on our results and enhance comprehension in this sector. It is necessary to conduct long-term monitoring and evaluation studies in order to determine the efficacy and durability of landscape management interventions over an extended period. Utilizing spatial modeling methodologies and scenario analysis allows for the simulation of possible consequences on ecosystem dynamics and human well-being resulting from various land-use and climate change scenarios. Moreover, economic valuation studies are crucial for measuring the advantages of ecosystem services offered by various land-use categories and guiding decision-making procedures.

Our work adds to the existing literature on landscape ecology, ecosystem services, and sustainable development by offering empirical facts and practical insights that can be used by policymakers and practitioners. By tackling the intricate issues of land-use alteration and degradation of ecosystems, we may provide the foundation for a future that is more robust and environmentally sustainable for places such as Taiping town and beyond.

6.1. Policy implications

- The research emphasizes the significance of implementing integrated landscape management strategies to achieve a harmonious equilibrium between economic progress and ecological preservation. Policy-makers should give priority to methods that improve ecosystem services while also promoting sustainable economic development.
- The results underscore the need of implementing strategic land-use planning at both the municipal and regional levels. Policies should give utmost importance to safeguarding and rehabilitating crucial ecological regions while also considering the needs of urbanization and infrastructure development, with a focus on minimizing negative effects on the environment.
- Efforts should be made to implement policies that encourage the use of ecosystem-based adaption mechanisms in order to reduce the negative impacts of climate change. Allocating resources towards green infrastructure, such as the restoration of wetlands and the planting of trees, may strengthen the ability of ecosystems to withstand and recover from climate-related challenges, while also providing protection to populations.
- Successful execution of landscape management strategies necessitates the active involvement and participation of local people and stakeholders. Policies should include systems that facilitate community engagement, dissemination of information, and enhancement of capabilities to guarantee the effectiveness and long-term viability of conservation endeavors.

6.2. Future research directions

- Subsequent investigations should prioritize the extended observation and assessment of landscape management initiatives to determine their efficacy and durability in the long run. This involves monitoring and analysing changes in ecosystem services, biodiversity, and socio-economic variables in order to provide information for the development of adaptive management plans.
- Additional investigation might investigate sophisticated spatial modeling methodologies and scenario analysis to replicate the possible consequences of various land-use and climate change scenarios on ecosystem dynamics and human well-being. This may facilitate the identification of optimum land-use options and provide valuable insights for policy-making.
- In order to get a deeper understanding of the intricate relationships between human activities and ecosystem dynamics, it is recommended that future research use a social-ecological systems approach. This multidisciplinary approach may provide useful insights into the factors that cause changes in the environment and help in creating more efficient management solutions.
- Additional extensive economic valuation studies are required to accurately measure the benefits of ecosystem services offered by various land-use types. Integrating the assessment of ecosystem services into decision-making processes may assist in accounting for the costs and benefits of the environment and encourage the adoption of sustainable land-use practices.

6.3. Limitation

Although this research has notable merits, it is important to acknowledge and take into account its many limitations. Firstly, the study mainly depends on secondary data sources, which may include biases or mistakes that are inherent in the process of collecting data. Furthermore, while the CLUE-S model is extensive, it is still susceptible to inaccuracies related to parameterization and calibration. Additionally, the study's concentration on a particular geographical location may restrict the applicability of its results to other places characterized by distinct socio-economic and environmental circumstances. In addition, the study's temporal scope is limited by the availability of data, which may result in the omission of long-term trends or gradual changes in land-use patterns. In addition, the study's dependence on quantitative approaches may fail to include qualitative components of land-use decision-making processes, such as cultural preferences or institutional dynamics. Although attempts were made to consider possible confounding variables, the intricate and ever-changing nature of land-use change processes may introduce unidentified elements that might impact the findings of the research.

Ethics approval and consent to participate

Not applicable.

Consent for publication

All of the authors consented to publish this manuscript.

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Data availability

We collected relevant data from World Bank open data available at https://data.worldbank.org/. For any further query on data, corresponding author at email address weihm10@sina.com may be approached.

CRediT authorship contribution statement

Weiwei Zhang: Writing – original draft, Supervision, Methodology, Formal analysis. **Hongman Wei:** Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Muhammad Haroon:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation, Conceptualization.

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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