Formulating a Map of Land Value Zones in Luong Son Town, Luong Son District, Hoa Binh Province

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Abstract

Value zones, first stipulated in the 2024 Land Law, serve as the foundation for developing land price tables for each plot of land, standard plot of land and specific land prices. The primary objective of this study is to delineate land value zones in Luong Son township based on factors influencing land prices. Drawing on a comprehensive literature review and the local socio-economic context, direct consultations were conducted with ten experts possessing in-depth knowledge of the study area. These consultations facilitated the identification of key factors affecting land prices and the determination of their relative importance using the Analytic Hierarchy Process (AHP). A weighted overlay analysis was subsequently applied to generate the land value zoning map. The results indicate that land prices are most strongly influenced by proximity to adjacent roads (0.284) and road density (0.228), followed by distance to markets (0.215). Based on the weighted overlay of the influencing factor layers, four land value zones - very high, high, medium, and low-were identified. Among these, the medium - value zone occupies the largest proportion of the study area (58.76%), followed by the high-value zone, which accounts for 34.6% of the total area. A comparison with actual land transaction prices reported by local residents reveals that the land value zoning map effectively captures the overall spatial distribution trends of market land prices. However, notable discrepancies remain when compared with land value zones defined under the state-regulated land price framework in Vietnam, particularly in low-value areas. These discrepancies not only pose a risk of revenue loss for the state in land management but also highlight inherent limitations in the current approach to land price table formulation. Therefore, the findings underscore the necessity of revising land price determination methods toward an approach grounded in land value zoning, thereby enhancing transparency, equity, and efficiency in land administration.

Keywords: AHP, GIS, Influencing Factors, Land Value Zone, Luong Son Town

1. Introduction

Land price is considered one of the important legal bases for calculating land use fees, land rent, fees, charges and financial obligations related to land such as buying, selling, transferring, leasing, mortgaging, compensation when the state reclaims land [1][2][3][4] and [5]. Land value zoning has been extensively studied and widely implemented worldwide, serving as an important tool in land administration, urban planning, and real estate market management [6] and [7]. Numerous studies have established land value zones based on cadastral map databases [8], updated land prices through land value zoning approaches [9], and developed land value zone maps by considering factors influencing the formation of land values [10][11] and [12]. Land values are affected by a wide range of criteria, and the relative influence of each criterion is commonly determined using methods such as the Analytic Hierarchy Process (AHP), multiple regression analysis, artificial neural networks, and fuzzy models [13] and [14] . In particular, the application of Geographic Information Systems (GIS) in combination with multi-criteria decision-making methods, notably the Analytic Hierarchy Process (AHP), has been proven to be highly effective in identifying and spatially representing land value zones [15][16] and [17].

Vietnam operates a socialist-oriented market economy, and in recent years, land administration institutions and management approaches have been gradually improved. However, land valuation practices in reality continue to face significant challenges. One of the prevailing issues is the "coexistence of two land price systems: state-regulated prices and market-based prices." The disparity between these two price systems has resulted in inconsistencies in the implementation of compensation and site clearance policies when land is reclaimed by the State [11]. Although the government has made efforts to adjust land valuation methods to better align with market prices, a substantial gap between state-regulated and market-based land prices remains.

Although GIS and the Analytic Hierarchy Process (AHP) have been applied in land value zoning studies in Vietnam, most existing research has primarily adopted a technical perspective and has not been fully integrated with land valuation requirements stipulated in the 2024 Land Law, in which land value zones are identified as the basis for developing land price tables. Furthermore, previous studies have rarely conducted independent validation of zoning results using actual market transaction price data, thereby limiting their ability to accurately reflect real-world conditions. In addition, the disparity between market-based land value zones and state-regulated land price tables has not yet been systematically quantified. These gaps highlight the need for studies that not only ensure the scientific robustness of analytical models but also closely align with the legal–institutional framework and market realities [15][16][18] and [19].

This research gap becomes particularly evident in Luong Son District, an area characterized by rapid urbanization and substantial land price fluctuations. Under current state regulations, land value zoning in Luong Son is primarily based on road classification and distance to major transport corridors, with limited consideration of spatial, economic, and social factors, leading to significant discrepancies between state-regulated land prices and market prices. Moreover, land price dynamics in Luong Son are influenced not only by the spatial continuity of transaction data but also by the simultaneous effects of various qualitative and institutional factors, such as road type and levels of access to infrastructure and services. The application of the Analytic Hierarchy Process (AHP) enables the quantification of the relative influence of each factor through expert judgment, while the integration of AHP with Geographic Information Systems (GIS) allows for the flexible incorporation of both quantitative variables (e.g., distance, road density) and qualitative variables (e.g., road classification). This approach is particularly appropriate in contexts where market transaction data are limited and unevenly distributed across space [20]. The study also explicitly acknowledges the limitations of the Analytic Hierarchy Process (AHP), including the subjectivity inherent in expert judgments and the influence of experts' individual experience [21]. Therefore, the experts involved were required to possess in-depth knowledge of the study area and substantial experience in the research field. In addition, the zoning results were independently validated using survey data from actual market transactions of 100 land parcels, thereby enhancing the reliability of the proposed model.

The objectives of this study are to: (i) identify the factors influencing land prices in Luong Son Town; (ii) determine the relative weights of these factors using the Analytic Hierarchy Process (AHP) based on expert opinions; (iii) develop a land value zoning map through weighted overlay analysis within a GIS environment; and (iv) evaluate the degree of consistency between market-based land value zones and those defined by the state-regulated land price table. Accordingly, the study provides scientific and practical foundations for improving land valuation systems and enhancing the effectiveness of state land administration.

2. Materials and Methods

2.1 Study Area

Luong Son Town illustrated in Figure 1 is located along the major transportation corridors of National Highway 6A and National Highway 12B, approximately 40 km from Hanoi, and serves as the eastern gateway of Hoa Binh Province. To the east, it borders Hanoi and Hoa Son Commune; to the north, it borders Hanoi; to the west, it borders Lam Son Commune; and to the south, it borders Tan Vinh and Nhuan Trach communes. As the administrative and economic center of Luong Son District, the town features a fishbone-pattern transportation network and increasingly well-coordinated infrastructure investment, providing favorable conditions for the development of commercial, service, and industrial activities. Strong emphasis on spatial planning and socio-economic development strategies has accelerated urbanization and increased land use demand. The economic structure of Luong Son Town has undergone a significant shift toward non-agricultural sectors, with commerce - services and industry - construction accounting for approximately 95% of the total economic structure. Luong Son Town covers a total administrative area of 1,736 ha [22].

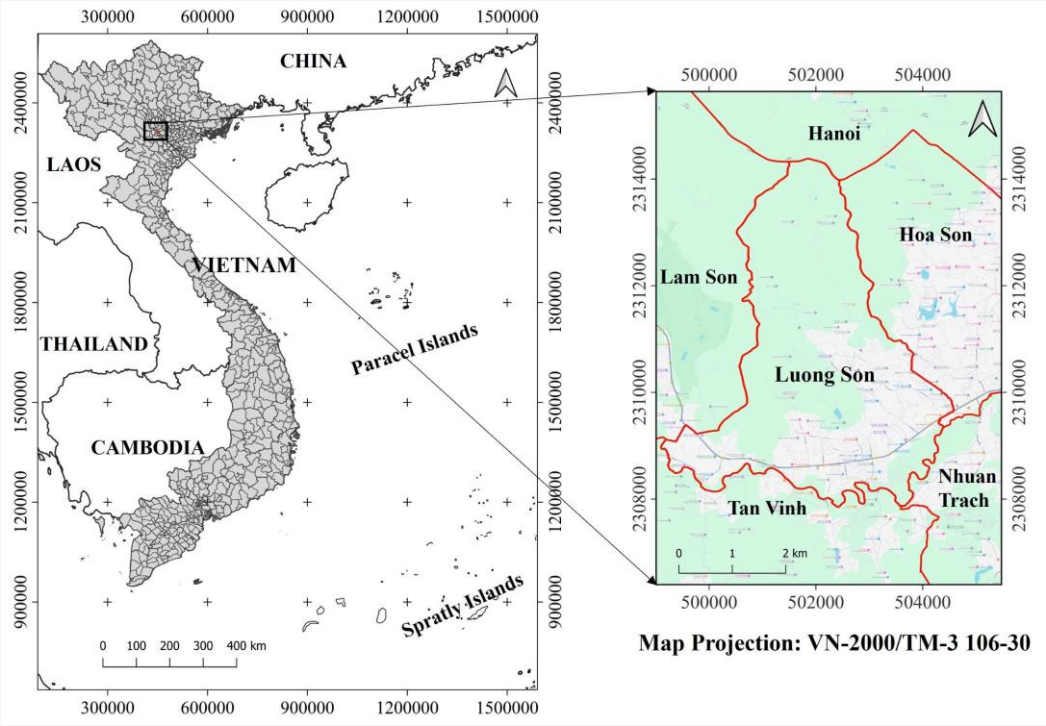


Figure 1: Luong Son Town, Luong Son District, Hoa Binh Province, Vietnam

As the district's development hub and under the direct influence of rapid urbanization, the town has experienced rising land demand, intensified investment in technical and social infrastructure, and pronounced land price fluctuations across the entire area. Urban residential land in Luong Son Town not only possesses high economic value but also most clearly reflects the combined effects of location, infrastructure, planning, and socio-economic development, particularly highlighting the disparity between state-regulated land prices and market transaction prices. Therefore, the validation of land value zoning results is conducted for residential land in Luong Son Town.

2.2 Data Collection

Secondary data sources included the Decision No. 48/2021/QĐ-UBND dated 25 August 2021 on amendments and supplements to the land price table for the 2020 - 2024 period in Hoa Binh Province, obtained from the Hoa Binh Provincial People's Committee. Data on natural conditions, socio - economic characteristics, and current land use were collected from the People's Committee of Luong Son District and the People's Committee of Luong Son Town. Vector data layers were derived from the land use status quo map of Luong Son Town at a scale of 1/5,000, provided by the People's Committee of Luong Son Town. The study employed the VN-2000 reference coordinate system with the TM-3 projection and a central meridian of 106°00′E (EPSG:9211) for the construction, analysis, and overlay of spatial data layers in Luong Son Town, Luong Son District, Hoa Binh Province.

2.3 Identification of Factors Influencing Land Prices

The factors influencing land prices in Luong Son Town were selected based on findings from previous scientific studies, the specific natural and socio - economic characteristics of the study area, and data availability. On this basis, direct consultations were conducted with 10 experts to identify the factors influencing land prices that are most appropriate for the local context.

Experts were selected based on the following criteria: (i) being directly involved in state land administration within the study area; (ii) having a minimum of five years of practical experience in land management, land valuation, or land registration; and (iii) possessing in-depth knowledge of local conditions, socio - economic characteristics, and land dynamics. The expert panel comprised cadastral officers, leaders of Luong Son Town, staff from the Department of Natural Resources and Environment, officers from the local branch of the Land Registration Office responsible for the study area, and real estate specialists. Through the expert consultation process, seven key factors influencing land prices in Luong Son Town were identified:(i) Distance to the People's Committee in town; (ii) The

distance to the school; (iii) The distance to healthcare facilities; (iv) The distance to the market; (v) The distance to the landfill; (vi) road density; and (vii) The distance to street.

a. Distance to the people's committee in town

Distance to the town center is considered one of the key factors reflecting the level of access to socio - economic activities. In Vietnam, this factor is commonly measured as the distance from a land parcel to the city center. Similarly, at the district level, distance to the district center is defined with the district People's Committee serving as the reference point [23]. Empirical studies have shown that land parcels located farther from the center tend to have lower prices compared to those situated closer to the center [24].

b. Distance to school

From the perspective of public services, the presence of educational institutions, particularly public schools, is considered to have a substantial impact on land values [25]. The relationship between land prices and proximity to schools is significant, as empirical evidence indicates that many residents are attracted to live near schools. Consequently, the presence of educational facilities is identified as a key factor influencing urban residential land prices [4] and [23].

c. Distance to healthcare facilities

Healthcare facilities and hospitals are generally regarded as essential public amenities that influence land values [4]. However, land parcels located in close proximity to hospitals may experience negative impacts on land value. The presence of a hospital or medical center can pose constraints on residential livability, potentially disrupting daily life due to factors such as emergency sirens, surrounding traffic congestion, and certain socio-cultural perceptions, including superstitious beliefs [25].

d. Distance to the market

In Vietnam, land parcels located near markets are often highly valued, reflecting the traditional perception expressed in the proverb "first near the market, second near the river, third near the road," which emphasizes the importance of proximity to markets, waterways, and transport routes. Proximity to markets and commercial centers has a significant influence on land values in surrounding residential areas. Shorter distances to markets and shopping centers facilitate convenient access to services and reduce travel costs [25]. Moreover, proximity to markets enhances access to commercial and business activities and essential services, thereby increasing land use value and income-generating potential. At the same time, areas near markets typically exhibit higher population density and greater levels of infrastructure investment, which further stimulate land demand and contribute to higher land prices.

e. Distance to landfill

With regard to surrounding environmental conditions, the presence of facilities that generate human discomfort, such as landfills, has a direct negative impact on land values [26]. Several studies have employed distance to landfills as a factor influencing land values [23]. This relationship is consistent with the increasing demand for higher environmental quality in residential living environments.

f. Road density

This factor relates to transportation conditions that influence land prices, together with aspects such as transport type, the connectivity of the locality with external areas, the overall structure of the transportation network, and the status of public transport systems [23]. Road networks with higher density provide greater advantages in terms of traffic flow and transport capacity compared to those with lower density. Improved transportation convenience enhances urban residents' daily mobility and facilitates exchanges and commercial interactions with surrounding areas [27]. Road density reflects the level of development and accessibility of the transportation network and is defined as the total length of roads within a specified search area. In this study, road density in Luong Son Town was calculated using the Line Density tool in ArcGIS with a search radius of 1 km and was expressed in units of km/km² (Table 1).

g. Distance to the street

Distance to adjacent roads is a critical factor directly influencing land prices, as it determines transportation accessibility and the level of convenience for daily living and commercial activities. Based on income-generating potential, infrastructure conditions supporting residential use, production, commerce, services, and tourism, as well as distance to the city center, the road system in Luong Son Town is classified into eight categories. Category 1 roads represent streets with the most favorable infrastructure conditions for residential, production, commercial, service, and tourism activities. Categories 2 to 8 comprise roads with progressively less favorable infrastructure conditions for these activities compared to the immediately preceding road category [28]. Based on the results of expert interviews, adjacent road types were synthesized and classified into four groups (I, II, III,

and IV) according to their degree of influence on land prices. For each road category, land parcels were further divided into four positional classes based on their distance to the adjacent road, where Position 1 represents the highest land price and Position 4 the lowest. On the basis of this hierarchical classification, scores were assigned to each position to serve as inputs for subsequent analytical steps in the study (Table 2). Each influencing factor was subdivided into value ranges and assigned impact levels ranging from low to very high, accompanied by corresponding scores, in order to quantify and compare the relative importance of the factors in land price formation. Detailed criteria are presented in Tables 1 and 2.

Table 1: The criteria and their influence levels ranges

No.	Influencing factors	Unit	Class	Land price area	Score	Source
1	Distance to the People's Committee in town (PC)	m	0-500	Very high	4	[11] and [23] Interview results with local experts
			500-1.000	High	3	
			1.000 -1.500	Medium	2	
			>1.500	Low	1	
2	The distance to the school (DS)	m	0-250	Very high	4	
			250-500	High	3	
			500 -1.000	Medium	2	
			>1.000	Low	1	
3	The distance to healthcare facilities (DH)	m	0-250	Very high	4	
			250-500	High	3	
			500 -1.000	Medium	2	
			>1.000	Low	1	
4	The distance to the market (DM)	m	0-250	Very high	4	
			250-500	High	3	
			500 -1.000	Medium	2	
			>1.000	Low	1	
5	The distance to the landfill (DL)	m	>1.000	Very high	4	[11] and Results of interviews with local experts
			500-1.000	High	3	
			100 -500	Medium	2	
			< 100	Low	1	
6	Road density (RD)	km/km^2	≤5	Low	1	[11] and [23] interview results with local experts
			5-10	Medium	2	
			10-15	High	3	
			>15	Very high	4	

Table 2: Distance to street and their Influence Levels Ranges

Influencing factors	Adjacent road groups	Adjacent road value	Class (m)	Adjacency distance value	Adjacency distance value for each road type	Source
The distance to street (DST)	I	4	20	4	4	[11] and [28] interview results with local experts
			30	3	3	
			50	2	2	
			>100	1	1	
	II	3	20	4	3.00	
			30	3	2.25	
			50	2	1.50	
			>100	1	0.75	
	III	2	20	4	2.00	
			30	3	1.50	
			50	2	1.00	
			>100	1	0.50	
	IV	1	20	4	1.00	
			30	3	0.75	
			50	2	0.50	
			>100	1	0.25	

2.4 Multi-Criteria Decision Analysis (AHP)

In recent years, multi-criteria decision analysis methods have been widely applied in land value zoning studies [15]. To determine the weights of factors influencing land prices, this study employs the Analytic Hierarchy Process (AHP), developed by Saaty in 1980. Building upon findings from previous studies, combined with an analysis of local conditions in the study area and expert consultations, a pairwise comparison matrix of land price - influencing factors was constructed. The weights of the criteria were derived through the pairwise comparison process, in which evaluation scores were obtained from interviews with experts, managers, and technical staff possessing in-depth knowledge of local land market dynamics and land price variations. The relative importance between two criteria is evaluated using a scale ranging from 1 to 9. In the AHP procedure, transitivity is not inherently ensured in pairwise comparisons. Therefore, to assess the consistency of the comparison judgments, the consistency ratio (CR) is examined from Equation 1. It was stipulated that the CR of the pairwise comparison matrix should not exceed 10% [21]. The Consistency Index (CI) is computed utilizing Equation 2:

$$CR = \frac{CI}{RI} \quad \text{Equation 1}$$

$$CI = \frac{\lambda_{max} - 1}{n - 1} \quad \text{Equation 2}$$

Where λ_{max} is the proncipal eigen value, and n is the numbers of criteria

2.5 Spatial Data Analysis and Mapping

Data preprocessing was carried out using the land use status quo map (DGN format) to separate and extract the required thematic layers, including transportation networks, township administrative boundaries, and socio-economic features such as markets, schools, healthcare facilities, landfills, and related infrastructure. The extracted datasets were subsequently standardized through spatial data normalization, which included unifying coordinate systems and spatial references, checking and correcting geometric inconsistencies (e.g., removing duplicate features, fixing geometry errors, and ensuring spatial continuity and topological correctness), standardizing attribute structures (harmonizing field names, data types, and measurement units), and classifying features into appropriate geometric types (point, line, and polygon) according to analytical requirements.

After the normalization process, all data layers were converted into shapefile (shp) format for cartographic editing and the development of the land value zoning map using ArcGIS software. ArcGIS is a powerful spatial analysis platform that supports advanced geospatial processing and analysis [15]. Specifically, buffer tools were applied to generate distance-based layers representing locational attributes, including distance to markets, distance to the People's Committees, distance to healthcare facilities, distance to schools, distance to landfills, and distance to street. In addition, the Line Density tool was employed to determine the spatial distribution of road density. Other geoprocessing tools, such as Erase and Dissolve, were also utilized to refine spatial boundaries and integrate thematic layers for subsequent analysis.

2.6 Field Survey and On-Site Investigation

After constructing the land value zoning map for the entire Luong Son township, the study validated the results through a survey of 100 land-use right transfer transactions involving urban residential land. The survey locations were recorded using handheld GPS devices and overlaid onto the land value zoning map to compare actual transaction prices with the representative price levels of each value zone. Although the zoning covered the entire township, the validation was conducted specifically for urban residential land, as this land-use category exhibits high economic value, strong price volatility, and is most directly influenced by the urbanization process. Focusing on this area enables an objective assessment of the degree of consistency between market-based land value zones and those defined under the state-regulated land pricing framework, thereby clearly demonstrating the rationality and reliability of the zoning results. Based on the aforementioned research methods, the overall research framework can be summarized and illustrated in the research flowchart presented in Figure 2.

(i) Literature review and expert consultation

Based on a comprehensive review of both domestic and international studies, the primary factors influencing land values were first identified. Subsequently, expert consultations were conducted with individuals possessing extensive experience and in-depth knowledge of the study area to select and refine the influencing factors, ensuring their suitability and relevance to the actual conditions of Luong Son town.

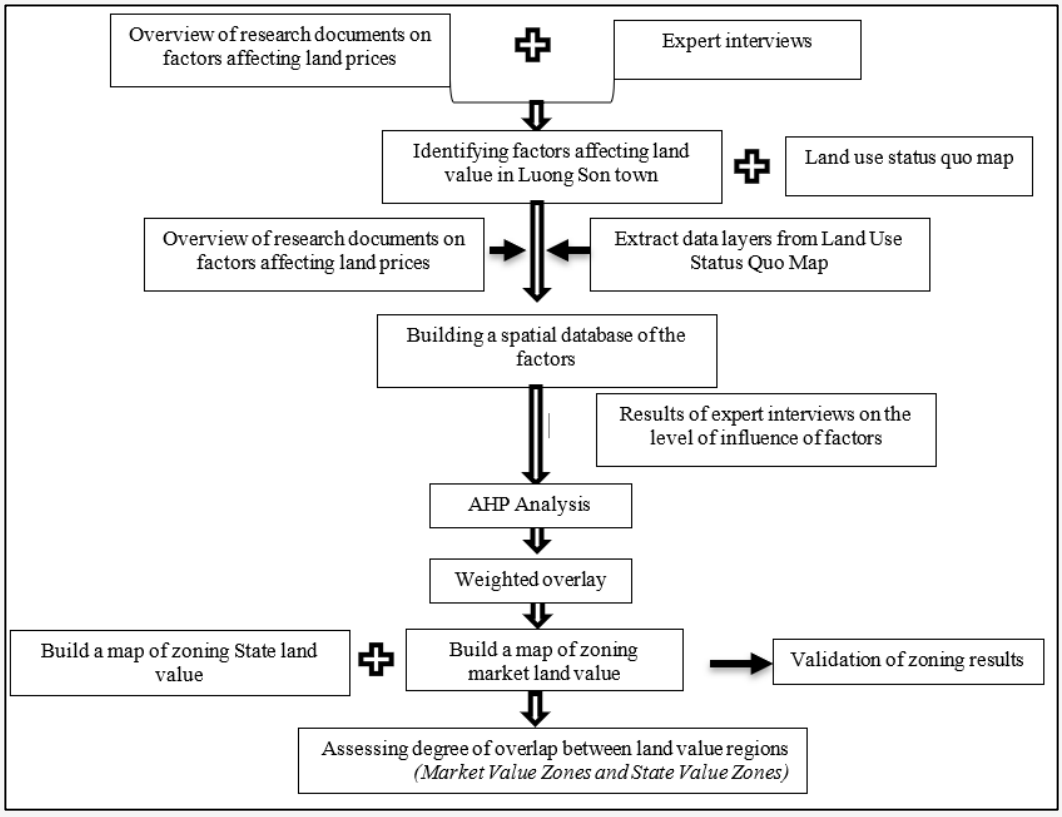


Figure 2: Methodological flowchart

(ii) Identifying factors affecting land value in luong son town

Based on the results of the literature review and expert opinions, the study selected key factors influencing land prices in the study area, ensuring both scientific and practical relevance as well as feasibility for representation and analysis within a GIS environment under local data conditions. The current land use map was regarded as a critical spatial data source, as it reflects the spatial distribution of land-use types and socio-technical infrastructure systems, including transportation networks, schools, hospitals, landfill sites, and parcel boundaries. This map served as the basis for extracting input data layers required for constructing the influencing factor layers.

(iii) Building a spatial database of the factors

The factors influencing land values were classified according to their levels of impact and transformed from qualitative attributes into quantitative indicators using criteria such as distance and density. After being extracted from the current land use map, all datasets were standardized in terms of coordinate systems and map projections, and geometric corrections were applied. The processed data were then imported into ArcGIS in shapefile (shp) format for spatial editing and analysis. Using spatial analysis tools, corresponding spatial layers were generated, including transportation networks, markets, schools, healthcare facilities, administrative areas, and landfill.

(iv) Analytic hierarchy process (AHP) analysis

Expert opinions were employed to construct pairwise comparison matrices among the influencing factors, from which the relative weights of each factor were derived using the Analytic Hierarchy Process (AHP). The consistency of the judgments was examined to ensure the reliability and robustness of the results.

(v) Weighted overlay analysis in GIS

The criterion layers were integrated within a GIS environment using a weighted linear combination approach, in which each layer was multiplied by its corresponding weight derived from the AHP analysis. This procedure resulted in the construction of a market-based land value zoning map, which reflects the spatial distribution of land value zones based on factors influencing actual land prices in the market. Given the high variability of market land prices, the resulting map provides a relatively close representation of the true economic value of land across different areas. The market-based land value zoning map was subsequently validated using data obtained from a survey of 100 urban residential land-

use right transfer transactions. This validation process enabled an assessment of the degree of consistency between the delineated land value zones and actual market transactions.

(vi) Map of zoning state land value

A land value zoning map was developed in accordance with state regulations based on the official land price framework promulgated under Decision No. 57/2019/QĐ-UBND dated 30 December 2019 for the period 2020–2024 [28], This map reflects the spatial distribution of land value zones determined by the type of adjacent road and the distance to the road. While this approach ensures a high level of stability, its ability to capture actual market-driven land price fluctuations remains limited.

(vii) Assessing degree of overlap between land value regions

The market-based land value zoning map and the state-regulated land value zoning map were overlaid to determine the degree of spatial consistency between corresponding value zones, as well as to analyze and evaluate their differences. The results provide a scientific basis for proposing adjustments and improvements to the official land price framework and land management policies.

3. Results and Discussion

3.1 Land Prices Influencing Factors

Based on the and use status quo map, several thematic layers were extracted, including the land use layer, the transportation network layer, and socio-economic factor layers represented by point features of social infrastructure facilities such as the People's Committee, schools, healthcare facilities, and landfill. The Buffer tool was applied to generate buffer zones corresponding to the classification levels of each factor, as defined in Tables 1 and 2. Using ArcGIS, seven thematic maps of factors influencing land prices were edited, compiled, and finalized. To perform weighted overlay analysis, vector data layers were converted into raster format. In raster datasets, smaller cell sizes provide higher spatial resolution and greater analytical accuracy. Because land value zoning requires high positional precision to accurately represent spatial patterns, a cell size of 2 m was selected to ensure the reliability and accuracy of the analytical results. The road density layer was generated using the Line Density tool with a search radius of 1 km. Four ordinal values (1, 2, 3, and 4) were assigned to represent the corresponding land value zones, classified as low, medium, high, and very high, respectively (Figure 3).

3.2. Infuencing Factor Weights Determination

The study applies the Analytic Hierarchy Process (AHP) to determine the weights of factors influencing land values based on expert judgment. Accordingly, a pairwise comparison matrix was constructed for the seven influencing factors (Table 3), enabling the relative importance of each criterion to be quantified through the corresponding weights.

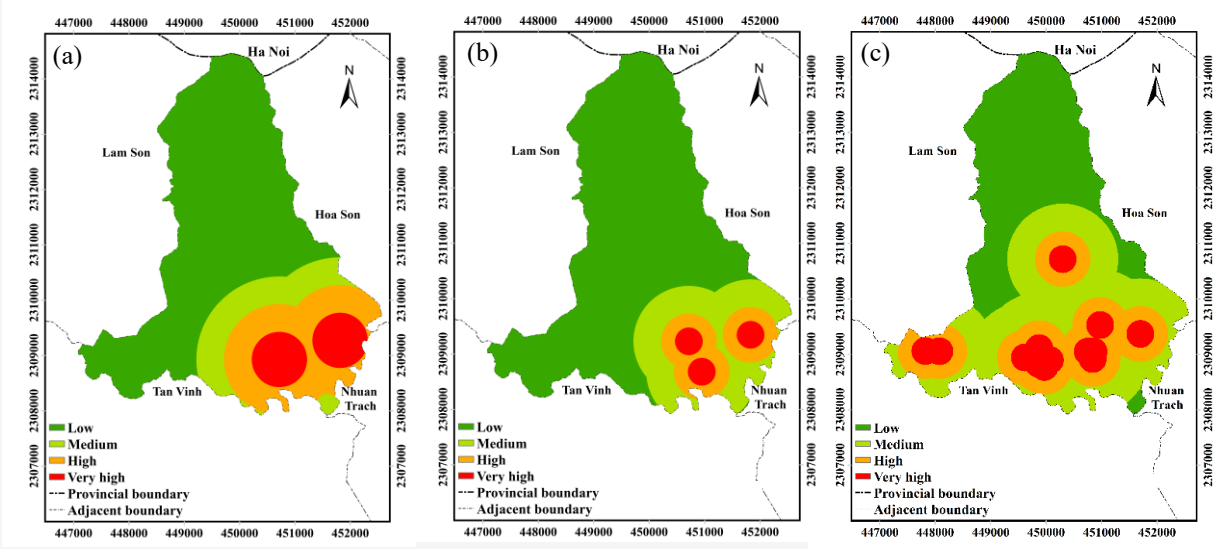
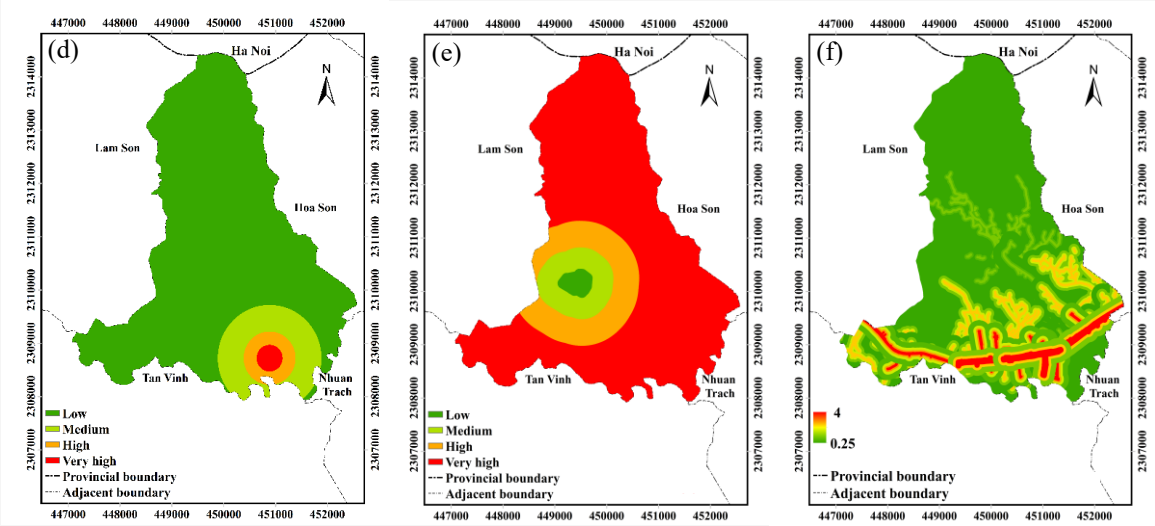


Figure 3: Land price influencing factors: (a) Distance to the Town People's Committee, (b) Distance to healthcare facilities, (c) Distance to the school (Continue next page)



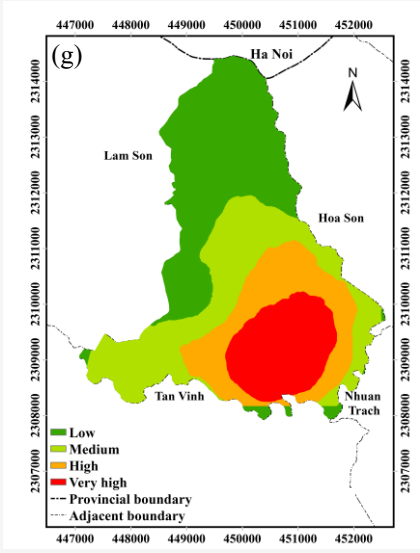


Figure 3: Results of mapping factors influencing land prices: (d) Distance to the market, (e) Distance to the landfill, (f) Distance to street, (f) Road density (Continue from previous page)

Table 3: Pairwise comparison matrix

Criteria	PC	DS	DH	DM	DL	DST	RD	Weights
PC	1.000	0.333	0.333	0.200	3.000	0.200	0.333	0.050
DS	3.000	1.000	1.000	0.333	5.000	0.333	0.333	0.098
DH	3.000	1.000	1.000	0.333	5.000	0.333	0.333	0.098
DM	5.000	3.000	3.000	1.000	7.000	1.000	0.333	0.215
DL	0.333	0.200	0.200	0.143	1.000	0.143	0.200	0.026
DST	5.000	3.000	3.000	1.000	7.000	1.000	3.000	0.284
RD	3.000	3.000	3.000	3.000	5.000	0.333	1.000	0.228
Sum	20.333	11.533	11.533	6.010	33.000	3.343	5.533	1.000

Consistency testing results indicate that all matrices satisfy the consistency ratio criterion (CR < 0.1), demonstrating a high level of internal consistency in expert evaluations and confirming that the derived weights are reliable and acceptable for further analysis (Table 4). The AHP results reveal clear differences in the degree to which various factors influence land prices in Luong Son Town, reflecting the area's socio-economic development characteristics and spatial structure. Among these, factors related to transport accessibility play a dominant role, as indicated by the highest weights

assigned to distance to the street (28.4%) and road density (22.8%). This finding suggests that land prices in Luong Son are strongly shaped by the level of spatial connectivity, which is consistent with the town's function as a gateway area with close economic linkages to Hanoi and surrounding regions. Distance to markets also exhibits a relatively high weight (21.5%), highlighting the central role of markets and commercial facilities. Areas with better accessibility to markets tend to have advantages in commercial activities and income-generating opportunities, thereby increasing land values. The findings of this study are consistent with previous research, which has consistently identified transport infrastructure as the most influential factor affecting land prices [15] and [16].

3.3. Land Value Zoning

Based on the raster layers representing the factors influencing land values in the study area, and in combination with the corresponding weights derived from the AHP method, spatial analysis was conducted in ArcGIS using the Raster Calculator tool. A weighted overlay of all factors was performed, resulting in an integrated raster layer that represents the land value zoning outcome for Luong Son Town (Figure 4(a)). As this study focuses on the evaluation and analysis of urban residential land, the raster layer of land value zoning for the entire town was clipped according to the boundary of urban residential land. This process resulted in the development of an urban residential land value zoning map for Luong Son Town (Figure 4(b)). The map clearly delineates land value zones and provides an essential basis for subsequent analysis and evaluation. The spatial distribution of urban residential land values in Luong Son Town exhibits a clear and systematic pattern. High-value zones, covering an area of 126.48 ha, account for 34.6% of the total urban land area, while very high-value zones occupy 22.84 ha, representing 6.25%. These zones are predominantly concentrated along major transportation corridors, which represent the most advantageous locations in terms of accessibility. This spatial pattern is closely consistent with the criterion weights derived from the AHP analysis, thereby confirming the reliability and robustness of the integrated AHP- GIS analytical framework applied in this study. Transportation infrastructure was identified as the most influential factor in the AHP results, and its critical role is clearly reflected in the land value zoning map. Areas with direct access to major roads or located within highly connected transportation networks are predominantly classified into high and very high value zones.

Table 4: Consistency assessment outcomes

Lamda	n	CI	RI	CR	Consistency
7.56	7	0.09	1.32	0.07	**Satisfactory**

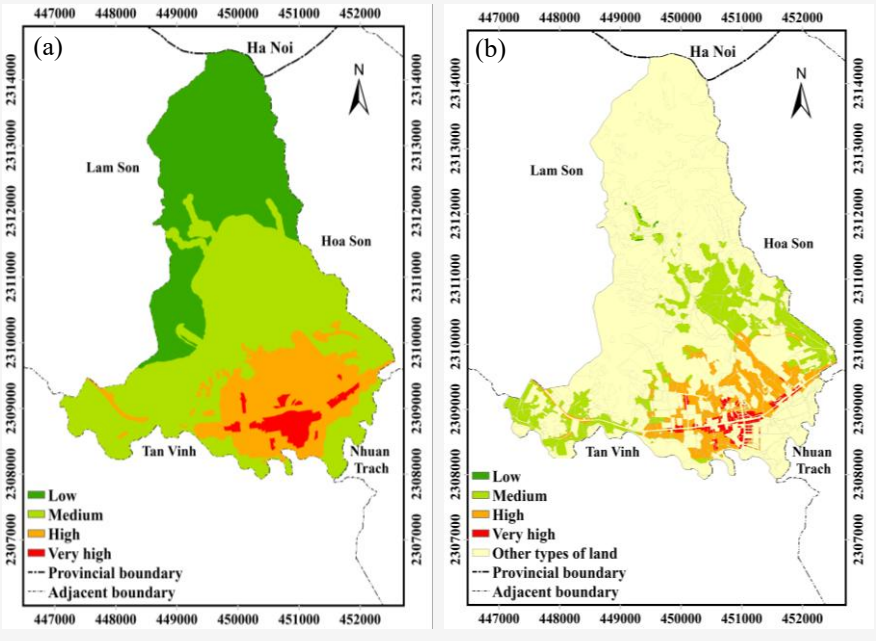


Figure 4: Land value zoning map: (a) AHP-based (b) urban residential-based

Table 5: Area of land value zones based on influencing factors

Value	Land Value Zone	Area (ha)	Area (%)	Market Surveyed Land Price (USD/m²)
0 - 1	Low	1.42	0.39	< 571
1 - 2	Medium	214.86	58.76	571 – 1,142
2 - 3	High	126.48	34.60	1,180 – 1,903
3 - 4	Very high	22.84	6.25	1,941 – 2,854

This finding is consistent with the mechanisms shaping residential land values in small but rapidly urbanizing towns such as Luong Son. Medium-value zones cover an area of 214.86 ha, accounting for the largest proportion at 58.76%, and are mainly distributed in transitional areas surrounding the town center. Although these areas maintain relatively good access to administrative institutions, commercial services, and social infrastructure, such accessibility is more indirect and dispersed, and remains considerably lower than that of the high- and very high - value zones, which are concentrated along major transportation corridors and frontage locations. Low - value zones occupy a relatively small area (1.42 ha) and are primarily located in peripheral areas where accessibility is limited. Overall, the high level of consistency between the factor weights derived from the AHP analysis and the resulting land value zoning further reinforces the reliability of the study's findings (Table 5).

3.4 Verification of Land Value Zoning Results Based on Influencing Factors

To verify the reliability of the land value zoning results, this study surveyed 100 urban residential land parcels with actual market transactions in Luong Son Town. The survey locations were georeferenced using handheld GPS devices to determine the coordinates of the sampled parcels and were subsequently overlaid onto the land value zoning map using ArcGIS software (Figure 5). This approach enabled a direct comparison between the zoning results and observed market land prices. The results indicate a strong correspondence between the identified land value zones and observed market transaction prices. Very high land value zones, with prices ranging from 1,941 - 2,854 USD/m² (51 - 75 million VND/m²), are mainly concentrated in the town center and along major transportation corridors, where administrative, commercial - service activities and well-developed infrastructure are clustered. High-value zones 1,180 - 1,903 USD/m² (31 - 50 million VND/m²) are distributed in areas adjacent to the town center, which benefit from good accessibility but exhibit a lower intensity of economic utilization. In contrast, medium - value zones 571 - 1,142 USD/m² (15 - 30 million VND/m²) and low-value zones < 571 USD/m² (< 15 million VND/m²) are predominantly located in peri-urban areas, where the level of urbanization, infrastructure quality, and connectivity remain limited (Table 5).

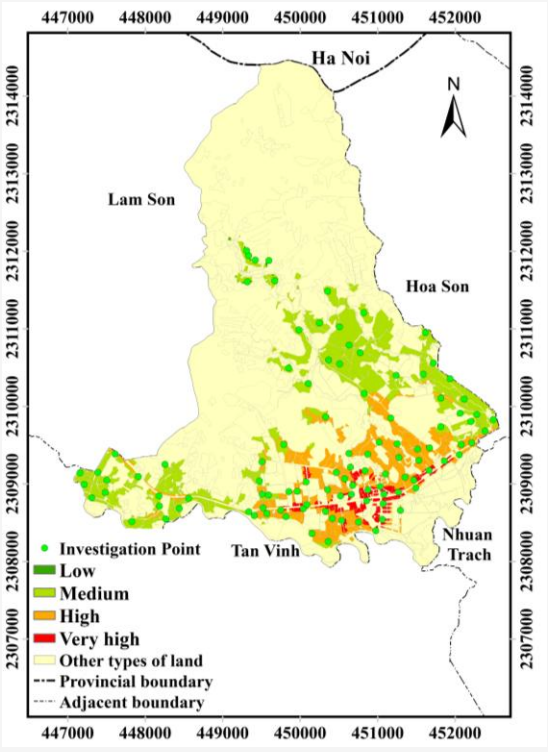


Figure 5: Land value zoning validation

3.5. Urban Residential Land Value Zoning based on the Decision of the Hoa Binh Provincial People's Committee

Based on Decision No. 57/2019/QĐ-UBND dated 30 December 2019 by the Hoa Binh Provincial People's Committee, urban residential land prices in Luong Son Town are determined according to the type of adjacent street and the frontage position of land parcels along each street. The transportation layer was extracted from the 1/5,000 land use status quo map provided by the Luong Son Town People's Committee. Buffer zones of 20 m, 50 m, 100 m, and greater than 100 m were generated to delineate frontage positions along each road, and land prices were assigned to each position in accordance with the official land price table. Combined with expert consultations, the study classified urban residential land into four land value zones (Figure 6). The land

value zoning map based on the land price table issued by the Hoa Binh Provincial People's Committee is primarily constructed using two factors: the type of adjacent road and the distance to the adjacent road.

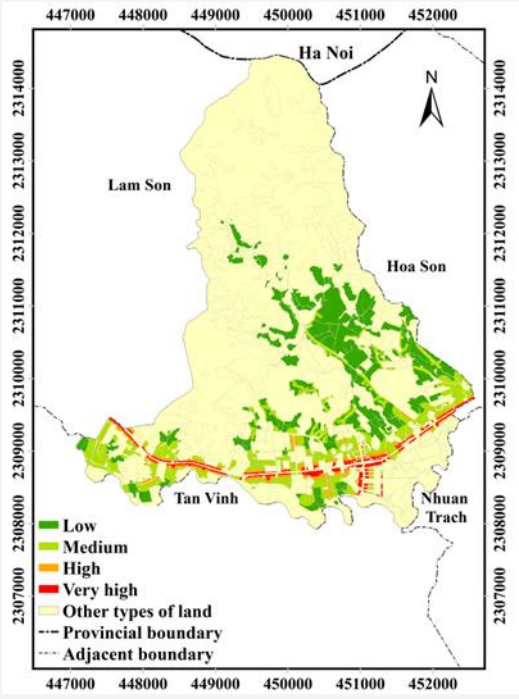


Figure 6: Zoning state land value

This approach results in a distinctly linear and relatively homogeneous spatial distribution of value zones, in which medium- and high-value zones are mainly distributed along major transportation corridors, covering areas of 130 ha and 25.4 ha, respectively. In contrast, the majority of urban residential land is classified as low-value zones, accounting for 188.8 ha (51.62%). Although transportation infrastructure is an important determinant of land value, relying solely on two transportation-related criteria is insufficient to fully capture the heterogeneity of urban land values in Luong Son Town, where land prices are influenced by the combined effects of multiple spatial, economic, and social factors (Table 6). A comparison of the differences in the area structure of land value zones is presented in detail in Table 7.

Table 6: Area of land value zones based on the official land price table of Hoa Binh Provincial People's Committee

Land Value Zone	Area (ha)	Area (%)	Official Land Price (USD/m^2)
Low	188.8	51.62	< 57
Medium	130.0	35.53	57 - 190
High	25.4	6.94	191 - 304
Very high	21.6	5.91	305 - 419

The comparison of area structures between land value zoning based on the provincial official land price table and the AHP - based approach reveals substantial differences in the spatial distribution of value zones. Under the AHP method, the proportions of medium- and high-value land are higher than those derived from the official land price table by 23.23% to 27.66%. Notably, the proportion of low - value land identified by the AHP approach is markedly lower - by as much as 51.23% - compared to the zoning based on the state-regulated price framework. This discrepancy indicates that land value zoning relying solely on the official land price table may lead to tax revenue losses in land - use right transfers and in the calculation of land - use fees collected by the State. The study assessed the degree of spatial overlap between the urban land value zoning map based on the state-issued official land price table and the land value zoning map derived from market-influencing factors (Figure 7). The results indicate a relatively low level of spatial agreement, with the overlapping area accounting for only 82.05 ha, equivalent to 22.8% of the study area, while the non-overlapping area reaches 278.3 ha (77.2%). This finding clearly reflects differences in the approaches used to construct the land price framework, as the current official land price table is primarily based on a limited set of traffic - related criteria and does not fully capture other influential factors such as location characteristics, infrastructure quality, and environmental conditions. These results highlight the necessity of revising land price determination methods toward a multi-factor integrated approach in order to improve their consistency with actual market land values.

Table 7: Comparison of the area structure of land value zones

Zone	Land value zoning based on the official land price table of Hoa Binh Provincial People's Committee		Land value zoning based on AHP (influencing factors)		Difference (%)
	Area (ha)	Area (%)	Area (ha)	Area (%)	
Low	188.8	51.62	1.42	0.39	-51.23
Medium	130.0	35.53	214.86	58.76	23.23
High	25.4	6.94	126.48	34.60	27.66
Very high	21.6	5.91	22.84	6.25	0.34

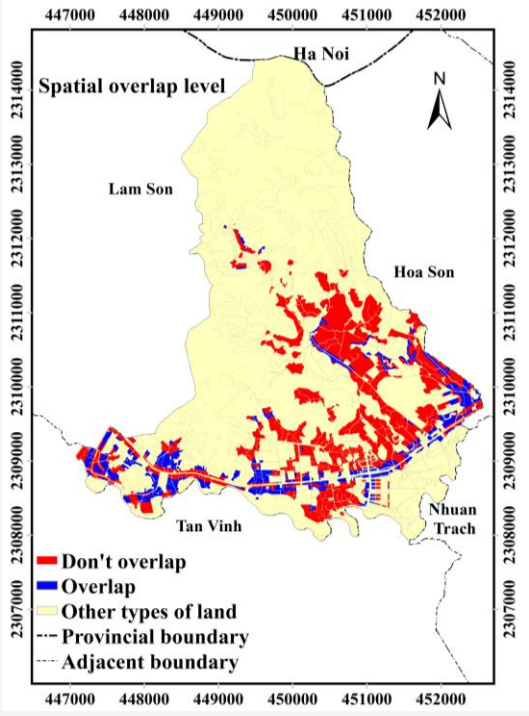


Figure 7: Degree of overlap between land value zones

4. Conclusion

This study was conducted to develop a land value zoning map for Luong Son Town by integrating market-influencing factors with the Analytic Hierarchy Process (AHP) and Geographic Information Systems (GIS), and to evaluate the consistency of the resulting zoning with the land value zoning derived from the state-regulated land price table currently applied in Vietnam. The findings provide not only methodological contributions but also policy-relevant evidence to support improvements in land valuation practices in the context of the 2024 Land Law. The results indicate that urban residential land values in Luong Son Town are influenced by a combination of factors, including distance to the town center, distance to schools, distance to medical facilities, distance to markets, distance to landfills, distance to adjacent roads, and road density, rather than relying solely on transportation-related criteria. Based on expert consultation, among the seven identified factors, distance to streets and road density exert the strongest influence on land values, highlighting the critical role of transport accessibility in a rapidly urbanizing gateway town adjacent to Hanoi. Proximity to markets also plays an important role, whereas distance to landfills has a relatively minor impact.

These findings confirm that land value formation is inherently multidimensional and cannot be adequately explained by a single factor or a narrowly defined set of indicators. By integrating AHP - derived weights with GIS-based spatial analysis, the study developed a land value zoning map consisting of four value categories: very high, high, medium, and low. This approach provides a more detailed and spatially explicit representation of land values compared to traditional methods. High and very high value zones are primarily concentrated in the town center and along major transportation corridors, where accessibility, infrastructure, and economic activities are most favorable. This spatial pattern closely corresponds to observed market transaction prices, indicating that the proposed AHP - GIS model is capable of capturing market dynamics with a relatively high degree of accuracy.

A key contribution of this study is the systematic comparison between the market-based land value zoning map and the zoning derived from the official land price table issued by the Hoa Binh Provincial People's Committee. The results reveal substantial discrepancies between the two approaches in terms of both area structure and spatial consistency. Specifically, high- and medium-value zones identified by the market-based model exceed those defined by the official framework by approximately 23.23–27.66%, while low-value land is underestimated by more than 50% under the state-regulated pricing system. Moreover, the spatial non-overlap between the two zoning maps accounts for up to 77.2% of the urban residential land area. These findings highlight methodological limitations in the current land price determination approach used in Hoa Binh Province, which relies primarily on road classification and distance to roads and does not sufficiently account for broader locational, infrastructural, and environmental factors.

From a policy perspective, the results underscore the necessity of reforming land price determination methods in Vietnam toward a land value zoning approach that integrates multiple influencing factors and more closely reflects market prices, in line with the objectives of the 2024 Land Law. Such an approach not only enhances transparency and equity in land administration but also helps reduce potential losses in state budget revenue related to land-use fees, taxes, and land-use right transfers. Despite these important findings, the study has several limitations. Given that land values are affected by a wide range of economic, legal, social, and parcel-specific factors - many of which are difficult to quantify spatially - the analysis was limited to seven factors that could be quantified using available data. The exclusion of variables such as detailed legal status, neighborhood socio - economic characteristics, and temporal land price fluctuations may affect the completeness of the

zoning results. Future studies could address these limitations by incorporating additional data sources to further refine and improve land value zoning methodologies.

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