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Land-Use and Land-Cover Changes and Urban Expansion in Central Vietnam: A Case Study in Hue City

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Abstract: During the past two decades, Hue city has undergone significant changes in its economic development, leading to a rapid transformation of its land-use and land-cover (LULC) patterns. This study used remote sensing data and Geographic Information Systems (GIS) to analyze changes in the land-use and land-cover in Hue city, providing essential insights for the city's future development. This research examines indicators such as area and land-cover changes, urban development trends, and the morphology of urban areas during the period from 2000 to 2020, with assessments conducted at ten-year intervals. The results showed that built-up and forest land have increased, while agricultural and unused land have decreased over time. By 2020, the urban area had expanded by more than 60% in the north and northeast directions. Hue city developed through infilling and edge expansion of existing urban areas, while some regions primarily expanded into outlying sections in the east and south by constructing high-end residential areas on former paddy rice fields. These findings yield valuable policy implications that extend beyond the case study of Hue city, offering insights for other cities to pursue inclusive and prosperous futures.

Keywords: Hue city; land-use land-cover changes; urban expansion; urban form; Vietnam

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1. Introduction

Over 60% of the increase in the world's urban population by 2030 is expected to occur in Asia, particularly in countries such as China, India, Pakistan, Bangladesh, the Philippines, and Vietnam [1]. Changes in land use and land cover (LULC) significantly impact urbanization driven by human activities [2,3]. Numerous recent studies indicate that grasslands and agricultural land are rapidly disappearing, while the amount of built-up space is increasing gradually [2,4,5]. Nowadays, changes in urban LULC should be evaluated not only as shifts in land-use purposes but also within the spatial context of the growth direction and urban area forms, serving as a foundation for spatial development plans. The directions of urban expansion are linked with the demands of increased quality of life among migrated populations [6], or due to the availability of production materials that create conditions for agricultural and vegetative land development within their settled areas [7]. Small-city urban form transformation is frequently disregarded, particularly in developing nations, and so needs to be explored more thoroughly in contemporary urban planning initiatives [8]. Many economic activities, such as foreign investment and the construction of free-trade or export-processing zones, benefit from urban development planning. These economic activities, on the other hand, will help shape urban growth [9]. The three primary types of urban growth in the world are grouped into three groups based on the locational interaction between newly created regions, infilling in existing urban

districts, and both edge expansion and outlying expansion [10–12]. The changes in urban form expansion can impact the density of the population [13]. In conclusion, urbanization and urban expansion can be a motivation for economic development as well as improving infrastructure; however, it also poses significant challenges relevant to environmental degradation and social inequality.

As of 2023, Vietnam had 883 urban areas, representing an urbanization rate of 41%. This is a consequence of the industrialized and urbanized transition process in recent years. Cities are home to nearly 40% of Vietnam's population, with many non-agricultural livelihood activities. Urbanization in Vietnam has made positive contributions to economic development; however, it still has many shortcomings when this development is not considered in terms of spatial planning and expansion direction. Particularly in the current context, the selection of areas for urban development is crucial as it not only ensures economic growth but also enhances resilience against natural disasters, especially flooding in urban areas. One of the prominent issues in the urbanization process in Vietnam is the conversion of agricultural land and land designated for public purposes into areas for housing and commercial developments. This trend poses significant challenges to food security, as the reduction in agricultural land limits the country's capacity to produce essential crops and undermines the healthy environment necessary for local residents. Therefore, changes in land cover, especially agricultural cover, occurred so rapidly that the Vietnamese government has recently enacted many laws and regulations to restrict the conversion of agricultural land use to non-agricultural land use. The study on LULC in urban areas is more meaningful in the context of Vietnam, which is moving toward the goal of sustainable urban development for medium-sized cities [14].

Particularly for heritage cities like Vietnam's Hue city, the direction and form of urban expansion will give city planners an overview to create more efficient city expansion alternatives. The effects of urbanization have caused this city to undergo substantial changes, although many of these developments have not received enough attention [15]. Many studies have researched urbanization in Hue city; however, they mainly focused on changes in land-cover area while neglecting other critical factors such as the direction and form of urban space [16–18]. Consequently, urban land-use planning concentrates solely on area allocation without considering the relevance of different regions within the city. This approach can lead to increased pressure on land prices in rapidly urbanizing areas, as well as inequitable access for residents to social services and facilities. Thus, research on urban space must ensure comprehensiveness in both the spatial and temporal dimensions. Therefore, the aims of this study were (1) to map the LULC change in Hue city during the last two decades; and (2) to determine and analyze the spatial directions and the forms of urban expansion during the period 2000 to 2020.

2. Materials and Methods

2.1. Research Area

Hue is located in Central Vietnam at 107°30′ to 107°38′ E and 16°30′ to 16°24′ N, where it is about 700 km south of Hanoi capital and about 1000 km north of Ho Chi Minh City (Figure 1). This historic city was the administrative center of Vietnam from 1802 until 1945, when the Nguyen dynasty, the nation's final feudal monarchy, ruled [19]. Hue city's imperial monument complex was designated as a World Cultural Heritage Site by UNESCO in 1993. According to the Hue Committee of People, the population of this city in 2020 was 362,000 people. Most residents lived in the inner city with their main livelihoods being from non-agricultural activities such as tourism and related services. The research site exhibits a low land topography, with an average elevation of about 5 m above sea level, decreasing from the southwest to the north and northeast [20]. In 2020, Hue had a total area of 7135 hectares, including 32.52% of agricultural land (including forest land); 64.78% of non-agricultural land (including residential land, built-up land, roads, and water bodies), and 2.70% of unused land [21]. The urbanization rate in Hue city reached 54% in 2020 [22].

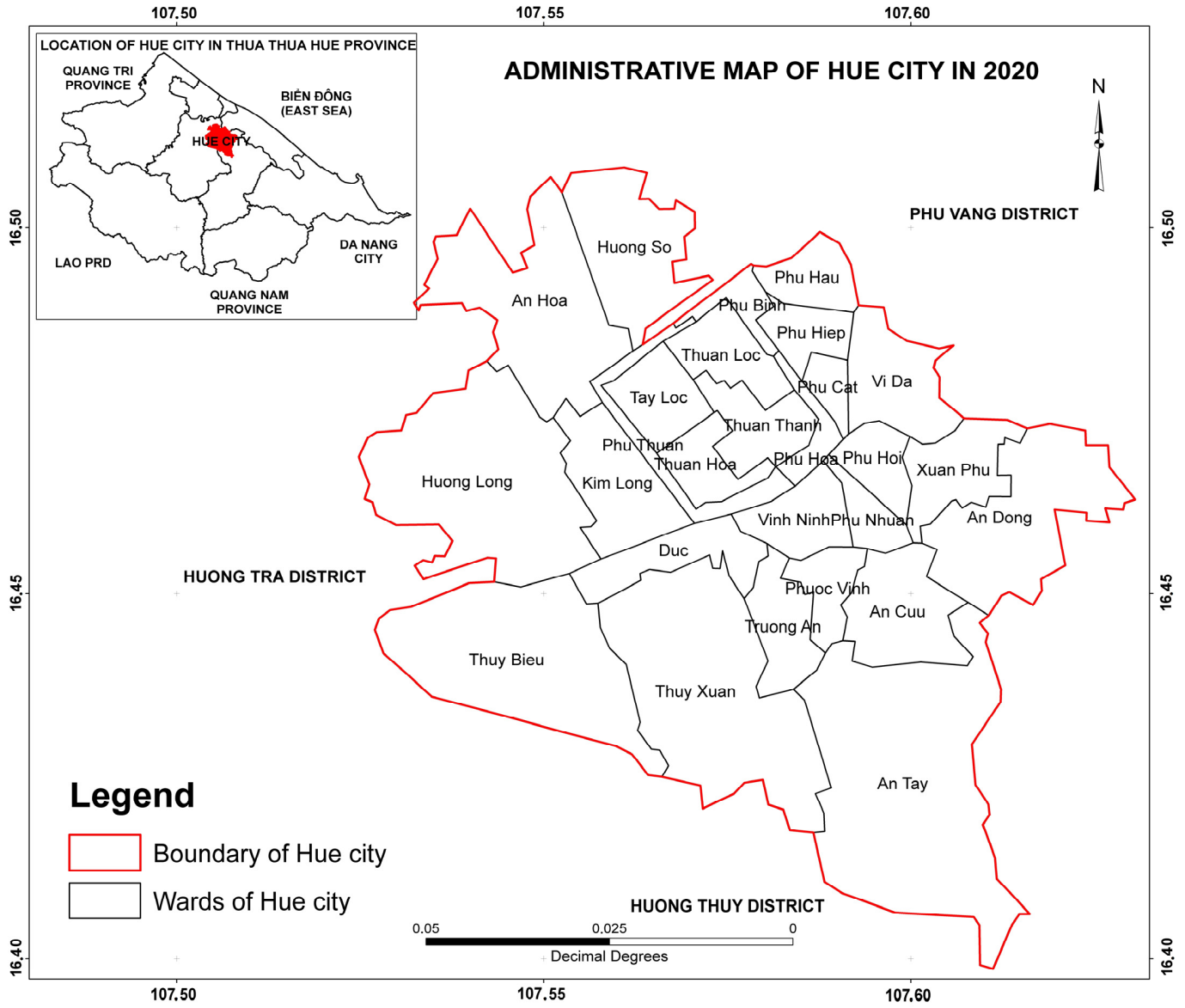

Figure 1. The location of Hue city (red color) in Thua Thien Hue province and administrative map of Hue in 2020.

2.2. Data

The information of Landsat 5 and Landsat 8 image data is described in Table 1. Due to the characteristics of a city where agricultural land area occupied large areas during the study period, remote sensing data will be collected simultaneously in selected years to limit the difference in the images due to the seasonality of crops. The interval time of images in this research is ten years, which is also consistent with some recent studies worldwide, as well as in the rest of Vietnam [23].

Table 1. Information on remote sensing data.

Satellite	Sensor ID	Path/Row	Date of Acquisition	Grid Cell Size (m)
Landsat 5TM	LT51250492000223BKT00	125/49	10 August 2000	30
	LT51250492010186BKT01	125/49	5 July 2010	30
Landsat 8 OLI	LC81250492020198LGN00	125/49	16 July 2020	30

For further processes, the images need to be atmospherically correct. Atmospheric correction requires editing satellite images from raw data right down to the bottom of the atmospheric reflections. This reflectivity must be the same as the reflectance measured at the ground level. In this study, Fast Line-of-sight Atmospheric Analysis of Hypercubus (FLAASH) of ENVI software (version 5.3) was applied for atmospheric correction [24].

2.3. Image Classification

The Landsat 5 images were used for the years 2000 and 2010, while Landsat 8 image was used for 2020. For the years 2000 and 2010, the selected points used for classification were based on the combination of the Google Earth platform and land-use maps for those years, while in the year 2020 we used selected points from fieldwork-based GPS (Ground Positioning System) data. The selected points were 280, 350, and 379 for 2000, 2010, and 2020, respectively. This selection sample method was applied in the recent research on LULC mapping [25,26]. The samples were center points of clear land-use type areas. The total area of sample areas we used was smallest in 2000, with 25.2 hectares, and reached the largest, at 34.11 hectares of the image, in 2020. The sample size was recommended by a previous researcher [27], who found that when performing land-cover classification using remote sensing images and machine learning algorithms, the training sample size should represent approximately 0.25% of the total study area. Six dominant LULC types in the research site were delimitated and they are shown in Table 2. For the classification algorithm, 70% of the sample points were used for training, and 30% were used for accuracy assessment, as recommended by many researchers in recent years who have applied Random Forest classifier for LULC mapping [27,28].

Table 2. LULC classification scheme.

LULC Types	Acronym	Description
Agricultural Land	AL	Paddy rice, vegetables
Built-up Land	BL	Houses, roads... areas where there is a high density of construction
Cemetery Land	CL	Cemetery
Forest Land	FL	Plantation forests; natural forests; perennials; and green streets trees
Unused land	UL	Bare land without cover, grass land
Water	WB	Rivers, lakes

2.4. LULC Change Detection

Change detection analyses show the differences between the maps/images of the same location/scene at the given times [29]. Recently, the detection changing method by intersect tool in ArcGIS software (version 10.2) has been used commonly [30,31]. The change in LULC is shown as a matrix in which the horizontal row represents the area of the LULC classes in the later period. In contrast, the vertical column represents the area of the LULC classes in the previous period. The diagonal elements of the matrix represent the constant area of the LULC classes. In this study, we identified the changes in each period from 2000 to 2010 and 2010–2020 to assess the rate of LULC changes between each duration.

Research on the directions of urban expansion often use the center of the study area in a geographical aspect [4,32]. Even so, Hue is the heritage site of the ancient capital with the highlight being the imperial citadel itself. The formation of Hue city originated from the early years of the 18th century with a focus on the imperial citadel. Therefore, in this study, we chose the point to determine the direction of urban development as the place of the imperial citadel with coordinates of 107°34′38.8″ E, and 16°28′11.5″ N. From this point, we studied the change of LULC in eight directions: north (N), northeast (NE), east (E),

southeast (SE), south (S), southwest (SW), west (W), and northwest (NW). The growth of BL cover was calculated as a percentage using the following formula:

$$\%\text{Increase} = \frac{(\text{Area of BL in later year} - \text{Area of BL in the past year})}{\text{Area of BL in the past year}} \times 100 \quad (1)$$

2.5. Urban Expansion Form Analysis

The urban expansion form was analyzed based on the Land Expansion Index (LEI), which was proposed by Liu et al. in 2010 [12]. This index has been used in many previous studies, and it has proven to be one of the most reliable indicators by which to analyze urban expansion in cities, especially in Asia [33,34]. The LEI can quantify the spatial patterns of landscape expansion within a series of time frames and can also capture information on the formation of landscape patterns [35]. The basic principle of this index is based on the spatial relationship between existing urban areas and newly developed areas, to classify urban expansion into three categories, which are as follows: infilling, edge expansion, and outlying expansion (Figure 2).

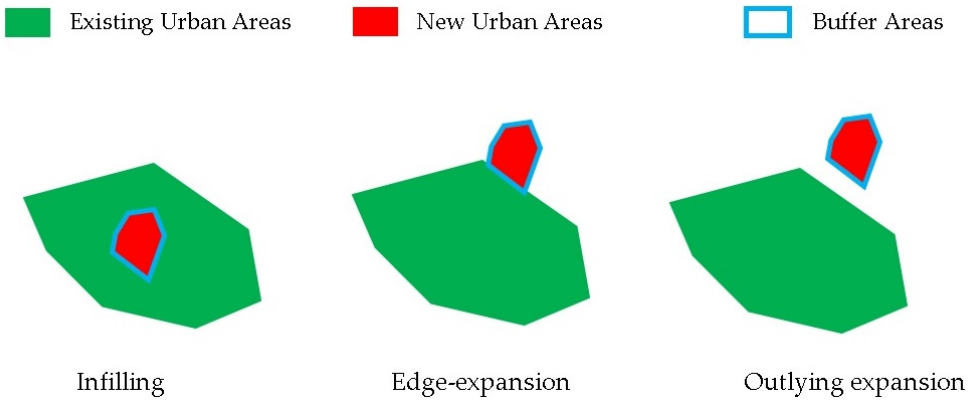

Figure 2. The classification of urban form expansions.

The LEI was calculated based on the overlapped areas between the existing urban areas and new urban areas via buffer zone distances using the following equation:

$$\text{LEI} = 100 * \frac{\text{A}_0}{\text{A}_0 - \text{A}_\text{v}} \quad (2)$$

The buffer zone is defined as a designed area surrounding new urban areas or as the perimeter line of new urban area. The LEI represents the value of the land expansion index for a newly expanded urban patch, where A_0 represents the intersection between the buffer zone with a specified distance around newly expanded areas and existing urban areas, and A_v represents the intersection between the buffer zone and vacant land. Urban expansion type is defined as infilling for LEI > 50, edge expansion for 0 < LEI $\leq$ 50, and outlying expansion for LEI = 0 [33,34]. In this research, we used the LEI calculation tool for ArcGIS 10.2 which was developed and introduced by Liu et al. [12].

2.6. Statistical Analysis

To gain a deeper understanding of urban morphological expansion, this study used independent-samples *T*-test statistical analysis techniques to compare the area between different types of urban expansion at the same time. Concurrent with this, we used one-way analysis of variance (ANOVA) to determine the difference in area of each type of urban expansion between the two study periods. All statistical analyses were performed using the SPSS tool with a confidence of 95%.

3. Results

3.1. LULC and Its Changes in the Period 2000 to 2020

The classified results indicate that 2020 achieved the highest overall accuracy, with an accuracy rate of 82% and a Kappa coefficient of 0.77. This was followed by 2010, which exhibited slightly lower precision. In contrast, the year 2000 recorded the lowest accuracy, with an overall rate of only 71% and a Kappa coefficient of 0.64. The User's Accuracy and Producer's Accuracy values reveal that the classification of the UL class had the lowest accuracy in 2000, at 41.67% and 45.45%, respectively. Conversely, the classification of clear types, such as WB, consistently yielded the most accurate results. For the BL class, the accuracy exceeded 80% in both 2010 and 2020, while in 2000 it was just above 73%. The classified maps of 2000, 2010, and 2020 and the percentage and change rates of the six main LULC types in Hue city from 2000 to 2020 are shown in Figure 3. In 2000, agricultural land (AL) accounted for the most significant proportion (36.93%), followed by BL (20.03%). Ten years later, BL accounted for the highest proportion (39.50%), followed by AL (23.35%) and forest land (FL) (15.73%). In 2020, AL continuously reduced and occupied 14.79% of the total area of Hue city, while the area of BL increased by 665 hectares. Between 2000 and 2020, most AL was converted to BL (39.09%) and FL (19.43%).

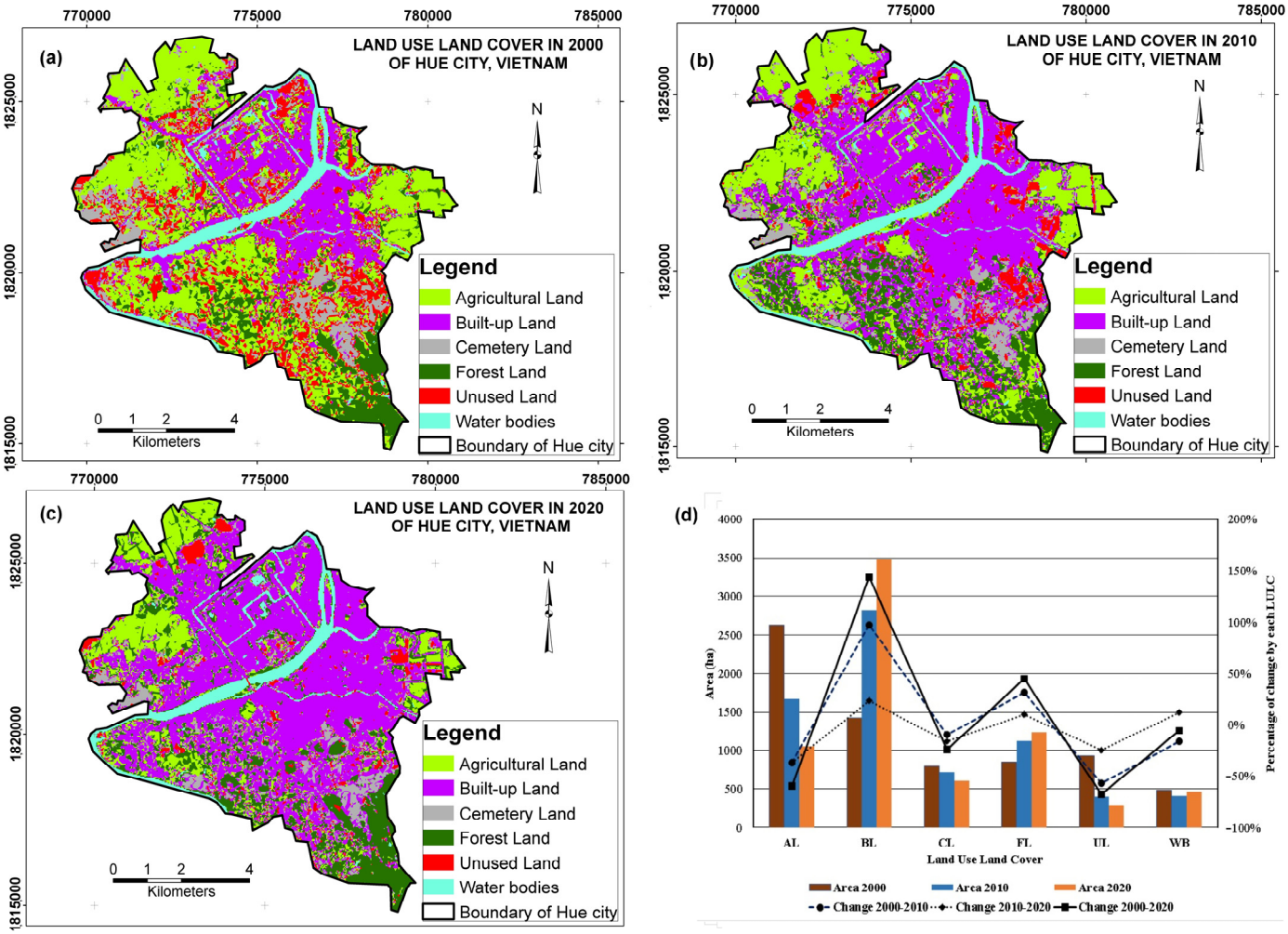

Figure 3. The LULC in 2000 (**a**), 2010 (**b**), and 2020 (**c**), and LULC change (**d**) of Hue city.

3.2. Direction of Urban Expansion

The urban expansion of Hue city by directions is shown in Table 3 and Figure 4. In 2000, the ratio of BL in the north, northeast, and east accounted for the highest proportion of 48.65%, 32.68%, and 25.18%, respectively. These urban areas mainly possessed residential

areas formed over long periods in and around the imperial citadel. In 2010–2020, the area of BL in these directions continued to increase, reaching 67.27%, 55.31%, and 44.06%, and 72.16%, 60.06%, and 57.84%, respectively. Particularly for the southern and western areas, in 2000, the BL accounted for only a modest proportion; however, by 2010, it increased significantly as in the south it increased by four times (158 hectares to 538 hectares); in the west it increased by nearly three times (126 hectares compared to 324 hectares); and in the southeast and southwest it increased by nearly two times (by 240 hectares and 158 hectares, respectively). Ten years later, the area of BL in these directions also increased and accounted for nearly 50% of the total area.

Table 3. The area of LULC by directions in 2000, 2010, and 2020.

Year	LULC (ha)	N	NE	E	SE	S	SW	W	NW
2000	AL	88	54	365	227	511	450	449	491
	BL	117	162	174	320	158	178	126	194
	CL	35	14	30	224	109	105	183	97
	FL	17	16	62	268	290	94	55	53
	UL	57	26	58	189	231	166	131	74
	WB	44	61	70	43	39	177	25	28
	Total Area (ha)	358	333	759	1271	1338	1170	969	937
	% BL	32.68	48.65	22.92	25.18	11.81	15.21	13.00	20.70
Year	**LULC (ha)**	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**
2010	AL	53	14	230	126	205	249	373	416
	BL	198	224	314	560	538	336	324	324
	CL	29	12	46	190	123	109	134	78
	FL	23	14	36	254	376	279	96	44
	UL	17	18	70	108	60	29	33	63
	WB	38	51	63	33	36	168	9	12
	Total Area	358	333	759	1271	1338	1170	969	937
	% BL	55.31	67.27	41.37	44.06	40.21	28.72	33.44	34.58
Year	**LULC (ha)**	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**
2020	AL	24	12	108	46	121	169	320	255
	BL	215	241	439	626	641	510	374	437
	CL	20	8	36	164	146	96	95	38
	FL	36	16	65	341	334	191	123	129
	UL	11	5	48	51	62	29	38	55
	WB	52	52	63	42	34	175	19	23
	Total Area (ha)	358	334	759	1270	1338	1170	969	937
	% BL	60.06	72.16	57.84	49.29	47.91	43.59	38.60	46.64

From 2000 to 2010, the urban expansion rate in the south was the fastest, at 28.40%, followed by that in the north, at 22.63%, while in the southwest and northwest the urban expansion rate was only about 13%. The remaining directions show that the urban expansion rate in this period was only about 18%. However, ten years later, Hue city mainly expanded to the east, southwest, and northwest, with expansion rates of 16.47%, 14.87%, and 12.06%, respectively. The urban expansion rate of the remaining directions in 2010–2020 slowed, ranging from 4.75% to 7.70%.

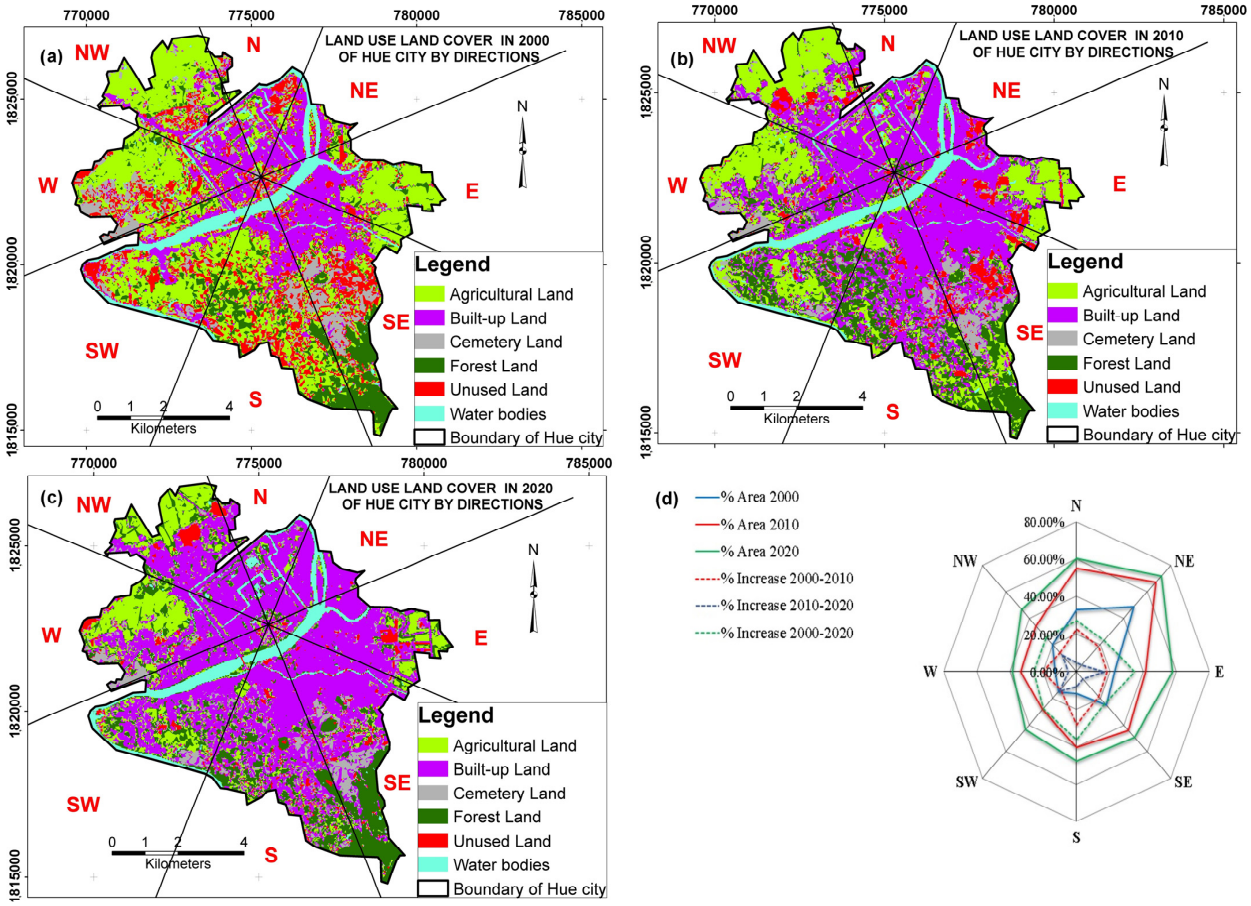

Figure 4. The LULC by direction in 2000 (**a**), 2010 (**b**), and 2020, (**c**) and the percentage of BL class (**d**) of Hue city.

3.3. Urban Form Expansion

The urban expansion forms in Hue city from 2000 to 2010 and from 2010 to 2020 are presented in Figure 5. In the former period, there were 25 areas of infilling expansion, totaling 626.17 ha; 611 areas of edge expansion, accounting for 627.84 ha; and the remaining areas, totaling 323.28 ha, were categorized as outlying expansion across 1302 locations. Ten years later, the infilling expansion type had the smallest number of locations but occupied the largest area, totaling 128 areas with 789.13 ha. In contrast, there were 737 locations of edge expansion covering 286.72 ha, and outlying expansion occupied only 67.76 ha across 434 locations.

There was a significant correlation between the areas of infilling expansion and other forms of urban development in both periods. Conversely, the areas of edge expansion and outlying expansion showed no significant differences at the measurement level of 0.05, even though the average of edge expansion appeared to be higher than outlying expansion areas for both periods. The areas of all urban form expansions in the period 2000–2010 were higher than those in the period of 2010–2020, the difference being at the significance level of 0.05 (Table 4).

Table 4. Comparison of areas of urban form expansions in 2000–2010 and 2010–2020.

Serial Times	Infilling Expansion	Edge Expansion	Outlying Expansion
2000–2010	25.05 ± 77.16aA	1.03 ± 4.34bA	0.25 ± 0.44bA
2010–2020	6.17 ± 33.95aB	0.39 ± 1.34bB	0.16 ± 0.16bB

Within rows, values followed by the same lower letter (a, b) are not significantly different ($p < 0.05$) between urban form expansions, while within columns, values followed by the same upper letters (A, B) are not significantly different ($p < 0.05$) between periods.

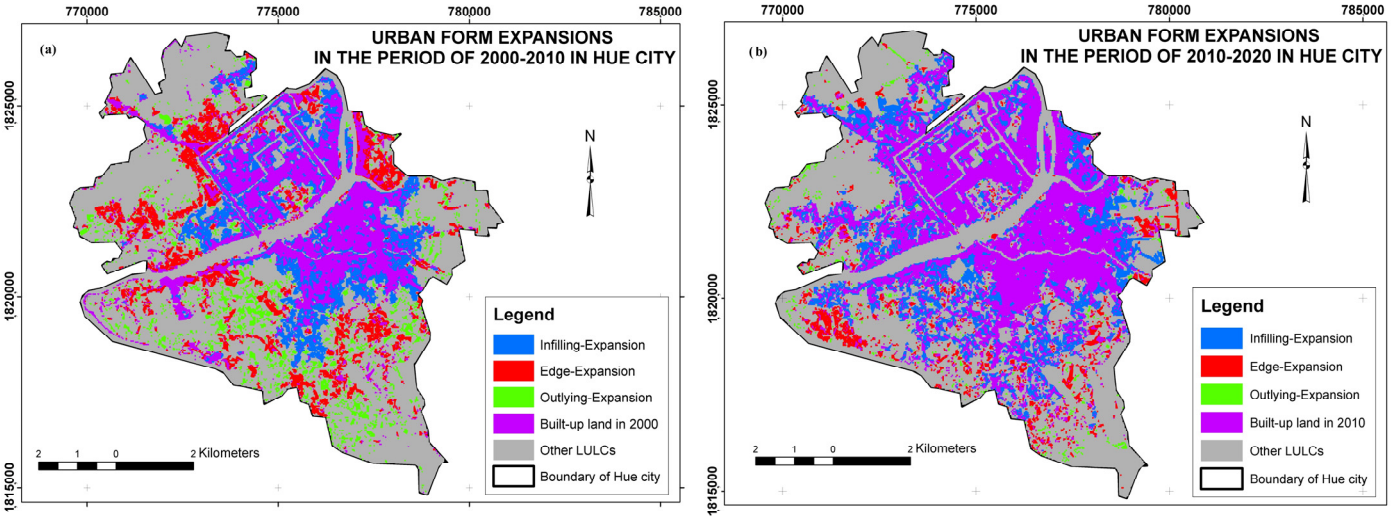

Figure 5. The urban form expansion of Hue city in the period 2000–2010 (**a**) and 2010–2020 (**b**).

4. Discussion

4.1. Urbanization and Land Conversion Challenges in Hue City

Turning agricultural land into commercial and residential space leads to a rising number of issues, which are particularly apparent in developing countries [36]. Our results corroborated other studies conducted in other Vietnamese cities, which found that, under pressure from population growth, flat agricultural land regions were consistently given precedence for conversion to built-up land [37,38]. This is especially true for Hue city, where during the previous 20 years, a sizable portion of the city's rice fields in the east and north have been transformed into residential zones. Converting the paddy rice areas into residential areas is a top priority of investors because the compensation costs for a farmer are based on the government's price, and it is very low in comparison to the land price market, while the prices of housing/land for building products are significantly higher, resulting in substantial profits for investors. It is unfair for farmers and, therefore, there is a need for the modification of the land compensation policies [39]. Cash compensation is not a sustainable approach; thus, we propose a policy to provide compensation through allocated areas or a sale with a prioritized price area within the project for the land being acquisitioned.

The conversion of the land-use purpose in Hue not only provides housing for people but is also a huge source of revenue for the city's budget. However, this is an unsustainable method of mobilizing budget revenue. In addition, along with urbanization, the price of BL has increased rapidly, so many land users have converted vegetable land (usually around the house) to residential land and the construction of buildings. This finding was also found by many previous researchers [40,41]. Over the past 20 years, the total built-up land area in Thua Thien Hue has increased by 150%, compared to 125% in Da Nang and 123% in Tam Ky [42]. This significant urbanization is largely driven by Hue's strategic plan to achieve centrally administered city status by 2025, which serves as a major motivation for various economic developments in the city. The economic factors and profit incentives play an important role in driving urbanization in Hue city.

Despite the vital urbanization process in Hue city, the area of the FL class (including forest land, street trees, and perennials) has increased significantly during the past 20 years by 380 ha. This increase was due to Hue city's attention to developing urban green spaces and street trees [20]. Therefore, Hue is considered one of the greenest cities in Vietnam [42], with a ratio of urban trees per capital of 2.5 m^2.

4.2. Urban Expansion by Directions and Industrial Park Development in Hue City

From 2000 to 2010, urban expansion in Hue city occurred at a relatively uniform rate in all directions, with the south, north, and west experiencing higher growth due to their

flat terrain and proximity to existing residential areas. Following a devastating flood in 1999, residents began seeking homes in higher regions, particularly in the southern part of the city. However, as drainage systems improved, social and economic factors became more influential than geographic considerations in urban development. Previous researchers who examined Beijing's urban growth over a 40-year period found that socioeconomic factors increased in effect, while neighborhood and physical characteristics declined, validating our finding [43]. The south of the city also has many green spaces created from forest land cover, and it was a good choice for residential land development due to the benefit of providing a more environmentally healthy life for urban citizens, as was confirmed by recent research [44].

Ten years later, Hue was still expanding, but the speed was slower compared to that of the 2000–2010 period. This period saw urban expansion to the east, southeast, and northwest. The creation of industrial parks and export processing zones, such as Huong Van Industrial Park in Huong Tra district (northwest of Hue city) and Phu Bai Industrial Park in Huong Thuy district (southeast of Hue), was the primary factor behind this shift. This implies that when planners create industrial zones in the future, they must also consider the requirements for the residences of the workers who will reside there. Our results are in line with other research which examined the favorable influences on urban expansion associated with marketization and expanding industry [45–47]. This leads to the formulation of strategies for developing industrial zones in Hue city in the future. The plan for Thua Thien Hue province until 2030 focuses on establishing three industrial centers in the Huong Thuy, Huong Tra, and Phong Dien districts, which correspond to the western, northwestern, and southeastern areas of Hue city [48]. These regions still have potential for urban development but require enhanced transportation infrastructure, particularly in the higher terrain areas of the southeast. The development of industrial zones in the periphery and outskirts of Hue city is poised to create essential momentum for balanced regional development while maintaining Hue's identity as a tourist city.

Although Hue is a tourist city, the urbanization rate in areas with many tourist attractions is lower than in other regions within city. This contrasts with other cities, such as Da Nang, Hanoi, and Ho Chi Minh City, where tourist attractions often correlate with the highest urbanization rates [49,50]. This situation can be attributed to the fact that Hue's tourist attractions are part of a world heritage cluster, which are strictly protected under regulations set by the Vietnamese government and UNESCO [51].

4.3. Urban Expansion Forms and Challenges on Social and Environment Issuses

Over 20 years in Hue city there were significant new areas of urban expansion made available due to infilling and edge expansion forms. This is the result of taking advantage of existing residential areas and infrastructure to respond to more convenience to access social services such as schools, hospitals, and shopping centers. In addition, the construction of hard infrastructure is a priority index to meet ranking criteria and, consequently, place the given city in a higher urban classification nationally [52]. Therefore, policymakers often prioritize expanding existing areas to create a larger area to meet urban upgrading criteria. However, this leads to potential problems with social infrastructure being unable to meet the needs of residents in newly expanded areas due to overpopulation. Therefore, before choosing to expand urban areas through infilling and edge expansion, a city needs to consider the social criteria indicators for urban residents, such as water supply, air quality, and traffic systems, in order to achieve sustainable development [53].

The number of outlying expansion areas in both time-frames studied was smaller than the other types of urban form expansion. This type of expansion was mainly concentrated in the paddy fields in the south and southeast of Hue city. They are favorable to investors, both domestic and foreign, for the creation of high-end residential units. In the creation of high-end housing facilities, investors are willing to cover the extra cost to build service facilities to meet the needs of potential residents with high incomes. The same thing has appeared in many localities in Vietnam and this has been stated in recent research [54].

This type of expansion can tend to have negative environmental consequences, resulting in landscape fragmentation, losses in biodiversity, and the disruption of ecosystem functions [55]. In Hue city, the urban areas have encroached on peri-urban agricultural in many ways, which has created a challenge for sustainable urban development in the future [56]. Biodiversity research in Vietnam primarily focuses on primary forest areas and nature reserves, often overlooking urban biodiversity [54]. To address this gap, it is essential to consider diversifying urban agricultural production activities by converting rice and vegetable cultivation to flowers and food gardens [55]. This approach should be integrated into urban development plans to enhance biodiversity and sustainability in urban environments. The changes in urban forms due to population expansion can tend not to be stable due to the urban development process being rushed, without proper consideration being given to long term environmental impacts or even social convenience [55].

4.4. Urban Development and Expansion Strategies for Hue City: Planning for the Future

According to Thua Thien Hue People's Committee, Hue city needs an additional 220 hectares of land by 2025 and 227 hectares by 2030 to facilitate the construction of houses and related services in urban development [21]. Consequently, with regard to the future development of Hue city, consideration should be given to initially develop urban areas in the available areas in combination with the expansion of Hue's urban boundaries by merging the existing rural communes that surround Hue city to concur with the current plan of Thua Thien Hue and Vietnam [57]. In addition, the spatial changes in Hue city have not only been horizontal but also vertical, marked by the emergence of numerous high-rise buildings recently. As of 2020, Hue city has 13 housing projects with a height of 50 m or more. It is planned that, by 2030, there will be an additional 17 projects [58]. This development can negatively impact the urban landscape and existing structures [59]. Although this study did not specifically address these vertical changes, we recognize them as a potential and intriguing research direction for the future. The application of remote sensing data and machine learning algorithms to analyze the vertical spatial parameters of construction in urban areas represents a promising approach [60]. This application could provide deeper insights into urban planning strategies.

5. Conclusions

LULC in Hue city has undergone significant changes from 2000 to 2020, with an increasing trend in built-up land and a corresponding decrease in agricultural land. Specifically, built-up land increased by 2054 hectares, while agricultural land decreased by 1580 hectares. Approximately 39.09% of the total area of agricultural land was converted to built-up land during this period. These changes are the result of mandated urban development planning that was implemented to serve the socioeconomic demands of the local population.

Analyzing the direction of development of Hue's urban areas indicated that the economic and industrial park development played an important role in this process and led to significant urbanization in the eastern, southeastern, and northwestern directions in the period 2010–2020. In contrast, from 2000 to 2010, urban expansion was primarily influenced by the convenience of terrain, driving growth in the north, southwest, and northwest directions.

Over the past 20 years, urban expansion has primarily manifested as infilling expansion, covering a total area of 1424.13 hectares. This is followed by edge expansion, which encompassed 914.56 hectares, while outlying expansion accounted for the smallest area at 391.04 hectares. Diversifying the forms of urban expansion can better meet the needs of residence places for local people; however, it may also pose certain risks to the provision of social services and the environment.

Under the pressure of population growth, as well as the economic transitions that come with it, the urban expansion of Hue must be carefully studied to ensure that the future design of Hue fosters and strengthens sustainability in terms of economic, social, and environmental aspects, based on equal development in all directions of the city.

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