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RESEARCH ARTICLE

Re-Framing the Interlinked between Demographic Transition and Land-Use Change in Developing Countries Peri-urbanization

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Abstract Recent peri-urbanization, primarily characterized by declining agricultural land and a growing population, is a primary driver of peri-urban dynamics. As urban-centric activities and demands rise, unmanaged urban sprawl causes socio-cultural disruptions, pollution, and economic instability. The intricate processes dependable for these negative impacts are primarily associated with population dynamics and land use changes. This study investigates the trends of demographic and land-use changes in the peri-urban area and evaluates the interrelationships between these two factors. We utilize the multi-decade population and land-use transformations from 1990 to 2020 in the peri-urban area of Denpasar City – one of the most metropolitan areas in Indonesia. The results reveal that the peri-urban areas encountered unprecedented population growth and urban sprawl. The results indicate that the inner peri-urban area has encountered more substantial changes in population and land use than the outer area. Nevertheless, specific demographic trends have a positive influence on peri-urban land-use transformation. This elucidates why land use is progressively diverging from household demographic dynamics, specifically in population growth, population density, and the proportion of males and individuals in non-productive age groups. The interlinked relationship between these variables suggests land use conversion in peri-urban areas. The results emphasize the need for governmental planners to carefully examine demographic and land-use trends when formulating regional cross-border plans to promote sustainable peri-urban development.

1. Introduction

Peri-urbanization in developing countries in Asia is a multifaceted and ever-changing phenomenon driven by the rapid expansion of cities, population increase, and economic transformations. The urbanization rates in the periphery are projected to experience an annual increase ranging from 1.4% to 7.5% over 10 years, ultimately reaching a range of 49% to 75% by the year 2050. The regions of South Asia, West Asia, and Central Asia are expected to witness the most rapid growth in urbanization (Li et al., 2020). The peri-urbanization of Asian cities is undergoing a transformation into more diverse and intricate "second-generation" landscapes. This is being propelled by swift economic and social changes, the emergence of more valuable economic activities, and new trends in lifestyle (Webster et al., 2014). The rapid urbanization that is occurring in Asia is causing an increase in the population growth in cities as well as the transformation of peri-urban area, which are connecting large cities in an urban region that is closely related to one another as well as rural areas.

The local spatial transformations in peri-urban areas in developing Asian countries are driven by significant economic and social changes, primarily influenced by spread, impulsive, and infiltration processes. The peri-urbanization process in developing Asian countries is distinct because it relies on metropolitan areas and city centre (Zhang et al., 2013), the accumulation of capital and the simultaneous presence of diversified and complex livelihoods (Webster et al., 2014). Moreover, policies targeted at promoting foreign direct investment have a significant impact on peri-urbanization in Asian countries, with approximately 50% of population growth taking place in communities that are defined as peri-urban (Kontgis et al., 2014; Li et al., 2016). Furthermore, increasing population growth rates in cities as a result of higher natural increases and net migration are two factors that contribute to the rapid peri-urbanization that is occurring in developing countries in Asia.

The rapid peri-urban transformation in developing Asian countries has resulted in a stage of demographic transition characterized by prolonged mortality, increased age at marriage, and reduced fertility rates (Winarso et al., 2015). The demographic transition led to a significant increase in the working-age population compared to the dependent people, thereby enhancing the per capita productive capacity of Asian economies (Kontgis et al., 2014). Furthermore, the growth of peri-urban populations has led to a rise in population density in most urban agglomerations in developing Asian countries. The process of peri-urban change may hinder the emergence of a new middle class and empower the aging population to become an essential factor in politics, thereby influencing socioeconomic policies.

Demographic change is acquiring prominence in debates about development and regional planning, as it is considered a determining factor in the future development of peri-urban areas (United Nations, 2019). Nonetheless, long-range records on the relationship between demographic trends and land-use changes remain scarce (Haase & Haase, 2007). Migration – the most potent factor in population growth - might become a more influential demographic trend that shapes population size and the transformation of population structure (Kroll & Haase, 2010). The process of migration is related to the existence of larger possibilities in the destination area, primarily related to factors that promise improvements in the living standard and social well-being of the residents. (Filho et al., 2022). Population growth and migration, along with a lack of public policies, are contributing to various socio-environmental issues in peri-urban areas. Peri-urbanization in developing countries in Asia presents advantages for enhancing the social and economic conditions of the population (Shi et al., 2012). However, it also entails potential peri-urban land-use changes.

Changes in land-use are commonly prevalent in peri-urban areas to accommodate the growth and functioning of the metropolitan regions (Seto et al., 2011). As cities expand, agricultural land or natural land from the rural-urban interface (i.e., peri-urban areas) changed to housing, business, or manufacturing properties (Christiawan & Nguyen, 2024; Mortoja et al., 2020). Peri-urban land conversion creates several challenges for peri-urban landscape management, which includes the loss of farmland (d'Amour et al., 2017), an erosion in native biodiversity (McKinney, 2002), and ecosystem depletion (Sutton et al., 2016). Furthermore, the loss of natural vegetation around cities diminishes public access to leisure activities and green spaces, potentially harming both mental and physical well-being (van den Bosch & Nieuwenhuijsen, 2017; van Vliet et al., 2020).

Indonesia, one of the most developing countries in Asia, has experienced massive peri-urbanization. Denpasar City, the Bali Provincial Capital, was one of the most populous cities in Indonesia. The growing urban population in Denpasar City strains the city's infrastructure. Central Bureau of Bali Statistics (2023) reported that Denpasar City's non-agricultural land increased by 1,303 hectares from 2009 to 2019, reflecting the city's population growth. Since 2009, the built-up area has consumed paddy fields, moor, swamp, mangrove forest, sports fields, reclamation land, and conservation land culturally (Christiawan, 2019). Due to Denpasar's land shortage, space and urban activities are being moved to the peri-urban area. Thus, the land-use of Denpasar City peri-urban areas has changed due to urban expansion.

Several studies have made efforts to measure and analyze the factors and outcomes of peri-urbanization (Biegańska et al., 2018; Colleoni, 2019; Pratomo et al., 2020; Smailes, 2007; Woltjer, 2014). Although there have been many studies conducted on changes in land use in peri-urban areas, further research is still required to fully understand the relationship between demographic transition and land-use change in peri-urban areas. Further research is necessary to comprehend the demographic patterns in peri-urban regions and conduct more comprehensive investigations exploring the correlation between demographics and land-use changes. A more rigorous examination of the correlation between demographic factors and changes in land use, specifically focusing on the peri-urban level, is necessary. Prior research employed demographic indicators that were restricted to measures of population size and density (Czekajlo et al., 2021; Oliver & Thomas, 2014). Our research aims to address this gap by examining the patterns of demographic and land-use changes in the peri-urban area. We will assess the connections between these two factors using various demographic variables and a study period that spans a long duration. An analysis of demographic and land-use change trends can improve the development of peri-urban sustainability models by providing a quantitative validation framework.

2. Methods

The peri-urban area of Denpasar City was selected as the study area due to its status as one of the most populous cities in Indonesia. This study examines explicitly peri-urban areas characterized by a combination of urban and rural elements, without one aspect significantly dominating the other. Hence, the main factors to consider when selecting study areas are peri-urban areas, encompassing inner and outer areas, where the proportion of rural or urban land-use is at least 25% or exceeds 75% (Figure 1).

An analysis of peri-urban land-use change using a spatial approach necessitates two distinct datasets. Initially, administrative maps are employed to ascertain the specific unit of analysis (sub-district and village). Furthermore, the land-use maps from the years 1990, 2000, 2010, and 2020 are employed to evaluate changes in land usage. The data was sourced from Indonesian government agencies at the district or city level, as obtained from the website of the Government of Indonesia (https://tanahair.indonesia.go.id/portal-web). The spatial data is stored in a vector format known as a shapefile, and it will be processed using a Geographic Information System (GIS). At the same time, we acquired population data for each sub-zone from 1990 to 2020 from the Statistics Bureau (Denpasar City Statistics Bureau, 2022).

The study used spatial and quantitative analysis. GIS spatial analysis involves three steps: input, processing, and output. Data is entered into ArcGIS software, and area coordinates and attribute table adjustments are made. Spatial analysis using overlay intersects on land-use maps from 1990, 2000, 2010, and 2020 is performed. Change detection is used to track land changes over time. Output shows land-use change maps. Moreover, this study uses descriptive statistics, crosstab techniques, Mann-Kendall test, and Sen's slope estimator to analyze demographic and land-use change trends in peri-urban regions. Descriptive statistics summarize demographic trends, while crosstab categorizes independent variables. The Mann-Kendall test identifies upward or downward trends, while Sen's slope estimator determines slope magnitude. The study also examines demographic and land-use change in the developed class, focusing on inner and outer peri-urban areas. SEM PLS uses observed and latent variables to explain peri-urban land-use change variability in the structural model. The SEM-PLS method can identify and analyze peri-urbanization factors using multiple dependent variables. The objective is to investigate land-use change dynamics and differences in development behavior between peri-urban areas.

3. Result and Discussion

The land-use change and expansion in peri-urban areas

Peri-urban areas often experience land-use change as they expand to accommodate the growing city centers. As urban areas expand, peri-urban natural lands undergo conversion into residential areas, commercial establishments,

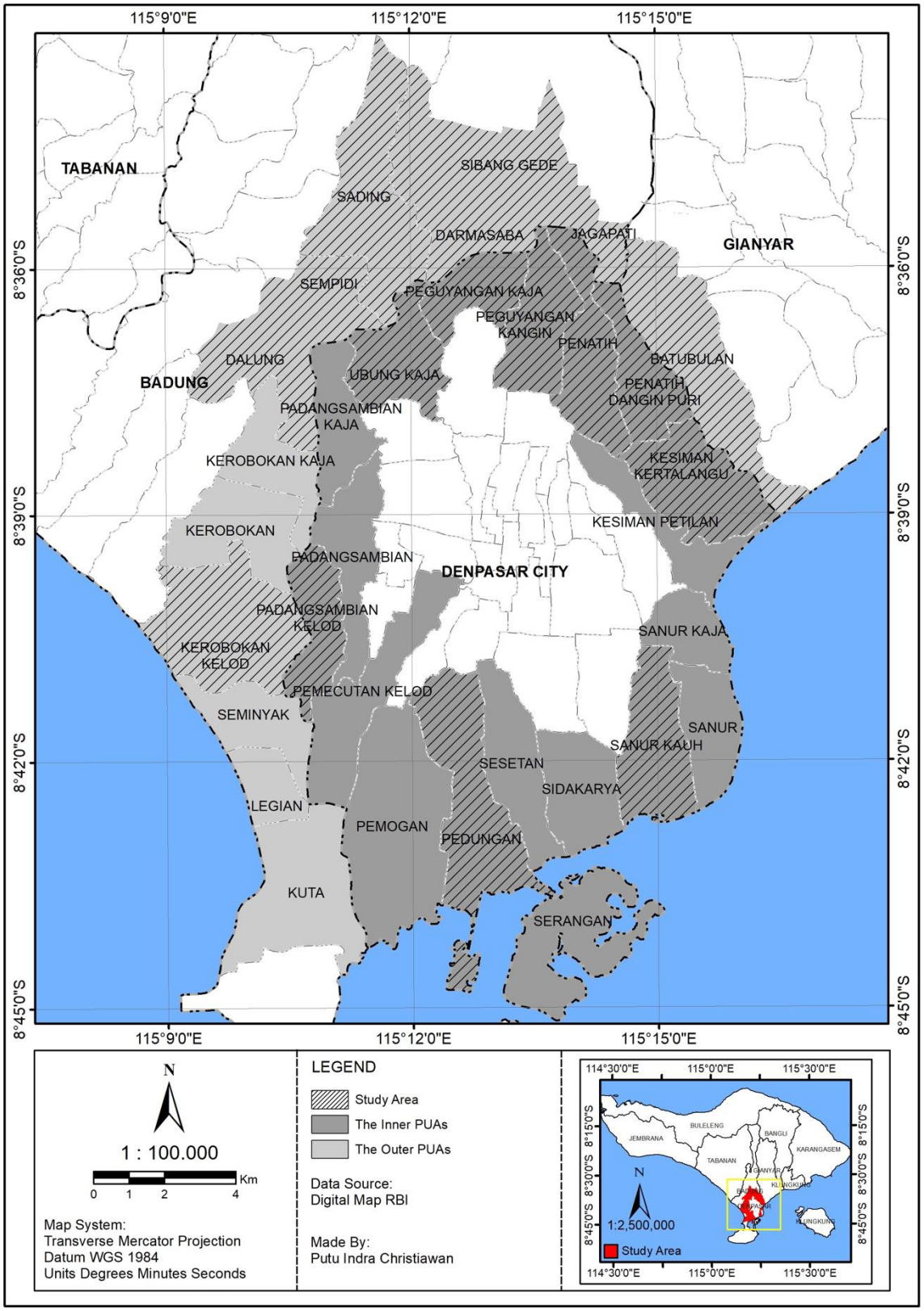

Figure 1. Map of the Study Area

and industrial facilities. This section presents an analysis of the patterns and shifts in land use in both the inner and outer peri-urban areas of Denpasar City. Denpasar City and its surrounding areas had significant peri-urban expansion. Between 1990 and 2000, it experienced a growth rate of approximately 13.15%. This was followed by a further increase of 15.19% between 2000 and 2010. Finally, from 2010 to 2020, it nearly doubled, with a growth rate of 43.26%. The rates of urban development have experienced exponential growth in the peri-urban areas of Denpasar City. Between 1990 and 2020, the expansion encompassed 86.72% of the area.

The land-use trends for each peri-urban area are illustrated in Figure 2. The spatial analysis indicated that 1990, 2000, and 2010, agriculture was the largest land-use class in inner and outer peri-urban areas. However, in 2020, the settlement covered most peri-urban areas, mostly inner. The cartographic results show significant change in peri-urban areas with diverse trajectories. The research suggests that

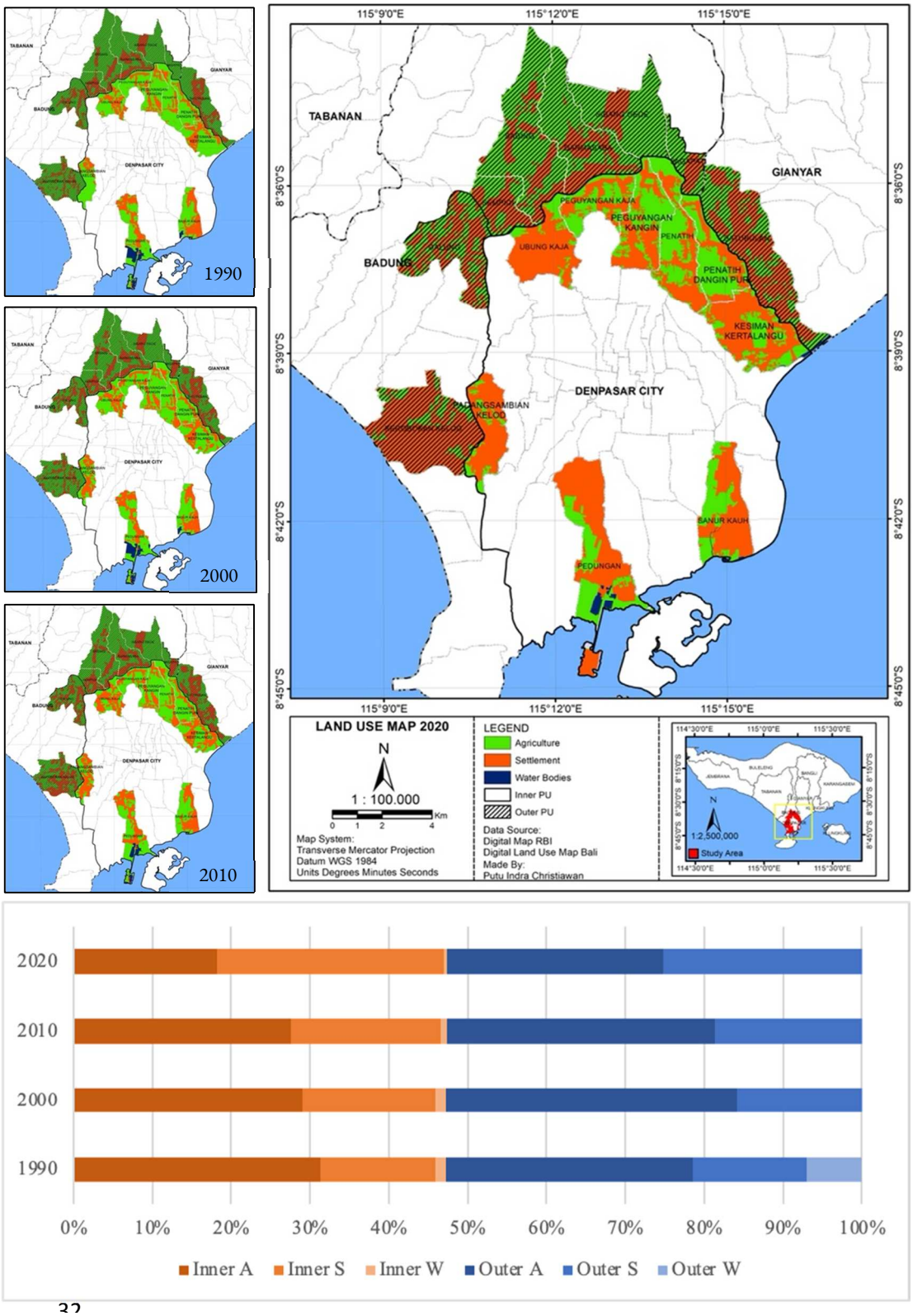

Figure 2. Land-use change in the Denpasar City's peri-urban areas 1990–2020, by land-use class (agriculture, settlement and water bodies)

peri-urban expansion with urban characteristics frequently converts natural landscapes into settlement areas. The most pronounced land-use changes in Denpasar City peri-urban areas between 1990 and 2020 were the rapid decrease in agricultural class and associated increase in settlement (built-up) class. The spatial analysis confirmed that the 2010-2020 period is the most massive decrease of agricultural classes, both in the inner and outer peri-urban areas (-34,04% and -19,23%, respectively). Conversely, settlement classes experienced a significant increase in the last decades, mainly in the inner peri-urban with 8,50 km2 or 51,28%.

Figure 2 also shows the cumulative gains and losses transition rate in three land-use classes in the study area. In inner peri-urban areas, settlement classes increased at 16,22% annually, with 7,51% over agricultural land. Outer peri-urban areas saw a 10,06% increase, while agricultural classes gained significance at 17,78% annually.

Table 1. The mann-kendall trend and sen's slope values of land-use change (1990-2020)

Indices	Inner PUAs				Outer PUAs				Total PUAs			
	MK	p-value	Trend	Sen's Slope	MK	p-value	Trend	Sen's Slope	MK	p-value	Trend	Sen's Slope
Agri-cultural	-2,91	0,01	Significant decrease	-0,29	-1,33	0,03	Non-significant decrease	-0,17	-1,66	0,03	Significant decrease	-0,43
Settle-ment	2,47	0,02	Significant increase	0,31	1,70	0,02	Significant increase	0,27	2,91	0,02	Significant increase	0,58
Water Bodies	-0,91	0,04	Non-significant decrease	-0,03	-1,87	0,03	Significant decrease	-0,10	-1,90	0,03	Significant decrease	-0,14

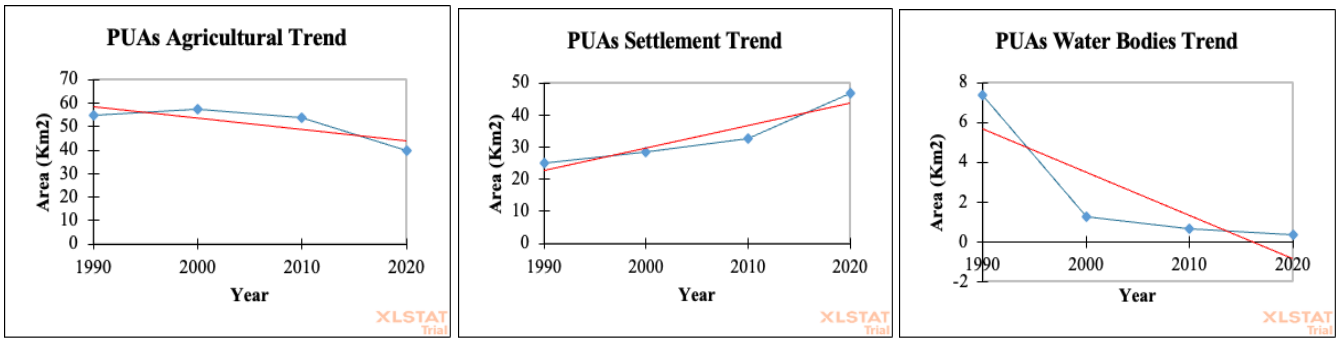

Figure 3. Trend of land-use change trends from 1990 to 2020 in Denpasar City peri-urban area

An evaluation of changes in land use from 1990 to 2020 was conducted using a non-parametric method, specifically the Mann-Kendall test and Sen's slope estimator. The Mann-Kendall test identifies trends in land-use change in the peri-urban areas of Denpasar City with a 95% confidence level, as shown in Table 1.

The land-use change trend consists of agricultural land, settlement, and water bodies in both inner and outer peri-urban areas. The agricultural land decreases by -0.43 km2, with the trend more significant in inner peri-urban areas. Settlements also show an increasing trend in all peri-urban areas. Water bodies also decrease, with the trend more significant in outer peri-urban areas. The analysis of Sen's slope indicates that the magnitude of the slope is in line with the Mann-Kendall value, revealing a declining trend in both agricultural and water bodies. Conversely, the settlement area demonstrates a significant increase (Figure 3).

The study demonstrates a substantial transformation of natural land into developed areas, particularly in inner peri-urban regions, during recent decades. This can be attributed to the economic expansion in these regions, which are primarily characterized by the prevalence of enterprises, industries, trade, hotels, and restaurants. These regions are appealing to commercial districts because of their excellent accessibility and abundant amenities. City land cover changes in China have exhibited a strong correlation with economic levels. Numerous agricultural communities have experienced the encroachment of urban development on their rice fields, resulting in farmers either selling their land or transforming it into urban commercial zones. The primary factors contributing to the decision to sell land are the challenges associated with acquiring reliable irrigation systems and the exorbitant expenses associated with farming. Declining productivity and the demands of complex urban life have made it increasingly difficult for farmers to sustain themselves.

The conversion of outer peri-urban regions in Canada is propelled by a significant need for land for residential purposes and the availability of reasonably priced land. Urban dwellers relocate to these regions as a result of restricted land availability and the presence of densely populated commercial structures. The swift rate of peri-urbanization has resulted in a surge in the need for housing, tourism, and commercial land utilization, while agricultural land utilization has suffered as a consequence. The construction of roads expedites this process, as they serve as crucial transportation infrastructure for peri-urban communities engaged in the sale of agricultural products beyond their villages. Improved road infrastructure not only benefits farming communities, but also enables urban residents and city activities to access and transform the physical layout of peri-urban areas.

The existence of roads as a condition of accessibility creates numerous business opportunities in peri-urban areas. One of the most profitable business opportunities is a housing development that meets the needs of urban residents who choose to live outside the city. In line with the construction of settlements, various commercial enterprises will crowd the residential area directly. According to Ustaoglu and Aydınoglu (2019), the need for land for commercial trading was contented by sacrificing agricultural land. Urban economics is believed to be more financially beneficial than remaining in the agricultural sector, considering that the conversion of farmland increases the cost of locating, storing, and purchasing food.

The demographic transition and trends in peri-urban areas

Peri-urbanization is a complex process of the rural population transitioning into more urban. Due to the widespread nature of the process, many people currently reside in peri-urban areas. This section discusses the trends and growth of population size, composition, and population

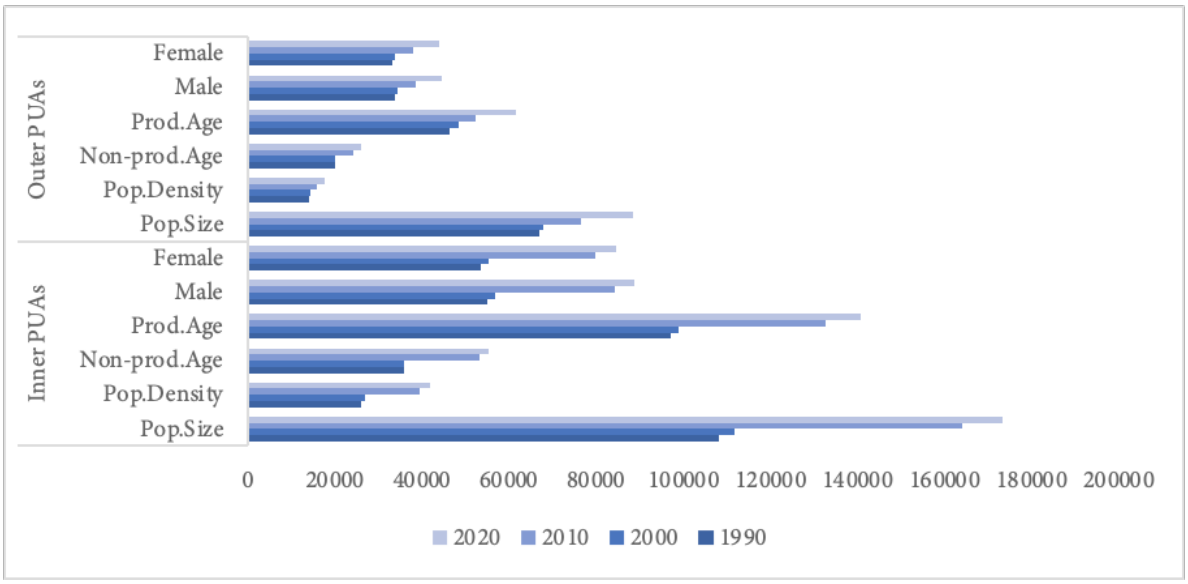

Figure 4. Denpasar city's peri-urban areas demographic trends

Figure 5. Population pyramid trends in inner peri-urban areas of Denpasar City

Figure 6. Population pyramid trends in outer peri-urban areas of Denpasar City

density of peri-urban demographic change in the inner and outer peri-urban areas of Denpasar City. The demographic trends for each peri-urban area are illustrated in Figure 4.

The inner peri-urban areas of Denpasar City have a larger population than outer area. However, both areas grew steadily from 1990 to 2020. Inner peri-urban population growth accelerated from 3.32% in the first decade to 46.8% in the second, then slowed to 5.67% in the last. The rise of outer peri-urban areas has demonstrated a sustained upward trend, surpassing that of inner peri-urban areas in the past decade.

Figures 5 and 6 illustrate population structure changes in Denpasar's inner and outer peri-urban areas. According to the findings, inner and outer peri-urban population pyramids are identical. To understand the changes in peri-urban population structure, the population pyramid is divided into three groups: the young (0-14 years), the working-age (15-65 years), and the elderly (65+ years).

Inner peri-urban youth have changed significantly. Births rose from 2000 to 2010, expanding the pyramid's 0–4-year-old wings. In mature age, 25–34 have longer pyramid wings than others. Immigration increased the inner peri-urban population, as shown by this wing's length. Moreover, inner peri-urban elderly populations are changing. Growth in 65-69-year-olds over the past 30 years is the leading cause of these structural changes. Increasing life expectancy, health insurance and elderly care contribute to this area's aging population. Meanwhile, younger population changes are stable in outer peri-urban areas. From 2000 to 2020, births fell. Pyramid wings shorten at this rate in 0–4 years. Aged 30-39-year-olds have longer wings than other age groups. The length of this wing suggests that in-migration has increased the outer peri-urban population. Elderly populations in outer peri-urban areas also change. In recent decades, 65–69-year-olds have increased primarily due to retirees moving to more conducive areas.

The population's growth, classified by gender, presents a distinct pattern. Females have been the predominant group driving population growth in inner peri-urban areas. The

Table 2. The mann-kendall trend and sen's slope values of demographic change (1990-2020)

Indices	Inner PUAs				Outer PUAs				Total PUAs			
	MK	p-value	Trend	Sen's Slope	MK	p-value	Trend	Sen's Slope	MK	p-value	Trend	Sen's Slope
Pop. Growth	1,96	0,03	Significant increase	2478	1,5	0,03	Non-significant increase	788	2,91	0,01	Significant increase	3075
Pop. Density	2,3	0,02	Significant increase	604	1,47	0,04	Non-significant increase	121	1,98	0,03	Significant increase	701
Non-Prod. Age	1,68	0,45	No trends	757	1,1	0,72	No trends	206	2,47	0,08	No trends	963
Prod. Age	1,98	0,03	Significant increase	1616	1,4	0,03	Non-significant increase	458	2,96	0,01	Significant increase	2025
Male	1,7	0,04	Significant increase	1301	1,38	0,03	Non-significant increase	396	2,5	0,02	Significant increase	1602
Female	1,8	0,04	Significant increase	1177	1,7	0,03	Significant increase	391	2,96	0,01	Significant increase	1472

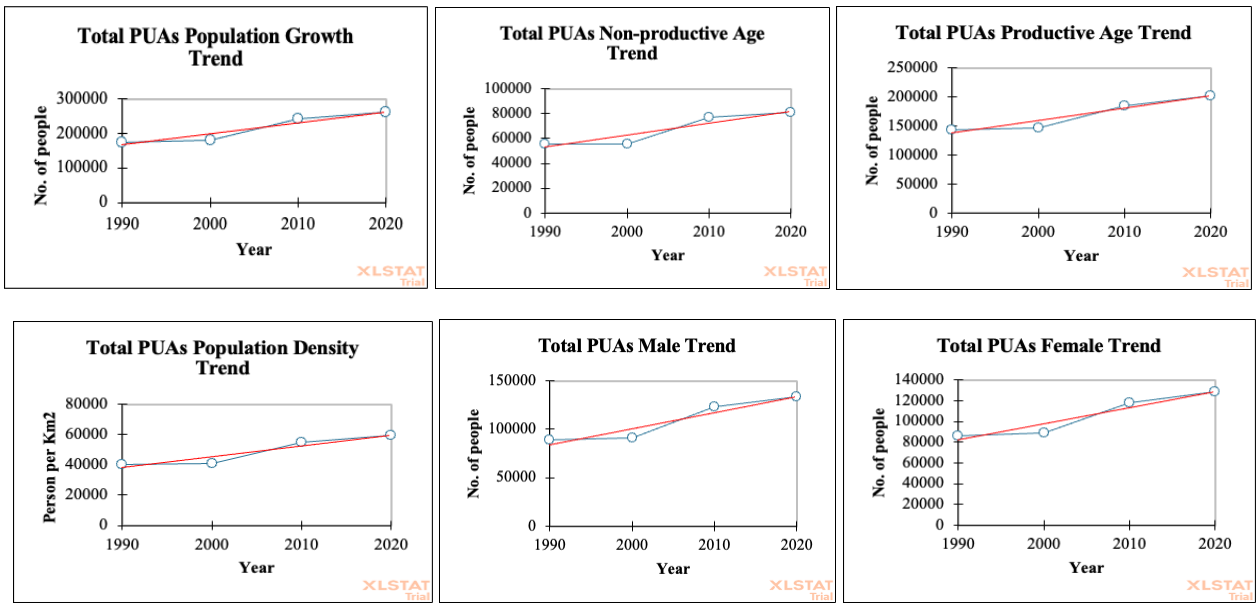

Figure 7. Sen's slope test for demographic trends in Denpasar city's peri-urban areas

growth rate was 3.35% in the first decades (1990-2000), 44.59% in the second decade (2000-2010), and experienced a reduction in the last decade (2010-2020). Meanwhile, the growth rates of males exhibited fluctuations, reaching a minimum of 3.29% in the initial decades, declining in the subsequent decades, and increasing in the final decades. In the outer peri-urban areas, female growth rates consistently rose, reaching 12.73% in the second decade and expanding to 15.64% in the last decade, whereas the growth of males was similar to the inner area.

Population density in inner and outer peri-urban areas varies significantly. Inner peri-urban areas have a denser population density than outer peri-urban areas, with growth accelerating from 1990 to 2020. Inner peri-urban areas experienced minimal growth from 1990 to 2000, reaching 47.77% in the second decade and slowed down in the last decade. Outer peri-urban areas experienced consistent growth, increasing from 2.10% in the first decade to 14,42% in the last decade.

The demographic change from 1990 to 2020, as determined by the Mann-Kendall test, is presented in Table 2. The population growth exhibits a substantial upward trend, with a total increase of 3075 individuals. However, this trend is more pronounced in the inner peri-urban areas compared to the outer ones. The population density exhibits a notable upward trend, with a total increase of 701 individuals per square kilometer. However, this trend is more pronounced in the inner peri-urban areas compared to the outer ones. No observable trend is observed in the non-productive age change in all peri-urban areas. On the contrary, the number of people in the productive age group is increasing significantly at a rate of 2025 individuals per square kilometer overall. However, this increase is more pronounced in the inner peri-urban areas compared to the outer peri-urban areas. The male population is experiencing a notable upward trend, with a growth rate of 1602 individuals per square kilometer overall. However, this trend is more pronounced in the inner peri-urban areas compared to the outer ones. The female population in all peri-urban areas exhibits a statistically significant upward trend. The rate of change was 1177 individuals for inner peri-urban areas, 391 individuals for outer peri-urban areas, and 1472 individuals for entire peri-urban areas. The Sen's slope analysis indicates that the magnitude of the slope aligns with the Mann-Kendall value, indicating a predominantly increasing trend for most demographic indices. However, no trend was observed for the change in the number of non-productive age individuals.

In addition, Sen's slope test indicates that population growth exhibits the highest demographic trend value of 30753.5. The positive trend value in peri-urban areas signifies a rising annual population growth trend. The notable surge suggests that peri-urban areas will surpass urban and rural areas in terms of population. Figure 7 depicts the comprehensive Sen's slope estimator for all demographic trends in peri-urban areas.

The peri-urban areas in Denpasar are undergoing ongoing population growth, with the inner peri-urban areas having a higher population. Nevertheless, the population growth trend in outer peri-urban areas is more consistent and exhibits a higher growth rate compared to urban areas. Peri-urban areas will emerge as the upcoming focal point for population growth. The growth trajectory is shaped by the rising levels of living standards, extended lifespans, increased life expectancy, and the aging of the population. The decline in mortality rates has resulted in a rise in both the absolute number and relative proportion of elderly individuals within the overall population. Moreover, a sudden surge in the influx of both working-age individuals and retirees has resulted in a substantial growth of peri-urban regions. The consistent pattern of population growth will expedite the demographic transformation of outer peri-urban areas towards urban nature at a faster rate compared to inner peri-urban areas.

The study indicates that the population in peri-urban areas, specifically inner peri-urban areas, predominantly comprises males in their productive age. This discovery aligns with prior research conducted in villages near the main urban area, which identified a notable rise in the population of working-age individuals (Mueller et al., 2019; Sikarwar et al., 2020). This phenomenon exhibits an inverse correlation with the growth of the population in urban areas, where the demographic composition is undergoing the process of aging (Kabisch & Haase, 2011; Kroll & Haase, 2010; Qibthiyyah & Utomo, 2016).

The significant movement of productive migrants into peri-urban areas implies the presence of a unique and persuasive attraction in this area. Recent research has identified three primary determinants that draw migrants to peri-urban areas: land prices, economic activity, and environmental conditions (Adedire & Adegbile, 2018; Sikarwar et al., 2020). The main factor that influences migrants, particularly those from urban areas, to decide on peri-urban areas near city workplaces as their settlement is the comparatively low land cost, including affordable house rental prices (Winarso et al., 2015). The urban expansion has led to the growth of diverse economic activities in peri-urban areas. Migrants, particularly those from rural areas, are drawn to engage in business activities within the informal sector due to the growth of economic activity (Adu-Gyamfi et al., 2022). Finally, green and environmentally friendly conditions in the neighborhood have encouraged migrants, particularly those with nuclear families (pioneers), to seek a safe and comfortable place to raise their children (Weldearegay et al., 2021). These three factors have a beneficial impact on the growth of the working-age population in peri-urban areas.

Regional economic growth is stimulated by a productive-age population (Castells-Quintana & Wenban-Smith, 2020; Chi & Ventura, 2011; Polyzos et al., 2022). The low proportion of youth and elderly will minimize expenditure to address their demands, liberating resources for economic growth. Regional or national economic benefits from a sizeable productive population are called "demographic bonuses" (Adioetomo, 2018). The demographic bonus arises if the productive-age population is larger than the non-productive population or when the dependency ratio is less than 50 (Adioetomo, 2018; Andriani & Yustini, 2021). In recent years, the dependency ratio has a tendency to rise, especially in outer areas. Peri-urban demographic advantage will be jeopardized if this trend continues to increase.

The population density in the peri-urban areas of Denpasar city increased consistently. The evidence indicates that the inner peri-urban areas are denser than the others. However, the increasing population density trend is more stable in the outer peri-urban areas. Previous studies have found that the population density is highest in areas adjacent to urban or peri-urban areas that are still within the city administration (Alfana et al., 2019; Kroll & Kabisch, 2012). Various studies have also defined that an increase in population density cannot be separated from the effect of high in-migration rates (Chi & Ventura, 2011).

Population density can serve as both a benefit and a barrier to regional economic development. Population density can impact the quality of life for its people. Improving the population's quality will be more difficult in high densities areas (Leeson, 2018; Matsukura et al., 2007). This difficulty raises socioeconomic issues, including welfare, food security, and clean water. Moreover, the high population density will increase job competition among community members. Urban expansion and regional autonomy create a plethora of jobs in peri-urban areas. This fact attracts migrants entering peri-urban areas. Without measurable rules, the presence of migrants poses a direct threat to the local's ability to utilize existing resources. Competition between residents, both among local people, local versus non-local, and between migrants, triggers various social conflicts (Danius, 2018; Wibowo et al., 2018). In contrast, a high population density accompanied by a large accumulation of human capital will stimulate economic growth. The individuals' expertise and knowledge will affect their performance. People with a high human capital will be able to generate innovative technological ideas to enhance their living and their livelihoods.

The inner peri-urban areas exhibit a considerably greater degree of peri-urbanization expansion compared to the outer peri-urban areas. The parametric t-test demonstrates a significant disparity in development between the two groups ($n = 17$, $p < 0.05$ for all), as indicated in Table 3.

The p-values obtained from Levene's test for each index are higher than the predetermined α level. We made the assumption that the variances of the two groups are equivalent. The p-values (two-tailed) of the two-sample t-test for most indices are all below the α level, indicating a significant difference among those indices. The p-values (2-tailed) of the two-sample t-test for settlement and non-productive age exceed the α level. As anticipated, our research revealed that peri-urban areas occupy an intermediate position between inner and outer peri-urban areas in terms of peri-urbanization. Furthermore, we observed that the peri-urban category exhibits distinct characteristics in terms of demographic changes, particularly in relation to gender (both male and female changes), population density, population growth, and changes in the productive age group.

The latent nexus between demographic transitions and land-use change

Using the SmartPLS, we analyze the latent nexus between demographic transition and land-use change in peri-urban area of Denpasar City. Data processing with SmartPLS has two stages: Outer Model Test and Inner Model Test.

The Outer Model Test and Inner Model Test evaluate structural equation modeling. Outer Model Test determines if research instrument can produce reliable data, including Convergent Validity, Discriminant Validity, and Composite Reliability. Each variable-indicator relationship is tested for convergent validity. If loading factor exceeds 0.5, indicator is valid. The Convergent Validity Test shows each variable loading factor exceeds the standard limit in, indicating the research model is valid and testable, as can be seen in Table 4.

Discriminant validity tests quantify one latent variable's relationship to all indicator variables. Quantification changes discriminant validity through cross-loading. Table 5 shows that the cross-loading values of all latent variables are highest in each variable block in the discriminant validity test. Data processing shows that the research instrument model's

Table 3. The outcome of two sample t-test

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
						Lower	Upper
Settlement CHG (km²)	3.015	.103	.312	15	.759	-119.991	161.213
Pop. Growth (person)	.620	.443	1.893	15	.048	-573.553	9.668.525
Pop. Density CHG (person)	3.021	.103	2.531	15	.023	208.409	2.431.953
Non-Prod. Age CHG (person)	4.648	.078	.081	15	.936	-2.252.214	2.430.242
Prod. Age CHG (person)	.059	.811	2.129	15	.050	-6.007	9.785.701
Male CHG(person)	3.048	.103	2.850	15	.012	738.792	5.118.847
Female CHG (person)	4.969	.078	2.746	15	.015	557.687	4.426.980

Table 4. Convergent validity test results

Variable	Demographic Change	Land Use Change
Population Growth (PG)	0.988	
Population Density (PD)	0.988	
Productive Age (PA)	0.778	
Non-Productive Age (NPA)	0.614	
Male (MA)	0.985	
Female (FE)	0.988	
Agricultural Land (AL)		-0.978
Settlement Area (SA)		0.794
Water Bodies (WB)		0.541

Table 5. Discriminant validity test results between latent variables

Variable	Demographic Change	Land Use Change
Demographic Change	0.602	
Land Use Change	0.297	0.471

Table 6. Path analysis verification

Path Analysis	Path Coefficient	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics	P Values	Description
DC à LUC	0.297	0.227	0.155	6.019	0.019	Significant

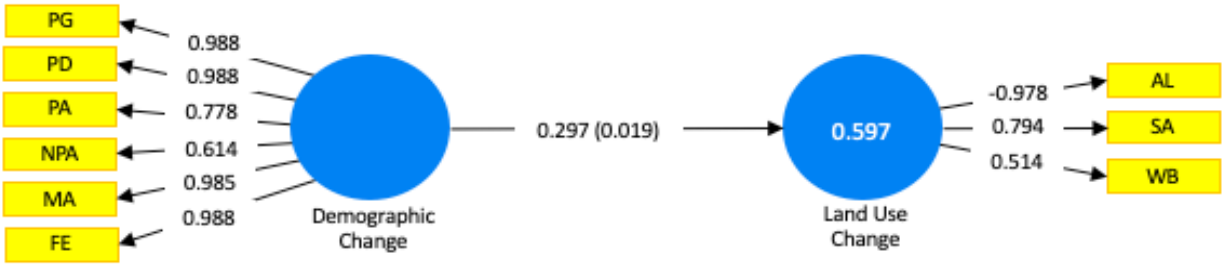

Figure 8. Interlinked between demographic and land-use change in Denpasar city's peri-urban areas

discriminant validity test has merit because it has valid data to continue.

Moreover, component reliability test results indicate that demographic and land-use change variables have Cronbach alpha values above 0.6 (0.949 and -1.261), composite reliability values above 0.7 (0.963 and 1.428), and average variance extracted values above 0.5 (0.813 and 0.594, respectively). Hence, data reliability implies research instrument model and design reliability.

Next, Inner Model Test (Structural Model). The inner model test classifies latent variable relationships. Considering the P-value and Original Sample value, the path coefficient value rejects or accepts the hypothesis. This study uses 5% significance or alpha of 0.05 with 95% confidence. A variable is significant if the P-value is < 0.05. Table 7 shows that variables in the inner model were positive and significantly affected data processing.

The R-square value quantifies the effect of the independent variable on the dependent variable. The analysis indicates that the R-square value is 0.597. This demonstrates that land-use change is impacted by demographic change variables, including population growth, productive age, non-productive age, gender and population density, with an effect of 59.70%. Therefore, the model employed in this research effectively describes the latent variables and has moderate explanatory power. Figure 8 presents the path analysis model using PLS-SEM. The results of the R-square value in the structural model can be seen in Figure 8.

Figure 8 illustrates the structural model diagram of peri-urban changes inter-relation. The result of the path analysis between demographic and land-use change was a P-value of 0.019, below the significance level of 0.05, and a positive effect of 0.297. Therefore, demographic changes positively and significantly impact the transition of peri-urban land use. An escalating demographic transition will result in a land-use transition out of the farming sector. The findings of this research validate the assertions presented by Kontgis et al. (2014) that urban extent and density have been amplified in peri-urban areas due to population expansion. These findings also align with the research of Abass et al. (2013) and York et al. (2011), which indicate that the proportion of the population in the working age group significantly influences land fragmentation and the reduction of cultivated land. In contrast, the findings of this investigation stand in opposition to the research presented by Li et al. (2015), which argues that population density provides a positive and statistically significant influence on the percentage increase in farmland area. Furthermore, the findings agree with the research of Mathan and Krishnaveni (2020) that increases in population density change land characteristics, resulting in a reduction in agriculture/fallow land and a rise in built-up area.

Peri-urban land-use change has been greatly impacted by demographic trends, resulting in the expansion of settlements and changes in both physical and socio-economic aspects. The rapid expansion of housing and the implementation of modern amenities have resulted in an increase in impervious surfaces, which in turn has led to a significant rise in heat retention capacity. The alteration of land use by human activities, such as converting agricultural land into impermeable surfaces and constructing small reservoirs, has led to significant modifications in the distribution of surface energy and heat transfer. Specifically, there has been an elevation in sensible heat transfer as a consequence of the reduction in peri-urban reservoirs and green areas.

The rate of peri-urban population growth has a significant effect on economic activity. Land-use modifications, which result in the process of urbanization, have an impact on the physical environment shaped by humans and the economic well-being of communities. The rapid expansion of urban areas in Denpasar City poses challenges for communities living on the outskirts of the city, especially in their efforts to achieve sustainable livelihoods. Land-use conversion and population migration are major factors that contribute to changes in peri-urban livelihoods, which in turn pose challenges to rural-urban connections and make it difficult to maintain this relationship. Rural communities experience an inequity in the advantages

they receive in comparison to urban, resulting in a decrease in the number of farmers and agricultural land. Certain rural communities actively seek employment opportunities in urban areas, while others attempt to replicate urban job roles. This disparity leads to limited rural-urban linkages, resulting in the conversion of agricultural land into residential land. Outer peri-urban areas frequently comprise of informal settlements, varying in quality from substandard to opulent. This issue is caused by the uneven backwash and dispersion effects.

Implication for policy toward mitigating and adapting to peri-urbanization

The relationship between demographic and land-use change needs to be addressed systematically. As is the case in peri-urban areas, where development is primarily the result of settlement expansion and population growth. This study presents a chronology of the peri-urbanization phenomenon reported and studied over the past three decades. Currently, the risks and disadvantages of peri-urbanization are most likely to be related to lower levels of physical and socioeconomic dimensions, whereas the advantages are more significant in urban areas than in rural locales (Mandere et al., 2010; Mondal & Banerjee, 2021). A systemic understanding of demographic transition and land-use changes could be promoted by introducing the concept of peri-urbanization into development planning and management.

Each stakeholder must gain a more comprehensive knowledge of the patterns and effects of peri-urbanization caused by dramatic land-use change and rapid population growth. Recently, debates regarding the patterns and effects of peri-urbanization, such as land consumption, environmental degradation, cultural threats, economic imbalance, and mitigation strategies, have been exclusive to scientific study and have not yet been adopted into official regulations (Christiawan, 2019; Habibi & Asadi, 2011). Furthermore, there are no official executive orders, such as specific policies or explicit rules, to mitigate the effects of and adapt to peri-urbanization in Denpasar City and other peri-urban areas in Indonesia. The dynamic of peri-urbanization effects in peri-urban areas is frequently neglected. Rural-urban linkage revitalization is considered an appropriate and practical approach for mitigating peri-urbanization effects. These actions included establishing urban boundaries, preserving arable land, managing in-and-out migration, and providing incentives for farmers and local entrepreneurs. Unfortunately, peri-urbanization mitigation is extremely difficult to implement due to intense competition for land and resources between non-locals and locals (Hudalah et al., 2007; Pratomo et al., 2020; Woltjer, 2014). Consequently, it is mandatory that local authorities, particularly in areas classified as peri-urban, redefine their regulations and implement definite plans for minimizing adverse effects and adapting to the new challenge of peri-urbanization. The study further indicates that peri-urban areas have a higher population size and density, a dominant productive age, and a balanced male-to-female ratio. It may stimulate Denpasar's peri-urban economy. Thus, planning and managing access and equal employment opportunities for locals, non-locals, men, and women is crucial. Improved youth education and elderly services are needed to respond to peri-urbanization and reduce reliance on productive-age people. In emerging regions such as peri-urban areas, demographic change can promote, restrict, or threaten peri-urban development.

4. Conclusion

The demographic transition impacts land-use change in peri-urban areas through a multitude of interconnected processes. The peri-urban areas of Denpasar City experienced significant peri-urbanization throughout the study, as evidenced by a sharp increase in the settlement area, resulting in the loss of cropland and water bodies. The peri-urban land-use changes correlate with demographic transitions and trends, as evidenced by a substantial rise in population growth and density, and are dominated by the productive age group, in which the male-to-female ratio is relatively balanced. Moreover, an in-depth comprehension of the findings suggests that each executive decision-making scenario should address the fundamental processes, structures, and patterns of land conversion and the response to peri-urbanization. Therefore, policymakers and developers could comprehensively review the ecological, social, and economic implications of various regional development contexts as well as establish an empirical framework for enhancing sustainable peri-urban planning and regulations to mitigate adverse outcomes and enforce the adaptability of peri-urbanization. This research also designed and implemented a dynamic peri-urban development approach to present robust data to obtain a better understanding of long-term land-use changes and population growth associated with the peri-urbanization of Indonesian metropolitan areas, as well as relationships between physical-demographic characteristics. Further research could examine the effects of migration patterns, housing and public services provision, and people's livelihoods on the spatial values associated with settings.

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