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The macroeconomic impact of population aging in Indonesia: Do older adults matter?

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ABSTRACT

Indonesia, the fourth most populous country globally, is approaching an aging population and is considered unprepared for its consequences. In this context, the effect of population aging on economic growth is a widely debated topic. Previous research has shown different perspectives, stating that population aging positively and negatively influences economic growth, while other analyses report an ambiguous relationship. Therefore, this research aimed to explore the phenomenon of population aging and its economic implications by using regional macro data at the district or city level from the official 2020 BPS-Statistics Indonesia publication. Using a linear regression method, the results showed that population aging, measured by the OADR (Old Age Dependency Ratio), both traditional and modified, possesses a substantial negative influence on economic growth. However, older workers contribute positively since an increase in labor force participation could mitigate the negative consequences of population aging. Increased inclusion of older adults in economic activities is also a potential strategy for mitigating the impact. The model suggests that this method reduces economic burdens associated with an aging population. However, further research is needed to determine the most effective methods to increase the inclusion of older adults in the workforce while safeguarding basic rights in terms of health and well-being.

Contribution/ Originality: This study introduces a novel approach by analyzing the impact of population aging on economic growth at the district or city level in a developing country like Indonesia. Additionally, it employs two measures of aging—the traditional and modified OADR—to assess the impact more comprehensively.

1. INTRODUCTION

Indonesia is currently the fourth most populous country globally (United Nations, 2022), with the population projected to reach 328.93 million by 2050 (BPS, 2023). The country is at the point of having an aging population (Adioetomo & Mujahid, 2014), and census data shows an increase in the number of individuals aged 60 and over between 1971 and 2020. Over the past five decades, the older population has grown rapidly, with the number in 2020 reaching five times that of 1971, as reported in Figure 1.

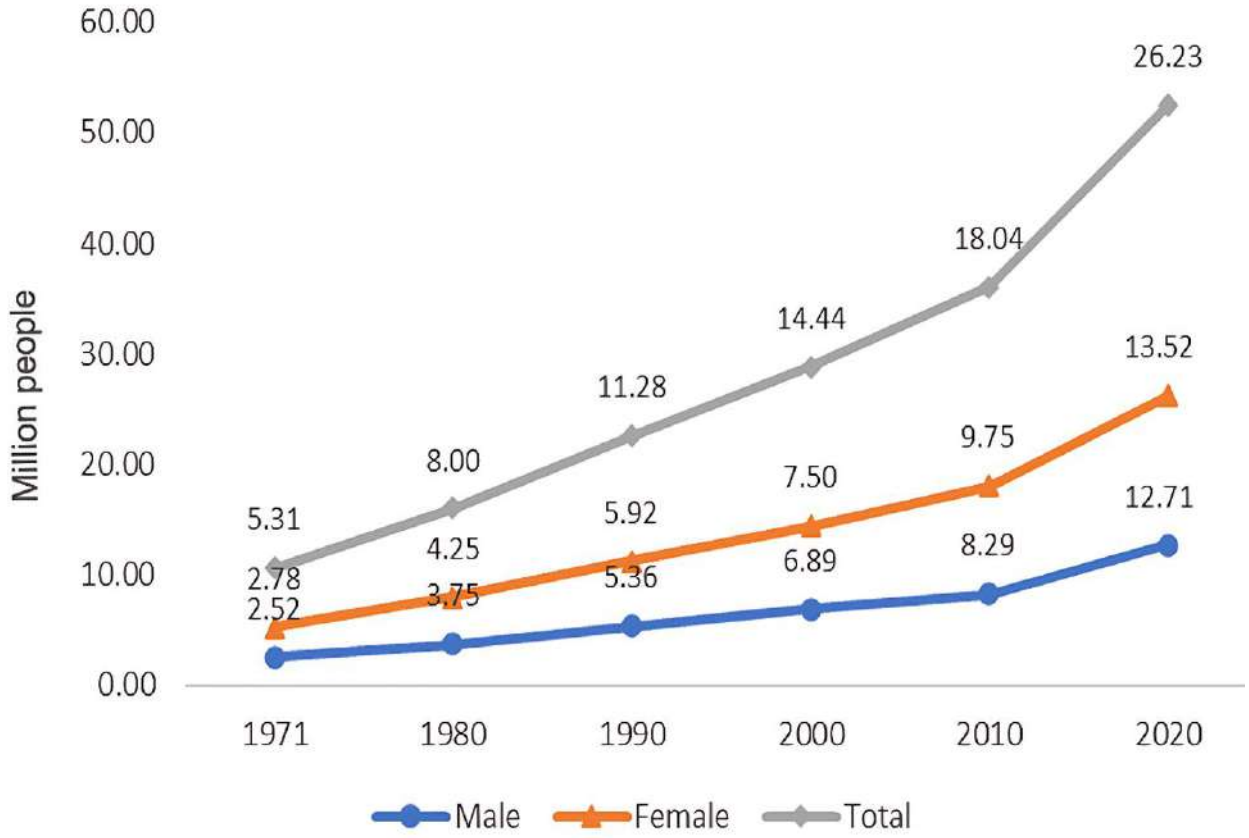


Figure 1. The population of older adults over 5 decades.

The transition of Indonesia into an aging society is becoming an urgent concern. Adioetomo and Mujahid (2014) reported that the country was not adequately prepared to tackle these challenges. A significant contributing factor is the limited social protection for older adults, including pension insurance and healthcare services, which predominantly cover retirees from government jobs and the formal sector. According to BPS (2020), only 10.76% of older adults had access to pension or old-age insurance in 2020. However, the population is described as relatively productive, with 51.04% of older adults engaged in work.

Economic growth is influenced by human resources and needs, which are shaped by the demographic age structure (Lindh & Malmberg, 1999). An important change in this structure is population aging, where the distribution shifts, resulting in a growing proportion. Several experts have analyzed the macroeconomic implications of population aging (Tang, Li, Hu, & Xiong, 2022). The association between the older adult population and economic growth is ambiguous. In contrast, the older adult population may be beneficial or detrimental to economic growth (Jayawardhana et al., 2023).

Several researchers found a connection between population aging and economic growth (David E Bloom, Canning, & Fink, 2010; Lisenkova, Mérette, & Wright, 2013). There are different views on the relationship between population aging and economic growth (Aksoy, Grasl, & Smith, 2012; Hu, Lei, & Zhao, 2021; Lindh & Malmberg, 1999). Conversely, population aging has a positive impact on economic growth (Acemoglu & Restrepo, 2017; Groezen, Meijdam, & Verbon, 2005; Prettner, 2013). The magnitude and direction of the effects of aging on economic performance are unknown (Rauhut, 2012). The impact of population aging on short-term macroeconomic stability is unclear or ambiguous (Guimaraes & Tiryaki, 2020).

This paper addresses the potential influence of population aging on the economy, which is investigated using macroeconomic data. Therefore, this research contributes to the empirical evidence and policy development related to population aging in developing countries. The economic impact of an aging population serves as a guide for creating policies in preparation for population aging.

This research differs from previous results, particularly in the context of Indonesia. First, a regional method is employed by focusing on 'kabupaten' or 'kota' (districts or cities). Second, a modified age limit is used for the OADR (Old Age Dependency Ratio) and YADR (Young Age Dependency Ratio) to balance the official retirement age. This raises the research question relating to the effect of population aging on economic growth.

To address this question, the first section provides an overview of population aging. Section 2 summarizes the literature on aging and its economic impact, while Section 3 explains the methods and data. The results and discussion are presented in Section 4, while Section 5 presents the main conclusions.

2. LITERATURE REVIEW

The influence of population aging affects different aspects of economic growth. The theory of demographic transition explains the influence of population development on economic growth since societies evolve from low to high socioeconomic levels (Kingsley, 1963; Van de Kaa, 2002).

Based on the description above, Nagarajan, Teixeira, and Silva (2016) identified three key channels through which population aging impacts economic growth. These include changes in public social expenditure, human capital, as well as consumption and savings patterns. Additionally, the consumption patterns of individuals shift after retirement, leading to changes in household spending (Aguila, Attanasio, & Meghir, 2011; Blau, 2008). The increase in the aging population also influences household requirements and general preferences (Aigner-Walder & Döring, 2012; Velarde & Herrmann, 2014) since older adults tend to have different consumption behaviors due to changes in disposable income. The growing proportion of older adults reduces per capita income across all age groups, resulting in a decrease in total family consumption (Lee & Mason, 2007). Additionally, an increase in the Old Age Dependency Ratio (OADR) is projected to lessen the disposable income of working populations as well as contribute to a decrease in fertility rates.

The second channel is the workforce, and the shrinking labor force slows GDP growth by reducing employment growth (Maestas, Mullen, & Powell, 2022). This leads to labor shortages in specific sectors, affecting overall economic output. The third channel is the rising dependency ratio. A higher old-age dependency ratio (OADR) places significant pressure on public finances since fewer working-age individuals are available to support dependents. This leads to increased government spending on healthcare, pensions, and social services (Temsumrit, 2023). According to Temsumrit (2023), population aging significantly raises aggregate government spending, specifically in developed countries, where social protection and environmental expenditures are affected.

The fourth channel is savings and investment (Liu, Chen, Lv, & Failler, 2023). Older adults save more and invest conservatively, leading to shifts in investment patterns toward safer and less risky assets. This shift affects capital markets and reduces the funds available for investment in areas such as infrastructure or innovation (Ansari, 2019).

Numerous research studies have examined the economic impact of aging, especially on growth. Lee and Mason (2017) found that an aging population and slower labor force growth affected economies by slowing GDP growth, increasing costs for the working-age population to support older adults, and straining public budgets due to rising healthcare and retirement costs. However, Bloom, Canning, and Finlay (2010) reported that population aging did not significantly slow economic growth in developing countries since behavioral responses, such as increased female labor force participation and policy reforms, mitigated the economic consequences.

Liu et al. (2023) reported that population aging significantly affects economic growth by impeding industrial advancement as well as the rationalization and optimization of industries. Kotschy and Bloom (2023) suggested that even though population aging is expected to decrease economic growth globally, enhancements in labor supply through improved functional capacity could offset the negative impact.

Beyond the negative impact, Mamun, Rahman, and Khanam (2020) stated that aging population growth affected per capita real GDP when the formation was outpaced. Therefore, the aging population is not an issue for Bangladesh, provided economic growth continues. Pham and Vo (2021) found that the aging population negatively impacted

economic growth in developing countries in the short term. There was also a positive association between the proportion of older adults and long-term economic performance. Quantile regression results showed the significance of an aging population on economic growth across distinct percentiles, where the estimated effects varied across the spectrum.

3. RESEARCH METHOD

3.1. Data

This research applies a quantitative method to obtain secondary data sourced from official publications of BPS-Statistics Indonesia. The data include printed and online publications from all BPS websites at the provincial and district or city levels. Furthermore, the complete data sources used in this research are described in Table 1.

Table 1. The list of data sources.

The data	Source
Population by age group and district or city.	Population projection by district or city 2020–2035 based on population census 2020 results in 34 provinces
Population by age groups and provinces.	Population projections 2020–2050 population census 2020 results
District gross regional domestic product by expenditure.	Gross regional domestic product of districts or cities by expenditure in 514 districts or cities
Gross fixed capital formation.	Gross regional domestic product of districts or cities by expenditure in 514 districts or cities
Characteristics of older adults.	Raw data for the 2020 national socio-economic survey
Employment aspects of older adults.	Labor force condition in august in 34 provinces across Indonesia for several periods

3.2. Methodology

The economic role of older adults in the labor market certainly affects national income (GDP). This is because national income represents a function of capital and labor, where $Y = f(K, L)$ (Solow, 1956).
The empirical form is expressed as follows:

$$\ln GDRP_i = \beta_0 + \beta_1 OADR_i + \beta_2 YADR_i + \beta_3 \ln older\ worker_i + \beta_4 \ln educatedemployment_i + \beta_5 lnphysicalcapital_i + \varepsilon_i \quad (1)$$

GDP refers to the Gross Domestic Product at the county level, while OADR and YADR stand for the Old Age Dependency Ratio and the Young Age Dependency Ratio, respectively. 'Older Adults' denotes the population aged 60 and over who are employed. 'Educated Employment' represents the number of adults with a diploma level, serving as a proxy for human capital. Gross fixed capital formation serves as a proxy for physical capital. The model was developed using 2020 regional-level data, including districts and cities across Indonesia. Therefore, the model is based on a sample of 514 district and city units.

This research uses a modified OADR based on the work of Islam, Ng, Manierre, Hamiduzzaman, and Tareque (2022). In this modified method, the OADR is the proportion of the population aged 60 and older to those aged 15 to 59. Similarly, YADR is calculated as the ratio of the population between the ages of 0 and 14 to those between the ages of 15 and 59. This revised age limit is used because retirement is set at 60 years. Furthermore, the model assumes that changes in age structure are exogenous factors.

4. RESULTS AND DISCUSSION

4.1. Describing Indonesian Population Aging

The overall situation of older adults must be described to gain a better understanding of population aging in Indonesia. According to Adioetomo and Mujahid (2014), Indonesia is on the brink of population aging. The 2020

Population Census showed that 9.78% of the population was 60 years of age or older (BPS, 2021), and by 2050, that percentage may rise to 21.9% (BPS, 2023).

Based on the description above, population projections show that the distribution of individuals aged 60 and over varies across provinces (Table 2). Significant variability is reported in older adults across Indonesian provinces, and the proportions change from 2020 to 2050. In 2020, DI Yogyakarta recorded the highest proportion of older adults at 15.94%, followed by Jawa Timur and Jawa Tengah at 13.07% and 12.22%, respectively. Meanwhile, provinces such as Papua Barat, Papua, and Maluku Utara, at 5.82%, 5.94%, and 7.04%, show the lowest proportions. These differences persist throughout the decades, and the gap between provinces is becoming increasingly pronounced.

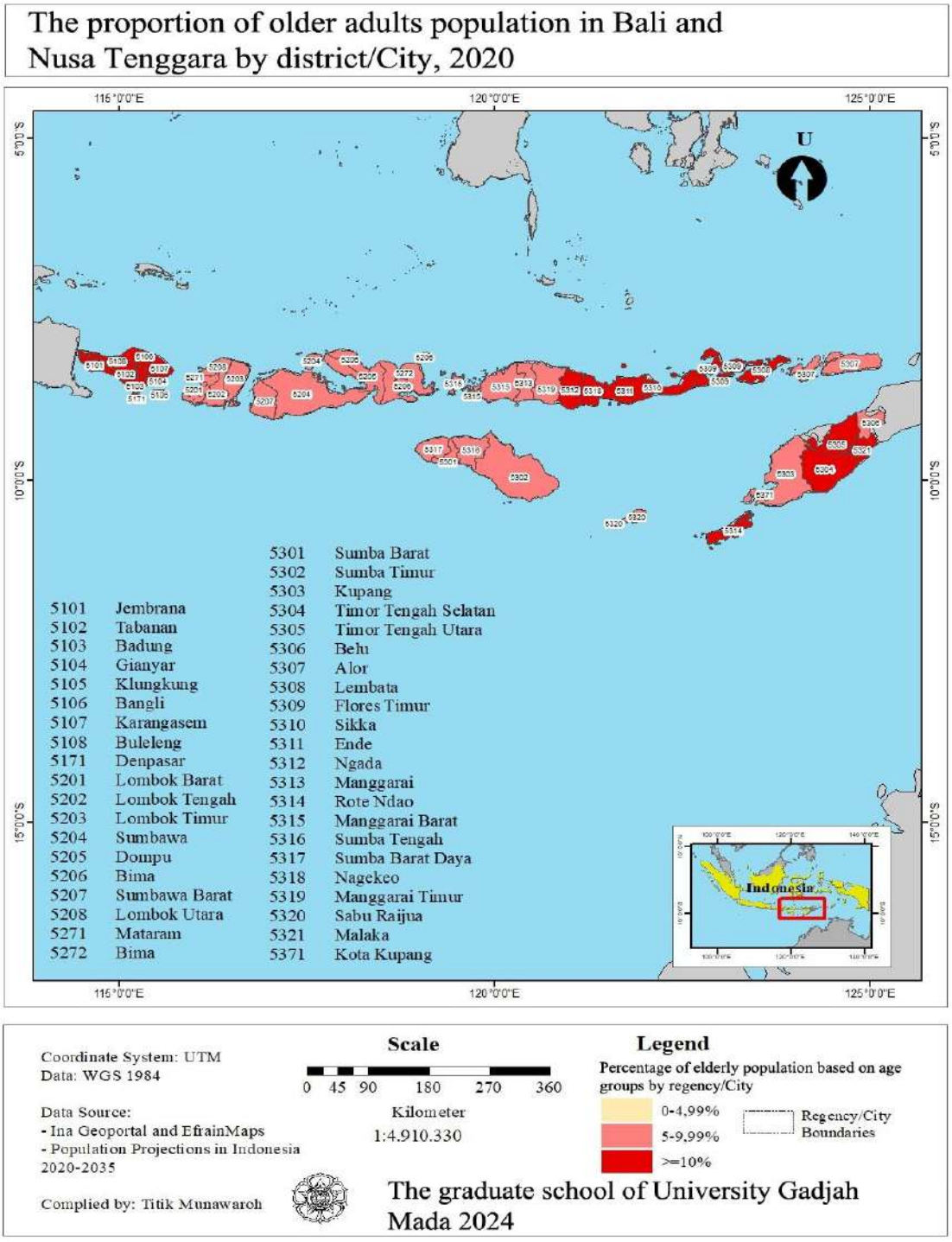
Table 2. Proportion of older adults by province in Indonesia, 2020-2050.

Province	The proportion of older adults			
	2020	2030	2040	2050
11. Aceh	8.14	11.18	14.96	18.31
12. Sumatera Utara	8.46	12.03	15.53	18.46
13. Sumatera Barat	10.46	13.52	16.48	18.92
14. Riau	6.53	10.93	15.96	19.99
15. Jambi	7.90	12.13	16.81	20.44
16. Sumatera Selatan	8.75	12.66	17.06	20.68
17. Bengkulu	8.32	12.26	16.50	19.97
18. Lampung	9.59	13.31	17.52	20.87
19. Kep. Bangka Belitung	8.35	12.26	16.86	20.72
21. Kepulauan Riau	6.07	10.44	16.34	20.81
31. DKI Jakarta	9.03	15.42	22.79	28.45
32. Jawa Barat	9.24	13.97	18.98	23.00
33. Jawa Tengah	12.22	16.66	20.83	24.04
34. DI Yogyakarta	15.94	19.82	23.29	25.50
35. Jawa Timur	13.07	17.89	22.42	25.41
36. Banten	7.15	12.14	17.86	22.66
51. Bali	12.88	17.41	21.92	24.58
52. Nusa Tenggara Barat	8.21	11.41	15.41	18.86
53. Nusa Tenggara Timur	9.03	10.94	13.20	15.44
61. Kalimantan Barat	8.12	11.78	16.18	20.09
62. Kalimantan Tengah	7.41	11.23	15.69	19.56
63. Kalimantan Selatan	8.06	12.35	17.28	20.16
64. Kalimantan Timur	7.47	10.07	13.76	17.70
65. Kalimantan Utara	6.97	10.79	15.67	20.02
71. Sulawesi Utara	12.19	16.10	20.03	22.31
72. Sulawesi Tengah	8.20	11.81	15.86	19.18
73. Sulawesi Selatan	10.20	13.33	16.84	19.80
74. Sulawesi Tenggara	7.51	10.34	13.77	16.88
75. Gorontalo	8.84	12.21	15.80	18.72
76. Sulawesi Barat	7.58	10.19	13.44	16.34
81. Maluku	8.46	10.81	13.94	17.34
82. Maluku Utara	7.04	10.28	14.56	19.94
91. Papua Barat	5.82	8.95	13.00	17.09
94. Papua	5.94	9.54	13.95	17.89
Indonesia	**9.93**	**14.10**	**18.47**	**21.90**

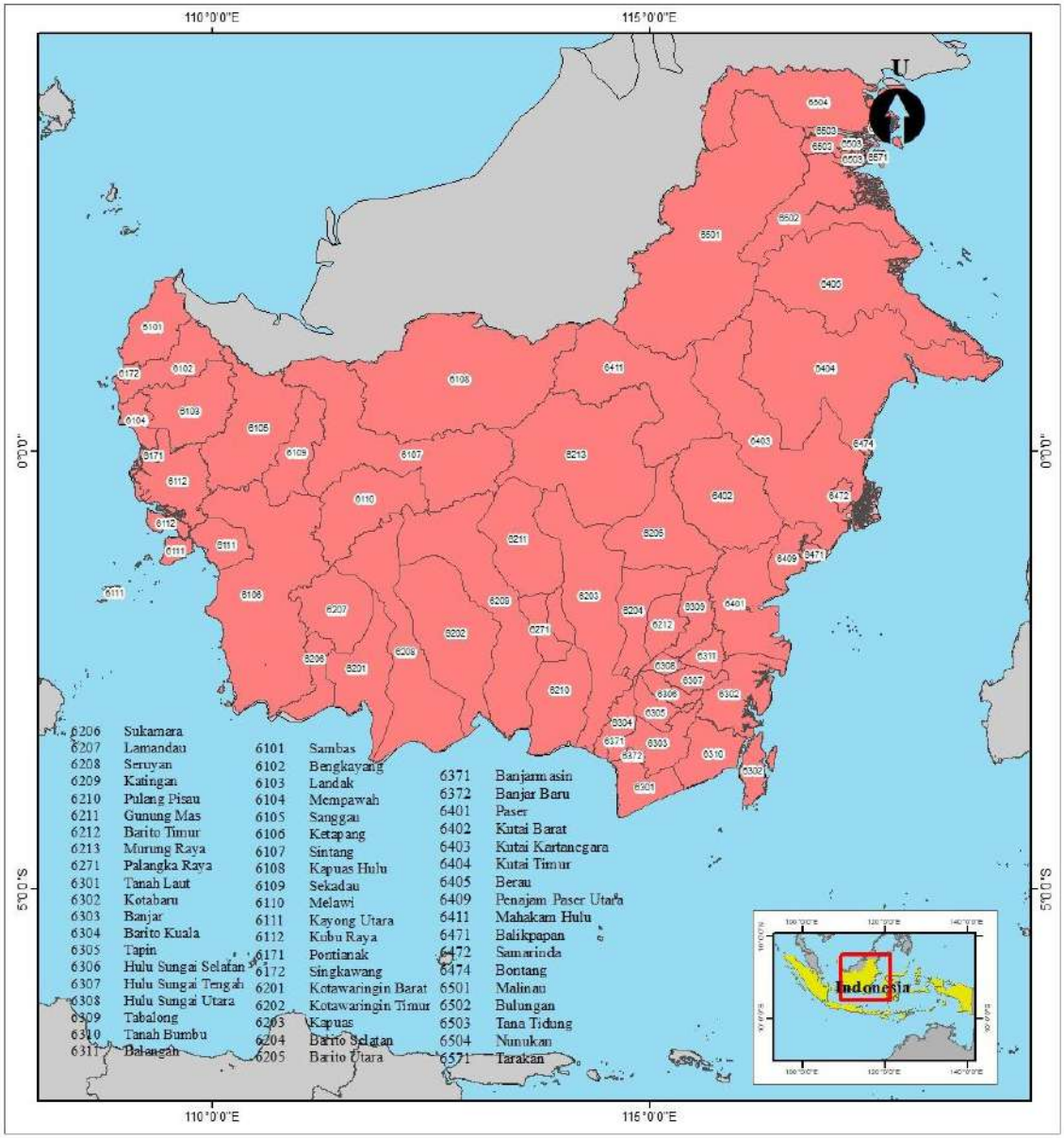
Source: Indonesian population projection 2020-2050 result of the 2020 Indonesian population census.

In 2050, DI Yogyakarta will be surpassed by DKI Jakarta as the province with the highest proportion of older adults, reaching 28.45%. East and Central Java experienced significant increases, with the proportions rising to 25.41% and 24.04%, respectively. The provinces with the lowest proportions of older adults are Nusa Tenggara Timur, Sulawesi Barat, Sulawesi Tenggara, and Papua Barat. The data shows a stark disparity in aging across regions, with some provinces experiencing a faster demographic transition than others. This also describes the diverse pace

and scale of demographic aging across Indonesian provinces, reflecting a complex regional pattern of population change.



The proportion of older adults population in Kalimantan by district/City, 2020



Coordinate System: UTM
Data: WGS 1984

Data Source:
- Ina Geoportal and EfrainMaps
- Population Projections in Indonesia 2020-2035

Complied by: Titik Munawaroh

Scale

0 40 80 160 240 320

Kilometer

1:4.705.026

Legend

Percentage of elderly population based on age groups by regency/City

- 0-4,99%
- 5-9,99%
- >=10%

Regency/City Boundaries

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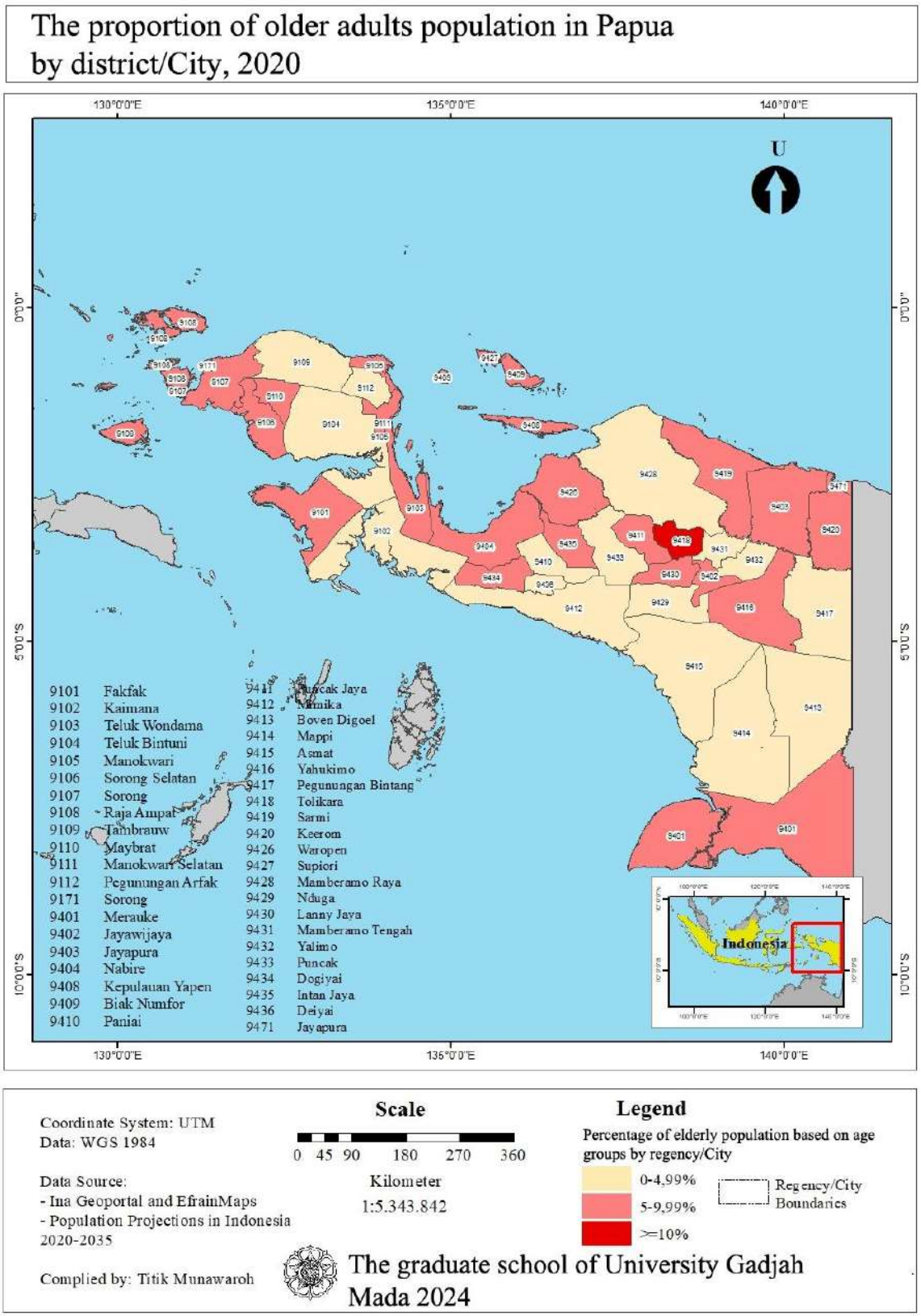
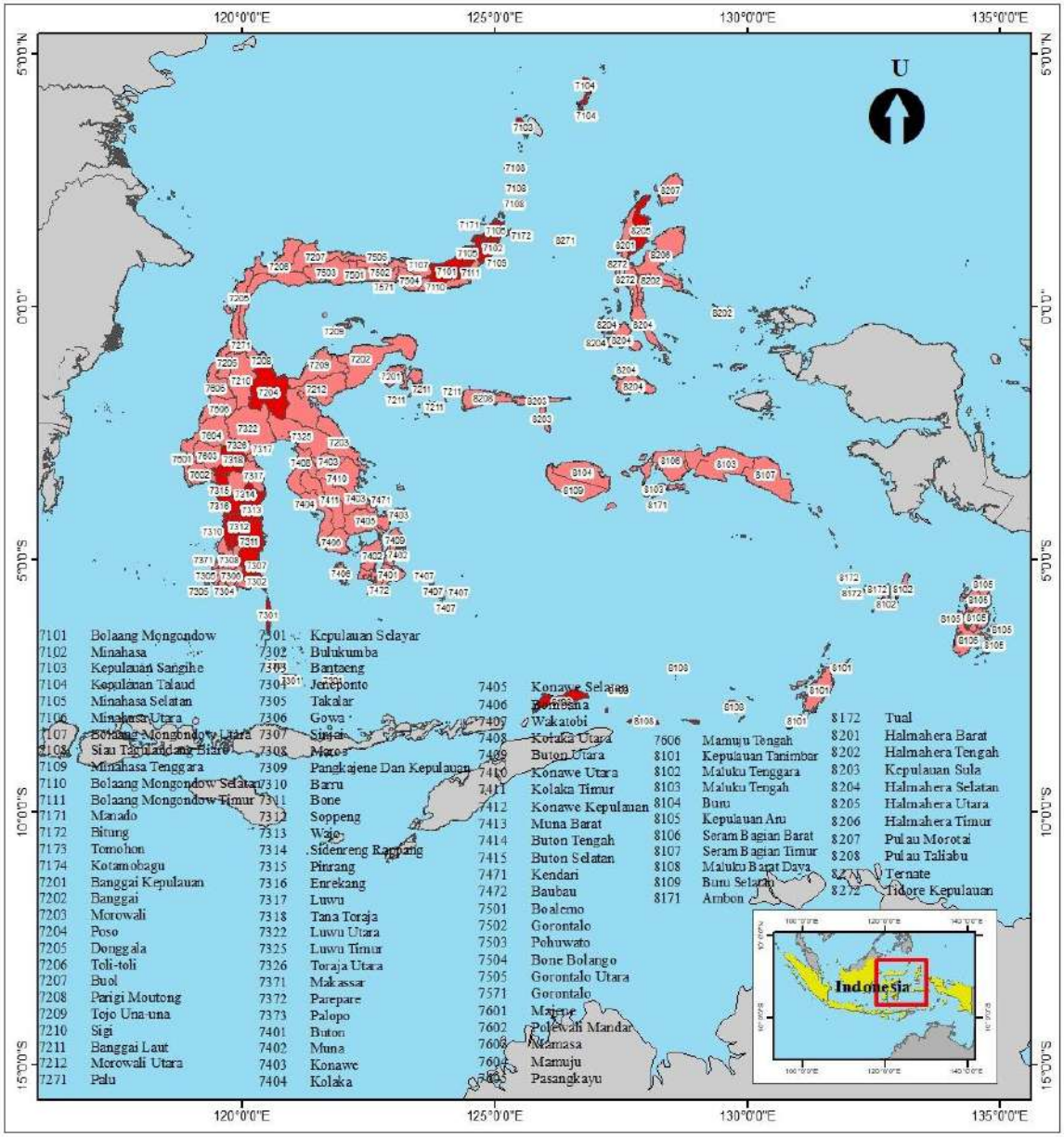


The proportion of older adults population in Sulawesi and Maluku by district/City, 2020



Coordinate System: UTM
Data: WGS 1984

Data Source:
- Ina Geoportal and EfrainMaps
- Population Projections in Indonesia 2020-2035

Complied by: Titik Munawaroh

Scale

0 75 150 300 450 600

Kilometer

1:8.153.804

Legend

Percentage of elderly population based on age groups by regency/City

0-4,99%
5-9,99%
>=10%
Regency/City Boundaries

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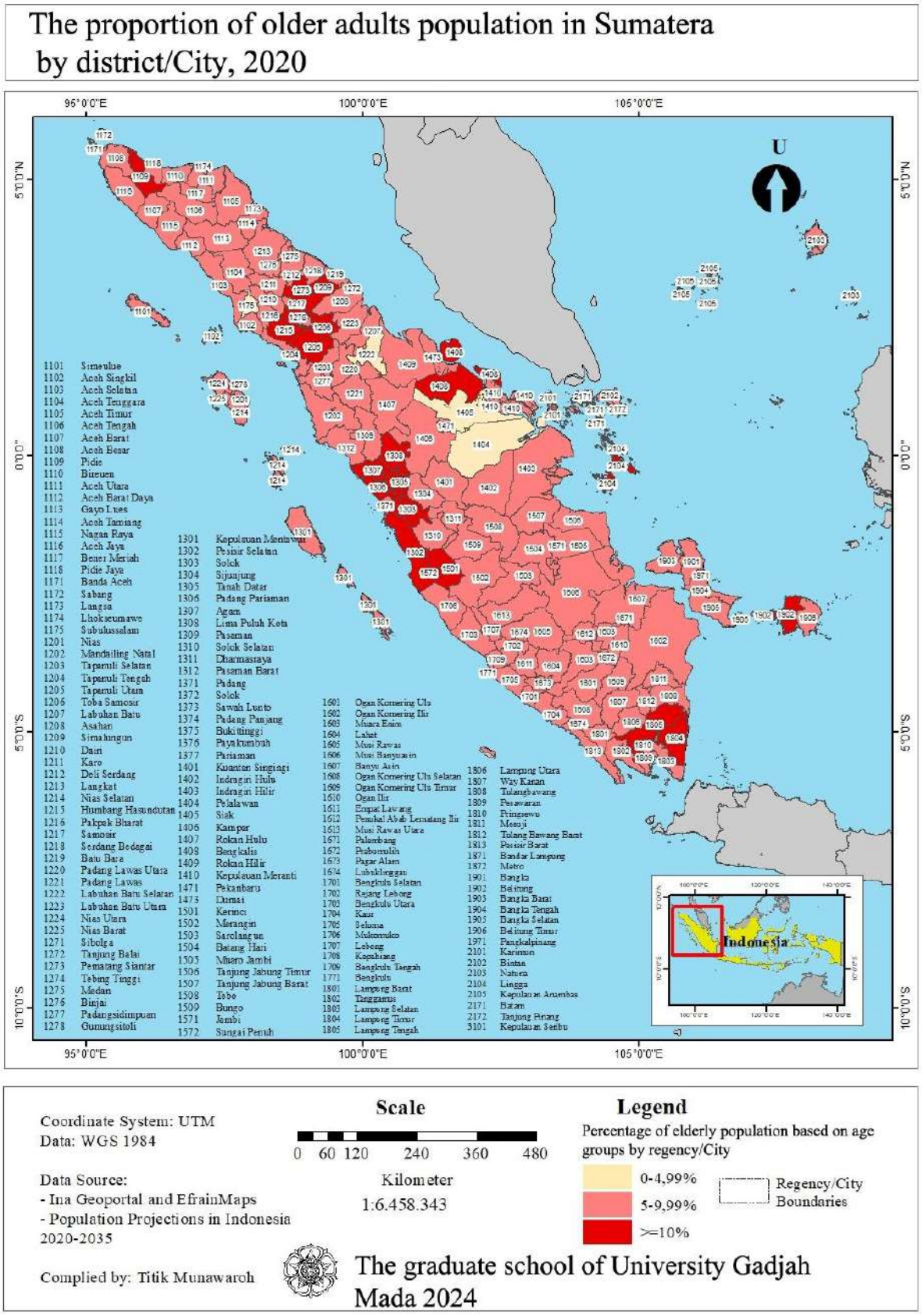

Figure 2. Distribution of the older adult population in each district or city by island in Indonesia, 2020.

Source: Indonesian population projection 2020-2035.

The distribution of older adults by province is not reflected at the district level. Provinces described as aging in 2020 are not automatically followed by all districts or cities. The distribution of the population aged 60 and over by district or city within the main island groups shows considerable regional variation (Figure 2). Java is predominantly pink, with some areas marked in dark red. Sulawesi, Bali, and Southeast Nusa Tenggara reported a fairly balanced distribution between districts with more and less than 10% older adults. Meanwhile, Papua has the fewest districts with 10% or more older adults.

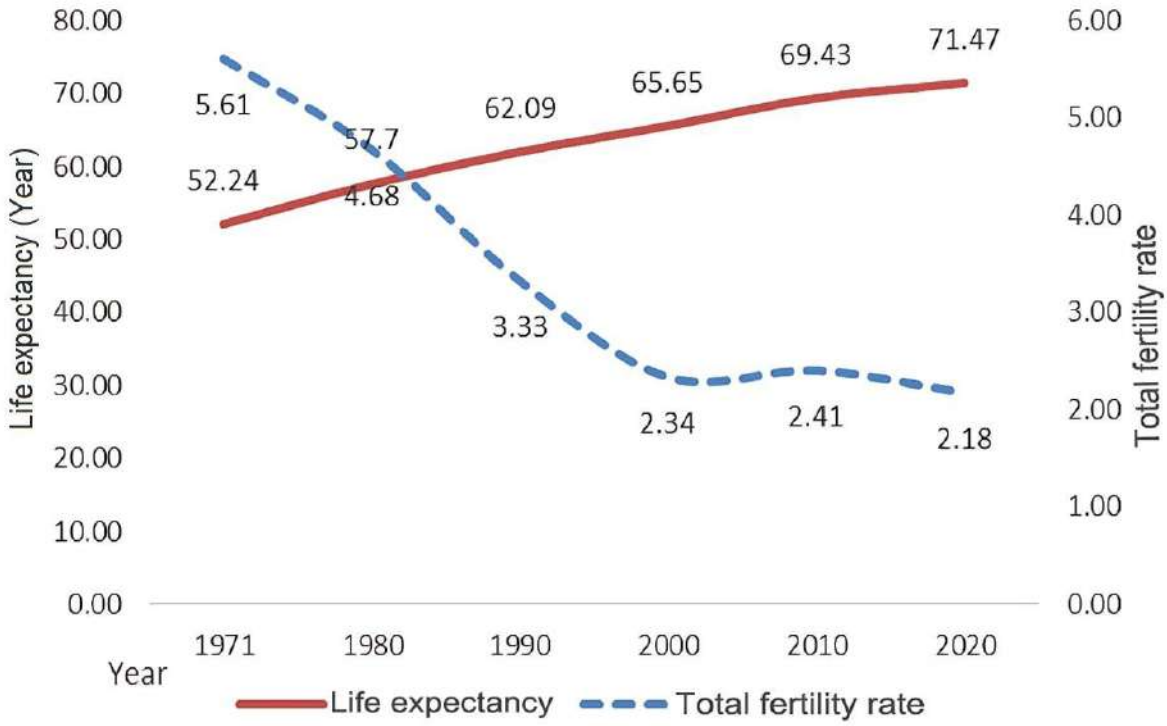

Figure 3. Trend of total fertility rate (TFR) and life expectancy 1971-2020.

Source: BPS (Author compilation).

Population aging is driven by a simultaneous rise in life expectancy and a decrease in birth rates. The fertility rate in Indonesia has decreased significantly since 1971, from 5.61 to 2.15 in 2020 (Figure 3). In this context, Hull (1987) argued that the decrease in the fertility rate was due to institutional developments, including changes in the economy, contraception, marriage, and reproduction, which influence individual behavior and fertility decisions. Even though fertility behavior is shaped by individual decision-making, the decisions are not entirely rational. The decisions are influenced by habit, guidance from others, and an environment shaped by government policies. According to Listyaningsih and Satiti (2021), the decline in fertility from 1970 to 1990 was primarily due to the success of the family planning program. From an individual perspective, a decline in the Total Fertility Rate (TFR) is also influenced by delayed marriage (Arsyad & Nurhayati, 2016) and the use of contraceptives (Ekawati, Rahayuwati, Nurhidayah, Agustina, & Rahayu, 2019).

The simultaneous rise in life expectancy and decline in the total fertility rate (TFR) have led to an aging population structure. In Indonesia, life expectancy has steadily increased from 1971 to 2020. The average life expectancy in the early 1970s was 52.24 years, meaning an individual born in that period could live to about 52 years of age. Improvements in health facilities, including reductions in infant and maternal mortality rates, have contributed to the increase in life expectancy. Life expectancy had reached 71.47 years by 2020, showing an increase of nearly 20 years over five decades.

Table 3. Trend of the total fertility rate (TFR) by province in Indonesia, 1971–2020.

Province	Total fertility rate					
	SP1971	SP1980	SP1990	SP2000	SP2010	LF SP2020
11. Aceh	6.27	5.24	4.37	2.81	2.79	2.42
12. Sumatera Utara	7.2	5.94	4.29	3.1	3.01	2.48
13. Sumatera Barat	6.18	5.76	3.89	3.06	2.91	2.46
14. Riau	5.94	5.44	4.09	2.77	2.82	2.28
15. Jambi	6.39	5.57	3.76	2.67	2.51	2.28
16. Sumatera Selatan	6.33	5.59	4.22	2.88	2.56	2.23
17. Bengkulu	6.72	6.2	3.97	2.68	2.51	2.3
18. Lampung	6.36	5.75	4.05	2.65	2.45	2.28
19. Kep. Bangka Belitung	-	-	-	2.6	2.54	2.24
21. Kepulauan Riau	-	-	-	-	2.38	2.21
31. DKI Jakarta	5.18	3.99	2.33	1.63	1.82	1.75
32. Jawa Barat	6.34	5.07	3.47	2.51	2.43	2.11
33. Jawa Tengah	5.33	4.37	3.05	2.06	2.2	2.09
34. DI Yogyakarta	4.76	3.42	2.08	1.44	1.94	1.89
35. Jawa Timur	4.72	3.56	2.46	1.71	2	1.98
36. Banten	-	-	-	2.72	2.35	2.01
51. Bali	5.96	3.97	2.28	1.89	2.13	2.04
52. Nusa Tenggara Barat	6.66	6.49	4.98	2.92	2.59	2.43
53. Nusa Tenggara Timur	5.96	5.54	4.61	3.37	3.82	2.79
61. Kalimantan Barat	6.27	5.52	4.44	2.99	2.64	2.33
62. Kalimantan Tengah	6.83	5.87	4.03	2.74	2.56	2.31
63. Kalimantan Selatan	5.43	4.6	3.24	2.33	2.35	2.31
64. Kalimantan Timur	5.41	4.99	3.28	2.5	2.61	2.18
65. Kalimantan Utara	-	-	-	-	-	2.35
71. Sulawesi Utara	6.79	4.91	2.69	2.13	2.43	2.1
72. Sulawesi Tengah	6.53	5.9	3.85	2.75	2.94	2.32
73. Sulawesi Selatan	5.71	4.88	3.54	2.56	2.55	2.22
74. Sulawesi Tenggara	6.45	5.82	4.91	3.31	3.2	2.57
75. Gorontalo	-	-	-	2.7	2.76	2.3
76. Sulawesi Barat	-	-	-	-	3.33	2.58
81. Maluku	6.89	6.16	4.59	3.39	3.56	2.52
82. Maluku Utara	-	-	-	3.18	3.35	2.47
91. Papua Barat	-	-	-	-	3.18	2.66
94. Papua	7.2	5.35	4.7	3.28	2.87	2.76
Indonesia	**5.61**	**4.68**	**3.33**	**2.34**	**2.41**	**2.18**

Source: BPS, results of the 1971–2020 population census.

The decline in TFR from 1971 to 2020 has been observed across all provinces at varying rates. DI Yogyakarta is the most rapidly aging province, possessing the lowest TFR from 1971 to the present. In 2020, the TFR was recorded at 1.89, below the national average, as reported in Table 3.

The feminization of aging refers to the phenomenon where women outnumber men in the older adult population (Sousa, Lima, Cesar, & Barros, 2018). This trend is also observed in Indonesia, as the older adult population is predominantly female. According to BPS (2020), 52.29% of older adults are women and 47.71% are men, respectively. The proportion of older women exceeds that of men across nearly all provinces, with the exceptions of Lampung, Kalimantan Timur, Kalimantan Tengah, Kalimantan Utara, Riau, Kepulauan Riau, Papua, and Papua Barat, where the difference ranges from 5.44% to 17.04% (Figure 4).

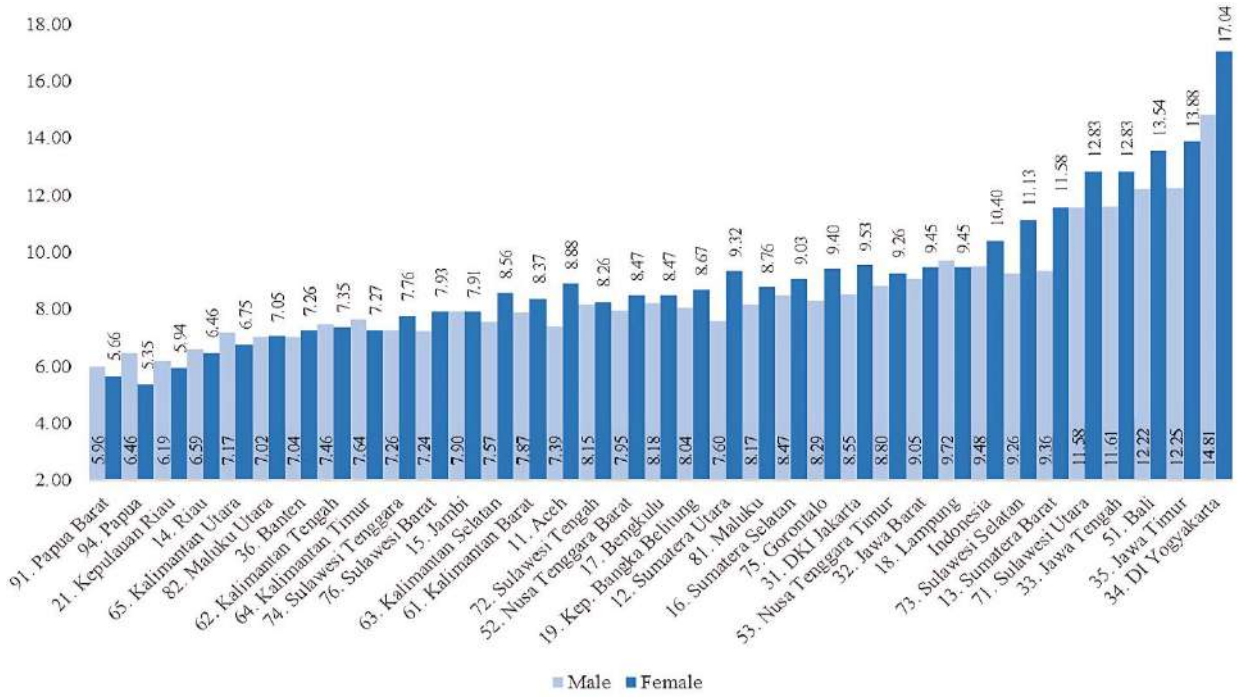

Figure 4. Proportion of population aged 60 years and over by gender and province.
Source: Indonesian population projection 2020-2050 result of the 2020 Indonesian population census.

Figure 5 illustrates the distribution of older adults by age group in each province of Indonesia. The categories of adults include young, middle-aged, and older adults within the ages of 60 to 69, 70 to 79, and 80 and above, respectively. The overall population is predominantly made up of young older adults, and this age group is the largest across all provinces. The proportion of older adults gradually decreases with increasing age. This trend suggests that Indonesia's aging population is still in the early stages of demographic transition. The proportion of middle-aged older adults varies across provinces, generally ranging between 20% and 31% of the total older adult population. Meanwhile, the share of older adults remains relatively low, typically below 10% in most provinces.

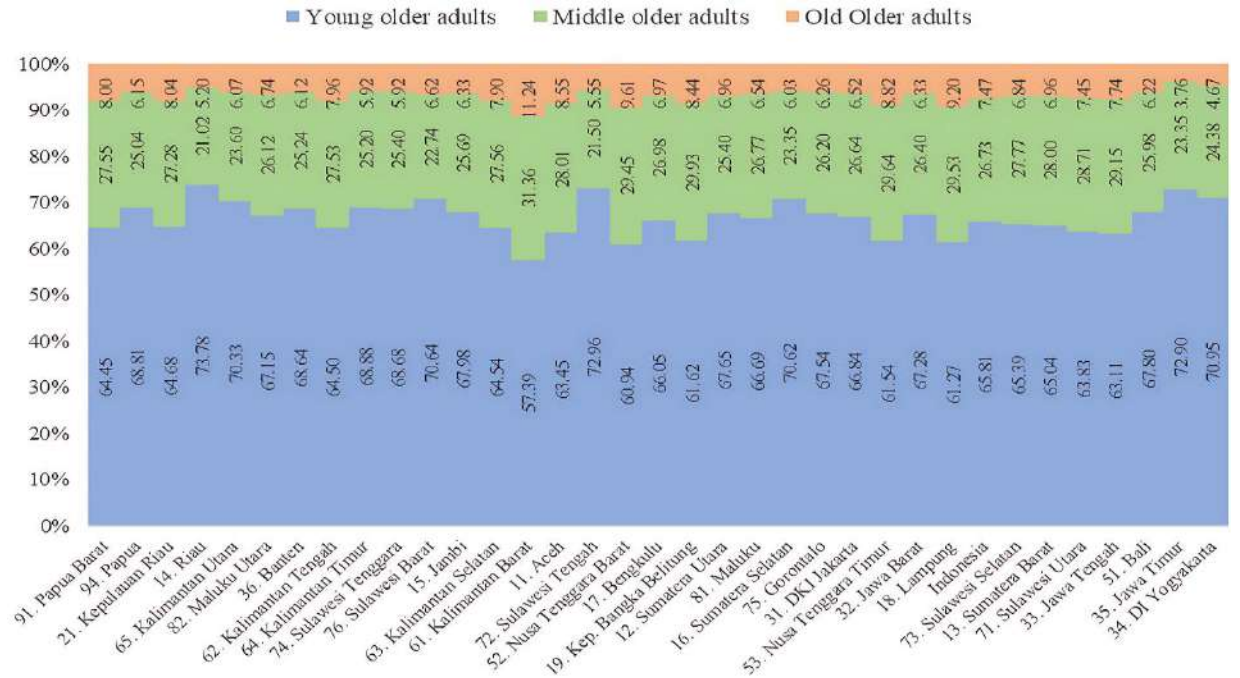

Figure 5. Distribution of older adults by age category and province.
Source: Indonesian population projection 2020-2050 result of the 2020 Indonesian population census.

According to BPS, the older adult population remains largely productive, with half of the group actively employed. The percentage of older adults in Indonesia who remain in the workforce over the past decade is presented in Figure 6. The data indicate an upward trend, with the proportion of working older adults rising from 44.76% in 2010 to 51.04% in 2020. This increase suggests a growing tendency for older adults to be highly employed due to several interrelated factors. Work must also be carried out to avoid poverty and earn a living, especially in the absence of adequate pension benefits or a reliable social security system (Sukamdi et al., 2024). The lack of pension security and sufficient social protection mechanisms forces older adults to keep working and maintain financial stability (TNP2K & SMERU, 2020). Therefore, work becomes an important method of survival (Sukamdi et al., 2024).

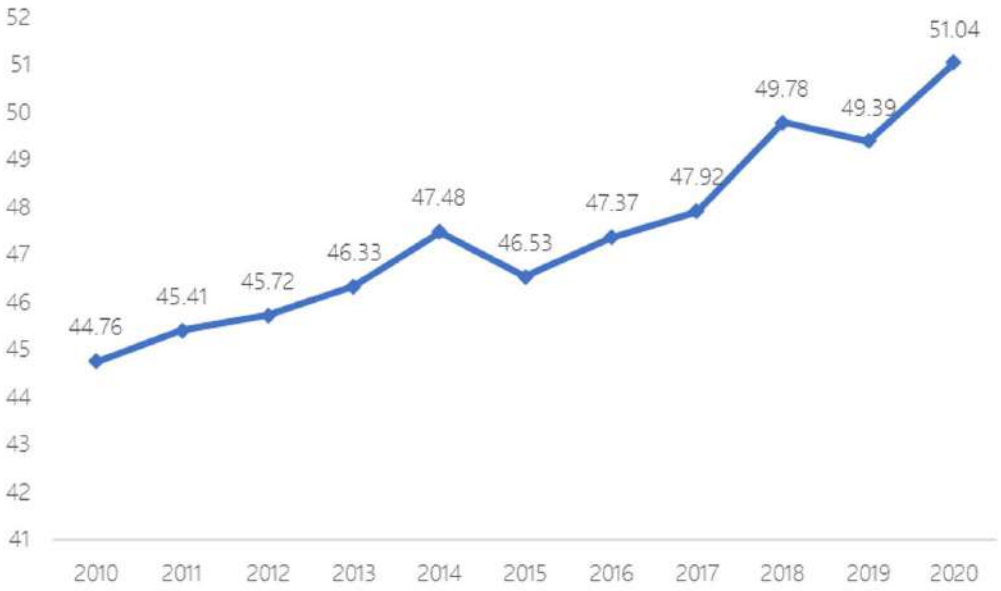

Figure 6. Proportion of older adults economically active in Indonesia 2010 and 2020 by province.
Source: BPS, compiled by the author.

Older adults without disabilities are easily employed since health status plays a crucial role in the ability to work. Physically active and healthy individuals tend to be more productive (Rahayuwati et al., 2024; Suriastini, Wijayanti, & Oktarina, 2024). Furthermore, health status is crucial for older adults concerning their ability to work. According to BPS (2020), the morbidity rate has decreased in recent years, contributing to greater physical productivity in this age group.

4.2. Population Aging and the Economy

An increase in the older adult population presents an economic risk to a region. In this context, the Older Adult Dependency Ratio (OADR) is the most commonly used statistic to analyze population aging from an economic perspective. The increase is viewed as an added burden due to the growing older adult population.

Figure 7 illustrates the trend of OADR and YADR in Indonesia from 1971 to 2020, along with projections up to 2050. The OADR has shown a consistent upward trend from 1971 to 2020 and is projected to continue rising with an increased population of older adults. Conversely, YADR has been declining rapidly up to 2020 and is expected to continue decreasing at a slower rate. OADR and YADR represent a burden on the productive age group since the consumption level of the population exceeds production, necessitating support from the working age.

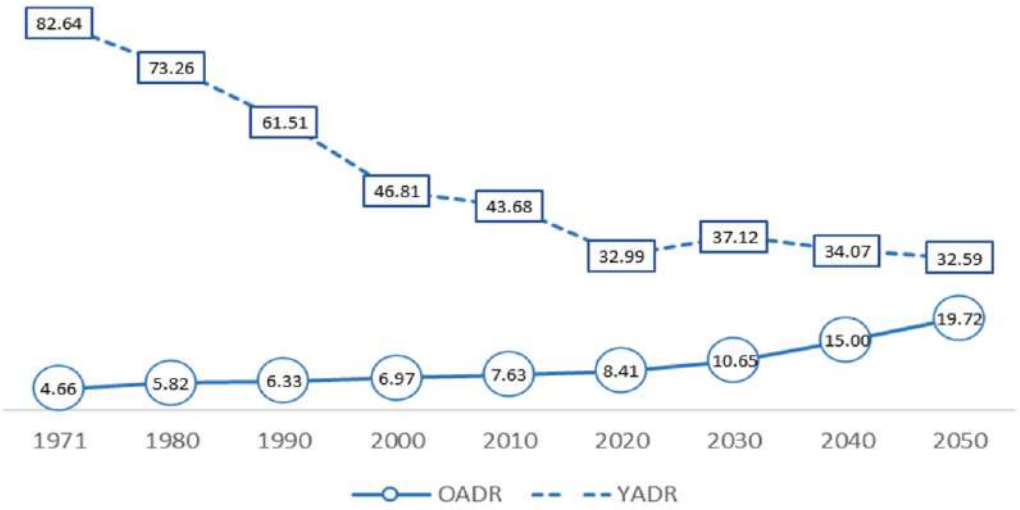

Figure 7. Trend of OADR and YADR in Indonesia, 1971–2050.
Source: Population census 1971–2020; Population projection 2020–2050.

Based on the description above, this research examines the association between population aging and the economy by focusing on the influence of aging on economic growth. According to the methodology using the Solow model, economic growth is indirectly influenced by capital and labor. Population aging, measured by the OADR indicator, possesses a negative association with economic growth. This negative effect is evident in the traditional and modified OADR, but the magnitudes are different. An aging population may slow the growth of the GDRP (Gross Domestic Regional Product) at the regional level. A 1% increase in the traditional OADR is estimated to reduce economic growth by 0.03%. In contrast, the impact of a 1% increase in the modified OADR is slightly smaller at 0.02%. The results were consistent with Pin Tan et al. (2021), where a rise in the aging population reduced economic growth. This contradicted the research by Mamun et al. (2020), where a positive association was reported between population aging and long-term economic growth.

Beyond OADR, YADR serves as an indicator of the young population's dependency on the working-age population and negatively impacts economic growth. In this case, a 1% increase in YADR reduced economic growth by 0.005%. Economic growth may be slowed down because of a rise in the young dependency ratio due to several reasons. An increase in this population compared to the working age leads to a smaller proportion of individuals available to work. This decrease in the labor force results in reduced economic output and growth (Bidisha, Abdullah, Siddiqua, & Islam, 2020; Huang, Lin, & Lee, 2019).

Table 4. The Impact of population aging on economic growth in Indonesia.

Model with traditional OADR and YADR	Coef.	Std. err.	t	P>t	Impact on economic growth*
OADR	-0.035	0.007	-5.010	0.000	-0.035
YADR	-0.005	0.002	-2.250	0.025	-0.005
Ln (Older worker)	0.214	0.026	8.090	0.000	0.214
Ln (Educated employment)	0.075	0.032	2.310	0.021	0.074
Ln (Capital)	0.780	0.025	31.690	0.000	0.780
_cons	2.166	0.247	8.770	0.000	---
Model with modified OADR and YADR					
OADR	-0.022	0.005	-4.530	0.000	-0.022
YADR	-0.005	0.002	-2.370	0.018	-0.005
Ln (Older worker)	0.210	0.027	7.850	0.000	0.210
Ln (Educated employment)	0.076	0.033	2.340	0.020	0.076
Ln (Capital)	0.784	0.025	31.810	0.000	0.784
_cons	2.165	0.249	8.710	0.000	---

Note: ln(Y)=B0 + B1*X + u ~ A change in X by one unit (ΔX=1) is associated with a (exp(B1)-1)*100% change in Y (Stock & Watson, 2006).
ln(Y)=B0 + B1*ln(X) + u ~ A 1% change in X is associated with a B1 percent change in Y, hence B1 is the elasticity of Y with respect to X.

The significantly positive coefficient for the rate of change in the older adult variable (Ln_olderworker) shows that individuals aged 60 and older in the workforce contribute positively to the GDP growth rate. The empirical findings suggest that an aging workforce has a positive influence. This is consistent with Huang et al. (2019), where older adults enhanced the learning abilities of younger and prime-age adults. This dynamic supports 'learning by seeing or interacting' relationships between distinct age groups to increase productivity. The results also suggest that older adults mitigate the negative effects of population aging on economic growth. Older adults reduce the early retirement burden and expand the tax base by remaining employed, contributing to economic growth (Huang et al., 2019).

The sharp rise in the old-age dependency ratio is expected to impose a social burden even though aging adults are seen as enhancing productivity. An increase in the OADR shows that the working-age population faces a greater economic burden to support retirees through taxes and social security contributions (Skirbekk et al., 2022). Additionally, governments and private sectors must allocate more resources to pensions and healthcare services for older adults (European Commission, 2021). An aging population typically requires more healthcare services (Boyd, 2019). The demand for chronic disease management, long-term care facilities, and geriatric care is expected to increase, necessitating significant investment in healthcare infrastructure and workforce training. This leads to budget reallocations that may underfund essential services, such as education and infrastructure, increasing societal inequalities (Hong et al., 2023; Vrhovec & Tajnikar, 2016). In Indonesia, an increase in the OADR raises health expenditures for older adults more than for pensioners since the coverage is insufficient. However, a higher OADR can increase the share of government spending on other social protection programs.

Capital as a determinant of economic growth is divided into two groups, namely human and physical capital. Educated employment, which proxies human capital, positively influences economic growth. This research showed that every 1% increase in educated employment improved economic growth by 0.08%. Therefore, the variable has a positive impact on economic growth, increasing productivity and efficiency. Amir, Khan, and Bilal (2015) stated that an educated labor force has a positive impact on economic growth by increasing productivity at the macro level.

Beyond an educated labor force, physical and human capital, reflected in the value of gross fixed formation, has a positive effect on growth. However, the effect of physical capital is larger than that of human capital. According to this research, a 1% rise in physical capital enhanced economic growth by 0.7%. This result was consistent with Bunyamin (2022), where human and physical capital had a substantial positive effect on economic growth. Agusalim, Anggraeni, and Pasaribu (2022) found that physical capital was the main driver of the Indonesian economy. The results also showed the dominance of physical capital investment, which is consistent with the theme of economic strategy in recovering from the Asian crisis.

Long-term investments in physical capital have been prioritized to stimulate growth. Even though human capital has been recognized as important in terms of education, the impact has been less significant in driving economic growth. This suggests that the quality and effectiveness of education do not meet the demands of the evolving economy. This analysis shows the complex interplay between population aging, as well as physical and human capital, in shaping economic growth. An aging population, indicated by a rising Old-Age Dependency Ratio (OADR), poses challenges to economic growth through increased dependency burdens. The positive contribution of older adults to the labor force reports the potential for mitigating the effects. The results show a significant role of physical capital in driving economic growth, reflecting a strategic focus on infrastructure development. According to the relatively modest impact of human capital, workforce development and further investments in education are necessary to fully harness the potential of the evolving economy. This balance between physical and human capital is crucial in navigating the economic implications of an aging population and ensuring long-term sustainable growth.

Several limitations were reported regarding the data used. The model relied on cross-sectional data to avoid capturing long-term growth trends. This limitation presented an opportunity for further research to analyze the influence of aging on population growth.

5. CONCLUSION AND POLICY RECOMMENDATION

In conclusion, population aging and its economic implications were analyzed. This research reported a significant trend of increasing population aging, with the proportion of older adults projected to rise substantially by 2050. Some provinces experienced more rapid aging than others due to regional disparities. The declining Total Fertility Rate (TFR) and rising life expectancy contributed to the demographic shift. Meanwhile, the feminization of aging showed a greater number of older women compared to men.

Based on economic perspectives, this research reported a complex relationship between aging and growth. Older adults showed a positive contribution to economic growth, even though an increase in the Old Age Dependency Ratio (OADR) was associated with a negative impact. Therefore, an aging population imposed a burden through increased dependency, and the continued participation of older adults in the workforce mitigated some of the effects. This research showed that physical capital investment had a more substantial effect on economic growth, emphasizing a strategic focus on infrastructure development. However, the relatively limited impact of human capital suggested a need for improved educational investments in line with the evolving economic landscape.

Despite the insights, this research was constrained by the reliance on cross-sectional data, limiting the ability to capture long-term trends. Future research could benefit from longitudinal analyses to examine the long-term influence of aging on economic growth and offer a more nuanced understanding of its dynamics. Indonesia could develop a labor market for older adults, considering the number of active workers and the positive influence on economic growth. However, the health and basic rights of older adults must be prioritized as foundational elements. Balancing investments in physical and human capital would be essential to effectively address the challenges and seize the opportunities presented by an aging population. These results highlight the need for strategies to promote economic growth and address the requirements of the aging population.

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Institutional Review Board Statement: The Ethical Committee of the Universitas Gadjah Mada, Indonesia has granted approval for this study on 4 June 2024 (Ref. No. 2504/UN1/DITLIT.1/PT.01.01/2024).
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Data Availability Statement: The corresponding author can provide the supporting data of this study upon a reasonable request.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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