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Assessing the Current State and Future Trends of Land Use Conversion: Implications for Food Security in Indonesia

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ABSTRACT: Indonesia grapples with land conversion, especially agricultural land. Paddy fields have shrunk from 8.4 million hectares in 1990 to 7.18 million in 2022, translating to a rate of more than 38 thousand hectares per year and yearly loss of around 140,000 hectares of potential rice production. This study aims to inform policymakers and stakeholders on achieving food security. Through a systematic literature review, the research explores factors like settlements, urbanization, and infrastructure development driving land conversion. These factors impact regions like Bali and Central Sumba, jeopardizing rice production. Understanding these challenges and opportunities is crucial for future solutions. Potential solutions include strengthening food security across the supply chain, regulating land conversion and ownership, and promoting government support, productivity enhancement, sustainable agriculture practices, and technological integration.

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INTRODUCTION

Land use conversion, especially of agricultural land, poses a significant challenge for Indonesia. This competition for land, driven by growing populations and needs for both agricultural and non-agricultural purposes, outpaces the ability to create new land (Rondhi et al., 2018). This conversion reduces the availability of agricultural land, threatening food security. Ironically, developing countries with large populations and high food consumption often face the highest rates of agricultural land conversion (Azadi et al., 2011; Deloitte, 2013 cited in Rondhi et al., 2018).

Indonesia exemplifies this challenge. Population growth has fueled the conversion of paddy fields. As shown in Figure 1 (not included here, but assumed to depict the data), paddy fields have shrunk from 8.4 million hectares in 1990 to 7.18 million hectares in 2022. This translates to a yearly loss of 140,000 hectares of potential rice harvest area (Tridakusumah et al., 2022). Studies in Deli Serdang Regency by Siagian et al. (2019) confirm this trend, highlighting a significant reduction in rice fields and forests between 1989 and 2018. Much of this land has been converted to plantations and urban areas. This shift further marginalizes farmers, with many now cultivating plots smaller than 0.5 hectares (Handayani et al., 2018).

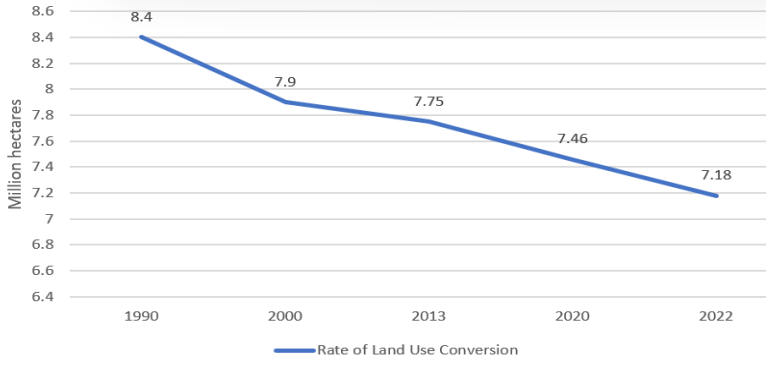

Figure 1. Rate of Land Use Conversion in Indonesia

Indonesia faces a complex challenge: land conversion and a growing population threaten its ability to achieve food self-sufficiency. While rice production has increased slightly (Setiawan et al., 2023), reaching 63.4 million tons in 2021, it remains insufficient to meet domestic needs. This necessitates ongoing food imports.

Land conversion is a critical factor jeopardizing national food security. It alters land use patterns, leading to a long-term decline in food security. This study aims to navigate this complex issue by examining the current state and future trends of land use conversion and its impact on Indonesia's agricultural sector. By providing valuable insights, it aspires to guide policymakers, researchers, and stakeholders in building a resilient and food-secure future for the nation.

MATERIALS AND METHODS

This study employed a Systematic Literature Review (SLR) following PRISMA guidelines. SLRs offer a transparent and comprehensive approach to gathering scientific evidence on a specific topic.

The review process involved two main stages: database selection and article selection. First, Scopus and Google Scholar were chosen for journal exploration. Specific keyword combinations were used in each database to target relevant studies. In Scopus, the search string included "land AND use AND conversion AND Indonesia AND food AND security" for publications between 2014-2023. Google Scholar used a broader search with "land AND use AND conversion AND Indonesia" for publications between 2014-2024.

Second, after initial searches, filters were applied to narrow down results based on publication year, article type, subject area, and open access availability (Scopus only). Abstracts were then reviewed to assess relevance to the research topic. Finally, a subset of the most relevant articles was selected for in-depth analysis. Following this process, 4 articles were identified from Scopus and 2 from Google Scholar, resulting in a total of 6 articles for this review.

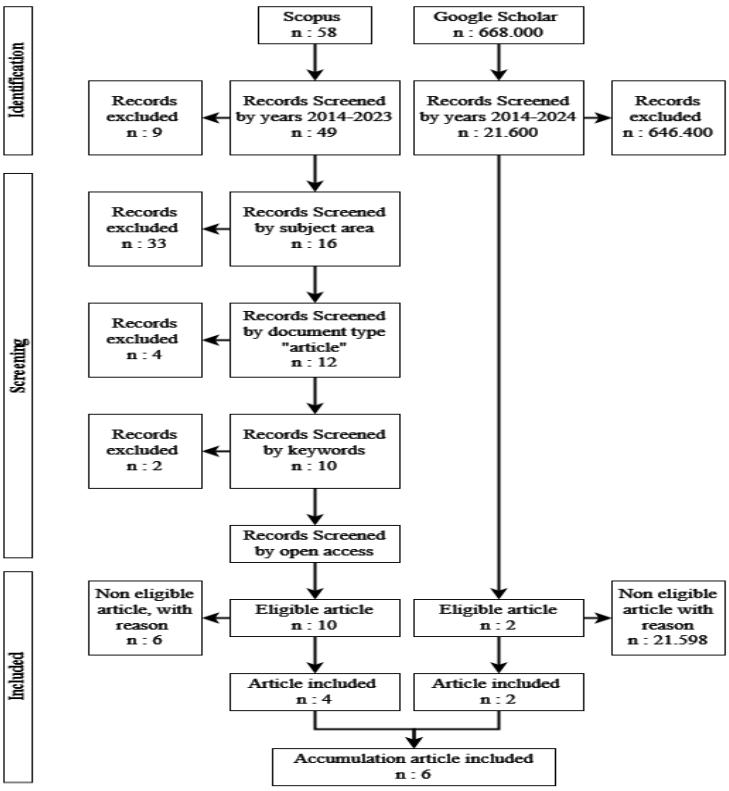

Figure 2. Flow Chart Methods Systematic Literature Review: Assessing the Current State and Future Trends of Land Use Conversion: Implications for Food Security in Indonesia

CURRENT STATE OF LAND USE CONVERSION IN INDONESIA

The current state of land use conversion in Indonesia is characterized by ongoing challenges and threats to agricultural land, particularly concerning the conversion of rice fields into non-agricultural land. Despite efforts to protect agricultural land through legislation such as the Spatial Plan Regulation and the Protection of Sustainable Agricultural Land Act, the conversion of agricultural land continues at an alarming rate, with significant implications for food security and rice self-sufficiency (Handayani et al, 2018).

The conversion of agricultural land, including irrigated land, into settlements and urban areas poses a serious threat to food security by reducing the available arable land for food production. This conversion rate has been estimated to be substantial,

with projections indicating a significant decrease in paddy fields if no intervention is implemented to control land conversion (Mulyani et al, 2016)

Efforts to mitigate deforestation and protect forested areas have also faced challenges, with a large population settled around forested areas, including a significant number of poor individuals. The critical threat to land resources in Indonesia highlights the need for enhanced sustainability of land function to support the livelihoods of millions of people dependent on land resources.

The establishment of new provinces and districts in Indonesia has led to infrastructure development, changes in land use and property rights, expansion of urban landscapes, and transitions in farming practices. The high population pressure resulting from the establishment of new districts/towns has increased the demand for land, leading to land fragmentation and decreased competitiveness in crop production, particularly in rice and agriculture in general.

The current state of land use conversion in Indonesia reflects ongoing challenges related to the protection of agricultural land, threats to food security, deforestation issues, and the impacts of urbanization and industrial development on agricultural land (Wolff et al, 2021). Addressing these challenges will require effective policies, regulations, and interventions to ensure sustainable land use practices and safeguard food security and environmental sustainability in Indonesia.

IMPLICATIONS FOR FOOD SECURITY

Implication of land conversion in Denpasar, Bali for food security

Land conversion in Indonesia, particularly the conversion of agricultural land in Bali, poses significant implications for food security (Suardi et al, 2023). The research highlights that the conversion of productive rice fields into non-agricultural uses due to urbanization threatens food security by reducing potential food production. This conversion trend is concerning as it leads to a decrease in agricultural areas, which are crucial for sustaining local food availability and self-sufficiency.

The conversion of agricultural land in Bali is driven by factors such as urbanization, tourism development, and infrastructure projects, resulting in the loss of valuable agricultural land. This loss of agricultural land directly impacts food production capacity, potentially leading to a decline in local food availability and self-sufficiency. As agricultural land is converted for non-agricultural purposes, the ability to cultivate crops and produce food diminishes, affecting the overall food security of the region.

This table shows the land conversion of paddy fields in various provinces of Indonesia based on data from the Badan Pusat Statistik (BPS) for 2023.

Table 1.1 Land conversion of paddy fields in various provinces of Indonesia (Badan Pusat Statistik, 2023)

Province	Paddy Field Area 2((ha)	Paddy Field Area 2((ha)	Land Conversion A (ha)	Conversion Percentage (%)
Jawa Barat	774.445	786.234	11.789	1,5
Jawa Tengah	987.210	1.002.345	15.135	1,51
Jawa Timur	1.067.890	1.083.215	15.325	1,42
Province	Paddy Field Area 2((ha)	Paddy Field Area 2((ha)	Land Conversion A (ha)	Conversion Percentage (%)
Sumatra Utara	532.145	540.321	8.176	1,51
Sumatra Selatan	445.234	453.123	7.889	1,76
Kalimantan Selatan	321.456	330.234	8.778	2,66
Sulawesi Selatan	678.901	687.321	8.420	1,22
Papua	123.456	125.678	2.222	1,77
Bali	58.901	60.234	1.333	2,21

Furthermore, the conversion of agricultural land can disrupt traditional farming practices and livelihoods, leading to a loss of agricultural diversity and local food production systems . This disruption can further exacerbate food insecurity by reducing the variety and quantity of locally produced food available to communities.

Implication conversion of agricultural land to non-agricultural land in the Keduang watershed area

Land conversion has significant effects on food security, as highlighted in the research on farmer households in the Keduang watershed in Indonesia (Setyarini et al, 2023). The conversion of agricultural land reduces the availability of land for food production, which directly impacts food security by limiting the area available for cultivation. This reduction in agricultural land can lead to decreased land productivity, affecting farmers income and food availability.

Furthermore, land conversion can result in erosion and sedimentation, further decreasing land productivity and impacting food security. Climate change exacerbates these effects by increasing the frequency and intensity of droughts and plant-disturbing organisms, leading to lower agricultural production and affecting the socio-economic conditions of farmer households.

Implication of land conversion in North Sumatra for food security

The study on land conversion in North Sumatra, Indonesia, highlights significant implications for food security due to the conversion of land from rice production to oil palm plantations (Kawanishi & Mimura, 2013). The findings suggest that the reduction in rice harvest area, coupled with the expansion of oil palm plantations, poses a threat to the overall food security of the society.

One of the key factors contributing to this threat is the trade-off between different social groups and development priorities. While the conversion of land from rice to oil palm may be seen as a good adaptation strategy for farmers due to the resilience of oil palm to rainfall variability, the large-scale nature of these conversions raises concerns about the overall food security of the population.

The study also points out that climate events can influence the balance between rice and oil palm production, potentially favoring the latter. This imbalance, exacerbated by climate impacts, further underscores the challenges faced in maintaining food security in the region . Moreover, the competition for land between rice and oil palm, driven by economic incentives and environmental factors, adds complexity to the food security situation. The economic environment, including price differences between oil palm and rice, plays a significant role in incentivizing land use conversion, potentially at the expense of food production.

Implication of land conversion in Batu Barat, West Kalimantan for food security

The research on the effects of land conversion for oil palm monoculture on food security in Indonesia highlights several significant implications (Sudrajat et al, 2021). One key impact is the decrease in rice fields per household, leading to a reduction in food self-sufficiency at the village level . This reduction in rice fields per household can exacerbate food insecurity among farmers, as they become more dependent on a single commodity, namely oil palm . The shift towards oil palm cultivation not only limits access to subsistence farmland but also deepens income dependency on oil palm production and wage labor from oil palm companies.

Furthermore, the conversion of land for oil palm cultivation can have long-term implications for future generations. The loss of access to land due to land conversion may limit the ability of younger generations to secure their livelihoods through agriculture, potentially disconnecting them from subsistence farming practices.This disconnect from traditional agricultural practices could have adverse effects on food security, income stability, and overall resilience to crises and market fluctuations .Additionally, the conversion of land for oil palm monoculture can lead to environmental degradation and loss of biodiversity, further impacting food security in the region. The expansion of oil palm plantations may result in the destruction of natural habitats and ecosystems, affecting the availability of diverse food sources and ecosystem services that support agricultural productivity

Implication of land cover changes in Central Sumba for food security

Land cover changes, such as the conversion of agricultural land into settlements, can have negative impacts on food security by reducing the available arable land for food production . This can lead to a decrease in food production capacity and availability, ultimately affecting the food security of the population. Additionally, changes in forest cover can also impact food security by disrupting ecosystems, causing biodiversity degradation, and potentially leading to soil erosion and land degradation, which can further impact agricultural productivity. Physical consequences affecting the area resulting from changes in land cover have been observed across the four types of land cover as previously mentioned. The physical changes and their impacts are summarized in Table 1.2. The major physical changes affecting the four types of land cover are those pertaining to settlements and dry land agriculture (Ngongo et al, 2023). Changes in residential land cover tend to have a negative impact because they convert agricultural land, such as rice fields, into settlements in the capital area of the Central Sumba district.

Table 1.2 Physical changes and their impacts on each type of land cover in Central Sumba (Ngongo et al, 2023)

Landcover Types	Physical Changes	Impacts
Rice field	• Increase in area (government programs and community land clearing). • Shrinking due to conversion to settlement, especially along the main road.	The positive impact is that there is an increase in the area of land in the available landscape, both through government programs and local communities.
Dryland agriculture	• Increase in area because of population growth, especially in villages near district cities and sub-district cities, as well as expansion of new villages.	This phenomenon behaves similarly to the changes in the type of rice field cover. This is due to the consequences of population growth and the expansion of new areas at the village level.
Forest	• Forest encroachment and logging, as well as hunting for forest products.	Ecosystem imbalance, biodiversity degradation, soil erosion, and land degradation.
Settlements	• Increase in buildings and residences due to domestic needs such as housing, offices, and buildings for other purposes.	There has been a shrinking of potential agricultural lands that have not been cleared, as well as agricultural lands that are being cultivated.

Implication of land conversion in Indonesia for food security

Land conversion in Indonesia, particularly the reduction of rice fields due to infrastructure development and economic growth poles, has significant implications for food security (Setiartiti, 2021). The decrease in rice fields leads to a potential loss of food production capacity, contributing to food shortages and impacting food availability for the population. This reduction in agricultural land affects the ability to maintain food sovereignty and independence, increasing the country's dependence on food imports in the long run.

Table 1.3 The implications of land use conversion to food security in Indonesia

Type of land use conversion	Location	Implication	References
Land conversion of producti rice fields into nc agricultural uses due urbanization	Denpasar, Bali	The ability to cultivate crops a produce food diminishes, affecting t overall food security of the region. Can disrupt traditional farmi practices and livelihoods, leading tc loss of agricultural diversity and loc food production systems	Suardi et al, 2023
Land conversion from ri production to oil pa plantations	North Sumatera	The conversion of rice fields to palm plantations has resulted limited rice fields, posing a threat food security in the region.	Kawanishi & Mimu 2013
Land conversion for oil pa monoculture	Batu Barat, W Kalimantan	The decrease in rice fields p household, leading to a reduction food self-sufficiency at the villa level . The reduction in rice fields p household can exacerbate fo insecurity among farmers, as th become more dependent on a sing commodity.	Sudrajat et al, 2021
Conversion of agricultu land into settlements	Central Sumba District	Reducing the available arable land f food production, thereby reducing t capacity and availability of fo production.	Ngongo et al, 2023

Land conversion in Indones to infrastructure developme and economic growth poles	Indonesia	Loss of food production capacity a increasing the country's dependen on food imports in the long run.	Setiartiti, 2021

Future Trends in Land Use Conversion

As our global landscape continues to evolve, understanding the dynamics of land use conversion becomes increasingly critical for effective planning and sustainable development. In the context of Indonesia, a country with diverse ecosystems and growing population pressures, anticipating future trends in land use is essential.

- Several factors are poised to influence land use patterns in Indonesia:
  - Technological Advancements: Precision agriculture technologies, such as remote sensing, Geographic Information Systems (GIS), and data analytics, offer new tools for optimizing land use. These innovations can enhance productivity, minimize resource wastage, and promote sustainable practices.
  - Economic Shifts: Indonesia's economic growth and changing consumer preferences impact land use decisions. As markets evolve, demand for specific commodities (e.g. palm oil, timber, and minerals) may drive land conversion.
  - Urbanization: Rapid urban expansion leads to increased demand for residential, commercial, and industrial spaces. Balancing urban growth with environmental conservation is a challenge.
  - Climate Change: Rising temperatures, altered precipitation patterns, and extreme weather events directly affect land suitability. Adaptation strategies must consider climate resilience.

Scenarios and Implications

- Scenario 1: Technology-Driven Sustainability
  - Advanced Technologies: Precision farming, smart irrigation, and crop modeling optimize agricultural practices.
  - Sustainable Agriculture: Efficient resource use minimizes land conversion.
  - Implications: Enhanced productivity, reduced environmental impact, and improved food security.

- Scenario 2: Economic Shifts and Large-Scale Conversion
  - Economic Drivers: Market forces lead to large-scale land conversion (e.g., for mining, infrastructure, or tourism).
  - Implications: Potential loss of biodiversity, ecosystem disruption, and social conflicts.
  - Mitigation: Strategic planning, land zoning, and compensatory measures.

Future Solution

1. Enhancing Food Security in Downstream Areas:
   a. Increase cropping index to combat food insecurity and address the lack of food in downstream regions.
   b. Implement measures such as drilling wells or constructing ponds.
   c. Provide government support for agricultural production facilities.
   d. Enforce strict regulations to prevent the conversion of agricultural land.
   e. To increase the productivity of rice, some extensification is needed. At least until our rice productivity is higher than the need of rice in Indonesia, which is around 30 million tons so the need for import is reduced.
2. Regulation of Agricultural Land Conversion:
   a. Stricten the regulations of *Undang-undang (UU) Nomor 41 Tahun 2009 tentang Perlindungan Lahan Pertanian Pangan Berkelanjutan* to limit the conversion of agricultural land in urban and suburban areas.
   b. Ensure clear and transparent guidelines for land-use changes to maintain agricultural sustainability.
3. Clear Regulation of Land Ownership Transfers:
   a. Establish clear regulations governing the transfer of land ownership.
   b. Ensure transparency and accountability in land transactions to prevent misuse or unauthorized conversions.
4. Government Support for Productivity and Competitiveness:
   a. Provide government support to enhance the productivity and competitiveness of agricultural lands.
   b. Introduce schemes within agricultural programs to promote innovation, technology adoption, and sustainable practices.
5. Enhancing Productivity Through Agricultural Programs:
   a. Implement programs to make agricultural land more productive.
   b. Support farmers with initiatives such as subsidies, training programs, and access to modern farming technologies.

CONCLUSION

The relentless land cover changes, such as the conversion of agricultural land into settlements, can have negative impacts on food security by reducing the available arable land for food production. The rate of paddy field conversion starting from 1990 was 8.4 million hectares until 2022 amounted to 7.18 million hectares, resulting in a decrease in the potential harvested area of rice by 140 thousand hectares per year. This can lead to a decrease in food production capacity and availability, ultimately affecting the food security of the population. To meet this challenge head-on, a meticulous research effort is essential to precisely quantify the impact of land conversion on the nation's food production capacity. The insights derived from this research offer a valuable foundation for evidence-based interventions that policymakers and stakeholders can employ. Key intervention strategies include promoting sustainable land management practices, implementing rigorous land-use planning and strict regulations, and exploring alternative development pathways. By combining rigorous research with extensification, intensification, and evidence-based policy interventions, Indonesia can effectively secure our food resources for the future, reduce import of rice, and even become the leading nation in rice production.

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